FANUC Robotics SYSTEM R-J3*i*C Controller KAREL Reference Manual

MARRCKREF09051E REV B

Applies to Version 7.20

© 2006 FANUC Robotics America, Inc.

About This Manual

Copyrights and Trademarks

This new publication contains proprietary information of FANUC Robotics America, Inc. furnished for customer use only. No other uses are authorized without the express written permission of FANUC Robotics America, Inc.

FANUC Robotics America, Inc
3900 W. Hamlin Road
Rochester Hills, Michigan 48309-3253

FANUC Robotics America, Inc. The descriptions and specifications contained in this manual were in effect at the time this manual was approved. FANUC Robotics America, Inc, hereinafter referred to as FANUC Robotics, reserves the right to discontinue models at any time or to change specifications or design without notice and without incurring obligations.

FANUC Robotics manuals present descriptions, specifications, drawings, schematics, bills of material, parts, connections and/or procedures for installing, disassembling, connecting, operating and programming FANUC Robotics' products and/or systems. Such systems consist of robots, extended axes, robot controllers, application software, the KAREL® programming language, INSIGHT® vision equipment, and special tools.

FANUC Robotics recommends that only persons who have been trained in one or more approved FANUC Robotics Training Course(s) be permitted to install, operate, use, perform procedures on, repair, and/or maintain FANUC Robotics' products and/or systems and their respective components. Approved training necessitates that the courses selected be relevant to the type of system installed and application performed at the customer site.



Warning

This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instruction manual, may cause interference to radio communications. As temporarily permitted by regulation, it has not been tested for compliance with the limits for Class A computing devices pursuant to subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference. Operation of the equipment in a residential area is likely to cause interference, in which case the user, at his own expense, will be required to take whatever measure may be required to correct the interference.

FANUC Robotics conducts courses on its systems and products on a regularly scheduled basis at its headquarters in Rochester Hills, Michigan. For additional information contact

FANUC Robotics America, Inc
Training Department
3900 W. Hamlin Road
Rochester Hills, Michigan48309-3253

www.fanucrobotics.com

For customer assistance, including Technical Support, Service, Parts & Part Repair, and Marketing Requests, contact the Customer Resource Center, 24 hours a day, at 1-800-47-ROBOT (1-800-477-6268). International customers should call 011-1-248-377-7159.

Send your comments and suggestions about this manual to:
product.documentation@fanucrobotics.com

The information illustrated or contained herein is not to be reproduced, copied, downloaded, translated into another language, distributed, or published in any physical or electronic format, including Internet, or transmitted in whole or in part in any way without the prior written consent of FANUC Robotics America, Inc.

AccuStat®, ArcTool®, KAREL®, PaintTool®,PalletTool®, SOCKETS®, SpotTool®, SpotWorks®, and TorchMate®are Registered Trademarks of FANUC Robotics.

FANUC Robotics reserves all proprietary rights, including but not limited to trademark and trade name rights, in the following names:

AccuAir™, AccuCal™, AccuChop™, AccuFlow™, AccuPath™, AccuSeal™, ARC Mate™, ARC Mate Sr.™, ARC Mate System 1™, ARC Mate System 2™, ARC Mate System 3™, ARC Mate System 4™, ARC Mate System 5™, ARCWorks Pro™, AssistTool™, AutoNormal™, AutoTCP™, BellTool™, BODYWorks™, Cal Mate™, Cell Finder™, Center Finder™, Clean Wall™, LR Tool™, MIG Eye™, MotionParts™, NoBots™, Paint Stick™, PaintPro™, PaintTool 100™, PAINTWorks™, PAINTWorks II™, PAINTWorks III™, PalletMate™, PalletMate PC™, PalletTool PC™, PayloadID™, RecipTool™, RemovalTool™, Robo Chop™, Robo Spray™, S-420i™, S-430i™, ShapeGen™, SoftFloat™, SOFT PARTS™, SpotTool+™, SR Mate™, SR ShotTool™, SureWeld™, SYSTEM R-J2 Controller™, SYSTEM R-J3 Controller™, SYSTEM R-J3*i*B Controller™, SYSTEM R-J3*i*C Controller™, TCP Mate™, TorchMate™, TurboMove™, visLOC™, visPRO-3D™, visTRAC™, WebServer™, WebTP™, and YagTool™.

Patents

One or more of the following U.S. patents might be related to the FANUC Robotics products described in this manual.

FRA Patent List

4,630,567 4,639,878 4,707,647 4,708,175 4,708,580 4,942,539 4,984,745 5,238,029 5,239,739 5,272,805 5,293,107 5,293,911 5,331,264 5,367,944 5,373,221 5,421,218 5,434,489 5,644,898 5,670,202 5,696,687 5,737,218 5,823,389 5,853,027 5,887,800 5,941,679 5,959,425 5,987,726 6,059,092 6,064,168 6,070,109 6,086,294 6,122,062 6,147,323 6,204,620 6,243,621 6,253,799 6,285,920 6,313,595 6,325,302 6,345,818 6,356,807 6,360,143 6,378,190 6,385,508 6,425,177 6,477,913 6,490,369 6,518,980 6,540,104 6,541,757 6,560,513 6,569,258 6,612,449 6,703,079 6,705,361 6,726,773 6,768,078 6,845,295 6,945,483

FANUC LTD Patent List

4,571,694 4,626,756 4,700,118 4,706,001 4,728,872 4,732,526 4,742,207 4,835,362 4,894,596 4,899,095 4,920,248 4,931,617 4,934,504 4,956,594 4,967,125 4,969,109 4,970,370 4,970,448 4,979,127 5,004,968 5,006,035 5,008,834 5,063,281 5,066,847 5,066,902 5,093,552 5,107,716 5,111,019 5,130,515 5,136,223 5,151,608 5,170,109 5,189,351 5,267,483 5,274,360 5,292,066 5,300,868 5,304,906 5,313,563 5,319,443 5,325,467 5,327,057 5,329,469 5,333,242 5,337,148 5,371,452 5,375,480 5,418,441 5,432,316 5,440,213 5,442,155 5,444,612 5,449,875 5,451,850 5,461,478 5,463,297 5,467,003 5,471,312 5,479,078 5,485,389 5,485,552 5,486,679 5,489,758 5,493,192 5,504,766 5,511,007 5,520,062 5,528,013 5,532,924 5,548,194 5,552,687 5,558,196 5,561,742 5,570,187 5,570,190 5,572,103 5,581,167 5,582,750 5,587,635 5,600,759 5,608,299 5,608,618 5,624,588 5,630,955 5,637,969 5,639,204 5,641,415 5,650,078 5,658,121 5,668,628 5,687,295 5,691,615 5,698,121 5,708,342 5,715,375 5,719,479 5,727,132 5,742,138 5,742,144 5,748,854 5,749,058 5,760,560 5,773,950 5,783,922 5,799,135 5,812,408 5,841,257 5,845,053 5,872,894 5,887,122 5,911,892 5,912,540 5,920,678 5,937,143 5,980,082 5,983,744 5,987,591 5,988,850 6,023,044 6,032,086 6,040,554 6,059,169 6,088,628 6,097,169 6,114,824 6,124,693 6,140,788 6,141,863 6,157,155 6,160,324 6,163,124 6,177,650 6,180,898 6,181,096 6,188,194 6,208,105 6,212,444 6,219,583 6,226,181 6,236,011 6,236,896 6,250,174 6,278,902 6,279,413 6,285,921 6,298,283 6,321,139 6,324,443 6,328,523 6,330,493 6,340,875 6,356,671 6,377,869 6,382,012 6,384,371 6,396,030 6,414,711 6,424,883 6,431,018 6,434,448 6,445,979 6,459,958 6,463,358 6,484,067 6,486,629 6,507,165 6,654,666 6,665,588 6,680,461 6,696,810 6,728,417 6,763,284 6,772,493 6,845,296 6,853,881 6,888,089 6,898,486 6,928,337 6,917,837 6,965,091 6,970,802 7,038,165 7,069,808 7,08,4900 7,092,791

VersaBell, ServoBell and SpeedDock Patents Pending.

Conventions

This manual includes information essential to the safety of personnel, equipment, software, and data. This information is indicated by headings and boxes in the text.



Warning

Information appearing under WARNING concerns the protection of personnel. It is boxed and in bold type to set it apart from other text.



Caution

Information appearing under **CAUTION** concerns the protection of equipment, software, and data. It is boxed to set it apart from other text.

Note Information appearing next to **NOTE** concerns related information or useful hints.

Contents

About This Manual i

Safety xxvii

Chapter 1 KAREL LANGUAGE OVERVIEW 1–1

1.1 OVERVIEW 1–2

1.2 KAREL PROGRAMMING LANGUAGE 1–2
1.2.1 Overview 1–2
1.2.2 Creating a Program 1–4
1.2.3 Translating a Program 1–4
1.2.4 Loading Program Logic and Data 1–4
1.2.5 Executing a Program 1–5
1.2.6 Execution History 1–5
1.2.7 Program Structure 1–5

1.3 SYSTEM SOFTWARE 1–6
1.3.1 Software Components 1–7
1.3.2 Supported Robots 1–7

1.4 CONTROLLER 1–7
1.4.1 Memory 1–8
1.4.2 Input/Output System 1–9
1.4.3 User Interface Devices 1–10

Chapter 2 LANGUAGE ELEMENTS 2–1

2.1 LANGUAGE COMPONENTS 2–2
2.1.1 Character Set 2–2
2.1.2 Operators 2–5
2.1.3 Reserved Words 2–5
2.1.4 User-Defined Identifiers 2–7
2.1.5 Labels 2–7
2.1.6 Predefined Identifiers 2–8
2.1.7 System Variables 2–9
2.1.8 Comments 2–9

2.2 **TRANSLATOR DIRECTIVES** 2–10

2.3 DATA TYPES 2–12

2.4 USER-DEFINED DATA TYPES AND STRUCTURES 2–13
2.4.1 User-Defined Data Types 2–13
2.4.2 User-Defined Data Structures 2–15

2.5 ARRAYS 2–17
2.5.1 Multi-Dimensional Arrays 2–18
2.5.2 Variable-Sized Arrays 2–20

Chapter 3 USE OF OPERATORS 3–1

3.1 EXPRESSIONS AND ASSIGNMENTS 3–2
3.1.1 Rule for Expressions and Assignments 3–2
3.1.2 Evaluation of Expressions and Assignments 3–2
3.1.3 Variables and Expressions 3–4
3.2 OPERATIONS 3–4
3.2.1 Arithmetic Operations 3–5
3.2.2 Relational Operations 3–6
3.2.3 Boolean Operations 3–7
3.2.4 Special Operations 3–8

Chapter 4 MOTION AND PROGRAM CONTROL 4–1
4.1 OVERVIEW 4–2
4.2 MOTION CONTROL STATEMENTS 4–2
4.2.1 Extended Axis Motion 4–4
4.2.2 Group Motion 4–4
4.3 PROGRAM CONTROL STRUCTURES 4–5
4.3.1 Alternation Control Structures 4–5
4.3.2 Looping Control Statements 4–6
4.3.3 Unconditional Branch Statement 4–6
4.3.4 Execution Control Statements 4–6
4.3.5 Condition Handlers 4–7

Chapter 5 ROUTINES 5–1
5.1 ROUTINE EXECUTION 5–2
5.1.1 Declaring Routines 5–2
5.1.2 Invoking Routines 5–5
5.1.3 Returning from Routines 5–7
5.1.4 Scope of Variables 5–8
5.1.5 Parameters and Arguments 5–9
5.1.6 Stack Usage 5–13
5.2 BUILT- IN ROUTINES 5–15

Chapter 6 CONDITION HANDLERS 6–1
6.1 CONDITION HANDLER OPERATIONS 6–3
6.1.1 Global Condition Handlers 6–3
6.1.2 Local Condition Handlers 6–6
6.2 CONDITIONS 6–8
6.2.1 Port_Id Conditions 6–9
6.2.2 Relational Conditions 6–9
6.2.3 System and Program Event Conditions 6–10
6.2.4 Local Conditions 6–13
6.2.5 Synchronization of Local Condition Handlers 6–14
6.3 ACTIONS 6–16
6.3.1 Assignment Actions 6–16
6.3.2 Motion Related Actions 6–17
6.3.3 Routine Call Actions 6–18
6.3.4 Miscellaneous Actions 6–19

Chapter 7 FILE INPUT/OUTPUT OPERATIONS 7–1
7.1 OVERVIEW 7–3
7.2 FILE VARIABLES 7–3

7.3 OPEN FILE STATEMENT 7–4
7.3.1 Setting File and Port Attributes 7–5
7.3.2 File String 7–10
7.3.3 Usage String 7–11
7.4 CLOSE FILE STATEMENT 7–14
7.5 READ STATEMENT 7–14
7.6 WRITE STATEMENT 7–16
7.7 INPUT/OUTPUT BUFFER 7–17
7.8 FORMATTING TEXT (ASCII) INPUT/OUTPUT 7–18
7.8.1 Formatting INTEGER Data Items 7–19
7.8.2 Formatting REAL Data Items 7–22
7.8.3 Formatting BOOLEAN Data Items 7–25
7.8.4 Formatting STRING Data Items 7–27
7.8.5 Formatting VECTOR Data Items 7–31
7.8.6 Formatting Positional Data Items 7–32
7.9 FORMATTING BINARY INPUT/OUTPUT 7–34
7.9.1 Formatting INTEGER Data Items 7–35
7.9.2 Formatting REAL Data Items 7–36
7.9.3 Formatting BOOLEAN Data Items 7–36
7.9.4 Formatting STRING Data Items 7–36
7.9.5 Formatting VECTOR Data Items 7–37
7.9.6 Formatting POSITION Data Items 7–37
7.9.7 Formatting XYZWPR Data Items 7–37
7.9.8 Formatting XYZWPREXT Data Items 7–38
7.9.9 Formatting JOINTPOS Data Items 7–38
7.10 USER INTERFACE TIPS 7–38
7.10.1 USER Menu on the Teach Pendant 7–38
7.10.2 USER Menu on the CRT/KB 7–40

Chapter 8 MOTION 8–1
8.1 OVERVIEW 8–2
8.2 POSITIONAL DATA 8–2
8.3 FRAMES OF REFERENCE 8–3
8.3.1 World Frame 8–4
8.3.2 User Frame (UFRAME) 8–5
8.3.3 Tool Definition (UTOOL) 8–5
8.3.4 Using Frames in the Teach Pendant Editor (TP) 8–6
8.4 JOG COORDINATE SYSTEMS 8–6
8.5 MOTION CONTROL 8–7
8.5.1 Motion Trajectory 8–9
8.5.2 Motion Trajectories with Extended Axes 8–17
8.5.3 Acceleration and Deceleration 8–18
8.5.4 Motion Speed 8–21
8.5.5 Motion Termination 8–26
8.5.6 Multiple Segment Motion 8–29
8.5.7 Path Motion 8–36
8.5.8 Motion Times 8–39
8.5.9 Correspondence Between Teach Pendant Program Motion and KAREL Program Motion 8–42

Chapter 9 FILE SYSTEM 9–1
9.1 OVERVIEW 9–2

9.2 FILE SPECIFICATION 9–3
9.2.1 Device Name 9–3
9.2.2 File Name 9–4
9.2.3 File Type 9–5
9.3 STORAGE DEVICE ACCESS 9–6
9.3.1 Overview 9–7
9.3.2 Memory File Devices 9–13
9.3.3 Virtual Devices 9–14
9.3.4 File Pipes 9–15
9.4 FILE ACCESS 9–20
9.5 FORMATTING XML INPUT 9–20
9.5.1 Overview 9–20
9.5.2 Installation Sequence 9–21
9.5.3 Example XML File 9–21
9.5.4 Example KAREL Program Referencing an XML File 9–22
9.5.5 Parse Errors 9–24
9.6 MEMORY DEVICE 9–25

Chapter 10 DICTIONARIES AND FORMS 10–1
10.1 OVERVIEW 10–3
10.2 CREATING USER DICTIONARIES 10–3
10.2.1 Dictionary Syntax 10–3
10.2.2 Dictionary Element Number 10–4
10.2.3 Dictionary Element Name 10–5
10.2.4 Dictionary Cursor Positioning 10–5
10.2.5 Dictionary Element Text 10–6
10.2.6 Dictionary Reserved Word Commands 10–8
10.2.7 Character Codes 10–10
10.2.8 Nesting Dictionary Elements 10–10
10.2.9 Dictionary Comment 10–11
10.2.10 Generating a KAREL Constant File 10–11
10.2.11 Compressing and Loading Dictionaries on the Controller 10–11
10.2.12 Accessing Dictionary Elements from a KAREL Program 10–12
10.3 CREATING USER FORMS 10–13
10.3.1 Form Syntax 10–14
10.3.2 Form Attributes 10–15
10.3.3 Form Title and Menu Label 10–16
10.3.4 Form Menu Text 10–17
10.3.5 Form Selectable Menu Item 10–18
10.3.6 Edit Data Item 10–19
10.3.7 Non-Selectable Text 10–25
10.3.8 Display Only Data Items 10–26
10.3.9 Cursor Position Attributes 10–26
10.3.10 Form Reserved Words and Character Codes 10–26
10.3.11 Form Function Key Element Name or Number 10–28
10.3.12 Form Function Key Using a Variable 10–29
10.3.13 Form Help Element Name or Number 10–30
10.3.14 Teach Pendant Form Screen 10–30
10.3.15 CRT/KB Form Screen 10–31
10.3.16 Form File Naming Convention 10–32
10.3.17 Compressing and Loading Forms on the Controller 10–32
10.3.18 Displaying a Form 10–34

Chapter 11 SYSTEM VARIABLES 11–1
11.1 ACCESS RIGHTS 11–2
11.1.1 System Variables Accessed by KAREL Programs 11–3
11.2 STORAGE 11–4

Chapter 12 KAREL COMMAND LANGUAGE (KCL) 12–1
12.1 COMMAND FORMAT 12–2
12.1.1 Default Program 12–2
12.1.2 Variables and Data Types 12–3
12.2 MOTION CONTROL COMMANDS 12–3
12.3 ENTERING COMMANDS 12–3
12.3.1 Abbreviations 12–4
12.3.2 Error Messages 12–4
12.3.3 Subdirectories 12–4
12.4 COMMAND PROCEDURES 12–4
12.4.1 Command Procedure Format 12–5
12.4.2 Creating Command Procedures 12–6
12.4.3 Error Processing 12–6
12.4.4 Executing Command Procedures 12–6

Chapter 13 INPUT/OUTPUT SYSTEM 13–1
13.1 USER-DEFINED SIGNALS 13–2
13.1.1 DIN and DOUT Signals 13–2
13.1.2 GIN and GOUT Signals 13–3
13.1.3 AIN and AOUT Signals 13–3
13.1.4 Hand Signals 13–5
13.2 SYSTEM-DEFINED SIGNALS 13–5
13.2.1 Robot Digital Input and Output Signals (RDI/RDO) 13–6
13.2.2 Operator Panel Input and Output Signals (OPIN/OPOUT) 13–6
13.2.3 Teach Pendant Input and Output Signals (TPIN/TPOUT) 13–17
13.3 Serial Input/Output 13–21
13.3.1 Serial Input/Output 13–21

Chapter 14 MULTI-TASKING 14–1
14.1 MULTI-TASKING TERMINOLOGY 14–2
14.2 INTERPRETER ASSIGNMENT 14–3
14.3 MOTION CONTROL 14–3
14.4 TASK SCHEDULING 14–4
14.4.1 Priority Scheduling 14–5
14.4.2 Time Slicing 14–6
14.5 STARTING TASKS 14–6
14.5.1 Running Programs from the User Operator Panel (UOP) PNS Signal 14–7
14.5.2 Child Tasks 14–7
14.6 TASK CONTROL AND MONITORING 14–8
14.6.1 From TPP Programs 14–8
14.6.2 From KAREL Programs 14–8
14.6.3 From KCL 14–9
14.7 USING SEMAPHORES AND TASK SYNCHRONIZATION 14–9
14.8 USING QUEUES FOR TASK COMMUNICATIONS 14–14

Appendix A KAREL LANGUAGE ALPHABETICAL DESCRIPTION A–1

A.1 OVERVIEW A–9

A.2 - A - KAREL LANGUAGE DESCRIPTION A–18
A.2.1 ABORT Action A–18
A.2.2 ABORT Condition A–18
A.2.3 ABORT Statement A–19
A.2.4 ABORT_TASK Built-In Procedure A–19
A.2.5 ABS Built-In Function A–20
A.2.6 ACOS Built-In Function A–21
A.2.7 ACT_SCREEN Built-In Procedure A–22
A.2.8 ADD_BYNAMEPC Built-In Procedure A–22
A.2.9 ADD_DICT Built-In Procedure A–24
A.2.10 ADD_INTPC Built-In Procedure A–25
A.2.11 ADD_REALPC Built-In Procedure A–26
A.2.12 ADD_STRINGPC Built-In Procedure A–27
A.2.13 %ALPHABETIZE Translator Directive A–29
A.2.14 APPEND_NODE Built-In Procedure A–29
A.2.15 APPEND_QUEUE Built-In Procedure A–30
A.2.16 APPROACH Built-In Function A–31
A.2.17 ARRAY Data Type A–31
A.2.18 ARRAY_LEN Built-In Function A–33
A.2.19 ASIN Built-In Function A–33
A.2.20 Assignment Action A–34
A.2.21 Assignment Statement A–35
A.2.22 AT NODE Condition A–37
A.2.23 ATAN2 Built-In Function A–37
A.2.24 ATTACH Statement A–38
A.2.25 ATT_WINDOW_D Built-In Procedure A–39
A.2.26 ATT_WINDOW_S Built-In Procedure A–40
A.2.27 AVL_POS_NUM Built-In Procedure A–40

A.3 - B - KAREL LANGUAGE DESCRIPTION A–41
A.3.1 BOOLEAN Data Type A–41
A.3.2 BYNAME Built-In Function A–42
A.3.3 BYTE Data Type A–43
A.3.4 BYTES_AHEAD Built-In Procedure A–44
A.3.5 BYTES_LEFT Built-In Function A–45

A.4 - C - KAREL LANGUAGE DESCRIPTION A–47
A.4.1 CALL_PROG Built-In Procedure A–47
A.4.2 CALL_PROGLIN Built-In Procedure A–47
A.4.3 CANCEL Action A–48
A.4.4 CANCEL Statement A–49
A.4.5 CANCEL FILE Statement A–50
A.4.6 CHECK_DICT Built-In Procedure A–51
A.4.7 CHECK_EPOS Built-In Procedure A–52
A.4.8 CHECK_NAME Built-In Procedure A–53
A.4.9 CHR Built-In Function A–53
A.4.10 CLEAR Built-In Procedure A–54
A.4.11 CLEAR_SEMA Built-In Procedure A–55
A.4.12 CLOSE FILE Statement A–55
A.4.13 CLOSE HAND Statement A–56
A.4.14 CLOSE_TPE Built-In Procedure A–57
A.4.15 CLR_IO_STAT Built-In Procedure A–57
A.4.16 CLR_PORT_SIM Built-In Procedure A–58
A.4.17 CLR_POS_REG Built-In Procedure A–58

A.4.18 %CMOSVARS Translator Directive A–59
A.4.19 %CMOS2SHADOW Translator Directive A–59
A.4.20 CNC_DYN_DISB Built-In Procedure A–60
A.4.21 CNC_DYN_DISE Built-In Procedure A–60
A.4.22 CNC_DYN_DISI Built-In Procedure A–61
A.4.23 CNC_DYN_DISP Built-In Procedure A–62
A.4.24 CNC_DYN_DISR Built-In Procedure A–62
A.4.25 CNC_DYN_DISS Built-In Procedure A–63
A.4.26 CNCL_STP_MTN Built-In Procedure A–64
A.4.27 CNV_CONF_STR Built-In Procedure A–65
A.4.28 CNV_INT_STR Built-In Procedure A–65
A.4.29 CNV_JPOS_REL Built-In Procedure A–66
A.4.30 CNV_REAL_STR Built-In Procedure A–67
A.4.31 CNV_REL_JPOS Built-In Procedure A–68
A.4.32 CNV_STR_CONF Built-In Procedure A–69
A.4.33 CNV_STR_INT Built-In Procedure A–69
A.4.34 CNV_STR_REAL Built-In Procedure A–70
A.4.35 CNV_STR_TIME Built-In Procedure A–71
A.4.36 CNV_TIME_STR Built-In Procedure A–71
A.4.37 %COMMENT Translator Directive A–72
A.4.38 COMMON_ASSOC Data Type A–73
A.4.39 CONDITION...ENDCONDITION Statement A–73
A.4.40 CONFIG Data Type A–75
A.4.41 CONNECT TIMER Statement A–76
A.4.42 CONTINUE Action A–77
A.4.43 CONTINUE Condition A–77
A.4.44 CONT_TASK Built-In Procedure A–78
A.4.45 COPY_FILE Built-In Procedure A–79
A.4.46 COPY_PATH Built-In Procedure A–80
A.4.47 COPY_QUEUE Built-In Procedure A–82
A.4.48 COPY_TPE Built-In Procedure A–83
A.4.49 COS Built-In Function A–84
A.4.50 CR Input/Output Item A–84
A.4.51 CREATE_TPE Built-In Procedure A–85
A.4.52 CREATE_VAR Built-In Procedure A–86
A.4.53 %CRTDEVICE A–89
A.4.54 CURJPOS Built-In Function A–89
A.4.55 CURPOS Built-In Function A–90
A.4.56 CURR_PROG Built-In Function A–91

A.5 - D - KAREL LANGUAGE DESCRIPTION A–92
A.5.1 DAQ_CHECKP Built-In Procedure A–92
A.5.2 DAQ_REGPIPE Built-In Procedure A–93
A.5.3 DAQ_START Built-In Procedure A–95
A.5.4 DAQ_STOP Built-In Procedure A–97
A.5.5 DAQ_UNREG Built-In Procedure A–98
A.5.6 DAQ_WRITE Built-In Procedure A–99
A.5.7 %DEFGROUP Translator Directive A–101
A.5.8 DEF_SCREEN Built-In Procedure A–101
A.5.9 DEF_WINDOW Built-In Procedure A–102
A.5.10 %DELAY Translator Directive A–103
A.5.11 DELAY Statement A–104
A.5.12 DELETE_FILE Built-In Procedure A–105
A.5.13 DELETE_NODE Built-In Procedure A–106
A.5.14 DELETE_QUEUE Built-In Procedure A–106
A.5.15 DEL_INST_TPE Built-In Procedure A–107

A.5.16 DET_WINDOW Built-In Procedure A–108
A.5.17 DISABLE CONDITION Action A–108
A.5.18 DISABLE CONDITION Statement A–109
A.5.19 DISCONNECT TIMER Statement A–111
A.5.20 DISCTRL_ALPH Built_In Procedure A–111
A.5.21 DISCTRL_FORM Built_In Procedure A–113
A.5.22 DISCTRL_LIST Built-In Procedure A–116
A.5.23 DISCTRL_PLMN Built-In Procedure A–117
A.5.24 DISCTRL_SBMN Built-In Procedure A–119
A.5.25 DISCTRL_TBL Built-In Procedure A–122
A.5.26 DISMOUNT_DEV Built-In Procedure A–124
A.5.27 DISP_DAT_T Data Type A–125

A.6 - E - KAREL LANGUAGE DESCRIPTION A–126
A.6.1 ENABLE CONDITION Action A–126
A.6.2 ENABLE CONDITION Statement A–127
A.6.3 %ENVIRONMENT Translator Directive A–128
A.6.4 ERR_DATA Built-In Procedure A–129
A.6.5 ERROR Condition A–131
A.6.6 EVAL Clause A–131
A.6.7 EVENT Condition A–132
A.6.8 EXP Built-In Function A–133

A.7 - F - KAREL LANGUAGE DESCRIPTION A–133
A.7.1 FILE Data Type A–133
A.7.2 FILE_LIST Built-In Procedure A–134
A.7.3 FOR...ENDFOR Statement A–135
A.7.4 FORCE_SPMENU Built-In Procedure A–137
A.7.5 FORMAT_DEV Built-In Procedure A–139
A.7.6 FRAME Built-In Function A–140
A.7.7 FROM Clause A–142

A.8 - G - KAREL LANGUAGE DESCRIPTION A–143
A.8.1 GET_ATTR_PRG Built-In Procedure A–143
A.8.2 GET_FILE_POS Built-In Function A–145
A.8.3 GET_JPOS_REG Built-In Function A–146
A.8.4 GET_JPOS_TPE Built-In Function A–146
A.8.5 GET_PORT_ASG Built-in Procedure A–147
A.8.6 GET_PORT_ATR Built-In Function A–149
A.8.7 GET_PORT_CMT Built-In Procedure A–151
A.8.8 GET_PORT_MOD Built-In Procedure A–152
A.8.9 GET_PORT_SIM Built-In Procedure A–154
A.8.10 GET_PORT_VAL Built-In Procedure A–154
A.8.11 GET_POS_FRM Built-In Procedure A–155
A.8.12 GET_POS_REG Built-In Function A–156
A.8.13 GET_POS_TPE Built-In Function A–157
A.8.14 GET_POS_TYP Built-In Procedure A–158
A.8.15 GET_PREG_CMT Built-In-Procedure A–158
A.8.16 GET_QUEUE Built-In Procedure A–159
A.8.17 GET_REG Built-In Procedure A–160
A.8.18 GET_REG_CMT A–161
A.8.19 GET_TIME Built-In Procedure A–161
A.8.20 GET_TPE_CMT Built-in Procedure A–162
A.8.21 GET_TPE_PRM Built-in Procedure A–163
A.8.22 GET_TSK_INFO Built-In Procedure A–165
A.8.23 GET_USEC_SUB Built-In Procedure A–167
A.8.24 GET_USEC_TIM Built-In Function A–168

A.8.25 GET_VAR Built-In Procedure A–169
A.8.26 GO TO Statement A–171
A.8.27 GROUP_ASSOC Data Type A–171
A.9 - H - KAREL LANGUAGE DESCRIPTION A–172
A.9.1 HOLD Action A–172
A.9.2 HOLD Statement A–173
A.10 - I - KAREL LANGUAGE DESCRIPTION A–174
A.10.1 IF ... ENDIF Statement A–174
A.10.2 IN Clause A–176
A.10.3 %INCLUDE Translator Directive A–176
A.10.4 INDEX Built-In Function A–177
A.10.5 INI_DYN_DISB Built-In Procedure A–178
A.10.6 INI_DYN_DISE Built-In Procedure A–180
A.10.7 INI_DYN_DISI Built-In Procedure A–181
A.10.8 INI_DYN_DISP Built-In Procedure A–183
A.10.9 INI_DYN_DISR Built-In Procedure A–184
A.10.10 INI_DYN_DISS Built-In Procedure A–185
A.10.11 INIT_QUEUE Built-In Procedure A–186
A.10.12 INIT_TBL Built-In Procedure A–187
A.10.13 IN_RANGE Built-In Function A–198
A.10.14 INSERT_NODE Built-In Procedure A–199
A.10.15 INSERT_QUEUE Built-In Procedure A–200
A.10.16 INTEGER Data Type A–201
A.10.17 INV Built-In Function A–202
A.10.18 IO_MOD_TYPE Built-In Procedure A–203
A.10.19 IO_STATUS Built-In Function A–204
A.11 - J - KAREL LANGUAGE DESCRIPTION A–205
A.11.1 J_IN_RANGE Built-In Function A–205
A.11.2 JOINTPOS Data Type A–206
A.11.3 JOINT2POS Built-In Function A–206
A.12 - K - KAREL LANGUAGE DESCRIPTION A–208
A.12.1 KCL Built-In Procedure A–208
A.12.2 KCL_NO_WAIT Built-In Procedure A–209
A.12.3 KCL_STATUS Built-In Procedure A–210
A.13 - L - KAREL LANGUAGE DESCRIPTION A–210
A.13.1 LN Built-In Function A–210
A.13.2 LOAD Built-In Procedure A–211
A.13.3 LOAD_STATUS Built-In Procedure A–212
A.13.4 LOCK_GROUP Built-In Procedure A–213
A.13.5 %LOCKGROUP Translator Directive A–214
A.14 - M - KAREL LANGUAGE DESCRIPTION A–215
A.14.1 MIRROR Built-In Function A–215
A.14.2 MODIFY_QUEUE Built-In Procedure A–217
A.14.3 MOTION_CTL Built-In Function A–218
A.14.4 MOUNT_DEV Built-In Procedure A–219
A.14.5 MOVE ABOUT Statement A–219
A.14.6 MOVE ALONG Statement A–221
A.14.7 MOVE AWAY Statement A–222
A.14.8 MOVE AXIS Statement A–224
A.14.9 MOVE_FILE Built-In Procedure A–225
A.14.10 MOVE NEAR Statement A–226
A.14.11 MOVE RELATIVE Statement A–227
A.14.12 MOVE TO Statement A–229

A.14.13 MSG_CONNECT Built-In Procedure A–230
A.14.14 MSG_DISCO Built-In Procedure A–231
A.14.15 MSG_PING A–232
A.15 - N - KAREL LANGUAGE DESCRIPTION A–233
A.15.1 NOABORT Action A–233
A.15.2 %NOABORT Translator Directive A–233
A.15.3 %NOBUSYLAMP Translator Directive A–234
A.15.4 NODE_SIZE Built-In Function A–234
A.15.5 %NOLOCKGROUP Translator Directive A–236
A.15.6 NOMESSAGE Action A–237
A.15.7 NOPAUSE Action A–238
A.15.8 %NOPAUSE Translator Directive A–238
A.15.9 %NOPAUSESHFT Translator Directive A–239
A.15.10 NOWAIT Clause A–239
A.16 - O - KAREL LANGUAGE DESCRIPTION A–240
A.16.1 OPEN FILE Statement A–240
A.16.2 OPEN HAND Statement A–241
A.16.3 OPEN_TPE Built-In Procedure A–241
A.16.4 ORD Built-In Function A–243
A.16.5 ORIENT Built-In Function A–243
A.17 - P - KAREL LANGUAGE DESCRIPTION A–244
A.17.1 PATH Data Type A–244
A.17.2 PATH_LEN Built-In Function A–246
A.17.3 PAUSE Action A–247
A.17.4 PAUSE Condition A–248
A.17.5 PAUSE Statement A–248
A.17.6 PAUSE_TASK Built-In Procedure A–249
A.17.7 PEND_SEMA Built-In Procedure A–250
A.17.8 PIPE_CONFIG Built-In Procedure A–251
A.17.9 POP_KEY_RD Built-In Procedure A–252
A.17.10 Port_Id Action A–253
A.17.11 Port_Id Condition A–253
A.17.12 POS Built-In Function A–254
A.17.13 POS2JOINT Built-In Function A–255
A.17.14 POS_REG_TYPE Built-In Procedure A–256
A.17.15 POSITION Data Type A–258
A.17.16 POST_ERR Built-In Procedure A–259
A.17.17 POST_SEMA Built-In Procedure A–260
A.17.18 PRINT_FILE Built-In Procedure A–260
A.17.19 %PRIORITY Translator Directive A–261
A.17.20 PROG_BACKUP Built-In Procedure A–263
A.17.21 PROG_CLEAR Built-In Procedure A–266
A.17.22 PROG_RESTORE Built-In Procedure A–268
A.17.23 PROG_LIST Built-In Procedure A–270
A.17.24 PROGRAM Statement A–271
A.17.25 PULSE Action A–272
A.17.26 PULSE Statement A–273
A.17.27 PURGE CONDITION Statement A–274
A.17.28 PURGE_DEV Built-In Procedure A–275
A.17.29 PUSH_KEY_RD Built-In Procedure A–276
A.18 - Q - KAREL LANGUAGE DESCRIPTION A–277
A.18.1 QUEUE_TYPE Data Type A–277
A.19 - R - KAREL LANGUAGE DESCRIPTION A–277
A.19.1 READ Statement A–277

A.19.2 READ_DICT Built-In Procedure A–279
A.19.3 READ_DICT_V Built-In-Procedure A–280
A.19.4 READ_KB Built-In Procedure A–281
A.19.5 REAL Data Type A–285
A.19.6 Relational Condition A–287
A.19.7 RELAX HAND Statement A–288
A.19.8 RELEASE Statement A–289
A.19.9 REMOVE_DICT Built-In Procedure A–289
A.19.10 RENAME_FILE Built-In Procedure A–290
A.19.11 RENAME_VAR Built-In Procedure A–291
A.19.12 RENAME_VARS Built-In Procedure A–291
A.19.13 REPEAT ... UNTIL Statement A–292
A.19.14 RESET Built-In Procedure A–293
A.19.15 RESUME Action A–294
A.19.16 RESUME Statement A–294
A.19.17 RETURN Statement A–295
A.19.18 ROUND Built-In Function A–296
A.19.19 ROUTINE Statement A–296
A.19.20 RUN_TASK Built-In Procedure A–298
A.20 - S - KAREL LANGUAGE DESCRIPTION A–299
A.20.1 SAVE Built-In Procedure A–299
A.20.2 SAVE_DRAM Built-In Procedure A–300
A.20.3 SELECT ... ENDSELECT Statement A–301
A.20.4 SELECT_TPE Built-In Procedure A–302
A.20.5 SEMA_COUNT Built-In Function A–302
A.20.6 SEMAPHORE Condition A–303
A.20.7 SEND_DATAPC Built-In Procedure A–303
A.20.8 SEND_EVENTPC Built-In Procedure A–305
A.20.9 SET_ATTR_PRG Built-In Procedure A–305
A.20.10 SET_CURSOR Built-In Procedure A–307
A.20.11 SET_EPOS_REG Built-In Procedure A–308
A.20.12 SET_EPOS_TPE Built-In Procedure A–309
A.20.13 SET_FILE_ATR Built-In Procedure A–310
A.20.14 SET_FILE_POS Built-In Procedure A–310
A.20.15 SET_INT_REG Built-In Procedure A–311
A.20.16 SET_JPOS_REG Built-In Procedure A–312
A.20.17 SET_JPOS_TPE Built-In Procedure A–313
A.20.18 SET_LANG Built-In Procedure A–314
A.20.19 SET_PERCH Built-In Procedure A–315
A.20.20 SET_PORT_ASG Built-In Procedure A–316
A.20.21 SET_PORT_ATR Built-In Function A–317
A.20.22 SET_PORT_CMT Built-In Procedure A–319
A.20.23 SET_PORT_MOD Built-In Procedure A–320
A.20.24 SET_PORT_SIM Built-In Procedure A–321
A.20.25 SET_PORT_VAL Built-In Procedure A–322
A.20.26 SET_POS_REG Built-In Procedure A–323
A.20.27 SET_POS_TPE Built-In Procedure A–324
A.20.28 SET_PREG_CMT Built-In-Procedure A–324
A.20.29 SET_REAL_REG Built-In Procedure A–325
A.20.30 SET_REG_CMT Built-In-Procedure A–325
A.20.31 SET_TIME Built-In Procedure A–326
A.20.32 SET_TPE_CMT Built-In Procedure A–327
A.20.33 SET_TRNS_TPE Built-In Procedure A–328
A.20.34 SET_TSK_ATTR Built-In Procedure A–329
A.20.35 SET_TSK_NAME Built-In Procedure A–330

A.20.36 SET_VAR Built-In Procedure A–330
A.20.37 %SHADOWVARS Translator Directive A–332
A.20.38 SHORT Data Type A–332
A.20.39 SIGNAL EVENT Action A–332
A.20.40 SIGNAL EVENT Statement A–333
A.20.41 SIGNAL SEMAPHORE Action A–333
A.20.42 SIN Built-In Function A–334
A.20.43 SQRT Built-In Function A–334
A.20.44 %STACKSIZE Translator Directive A–335
A.20.45 STD_PTH_NODE Data Type A–335
A.20.46 STOP Action A–336
A.20.47 STOP Statement A–337
A.20.48 STRING Data Type A–338
A.20.49 STR_LEN Built-In Function A–339
A.20.50 STRUCTURE Data Type A–340
A.20.51 SUB_STR Built-In Function A–341

A.21 - T - KAREL LANGUAGE DESCRIPTION A–342
A.21.1 TAN Built-In Function A–342
A.21.2 TIME Condition A–343
A.21.3 %TIMESLICE Translator Directive A–344
A.21.4 %TPMOTION Translator Directive A–344
A.21.5 TRANSLATE Built-In Procedure A–344
A.21.6 TRUNC Built-In Function A–346

A.22 - U - KAREL LANGUAGE DESCRIPTION A–347
A.22.1 UNHOLD Action A–347
A.22.2 UNHOLD Statement A–348
A.22.3 UNINIT Built-In Function A–349
A.22.4 %UNINITVARS Translator Directive A–350
A.22.5 UNLOCK_GROUP Built-In Procedure A–350
A.22.6 UNPAUSE Action A–352
A.22.7 UNPOS Built-In Procedure A–353
A.22.8 UNTIL Clause A–353
A.22.9 USING ... ENDUSING Statement A–354

A.23 - V - KAREL LANGUAGE DESCRIPTION A–355
A.23.1 VAR_INFO Built-In Procedure A–355
A.23.2 VAR_LIST Built-In Procedure A–358
A.23.3 VECTOR Data Type A–360
A.23.4 VIA Clause A–361
A.23.5 VOL_SPACE Built-In Procedure A–361

A.24 - W - KAREL LANGUAGE DESCRIPTION A–363
A.24.1 WAIT FOR Statement A–363
A.24.2 WHEN Clause A–364
A.24.3 WHILE...ENDWHILE Statement A–364
A.24.4 WITH Clause A–365
A.24.5 WRITE Statement A–366
A.24.6 WRITE_DICT Built-In Procedure A–367
A.24.7 WRITE_DICT_V Built-In Procedure A–368

A.25 - X - KAREL LANGUAGE DESCRIPTION A–369
A.25.1 XML_ADDTAG Built-In Procedure A–369
A.25.2 XML_GETDATA Built-In Procedure A–370
A.25.3 XML_REMTAG Built-In Procedure A–371
A.25.4 XML_SCAN Built-In Procedure A–371
A.25.5 XML_SETVAR Built-In Procedure A–373
A.25.6 XYZWPR Data Type A–374

A.25.7 XYZWPREXT Data Type A–375
A.26 - Y - KAREL LANGUAGE DESCRIPTION A–375
A.27 - Z - KAREL LANGUAGE DESCRIPTION A–375

Appendix B KAREL EXAMPLE PROGRAMS B–1
B.1 SETTING UP DIGITAL OUTPUT PORTS FOR PROCESS MONITORING B–7
B.2 COPYING PATH VARIABLES B–18
B.3 SAVING DATA TO THE DEFAULT DEVICE B–28
B.4 STANDARD ROUTINES B–31
B.5 USING REGISTER BUILT-INS B–33
B.6 PATH VARIABLES AND CONDITION HANDLERS PROGRAM B–38
B.7 LISTING FILES AND PROGRAMS AND MANIPULATING STRINGS B–44
B.8 GENERATING AND MOVING ALONG A HEXAGON PATH B–49
B.9 USING THE FILE AND DEVICE BUILT-INS B–53
B.10 USING DYNAMIC DISPLAY BUILT-INS B–57
B.11 MANIPULATING VALUES OF DYNAMICALLY DISPLAYED VARIABLES B–67
B.12 DISPLAYING A LIST FROM A DICTIONARY FILE B–70
B.12.1 Dictionary Files B–79
B.13 USING THE DISCTRL_ALPHA BUILT-IN B–80
B.13.1 Dictionary Files B–84
B.14 APPLYING OFFSETS TO A COPIED TEACH PENDANT PROGRAM B–85

Appendix C KCL COMMAND ALPHABETICAL DESCRIPTION C–1
C.1 ABORT command C–5
C.2 APPEND FILE command C–6
C.3 APPEND NODE command C–6
C.4 CHDIR command C–7
C.5 CLEAR ALL command C–7
C.6 CLEAR BREAK CONDITION command C–8
C.7 CLEAR BREAK PROGRAM command C–8
C.8 CLEAR DICT command C–8
C.9 CLEAR PROGRAM command C–9
C.10 CLEAR VARS command C–9
C.11 COMPRESS DICT command C–10
C.12 COMPRESS FORM command C–10
C.13 CONTINUE command C–10
C.14 COPY FILE command C–11
C.15 CREATE VARIABLE command C–12
C.16 DELETE FILE command C–12
C.17 DELETE NODE command C–13
C.18 DELETE VARIABLE command C–13
C.19 DIRECTORY command C–14

C.20 DISABLE BREAK PROGRAM command C–14
C.21 DISABLE CONDITION command C–15
C.22 DISMOUNT command C–15
C.23 EDIT command C–15
C.24 ENABLE BREAK PROGRAM C–16
C.25 ENABLE CONDITION command C–16
C.26 FORMAT command C–17
C.27 HELP command C–17
C.28 HOLD command C–17
C.29 INSERT NODE command C–18
C.30 LOAD ALL command C–18
C.31 LOAD DICT command C–19
C.32 LOAD FORM command C–19
C.33 LOAD MASTER command C–20
C.34 LOAD PROGRAM command C–20
C.35 LOAD SERVO command C–21
C.36 LOAD SYSTEM command C–21
C.37 LOAD TP command C–22
C.38 LOAD VARS command C–22
C.39 LOGOUT command C–23
C.40 MKDIR command C–24
C.41 MOUNT command C–24
C.42 MOVE FILE command C–24
C.43 PAUSE command C–25
C.44 PURGE command C–26
C.45 PRINT command C–26
C.46 RECORD command C–26
C.47 RENAME FILE command C–27
C.48 RENAME VARIABLE command C–27
C.49 RENAME VARS command C–28
C.50 RESET command C–29
C.51 RMDIR command C–29
C.52 RUN command C–29
C.53 RUNCF command C–30
C.54 SAVE MASTER command C–30
C.55 SAVE SERVO command C–31
C.56 SAVE SYSTEM command C–31
C.57 SAVE TP command C–32
C.58 SAVE VARS command C–32
C.59 SET BREAK CONDITION command C–33
C.60 SET BREAK PROGRAM command C–33

C.61 SET CLOCK command C–34
C.62 SET DEFAULT command C–35
C.63 SET GROUP command C–35
C.64 SET LANGUAGE command C–35
C.65 SET LOCAL VARIABLE command C–36
C.66 SET PORT command C–36
C.67 SET TASK command C–37
C.68 SET TRACE command C–37
C.69 SET VARIABLE command C–38
C.70 SET VERIFY command C–39
C.71 SHOW BREAK command C–39
C.72 SHOW BUILTINS command C–40
C.73 SHOW CONDITION command C–40
C.74 SHOW CLOCK command C–40
C.75 SHOW CURPOS command C–40
C.76 SHOW DEFAULT command C–41
C.77 SHOW DEVICE command C–41
C.78 SHOW DICTS command C–41
C.79 SHOW GROUP command C–41
C.80 SHOW HISTORY command C–41
C.81 SHOW LANG command C–42
C.82 SHOW LANGS command C–42
C.83 SHOW LOCAL VARIABLE command C–42
C.84 SHOW LOCAL VARS command C–43
C.85 SHOW MEMORY command C–44
C.86 SHOW PROGRAM command C–44
C.87 SHOW PROGRAMS command C–44
C.88 SHOW SYSTEM command C–45
C.89 SHOW TASK command C–45
C.90 SHOW TASKS command C–45
C.91 SHOW TRACE command C–46
C.92 SHOW TYPES command C–46
C.93 SHOW VARIABLE command C–46
C.94 SHOW VARS command C–47
C.95 SHOW data_type command C–47
C.96 SIMULATE command C–48
C.97 SKIP command C–49
C.98 STEP OFF command C–49
C.99 STEP ON command C–50
C.100 TRANSLATE command C–50
C.101 TYPE command C–50

C.102 UNSIMULATE command C–51
C.103 WAIT command C–51

Appendix D CHARACTER CODES D–1
D.1 CHARACTER CODES D–2

Appendix E SYNTAX DIAGRAMS E–1

Glossary GL–30

List of Figures

Figure 1–1. Controller Memory 1–9
Figure 1–2. R-J3iC Controller 1–10
Figure 3–1. Determining **w_handle** Relative to WORLD Frame 3–10
Figure 3–2. Determining **b_handle** Relative to BUMPER Frame 3–11
Figure 6–1. Timing of BEFORE, AT and AFTER Conditions 6–14
Figure 7–1. "t_sc" Screen 7–39
Figure 7–2. "t_sc" Screen with $TP_USESTAT = TRUE 7–39
Figure 7–3. "c_sc" Screen 7–40
Figure 7–4. "c_sc" Screen with $CRT_USERSTAT = TRUE 7–41
Figure 8–1. Referencing Positions in KAREL 8–4
Figure 8–2. Motion Terms 8–8
Figure 8–3. Motion Characteristics 8–9
Figure 8–4. Interpolation Rates 8–10
Figure 8–5. Location Interpolation of the TCP 8–11
Figure 8–6. CIRCULAR Interpolated Motion 8–12
Figure 8–7. Two-Angle Orientation Control 8–13
Figure 8–8. Three-Angle Orientation Control 8–14
Figure 8–9. Acceleration and Velocity Profile with Stage_1 = Stage_2 8–19
Figure 8–10. Acceleration and Velocity Profile with Stage_2 = 0 8–19
Figure 8–11. Acceleration and Velocity Profile with Stage_1 = 2* Stage_2 8–20
Figure 8–12. Effect of $TERMTYPE on Timing 8–30
Figure 8–13. Effect of $TERMTYPE on Path 8–31
Figure 8–14. NOWAIT Example 8–32
Figure 8–15. NODECEL Example 8–33
Figure 8–16. NOSETTLE Example 8–33
Figure 8–17. COARSE Example 8–34
Figure 8–18. Local Condition Handler When Timer Before Example 8–34
Figure 8–19. Effect of Speed on Path 8–35
Figure 8–20. Short Motions and Long Motions 8–41
Figure 9–1. XML Program 9–22
Figure 9–2. KAREL Program 9–22
Figure 10–1. Dictionary Compressor and User Dictionary File 10–12
Figure 10–2. Teach Pendant Form Screen 10–31

Figure 10–3. CRT/KB Form Screen 10–31
Figure 10–4. Dictionary Compressor and Form Dictionary File 10–33
Figure 10–5. Example of Selectable Menu Items 10–35
Figure 10–6. Example of Edit Data Items 10–37
Figure 10–7. Example of Display Only Data Items 10–41
Figure 13–1. KAREL Logic for Converting Input to a Real Value Representing the Voltage 13–4
Figure 13–2. RSR Timing Diagram 13–16
Figure 13–3. PNS Timing Diagram 13–17
Figure 13–4. Location of Ports on the Controller 13–22
Figure 14–1. Task Synchronization Using a Semaphore 14–10
Figure A–1. FRAME Built-In Function A–141
Figure A–2. GET_USEC_SUB Built-In Function A–168
Figure E–1. ..... E–3
Figure E–2. ..... E–4
Figure E–3. ..... E–5
Figure E–4. ..... E–6
Figure E–5. ..... E–7
Figure E–6. ..... E–8
Figure E–7. ..... E–9
Figure E–8. ..... E–10
Figure E–9. ..... E–11
Figure E–10. ..... E–12
Figure E–11. ..... E–13
Figure E–12. ..... E–14
Figure E–13. ..... E–15
Figure E–14. ..... E–16
Figure E–15. ..... E–17
Figure E–16. ..... E–18
Figure E–17. ..... E–19
Figure E–18. ..... E–20
Figure E–19. ..... E–21
Figure E–20. ..... E–22
Figure E–21. ..... E–23
Figure E–22. ..... E–24
Figure E–23. ..... E–25
Figure E–24. ..... E–26
Figure E–25. ..... E–27
Figure E–26. ..... E–28
Figure E–27. ..... E–29

List of Tables

Table 2–1. ASCII Character Set 2–2
Table 2–2. Multinational Character Set 2–3
Table 2–3. Graphics Character Set 2–4
Table 2–4. KAREL Operators 2–5
Table 2–5. KAREL Operator Precedence 2–5
Table 2–6. Reserved Word List 2–6
Table 2–7. Predefined Identifier and Value Summary 2–8
Table 2–8. Port and File Predefined Identifier Summary 2–8
Table 2–9. Translator Directives 2–10
Table 2–10. Simple and Structured Data Types 2–13
Table 3–1. Summary of Operation Result Types 3–3
Table 3–2. KAREL Operators 3–5
Table 3–3. Arithmetic Operations Using +, -, and * Operators 3–5
Table 3–4. Arithmetic Operations Examples 3–5
Table 3–5. Arithmetic Operations Using Bitwise Operands 3–6
Table 3–6. KAREL Operator Precedence 3–6
Table 3–7. Relational Operation Examples 3–7
Table 3–8. BOOLEAN Operation Summary 3–8
Table 3–9. BOOLEAN Operations Using AND, OR, and NOT Operators 3–8
Table 3–10. Examples of Vector Operations 3–13
Table 5–1. Stack Usage 5–13
Table 5–2. KAREL Built—In Routine Summary 5–16
Table 6–1. Conditions 6–2
Table 6–2. Actions 6–2
Table 6–3. Condition Handler Operations 6–3
Table 6–4. Interval Between Global Condition Handler Scans 6–4
Table 6–5. Port_Id Conditions 6–9
Table 6–6. Relational Conditions 6–10
Table 6–7. System and Program Event Conditions 6–11
Table 6–8. Local Conditions 6–13
Table 6–9. Assignment Actions 6–16
Table 6–10. Motion Related Actions 6–17
Table 6–11. Miscellaneous Actions 6–19

Table 7–1. Predefined File Variables 7–3
Table 7–2. Predefined Attribute Types 7–5
Table 7–3. Attribute Values 7–6
Table 7–4. Usage Specifiers 7–11
Table 7–5. Text (ASCII) Input Format Specifiers 7–18
Table 7–6. Text (ASCII) Output Format Specifiers 7–19
Table 7–7. Examples of INTEGER Input Data Items 7–20
Table 7–8. Examples of INTEGER Output Data Items 7–21
Table 7–9. Examples of REAL Input Data Items 7–23
Table 7–10. Examples of REAL Output Data Items 7–24
Table 7–11. Examples of BOOLEAN Input Data Items 7–26
Table 7–12. Examples of BOOLEAN Output Data Items 7–27
Table 7–13. Examples of STRING Input Data Items 7–28
Table 7–14. Examples of STRING Output Data Items 7–30
Table 7–15. Examples of VECTOR Output Data Items 7–32
Table 7–16. Examples of POSITION Output Data Items (p = POS(2.0,-4.0,8.0,0.0,90.0,0.0,config_var)) 7–33
Table 7–17. Binary Input/Output Format Specifiers 7–35
Table 7–18. Defined Windows for t_sc" 7–38
Table 7–19. Defined Windows for c_sc" 7–40
Table 8–1. Turn Number Definitions 8–3
Table 8–2. Motion Time Symbols 8–40
Table 8–3. Correspondence between $GROUP System Variables and Teach Pendant Motion Instructions 8–43
Table 9–1. File Type Descriptions 9–5
Table 9–2. Virtual Devices 9–14
Table 9–3. System Variable Field Descriptions 9–17
Table 9–4. File Listings for the MD Device 9–25
Table 9–5. Testing Restrictions when Using the MD: Device 9–28
Table 10–1. Conversion Characters 10–7
Table 10–2. Reserved Words 10–9
Table 10–3. Conversion Characters 10–20
Table 10–4. Reserved Words 10–26
Table 10–5. Reserved Words for Scrolling Window 10–28
Table 11–1. Access Rights for System Variables 11–2
Table 11–2. System Variables Accessed by Programs 11–3
Table 13–1. Standard Operator Panel Input Signals 13–7
Table 13–2. Standard Operator Panel Output Signals 13–7
Table 13–3. User Operator Panel Input Signals 13–9
Table 13–4. User Operator Panel Output Signals 13–14
Table 13–5. Teach Pendant Input Signal Assignments 13–17

Table 13–6. Ports P1 - P4 13–23
Table 13–7. Default Communications Settings for Devices 13–23
Table 14–1. System Function Priority Table 14–6
Table A–1. Syntax Notation A–9
Table A–2. Actions A–11
Table A–3. Clauses A–11
Table A–4. Conditions A–12
Table A–5. Data Types A–12
Table A–6. Directives A–13
Table A–7. KAREL Built—In Routine Summary A–13
Table A–8. Items A–16
Table A–9. Statements A–17
Table A–10. Valid and Invalid BOOLEAN Values A–41
Table A–11. INTEGER Representation of Current Time A–162
Table A–12. Conversion Characters A–182
Table A–13. Conversion Characters A–190
Table A–14. Valid and Invalid INTEGER Literals A–201
Table A–15. IO_STATUS Errors A–204
Table A–16. Group_mask Setting A–213
Table A–17. Group_mask Setting A–218
Table A–18. Valid and Invalid REAL operators A–286
Table A–19. Group_mask setting A–299
Table A–20. Attribute Values A–318
Table A–21. 32–Bit INTEGER Format of Time A–326
Table A–22. Example STRING Literals A–338
Table A–23. Group_mask Settings A–350
Table A–24. Valid Data Types A–356
Table A–25. Valid Data Types A–358
Table B–1. KAREL Example Programs B–3
Table D–1. ASCII Character Codes D–2
Table D–2. Special ASCII Character Codes D–3
Table D–3. Multinational Character Codes D–4
Table D–4. Graphics Character Codes D–6
Table D–5. Teach Pendant Input Codes D–7
Table D–6. European Character Codes D–8
Table D–7. Graphics Characters D–10

Safety

FANUC Robotics is not and does not represent itself as an expert in safety systems, safety equipment, or the specific safety aspects of your company and/or its work force. It is the responsibility of the owner, employer, or user to take all necessary steps to guarantee the safety of all personnel in the workplace.

The appropriate level of safety for your application and installation can best be determined by safety system professionals. FANUC Robotics therefore, recommends that each customer consult with such professionals in order to provide a workplace that allows for the safe application, use, and operation of FANUC Robotic systems.

According to the industry standard ANSI/RIA R15-06, the owner or user is advised to consult the standards to ensure compliance with its requests for Robotics System design, usability, operation, maintenance, and service. Additionally, as the owner, employer, or user of a robotic system, it is your responsibility to arrange for the training of the operator of a robot system to recognize and respond to known hazards associated with your robotic system and to be aware of the recommended operating procedures for your particular application and robot installation.

FANUC Robotics therefore, recommends that all personnel who intend to operate, program, repair, or otherwise use the robotics system be trained in an approved FANUC Robotics training course and become familiar with the proper operation of the system. Persons responsible for programming the system-including the design, implementation, and debugging of application programs-must be familiar with the recommended programming procedures for your application and robot installation.

The following guidelines are provided to emphasize the importance of safety in the workplace.

CONSIDERING SAFETY FOR YOUR ROBOT INSTALLATION

Safety is essential whenever robots are used. Keep in mind the following factors with regard to safety:

- The safety of people and equipment
- Use of safety enhancing devices
- Techniques for safe teaching and manual operation of the robot(s)
- Techniques for safe automatic operation of the robot(s)
- Regular scheduled inspection of the robot and workcell
- Proper maintenance of the robot

Keeping People and Equipment Safe

The safety of people is always of primary importance in any situation. However, equipment must be kept safe, too. When prioritizing how to apply safety to your robotic system, consider the following:

- People
- External devices
- Robot(s)
- Tooling
- Workpiece

Using Safety Enhancing Devices

Always give appropriate attention to the work area that surrounds the robot. The safety of the work area can be enhanced by the installation of some or all of the following devices:

- Safety fences, barriers, or chains
- Light curtains
- Interlocks
- Pressure mats
- Floor markings
- Warning lights
- Mechanical stops
- EMERGENCY STOP buttons
- DEADMAN switches

Setting Up a Safe Workcell

A safe workcell is essential to protect people and equipment. Observe the following guidelines to ensure that the workcell is set up safely. These suggestions are intended to supplement and **not** replace existing federal, state, and local laws, regulations, and guidelines that pertain to safety.

- Sponsor your personnel for training in approved FANUC Robotics training course(s) related to your application. Never permit untrained personnel to operate the robots.
- Install a lockout device that uses an access code to prevent unauthorized persons from operating the robot.
- Use anti-tie-down logic to prevent the operator from bypassing safety measures.
- Arrange the workcell so the operator faces the workcell and can see what is going on inside the cell.

- Clearly identify the work envelope of each robot in the system with floor markings, signs, and special barriers. The work envelope is the area defined by the maximum motion range of the robot, including any tooling attached to the wrist flange that extend this range.
- Position all controllers outside the robot work envelope.
- Never rely on software or firmware based controllers as the primary safety element unless they comply with applicable current robot safety standards.
- Mount an adequate number of EMERGENCY STOP buttons or switches within easy reach of the operator and at critical points inside and around the outside of the workcell.
- Install flashing lights and/or audible warning devices that activate whenever the robot is operating, that is, whenever power is applied to the servo drive system. Audible warning devices shall exceed the ambient noise level at the end-use application.
- Wherever possible, install safety fences to protect against unauthorized entry by personnel into the work envelope.
- Install special guarding that prevents the operator from reaching into restricted areas of the work envelope.
- Use interlocks.
- Use presence or proximity sensing devices such as light curtains, mats, and capacitance and vision systems to enhance safety.
- Periodically check the safety joints or safety clutches that can be optionally installed between the robot wrist flange and tooling. If the tooling strikes an object, these devices dislodge, remove power from the system, and help to minimize damage to the tooling and robot.
- Make sure all external devices are properly filtered, grounded, shielded, and suppressed to prevent hazardous motion due to the effects of electro-magnetic interference (EMI), radio frequency interference (RFI), and electro-static discharge (ESD).
- Make provisions for power lockout/tagout at the controller.
- Eliminate *pinch points* . Pinch points are areas where personnel could get trapped between a moving robot and other equipment.
- Provide enough room inside the workcell to permit personnel to teach the robot and perform maintenance safely.
- Program the robot to load and unload material safely.
- If high voltage electrostatics are present, be sure to provide appropriate interlocks, warning, and beacons.
- If materials are being applied at dangerously high pressure, provide electrical interlocks for lockout of material flow and pressure.

Staying Safe While Teaching or Manually Operating the Robot

Advise all personnel who must teach the robot or otherwise manually operate the robot to observe the following rules:

- Never wear watches, rings, neckties, scarves, or loose clothing that could get caught in moving machinery.
- Know whether or not you are using an intrinsically safe teach pendant if you are working in a hazardous environment.
- Before teaching, visually inspect the robot and *work envelope* to make sure that no potentially hazardous conditions exist. The work envelope is the area defined by the maximum motion range of the robot. These include tooling attached to the wrist flange that extends this range.
- The area near the robot must be clean and free of oil, water, or debris. Immediately report unsafe working conditions to the supervisor or safety department.
- FANUC Robotics recommends that no one enter the work envelope of a robot that is on, except for robot teaching operations. However, if you must enter the work envelope, be sure all safeguards are in place, check the teach pendant DEADMAN switch for proper operation, and place the robot in teach mode. Take the teach pendant with you, turn it on, and be prepared to release the DEADMAN switch. Only the person with the teach pendant should be in the work envelope.

> **Warning**
>
> **Never bypass, strap, or otherwise deactivate a safety device, such as a limit switch, for any operational convenience. Deactivating a safety device is known to have resulted in serious injury and death.**

- Know the path that can be used to escape from a moving robot; make sure the escape path is never blocked.
- Isolate the robot from all remote control signals that can cause motion while data is being taught.
- Test any program being run for the first time in the following manner:

> **Warning**
>
> **Stay outside the robot work envelope whenever a program is being run. Failure to do so can result in injury.**

  — Using a low motion speed, single step the program for at least one full cycle.

  — Using a low motion speed, test run the program continuously for at least one full cycle.

  — Using the programmed speed, test run the program continuously for at least one full cycle.

- Make sure all personnel are outside the work envelope before running production.

Staying Safe During Automatic Operation

Advise all personnel who operate the robot during production to observe the following rules:

- Make sure all safety provisions are present and active.
- Know the entire workcell area. The workcell includes the robot and its work envelope, plus the area occupied by all external devices and other equipment with which the robot interacts.
- Understand the complete task the robot is programmed to perform before initiating automatic operation.
- Make sure all personnel are outside the work envelope before operating the robot.
- Never enter or allow others to enter the work envelope during automatic operation of the robot.
- Know the location and status of all switches, sensors, and control signals that could cause the robot to move.
- Know where the EMERGENCY STOP buttons are located on both the robot control and external control devices. Be prepared to press these buttons in an emergency.
- Never assume that a program is complete if the robot is not moving. The robot could be waiting for an input signal that will permit it to continue activity.
- If the robot is running in a pattern, do not assume it will continue to run in the same pattern.
- Never try to stop the robot, or break its motion, with your body. The only way to stop robot motion immediately is to press an EMERGENCY STOP button located on the controller panel, teach pendant, or emergency stop stations around the workcell.

Staying Safe During Inspection

When inspecting the robot, be sure to

- Turn off power at the controller.
- Lock out and tag out the power source at the controller according to the policies of your plant.
- Turn off the compressed air source and relieve the air pressure.
- If robot motion is not needed for inspecting the electrical circuits, press the EMERGENCY STOP button on the operator panel.
- Never wear watches, rings, neckties, scarves, or loose clothing that could get caught in moving machinery.
- If power is needed to check the robot motion or electrical circuits, be prepared to press the EMERGENCY STOP button, in an emergency.
- Be aware that when you remove a servomotor or brake, the associated robot arm will fall if it is not supported or resting on a hard stop. Support the arm on a solid support before you release the brake.

Staying Safe During Maintenance

When performing maintenance on your robot system, observe the following rules:

- Never enter the work envelope while the robot or a program is in operation.
- Before entering the work envelope, visually inspect the workcell to make sure no potentially hazardous conditions exist.
- Never wear watches, rings, neckties, scarves, or loose clothing that could get caught in moving machinery.
- Consider all or any overlapping work envelopes of adjoining robots when standing in a work envelope.
- Test the teach pendant for proper operation before entering the work envelope.
- If it is necessary for you to enter the robot work envelope while power is turned on, you must be sure that you are in control of the robot. Be sure to take the teach pendant with you, press the DEADMAN switch, and turn the teach pendant on. Be prepared to release the DEADMAN switch to turn off servo power to the robot immediately.
- Whenever possible, perform maintenance with the power turned off. Before you open the controller front panel or enter the work envelope, turn off and lock out the 3-phase power source at the controller.
- Be aware that an applicator bell cup can continue to spin at a very high speed even if the robot is idle. Use protective gloves or disable bearing air and turbine air before servicing these items.
- Be aware that when you remove a servomotor or brake, the associated robot arm will fall if it is not supported or resting on a hard stop. Support the arm on a solid support before you release the brake.



Warning

Lethal voltage is present in the controller WHENEVER IT IS CONNECTED to a power source. Be extremely careful to avoid electrical shock.HIGH VOLTAGE IS PRESENT at the input side whenever the controller is connected to a power source. Turning the disconnect or circuit breaker to the OFF position removes power from the output side of the device only.

- Release or block all stored energy. Before working on the pneumatic system, shut off the system air supply and purge the air lines.
- Isolate the robot from all remote control signals. If maintenance must be done when the power is on, make sure the person inside the work envelope has sole control of the robot. The teach pendant must be held by this person.

- Make sure personnel cannot get trapped between the moving robot and other equipment. Know the path that can be used to escape from a moving robot. Make sure the escape route is never blocked.
- Use blocks, mechanical stops, and pins to prevent hazardous movement by the robot. Make sure that such devices do not create pinch points that could trap personnel.



Warning

Do not try to remove any mechanical component from the robot before thoroughly reading and understanding the procedures in the appropriate manual. Doing so can result in serious personal injury and component destruction.

- Be aware that when you remove a servomotor or brake, the associated robot arm will fall if it is not supported or resting on a hard stop. Support the arm on a solid support before you release the brake.
- When replacing or installing components, make sure dirt and debris do not enter the system.
- Use only specified parts for replacement. To avoid fires and damage to parts in the controller, never use nonspecified fuses.
- Before restarting a robot, make sure no one is inside the work envelope; be sure that the robot and all external devices are operating normally.

KEEPING MACHINE TOOLS AND EXTERNAL DEVICES SAFE

Certain programming and mechanical measures are useful in keeping the machine tools and other external devices safe. Some of these measures are outlined below. Make sure you know all associated measures for safe use of such devices.

Programming Safety Precautions

Implement the following programming safety measures to prevent damage to machine tools and other external devices.

- Back-check limit switches in the workcell to make sure they do not fail.
- Implement “failure routines” in programs that will provide appropriate robot actions if an external device or another robot in the workcell fails.
- Use *handshaking* protocol to synchronize robot and external device operations.
- Program the robot to check the condition of all external devices during an operating cycle.

Mechanical Safety Precautions

Implement the following mechanical safety measures to prevent damage to machine tools and other external devices.

- Make sure the workcell is clean and free of oil, water, and debris.
- Use software limits, limit switches, and mechanical hardstops to prevent undesired movement of the robot into the work area of machine tools and external devices.

KEEPING THE ROBOT SAFE

Observe the following operating and programming guidelines to prevent damage to the robot.

Operating Safety Precautions

The following measures are designed to prevent damage to the robot during operation.

- Use a low override speed to increase your control over the robot when jogging the robot.
- Visualize the movement the robot will make before you press the jog keys on the teach pendant.
- Make sure the work envelope is clean and free of oil, water, or debris.
- Use circuit breakers to guard against electrical overload.

Programming Safety Precautions

The following safety measures are designed to prevent damage to the robot during programming:

- Establish *interference zones* to prevent collisions when two or more robots share a work area.
- Make sure that the program ends with the robot near or at the home position.
- Be aware of signals or other operations that could trigger operation of tooling resulting in personal injury or equipment damage.
- In dispensing applications, be aware of all safety guidelines with respect to the dispensing materials.

Note Any deviation from the methods and safety practices described in this manual must conform to the approved standards of your company. If you have questions, see your supervisor.

ADDITIONAL SAFETY CONSIDERATIONS FOR PAINT ROBOT INSTALLATIONS

Process technicians are sometimes required to enter the paint booth, for example, during daily or routine calibration or while teaching new paths to a robot. Maintenance personal also must work inside the paint booth periodically.

Whenever personnel are working inside the paint booth, ventilation equipment must be used. Instruction on the proper use of ventilating equipment usually is provided by the paint shop supervisor.

Although paint booth hazards have been minimized, potential dangers still exist. Therefore, today's highly automated paint booth requires that process and maintenance personnel have full awareness of the system and its capabilities. They must understand the interaction that occurs between the vehicle moving along the conveyor and the robot(s), hood/deck and door opening devices, and high-voltage electrostatic tools.

Paint robots are operated in three modes:

- Teach or manual mode
- Automatic mode, including automatic and exercise operation
- Diagnostic mode

During both teach and automatic modes, the robots in the paint booth will follow a predetermined pattern of movements. In teach mode, the process technician teaches (programs) paint paths using the teach pendant.

In automatic mode, robot operation is initiated at the System Operator Console (SOC) or Manual Control Panel (MCP), if available, and can be monitored from outside the paint booth. All personnel must remain outside of the booth or in a designated safe area within the booth whenever automatic mode is initiated at the SOC or MCP.

In automatic mode, the robots will execute the path movements they were taught during teach mode, but generally at production speeds.

When process and maintenance personnel run diagnostic routines that require them to remain in the paint booth, they must stay in a designated safe area.

Paint System Safety Features

Process technicians and maintenance personnel must become totally familiar with the equipment and its capabilities. To minimize the risk of injury when working near robots and related equipment, personnel must comply strictly with the procedures in the manuals.

This section provides information about the safety features that are included in the paint system and also explains the way the robot interacts with other equipment in the system.

The paint system includes the following safety features:

- Most paint booths have red warning beacons that illuminate when the robots are armed and ready to paint. Your booth might have other kinds of indicators. Learn what these are.
- Some paint booths have a blue beacon that, when illuminated, indicates that the electrostatic devices are enabled. Your booth might have other kinds of indicators. Learn what these are.
- EMERGENCY STOP buttons are located on the robot controller and teach pendant. Become familiar with the locations of all E-STOP buttons.
- An intrinsically safe teach pendant is used when teaching in hazardous paint atmospheres.
- A DEADMAN switch is located on each teach pendant. When this switch is held in, and the teach pendant is on, power is applied to the robot servo system. If the engaged DEADMAN switch is released during robot operation, power is removed from the servo system, all axis brakes are applied, and the robot comes to an EMERGENCY STOP. Safety interlocks within the system might also E-STOP other robots.



Warning

An EMERGENCY STOP will occur if the DEADMAN switch is released on a bypassed robot.

- Overtravel by robot axes is prevented by software limits. All of the major and minor axes are governed by software limits. Limit switches and hardstops also limit travel by the major axes.
- EMERGENCY STOP limit switches and photoelectric eyes might be part of your system. Limit switches, located on the entrance/exit doors of each booth, will EMERGENCY STOP all equipment in the booth if a door is opened while the system is operating in automatic or manual mode. For some systems, signals to these switches are inactive when the switch on the SCC is in teach mode.When present, photoelectric eyes are sometimes used to monitor unauthorized intrusion through the entrance/exit silhouette openings.
- System status is monitored by computer. Severe conditions result in automatic system shutdown.

Staying Safe While Operating the Paint Robot

When you work in or near the paint booth, observe the following rules, in addition to all rules for safe operation that apply to all robot systems.



Warning

Observe all safety rules and guidelines to avoid injury.

Warning

Never bypass, strap, or otherwise deactivate a safety device, such as a limit switch, for any operational convenience. Deactivating a safety device is known to have resulted in serious injury and death.

Warning

Enclosures shall not be opened unless the area is know to be nonhazardous or all power has been removed from devices within the enclosure. Power shall not be restored after the enclosure has been opened until all combustible dusts have been removed from the interior of the enclosure and the enclosure purged. Refer to the Purge chapter for the required purge time.

- Know the work area of the entire paint station (workcell).
- Know the work envelope of the robot and hood/deck and door opening devices.
- Be aware of overlapping work envelopes of adjacent robots.
- Know where all red, mushroom-shaped EMERGENCY STOP buttons are located.
- Know the location and status of all switches, sensors, and/or control signals that might cause the robot, conveyor, and opening devices to move.
- Make sure that the work area near the robot is clean and free of water, oil, and debris. Report unsafe conditions to your supervisor.
- Become familiar with the complete task the robot will perform BEFORE starting automatic mode.
- Make sure all personnel are outside the paint booth before you turn on power to the robot servo system.
- Never enter the work envelope or paint booth before you turn off power to the robot servo system.
- Never enter the work envelope during automatic operation unless a safe area has been designated.
- Never wear watches, rings, neckties, scarves, or loose clothing that could get caught in moving machinery.
- Remove all metallic objects, such as rings, watches, and belts, before entering a booth when the electrostatic devices are enabled.
- Stay out of areas where you might get trapped between a moving robot, conveyor, or opening device and another object.
- Be aware of signals and/or operations that could result in the triggering of guns or bells.
- Be aware of all safety precautions when dispensing of paint is required.
- Follow the procedures described in this manual.

Special Precautions for Combustible Dusts (powder paint)

When the robot is used in a location where combustible dusts are found, such as the application of powder paint, the following special precautions are required to insure that there are no combustible dusts inside the robot.

- Purge maintenance air should be maintained at all times, even when the robot power is off. This will insure that dust can not enter the robot.
- A purge cycle will not remove accumulated dusts. Therefore, if the robot is exposed to dust when maintenance air is not present, it will be necessary to remove the covers and clean out any accumulated dust. Do not energize the robot until you have performed the following steps.

1. Before covers are removed, the exterior of the robot should be cleaned to remove accumulated dust.
2. When cleaning and removing accumulated dust, either on the outside or inside of the robot, be sure to use methods appropriate for the type of dust that exists. Usually lint free rags dampened with water are acceptable. Do not use a vacuum cleaner to remove dust as it can generate static electricity and cause an explosion unless special precautions are taken.
3. Thoroughly clean the interior of the robot with a lint free rag to remove any accumulated dust.
4. When the dust has been removed, the covers must be replaced immediately.
5. Immediately after the covers are replaced, run a complete purge cycle. The robot can now be energized.

Staying Safe While Operating Paint Application Equipment

When you work with paint application equipment, observe the following rules, in addition to all rules for safe operation that apply to all robot systems.



Warning

When working with electrostatic paint equipment, follow all national and local codes as well as all safety guidelines within your organization. Also reference the following standards: *NFPA 33 Standards for Spray Application Using Flammable or Combustible Materials* , and *NFPA 70 National Electrical Code* .

- **Grounding** : All electrically conductive objects in the spray area must be grounded. This includes the spray booth, robots, conveyors, workstations, part carriers, hooks, paint pressure pots, as well as solvent containers. Grounding is defined as the object or objects shall be electrically connected to ground with a resistance of not more than 1 megohms.

- **High Voltage** : High voltage should only be on during actual spray operations. Voltage should be off when the painting process is completed. Never leave high voltage on during a cap cleaning process.
- Avoid any accumulation of combustible vapors or coating matter.
- Follow all manufacturer recommended cleaning procedures.
- Make sure all interlocks are operational.
- No smoking.
- Post all warning signs regarding the electrostatic equipment and operation of electrostatic equipment according to NFPA 33 Standard for Spray Application Using Flammable or Combustible Material.
- Disable all air and paint pressure to bell.
- Verify that the lines are not under pressure.

Staying Safe During Maintenance

When you perform maintenance on the painter system, observe the following rules, and all other maintenance safety rules that apply to all robot installations. Only qualified, trained service or maintenance personnel should perform repair work on a robot.

- Paint robots operate in a potentially explosive environment. Use caution when working with electric tools.
- When a maintenance technician is repairing or adjusting a robot, the work area is under the control of that technician. All personnel not participating in the maintenance must stay out of the area.
- For some maintenance procedures, station a second person at the control panel within reach of the EMERGENCY STOP button. This person must understand the robot and associated potential hazards.
- Be sure all covers and inspection plates are in good repair and in place.
- Always return the robot to the ‘‘home’’ position before you disarm it.
- Never use machine power to aid in removing any component from the robot.
- During robot operations, be aware of the robot’s movements. Excess vibration, unusual sounds, and so forth, can alert you to potential problems.
- Whenever possible, turn off the main electrical disconnect before you clean the robot.
- When using vinyl resin observe the following:
  - — Wear eye protection and protective gloves during application and removal
  - — Adequate ventilation is required. Overexposure could cause drowsiness or skin and eye irritation.
  - — If there is contact with the skin, wash with water.

- — Follow the Original Equipment Manufacturer's Material Safety Data Sheets.

- When using paint remover observe the following:
  - — Eye protection, protective rubber gloves, boots, and apron are required during booth cleaning.
  - — Adequate ventilation is required. Overexposure could cause drowsiness.
  - — If there is contact with the skin or eyes, rinse with water for at least 15 minutes. Then, seek medical attention as soon as possible.
  - — Follow the Original Equipment Manufacturer's Material Safety Data Sheets.

Chapter 1

KAREL LANGUAGE OVERVIEW

Contents

Chapter 1	KAREL LANGUAGE OVERVIEW	1–1
1.1	OVERVIEW	1–2
1.2	KAREL PROGRAMMING LANGUAGE	1–2
1.2.1	Overview	1–2
1.2.2	Creating a Program	1–4
1.2.3	Translating a Program	1–4
1.2.4	Loading Program Logic and Data	1–4
1.2.5	Executing a Program	1–5
1.2.6	Execution History	1–5
1.2.7	Program Structure	1–5
1.3	SYSTEM SOFTWARE	1–6
1.3.1	Software Components	1–7
1.3.2	Supported Robots	1–7
1.4	CONTROLLER	1–7
1.4.1	Memory	1–8
1.4.2	Input/Output System	1–9
1.4.3	User Interface Devices	1–10

1.1 OVERVIEW

FANUC Robotics' KAREL system consists of a robot, a controller, and system software. It accomplishes industrial tasks using programs written in the KAREL programming language. KAREL can direct robot motion, control and communicate with related equipment, and interact with an operator.

The SYSTEM R-J3*i*C controller with KAREL works with a wide range of robot models to handle a variety of applications. This means common operating, programming, and troubleshooting procedures, as well as fewer spare parts. KAREL systems expand to include a full line of support products such as integral vision, off-line programming, and application-specific software packages.

The KAREL programming language is a practical blend of the logical, English-like features of high-level languages, such as Pascal and PL/1, and the proven factory-floor effectiveness of machine control languages. KAREL incorporates structures and conventions common to high-level languages as well as features developed especially for robotics applications. These KAREL features include

- Simple and structured data types
- Arithmetic, relational, and Boolean operators
- Control structures for loops and selections
- Condition handlers
- Procedure and function routines
- Motion control statements
- Input and output operations
- Multi-programming and concurrent motion support

This chapter summarizes the KAREL programming language, and describes the KAREL system software and the R-J3*i* C controller.

1.2 KAREL PROGRAMMING LANGUAGE

1.2.1 Overview

A KAREL program is made up of declarations and executable statements stored in a source code file. The variable data values associated with a program are stored in a variable file.

KAREL programs are created and edited using OLPC PRO, or another editor such as Word Pad.

The KAREL language translator turns the source code into an internal format called p-code and generates a p-code file. The translator is provided with OLPC PRO. After translated, the resulting

p-code program can be loaded onto the controller using the *KAREL Command Language (KCL)*, or the FILE menu.

During loading, the system will create any required variables that are not in RAM and set them uninitialized. When you run the program, the KAREL interpreter executes the loaded p-code instructions.

A KAREL program is composed of the program logic and the program data. Program logic defines a sequence of steps to be taken to perform a specific task. Program data is the task-related information that the program logic uses. In KAREL the program logic is separate from the program data.

Program logic is defined by KAREL executable statements between the BEGIN and the END statements in a KAREL program. Program data includes variables that are identified in the VAR declaration section of a KAREL program by name, data type and storage area in RAM.

Values for program data can be taught using the teach pendant to jog the robot, computed by the program, read from data files, set from within the CRT/KB or teach pendant menu structure, or accepted as input to the program during execution. The data values can change from one execution to the next, but the same program logic is used to manipulate the data.

Program logic and program data are separate in a KAREL program for the following reasons:

- To allow a single taught position to be referenced from several places in the same program
- To allow more than one program to reference or share the same data
- To allow a program to use alternative data
- To facilitate the building of data files by an off-line computer-aided design (CAD) system

The executable section of the program contains the motion statements, I/O statements, and routine calls.

The program development cycle is described briefly in the following list. Section 1.2.2 - Section 1.2.6 that follow provide details on each phase.

- Create a program source code file
- Translate the program file.
- Load the program logic and data.
- Execute the program.
- Maintain the execute history of the program.

A log or history of programs that have been executed is maintained by the controller and can be viewed.

1.2.2 Creating a Program

You can create a KAREL program using an off-line editor such as OLPC PRO or any text editor such as WordPad. The resulting file is called the *source file* or *source code*.

1.2.3 Translating a Program

KAREL source files must be translated into internal code, called *p-code*, before they are executed. The KAREL language translator performs this function and also checks for errors in the source code.

The KAREL language translator starts at the first line of the source code and continues until it encounters an error or translates the program successfully. If an error is encountered, the translator tries to continue checking the program, but no p-code will be generated.

You can invoke the translator from OLPC PRO, and the source code you were editing will be translated. After a successful translation, the translator displays a successful translation message and creates a p-code file. The p-code file will use the source code file name and a .pc file type. This file contains an internal representation of the source code and information the system needs to link the program to variable data and routines.

If the translator detects any errors, it displays the error messages and the source lines that were being translated. After you have corrected the errors, you can translate the program again.

1.2.4 Loading Program Logic and Data

The p-code for a program is loaded onto a controller where it can be executed. When a program is loaded, a variable data table, containing all the static variables in the program, is created in RAM. The variable data table contains the program identifier, all of the variable identifiers, and the name of the storage area in RAM where the variables are located.

Loading a program also establishes the links between statements and variables. Initially, the values in the variable data table will be uninitialized. If a variable file (.vr) is loaded successfully, the values of any variables will be stored in the variable data storage area (CMOS, DRAM, SHADOW).

Multiple programs are often used to break a large application or problem into smaller pieces that can be developed and tested separately. The KAREL system permits loading of multiple programs. Each program that is loaded has its own p-code structure.

Variable data can be shared among multiple programs. In this case, the KAREL language FROM clause must be specified in the VAR declaration so that the system can perform the link when the program is loaded. This saves the storage required to include multiple copies of the data.

The following limits apply to the number and size of KAREL programs that can be loaded:

- Number of programs is limited to 2704 or available RAM.
- Number of variables per program is limited to 2704 or available RAM.

1.2.5 Executing a Program

After you have selected a program from the program list and the p-code and variable files are loaded into RAM, test and debug the program to make sure that the robot moves the way it should.

Program execution begins at the first executable line. A stack of 300 words is allocated unless you specify a stack size. The stack is allocated from available user RAM. Stack usage is described in Section 5.1.6 .

1.2.6 Execution History

Each time a program is executed, a log of the nested routines and the line numbers that have been executed can be displayed from KCL with the SHOW HISTORY command.

This is useful when a program has paused or been aborted unexpectedly. Execution history displays the sequence of events that led to the disruption.

1.2.7 Program Structure

A KAREL program is composed of declaration and executable sections made up of KAREL language statements, as shown in Structure of a KAREL Program .

Structure of a KAREL Program

```
PROGRAM  prog_name
     Translator Directives
     CONST, TYPE, and/or VAR Declarations
     ROUTINE Declarations
  BEGIN
     Executable Statements
  END  prog_name
     ROUTINE Declarations
```

In Structure of a KAREL Program , the words shown in uppercase letters are KAREL reserved words, which have dedicated meanings. PROGRAM, CONST, TYPE, VAR, and ROUTINE indicate

declaration sections of the program. BEGIN and END mark the executable section. Reserved words are described in Section 2.1.3 .

The PROGRAM statement, which identifies the program, must be the first statement in any KAREL program. The PROGRAM statement consists of the reserved word PROGRAM and an identifier of your choice (prog_name in Structure of a KAREL Program). Identifiers are described in Section 2.1.4 .

Note Your program must reside in a file. The file can, but does not have to, have the same name as the program. This distinction is important because you invoke the translator and load programs with the name of the file containing your program, but you initiate execution of the program and clear the program with the program name.

For example, if a program named **mover** was contained in a file named **transfer** , you would reference the file by **transfer** to translate it, but would use the program name **mover** to execute the program. If both the program and the file were named **mover** , you could use mover to translate the file and also to execute the program.

A task is created to execute the program and the task name is the name of the program you initiate. The program can call a routine in another program, but the task name does not change.

The identifier used to name the program cannot be used in the program for any other purpose, such as to identify a variable or constant.

The CONST (constant), TYPE (type), and VAR (variable) declaration sections come after the PROGRAM statement. A program can contain any number of CONST, TYPE, and VAR sections. Each section can also contain any number of individual declaration statements. Also, multiple CONST, TYPE, and VAR sections can appear in any order. The number of CONST, TYPE, and VAR sections, and declaration statements are limited only by the amount of memory available.

ROUTINE declarations can follow the CONST, TYPE, and VAR sections. Each routine begins with the reserved word ROUTINE and is similar in syntax to a program. ROUTINE declarations can also follow the executable section of the main program after the END statement.

The executable section must be marked by BEGIN at the beginning and END, followed by the program identifier (prog_name in Structure of a KAREL Program), at the end. The same program identifier must be used in the END statement as in the PROGRAM statement. The executable section can contain any number of executable statements, limited only by the amount of memory available.

See Also: Chapter 2 *LANGUAGE ELEMENTS* , Chapter 3 *USE OF OPERATORS* , and Chapter 5 *ROUTINES* .

1.3 SYSTEM SOFTWARE

The R-J3*i*C system includes a robot and controller electronics. Hardware interfaces and system software support programming, daily operation, maintenance, and troubleshooting.

This section provides an overview of the supported system software and robot models.

Hardware topics are covered in greater detail in the Maintenance Manual specific for your robot and controller model.

1.3.1 Software Components

R-J3*i*C system software is the FANUC Robotics-supplied software that is executed by the controller CPU, which allows you to operate the R-J3*i*C system. You use the system software to run programs, as well as to perform daily operations, maintenance, and troubleshooting.

The components of the system software include:

- **Motion Control** - movement of the tool center point (TCP) from an initial position to a desired destination position
- **File System** - storage of data on the RAM disk or peripheral storage devices
- **System Variables** - permanently defined variables declared as part of the KAREL system software
- **CRT/KB or Teach Pendant Screens** - screens that facilitate operation of the KAREL system
- **KCL** - KAREL Command Language
- **KAREL Interpreter** - executes KAREL programs

See Also: *FANUC Robotics SYSTEM R-J3iC Controller HandlingTool Setup and Operations Manual* for detailed operation procedures using the CRT/KB and teach pendant screens.

1.3.2 Supported Robots

The robot, using the appropriate tooling, performs application tasks directed by the system software and controller. The R-J3*i*C system supports a variety of robots, each designed for a specific type of application.

For a current list of supported robot models, consult your FANUC Robotics technical representative.

See Also: The Maintenance Manual for your specific robot type, for more information on your robot.

1.4 CONTROLLER

The R-J3*i*C controller contains the electronic circuitry and memory required to operate the R-J3*i*C system. The electronic circuitry, supported by the system software, directs the operation and motion of the robot and allows communication with peripheral devices.

Controller electronics includes a central processing unit (CPU), several types of memory, an *input/output (I/O)* system, and user interface devices. A cabinet houses the controller electronics and the ports to which remote user interface devices and other peripheral devices are connected.

1.4.1 Memory

There are three kinds of controller memory:

- Dynamic Random Access Memory (DRAM)
- A limited amount of battery-backed static/random access memory (SRAM)
- Flash Programmable Read Only Memory (FROM)

In addition, the controller is capable of storing information externally.

DRAM

DRAM memory is volatile. Memory contents do not retain their stored values when power is removed. DRAM memory is also referred to as temporary memory (TEMP). The system software is executed in DRAM memory. KAREL programs and most KAREL variables are loaded into DRAM and executed from here also.

SRAM

SRAM memory is nonvolatile. Memory contents retain their stored values when power is removed. SRAM memory is also referred to as CMOS or as permanent memory (PERM).

The TPP memory pool (used for teach pendant programs) is allocated from PERM. KAREL programs can designate variables to be stored in CMOS. A portion of SRAM memory can be defined as a user storage device called RAM Disk (RD:).

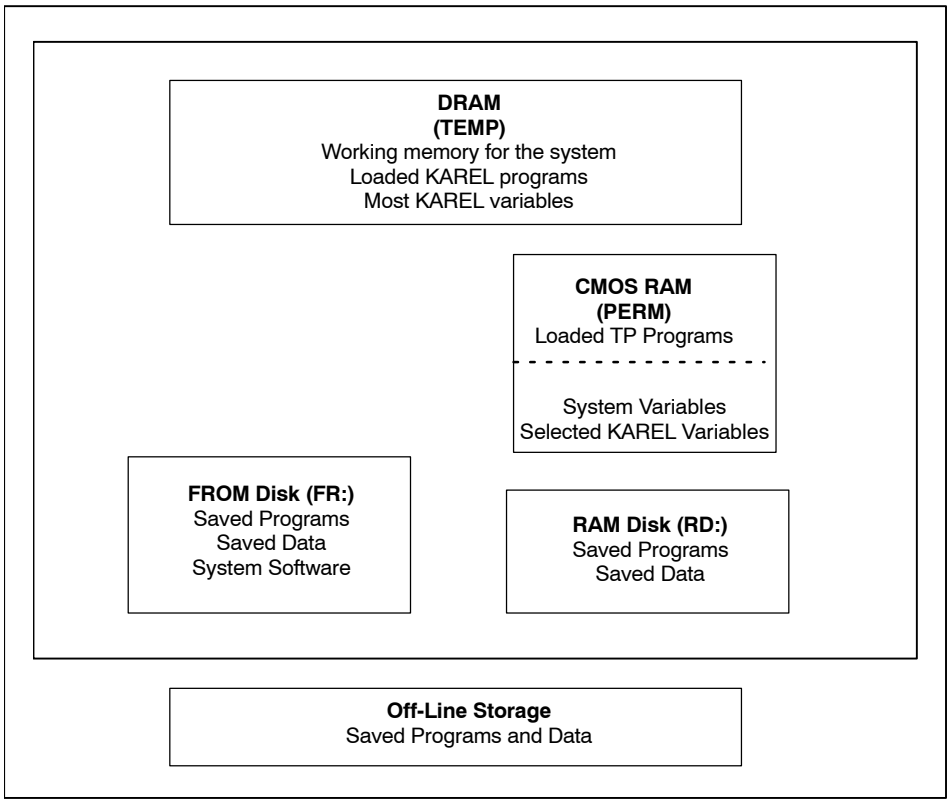
Flash memory (FROM)

FROM memory is nonvolatile. Memory contents retain their stored values when power is removed. FROM is used for permanent storage of the system software. FROM is also available for user storage as the FROM device (FR:).

SHADOW

Shadow memory provides the same capabilities as SRAM. Any values set in shadow are non-volatile and will maintain their state through power cycle. Shadow memory is intended for data which tends to be static. Storing dynamic variables in shadow memory, such as FOR loop indexes or other rapidly changing data, is not efficient.

Figure 1–1. Controller Memory



External Storage

You can back up and store files on external devices. You can use the following devices:

- Memory card
- Ethernet via FTP
- USB Memory Stick

1.4.2 Input/Output System

The R-J3*i*C controller can support a modular I/O structure, allowing you to add I/O boards as required by your application. Both digital and analog input and output modules are supported. In addition, you can add optional process I/O boards for additional I/O. The type and number of I/O signals you have depends on the requirements of your application.

See Also: Chapter 13 *INPUT/OUTPUT SYSTEM* , for more information

1.4.3 User Interface Devices

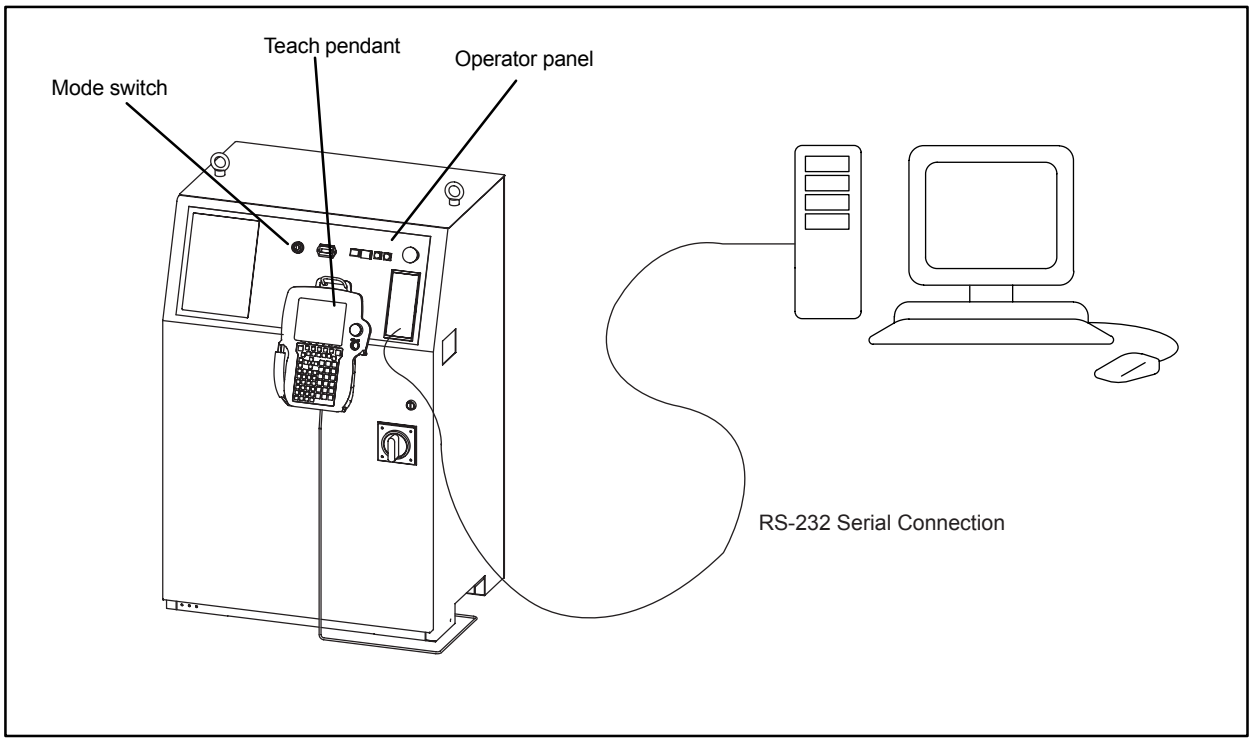
The user interface devices enable you to program and operate the KAREL system. The common user interface devices supported by KAREL include the operator panel, the teach pendant or the CRT/KB.

Figure 1–2 illustrates these user interface devices. The operator panel and teach pendant have the same basic functions for all models; however, different configurations are also available.

The operator panel, located on the front of the controller cabinet, provides buttons for performing daily operations such as powering up, running a program, and powering down. Lights on the operator panel indicate operating conditions such as when the power is on and when the robot is in cycle.

The R-J3*i*C system also supports I/O signals for a *user operator panel (UOP)* , which is a user-supplied device such as a custom control panel, a programmable controller, or a host computer. Refer to Chapter 13 *INPUT/OUTPUT SYSTEM* .

Figure 1–2. R-J3iC Controller



The CRT/KB is a software option on the R-J3iC controller that allows an external terminal such as a PC running TelNet to display a Menu System that looks similar to the one seen on the teach pendant.

The teach pendant consists of an LCD display, menu-driven function keys, keypad keys, and status LEDs. It is connected to the controller cabinet via a cable, allowing you to perform operations away from the controller.

Internally, the teach pendant connects to the controller's Main CPU board. It is used to jog the robot, teach program data, test and debug programs, and adjust variables. It can also be used to monitor and control I/O, to control end-of-arm tooling, and to display information such as the current position of the robot or the status of an application program.

The *FANUC Robotics SYSTEM R-J3iC Controller HandlingTool Setup and Operations Manual* provides descriptions of each of the user interface devices, as well as procedures for operating each device.

Chapter 2

LANGUAGE ELEMENTS

Contents

Chapter 2	LANGUAGE ELEMENTS	2–1
2.1	LANGUAGE COMPONENTS	2–2
2.1.1	Character Set	2–2
2.1.2	Operators	2–5
2.1.3	Reserved Words	2–5
2.1.4	User-Defined Identifiers	2–7
2.1.5	Labels	2–7
2.1.6	Predefined Identifiers	2–8
2.1.7	System Variables	2–9
2.1.8	Comments	2–9
2.2	TRANSLATOR DIRECTIVES	2–10
2.3	DATA TYPES	2–12
2.4	USER-DEFINED DATA TYPES AND STRUCTURES	2–13
2.4.1	User-Defined Data Types	2–13
2.4.2	User-Defined Data Structures	2–15
2.5	ARRAYS	2–17
2.5.1	Multi-Dimensional Arrays	2–18
2.5.2	Variable-Sized Arrays	2–20

The KAREL language provides the elements necessary for programming effective robotics applications. This chapter lists and describes each of the components of the KAREL language, the available translator directives and the available data types.

2.1 LANGUAGE COMPONENTS

This section describes the following basic components of the KAREL language:

- Character set
- Operators
- Reserved words
- User-defined Identifiers
- Labels
- Predefined Identifiers
- System Variables
- Comments

2.1.1 Character Set

The ASCII character set is available in the KAREL language. Table 2–1 lists the elements in the ASCII character set. Three character sets are available in the KAREL language:

- ASCII Character Set
- Multinational Character Set
- Graphics Character Set

All of the characters recognized by the KAREL language are listed in Table 2–1 , Table 2–2 , and Table 2–3 . The default character set is ASCII. The multinational and graphics character sets are permitted only in literals, data, and comments.

See Also: CHR Built-In Procedure, Appendix A .

Table 2–1. ASCII Character Set

Letters	a b c d e f g h i j k l m n o p q r s t u v w x y z A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
Digits	0 1 2 3 4 5 6 7 8 9

Table 2–1. ASCII Character Set (Cont'd)

Symbols	@ < > = / * + - _ , ; : . # $ ' [ ] ( ) & % { }
Special Characters	blank or space form feed (treated as new line) tab (treated as a blank space)

The following rules are applicable for the ASCII character set:

- Blanks or spaces are:
  - — Required to separate reserved words and identifiers. For example, the statement **PROGRAM prog_name** must include a blank between **PROGRAM** and **prog_name** .
  - — Allowed but are not required within expressions between symbolic operators and their operands. For example, the statement **a = b** is equivalent to **a=b** .
  - — Used to indent lines in a program.
- Carriage return or a semi-colon (;) separate statements. Carriage returns can also appear in other places.

Table 2–2. Multinational Character Set

Symbols	¡	¢	£	¥	§	¤
	©	a	«	O	±	2
	3	µ	¶	•	1	o
	»	¼	½	¿		

Table 2–2. Multinational Character Set (Cont'd)

Special Characters	À	Á	Â	Ã	Ä	Å
	Æ	Ç	È	É	Ê	Ë
	Ì	Í	Î	Ï	Ñ	Ò
	Ó	Ô	Õ	Ö	Œ	Ø
	Ù	Ú	Û	Ü	Y	ß
	à	á	â	ã	ä	å
	æ	ç	è	é	ê	ë
	ì	í	î	ï	ç	ñ
	ò	ó	ô	õ	ö	œ
	ø	ù	ú	û	ü	ÿ

Table 2–3. Graphics Character Set

Letters	A B C D E F G H I J K L MN O P Q R S T U V W X Y Z													
Digits	0 1 2 3 4 5 6 7 8 9													
Symbols	@ < > = / * + - , ; : . # $ ' \ [ ] ( ) & % ! " ^													
Special Characters	♦	▒	HT	FF	CR	LF	O	±	NL	VT	┘	┐	┌	└
	+	-	-	-	-	_	├	┤	┴	┬	|	≤	≥	Π
	≠	£	.											

See Also: Appendix D for a listing of the character codes for each character set

2.1.2 Operators

KAREL provides operators for standard arithmetic operations, relational operations, and Boolean (logical) operations. KAREL also includes special operators that can be used with positional and VECTOR data types as operands.

Table 2–4 lists all of the operators available for use with KAREL.

Table 2–4. KAREL Operators

Arithmetic	+	-	*	/	DIV	MOD
Relational	<	< =	=	< >	> =	>
Boolean	AND	OR	NOT			
Special	> = <	:	#	@		

The precedence rules for these operators are as follows:

- Expressions within parentheses are evaluated first.
- Within a given level of parentheses, operations are performed starting with those of highest precedence and proceeding to those of lowest precedence.
- Within the same level of parentheses and operator precedence, operations are performed from left to right.

Table 2–5 lists the precedence levels for the KAREL operators.

Table 2–5. KAREL Operator Precedence

OPERATOR	PRECEDENCE LEVEL
NOT	High
:, @, #	↓
*, /, AND, DIV, MOD	↓
Unary + and -, OR, +, -	↓
<, >, =, < >, < =, > =, > = <	Low

See Also: Chapter 3 *USE OF OPERATORS* , for descriptions of functions operators perform

2.1.3 Reserved Words

Reserved words have a dedicated meaning in KAREL. They can be used only in their prescribed contexts. All KAREL reserved words are listed in Table 2–6 .

Table 2–6. Reserved Word List

ABORT	CONST	GET_VAR	NOPAUSE	STOP
ABOUT	CONTINUE	GO	NOT	STRING
ABS	COORDINATED	GOTO	NOWAIT	STRUCTURE
AFTER	CR	GROUP	OF	THEN
ALONG	DELAY	GROUP_ASSOC	OPEN	TIME
ALSO	DISABLE	HAND	OR	TIMER
AND	DISCONNECT	HOLD	PATH	TO
ARRAY	DIV	IF	PATHHEADER	TPENABLE
ARRAY_LEN	DO	IN	PAUSE	TYPE
AT	DOWNTO	INDEPENDENT	POSITION	UNHOLD
ATTACH	DRAM	INTEGER	POWERUP	UNINIT
AWAY	ELSE	JOINTPOS	PROGRAM	UNPAUSE
AXIS	ENABLE	JOINTPOS1	PULSE	UNTIL
BEFORE	END	JOINTPOS2	PURGE	USING
BEGIN	ENDCONDITION	JOINTPOS3	READ	VAR
BOOLEAN	ENDFOR	JOINTPOS4	REAL	VECTOR
BY	ENDIF	JOINTPOS5	RELATIVE	VIA
BYNAME	ENDMOVE	JOINTPOS6	RELAX	VIS_PROCESS
BYTE	ENDSELECT	JOINTPOS7	RELEASE	WAIT
CAM_SETUP	ENDSTRUCTURE	JOINTPOS8	REPEAT	WHEN
CANCEL	ENDUSING	JOINTPOS9	RESTORE	WHILE
CASE	ENDWHILE	MOD	RESUME	WITH
CLOSE	ERROR	MODEL	RETURN	WRITE
CMOS	EVAL	MOVE	ROUTINE	XYZWPR
COMMAND	EVENT	NEAR	SELECT	XYZWPREXT
COMMON_ASSOC	END	NOABORT	SEMAPHORE	
CONDITION	FILE	NODE	SET_VAR	
CONFIG	FOR	NODEDATA	SHORT	
CONNECT	FROM	NOMESSAGE	SIGNAL	

See Also: Index for references to descriptions of KAREL reserved words

2.1.4 User-Defined Identifiers

User-defined identifiers represent constants, data types, statement labels, variables, routine names, and program names. Identifiers

- Start with a letter
- Can include letters, digits, and underscores
- Can have a maximum of 12 characters
- Can have only one meaning within a particular scope. Refer to Section 5.1.4 .
- Cannot be reserved words
- Must be defined before they can be used.

For example, the program excerpt in Declaring Identifiers shows how to declare program, variable, and constant identifiers.

Declaring Identifiers

```
PROGRAM mover  --program identifier (mover)
    VAR
      original     :  POSITION  --variable identifier (original)
    CONST
      no_of_parts = 10  --constant identifier (no_of_parts)
```

2.1.5 Labels

Labels are special identifiers that mark places in the program to which program control can be transferred using the GOTO Statement.

- Are immediately followed by two colons (::). Executable statements are permitted on the same line and subsequent lines following the two colons.
- Cannot be used to transfer control into or out of a routine.

In Using Labels , **weld: :** denotes the section of the program in which a part is welded. When the statement **go to weld** is executed, program control is transferred to the **weld** section.

Using Labels

```
weld::  --label
   .     --additional program statements
   .
   .
GOTO weld
```

2.1.6 Predefined Identifiers

Predefined identifiers within the KAREL language have a predefined meaning. These can be constants, types, variables, or built-in routine names. Table 2–7 and Table 2–8 list the predefined identifiers along with their corresponding values. Either the identifier or the value can be specified in the program statement. For example, $MOTYPE = 7 is the same as $MOTYPE = LINEAR. However, the predefined identifier MININT is an exception to this rule. This identifier must always be used in place of its value, -2147483648. The value or number itself can not be used.

Table 2–7. Predefined Identifier and Value Summary

Predefined Identifier	Type	Value
TRUE FALSE	BOOLEAN	ON OFF
ON OFF	BOOLEAN	ON OFF
MAXINT MININT	INTEGER	+2147483647 -2147483648
RSWORLD AESWORLD WRISTJOINT	Orientation Type: $ORIENT_TYPE	1 2 3
JOINT LINEAR (or STRAIGHT) CIRCULAR	Motion Type: $MOTYPE	6 7 8
FINE COARSE NOSETTLE NODECEL VARDECEL	Termination Types: $TERMTYPE and $SEGTERMTYPE	1 2 3 4 5

Table 2–8. Port and File Predefined Identifier Summary

Predefined Identifier	Type
DIN (Digital input) DOUT (Digital output)	Boolean port array
GIN (Group input) GOUT (Group output) AIN (Analog output) AOUT (Analog output)	Integer port array

Table 2–8. Port and File Predefined Identifier Summary (Cont'd)

Predefined Identifier	Type
TPIN (Teach pendant input) TPOUT (Teach pendant output) RDI (Robot digital input) RDO (Robot digital output) OPIN (Operator panel input) OPOUT (Operator panel output) WDI (Weld input) WDOUT (Weld output)	Boolean port array
TPDISPLAY (Teach pendant KAREL display)* TPERROR (Teach pendant message line) TPPROMPT (Teach pendant function key line)* TPFUNC (Teach pendant function key line)* TPSTATUS (Teach pendant status line)* INPUT (CRT/KB KAREL keyboard)* OUTPUT (CRT/KB KAREL screen)* CRTERROR (CRT/KB message line) CRTFUNC (CRT function key line)* CRTSTATUS (CRT status line)* CRTPROMPT (CRT prompt line)* VIS_MONITOR (Vision Monitor Screen)	File

*Input and output occurs on the USER menu of the teach pendant or CRT/KB.

2.1.7 System Variables

System variables are variables that are declared as part of the KAREL system software. They have permanently defined variable names, that begin with a dollar sign ($). Many are robot specific, meaning their values depend on the type of robot that is attached to the system.

Some system variables are not accessible to KAREL programs. Access rights govern whether or not a KAREL program can read from or write to system variables.

See Also: *FANUC Robotics SYSTEM R-J3iC Controller Software Reference Manual* for a complete list and description of all available system variables.

2.1.8 Comments

Comments are lines of text within a program used to make the program easier for you or another programmer to understand. For example, Comments From Within a Program contains some

comments from %INCLUDE Directive in a KAREL Program and Include File mover_decs for a KAREL Program .

Comments From Within a Program

```
--This program, called mover, picks up 10 objects
--from an original POSITION and puts them down
--at a destination POSITION.
original :  POSITION   --POSITION of objects
destination :  POSITION   --Destination of objects
count  :  INTEGER    --Number of objects moved
```

A comment is marked by a pair of consecutive hyphens (- -). On a program line, anything to the right of these hyphens is treated as a comment.

Comments can be inserted on lines by themselves or at the ends of lines containing any program statement. They are ignored by the translator and have absolutely no effect on a running program.

2.2 TRANSLATOR DIRECTIVES

Translator directives provide a mechanism for directing the translation of a KAREL program. Translator directives are special statements used within a KAREL program to

- Include other files into a program at translation time
- Specify program and task attributes

All directives except %INCLUDE must be after the program statement but before any other statements. Table 2–9 lists and briefly describes each translator directive. Refer to Appendix A for a complete description of each translator directive.

Table 2–9. Translator Directives

Directive	Description
%ALPHABETIZE	Specifies that variables will be created in alphabetical order when p-code is loaded.
%CMOSVARS	Specifies the default storage for KAREL variables is CMOS RAM.
%CMOS2SHADOW	Instructs the translator to put all CMOS variables in SHADOW memory.
%COMMENT = 'comment'	Specifies a comment of up to 16 characters. During load time, the comment is stored as a program attribute and can be displayed on the SELECT screen of the teach pendant or CRT/KB.

Table 2–9. Translator Directives (Cont'd)

Directive	Description
%CRTDEVICE	Specifies that the CRT/KB user window will be the default in the READ and WRITE statements instead of the TPDISPLAY window.
%DEFGROUP = n	Specifies the default motion group to be used by the translator.
%DELAY	Specifies the amount of time the program will be delayed out of every 250 milliseconds.
%ENVIRONMENT filename	Used by the off-line translator to specify that a particular environment file should be loaded.
%INCLUDE filename	Specifies files to insert into a program at translation time.
%LOCKGROUP =n,n	Specifies the motion group(s) locked by this task.
%NOABORT = option	Specifies a set of conditions which will be prevented from aborting the program.
%NOBUSYLAMP	Specifies that the busy lamp will be OFF during execution.
%NOLOCKGROUP	Specifies that no motion groups will be locked by this task.
%NOPAUSE = option	Specifies a set of conditions which will be prevented from pausing the program.
%NOPAUSESHFT	Specifies that the task is not paused if the teach pendant shift key is released.
%PRIORITY = n	Specifies the task priority.
%SHADOWVARS	Specifies that all variables by default are created in SHADOW.
%STACKSIZE = n	Specifies the stack size in long words.
%TIMESLICE = n	Supports round-robin type time slicing for tasks with the same priority.
%TPMOTION	Specifies that task motion is enabled only when the teach pendant is enabled.
%UNINITVARS	Specifies that all variables are by default uninitialized.

%INCLUDE Directive in a KAREL Program illustrates the %INCLUDE directive. Include File mover_decs for a KAREL Program shows the included file.

%INCLUDE Directive in a KAREL Program

```
PROGRAM mover
-- This program, called mover, picks up 10 objects
-- from an original POSITION and puts them down
-- at a destination POSITION.
%INCLUDE mover_decs
-- Uses %INCLUDE directive to include the file
```

```
-- called mover_decs containing declarations
BEGIN
   $SPEED = 200.0
   $MOTYPE = LINEAR
   OPEN HAND gripper
-- Loop to move total number of objects
   FOR count = 1 TO num_of_parts DO
      MOVE TO original
      CLOSE HAND gripper
      MOVE TO destination
      OPEN HAND gripper
   ENDFOR                -- End of loop
END mover
```

Include File mover_decs for a KAREL Program

```
-- Declarations for program mover in file mover_decs
VAR
   original  :  POSITION     --POSITION of objects
   destination :  POSITION     --Destination of objects
   count  :  INTEGER      --Number of objects moved
CONST
   gripper = 1    -- Hand number 1
   num_of_parts = 10    -- Number of objects to move
```

2.3 DATA TYPES

Three forms of data types are provided by KAREL to define data items in a program:

- Simple type data items
  - — Can be assigned constants or variables in a KAREL program
  - — Can be assigned actual (literal) values in a KAREL program
  - — Can assume only single values
- Structured type data items
  - — Are defined as data items that permit or require more than a single value
  - — Are composites of simple data and structured data
- User-defined type data items
  - — Are defined in terms of existing data types including other user-defined types
  - — Can be defined as structures consisting of several KAREL variable data types

— Cannot include itself

Table 2–10 lists the simple and structured data types available in KAREL. User-defined data types are described in Section 2.4 .

Table 2–10. Simple and Structured Data Types

Simple	Structured	
BOOLEAN	ARRAY OF BYTE	JOINTPOS7
FILE	CAM_SETUP	JOINTPOS8
INTEGER	COMMON_ASSOC	JOINTPOS9
REAL	CONFIG	MODEL
STRING	GROUP_ASSOC	PATH
	JOINTPOS	POSITION
	JOINTPOS1	QUEUE_TYPE
	JOINTPOS2	ARRAY OF SHORT
	JOINTPOS3	VECTOR
	JOINTPOS4	VIS_PROCESS
	JOINTPOS5	XYZWPR
	JOINTPOS6	XYZWPREXT

See Also: Appendix A for a detailed description of each data type.

2.4 USER-DEFINED DATA TYPES AND STRUCTURES

User-defined data types are data types you define in terms of existing data types. User-defined data structures are data structures in which you define a new data type as a structure consisting of several KAREL variable data types, including previously defined user data types.

2.4.1 User-Defined Data Types

User-defined data types are data types you define in terms of existing data types. With user-defined data types, you

- Include their declarations in the TYPE sections of a KAREL program.
- Define a KAREL name to represent a new data type, described in terms of other data types.
- Can use predefined data types required for specific applications.

User-defined data types can be defined as structures, consisting of several KAREL variable data types.

The continuation character, "&", can be used to continue a declaration on a new line.

User-Defined Data Type Example shows an example of user-defined data type usage and continuation character usage.

User-Defined Data Type Example

```
CONST
   n_pages = 20
   n_lines = 40
   std_str_lng = 8
TYPE
   std_string_t = STRING [std_str_lng]
   std_table_t = ARRAY [n_pages]&          --continuation character
    OF ARRAY [n_lines] OF std_string_t
   path_hdr_t FROM main_prog = STRUCTURE   --user defined data type
     ph_uframe:  POSITION
     ph_utool:  POSITION
   ENDSTRUCTURE
   node_data_t FROM main_prog = STRUCTURE
     gun_on:  BOOLEAN
     air_flow:  INTEGER
   ENDSTRUCTURE
std_path_t FROM main_prog =
  PATH PATHDATA = path_hdr_t NODEDATA = node_data_t
VAR
   msg_table_1:  std_table_t
   msg_table_2:  std_table_t
   temp_string:  std_string_t
   seam_1_path:  std_path_t
```

Usage

User-defined type data can be

- Assigned to other variables of the same type
- Passed as a parameter
- Returned as a function

Assignment between variables of different user-defined data types, even if identically declared, is not permitted. In addition, the system provides the ability to load and save variables of user-defined data types, checking consistency during the load with the current declaration of the data type.

Restrictions

A user-defined data type cannot

- Include itself
- Include any type that includes it, either directly or indirectly
- Be declared within a routine

2.4.2 User-Defined Data Structures

A structure is used to store a collection of information that is generally used together. User-defined data structures are data structures in which you define a new data type as a structure consisting of several KAREL variable data types.

When a program containing variables of user-defined data types is loaded, the definitions of these types are checked against a previously created definition. If a previously created definition does not exist, a new one is created.

With user-defined data structures, you

- Define a data type as a structure consisting of a list of component fields, each of which can be a standard data type or another, previously defined, user data type. See Defining a Data Type as a User-Defined Structure .

Defining a Data Type as a User-Defined Structure

```
new_type_name = STRUCTURE
  field_name_1:  type_name_1
  field_name_2:  type_name_2
  ..
ENDSTRUCTURE
```

- Access elements of a data type defined as a structure in a KAREL program. The continuation character, "&", can be used to continue access of the structure elements. See Accessing Elements of a User-Defined Structure in a KAREL Program .

Accessing Elements of a User-Defined Structure in a KAREL Program

```
var_name = new_type_name.field_nam_1
new_type_name.field_name_2 = expression
outer_struct_name.inner_struct_name&
  .field_name = expression
```

- Access elements of a data type defined as a structure from the CRT/KB and at the teach pendant.
- Define a range of executable statements in which fields of a STRUCTURE type variable can be accessed without repeating the name of the variable. See Defining a Range of Executable Statements .

Defining a Range of Executable Statements

```
USING struct_var, struct_var2 DO
  statements
  ..
ENDUSING
```

In the above example, struct_var and struct_var2 are the names of structure type variables.

Note If the same name is both a field name and a variable name, the field name is assumed. If the same field name appears in more than one variable, the right-most variable in the USING statement is used.

Restrictions

User-defined data structures have the following restrictions:

- The following data types are **not valid** as part of a data structure:
  - — STRUCTURE definitions; types that are declared structures are permitted. See Valid STRUCTURE Definitions .

Valid STRUCTURE Definitions

```
The following is valid:
  TYPE
   sub_struct = STRUCTURE
      subs_field_1:  INTEGER
      subs_field_2:  BOOLEAN
   ENDSTRUCTURE
   big_struct = STRUCTURE
      bigs_field_1:  INTEGER
      bigs_field_2:  sub_struct
   ENDSTRUCTURE
The following is not valid:
    big_struct = STRUCTURE
      bigs_field_1:  INTEGER
```

```
        bigs_field_2:  STRUCTURE
        subs_field_1:  INTEGER
        subs_field_2:  BOOLEAN
      ENDSTRUCTURE
  ENDSTRUCTURE
```

- — PATH types
- — FILE types
- — VISION types
- — Variable length arrays
- — The data structure itself, or any type that includes it, either directly or indirectly
- — Any structure not previously defined.

- A variable can not be defined as a structure, but can be defined as a data type previously defined as a structure. See Defining a Variable as a Type Previously Defined as a Structure .

Defining a Variable as a Type Previously Defined as a Structure

```
The following is valid:
  TYPE
    struct_t = STRUCTURE
      st_1:  BOOLEAN
      st_2:  REAL
    ENDSTRUCTURE
  VAR
    var_name:  struct_t
The following is not valid:
  VAR
    var_name:  STRUCTURE
      vn_1:  BOOLEAN
      vn_2:  REAL
    ENDSTRUCTURE
```

2.5 ARRAYS

You can declare arrays of any data type except PATH.

You can access elements of these arrays in a KAREL program, from the CRT/KB, and from the teach pendant.

In addition, you can define two types of arrays:

- Multi-dimensional arrays
- Variable-sized arrays

2.5.1 Multi-Dimensional Arrays

Multi-dimensional arrays are arrays of elements with two or three dimensions. These arrays allow you to identify an element using two or three subscripts.

Multi-dimensional arrays allow you to

- Declare variables as arrays with two or three (but not more) dimensions. See Declaring Variables as Arrays with Two or Three Dimensions .

Declaring Variables as Arrays with Two or Three Dimensions

```
VAR
  name:  ARRAY [size_1] OF ARRAY [size_2] .., OF element_type
  OR
VAR
  name:  ARRAY [size_1, size_2,...] OF element_type
```

- Access elements of these arrays in KAREL statements. See Accessing Elements of Multi-Dimensional Arrays in KAREL Statements .

Accessing Elements of Multi-Dimensional Arrays in KAREL Statements

```
name [subscript_1, subscript_2,...] = value
value = name [subscript_1, subscript_2,...]
```

- Declare routine parameters as multi-dimensional arrays. See Declaring Routine Parameters as Multi-Dimensional Arrays .

Declaring Routine Parameters as Multi-Dimensional Arrays

```
Routine expects 2-dimensional array of INTEGER.
```

```
   ROUTINE array_user (array_param:ARRAY [*,*] OF INTEGER)
The following are equivalent:
  ROUTINE rtn_name(array_param:  ARRAY[*] OF INTEGER)
  and
  ROUTINE rtn_name(array_param:  ARRAY OF INTEGER)
```

- Access elements with KCL commands and the teach pendant.
- Save and load multi-dimensional arrays to and from variable files.

Restrictions

The following restrictions apply to multi-dimensional arrays:

- A subarray can be passed as a parameter or assigned to another array by omitting one or more of the right-most subscripts only if it was defined as a separate type. See Using a Subarray .

Using a Subarray

```
TYPE
   array_30 = ARRAY[30] OF INTEGER
   array_20_30 = ARRAY[20] OF array_30
VAR
   array_1:  array_30
   array_2:  array_20_30
   array_3:  ARRAY[10] OF array_20_30
ROUTINE array_user(array_data:  ARRAY OF INTEGER
   FROM other-prog
BEGIN
array_2 = array_3[10]          -- assigns elements array_3[10,1,1]
                                  -- through array_3[10,20,30] to
array_2
array_2[2] = array_1           -- assigns elements array_1[1] through
                                  -- array_1 [30] to elements array_2[2,1]
                                  -- through array_2[2,30]
array_user(array_3[5,3])      -- passes elements array_3[5,3,1]
                                  -- through array_3[5,3,30] to array_user
```

- The element type cannot be any of the following:
  - Array (but it can be a user-defined type that is an array)
  - Path

2.5.2 Variable-Sized Arrays

Variable-sized arrays are arrays whose actual size is not known, and that differ from one use of the program to another. Variable-sized arrays allow you to write KAREL programs without establishing dimensions of the array variables. In all cases, the dimension of the variable must be established before the .PC file is loaded.

Variable-sized arrays allow you to

- Declare an array size as ‘‘to-be-determined ’’ (*). See Indicates that the Size of an Array is "To-Be-Determined" .

Indicates that the Size of an Array is "To-Be-Determined"

```
VAR
   one_d_array:  ARRAY[*] OF type
   two_d_array:  ARRAY[*,*] OF type
```

- Determine an array size from that in a variable file or from a KCL CREATE VAR command rather than from the KAREL source code.

The actual size of a variable-sized array will be determined by the actual size of the array if it already exists, the size of the array in a variable file if it is loaded first, or the size specified in a KCL CREATE VAR command executed before the program is loaded. Dimensions explicitly specified in a program must agree with those specified from the .VR file or specified in the KCL CREATE VAR command.

Restrictions

Variable-sized arrays have the following restrictions:

- The variable must be loaded or created in memory (in a .VR file or using KCL), with a known length, before it can be used.
- When the .PC file is loaded, it uses the established dimension, otherwise it uses 0.
- Variable-sized arrays are only allowed in the VAR section and not the TYPE section of a program.
- Variable-sized arrays are only allowed for static variables.

Chapter 3

USE OF OPERATORS

Contents

Chapter 3	USE OF OPERATORS	3–1
3.1	EXPRESSIONS AND ASSIGNMENTS	3–2
3.1.1	Rule for Expressions and Assignments	3–2
3.1.2	Evaluation of Expressions and Assignments	3–2
3.1.3	Variables and Expressions	3–4
3.2	OPERATIONS	3–4
3.2.1	Arithmetic Operations	3–5
3.2.2	Relational Operations	3–6
3.2.3	Boolean Operations	3–7
3.2.4	Special Operations	3–8

This chapter describes how operators are used with other language elements to perform operations within a KAREL application program. Expressions and assignments, which are program statements that include operators and operands, are explained first. Next, the kinds of operations that can be performed using each available KAREL operator are discussed.

3.1 EXPRESSIONS AND ASSIGNMENTS

Expressions are values defined by a series of operands, connected by operators and cause desired computations to be made. For example, **4 + 8** is an expression in which **4** and **8** are the *operands* and the plus symbol (+) is the *operator* .

Assignments are statements that set the value of variables to the result of an evaluated expression.

3.1.1 Rule for Expressions and Assignments

The following rules apply to expressions and assignments:

- Each operand of an expression has a data type determined by the nature of the operator.
- Each KAREL operator requires a particular operand type and causes a computation that produces a particular result type.
- Both operands in an expression must be of the same data type. For example, the AND operator requires that both its operands are INTEGER values or that both are BOOLEAN values. The expression **i AND b** , where **i** is an INTEGER and **b** is a BOOLEAN, is invalid.
- Five special cases in which the operands can be mixed provide an exception to this rule. These five cases include the following:
  - — INTEGER and REAL operands to produce a REAL result
  - — INTEGER and REAL operands to produce a BOOLEAN result
  - — INTEGER and VECTOR operands to produce a VECTOR
  - — REAL and VECTOR operands to produce a VECTOR
  - — POSITION and VECTOR operands to produce a VECTOR
- Any positional data type can be substituted for the POSITION data type.

3.1.2 Evaluation of Expressions and Assignments

Table 3–1 summarizes the data types of the values that result from the evaluation of expressions containing KAREL operators and operands.

Table 3–1. Summary of Operation Result Types

Operator	+	-	*	/	DIV MOD	< >,>= <=, <, >, =	> =<	AND OR NOT	#	@	:
Types of Operators											
INTEGER	I	I	I	R	I	B	–	I	–	–	–
REAL	R	R	R	R	–	B	–	–	–	–	–
Mixed** INTEGER-REAL	R	R	R	R	–	B	–	–	–	–	–
BOOLEAN	–	–	–	–	–	B	–	B	–	–	–
STRING	S	–	–	–	–	B	–	–	–	–	–
Mixed** INTEGER-VECTOR	–	–	V	V	–	–	–	–	–	–	–
Mixed** REAL-VECTOR	–	–	V	V	–	–	–	–	–	–	–
VECTOR	V	V	–	–	–	B***	–	–	V	R	–
POSITION	–	–	–	–	–	–	B	–	–	–	P
Mixed** POSITION-VECTOR	–	–	–	–	–	–	–	–	–	–	V

**Mixed means one operand of each type

***VECTOR values can be compared using = < > only

–Operation not allowed

I INTEGER

R REAL

B BOOLEAN

V VECTOR

P POSITION

3.1.3 Variables and Expressions

Assignment statements contain variables and expressions. The variables can be any user-defined variable, a system variable with write access, or an output port array with write access. The expression can be any valid KAREL expression. The following examples are acceptable assignments:

$SPEED = 200.00 -- assigns a REAL value to a system variable

count = count + 1 -- assigns an INTEGER value to an INTEGER variable

The data types of **variable** and **expression** must match with three exceptions:

- INTEGER variables can be assigned to REAL variables. In this case, the INTEGER is treated as a REAL number during evaluation of the expression. However, a REAL number cannot be used where an INTEGER value is expected.
- If required, a REAL number can be converted to an INTEGER using the ROUND or TRUNC built-in functions.
- INTEGER, BYTE, and SHORT types can be assigned to each other, although a run-time error will occur if the assigned value is out of range.
- Any positional type can be assigned to any other positional type. A run-time error will result if a JOINTPOS from a group without kinematics is assigned to an XYZWPR.

See Also: Relational Operations, ROUND and TRUNC built-in functions, Appendix A, ‘‘KAREL Language Alphabetical Description’’

3.2 OPERATIONS

Operations include the manipulation of variables, constants, and literals to compute values using the available KAREL operators. The following operations are discussed:

- Arithmetic Operations
- Relational Operations
- Boolean Operations
- Special Operations

Table 3–2 lists all of the operators available for use with KAREL.

Table 3–2. KAREL Operators

Operation	Operator					
Arithmetic	+	-	*	/	DIV	MOD
Relational	<	< =	=	< >	> =	>
Boolean	AND	OR	NOT			
Special	> = <	:	#	@		

3.2.1 Arithmetic Operations

The addition (+), subtraction (-), and multiplication (*) operators, along with the DIV and MOD operators, can be used to compute values within arithmetic expressions. Refer to Table 3–3 .

Table 3–3. Arithmetic Operations Using +, -, and * Operators

EXPRESSION	RESULT
3 + 2	5
3 - 2	1
3 * 2	6

- The DIV and MOD operators are used to perform INTEGER division. Refer to Table 3–4 .

Table 3–4. Arithmetic Operations Examples

EXPRESSION	RESULT
11 DIV 2	5
11 MOD 2	1

  - — The DIV operator truncates the result of an equation if it is not a whole number.
  - — The MOD operator returns the remainder of an equation that results from dividing the left-side operand by the right-side operand.
  - — If the right-side operand of a MOD equation is a negative number, the result is also negative.
  - — If the divisor in a DIV equation or the right-side operand of a MOD equation is zero, the KAREL program is aborted with the “Divide by zero” error.
- The INTEGER bitwise operators, AND, OR, and NOT, produce the result of a binary AND, OR, or NOT operation on two INTEGER values. Refer to Table 3–5 .

Table 3–5. Arithmetic Operations Using Bitwise Operands

EXPRESSION	BINARY EQUIVALENT	RESULT
5 AND 8 5 OR 8	0101 AND 1000 0101 OR 1000	0000 = 0 1101 = 13
-4 AND 8 -4 OR 8	1100 AND 1000 1100 OR 1000	1000 = 8 1100 = -4
NOT 5 NOT -15	NOT 0101 NOT 110001	1010 = -6* 1110 = 14*

*Because negative INTEGER values are represented in the two's complement form, NOT i is not the same as -i.

- If an INTEGER or REAL equation results in a value exceeding the limit for INTEGER or REAL variables, the program is aborted with an error. If the result is too small to represent, it is set to zero.

Table 3–6 lists the precedence levels for the KAREL operators.

Table 3–6. KAREL Operator Precedence

OPERATOR	PRECEDENCE LEVEL
NOT	High
:, @, #	↓
*, /, AND, DIV, MOD	↓
Unary + and -, OR, +, -	↓
<, >, =, < >, < =, > =, > = <	Low

3.2.2 Relational Operations

Relational operators (< >, =, >, <, <=, >=) produce a BOOLEAN (TRUE/FALSE) result corresponding to whether or not the values of the operands are in the relation specified. In a relational expression, both operands must be of the same simple data type. Two exceptions to this rule exist:

- REAL and INTEGER expressions can be mixed where the INTEGER operand is converted to a REAL number.

  For example, in the expression **1 > .56** , the number **1** is converted to **1.0** and the result is TRUE.

- VECTOR operands, which are a structured data type, can be compared in a relational expression but only by using the equality (=) or inequality (<>) operators.

The relational operators function with INTEGER and REAL operands to evaluate standard mathematical equations. Refer to Table 3–7 .

Note Performing equality (=) or inequality (<>) tests between REAL values might not yield the results you expect. Because of the way REAL values are stored and manipulated, two values that would appear to be equal might not be exactly equal. This is also true of VECTOR values which are composed of REAL values. Use >= or <= where appropriate instead of =.

Relational operators can also have STRING values as operands. STRING values are compared lexically character by character from left to right until one of the following occurs. Refer to Table 3–7 .

- The character code for a character in one STRING is greater than the character code for the corresponding character in the other STRING. The result in this case is that the first string is greater. For example, the ASCII code for A is 65 and for a is 97. Therefore, a > A = TRUE.
- One STRING is exhausted while characters remain in the other STRING. The result is that the first STRING is less than the other STRING.
- Both STRING expressions are exhausted without finding a mismatch. The result is that the STRINGs are equal.

Table 3–7. Relational Operation Examples

EXPRESSION	RESULT
'A' < 'AA'	TRUE
'A' = 'a'	FALSE
4 > 2	TRUE
17.3< > 5.6	TRUE
(3 *4) < > (4* 3)	FALSE

With BOOLEAN operands, TRUE > FALSE is defined as a true statement. Thus the expression FALSE >= TRUE is a false statement. The statements FALSE >= FALSE and TRUE >= FALSE are also true statements.

3.2.3 Boolean Operations

The Boolean operators AND, OR, and NOT, with BOOLEAN operands, can be used to perform standard mathematical evaluations. Table 3–8 summarizes the results of evaluating Boolean expressions, and some examples are listed in Table 3–9 .

Table 3–8. BOOLEAN Operation Summary

OPERATOR	OPERAND 1	OPERAND 2	RESULT
NOT	TRUE	–	FALSE
	FALSE	–	TRUE
OR	TRUE	TRUE	TRUE
		FALSE	
	FALSE	TRUE	
		FALSE	FALSE
AND	TRUE	TRUE	TRUE
		FALSE	FALSE
	FALSE	TRUE	
		FALSE	

Table 3–9. BOOLEAN Operations Using AND, OR, and NOT Operators

EXPRESSION	RESULT
DIN[1] AND DIN[2]	TRUE if DIN[1] and DIN[2] are both TRUE; otherwise FALSE
DIN[1] AND NOT DIN[2]	TRUE if DIN[1] is TRUE and DIN[2] is FALSE; otherwise FALSE
(x < y) OR (y > z)	TRUE if x < y or if y > z; otherwise FALSE
(i = 2) OR (i = 753)	TRUE if i = 2 or if i = 753; otherwise FALSE

3.2.4 Special Operations

The KAREL language provides special operators to perform functions such as testing the value of approximately equal POSITION variables, relative POSITION variables, VECTOR variables, and STRING variables. This section describes their operations and gives examples of their usage.

The following rules apply to approximately equal operations:

- The relational operator (>=<) determines if two POSITION operands are approximately equal and produces a BOOLEAN result. The comparison is similar to the equality (=) relation except that the operands compared need not be identical. Extended axis values are not considered.
- Approximately equal operations must be used in conjunction with the system variables, $LOCTOL, $ORIENTTOL, and $CHECKCONFIG to determine how close two positions must be. Refer to the *FANUC Robotics SYSTEM R-J3iC Controller Software Reference Manual* for a description of these variables.

- The relational operator (>=<) is allowed only in normal program use and cannot be used as a condition in a condition handler statement.

In the following example the relational operator (>=<) is used to determine if the current robot position (determined by using the CURPOS built-in procedure) is near the designated perch position:

Relational Operator

```
IF perch >=< CURPOS (0,0) THEN MOVE TO perch
ELSE
     ABORT
ENDIF
```

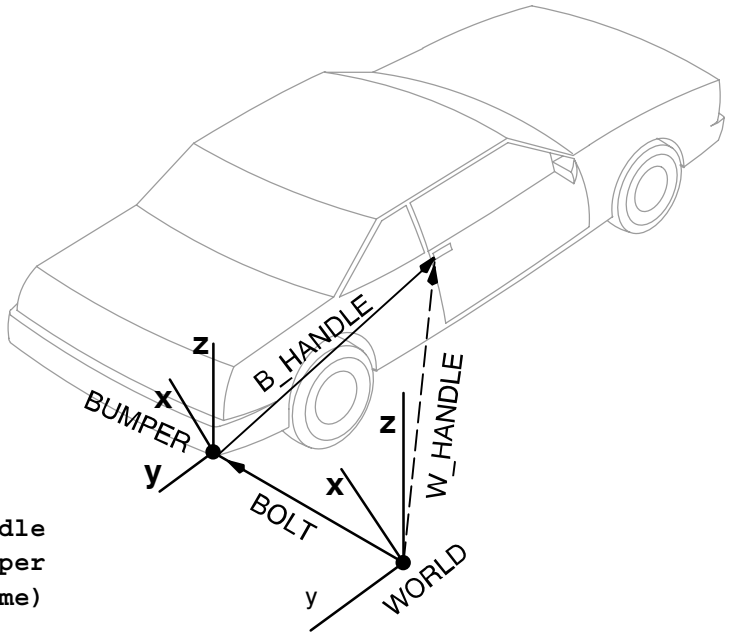
Relative Position Operations

To locate a position in space, you must reference it to a specific coordinate frame. In KAREL, reference frames have the POSITION data type. The relative position operator (:) allows you to reference a position or vector with respect to the coordinate frame of another position (that is, the coordinate frame that has the other position as its origin point).

The relative position operator (:) is used to transform a position from one reference frame to another frame.

In the example shown in Figure 3–1 , a vision system is used to locate a target on a car such as a bolt head on a bumper. The relative position operator is used to calculate the position of the door handle based on data from the car drawings. The equation shown in Figure 3–1 is used to calculate the position of **w_handle** in the WORLD frame.

Figure 3–1. Determining w_handle Relative to WORLD Frame




```
w_handle = bolt : b_handle
(world     (world    (bumper
 frame)     frame)    frame)
```

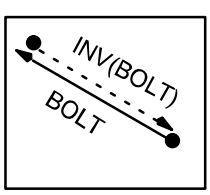
where:

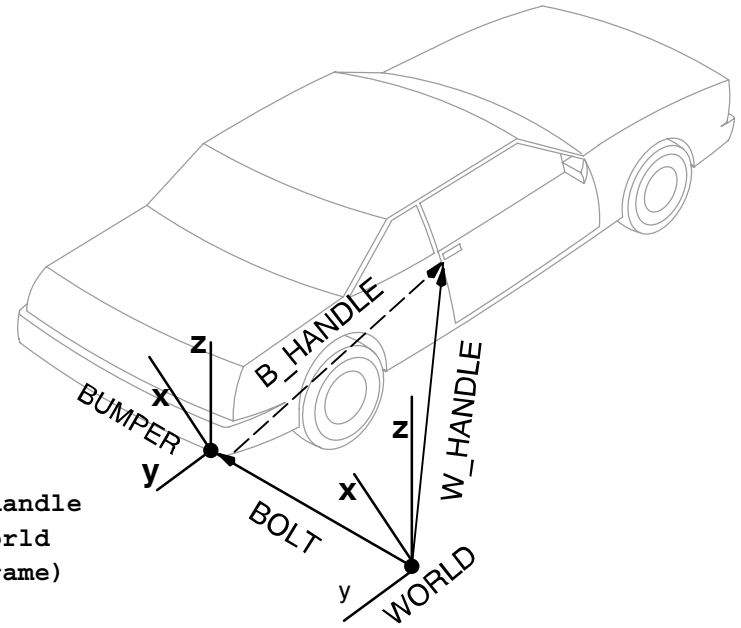
bolt is the position of the BUMPER frame origin referenced in the WORLD frame.
w_handle is the handle position referenced in the WORLD frame.
b_handle is the handle position referenced in the BUMPER frame.

The KAREL INV Built-In Function reverses the direction of the reference.

For example, to determine the position of the door handle target **(b_handle)** relative to the position of the **bolt** , use the equation shown in Figure 3–2 .

Figure 3–2. Determining b_handle Relative to BUMPER Frame






```
b_handle = INV(bolt) : w_handle
(bumper     (bumper      (world
 frame)      frame)       frame)
```

where:

INV(bolt) is the position of the WORLD frame origin referenced in the BUMPER frame.
w_handle is the handle position referenced in the WORLD frame.
b_handle is the handle position referenced in the BUMPER frame.

Note The order of the relative operator (:) is important.where:b_handle = bolt : w_handle *is NOT the same as* b_handle = w_handle : bolt

See Also: Chapter 8 *MOTION* , INV Built-In Function, Appendix A .

Vector Operations

The following rules apply to VECTOR operations:

- A VECTOR expression can perform addition (+) and subtraction (-) equations on VECTOR operands. The result is a VECTOR whose components are the sum or difference of the corresponding components of the operands. For example, the components of the VECTOR **vect_3** will equal (5, 10, 9) as a result of the following program statements:

Vector Operations

```
vect_1.x = 4; vect_1.y = 8; vect_1.z = 5
vect_2.x = 1; vect_2.y = 2; vect_2.z = 4
vect_3 = vect_1 + vect_2
```

- The multiplication (*) and division (/) operators can be used with either
  - — A VECTOR and an INTEGER operand
  - — A VECTOR and a REAL operand

  The product of a VECTOR and an INTEGER or a VECTOR and a REAL is a scaled version of the VECTOR. Each component of the VECTOR is multiplied by the INTEGER (treated as a REAL number) or the REAL.

  For example, the VECTOR (8, 16, 10) is produced as a result of the following operation:

```
(4, 8, 5) * 2
```

  VECTOR components can be on the left or right side of the operator.
- A VECTOR divided by an INTEGER or a REAL causes each component of the VECTOR to be divided by the INTEGER (treated as a REAL number) or REAL. For example, (4, 8, 5) / 2 results in (2, 4, 2.5).

  If the divisor is zero, the program is aborted with the ‘‘Divide by zero’’ error.
- An INTEGER or REAL divided by a VECTOR causes the INTEGER (treated as a REAL number) or REAL to be multiplied by the reciprocal of each element of the VECTOR, thus producing a new VECTOR. For example, 3.5 / VEC(7.0,8.0,9.0) results in (0.5,0.4375,0.38889).

  If any of the elements of the VECTOR are zero, the program is aborted with the ‘‘Divide by zero’’ error.
- The cross product operator (#) produces a VECTOR that is normal to the two operands in the direction indicated by the right hand rule and with a magnitude equal to the product of the magnitudes of the two vectors and SIN(Θ), whereΘis the angle between the two vectors. For example, VEC(3.0,4.0,5.0) # VEC(6.0,7.0,8.0) results in (-3.0, 6.0, -3.0).

  If either vector is zero, or the vectors are exactly parallel, an error occurs.
- The inner product operator (@) results in a REAL number that is the sum of the products of the corresponding elements of the two vectors. For example, VEC(3.0,4.0,5.0) @ VEC(6.0,7.0,8.0) results in 86.0.
- If the result of any of the above operations is a component of a VECTOR with a magnitude too large for a KAREL REAL number, the program is aborted with the ‘‘Real overflow’’ error.

Table 3–10 lists additional examples of vector operations.

Table 3–10. Examples of Vector Operations

EXPRESSION	RESULT
VEC(3.0,7.0,6.0) + VEC(12.6,3.2,7.5)	(15.6,10.2,13.5)
VEC(7.6,9.0,7.0) - VEC(14.0,3.5,17.0)	(-6.4,5.5,-10)
4.5 * VEC(3.2,7.6,4.0)	(14.4,34.2,18.0)
VEC(12.7,2.0,8.3) * 7.6	(96.52,15.2,63.08)
VEC(17.3,1.5,0.23) /2	(8.65,0.75,0.115)

String Operations

The following rules apply to STRING operations:

- You can specify that a KAREL routine returns a STRING as its value. See Specifying a KAREL Routine to Return a STRING Value .

Specifying a KAREL Routine to Return a STRING Value

```
ROUTINE name(parameter_list):  STRING
    declares name as returning a STRING value
```

- An operator can be used between strings to indicate the concatenation of the strings. See Using an Operator to Concatenate Strings .

Using an Operator to Concatenate Strings

```
string_1 = string_2 + string_3 + 'ABC' + 'DEF'
```

- STRING expressions can be used in WRITE statements. See Using a STRING Expression in a WRITE Statement .

Using a STRING Expression in a WRITE Statement

```
WRITE(CHR(13) + string_1 + string_2)
    writes a single string consisting of a return
    character followed by string_1 and string_2
```

- During STRING assignment, the string will be truncated if the target string is not large enough to hold the same string.
- You can compare or extract a character from a string. For example if *string_1 = 'ABCDE'* . Your output would be *'D'* . See String Comparison .

String Comparison

```
IF SUB_STR(string_1, 4, 1) = 'D' THEN
```

- You can build a string from another string. See Building a String from Another String .

Building a String from Another String

```
ROUTINE toupper(p_char: INTEGER): STRING
 BEGIN
   IF (p_char > 96) AND (p_char < 123) THEN
      p_char = p_char - 32
   ENDIF
   RETURN (CHR(p_char))
 END toupper
 BEGIN
    WRITE OUTPUT ('Enter string: ')
    READ INPUT (string_1)
    string_2 = ''
    FOR idx = 1 TO STR_LEN(string_1) DO
     string_2 = string_2 + toupper(ORD(string_1, idx))
    ENDFOR
```

Chapter 4

MOTION AND PROGRAM CONTROL

Contents

Chapter 4	MOTION AND PROGRAM CONTROL	4–1
4.1	OVERVIEW	4–2
4.2	MOTION CONTROL STATEMENTS	4–2
4.2.1	Extended Axis Motion	4–4
4.2.2	Group Motion	4–4
4.3	PROGRAM CONTROL STRUCTURES	4–5
4.3.1	Alternation Control Structures	4–5
4.3.2	Looping Control Statements	4–6
4.3.3	Unconditional Branch Statement	4–6
4.3.4	Execution Control Statements	4–6
4.3.5	Condition Handlers	4–7

4.1 OVERVIEW

The KAREL language provides several motion control statements that direct the movement of the tool center point or the auxiliary axes. Optional clauses used in conjunction with the motion control statements specify motion characteristics, intermediate positions, and conditions to be monitored.

Program control structures define the flow of execution within a program or routine and include alternation, looping, and unconditional branching as well as execution control.

Note Almost all robot motion programming can be accomplished using teach pendant programs. Additionally, all motion options are supported in teach pendant programs, whereas most advanced motion options are NOT supported for motion statements in KAREL programs. Due to the very limited availability of motion options, motion programming should not be used in KAREL programs unless teach pendant programs specifically cannot be used.

4.2 MOTION CONTROL STATEMENTS

In robotic applications, motion is the movement of the tool center point (TCP) from an initial position to a desired destination position. Some applications also involve the movement of other objects, such as auxiliary axes. Auxiliary axes can be set up either in the same group as robot axes or a separate group. If auxiliary axes are set up in the robot group, they are called extended axes.

The MOVE statement directs the motion of the TCP, as well as any auxiliary axes, in a KAREL program. A MOVE statement specifies the object and the destination of that object.

This chapter briefly lists the MOVE statements that are available in KAREL. For a detailed description of each statement, action, or clause listed in this section, refer to . Appendix A.' A more in-depth view of the motion environment is provided in Chapter 8 *MOTION* .

The following MOVE statements are available in KAREL:

- **MOVE TO** - specifies the destination of the move when the destination is TO a particular position or individual path node. Auxiliary axes can be the object of the move if the destination position is specified as the extended position type, ''XYZWPREXT.''
- **MOVE ALONG** - causes motion along the nodes defined for a PATH variable. The object being moved (TCP and/or AUX) depends on the data stored in each path node or a subset can be specified in the MOVE statement.
- **MOVE NEAR** - allows you to specify a destination that is NEAR a position value, using a REAL value for the offset distance. The specified offset is measured in millimeters along the negative z-axis of the specified POSITION.
- **MOVE RELATIVE** - allows you to specify a destination that is RELATIVE to the current location of the group of axes using a VECTOR value for the offset distance. The (x, y, z) components of the offset VECTOR value are in the user coordinate system ($UFRAME).

- **MOVE AWAY** - allows you to specify a destination that is AWAY from the current position of the group of axes, using a REAL value for the offset distance. The specified offset is measured in millimeters along the negative z-axis of the tool coordinate system.
- **MOVE ABOUT** - allows you to specify a destination that is an angular distance about a specified vector from the current position of a group of axes. The angular distance of the destination of a group of axes is measured from the current position of a group of axes ABOUT the specified VECTOR value in tool coordinates by the specified angle (in degrees).
- **MOVE AXIS** - allows you to specify a particular robot or auxiliary axis as the object being moved BY a distance that is specified as a REAL value.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly, personnel could be injured, and equipment could be damaged.

Optional clauses included in a MOVE statement can specify motion characteristics for a single move, intermediate positions for circular moves, and conditions to be monitored during a move. KAREL provides the following clauses to be used for these purposes:

- **WITH Clause** - allows you to specify a temporary value for a system variable. This temporary value is used by the motion environment while executing the move in which the WITH clause is used. It remains in effect until the move statement, containing the WITH clause, is done executing. At that time, the temporary value ceases to exist.
- **VIA Clause** - specifies a VIA position for moves that use circular interpolation. The VIA position is used to define the circular arc between the initial position and the destination of a MOVE TO motion.
- **NOWAIT Clause** - allows the interpreter to continue program execution beyond the current motion statement while the motion environment carries out the motion.
- **Local Condition Handler Clause** - specifies local condition handlers to be defined at the end of a MOVE statement. Each local condition handler takes effect when the motion starts and is purged either when the conditions are satisfied and the actions have been taken or when the motion interval is complete.

The following KAREL statements and condition handler actions terminate the motion but have no effect on program execution.

- **CANCEL** - causes any motion in progress and any pending motion to be canceled.
- **STOP** - causes the robot and auxiliary axes to decelerate smoothly to a stop but the remainder of the motion command is not lost. Instead, a record of the motion is saved and the motion command can be resumed.

- **HOLD** - causes all robot and auxiliary axes to decelerate to a stop. HOLD also prevents motion from being started or resumed by any KAREL motion statement or condition handler action other than UNHOLD.

See Also: Appendix A for more detailed information on each motion instruction, Chapter 6 *CONDITION HANDLERS* , for more information on local condition handlers, Chapter 8 *MOTION*

4.2.1 Extended Axis Motion

Auxiliary axes can be set up either in the same group as the robot axes or in a separate group. If the auxiliary axes are set up as part of the robot axes group, they are called extended axes. If the auxiliary axes are separate from the robot axes group, the motion becomes group motion. Section 4.2.2 contains more information about group motion.

Since extended axes are in the same group as robot axes, a kinematics relationship needs to be established. Three types of kinematics relationships can be specified for any extended axis: integrated rail, swing rotary axis, and no kinematics. Because extended axis are in the same group as the robot axis, they are usually moved, started, and stopped at the same time as the robot axis. To control extended axis motion in KAREL, the ‘‘XYZWPREXT’’ position type is used. All MOVE statements described in Section 4.2 are supported for extended axes.

4.2.2 Group Motion

Group motion refers to the ability of moving several groups of axes at the same time in an overlapping manner. Group motion has the following characteristics:

- A **group** is referred to as a mutually exclusive collection of axes.
- Up to a maximum of three groups can be defined. Group numbers will be designated as 1, 2, and 3. Each group can support up to nine axes. The total number of axes per controller cannot exceed 16.
- Group definitions are set by the user only during a controlled start.
- Within a group, the motion of all axes will start and stop at the same time.
- Among groups, motions are independent of each other.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly, personnel could be injured, and equipment could be damaged.

- A group is *kinematic* if there is a correspondence between the position in Cartesian space and the joint angles.

> **Caution**
>
> If you add a second motion group to a system, and there are KAREL programs currently loaded that reference the $xxx_GRP system variables, all of these programs must be reloaded to reference these variables properly.

4.3 PROGRAM CONTROL STRUCTURES

Program control structures can be used to define the flow of execution within a program or routine. By default, execution starts with the first statement following the BEGIN statement and proceeds sequentially until the END statement (or a RETURN statement) is encountered. The following control structures are available in KAREL:

- Alternation
- Looping
- Unconditional Branching
- Execution Control
- Condition Handlers

For detailed information on each type of control structure, refer to Appendix A, "KAREL Language Alphabetical Description."

4.3.1 Alternation Control Structures

An alternation control structure allows you to include alternative sequences of statements in a program or routine. Each alternative can consist of several statements.

During program execution, an alternative is selected based on the value of one or more data items. Program execution then proceeds through the selected sequence of statements.

Two types of alternation control structures can be used:

- **IF Statement** - provides a means of specifying one of two alternatives based on the value of a BOOLEAN expression.
- **SELECT Statement** - used when a choice is to be made between several alternatives. An alternative is chosen depending on the value of the specified INTEGER expression.

See Also: IF...THEN Statement, Appendix A, SELECT Statement, Appendix A.

4.3.2 Looping Control Statements

A looping control structure allows you to specify that a set of statements be repeated an arbitrary number of times, based on the value of data items in the program. KAREL supports three looping control structures:

- The **FOR statement** - used when a set of statements is to be executed a specified number of times. The number of times is determined by INTEGER data items in the FOR statement. At the beginning of the FOR loop, the initial value in the range is assigned to an INTEGER counter variable. Each time the cycle is repeated, the counter is reevaluated.
- The **REPEAT statement** - allows execution of a sequence of statements to continue as long as some BOOLEAN expression remains FALSE. The sequence of executable statements within the REPEAT statement will always be executed once.
- The **WHILE statement** - used when an action is to be executed as long as a BOOLEAN expression remains TRUE. The boolean expression is tested at the start of each iteration, so it is possible for the action to be executed zero times.

See Also: FOR Statement, Appendix A, REPEAT Statement, Appendix A, WHILE Statement, Appendix A

4.3.3 Unconditional Branch Statement

Unconditional branching allows you to use a GO TO Statement to transfer control from one place in a program to a specified label in another area of the program, without being dependent upon a condition or BOOLEAN expression.



Warning

Never include a GO TO Statement into or out of a FOR loop. The program might be aborted with a "Run time stack overflow" error.

See Also: GO TO Statement, Appendix A.

4.3.4 Execution Control Statements

The KAREL language provides the following program control statements, which are used to terminate or suspend program execution:

- **ABORT** - causes the execution of the program, including any motion in progress, to be terminated. The program cannot be continued after being aborted.
- **DELAY** - causes execution to be suspended for a specified time, expressed in milliseconds.

- **PAUSE** - causes execution to be suspended until a CONTINUE operation is executed.
- **WAIT FOR** - causes execution to be suspended until a specified condition or list of conditions is satisfied.

See Also: ABORT Statement, DELAY Statement, PAUSE Statement, WAIT FOR Statement, all in Appendix A, Chapter 6 *CONDITION HANDLERS*

4.3.5 Condition Handlers

A condition handler defines a series of actions which are to be performed whenever a specified condition is satisfied. Once defined, a condition handler can be ENABLED or DISABLED.

Chapter 5

ROUTINES

Contents

Chapter 5 ROUTINES 5–1
5.1 ROUTINE EXECUTION 5–2
5.1.1 Declaring Routines 5–2
5.1.2 Invoking Routines 5–5
5.1.3 Returning from Routines 5–7
5.1.4 Scope of Variables 5–8
5.1.5 Parameters and Arguments 5–9
5.1.6 Stack Usage 5–13
5.2 BUILT- IN ROUTINES 5–15

Routines, similar in structure to a program, provide a method of modularizing KAREL programs. Routines can include VAR and/or CONST declarations and executable statements. Unlike programs, however, a routine must be declared within an upper case program, and cannot include other routine declarations.

KAREL supports two types of routines:

- Procedure Routines - do not return a value
- Function Routines - return a value

KAREL routines can be predefined routines called built-in routines or they can be user-defined.

The following rules apply to all KAREL routines:

- Parameters can be included in the declaration of a routine. This allows you to pass data to the routine at the time it is called, and return the results to the calling program.
- Routines can be called or invoked:
  - — By the program in which they are declared
  - — By any routine contained in that program
  - — With declarations by another program, refer to Section 5.1.1

5.1 ROUTINE EXECUTION

This section explains the execution of procedure and function routines:

- Declaring routines
- Invoking routines
- Returning from routines
- Scope of variables
- Parameters and Arguments

5.1.1 Declaring Routines

The following rules apply to routine declarations:

- A routine cannot be declared in another routine.
- The ROUTINE statement is used to declare both procedure and function routines.
- Both procedure and function routines must be declared before they are called.

- Routines that are local to the program are completely defined in the program. Declarations of local routines include:
  - The ROUTINE statement
  - Any VAR and/or CONST declarations for the routine
  - The executable statements of the routine
- While the VAR and CONST sections in a routine are identical in syntax to those in a program, the following restrictions apply:
  - PATH, FILE, and vision data types cannot be specified.
  - FROM clauses are not allowed.
  - IN clauses are not allowed.
- Routines that are local to the program can be defined after the executable section if the routine is declared using a FROM clause with the same program name. The parameters should only be defined once. See Defining Local Routines Using a FROM Clause .

Defining Local Routines Using a FROM Clause

```
PROGRAM funct_lib
  ROUTINE done_yet(x: REAL; s1, s2: STRING): BOOLEAN FROM funct_lib
BEGIN
IF done_yet(3.2, 'T', '')
--
END funct_lib
ROUTINE done_yet
BEGIN
--
END done_yet
```

- Routines that are external to the program are declared in one program but defined in another.
  - Declarations of external routines include only the ROUTINE statement and a FROM clause.
  - The FROM clause identifies the name of the program in which the routine is defined.
  - The routine must be defined local to the program named in the FROM clause.
- You can include a list of parameters in the declaration of a routine. A parameter list is an optional part of the ROUTINE statement.
- If a routine is external to the program, the names in the parameter list are of no significance but must be included to specify the parameters. If there are no parameters, the parentheses used to enclose the list must be omitted for both external and local routines.

The examples in Local and External Procedure Declarations illustrate local and external procedure routine declarations.

Local and External Procedure Declarations

```
PROGRAM procs_lib
ROUTINE wait_a_bit
 --local procedure, no parameters
   BEGIN
   DELAY 20
 END wait_a_bit
ROUTINE move_there(p: POSITION)
 --local procedure, one parameter
   BEGIN
   MOVE TO p     --reference to parameter p
 END move_there
ROUTINE calc_dist(p1,p2: POSITION; dist: REAL)
 FROM math_lib
 --external procedure defined in math_lib.kL
```

The example in Function Declarations illustrate local and external function routine declarations.

Function Declarations

```
PROGRAM funct_lib
  ROUTINE done_yet(x: REAL; s1, s2 :STRING): BOOLEAN
      FROM bool_lib
   --external function routine defined in bool_lib.kl
   --returns a BOOLEAN value
  ROUTINE xy_dist(x1,y1,x2,y2: REAL): REAL
   -local function, returns a REAL value
   VAR
     sum_square: REAL  --dynamic local variable
     dx,dy: REAL       --dynamic local variables
  BEGIN
      dx = x2-x1   --references parameters x2 and x1
      dy = y2-y1   --references parameters y2 and y1
      sum_square = dx * dx + dy * dy
      RETURN(SQRT(sum_square))  --SQRT is a built-in
  END xy_dist
  BEGIN
  END funct_lib
```

See Also: FROM Clause, Appendix A, ROUTINE Statement, Appendix A.

5.1.2 Invoking Routines

Routines that are declared in a program can be called within the executable section of the program, or within the executable section of any routine contained in the program. Calling a routine causes the routine to be invoked. A routine is invoked according to the following procedure:

- When a routine is invoked, control of execution passes to the routine.
- After execution of a procedure is finished, control returns to the next statement after the point where the procedure was called.
- After execution of a function is finished, control returns to the assignment statement where the function was called.

The following rules apply when invoking procedure and function routines:

- Procedure and function routines are both called with the routine name followed by an argument for each parameter that has been declared for the routine.
- The argument list is enclosed in parentheses.
- Routines without parameters are called with only the routine name.
- A procedure is invoked as though it were a statement. Consequently, a procedure call constitutes a complete executable statement.

Procedure Calls shows the declarations for two procedures followed by the procedure calls to invoke them.

Procedure Calls

```
ROUTINE wait_a_bit FROM proc_lib
   --external procedure with no parameters
ROUTINE calc_dist(p1,p2: POSITION; dist: REAL)&
FROM math_lib
   --external procedure with three parameters
 BEGIN
 ...
 wait_a_bit     --invokes wait_a_bit procedure
 calc_dist (start_pos, end_pos, distance)
   --invokes calc_dist using three arguments for
   --the three declared parameters
```

- Because a function returns a value, a function call must appear as part or all of an expression.
- When control returns to the calling program or routine, execution of the statement containing the function call is resumed using the returned value.

Function Calls shows the declarations for two functions followed by the function calls to invoke them.

Function Calls

```
ROUTINE error_check : BOOLEAN FROM error_prog
 --external function with no parameters returns a BOOLEAN value
ROUTINE distance(p1, p2: POSITION) : REAL &
FROM funct_lib
 --external function with two parameters returns a REAL value
 BEGIN  --Main program
 --the function error_check is invoked and returns a BOOLEAN
 --expression in the IF statement
   IF error_check THEN
   ...
   ENDIF
   travel_time = distance(prev_pos, next_pos)/current_spd
 --the function distance is invoked as part of an expression in
 --an assignment statement
```

- Routines can call other routines as long as the other routine is declared in the program containing the initial routine. For example, if a program named **master_prog** contains a routine named **call_proc** , that routine can call any routine that is declared in the program, **master_prog** .
- A routine that calls itself is said to be recursive and is allowed in KAREL. For example, the routine **factorial** , shown in Recursive Function , calls itself to calculate a factorial value.

Recursive Function

```
ROUTINE factorial(n: INTEGER) : INTEGER
 --calculates the factorial value of the integer n
 BEGIN
  IF n = 0 THEN RETURN (1)
  ELSE RETURN (n * factorial(n-1))
 --recursive call to factorial
   ENDIF
 END factorial
```

- The only constraint on the depth of routine calling is the use of the KAREL *stack* , an area used for storage of temporary and local variables and for parameters. Routine calls cause information to be placed in memory on the stack. When the RETURN or END statement is executed in the routine, this information is taken off of the stack. If too many routine calls are made without this information being removed from the stack, the program will run out of stack space.

See Also: Section 5.1.6 for information on how much space is used on the stack for routine calls

5.1.3 Returning from Routines

The RETURN statement is used in a routine to restore execution control from a routine to the calling routine or program.

The following rules apply when returning from a routine:

- In a procedure, the RETURN statement cannot include a value.
- If no RETURN statement is executed, the END statement restores control to the calling program or routine.

Procedure RETURN Statements illustrates some examples of using the RETURN statement in a procedure.

Procedure RETURN Statements

```
ROUTINE gun_on (error_flag: INTEGER)
 --performs some operation while a "gun" is turned on
 --returns from different statements depending on what,
 --if any, error occurs.
VAR gun: INTEGER
BEGIN
IF error_flag = 1 THEN RETURN
--abnormal exit from routine, returns before
--executing WHILE loop
 ENDIF
  WHILE DIN[gun] DO
--continues until gun is off
  ...
IF error_flag = 2 THEN RETURN
--abnormal exit from routine, returns from
--within WHILE loop
  ENDIF
ENDWHILE  --gun is off
END gun_on  --normal exit from routine
```

- In a function, the RETURN statement must specify a value to be passed back when control is restored to the calling routine or program.
- The function routine can return any data type except
  - — FILE
  - — PATH
  - — Vision types
- If the return type is an ARRAY, you cannot specify a size. This allows an ARRAY of any length to be returned by the function. The returned ARRAY, from an ARRAY valued function, can

be used only in a direct assignment statement. ARRAY valued functions cannot be used as parameters to other routines. Refer to Correct Passage of an ARRAY , for an example of an ARRAY passed between two function routines.

- If no value is provided in the RETURN statement of a function, a translator error is generated.
- If no RETURN statement is executed in a function, execution of the function terminates when the END statement is reached. No value can be passed back to the calling routine or program, so the program aborts with an error.

Function RETURN Statements illustrates some examples using the RETURN statement in function routines.

Function RETURN Statements

```
ROUTINE index_value (table: ARRAY of INTEGER;
   table_size: INTEGER): INTEGER
 --Returns index value of FOR loop (i) depending on
 --condition of IF statement.  Returns 0 in cases where
 --IF condition is not satisfied.
 VAR i: INTEGER
 BEGIN
  FOR i = 1 TO table_size DO
    IF table[i] = 0 THEN RETURN (i)  --returns index
    ENDIF
    ENDFOR
    RETURN (0)  --returns 0
 END index_value
 ROUTINE compare (test_var_1: INTEGER;
    test_var_2: INTEGER): BOOLEAN
 --Returns TRUE value in cases where IF test is
 --satisfied.  Otherwise, returns FALSE value.
 BEGIN
  IF test_var_1 = test_var_2 THEN
    RETURN (TRUE)   --returns TRUE
  ELSE
    RETURN (FALSE)  --returns FALSE
  ENDIF
 END compare
```

See Also: ROUTINE Statement, Appendix A.

5.1.4 Scope of Variables

The scope of a variable declaration can be

- Global

- Local

Global Declarations and Definitions

The following rules apply to global declarations and definitions:

- Global declarations are recognized throughout a program.
- Global declarations are referred to as *static* because they are given a memory location that does not change during program execution, even if the program is cleared or reloaded (unless the variables themselves are cleared.)
- Declarations made in the main program, as well as predefined identifiers, are global.
- The scope rules for predefined and user-defined routines, types, variables, constants, and labels are as follows:
  - — All predefined identifiers are recognized throughout the entire program.
  - — Routines, types, variables, and constants declared in the declaration section of a program are recognized throughout the entire program, including routines that are in the program.

Local Declarations and Definitions

The following rules apply to local declarations and definitions:

- Local declarations are recognized only within the routines where they are declared.
- Local data is created when a routine is invoked. Local data is destroyed when the routine finishes executing and returns.
- The scope rules for predefined and user-defined routines, variables, constants, and labels are as follows:
  - — Variables and constants, declared in the declaration section of a routine, and parameters, declared in the routine parameter list, are recognized only in that routine.
  - — Labels defined in a program (not in a routine of the program) are local to the body of the program and are not recognized within any routines of the program.
  - — Labels defined in a routine are local to the routine and are recognized only in that routine.
- Types cannot be declared in a routine, so are never local.

5.1.5 Parameters and Arguments

Identifiers that are used in the parameter list of a routine declaration are referred to as parameters. A parameter declared in a routine can be referenced throughout the routine. Parameters are used to pass data between the calling program and the routine. The data supplied in a call, referred to as arguments, can affect the way in which the routine is executed.

The following rules apply to the parameter list of a routine call:

- As part of the routine call, you must supply a data item, referred to as an argument, for each parameter in the routine declaration.
- An argument can be a variable, constant, or expression. There must be one argument corresponding to each parameter.
- Arguments must be of the same data type as the parameters to which they correspond, with three exceptions:
  - An INTEGER argument can be passed to a REAL parameter. In this case, the INTEGER value is treated as type REAL, and the REAL equivalent of the INTEGER is passed by value to the routine.
  - A BYTE or SHORT argument can be passed by value to an INTEGER or REAL parameter.
  - Any positional types can be passed to any other positional type. If they are being passed to a user-defined routine, the argument positional type is converted and passed by value to the parameter type.
  - ARRAY or STRING arguments of any length can be passed to parameters of the same data type.

Corresponding Parameters and Arguments shows an example of a routine declaration and three calls to that routine.

Corresponding Parameters and Arguments

```
PROGRAM params
  VAR
    long_string: STRING[10]; short_string: STRING[5]
    exact_dist: REAL; rough_dist: INTEGER
  ROUTINE label_dist (strg: STRING; dist: REAL) &
    FROM procs_lib
  BEGIN
  ...
    label_dist(long_string, exact_dist)
      --long_string corresponds to strg;
      --exact_dist corresponds to dist
    label_dist(short_string, rough_dist)
      --short_string, of a different length,
      --corresponds to strg; rough_dist, an
      --INTEGER, corresponds to REAL dist
    label_dist('new distance', (exact_dist * .75))
      --literal constant and REAL expression
      --arguments correspond to the parameters
END params
```

- When the routine is invoked, the argument used in the routine call is passed to the corresponding parameter. Two methods are used for passing arguments to parameters:
  - **Passing Arguments By Reference**

If an argument is passed by reference, the corresponding parameter shares the same memory location as the argument. Therefore, changing the value of the parameter changes the value of the corresponding argument.

— **Passing Arguments By Value**

If an argument is passed by value, a temporary copy of the argument is passed to the routine. The corresponding parameter uses this temporary copy. Changing the parameter does not affect the original argument.

- Constant and expression arguments are always passed to the routine by value. Variables are normally passed by reference. The following variable arguments, however, are passed by value:
  - — Port array variables
  - — INTEGER variables passed to REAL parameters
  - — BYTE and SHORT arguments passed to INTEGER or REAL parameters
  - — System variables with read only (RO) access
  - — Positional parameters that need to be converted
- While variable arguments are normally passed by reference, you can pass them by value by enclosing the variable identifier in parentheses. The parentheses, in effect, turn the variable into an expression.
- PATH, FILE, and vision variables can not be passed by value. ARRAY elements (indexed form of an ARRAY variable) can be passed by value, but entire ARRAY variables cannot.

Passing Variable Arguments shows a routine that affects the argument being passed to it differently depending on how the variable argument is passed.

Passing Variable Arguments

```
PROGRAM reference
  VAR arg :  INTEGER
  ROUTINE test(param : INTEGER)
  BEGIN
    param = param * 3
    WRITE ('value of param:', param, CR)
  END test
  BEGIN
    arg = 5
    test((arg))     --arg passed to param by value
    WRITE('value of arg:', arg, CR)
    test(arg)       --arg passed to param by reference
    WRITE('value of arg:', arg, CR)
  END reference
```

The output from the program in Passing Variable Arguments is as follows:

```
value of param: 15
```

```
value of arg: 5
value of param: 15
value of arg: 15
```

If the routine calls from Passing Variable Arguments were made in reverse order, first passing **arg** by reference using **"test(arg)"** and then passing it by value using **"test ((arg)),"** the output would be affected as follows:

```
value of param: 15
value of arg: 15
value of param: 45
value of arg: 15
```

- To pass a variable as a parameter to a KAREL routine you can use one of two methods:
  - — You can specify the name of the variable in the parameter list. For example, **other_rtn(param_var)** passes the variable **param_var** to the routine **other_rtn.** To write this statement, you have to know the name of the variable to be passed.
  - — You can use BYNAME. The BYNAME feature allows a program to pass as a parameter to a routine a variable whose name is contained in a string. For example, if the string variables **prog_name** and **var_name** contain the name of a program and variable the operator has entered, this variable is passed to a routine using this syntax:

    other_rtn(BYNAME(prog_name,var_name, entry))

    Refer to Appendix A for more information about BYNAME.
- If a function routine returns an ARRAY, a call to this function cannot be used as an argument to another routine. If an incorrect pass is attempted, a translation error is detected.

  Correct Passage of an ARRAY shows the correct use of an ARRAY passed between two function routines.

Correct Passage of an ARRAY

```
PROGRAM correct
     VAR a : ARRAY[8] of INTEGER
       ROUTINE rtn_ary : ARRAY of INTEGER  FROM util_prog
       ROUTINE print_ary(arg : ARRAY of INTEGER)
         VAR i : INTEGER
       BEGIN
         FOR i = 1 to ARRAY_LEN(arg) DO
           WRITE(arg[i],cr)
         ENDFOR
       END print_ary
     BEGIN
       a = rtn_ary
       print_ary(a)
```

```
END correct
```

Incorrect Passage of an ARRAY shows the incorrect use of an ARRAY passed between two function routines.

Incorrect Passage of an ARRAY

```
PROGRAM wrong
  ROUTINE rtn_ary : ARRAY of INTEGER  FROM util_prog
  ROUTINE print_ary(arg : ARRAY of INTEGER)
    VAR i : INTEGER
    BEGIN
      FOR i = 1 to ARRAY_LEN(arg) DO
        WRITE(arg[i],cr)
      ENDFOR
    END print_ary
  BEGIN
    print_ary(rtn_ary)
  END wrong
```

See Also: ARRAY_LEN Built-In Function, Appendix A, STR_LEN Built-In Function, Appendix A, Appendix E, "Syntax Diagrams

5.1.6 Stack Usage

When a program is executed, a stack of 300 words is allocated unless you specify a stack size. The stack is allocated from available user RAM.

Stack usage can be calculated as follows:

- Each call (or function reference) uses at least five words of stack.
- In addition, for each parameter and local variable in the routine, additional space on the stack is used, depending on the variable or parameter type as shown in Table 5–1 .

Table 5–1. Stack Usage

Type	Parameter Passed by Reference	Parameter Passed by Value	Local Variable
BOOLEAN ARRAY OF BOOLEAN	1	2 not allowed	1 1 + array size
ARRAY OF BYTE	1	not allowed	1 + (array size)/4

Table 5–1. Stack Usage (Cont'd)

Type	Parameter Passed by Reference	Parameter Passed by Value	Local Variable
CAM_SETUP ARRAY OF CAM_SETUP	1	not allowed not allowed	not allowed not allowed
COMMON_ASSOC ARRAY OF COMMON_ASSOC	1	2 not allowed	1 1 + array size
CONFIG ARRAY OF CONFIG	1	2 not allowed	1 1 + array size
GROUP_ASSOC ARRAY OF GROUP_ASSOC	1	2 not allowed	1 1 + array size
INTEGER ARRAY OF INTEGER	1	2 not allowed	1 1 + array size
FILE ARRAY OF FILE	1	not allowed not allowed	not allowed not allowed
JOINTPOS ARRAY OF JOINTPOS	2 1	12 not allowed	10 1 + 10 * array size
JOINTPOS1 ARRAY OF JOINTPOS1	2 1	4 not allowed	2 1 + 2 * array size
JOINTPOS2 ARRAY OF JOINTPOS2	2 1	5 not allowed	3 1 + 3 * array size
JOINTPOS3 ARRAY OF JOINTPOS3	2 1	6 not allowed	4 1 + 4 * array size
JOINTPOS4 ARRAY OF JOINTPOS4	2 1	7 not allowed	5 1 + 5 * array size
JOINTPOS5 ARRAY OF JOINTPOS5	2 1	8 not allowed	6 1 + 6 * array size
JOINTPOS6 ARRAY OF JOINTPOS6	2 1	9 not allowed	7 1 + 7 * array size
JOINTPOS7 ARRAY OF JOINTPOS7	2 1	10 not allowed	8 1 + 8 * array size
JOINTPOS8 ARRAY OF JOINTPOS8	2 1	11 not allowed	9 1 + 9 * array size
JOINTPOS9 ARRAY OF JOINTPOS9	2 1	12 not allowed	10 1 + 10 * array size
MODEL ARRAY OF MODEL	1 1	not allowed not allowed	not allowed not allowed

Table 5–1. Stack Usage (Cont'd)

Type	Parameter Passed by Reference	Parameter Passed by Value	Local Variable
PATH	2	not allowed	not allowed
POSITION ARRAY OF POSITION	2 1	16 not allowed	14 1 + 14 * array size
REAL ARRAY OF REAL	1 1	2 not allowed	1 1 + array size
ARRAY OF SHORT	1	not allowed	1 + (array size)/2
STRING ARRAY OF STRING	2 1	2 + (string length+2)/4not allowed	(string length+2)/4 1+((string length+2) *array size)/4
VECTOR ARRAY OF VECTOR	1 1	4 not allowed	3 1 + 3 * array size
VIS_PROCESS ARRAY OF VIS_PROCESS	1 1	not allowed not allowed	not allowed not allowed
XYZWPR ARRAY OF XYZWPR	2 1	10 not allowed	8 1 + 8 * array size
XYZWPREXT ARRAY OF XYZWPREX	2 1	13 not allowed	11 1 + 11 * array size
ARRAY [m,n] OF some_type	1	not allowed	m(ele size/4 * n + 1)+1
ARRAY [l,m,n] OF some_type	1	not allowed	l(m(ele size/4 * n + 1)+1)+1

5.2 BUILT- IN ROUTINES

The KAREL language includes predefined routines referred to as KAREL built-in routines, or built-ins. Predefined routines can be either procedure or function built-ins. They are provided as a programming convenience and perform commonly needed services.

Many of the built-ins return a status parameter that signifies an error if not equal to 0. The error returned can be any of the error codes defined in the *FANUC Robotics SYSTEM R-J3iC Controller HandlingTool Setup and Operations Manual* . These errors can be posted to the error log and displayed on the error line by calling the POST_ERR built-in routine with the returned status parameter.

Table A–7 is a summary list of all the predefined built-in routines included in the KAREL language. A detailed description of all the KAREL built-in routines is provided in Appendix A .

See Also: Appendix A , which lists optional KAREL built-ins and where they are documented.

Table 5–2. KAREL Built—In Routine Summary

Category	Identifier		
Byname	CALL_PROG CALL_PROGLIN	CURR_PROG FILE_LIST	PROG_LIST VAR_INFO VAR_LIST
Data Acquisition	DAQ_CHECKP DAQ_REGPIPE	DAQ_START DAQ_STOP	DAQ_UNREG DAQ_WRITE
Error Code Handling	ERR_DATA	POST_ERR	
File and Device Operation	CHECK_NAME COPY_FILE DELETE_FILE DISMOUNT_DEV FORMAT_DEV	MOUNT_DEV MOVE_FILE PRINT_FILE PURGE_DEV RENAME_FILE	XML_ADDTAG XML_GETDATA XML_REMTAG XML_SCAN XML_SETVAR
Serial I/O, File Usage	BYTES_AHEAD BYTES_LEFT CLR_IO_STAT GET_FILE_POS GET_PORT_ATR	IO_STATUS MSG_CONNECT MSG_DISCO MSG_PING PIPE_CONFIG	SET_FILE_ATR SET_FILE_POS SET_PORT_ATR VOL_SPACE
Process I/O Setup	CLR_PORT_SIM GET_PORT_ASG GET_PORT_CMT GET_PORT_MOD GET_PORT_SIM	GET_PORT_VAL IO_MOD_TYPE SET_PORT_ASG	SET_PORT_CMT SET_PORT_MOD SET_PORT_SIM SET_PORT_VAL
KCL Operation	KCL	KCL_NO_WAIT	KCL_STATUS
Memory Operation	CLEAR CREATE_VAR LOAD LOAD_STATUS	PROG_BACKUP PROG_CLEAR PROG_RESTORE RENAME_VAR	RENAME_VARS SAVE SAVE_DRAM
MIRROR	MIRROR		
Program and Motion Control	CNCL_STP_MTN	MOTION_CTL	RESET
Multi-programming	ABORT_TASK CLEAR_SEMA CONT_TASK GET_TSK_INFO LOCK_GROUP	PAUSE_TASK PEND_SEMA POST_SEMA RUN_TASK SEMA_COUNT	SET_TSK_ATTR SET_TSK_NAME UNLOCK_GROUP
Path Operation	APPEND_NODE COPY_PATH DELETE_NODE	INSERT_NODE NODE_SIZE	PATH_LEN

Table 5–2. KAREL Built—In Routine Summary (Cont'd)

Category	Identifier		
Personal Computer Communications	ADD_BYNAMEPC ADD_INTPC ADD_REALPC	ADD_STRINGPC SEND_DATAPC SEND_EVENTPC	
Position	CHECK_EPOS CNV_JPOS_REL CNV_REL_JPOS CURPOS	CURJPOS FRAME IN_RANGE J_IN_RANGE	JOINT2POS POS POS2JOINT SET_PERCH UNPOS
Register Operation	SET_PREG_CMT	SET_REG_CMT	
Queue Manager	APPEND_QUEUE COPY_QUEUE DELETE_QUEUE	GET_QUEUE INIT_QUEUE INSERT_QUEUE	MODIFY_QUEUE
Register Operation	CLR_POS_REG GET_JPOS_REG GET_POS_REG GET_PREG_CMT	GET_REG GET_REG_CMT POS_REG_TYPE SET_EPOS_REG	SET_INT_REG SET_JPOS_REG SET_POS_REG SET_REAL_REG
String Operation	CNV_CONF_STR CNV_INT_STR	CNV_REAL_STR CNV_STR_CONF	CNV_STR_INT CNV_STR_REAL
System	ABS ACOS ARRAY_LEN ASIN ATAN2 BYNAME CHR COS	EXP GET_VAR INDEX INV LN ORD ROUND SET_VAR	SIN SQRT STR_LEN SUB_STR TAN TRUNC UNINIT
Time-of-Day Operation	CNV_STR_TIME CNV_TIME_STR	GET_TIME GET_USEC_SUB	GET_USEC_TIM SET_TIME
TPE Program	AVL_POS_NUM CLOSE_TPE COPY_TPE CREATE_TPE DEL_INST_TPE GET_ATTR_PRG	GET_JPOS_TPE GET_POS_FRM GET_POS_TPE GET_POS_TYP GET_TPE_CMT GET_TPE_PRM OPEN_TPE SELECT_TPE	SET_ATTR_PRG SET_EPOS_TPE SET_JPOS_TPE SET_POS_TPE SET_TPE_CMT SET_TRNS_TPE
Translate	TRANSLATE		

Table 5–2. KAREL Built—In Routine Summary (Cont'd)

Category	Identifier		
User Interface	ACT_SCREEN ADD_DICT ATT_WINDOW_D ATT_WINDOW_S CHECK_DICT CNC_DYN_DISB CNC_DYN_DISE CNC_DYN_DISI CNC_DYN_DISP CNC_DYN_DISR CNC_DYN_DISS DEF_SCREEN	DEF_WINDOW DET_WINDOW DISCTRL_ALPH DISCTRL_FORM DISCTRL_LIST DISCTRL_PLMN DISCTRL_SBMN DISCTRL_TBL FORCE_SPMENU INI_DYN_DISB INI_DYN_DISE INI_DYN_DISI INI_DYN_DISP INI_DYN_DISR INI_DYN_DISS POP_KEY_RD	PUSH_KEY_RD READ_DICT READ_DICT_V READ_KB REMOVE_DICT SET_CURSOR SET_LANG WRITE_DICT WRITE_DICT_V
Vector	APPROACH	ORIENT	

Chapter 6

CONDITION HANDLERS

Contents

Chapter 6	CONDITION HANDLERS	6–1
6.1	CONDITION HANDLER OPERATIONS	6–3
6.1.1	Global Condition Handlers	6–3
6.1.2	Local Condition Handlers	6–6
6.2	CONDITIONS	6–8
6.2.1	Port_Id Conditions	6–9
6.2.2	Relational Conditions	6–9
6.2.3	System and Program Event Conditions	6–10
6.2.4	Local Conditions	6–13
6.2.5	Synchronization of Local Condition Handlers	6–14
6.3	ACTIONS	6–16
6.3.1	Assignment Actions	6–16
6.3.2	Motion Related Actions	6–17
6.3.3	Routine Call Actions	6–18
6.3.4	Miscellaneous Actions	6–19

The condition handler feature of the KAREL language allows a program to respond to external conditions more efficiently than conventional program control structures allow. Two kinds of condition handlers are available in KAREL:

- Global - used to monitor and act on conditions throughout an entire program.
- Local - defined as part of a move statement and are in effect only while the motion is in progress.

These condition handlers allow specified conditions to be monitored in parallel with normal program execution and, if the conditions occur, corresponding actions to be taken in response.

For a condition handler to be monitored, it must be defined first and then enabled. Disabling a condition handler removes it from the group being scanned. Purging condition handlers deletes their definition.

Table 6–1 lists the conditions that can be monitored by condition handlers.

Table 6–1. Conditions

GLOBAL OR LOCAL CONDITIONS		LOCAL CONDITIONS
port_id[n]	ERROR[n]	AT NODE[n]
NOT port_id[n]	EVENT[n]	TIME t BEFORE NODE[n]
port_id[n]+	ABORT	TIME t AFTER NODE[n]
port_id[n]-	PAUSE	
operand = operand	CONTINUE	
operand <> operand	SEMAPHORE[n]	
operand < operand		
operand <= operand		
operand > operand		
operand >= operand		

Table 6–2 lists the actions that can be taken.

Table 6–2. Actions

variable = expression	NOABORT
port_id[n] = expression	NOMESSAGE
STOP	NOPAUSE
CANCEL	ENABLE CONDITION[n]
RESUME	DISABLE CONDITION[n]

Table 6–2. Actions (Cont'd)

HOLD	PULSE DOUT[n] FOR t
UNHOLD	UNPAUSE
routine_name	ABORT
SIGNAL EVENT[n]	CONTINUE
	PAUSE
	SIGNAL SEMAPHORE[n]

6.1 CONDITION HANDLER OPERATIONS

Global condition handler operations differ from those of local condition handlers. Table 6–3 summarizes condition handler operations.

Table 6–3. Condition Handler Operations

OPERATION	GLOBAL CONDITION HANDLER	LOCAL CONDITION HANDLER
Define	CONDITION[n]:<WITH $SCAN_TIME = n>. WHEN conds DO actions ENDCONDITION	MOVE ... , WHEN conds DO actions UNTIL conds UNTIL conds THEN actions ENDMOVE
Enable	ENABLE CONDITION[n] (statement or action)	Motion start, RESUME or UNHOLD
Disable	DISABLE CONDITION[n] (statement or action) or conditions satisfied	Motion STOP or HOLD
Purge	PURGE CONDITION[n] (statement), program terminated	Motion completed or canceled, program terminated, or conditions satisfied

6.1.1 Global Condition Handlers

Global condition handlers are defined by executing a CONDITION statement in the executable section of a program. The definition specifies conditions/actions pairs. The following rules apply to global condition handlers.

- Each global condition handler is referenced throughout the program by a specified number, from 1 to 1000. If a condition handler with the specified number was previously defined, it must be purged before it is replaced by the new one.
- The conditions/action s pairs of a global condition handler are specified in the WHEN clauses of a CONDITION statement. All WHEN clauses for a condition handler are enabled, disabled, and purged together.
- The condition list represents a list of conditions to be monitored when the condition handler is scanned.
- By default, each global condition handler is scanned at a rate based on the value of $SCR.$cond_time. If the ‘‘WITH $SCAN_TIME = n’’ clause is used in a CONDITION statement, the condition will be scanned roughly every ‘‘n’’ milliseconds. The actual interval between the scans is determined as shown in Table 6–4 .

Table 6–4. Interval Between Global Condition Handler Scans

"n"	Interval Between Scans
n <= $COND_TIME	$COND_TIME
$COND_TIME < n <= (2 * $COND_TIME)	(2 * $COND_TIME)
(2 * $COND_TIME) < n <= (4 * $COND_TIME)	(4 * $COND_TIME)
(4 * $COND_TIME) < n <= (8 * $COND_TIME)	(8 * $COND_TIME)
(8 * $COND_TIME) < n <= (16 * $COND_TIME)	(16 * $COND_TIME)
(16 * $COND_TIME) < n <= (32 * $COND_TIME)	(32 * $COND_TIME)
(32 * $COND_TIME) < n <= (64 * $COND_TIME)	(64 * $COND_TIME)
(64 * $COND_TIME) < n <= (128 * $COND_TIME)	(128 * $COND_TIME)
(128 * $COND_TIME) < n <= (256 * $COND_TIME)	(256 * $COND_TIME)
(256 * $COND_TIME) < n	(512 * $COND_TIME)

- Multiple conditions must all be separated by the AND operator or the OR operator. Mixing of AND and OR is not allowed.
- If AND is used, all of the conditions of a single WHEN clause must be satisfied simultaneously for the condition handler to be triggered.
- If OR is used, the actions are triggered when any of the conditions are TRUE.
- The action list represents a list of actions to be taken when the corresponding conditions of the WHEN clause are simultaneously satisfied.
- Multiple actions must be separated by a comma or a new line.

Global Condition Handler Definitions shows three examples of defining global condition handlers.

See Also: $SCR.$cond_time System Variable, *FANUC Robotics SYSTEM R-J3iC Controller Software Reference Manual* $SCAN_TIME Condition Handler Qualifier, *FANUC Robotics SYSTEM R-J3iC Controller Software Reference Manual*

Global Condition Handler Definitions

```
CONDITION[1]:    --defines condition handler number
1
   WHEN DIN[1] DO DOUT[1] = TRUE      --triggered if any one
   WHEN DIN[2] DO DOUT[2] = TRUE       --of the WHEN clauses
   WHEN DIN[3] DO DOUT[3] = TRUE       --is satisfied
ENDCONDITION
CONDITION[2]:   --defines condition handler number 2
   WHEN PAUSE DO                  --one condition triggers
     AOUT[speed_out] = 0            --multiple actions
     DOUT[pause_light] = TRUE
     ENABLE CONDITION [2]         --enables this condition
ENDCONDITION                            --handler again
CONDITION[3]:
   WHEN DIN[1] AND DIN[2] AND DIN[3] DO --multiple
    DOUT[1] = TRUE      --conditions separated by AND;
    DOUT[2] = TRUE        --all three conditions must be
    DOUT[3] = TRUE        --satisfied at the same time
ENDCONDITION
```

- You can enable, disable, and purge global condition handlers as needed throughout the program. Whenever a condition handler is triggered, it is automatically disabled, unless an ENABLE action is included in the action list. (See condition handler 2 in Global Condition Handler Definitions .)
  - — The ENABLE statement or action enables the specified condition handler. The condition handler will be scanned during the next scan operation and will continue to be scanned until it is disabled.
  - — The DISABLE statement or action removes the specified condition handler from the group of scanned condition handlers. The condition handler remains defined and can be enabled again with the ENABLE statement or action.
  - — The PURGE statement deletes the definition of the specified condition handler.
- ENABLE, DISABLE, and PURGE have no effect if the specified condition handler is not defined. If the specified condition handler is already enabled, ENABLE has no effect; if it is already disabled, DISABLE has no effect.

Using Global Condition Handlers shows examples of enabling, disabling, and purging global condition handlers.

Using Global Condition Handlers

```
CONDITION[1]:   --defines condition handler number 1
   WHEN line_stop = TRUE DO DOUT[1] = FALSE
 ENDCONDITION
 CONDITION[2]:   --defines condition handler number 2
   WHEN line_go = TRUE DO
    DOUT[1] = TRUE, ENABLE  CONDITION [1]
 ENDCONDITION
 ENABLE CONDITION[2]  --condition handler 2 is enabled
 . . .
 IF ready THEN line_go = TRUE; ENDIF
 --If ready is TRUE condition handler 2 is triggered (and
 --disabled) and condition handler 1 is enabled.
 --Otherwise, condition handler 2 is not triggered (and is
 --still enabled), condition handler 1 is not yet enabled,
 --and the next two statements will have no effect.
 DISABLE CONDITION[1]
 ENABLE CONDITION[2]
 . . .
 ENABLE CONDITION[1] --condition handler 1 is enabled
 . . .
 line_stop = TRUE  --triggers (and disables) condition handler 1
 . . .
 PURGE CONDITION[2]  --definition of condition handler 2 deleted
 ENABLE CONDITION[2] --no longer has any effect
 line_go = TRUE      --no longer a monitored condition
```

6.1.2 Local Condition Handlers

A local condition handler is defined at the end of a MOVE statement and includes one or more conditions/actions pairs in conjunction with the WHEN or UNTIL clauses. The following rules apply to local condition handlers:

- They are defined only during execution of a particular motion statement and are automatically enabled when the motion starts, and purged when the motion completes or is cancelled.
- A comma (,) separates the condition handler definition from the rest of the MOVE statement.
- The reserved word ENDMOVE, which must be on a new line, ends a MOVE statement that contains condition handler definitions.
- The conditions/actions pairs of a local condition handler can be specified in WHEN clauses or UNTIL clauses.
- WHEN clauses and UNTIL clauses can be used in any order and combination; each must begin on a separate line.

— The WHEN clause specifies conditions to be monitored and actions to be taken when the conditions are satisfied.

— The UNTIL clause specifies that the motion is to be canceled if the conditions are satisfied.

The optional THEN portion of the UNTIL clause an be used to specify other actions (in addition to canceling the motion) to be taken when the conditions are satisfied.

- The condition list represents a list of conditions to be monitored when the condition handler is scanned. Each condition handler is scanned at a rate based on the value of the $SCR.$COND_TIME system variable.
  - — Multiple conditions must all be separated by the AND operator or the OR operator. Mixing of AND and OR is not allowed.
  - — When AND is used, all of the conditions in a single WHEN or UNTIL clause must be satisfied simultaneously for the condition handler to be triggered.
  - — When OR is used, the condition handler is triggered when any of the conditions are satisfied.
- The action list represents a list of actions to be taken when the corresponding conditions in the WHEN or UNTIL clause are simultaneously satisfied. Multiple actions must be separated by a comma or a new line.
- A local condition handler is automatically enabled when the physical motion starts. It is automatically purged when the condition handler is triggered, when the motion is completed, or when the motion is canceled. Unlike global condition handlers, each WHEN block in a MOVE is a separate condition handler. If one WHEN block triggers, only that WHEN block is disabled.
- The time delay between executing the MOVE statement and enabling a condition handler might be long for MOVE statements following incomplete NOWAIT moves.
- Local condition handlers automatically are disabled when the motion is held or stopped and are re-enabled when the motion starts again due to execution of an UNHOLD or RESUME statement or action.

Local Condition Handler Examples shows an example of local condition handlers in MOVE statements with both WHEN and UNTIL clauses.

See Also: $SCR.$cond_time System Variable, *FANUC Robotics SYSTEM R-J3iC Controller Software Reference Manual*

Local Condition Handler Examples

```
--local condition handler at end of move statement
  WITH $SPEED = 200, $MOTYPE = CIRCULAR
   MOVE ALONG paint_path NOWAIT,          --comma
     --start of local condition handler
     WHEN TIME 100 BEFORE NODE[2] DO DOUT[2] = TRUE
   ENDMOVE      --end of local condition handler
  MOVE TO posn,
   WHEN AT NODE[3] AND DIN[1] DO  --multiple conditions
```

```
   CANCEL
ENDMOVE
MOVE ALONG weld_pth,      --multiple cond/action pairs
 UNTIL ERROR[stop_error] THEN
   SIGNAL EVENT[shut_off]          --multiple actions
   clean_up --call interrupt routine
 WHEN PAUSE DO
   tmp_clean_up --call interrupt routine
 WHEN TIME 100 BEFORE NODE[last_node] DO
   clean_up --call interrupt routine
ENDMOVE
```

6.2 CONDITIONS

One or more conditions are specified in the condition list of a WHEN or UNTIL clause, defining the conditions portion of a conditions/actions pair. Conditions can be

- States - which remain satisfied as long as the state exists. Examples of states are DIN[1] and (VAR1 > VAR2).
- Events - which are satisfied only at the instant the event occurs. Examples of events are ERROR[n], DIN[n]+, and PAUSE.

The following rules apply to system and program event conditions:

- After a condition handler is enabled, the specified conditions are monitored.
  - — If all of the conditions of an AND, WHEN, or UNTIL clause are simultaneously satisfied, the condition handler is triggered and corresponding actions are performed.
  - — If all of the conditions of an OR, WHEN, or UNTIL clause are satisfied, the condition handler is triggered and corresponding actions are performed.
- Event conditions very rarely occur simultaneously. Therefore, you should never use AND between two event conditions in a single WHEN or UNTIL clause because, both conditions will not be satisfied simultaneously.
- While many conditions are similar in form to BOOLEAN expressions in KAREL, and are similar in meaning, only the forms listed in this section, not general BOOLEAN expressions, are permitted.
- Expressions are permitted within an EVAL clause. More general expressions may be used on the right side of comparison conditions, by enclosing the expression in an EVAL clause: EVAL (expression). However, expressions in an EVAL clause are evaluated when the condition handler is defined. They are not evaluated dynamically.
- The value of an EVAL clause expression must be INTEGER, REAL, or BOOLEAN.

See Also: EVAL Clause, Appendix A .

6.2.1 Port_Id Conditions

Port_id conditions are used to monitor digital port signals. Port_id must be one of the predefined BOOLEAN port array identifiers (DIN, DOUT, OPIN, OPOUT, TPIN, TPOUT, RDI, RDO, WDI, or WDO). The value of **n** specifies the port array signal to be monitored. Table 6–5 lists the available port_id conditions.

Table 6–5. Port_Id Conditions

CONDITION	SATISFIED (TRUE) WHEN
port_id[n]	Digital port n is TRUE. (state)
NOT port_id[n]	Digital port n is FALSE. (state)
port_id[n]+	Digital port n changes from FALSE to TRUE. (event)
port_id[n]-	Digital port n changes from TRUE to FALSE. (event)

- For the state conditions, **port_id[n]** and **NOT port_id[n]** , the port is tested during every scan. The following conditions would be satisfied if, during a scan, DIN[1] was TRUE and DIN[2] was FALSE:

  ```
  WHEN DIN[1] AND NOT DIN[2] DO . . .
  ```

  Note that an input signal should remain ON or OFF for the minimum scan time to ensure that its state is detected.

- For the event condition **port_id[n]+** , the initial port value is tested when the condition handler is enabled. Each scan tests for the specified change in the signal. The change must occur while the condition handler is enabled.

  The following condition would only be satisfied if, while the condition handler was enabled, DIN[1] changed from TRUE to FALSE since the last scan.

  ```
  WHEN DIN[1]- DO . . .
  ```

6.2.2 Relational Conditions

Relational conditions are used to test the relationship between two operands. They are satisfied when the specified relationship is TRUE. Relational conditions are state conditions, meaning the relationship is tested during every scan. Table 6–6 lists the relational conditions.

Table 6–6. Relational Conditions

CONDITION	SATISFIED (TRUE) WHEN
operand = operand	Relationship specified is TRUE. Operands on the left can be a port array element, referenced as port_id[n], or a variable. Operands on the right can be a variable, a constant, or an EVAL clause. (state)
operand < > operand	
operand < operand	
operand < = operand	
operand > operand	
operand > = operand	

The following rules apply to relational conditions:

- Both operands must be of the same data type and can only be of type INTEGER, REAL, or BOOLEAN. (As in other situations, INTEGER constants can be used where REAL values are required, and will be treated as REAL values.)
- The operand on the left side of the condition can be any of the port array signals, a user-defined variable, a static variable, or a system variable that can be read by a KAREL program.
- The operand on the right side of the condition can be a user-defined variable, a static variable, a system variable that can be read by a KAREL program, any constant, or an EVAL clause. For example:

```
WHEN DIN[1] = ON DO . . .      --port_id and constant
WHEN flag = TRUE DO . . .      --variable and constant
WHEN AIN[1] >= temp DO . . .   --port_id and variable
WHEN flag_1 <> flag_2 DO . . . --variable and variable
WHEN AIN[1] <= EVAL(temp * scale) DO . . .
   --port_id and EVAL clause
WHEN dif > EVAL(max_count - count) DO . . .
   --variable and EVAL clause
```

- The EVAL clause allows you to include expressions in relational conditions. However, it is evaluated only when the condition handler is defined. The expression in the EVAL clause cannot include any routine calls.

See Also: EVAL Clause, Appendix A .

6.2.3 System and Program Event Conditions

System and program event conditions are used to monitor system and program generated events. The specified condition is satisfied only if the event occurs when the condition handler is enabled.

Enabled condition handlers containing ERROR, EVENT, PAUSE, ABORT, POWERUP, or CONTINUE conditions are scanned only if the specified type of event occurs. For example, an enabled condition handler containing an ERROR condition will be scanned only when an error occurs. Table 6–7 lists the available system and program event conditions.

Table 6–7. System and Program Event Conditions

CONDITION	SATISFIED (TRUE) WHEN
ERROR [n]	The error specified by n is reached or, if n = *, any error occurs. (event)
EVENT[n]	The event specified by n is signaled. (event)
ABORT	The program is aborted. (event)
PAUSE	The program is paused. (event)
CONTINUE	The program is continued. (event)
POWERUP	The program is continued. (event)
SEMAPHORE[n]	The value of the semaphore specified by n is posted.

The following rules apply to these conditions:

ERROR Condition

- The ERROR condition can be used to monitor the occurrence of a particular error by specifying the error code for that error. For example, ERROR[15018] monitors the occurrence of the error represented by the error code 15018.

  The error codes are listed in the following format:

  ```
  ffccc (decimal)
  ```

  where

  ```
  ff represents the facility code of the error
  ccc represents the error code within the specified facility
  ```

  For example, 15018 is MOTN-018, which is "Position not reachable." The facility code is 15 and the error code is 018. Refer to the *FANUC Robotics SYSTEM R-J3iC Controller Error Code Manual* for a complete listing of error codes.

- The ERROR condition can also be used to monitor the occurrence of any error by specifying an asterisk (*), the wildcard character, in place of a specific error code. For example, ERROR[*] monitors the occurrence of any error.

- The ERROR condition is satisfied only for the scan performed when the error was detected. The error is not remembered in subsequent scans.

EVENT Condition

- The EVENT condition monitors the occurrence of the specified program event. The SIGNAL statement or action in a program indicates that an event has occurred.
- The EVENT condition is satisfied only for the scan performed when the event was signaled. The event is not remembered in subsequent scans.

ABORT Condition

- The ABORT condition monitors the aborting of program execution. If an ABORT occurs, the corresponding actions are performed. However, if one of the actions is a routine call, the routine will not be executed because program execution has been aborted.

  If an ABORT condition is used in a condition handler all actions, except routine calls, will be performed even though the program has aborted.

PAUSE Condition

- The PAUSE condition monitors the pausing of program execution. If one of the corresponding actions is a routine call, it is also necessary to specify a NOPAUSE or UNPAUSE action.

CONTINUE Condition

- The CONTINUE condition monitors the resumption of program execution. If program execution is paused, the CONTINUE action, the KCL> CONTINUE command, a CYCLE START from the operator panel, or the teach pendant FWD key will continue program execution and satisfy the CONTINUE condition.

POWERUP Condition

- The POWERUP condition monitors the resumption of program execution after a power failure recovery. The controller must be able to recover successfully from a power failure before the program can be resumed.

SEMAPHORE Condition

- The SEMAPHORE condition monitors the specified semaphore. The CLEAR_SEMA built-in can be used to set the semaphore value to 0. The POST_SEMA built-in or the SIGNAL SEMAPHORE action can be used to increment the semaphore value and satisfy the SEMAPHORE condition.

See Also: In Appendix A :

ABORT Condition

CONTINUE Condition

ERROR Condition

EVENT Condition

PAUSE Condition

POWERUP Condition

SEMAPHORE Condition

FANUC Robotics SYSTEM R-J3iC Controller Application-Specific Setup and Operations Manual for error codes. *FANUC Robotics SYSTEM R-J3iC Controller Error Code Manual.*

6.2.4 Local Conditions

The conditions that can be monitored only by local condition handlers are listed in Table 6–8 .

Table 6–8. Local Conditions

CONDITION	SATISFIED (TRUE) WHEN
AT NODE[**n**]	The node specified by **n** is reached or, in **n = *** , any node is reached. (event)
TIME **t** BEFORE NODE[**n**]	It is specified time t before the specified node **n** (or any node if **n = ***) will be reached during a move. (event)
TIME **t** AFTER NODE[**n**]	It is specified time **t** after the specified node **n** (or any node if **n = ***) was reached during a move. (event)

These are used for monitoring the progress of a move to a position or along a PATH.

The following rules apply to local conditions:

- **n** is an INTEGER that indicates the path node or a position AT which, BEFORE which, or AFTER which the condition is satisfied. The wildcard character (*) can be specified for n, indicating every path node.
- TIME t is an INTEGER expression specifying a time interval in milliseconds.
- If the motion segment preceding NODE[n] is less than **t** milliseconds long for a TIME **t** BEFORE condition, the condition is considered satisfied at the start of the segment.
- If the motion completes or is canceled before t milliseconds after NODE[**n**] (or any node if **n = *)** is reached for a TIME t AFTER condition, the condition is never satisfied.
- NODE[**0**] represents the start of the move.
- For non-path moves such as MOVE TO position, MOVE AWAY, and MOVE NEAR, NODE[1] represents the destination of the move.

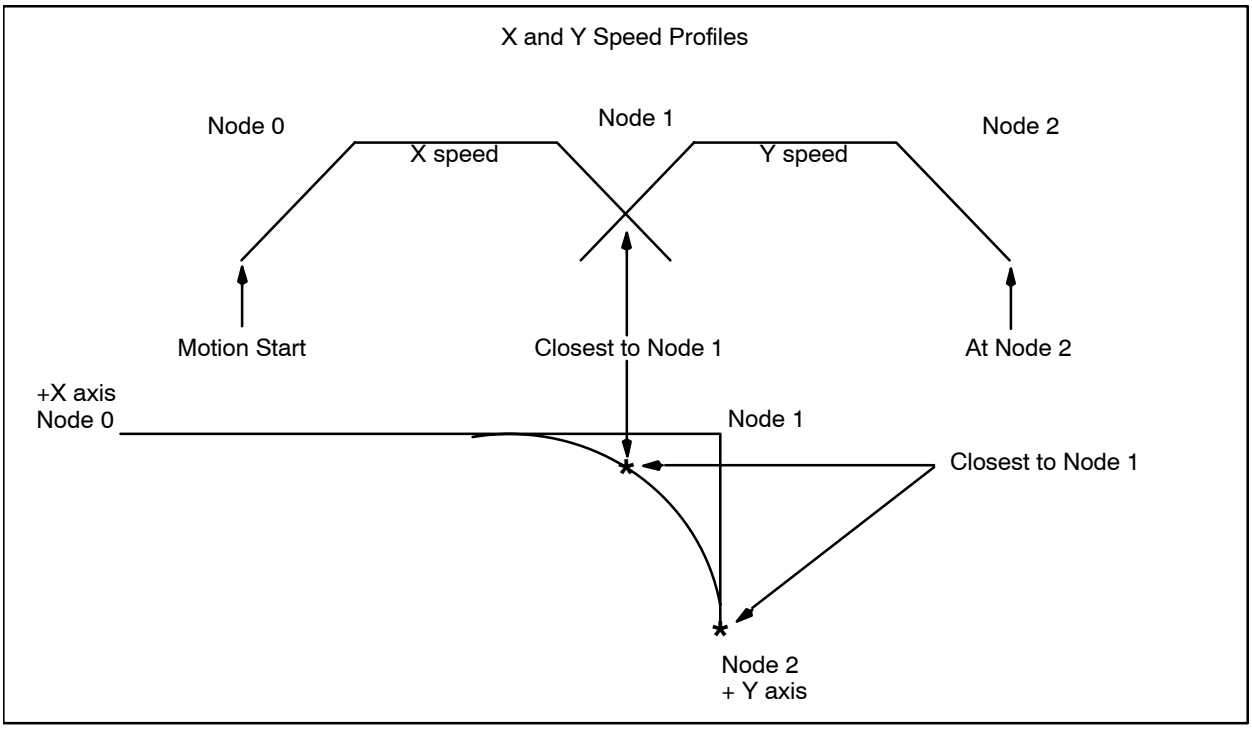
- The TIME **t** BEFORE condition will not be satisfied before NODE[0]. The TIME **t** AFTER condition will not be satisfied after the last node.

6.2.5 Synchronization of Local Condition Handlers

The triggering of local conditions depends on the motion segment termination type. The timing associated with interval and segment termination is shown in Figure 6–1 .

This figure shows a two-node PATH in Cartesian coordinates. The first segment is a motion along the x-axis in the negative direction followed by a segment with motion parallel to the y-axis in the positive direction. The PATH is the xy_path used in the examples that follow.

Figure 6–1. Timing of BEFORE, AT and AFTER Conditions



The following MOVE statement, which moves the tool center point (TCP) along the PATH in Figure 6–1 , is used in the remainder of this section to clarify the timing associated with the motion and the triggering of conditions. The numbers in parentheses to the left of the WHEN clauses are used to refer to specific clauses in the discussion that follows.

WITH $TERMTYPE = COARSE

MOVE ALONG xy_path,

(1) WHEN AT NODE[0] DO DOUT[1] = TRUE

(2) WHEN TIME 100 AFTER NODE[0] DO DOUT[2] = TRUE

(3) WHEN TIME 100 BEFORE NODE[1] DO DOUT[3] = TRUE

(4) WHEN AT NODE[1] DO DOUT[4] = TRUE

(5) WHEN TIME 100 AFTER NODE[1] DO DOUT[5] = TRUE

(6) WHEN AT NODE[2] DO DOUT[6] = TRUE

(7) WHEN TIME 100 AFTER NODE[2] DO DOUT[7] = TRUE

ENDMOVE

First, note the numbering used for nodes. Node[0] is used to denote the starting position of the motion. If the motion were a single segment motion (MOVE TO posn), then Node[0] would refer to the start of the motion and Node[1] to the end of the motion, even though a PATH is not actually used.

Clause 1 asks for a digital output to be turned on at the start of the motion. In this case, since the node specified is Node[0], ‘‘AT’’ means the time when motion first begins (labeled “Motion Start” in Figure 6–1).

In Clause 2, the time is measured from the start of motion. That is, the digital output would be set 100 ms after the point marked ‘‘Motion Start’’ in Figure 6–1 .

In Clause 3, the time is measured back from the point when the TCP would come closest to the taught node in the path.

Clause 6 uses the end of the motion as the basis for timing because NODE[2] is the final node in the PATH.

The entire deceleration time is included in the segment time whenever anything but NODECEL or VARDECEL is used for the termination type for the last node in the path. If NODECEL is used, then the timing for the last node would include half the deceleration time.

Clause 7 is an example of a condition handler that will never be triggered. All local condition handlers are deleted when the interval for which they are defined terminates. Therefore, actions **after** the last node cannot be performed.

See Also: Program Synchronization, Chapter 8 *MOTION*

’’User-Defined Associated Data, Chapter 8 *MOTION*

AT NODE and TIME Conditions, Appendix A .

'$USETIMESHFT optional System Variable in *FANUC Robotics SYSTEM R-J3iC Controller Software Reference Manual*

6.3 ACTIONS

Actions are specified in the action list of a WHEN or UNTIL clause. Actions can be

- Specially defined KAREL actions that are executed in parallel with the program
- A routine call, which will interrupt program execution

When the conditions of a condition handler are satisfied, the condition handler is triggered. The actions corresponding to the satisfied conditions are performed in the sequence in which they appear in the condition handler definition, except for routine calls. Routines are executed after all of the other actions have been performed.

Note that, although many of the actions are similar in form to KAREL statements and the effects are similar to corresponding KAREL statements, the actions are not executable statements. Only the forms indicated in this section are permitted.

See Also: Actions and Statements, Appendix A .

6.3.1 Assignment Actions

The available assignment actions are given in Table 6–9 .

Table 6–9. Assignment Actions

ACTION	RESULT
variable = expression	The value of the expression is assigned to the variable. The expression can be a variable, a constant, a port array element, or an EVAL clause.
port_id[n] = expression	The value of the expression is assigned to the port array element referenced by n. The expression can be a variable, a constant, or an EVAL clause.

The following rules apply to assignment actions:

- The assignment actions, ‘‘variable = expression’’ and ‘‘port_id[n] = expression’’ can be used to assign values to variables and port array elements.
  - — The variable must be either a user-defined variable, a static variable, or a system variable without a minimum/maximum range and that can be written to by a KAREL program.

— The port array, if on the left, must be an output port array that can be set by a KAREL program.

— The expression can be a user-defined variable, a static variable. a system variable that can be read by a KAREL program, any constant, or an EVAL clause.

- If a variable is on the left side of the assignment, the expression can also be a port array element. However, you cannot assign a port array element to a port array element directly. For example, the first assignment shown is invalid, but the next two are valid:

```
DOUT[1] = DOUT[2]    --invalid action
   port_var = DOUT[2]  --valid action, where port_var is a variable
   DOUT[1] = port_var  --another valid action, which if executed
                       --after port_var = DOUT[2], would in effect
                       --assign DOUT[2] to DOUT[1]
```

- If the expression is a variable, it must be a global variable. The value used is the current value of the variable at the time the action is taken, not when the condition handler is defined. If the expression is an EVAL clause, it is evaluated when the condition handler is defined and that value is assigned when the action is taken.
- Both sides of the assignment action must be of the same data type. An INTEGER or EVAL clause is permitted on the right side of the assignment with an INTEGER, REAL, or BOOLEAN on the left.

6.3.2 Motion Related Actions

Motion related actions affect the current motion and might affect subsequent motions. They are given in Table 6–10 .

Table 6–10. Motion Related Actions

ACTION	RESULT
STOP	Current motion is stopped.
RESUME	The last stopped motion is resumed.
CANCEL	Current motion is canceled.
HOLD	Current motion is held. Subsequent motions are not started.
UNHOLD	Held motion is released.

The following rules apply to motion related actions:

- If a STOP is issued, the current motion and any queued motions are pushed as a set on a stopped motion stack. If no motion is in progress, an empty entry is pushed on the stack.

- If a RESUME is issued, the newest stopped motion set on the stopped motion stack is queued for execution.
- If a CANCEL is issued, the motion currently in progress is canceled. If no motion is in progress, the action has no effect.

Note The CANCEL action in a local condition handler differs from the same action in a global condition handler and the CANCEL statement. In a local condition handler, a CANCEL action cancels only the motion in progress, permitting any queued behind it to start. For a CANCEL action in a global condition handler or a CANCEL statement, any motions queued to the same group behind the current motion are also canceled.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly, personnel could be injured, and equipment could be damaged.

- If a HOLD is issued, the current motion is held and subsequent motions are prevented from starting. The UNHOLD action releases held motion.

See Also: Chapter 8 *MOTION* , for more information on stopping and starting motions.

6.3.3 Routine Call Actions

Routine call actions, or interrupt routines, are specified by

<WITH $PRIORITY = n> routine_name

The following restrictions apply to routine call actions or interrupt routines:

- The interrupt routine cannot have parameters and must be a procedure (not a function).
- If the interrupted program is using READ statements, the interrupt routine cannot read from the same file variable. If an interrupted program is reading and the interrupt routine attempts a read from the same file variable, the program is aborted.
- When an interrupt routine is started, the interrupted KAREL program is suspended until the routine returns.
- Interrupt routines, like KAREL programs, can be interrupted by other routines. The maximum depth of interruption is limited only by stack memory size.
- Routines are started in the sequence in which they appear in the condition handler definition, but since they interrupt each other, they will actually execute in reverse order.

- Interrupts can be prioritized so that certain interrupt routines cannot be interrupted by others. The $PRIORITY condition handler qualifier can be used to set the priority of execution for an indicated routine action. $PRIORITY values must be 0-255 where the lower value represents a lower priority. If a low priority routine is called while a routine with a higher priority is running, it will be executed only when the higher priority routine has completed. If $PRIORITY is not specified, the routine's priority will default to the current value of the $PRIORITY system variable.

See Also: WITH Clause, Appendix A, ‘‘KAREL Language Alphabetical Description," for more information on $PRIORITY

6.3.4 Miscellaneous Actions

Table 6–11 describes other allowable actions.

Table 6–11. Miscellaneous Actions

ACTION	RESULT
SIGNAL EVENT[n]	The event specified by n is signaled.
NOMESSAGE	The error message that otherwise would have been generated is not displayed or logged.
NOPAUSE	Program execution is resumed if the program was paused, or is prevented from pausing.
NOABORT	Program execution is resumed if the program was aborted, or is prevented from aborting.
ABORT	Program execution is aborted.
CONTINUE	Program execution is continued.
PAUSE	Program execution is paused.
SIGNAL SEMAPHORE[n]	Specified semaphore is signaled.
ENABLE CONDITION[n]	Condition handler n is enabled.
DISABLE CONDITION[n]	Condition handler n is disabled.
PULSE DOUT[n] FOR t	Specified port n is pulsed for the time interval t (in milliseconds).
UNPAUSE	If a routine_name is specified as an action, but program execution is paused, execution is resumed only for the duration of the routine and then is paused again.

See Also: Appendix A for more information on each miscellaneous action.

Chapter 7

FILE INPUT/OUTPUT OPERATIONS

Contents

Chapter 7 FILE INPUT/OUTPUT OPERATIONS 7–1
7.1 OVERVIEW 7–3
7.2 FILE VARIABLES 7–3
7.3 OPEN FILE STATEMENT 7–4
7.3.1 Setting File and Port Attributes 7–5
7.3.2 File String 7–10
7.3.3 Usage String 7–11
7.4 CLOSE FILE STATEMENT 7–14
7.5 READ STATEMENT 7–14
7.6 WRITE STATEMENT 7–16
7.7 INPUT/OUTPUT BUFFER 7–17
7.8 FORMATTING TEXT (ASCII) INPUT/OUTPUT 7–18
7.8.1 Formatting INTEGER Data Items 7–19
7.8.2 Formatting REAL Data Items 7–22
7.8.3 Formatting BOOLEAN Data Items 7–25
7.8.4 Formatting STRING Data Items 7–27
7.8.5 Formatting VECTOR Data Items 7–31
7.8.6 Formatting Positional Data Items 7–32
7.9 FORMATTING BINARY INPUT/OUTPUT 7–34
7.9.1 Formatting INTEGER Data Items 7–35
7.9.2 Formatting REAL Data Items 7–36
7.9.3 Formatting BOOLEAN Data Items 7–36
7.9.4 Formatting STRING Data Items 7–36
7.9.5 Formatting VECTOR Data Items 7–37
7.9.6 Formatting POSITION Data Items 7–37
7.9.7 Formatting XYZWPR Data Items 7–37
7.9.8 Formatting XYZWPREXT Data Items 7–38
7.9.9 Formatting JOINTPOS Data Items 7–38

7.10 USER INTERFACE TIPS 7–38
7.10.1 USER Menu on the Teach Pendant 7–38
7.10.2 USER Menu on the CRT/KB 7–40

7.1 OVERVIEW

The KAREL language facilities allow you to perform the following serial input/output (I/O) operations:

- Open data files and serial communication ports using the OPEN FILE Statement
- Close data files and serial communication ports using the CLOSE FILE Statement
- Read from files, communication ports, and user interface devices using the READ Statement
- Write to files, communication ports, and user interface devices using the WRITE Statement
- Cancel read or write operations

File variables are used to indicate the file, communication port, or device on which a serial I/O operation is to be performed.

Buffers are used to hold data that has not yet been transmitted. The use of data items in READ and WRITE statements and their format specifiers depend on whether the data is text (ASCII) or binary, and on the data type.

7.2 FILE VARIABLES

A KAREL program can perform serial I/O operations on the following:

- Data files residing in the KAREL file system
- Serial communication ports associated with connectors on the KAREL controller
- User interface devices including the CRT/KB and teach pendant

A file variable is used to indicate the file, communication port, or device on which you want to perform a particular serial I/O operation.

Table 7–1 lists the predefined file variables for user interface devices. These file variables are already opened and can be used in the READ or WRITE statements.

Table 7–1. Predefined File Variables

IDENTIFIER	DEVICE	OPERATIONS
TPFUNC*	Teach pendant function key line	Both
TPDISPLAY*	Teach pendant KAREL display	Both
TPPROMPT*	Teach pendant prompt line	Both
TPERROR	Teach pendant message line	Write
TPSTATUS*	Teach pendant status line	Write

Table 7–1. Predefined File Variables (Cont'd)

CRTFUNC*	CRT/KB function key line	Both
INPUT	CRT/KB keyboard	Read
OUTPUT*	CRT/KB KAREL screen	Write
CRTPROMPT*	CRT/KB prompt line	Both
CRTERROR	CRT/KB message line	Write
CRTSTATUS*	CRT/KB status line	Write

* Only displayed when teach pendant or CRT is in the user menu.

A file variable can be specified in a KAREL statement as a FILE variable. Using FILE in a KAREL Program shows an example of declaring a FILE variable and of using FILE in the executable section of a program.

Using FILE in a KAREL Program

```
PROGRAM lun_prog
  VAR
    curnt_file : FILE
  ROUTINE input_data(file_spec:FILE) FROM util_prog
  BEGIN
    OPEN FILE curnt_file ('RW','text.dt')  --variable FILE
    input_data(curnt_file)  --file variable argument
    WRITE TPERROR ('Error has occurred')
  END lun_prog
```

Sharing FILE variables between programs is allowed as long as a single task is executing the programs. Sharing file variables between tasks is not allowed.

7.3 OPEN FILE STATEMENT

The OPEN FILE statement associates the file variable with a particular data file or communication port.

The association remains in effect until the file is closed, either explicitly by a CLOSE FILE statement or implicitly when program execution terminates or is aborted.

The OPEN FILE statement specifies how the file is to be used (usage string), and which file or port (file string) is used.

7.3.1 Setting File and Port Attributes

Attributes specify the details of operation of a serial port, or KAREL FILE variable. The SET_PORT_ATR and SET_FILE_ATR built-ins are used to set these attributes. SET_FILE_ATR must be called before the FILE is opened. SET_PORT_ATR can be called before or after the FILE that is using a serial port, is opened.

Table 7–2 lists each attribute type, its function and whether the attribute is intended for use with teach pendant and CRT/KB devices, serial ports, data files, or pipes. Refer to Appendix A for more information.

Table 7–2. Predefined Attribute Types

ATTRIBUTE TYPE	FUNCTION	SET_PORT_ATR OR SET_FILE_ATR	TP/ CRT	SERIAL PORTS	DATA FILES	PIPES	SOCKET MESSAGING
ATR_BAUD	Baud rate	SET_PORT_ATR	not used	valid	not used	not used	not used
ATR_DBITS	Data length	SET_PORT_ATR	not used	valid	not used	not used	not used
ATR_EOL	End of line	SET_FILE_ATR	not used	valid	not used	valid	valid
ATR_FIELD	Field	SET_FILE_ATR	valid	valid	valid	valid	valid
ATR_IA	Interactively write	SET_FILE_ATR	valid	valid	valid	valid	valid
ATR_MODEM	Modem line	SET_PORT_ATR	not used	valid	not used	not used	not used
ATR_PARITY	Parity	SET_PORT_ATR	not used	valid	not used	not used	not used
ATR_PASSALL	Passall	SET_FILE_ATR	valid	valid	not used	valid	valid
ATR_READAHD	Read ahead buffer	SET_PORT_ATR	not used	valid	not used	not used	not used
ATR_REVERSE	Reverse transfer	SET_FILE_ATR	not used	valid	valid	valid	valid
ATR_SBITS	Stop bits	SET_PORT_ATR	not used	valid	not used	not used	not used
ATR_TIMEOUT	Timeout	SET_FILE_ATR	valid	valid	not used	valid	valid
ATR_UF	Unformatted transfer	SET_FILE_ATR	not used	valid	valid	valid	valid

Table 7–2. Predefined Attribute Types (Cont'd)

ATTRIBUTE TYPE	FUNCTION	SET_PORT_ATR OR SET_FILE_ATR	TP/ CRT	SERIAL PORTS	DATA FILES	PIPES	SOCKET MESSAGING
ATR_XONOFF	XON/XOFF	SET_PORT_ATR	not used	valid	not used	not used	not used
ATR_PIPOVADV	Pipe Overflow	SET_FILE_ATR	not used	not used	not used	valid	valid
ATR_PIPWAIT	Wait for data	SET_FILE_ATR	not used	not used	not used	valid	valid

Table 7–3 contains detailed explanations of each attribute.

Table 7–3. Attribute Values

Attribute Type	Description	Valid Device	Usage Mode	Valid Values	Default Value
ATR_BAUD Baud rate	The baud rate of a serial port can be changed to one of the valid attribute values.	PORT	Read/ Write	BAUD_9600: 9600 baud BAUD_4800: 4800 baud BAUD_2400: 2400 baud BAUD_1200: 1200 baud	BAUD_9600
ATR_DBITS Data length	If specified, the data length for a serial port is changed to the specified attribute values.	PORT	Read/ Write	DBITS_5: 5 bits DBITS_6: 6 bits DBITS_7: 7 bits DBITS_8: 8 bits	DBITS_8
ATR_EOL End of line	If specified, the serial port is changed to terminate read when the specified attribute value. Refer to Appendix D , for a listing of valid attribute values.	PORT	Read/ Write	Any ASCII character code	13 (carriage return)
ATR_FIELD Field	If specified, the amount of data read depends on the format specifier in the READ statement, or the default value of the data type being read. If not specified, the data is read until the terminator character (EOL) appears.	TP/CRT, PORT, FILE	Read only	Ignored	Read data until terminator character (EOL) appears

Table 7–3. Attribute Values (Cont'd)

Attribute Type	Description	Valid Device	Usage Mode	Valid Values	Default Value
ATR_IA Interactively write	If specified, the contents of the buffer are output when each write operation to the buffer is complete. (Interactive) If not specified, the contents of the buffer are output only when the buffer becomes full or when CR is specified. The size of the output buffer is 256 bytes. (Not interactive)	TP/CRT, PORT, FILE	Write only	Ignored	TP/CRT is interactive, PORT, FILE are not interactive
ATR_MODEM Modem line	Refer to "Modem Line" section that follows for information.				
ATR_PARITY Parity	The parity for a serial port can be changed to one of the valid attribute values.	PORT	Read/ Write	PARITY_NONE: No parity PARITY_ODD: Odd parity PARITY_EVEN: Even parity	PARITY_NONE
ATR_PASSALL Passall	If specified, input is read without interpretation or transaction. Since the terminator character (EOL) will not terminate the read, the field attribute automatically assumes the ‘‘field’’ option.	TP/CRT, PORT	Read only	Ignored	Read only the displayable keys until enter key is pressed
ATR_PIPOVADV	Configures the behavior of the read when an overflow occurs. By default the behavior is to signal an end of file (EOF) when the overflow occurs.	PIPE	Read	The value must be between 0 and the total number of bytes in the pipe. The value will be rounded up to the nearest binary record.	The value parameter is either OVF_EOF (sets the default behavior) or the number of bytes to advance when an overflow occurs.

Table 7–3. Attribute Values (Cont'd)

Attribute Type	Description	Valid Device	Usage Mode	Valid Values	Default Value
ATR_PIPWAIT	The read operation waits for data to arrive in the pipe.	PIPE	Read	WAIT_USED or WAIT_NOTUSED	The default is snapshot which means that the system returns an EOF when all the data in the pipe has been read.
ATR_READAHD Read Ahead Buffer	The attribute value is specified in units of 128 bytes, and allocates a read ahead buffer of the indicated size.	PORT	Read/ Write	any positive integer 1=128 bytes 2=256 bytes 0=disable bytes	1 (128 byte buffer)
ATR_REVERSE Reverse transfer	The bytes will be swapped.	PORT, FILE	Read/ Write	Ignored	Not reverse transfer
ATR_SBITS Stop bits	This specifies the number of stop bits for the serial port.	PORT	Read/ Write	SBITS_1:1 bit SBITS_15: 1.5 bits SBITS_2:2 bits	SBITS_1
ATR_TIMEOUT Timeout	If specified, an error will be returned by IO_STATUS if the read takes longer than the specified attribute value.	TP/CRT, PORT	Read only	Any integer value (units are in msec)	0 (external)
ATR_UF Unformatted transfer	If specified, a binary transfer is performed. For read operations, the terminator character (EOL) will not terminate the read, and therefore automatically assumes the ‘‘field’’ option. If not specified, ASCII transfer is performed.	PORT, FILE	Read/ Write	Ignored	ASCII transfer
ATR_XONOFF XON/XOFF	If specified, the XON/XOFF for a serial port is changed to the specified attribute value.	PORT	Read/ Write	XF_NOT_USED: Not used XF_USED: Used	XF_USED

Modem line

Valid device : PORT

Usage mode : Read/Write

Default value : MD_NOT_USED: DSR, DTR, and RTS not used

Valid attribute values : MD_NOT_USED: DSR, DTR, and RTS not used

MD_USE_DSR: DSR used

MD_NOUSE_DSR: DSR not used

MD_USE_DTR: DTR used

MD_NOUSE_DTR: DTR not used

MD_USE_RTS: RTS used

MD_NOUSE_RTS: RTS not used

- This attribute controls the operation of the modem line. The control is based on the following binary mask, where the flag bits are used to indicate what bit value you are changing.

RTS value	DSR value	DTR value	RTS flag	DSR flag	DTR flag

  — RTS (request to send) and DTR (data terminal ready) are both outputs.

  — DSR (data set ready) is an input.

- Set the modem line attribute by doing the following.

  — To indicate RTS is used (HIGH/ON): status = SET_PORT_ATR (port_name, ATR_MODEM, MD_USE_RTS)

  — To indicate RTS is NOT used (LOW/OFF):status = SET_PORT_ATR (port_name, ATR_MODEM, MD_NOUSE_RTS)

  — To indicate RTS is used (HIGH/ON) and DTR is not used (LOW/OFF):status = SET_PORT_ATR (port_name, ATR_MODEM, MD_USE_RTS **or** MD_NOUSE_DTR)

- The following examples demonstrate how to use the returned attribute value from the GET_PORT_ATR built-in.

```
status = GET_PORT_ATR (port, ATR_MODEM, atr_value)
```

  — To determine if DTR is used:

```
IF ((atr_value AND MD_USE_DTR) = MD_USE_DTR) THEN
```

```
            write ('DTR is in use',cr)
        ENDIF
```

— To determine if DTR is not used (LOW/OFF)

```
IF (atr_value AND MD_USE_DTR) = MD_NOUSE_DTR) THEN
            write ('DTR is not in use', cr)
        ENDIF
```

For more information on GET_PORT_ATR Built-in, refer to Appendix A .

7.3.2 File String

The file string in an OPEN FILE statement specifies a data file name and type, or a communication port.

- The OPEN FILE statement associates the data file or port specified by the file string with the file variable. For example, OPEN FILE file_var ('RO', 'data_file.dt') associates the data file called 'data_file.dt' with the file file_var.
- If the file string is enclosed in single quotes, it is treated as a literal. Otherwise, it is treated as a STRING variable or constant identifier.
- When specifying a data file, you must include both a file name and a valid KAREL file type (any 1, 2, or 3 character file extension).
- The following STRING values can be used to associate file variables with serial communication ports on the KAREL controller. Defaults for R-J3*i*C are:
  - **'P2:'** - Debug console connector on the outside of the operator panel
  - **'P3:'** - RS-232-C, JD17 connector on the Main CPU board (CRT/KB)
  - **'P4:'** - RS-422, JD17 connector on the Main CPU board
  - **'KB:tp kb'** - Input from numeric keypad on the teach pendant. TPDISPLAY or TPPROMPT are generally used, so OPEN FILE is not required.
  - **'KB:cr kb'** - Input from CRT/KB. INPUT or CRTPROMPT are generally used, so OPEN FILE is not required.
  - **'WD:window_name'** - Writes to a window.
  - **'WD:window_name</keyboard_name>'** , where **keyboard_name** is either **'tpkb'** or **'crkb'** - Writes to the specified window. Inputs are from the TP keypad (tpkb) or the CRT keyboard (crkb). Inputs will be echoed in the specified window.

See Also: Chapter 9 *FILE SYSTEM* , for a description of file names and file types.

7.3.3 Usage String

The usage string in an OPEN FILE statement indicates how the file is to be used.

- It is composed of one usage specifier.
- It applies only to the file specified by the OPEN FILE statement and has no effect on other FILEs.
- It must be enclosed in single quotes if it is expressed as a literal.
- It can be expressed as a variable or a constant.

Table 7–4 lists each usage specifier, its function, and the devices or ports for which it is intended.

- ‘‘TP/CRT’’ indicates teach pendant and CRT/KB.
- ‘‘Ports’’ indicates serial ports.
- ‘‘Files’’ indicates data files.
- ‘‘Pipes’’ indicates pipe devices.
- ‘‘Valid’’ indicates a permissible use.
- ‘‘No use’’ indicates a permissible use that might have unpredictable side effects.

Table 7–4. Usage Specifiers

SPECIFIER	FUNCTION	TP/CRT	PORTS	FILES	PIPES
RO	— Permits only read operations — Sets file position to beginning of file — File must already exist	valid	valid	valid	valid

Table 7–4. Usage Specifiers (Cont'd)

RW	— Rewrites over existing data in a file, deleting existing data — Permits read and write operations — Sets file position to beginning of file — File will be created if it does not exist	valid	valid	valid No use on FRx:	valid
AP	— Appends to end of existing data — Permits read and write (First operation must be a write.) — Sets file position to end of file — File will be created if it does not exist	no use	valid	valid -RAM disk* no use on FRx:	valid
UD	— Updates from beginning of existing data. (Number of characters to be written must equal number of characters to be replaced.) — Overwrites the existing data with the new data — Permits read and write — Sets file position to beginning of existing file	no use	valid	valid -RAM disk* no use on FRx:	no use

* AP and UD specifiers can only be used with uncompressed files on the RAM disk. Refer to Chapter 9 *FILE SYSTEM* , for more information on the RAM disk and Pipe devices.

File String Examples shows a program that includes examples of various file strings in OPEN FILE statements. The CONST and VAR sections are included to illustrate how file and port strings are declared.

File String Examples

```
PROGRAM open_luns
  CONST
    part_file_c ='parts.dt' --data file STRING constant
    comm_port = 'P3:'       --port STRING constant
  VAR
    file_var1 : FILE
    file_var2 : FILE
    file_var3 : FILE
    file_var4 : FILE
    file_var5 : FILE
    file_var12 : FILE
    temp_file : STRING[19]
     --a STRING size of 19 accommodates 4 character device names,
     --12 character file names, the period, and 2 character,
     --file types.
     port_var : STRING[3]
  BEGIN
     --literal file name and type
     OPEN FILE file_var1 ('RO','log_file.dt')
     --constant specifying parts.dt
     OPEN FILE file_var2 ('RW', part_file_c)
     --variable specifying new_file_dt
     temp_file = 'RD:new_file.dt'
     OPEN FILE file_var3 ('AP', temp_file)
     --literal communication port
     OPEN FILE file_var4 ('RW', 'P2:')
     --constant specifying C0:
     OPEN FILE file_var5 ('RW', comm_port)
     --variable specifying C3:
     port_var = 'C3:'
     OPEN FILE file_var12 ('RW', port_var)
END open_luns
```

See Also: Chapter 9 *FILE SYSTEM* , for more information on the available storage devices

Chapter 13 *INPUT/OUTPUT SYSTEM* , for more information on the C0: and C3: ports

7.4 CLOSE FILE STATEMENT

The CLOSE FILE statement is used to break the association between a specified file variable and its data file or communication port. It accomplishes two objectives:

- Any buffered data is written to the file or port.
- The file variable is freed for another use.

CLOSE FILE Example shows a program that includes an example of using the CLOSE FILE statement in a FOR loop, where several files are opened, read, and then closed. The same file variable is used for each file.

CLOSE FILE Example

```
PROGRAM read_files
   VAR
     file_var   : FILE
     file_names : ARRAY[10] OF STRING[15]
     loop_count : INTEGER
     loop_file  : STRING[15]
ROUTINE read_ops(file_spec:FILE) FROM util_prog
--performs some read operations
ROUTINE get_names(names:ARRAY OF STRING) FROM util_prog
--gets file names and types
BEGIN
   get_names(file_names)
   FOR loop_count = 1 TO 10 DO
     loop_file = file_names[loop_count]
     OPEN FILE file_var ('RO', loop_file)
     read_ops(file_var) --call routine for read operations
     CLOSE FILE file_var
   ENDFOR END read_files
```

See Also: CLOSE FILE Statement, Appendix A .

IO_STATUS Built-In Function, Appendix A for a description of errors.

7.5 READ STATEMENT

The READ statement is used to read one or more specified data items from the indicated device. The data items are listed as part of the READ statement. The following rules apply to the READ statement:

- The OPEN FILE statement must be used to associate the file variable with the file opened in the statement before any read operations can be performed unless one of the predefined files is used (refer to Table 7–1).
- If the file variable is omitted from the READ statement, then TPDISPLAY is used as the default.
- Using the %CRTDEVICE directive will change the default to INPUT (CRT input window).
- Format specifiers can be used to control the amount of data that is read for each data item. The effect of format specifiers depends on the data type of the item being read and on whether the data is in text (ASCII) or binary (unformatted) form.
- When the READ statement is executed (for ASCII files), data is read beginning with the next nonblank input character and ending with the last character before the next blank, end of line, or end of file for all input types except STRING.
- With STRING values, the input field begins with the next character and continues to the end of the line or end of the file. If a STRING is read from the same line following a nonstring field, any separating blanks are included in the STRING.
- ARRAY variables must be read element by element; they cannot be read in unsubscripted form. Frequently, they are read using a READ statement in a FOR loop.
- PATH variables can be specified as follows in a READ statement, where ‘‘path_name’’ is a PATH variable and ‘‘n’’ and ‘‘m’’ are PATH node indexes:
  - path_name : specifies that the entire path, starting with a header and including all of the nodes and their associated data, is to be read. The header consists of the path length and the associated data description in effect when the PATH was written.
  - path_name [0] : specifies that only the header is to be read. The path header consists of the path length and the associated data description in effect when the PATH was written. Nodes are deleted or created to make the path the correct length, and all new nodes are set uninitialized.
  - path_name [n] : specifies that data is to be read into node[n] from the current file position. The value of n must be in the range from 0 to the length of the PATH.
  - path_name [n .. m] : specifies that data is to be read into nodes n through m. The value of n must be in the range from 0 to the length of the PATH and can be less than, equal to, or greater than the value of m. The value of m must be in the range from 1 to the length of the PATH.

If an error occurs while reading node n (where n is greater than 0), it is handled as follows:

If n > **original path length** (prior to the read operation), the nodes from n to the new path length are set uninitialized.

If n <= **original path length** , the nodes from n to the original path length remain as they were prior to the read operation and any new nodes (greater than the original path length) are set uninitialized.

- If the associated data description that is read from the PATH does not agree with the current user associated data, the read operation is terminated and the path will remain as it was prior to the read operation. The IO_STATUS built-in function will return an error if this occurs.

- PATH data must be read in binary (unformatted) form.

READ Statement Examples shows several examples of the READ statement using a variety of file variables and data lists.

READ Statement Examples

```
READ (next_part_no)    --uses default TPDISPLAY
  OPEN FILE file_var ('RO','data_file.dt')
  READ file_var (color, style, option)
  READ host_line (color, style, option, CR)
  FOR i = 1 TO array_size DO
    READ data (data_array[i])
  ENDFOR
```

If any errors occur during input, the variable being read and all subsequent variables up to CR in the data list are set uninitialized unless the file variable is open to a window device.

If reading from a window device, an error message is displayed indicating the bad data_item and you are prompted to enter a replacement for the invalid data_item and to reenter all subsequent items.

The built-in function IO_STATUS can be used to determine the success or failure (and the reason for the failure) of a READ operation.

See Also: READ Statement, Appendix A .

IO_STATUS Built-In Functions, Appendix A for a list of I/O error messages

%CRTDEVICE Translator Directive, Appendix A .

7.6 WRITE STATEMENT

The WRITE statement is used to write one or more specified data items to the indicated device. The data items are listed as part of the WRITE statement. The following rules apply to the WRITE statement:

- The OPEN FILE statement must be used to associate the file variable with the file opened in the statement before any write operations can be performed unless one of the predefined files is used (refer to Table 7–1).
- If the file variable is omitted from the WRITE statement, then TPDISPLAY is used as the default.
- Using the %CRTDEVICE directive will change the default to OUTPUT (CRT output window).

- Format specifiers can be used to control the format of data that is written for each data_item. The effect of format specifiers depends on the data type of the item being written and on whether the data is in text (ASCII) or binary (unformatted) form.
- ARRAY variables must be written element by element; they cannot be written in unsubscripted form. Frequently, they are written using a WRITE statement in a FOR loop.
- PATH variables can be specified as follows in a WRITE statement, where ‘‘path_name’’ is a PATH variable and ‘‘n’’ and ‘‘m’’ are PATH node indexes:
  - path_name : specifies that the entire path is to be written, starting with a header that provides the path length and associated data table, and followed by all of the nodes, including their associated data.
  - path_name [0] : specifies that only the header is to be written. The path header consists of the path length and a copy of the associated data table.
  - path_name [n] : specifies that node[n] is to be written.
  - path_name [n .. m] : specifies that nodes n through m are to be written. The value of n must be in the range from 0 to the length of the PATH and can be less than, equal to, or greater than the value of m. The value of m must be in the range from 1 to the length of the PATH.
- PATH data must be written in binary (unformatted) form.

WRITE Statement Examples shows several examples of the WRITE statement using a variety of file variables and data lists.

WRITE Statement Examples

```
WRITE TPPROMPT('Press T.P. key "GO" when ready')
  WRITE TPFUNC ('  GO     RECD    QUIT    BACK1    FWD-1')
  WRITE log_file (part_no:5, good_count:5, bad_count:5, operator:3,
CR)
  WRITE ('This is line 1', CR, 'This is line 2', CR)
  --uses default TPDISPLAY
  FOR i = 1 TO array_size DO
    WRITE data (data_array[i])
  ENDFOR
```

See Also: WRITE Statement, Appendix A .

IO_STATUS Built-In Functions, Appendix A .

7.7 INPUT/OUTPUT BUFFER

An area of RAM, called a *buffer* , is used to hold up to 256 bytes of data that has not yet been transmitted during a read or write operation.

Buffers are used by the READ and WRITE statements as follows:

- During the execution of a READ statement, if more data was read from the file than required by the READ statement, the remaining data is kept in a buffer for subsequent read operations. For example, if you enter more data in a keyboard input line than is required to satisfy the READ statement the extra data is kept in a buffer.
- If a WRITE statement is executed to a non-interactive file and the last data item was not a CR, the data is left in a buffer until a subsequent WRITE either specifies a CR or the buffer is filled.
- The total data that can be processed in a single READ or WRITE statement is limited to 127 bytes.

7.8 FORMATTING TEXT (ASCII) INPUT/OUTPUT

This section explains the format specifiers used to read and write ASCII (formatted) text for each data type.

The following rules apply to formatting data types:

- For text files, data items in READ and WRITE statements can be of any of the simple data types (INTEGER, REAL, BOOLEAN, and STRING).
- Positional and VECTOR variables cannot be read from text files but can be used in WRITE statements.
- ARRAY variables cannot be read or written in unsubscripted form. The elements of an ARRAY are read or written in the format that corresponds to the data type of the ARRAY.
- PATH variables cannot be read or written.
- Some formats and data combinations are not read in the same manner as they were written or become invalid if read with the same format.

The amount of data that is read or written can be controlled using zero, one, or two format specifiers for each data item in a READ or WRITE statement. Each format specifier, represented as an INTEGER literal, is preceded by double colons (::).

Table 7–5 summarizes the input format specifiers that can be used with the data items in a READ statement. The default format of each data type and the format specifiers that can affect each data type are explained in Section 7.8.1 , through Section 7.8.6 .

Table 7–5. Text (ASCII) Input Format Specifiers

DATA TYPE	1ST FORMAT SPECIFIER	2ND FORMAT SPECIFIER
INTEGER	Total number of characters read	Number base in range 2 - 16
REAL	Total number of characters read	Ignored

Table 7–5. Text (ASCII) Input Format Specifiers (Cont'd)

DATA TYPE	1ST FORMAT SPECIFIER	2ND FORMAT SPECIFIER
BOOLEAN	Total number of characters read	Ignored
STRING	Total number of characters read	0 - unquoted STRING 2 - quoted STRING

Table 7–6 summarizes the output format specifiers that can be used with the data items in a WRITE statement. The default format of each data type and the format specifiers that can affect each data type are explained in Section 7.8.1 through Section 7.8.6 .

Table 7–6. Text (ASCII) Output Format Specifiers

DATA TYPE	1ST FORMAT SPECIFIER	2ND FORMAT SPECIFIER
INTEGER	Total number of characters written	Number base in range 2-16
REAL	Total number of characters written	Number of digits to the right of decimal point to be written If negative, uses scientific notation
BOOLEAN	Total number of characters written	0 - Left justified 1 - Right justified
STRING	Total number of characters written	0 - Left justified 1 - Right justified 2 - Left justified in quotes (leading blank) 3 - Right justified n quotes (leading blank)
VECTOR	Uses REAL format for each component	Uses REAL format for each component
POSITION	Uses REAL format for each component	Uses REAL format for each component
XYZWPR	Uses REAL format for each component	Uses REAL format for each component
XYZWPREXT	Uses REAL format for each component	Uses REAL format for each component
JOINTPOSn	Uses REAL format for each component	Uses REAL format for each component

7.8.1 Formatting INTEGER Data Items

INTEGER data items in a READ statement are processed as follows:

Default: Read as a decimal (base 10) INTEGER, starting with the next nonblank character on the input line and continuing until a blank or end of line is encountered. If the characters read do not form a valid INTEGER, the read operation fails.

First Format Specifier: Indicates the total number of characters to be read. The input field must be entirely on the current input line and can include leading, but not trailing, blanks.

Second Format Specifier: Indicates the number base used for the input and must be in the range of 2 (binary) to 16 (hexadecimal).

For bases over 10, the letters A, B, C, D, E, and F are used as input for the digits with values 10, 11, 12, 13, 14, and 15, respectively. Lowercase letters are accepted.

Table 7–7 lists examples of INTEGER input data items and their format specifiers. The input data and the resulting value of the INTEGER data items are included in the table. (The symbol [eol] indicates end of line.)

Table 7–7. Examples of INTEGER Input Data Items

DATA ITEM	INPUT DATA	RESULT
int_var	-2[eol]	int_var = -2
int_var	20 30 ...	int_var = 20
int_var::3	10000	int_var = 100
int_var::5::2	10101 (base 2 input)	int_var = 21 (base 10 value)
int_var	1.00	format error (invalid INTEGER)
int_var::5	100[eol]	format error (too few digits)

INTEGER data items in a WRITE statement are formatted as follows:

Default: Written as a decimal (base 10) INTEGER using the required number of digits and one leading blank. A minus sign precedes the digits if the INTEGER is a negative value.

First Format Specifier: Indicates the total number of characters to be written, including blanks and minus sign. If the format specifier is larger than required for the data, leading blanks are added. If it is smaller than required, the field is extended as required.

The specifier must be in the range of 1 to 127 for a file or 1 to 126 for other output devices.

Second Format Specifier: Indicates the number base used for the output and must be in the range of 2 (binary) to 16 (hexadecimal).

If a number base other than 10 (decimal) is specified, the number of characters specified in the first format specifier (minus one for the leading blank) is written, with leading zeros added if needed.

For bases over 10, the letters A, B, C, D, E, and F are used as input for the digits with values 10, 11, 12, 13, 14, and 15, respectively.

Table 7–8 lists examples of INTEGER output data items and their format specifiers. The output values of the INTEGER data items are also included in the table. Double quotes are used in the table as delimiters to show leading blanks; however, double quotes are not written by KAREL programs.

Table 7–8. Examples of INTEGER Output Data Items

DATA ITEM	OUTPUT	COMMENT
123	" 123 "	Leading blank
-5	" -5 "	Leading blank
123::6	" 123 "	Right justified (leading blanks)
-123::2	" -123 "	Expanded as required
1024::0::16	" 400 "	Hexadecimal output

Table 7–8. Examples of INTEGER Output Data Items (Cont'd)

DATA ITEM	OUTPUT	COMMENT
5::6::2	" 00101 "	Binary output (leading zeros)
-1::9::16	" FFFFFFFF "	Hexadecimal output

7.8.2 Formatting REAL Data Items

REAL data items in a READ statement are processed as follows:

Default: Read starting with the next nonblank character on the input line and continuing until a blank or end of line is encountered.

Data can be supplied with or without a fractional part. The E used for scientific notation can be in upper or lower case. If the characters do not form a valid REAL, the read operation fails.

First Format Specifier: Indicates the total number of characters to be read. The input field must be entirely on the current input line and can include leading, but not trailing, blanks.

Second Format Specifier: Ignored for REAL data items.

Table 7–9 lists examples of REAL input data items and their format specifiers. The input data and the resulting value of the REAL data items are included in the table. The symbol [eol] indicates end of line and X indicates extraneous data on the input line.

Table 7–9. Examples of REAL Input Data Items

DATA ITEM	INPUT DATA	RESULT
real_var	1[eol]	1.0
real_var	1.000[eol]	1.0
real_var	2.5 XX	2.50
real_var	1E5 XX	100000.0
real_var::7	2.5 XX	format error (trailing blank)
real_var	1E	format error (no exponent)
real_var::4	1E 2	format error (embedded blank)

REAL data items in a WRITE statement are formatted as follows:

Default: Written in scientific notation in the following form:

(blank)(msign)(d).(d)(d)(d)(d)(d)E(esign)(d)(d)

where:

(blank) is a single blank

(msign) is a minus sign, if required

(d) is a digit

(esign) is a plus or minus sign

First Format Specifier: Indicates the total number of characters to be written, including all the digits, blanks, signs, and a decimal point. If the format specifier is larger than required for the data, leading blanks are added. If it is smaller than required, the field is extended as required.

In the case of scientific notation, character length should be greater than (8 + 2nd format specifier) to write the data completely.

The specifier must be in the range of 1 to 127 for a file or 1 to 126 for other output devices.

Second Format Specifier: Indicates the number of digits to be output to the right of the decimal point, whether or not scientific notation is to be used.

The absolute value of the second format specifier indicates the number of digits to be output to the right of the decimal point.

If the format specifier is positive, the data is displayed in fixed format (that is, without an exponent). If it is negative, scientific notation is used.

Table 7–10 lists examples of REAL output data items and their format specifiers. The output values of the REAL data items are also included in the table. Double quotes are used in the table as delimiters to show leading blanks; however, double quotes are not written by KAREL programs.

Table 7–10. Examples of REAL Output Data Items

DATA ITEM	OUTPUT	COMMENT
123.0	" 1.23000E+02 "	Scientific notation (default format)
123.456789	" 1.23457E+02 "	Rounded to 5 digits in fractional part
.00123	" 1.23000E-03 "	Negative exponent
-1.00	" -1.00000E+00 "	Negative value
-123.456::9	" -1.234560E+02 "	Field expanded
123.456::12	" 1.234560E+02 "	Leading blank added

Table 7–10. Examples of REAL Output Data Items (Cont'd)

DATA ITEM	OUTPUT	COMMENT
123.456::9::2	" 123.46 "	Right justified and rounded
123.::12::-3	" 1.230E+02 "	Scientific notation

7.8.3 Formatting BOOLEAN Data Items

BOOLEAN data items in a READ statement are formatted as follows:

Default: Read starting with the next nonblank character on the input line and continuing until a blank or end of line is encountered.

Valid input values for TRUE include TRUE, TRU, TR, T, and ON. Valid input values for FALSE include FALSE, FALS, FAL, FA, F, OFF, and OF. If the characters read do not form a valid BOOLEAN, the read operation fails.

First Format Specifier: Indicates the total number of characters to be read. The input field must be entirely on the current input line and can include leading, but not trailing, blanks.

Second Format Specifier: Ignored for BOOLEAN data items.

Table 7–11 lists examples of BOOLEAN input data items and their format specifiers. The input data and the resulting value of the BOOLEAN data items are included in the table. (The symbol [eol] indicates end of line and X indicates extraneous data on the input line.)

Table 7–11. Examples of BOOLEAN Input Data Items

DATA ITEM	INPUT DATA	RESULT
bool_var	FALSE[eol]	FALSE
bool_var	FAL 3...	FALSE
bool_var	T[eol]	TRUE
bool_var::1	FXX	FALSE (only reads “ F”)
bool_var	O[eol]	format error (ambiguous)
bool_var	1.2[eol]	format error (not BOOLEAN)
bool_var::3	F [eol]	format error (trailing blanks)
bool_var::6	TRUE[eol]	format error (not enough data)

BOOLEAN data items in a WRITE statement are formatted as follows:

Default: Written as either “TRUE” or “FALSE". (Double quotes are used in the table as delimiters to show leading blanks; however, double quotes are not written by KAREL programs.)

First Format Specifier: Indicates the total number of characters to be written, including blanks (a leading blank is always included). If the format specifier is larger than required for the data, trailing blanks are added. If it is smaller than required, the field is truncated on the right.

The specifier must be in the range of 1 to 127 for a file or 1 to 126 for other output devices.

Second Format Specifier: Indicates whether the data is left or right justified. If the format specifier is equal to 0, the output word is left justified in the output field with one leading blank, and trailing blanks as required. If it is equal to 1, the output word is right justified in the output field, with leading blanks as required.

Table 7–12 lists examples of BOOLEAN output data items and their format specifiers. The output values of the BOOLEAN data items are also included in the table. Double quotes are used in the table as delimiters to show leading blanks; however, double quotes are not written by KAREL programs.

Table 7–12. Examples of BOOLEAN Output Data Items

DATA ITEM	OUTPUT	COMMENT
FALSE	" **FALSE** "	Default includes a leading blank
TRUE	" **TRUE** "	TRUE is shorter than FALSE
FALSE::8	" **FALSE** "	Left justified (default)
FALSE::8::1	" **FALSE** "	Right justified
TRUE::2	" **T** "	Truncated

7.8.4 Formatting STRING Data Items

STRING data items in a READ statement are formatted as follows:

Default: Read starting at the current position and continuing to the end of the line. If the length of the data obtained is longer than the declared length of the STRING, the data is truncated on the right. If it is shorter, the current length of the STRING is set to the actual length.

First Format Specifier: Indicates the total field length of the input data. If the field length is longer than the declared length of the STRING, the input data is truncated on the right. If it is shorter, the current length of the STRING is set to the specified field length.

Second Format Specifier: Indicates whether or not the input STRING is enclosed in single quotes. If the format specifier is equal to 0, the input is not enclosed in quotes.

If it is equal to 2, the input must be enclosed in quotes. The input is scanned for the next nonblank character. If the character is not a quote, the STRING is not valid and the read operation fails.

If the character is a quote, the remaining characters are scanned until another quote or the end of line is found. If another quote is not found, the STRING is not valid and the read operation fails.

If both quotes are found, all of the characters between them are read into the STRING variable, unless the declared length of the STRING is too short, in which case the data is truncated on the right.

Table 7–13 lists examples of STRING input data items and their format specifiers, where str_var has been declared as a STRING[5]. The input data and the resulting value of the STRING data items are included in the table. The symbol [eol] indicates end of line and X indicates extraneous data on the input line.

Table 7–13. Examples of STRING Input Data Items

DATA ITEM	INPUT DATA	RESULT
str_var	" ABC[eol] "	" ABC "
str_var	" ABCDEFG[eol] "	" ABCDE " (FG is read but the STRING is truncated to 5 characters)

Table 7–13. Examples of STRING Input Data Items (Cont'd)

DATA ITEM	INPUT DATA	RESULT
str_var	" 'ABC'XX "	" 'AB " (blanks and quote are read as data)
str_var::0::2	" 'ABC'XX "	" 'ABC' " (read ends with second quote)

STRING data items in a WRITE statement are formatted as follows:

Default: Content of the STRING is written with no trailing or leading blanks or quotes.

The STRING must not be over 127 bytes in length for files or 126 bytes in length for other output devices. Otherwise, the program will be aborted with the ''STRING TOO LONG'' error.

First Format Specifier: Indicates the total number of characters to be written, including blanks. If the format specifier is larger than required for the data, the data is left justified and trailing blanks are added. If the format specifier is smaller than required, the STRING is truncated on the right.

The specifier must be in the range of 1 to 127 for a file or 1 to 126 for other output devices.

Second Format Specifier: Indicates whether the output is to be left or right justified and whether the STRING is to be enclosed in quotes using the following values:

0 left justified, no quotes

1 right justified, no quotes

2 left justified, quotes

3 right justified, quotes

Quoted STRING values, even if left justified, are preceded by a blank. Unquoted STRING values are not automatically preceded by a blank.

Table 7–14 lists examples of STRING output data items and their format specifiers. The output values of the STRING data items are also included in the table. Double quotes are used in the table as delimiters to show leading blanks; however, double quotes are not written by KAREL programs.

Table 7–14. Examples of STRING Output Data Items

DATA ITEM	OUTPUT	COMMENT
'ABC'	" ABC "	No leading blanks
'ABC'::2	" AB "	Truncated on right
'ABC'::8	" ABC "	Left justified
'ABC'::8::0	" ABC "	Same as previous
'ABC'::8::1	" ABC "	Right justified
'ABC'::8::2	" 'ABC' "	Note leading blank

Table 7–14. Examples of STRING Output Data Items (Cont'd)

DATA ITEM	OUTPUT	COMMENT
'ABC'::8::3	" 'ABC' "	Right justified
'ABC'::4::2	" 'A' "	Truncated

Format specifiers for STRING data items can cause the truncation of the original STRING values or the addition of trailing blanks when the values are read again.

If STRING values must be successively written and read, the following guidelines will help you ensure that STRING values of varying lengths can be read back identically:

- The variable into which the STRING is being read must have a declared length at least as long as the actual STRING that is being read, or truncation will occur.
- Some provision must be made to separate STRING values from preceding variables on the same data line. One possibility is to write a ' ' (blank) between a STRING and the variable that precedes it.
- If format specifiers are not used in the read operation, write STRING values at the ends of their respective data lines (that is, followed in the output list by a CR) because STRING variables without format specifiers are read until the end of the line is reached.
- The most general way to write string values to a file and read them back is to use the format ::0::2 for both the read and write.

7.8.5 Formatting VECTOR Data Items

VECTOR data items cannot be read from text (ASCII) files. However, you can read three REAL values and assign them to the elements of a VECTOR variable. VECTOR data items in a WRITE statement are formatted as three REAL values on the same line.

Table 7–15 lists examples of VECTOR output data items and their format specifiers, where vect.x = 1.0, vect.y= 2.0, vect.z = 3.0. The output values of the VECTOR data items are also included in

the table. Double quotes are used in the table as delimiters to show leading blanks; however, double quotes are not written by KAREL programs.

See Also: Section 7.8.2 , "Formatting REAL Data Items," for information on the default output format and format specifiers used with REAL data items

Table 7–15. Examples of VECTOR Output Data Items

DATA ITEM	OUTPUT
vect	" 1. 2. 3. "
vect::6::2	" 1.00 2.00 3.00 "
vect::12::-3	" 1.000E+00 2.000E+00 3.000E+00 "

7.8.6 Formatting Positional Data Items

Positional data items cannot be read from text (ASCII) files. However, you can read six REAL values and a STRING value and assign them to the elements of an XYZWPR variable or use the POS built-in function to compose a POSITION. The CNV_STR_CONF built-in can be used to convert a STRING to a CONFIG data type.

POSITION and XYZWPR data items in a WRITE statement are formatted in three lines of output. The first line contains the location (x,y,z) component of the POSITION, the second line contains the orientation (w,p,r), and the third line contains the configuration string.

The location and orientation components are formatted as six REAL values. The default format for the REAL values in a POSITION is the default format for REAL(s). Refer to Section 7.8.2 .

The configuration string is not terminated with a CR, meaning you can follow it with other data on the same line.

Table 7–16 lists examples of POSITION output data items and their format specifiers, where p = POS(2.0,-4.0,8.0,0.0,90.0,0.0,config_var). The output values of the POSITION data items are also included in the table. Double quotes are used in the table as delimiters to show leading blanks; however, double quotes are not written by KAREL programs.

Table 7–16. Examples of POSITION Output Data Items (p = POS(2.0,-4.0,8.0,0.0,90.0,0.0,config_var))

DATA ITEM	OUTPUT

p	"
	  2. -4. 8.
	"
	
	"
	  0. 9. 0.
	"
	
	"
	N, 127, , -1
	"

p::7::2	"
	  2.00-4.00 8.00
	"
	
	"
	  0.0090.00 0.00
	"
	
	"
	N, 127, , -1
	"

JOINTPOS data items in a WRITE statement are formatted similarly to POSITION types with three values on one line.

See Also: Section 7.8.2 , for information on format specifiers used with REAL data items

POS Built-In Function, Appendix A .

7.9 FORMATTING BINARY INPUT/OUTPUT

This section explains the format specifier used in READ and WRITE statements to read and write binary (unformatted) data for each data item. Binary input/output operations are sometimes referred to as unformatted, as opposed to text (ASCII) input/output operations that are referred to as formatted.

The built-in SET_FILE_ATR with the ATR_UF attribute is used to designate a file variable for binary operations. If not specified, ASCII text operations will be used.

Data items in READ and WRITE statements can be any of the following data types for binary files:

INTEGER
REAL
BOOLEAN
STRING
VECTOR
POSITION
XYZWPR
XYZWPREXT
JOINTPOS

Vision and array variables cannot be read or written in unsubscripted form. The elements of an ARRAY are read or written in the format that corresponds to the data type of the ARRAY.

Entire PATH variables can be read or written, or you can specify that only node[0] (containing the PATH header), a specific node, or a range of nodes be read or written. Format specifiers have no effect on PATH data. PATH data can be read or written only to a file and not to a serial port, CRT/KB, or teach pendant.

Binary I/O is preferred to text I/O when creating files that are to be read only by KAREL programs for the following reasons:

- Positional, VECTOR, and PATH variables cannot be read directly from text input.
- Some formats and data combinations are not read in the same manner as they were written in text files or they become invalid if read with the same format.
- Binary data is generally more compact, reducing both the file size and the I/O time.
- There is some inevitable loss of precision when converting from REAL data to its ASCII representation and back.

Generally, no format specifiers need to be used with binary I/O. If this rule is followed, all input data can be read exactly as it was before it was written.

However, if large numbers of INTEGER values are to be written and their values are known to be small, writing these with format specifiers reduces both storage space and I/O time.

For example, INTEGER values in the range of -128 to +127 require only one byte of storage space, and INTEGER values in the range of -32768 to +32767 require two bytes of storage space. Writing INTEGER values in these ranges with a first format specifier of 1 and 2, respectively, results in reduced storage space and I/O time requirements, with no loss of significant digits.

Table 7–17 summarizes input and output format specifiers that can be used with the data items in READ and WRITE statements. The default format of each data type is also included. Section 7.8.1 through Section 7.8.6 explain the effects of format specifiers on each data type in more detail.

See Also: SET_FILE_ATR Built-In Routine, Appendix A .

Table 7–17. Binary Input/Output Format Specifiers

DATA TYPE	DEFAULT	1ST FORMAT SPECIFIER	2ND FORMAT SPECIFIER
INTEGER	Four bytes read or written	Specified number of least significant bytes read or written, starting with most significant (1-4)	Ignored
REAL	Four bytes read or written	Ignored	Ignored
BOOLEAN	Four bytes read or written	Specified number of least significant bytes read or written, starting with most significant (1-4)	Ignored
STRING	Current length of string (1 byte), followed by data bytes	Number of bytes read or written	Ignored
VECTOR	Three 4-byte REAL numbers read or written	Ignored	Ignored
POSITION	56 bytes read or written	Ignored	Ignored
XYZWPR	32 bytes read or written	Ignored	Ignored
XYZWPREXT	44 bytes read or written	Ignored	Ignored
JOINTPOSn	4 + n*4 bytes read or written	Ignored	Ignored
PATH	Depends on size of structure	Ignored	Ignored

7.9.1 Formatting INTEGER Data Items

INTEGER data items in a READ or WRITE statement are formatted as follows:

Default: Four bytes of data are read or written starting with the most significant byte.

First Format Specifier: Indicates the number of least significant bytes of the INTEGER to read or write, with the most significant of these read or written first. The sign of the most significant byte read is extended to unread bytes. The format specifier must be in the range from 1 to 4.

For example, if an INTEGER is written with a format specifier of 2, bytes 3 and 4 (where byte 1 is the most significant byte) will be written. There is no check for loss of significant bytes when INTEGER values are formatted in binary I/O operations.

Note Formatting of INTEGER values can result in undetected loss of high order digits.

Second Format Specifier: Ignored for INTEGER data items.

7.9.2 Formatting REAL Data Items

REAL data items in a READ or WRITE statement are formatted as follows:

Default: Four bytes of data are read or written starting with the most significant byte.

First Format Specifier: Ignored for REAL data items.

Second Format Specifier: Ignored for REAL data items.

7.9.3 Formatting BOOLEAN Data Items

BOOLEAN data items in a READ or WRITE statement are formatted as follows:

Default: Four bytes of data are read or written. In a read operation, the remainder of the word, which is never used, is set to 0.

First Format Specifier: Indicates the number of least significant bytes of the BOOLEAN to read or write, the most significant of these first. The format specifier must be in the range from 1 to 4. Since BOOLEAN values are always 0 or 1, it is always safe to use a field width of 1.

Second Format Specifier: Ignored for BOOLEAN data items.

7.9.4 Formatting STRING Data Items

STRING data items in a READ or WRITE statement are formatted as follows:

Default: The current length of the STRING (not the declared length) is read or written as a single byte, followed by the content of the STRING. STRING values written without format specifiers have their lengths as part of the output, while STRING values written with format specifiers do not.

Likewise, if a STRING is read without a format specifier, the length is expected in the data, while if a STRING is read with a format specifier, the length is not expected.

This means that, if you write and then read STRING data, you must make sure your use of format specifiers is consistent.

First Format Specifier: Indicates the number of bytes to be read or written.

Second Format Specifier: Ignored for STRING data items.

In a read operation, if the first format specifier is greater than the declared length of the STRING, the data is truncated on the right. If it is less than the declared length of the STRING, the current length of the STRING is set to the number of bytes read.

In a write operation, if the first format specifier indicates a shorter field than the current length of the STRING, the STRING data is truncated on the right. If it is longer than the current length of the STRING, the output is padded on the right with blanks.

Writing STRING values with format specifiers can cause truncation of the original STRING values or padding blanks on the end of the STRING values when reread.

7.9.5 Formatting VECTOR Data Items

VECTOR data items in a READ or WRITE statement are formatted as follows:

Default: Data is read or written as three 4-byte binary REAL numbers.

First Format Specifier: Ignored for VECTOR data items.

Second Format Specifier: Ignored for VECTOR data items.

7.9.6 Formatting POSITION Data Items

POSITION data items in a READ or WRITE statement are formatted as follows:

Default: Read or written in the internal format of the controller, which is 56 bytes long.

7.9.7 Formatting XYZWPR Data Items

XYZWPR data items in a READ or WRITE statement are formatted as follows:

Default: Read or written in the internal format of the controller, which is 32 bytes long.

7.9.8 Formatting XYZWPREXT Data Items

XYZWPREXT data items in a READ or WRITE statement are formatted as follows:

Default: Read or written in the internal format of the controller, which is 44 bytes long.

7.9.9 Formatting JOINTPOS Data Items

JOINTPOS data items in a READ or WRITE statement are formatted as follows:

Default: Read or written in the internal format of the controller, which is 4 bytes plus 4 bytes for each axis.

7.10 USER INTERFACE TIPS

Input and output to the teach pendant or CRT/KB is accomplished by executing "READ" and "WRITE" statements within a KAREL program. If the USER menu is not the currently selected menu, the input will remain pending until the USER menu is selected. The output will be written to the "saved" windows that will be displayed when the USER menu is selected. You can have up to eight saved windows.

7.10.1 USER Menu on the Teach Pendant

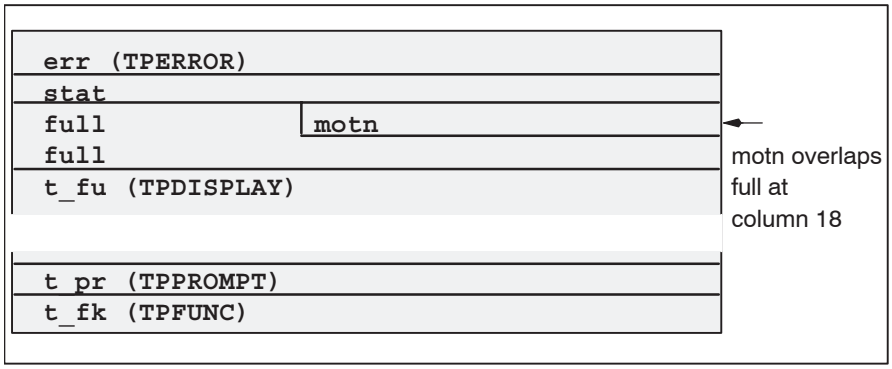
The screen that is activated when the USER menu is selected from the teach pendant is named "t_sc". The windows listed in Table 7–18 are defined for "t_sc".

Table 7–18. Defined Windows for t_sc"

Window Name	Lines	Predefined FILE Name	Scrolled	Rows
"t_fu"	10	TPDISPLAY	yes	5-14
"t_pr"	1	TPPROMPT	no	15
"t_st"	3	TPSTATUS	no	2-4
"t_fk"	1	TPFUNC	no	16
"err"	1	TPERROR	no	1
"stat"	1		no	2
"full"	2		no	3-4
"motn"	1		no	3

By default, the USER menu will attach the "err", "stat", "full", "motn", "t_fu", "t_pr", and "t_fk" windows to the "t_sc" screen. See Figure 7–1 .

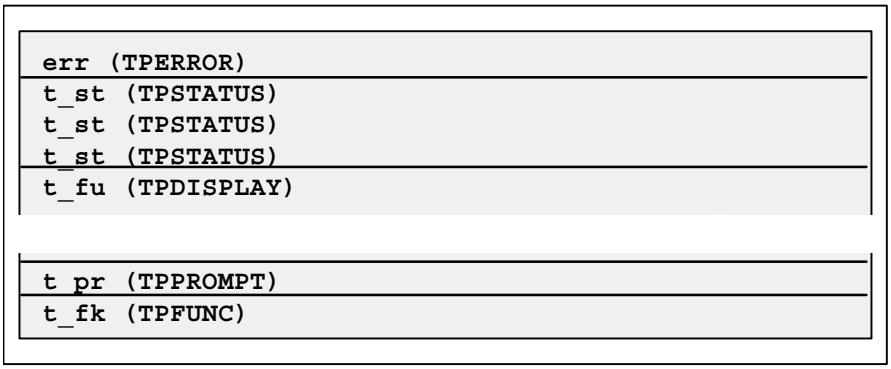
Figure 7–1. "t_sc" Screen



The following system variables affect the teach pendant USER menu:

- **$TP_DEFPROG: STRING** - Identifies the teach pendant default program. This is automatically set when a program is selected from the teach pendant SELECT menu.
- **$TP_INUSER: BOOLEAN** - Set to TRUE when the USER menu is selected from the teach pendant.
- **$TP_LCKUSER: BOOLEAN** - Locks the teach pendant in the USER menu while $TP_DEFPROG is running and $TP_LCKUSER is TRUE.
- **$TP_USESTAT: BOOLEAN** - Causes the user status window "t_st" (TPSTATUS) to be attached to the user screen while $TP_USESTAT is TRUE. While "t_st" is attached, the "stat", "motn", and "full" windows will be detached. See Figure 7–2 .

Figure 7–2. "t_sc" Screen with $TP_USESTAT = TRUE



7.10.2 USER Menu on the CRT/KB

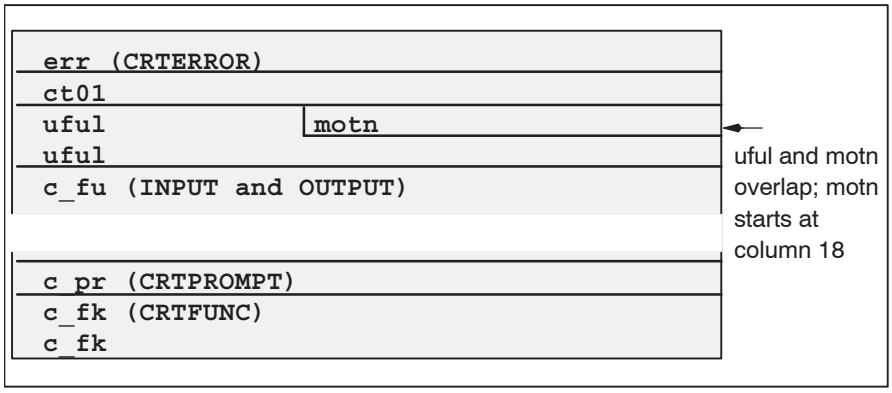
The screen that is activated when the USER menu is selected from the CRT is named "c_sc". The windows listed in Table 7–19 are defined for "c_sc".

Table 7–19. Defined Windows for c_sc"

Window Name	Lines	Predefined FILE Name	Scrolled	Rows
"c_fu"	17	INPUT and OUTPUT	yes	5-21
"c_pr"	1	CRTPROMPT	no	22
"c_st"	3	CRTSTATUS	no	2-4
"c_fk"	2	CRTFUNC	no	23-24
"err"	1	CRTERROR	no	1
"ct01"	1		no	2
"uful"	2		no	3-4
"motn"	1		no	3

By default, the USER menu will attach the "err", "ct01", "uful", "motn", "c_fu", "c_fk", and "uftn" windows to the "c_sc" screen. The "c_fk" window will label the function keys an show FCTN and MENUS for F9 and F10. See Figure 7–3 .

Figure 7–3. "c_sc" Screen

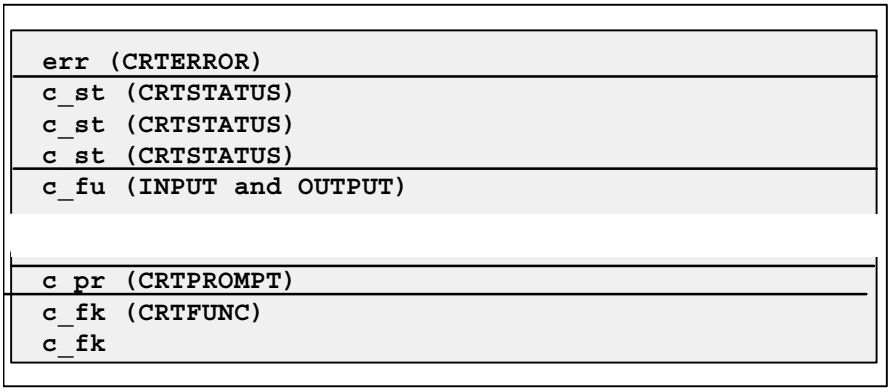


The following system variables affect the CRT USER menu:

- **$CRT_DEFPROG: STRING** - This variable identifies the CRT default program. This is automatically set when a program is selected from the CRT SELECT menu.
- **$CRT_INUSER: BOOLEAN** - This variable is set to TRUE when the USER menu is selected from the CRT.

- **$CRT_LCKUSER: BOOLEAN** - This variable locks the CRT in the USER menu while $CRT_DEFPROG is running and $CRT_LCKUSER is TRUE.
- **$CRT_USERSTAT: BOOLEAN** - This variable causes the user status window "c_st" (CRTSTATUS) to be attached to the user screen while $CRT_USERSTAT is TRUE. While "c_st" is attached, the "ct01", "motn", and "uful" windows will be detached. See Figure 7–4 .

Figure 7–4. "c_sc" Screen with $CRT_USERSTAT = TRUE



Chapter 8

MOTION

Contents

Chapter 8	MOTION	8–1
8.1	OVERVIEW	8–2
8.2	POSITIONAL DATA	8–2
8.3	FRAMES OF REFERENCE	8–3
8.3.1	World Frame	8–4
8.3.2	User Frame (UFRAME)	8–5
8.3.3	Tool Definition (UTOOL)	8–5
8.3.4	Using Frames in the Teach Pendant Editor (TP)	8–6
8.4	JOG COORDINATE SYSTEMS	8–6
8.5	MOTION CONTROL	8–7
8.5.1	Motion Trajectory	8–9
8.5.2	Motion Trajectories with Extended Axes	8–17
8.5.3	Acceleration and Deceleration	8–18
8.5.4	Motion Speed	8–21
8.5.5	Motion Termination	8–26
8.5.6	Multiple Segment Motion	8–29
8.5.7	Path Motion	8–36
8.5.8	Motion Times	8–39
8.5.9	Correspondence Between Teach Pendant Program Motion and KAREL Program Motion	8–42

8.1 OVERVIEW

In robotic applications, single segment motion is the movement of the tool center point (TCP) from an initial position to a desired destination position. The KAREL system represents positional data in terms of location (x, y, z), orientation (w, p, r), and configuration. The location and orientation are defined relative to a Cartesian coordinate system (user frame), making them independent of the robot joint angles. Configuration represents the unique set of joint angles at a particular location and orientation.

The KAREL system uses the motion environment to control motion. KAREL motion control regulates the characteristics of the movement including trajectory, acceleration/deceleration , speed, and termination.

In addition to single segment motion, KAREL can control multiple segment motion including path motion and provides for the estimation of cycle times.

Note Almost all robot motion programming can be accomplished using teach pendant programs. Additionally, all motion options are supported in teach pendant programs, whereas most advanced motion options are NOT supported for motion statements in KAREL programs. Due to the very limited availability of motion options, motion programming should not be used in KAREL programs unless teach pendant programs specifically cannot be used.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly, personnel could be injured, and equipment could be damaged.

8.2 POSITIONAL DATA

The KAREL language uses the POSITION, XYZWPR, XYZWPREXT, JOINTPOS, and PATH data types to represent positional data. The POSITION data type is composed of the following:

- Three REAL values representing an x, y, z location expressed in millimeters
- Three REAL values representing a w, p, r orientation expressed in degrees
- One CONFIG Data Type, consisting of 4 booleans and 3 integers, which represent the configuration in terms of joint placement and turn number. Before you specify the config data type, make sure it is valid for the robot being used. Valid joint placement values include:
  - — ‘R’ or ‘L’ (shoulder right or left)
  - — ‘U’ or ‘D’ (elbow up or down)

— ‘N’ or ‘F’ (wrist no-flip or flip)

— ‘T’ or ‘B’ (config front or back)

A turn number is the number of complete turns a multiple turn joint makes beyond the required rotation to reach a position. Table 8–1 lists the valid turn number definitions.

Table 8–1. Turn Number Definitions

Turn Number	Rotation (degrees)
-8	-2700 to -3059
-7	-2340 to -2699
-6	-1980 to -2339
-5	-1620 to -1979
-4	-1260 to -1619
-3	-900 to -1259
-2	-540 to -899
-1	-180 to -539
0	-179 to 179
1	180 to 539
2	540 to 899
3	900 to 1259
4	1260 to 1619
5	1620 to 1979
6	1980 to 2339
7	2340 to 2699

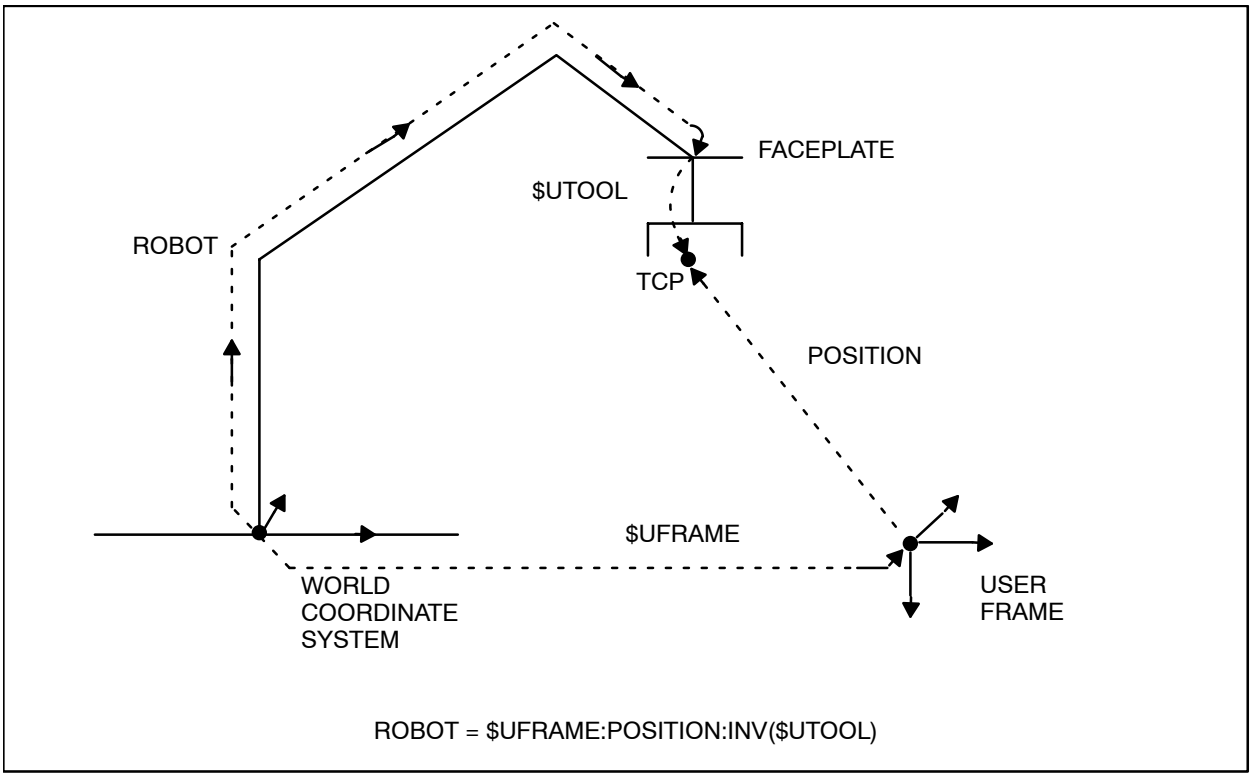
The PATH data type consists of a varying-length list of elements called path nodes.

See Also: The appropriate application-specific *FANUC Robotics SYSTEM R-J3iC Controller Setup and Operations Manual* for configuration information on each supported robot model. The POSITION, XYZWPR, XYZWPREXT, JOINTPOS, and PATH Data Types, Appendix A, ‘‘KAREL Language Alphabetical Description.’’

8.3 FRAMES OF REFERENCE

The KAREL system defines the location and orientation of positional data relative to a user-defined frame of reference, called user frame, as shown in Figure 8–1 .

Figure 8–1. Referencing Positions in KAREL



Three frames of reference exist:

- WORLD - predefined
- UFRAME - determined by the user
- UTOOL - defined by the tool

Using kinematic equations, the controller computes its positional information based on the known world frame and the data stored in the system variables $UFRAME (for user frame) and $UTOOL (for tool frame).

8.3.1 World Frame

The world frame is predefined for each robot. It is used as the default frame of reference. The location of world frame differs for each robot model.

8.3.2 User Frame (UFRAME)

The programmer defines user frame relative to the world frame by assigning a value to the system variable $UFRAME.



Warning

Be sure $UFRAME is set to the same value whether you are teaching positional data or running a program with that data, or damage to the tool could occur.

The location of UFRAME represents distances along the x-axis, y-axis, and z-axis of the world coordinate system; the orientation represents rotations around those axes.

By default, the system assigns a (0,0,0) location value and a (0,0,0) orientation value to $UFRAME, meaning the user frame is identical to that of the world coordinate system. All positions are recorded relative to UFRAME.

To use a teach pendant user frame in a KAREL program, set $GROUP[group_no].$UFRAME = $MNUFRAME[group_no, $MNUFRAMENUM[group_no]] before executing any motion.

8.3.3 Tool Definition (UTOOL)

The *tool center point (TCP)* is the origin of the UTOOL frame of reference. The programmer defines the position of the TCP relative to the faceplate of the robot by assigning a value to the system variable $UTOOL. By default, the system assigns a (0,0,0) location and a (0,0,0) orientation to $UTOOL, meaning $UTOOL is identical to the faceplate coordinate system. The positive z-axis of UTOOL defines the *approach vector* of the tool.



Warning

Be sure $UTOOL correctly defines the position of the TCP for the tool you are using, or damage to the tool could occur.

The faceplate coordinate system has its origin at the center of the faceplate surface. Its orientation is defined with the plane of the x-axis and y-axis on the faceplate and the positive z-axis pointing straight out from the faceplate.

To use a teach pendant tool frame in a KAREL program, set $GROUP[group_no].$utool = $MNUTOOL[group_no], $MNUTOOLNUM[group_no] before you execute any motion.

Note Do not use more than one motion group in a KAREL program. If you need to use more than one motion group, you must use a teach pendant program.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly, personnel could be injured, and equipment could be damaged.

8.3.4 Using Frames in the Teach Pendant Editor (TP)

The system variable $USEUFRAME defines whether the current value of $MNUFRAMENUM[group_no] will be assigned to the position's user frame when it is being recorded or touched up.

- When **$USEUFRAME = FALSE** , the initial recording of positions and the touching up of positions is done with the user frame number equal to 0, regardless of the value of $MNUFRAMENUM[group_no].
- When **$USEUFRAME = TRUE** , the initial recording of positions is done with the position's user frame equal to the user frame defined by $MNUFRAMENUM[group_no]. The touching up of positions must also be done with the position's user frame equal to the user frame defined by $MNUFRAMENUM[group_no].

When a position is recorded in the teach pendant editor, the value of the position's tool frame will always equal the value of $MNUTOOLNUM[group_no] at the time the position was recorded. When a teach pendant program is executed, you must make sure that the user frame and the tool frame of the position equal the values of $MNUFRAMENUM[group_no] and $MNUTOOLNUM[group_no]; otherwise, an error will occur. Set the values of $MNUFRAMENUM[1] and $MNUTOOLNUM[1] using the UFRAME_NUM = n and UTOOL_NUM = n instructions in the teach pendant editor before you record the position to guarantee that the user and tool frame numbers match during program execution.

8.4 JOG COORDINATE SYSTEMS

The KAREL system provides five different jog coordinate systems:

- **JOINT** - a joint coordinate system in which individual robot axes move. The motion is joint interpolated.
- **WORLD** - a Cartesian coordinate system in which the TCP moves parallel to, or rotates around, the x, y, and z-axes of the predefined WORLD frame. The motion is linearly interpolated.
- **TOOLFRAME** - a Cartesian coordinate system in which the TCP moves parallel to, or rotates around, the x, y, and z-axes of the currently selected tool frame. The motion is linearly interpolated. The tool frame is normally selected using the SETUP Frames menu. To jog using $GROUP[group_no].$utool, set $MNUTOOLNUM[group_no] = 14.

- **JOGFRAME** - a Cartesian coordinate system in which the TCP moves parallel to, or rotates around, the x, y, and z-axes of the coordinate system defined by the $JOG_GROUP[group _no].$jogframe system variable. The motion is linearly interpolated.
- **USER FRAME** - a Cartesian coordinate system in which the TCP moves parallel to, or rotates around, the x, y, and z-axes of the currently selected user frame. The motion is linearly interpolated. The user frame is normally selected using the SETUP Frames menu. To jog using $GROUP[group_no].$uframe, set $MNUFRAMENUM[group_no] = 14.

The robot can be jogged in any one of these jog coordinate systems to reach a destination position. Once that position is reached, however, the positional data is recorded with reference to the user frame as discussed in Section 8.3 .

See Also: The application-specific *FANUC Robotics SYSTEM R-J3iC Controller Setup and Operations Manual* for step-by-step explanations of how to jog and define frames.

8.5 MOTION CONTROL

A single segment motion is the simplest form of motion. This motion consists of accelerating from the initial position, traveling along the desired trajectory at the programmed speed, and decelerating to arrive at the destination position.

Motion control regulates the characteristics of the movement which includes:

- Trajectory
- Acceleration/Deceleration
- Speed
- Termination

These motion characteristics are explained in terms of single segment motion. In some applications, motion control extends to the movement of extended axes as well.

In addition to single segment motion, the KAREL system can control multiple segment motion (movement to a sequence of positions without stopping). Motion times can be estimated using the tables and formulas included in this section. In the KAREL system, motion can be initiated in two ways:

- Manually, by jogging the robot or issuing a KCL motion command.
- By issuing KAREL program statements. All motion that is generated by a KAREL program is program controlled motion.

The motion environment executes program controlled motion as follows:

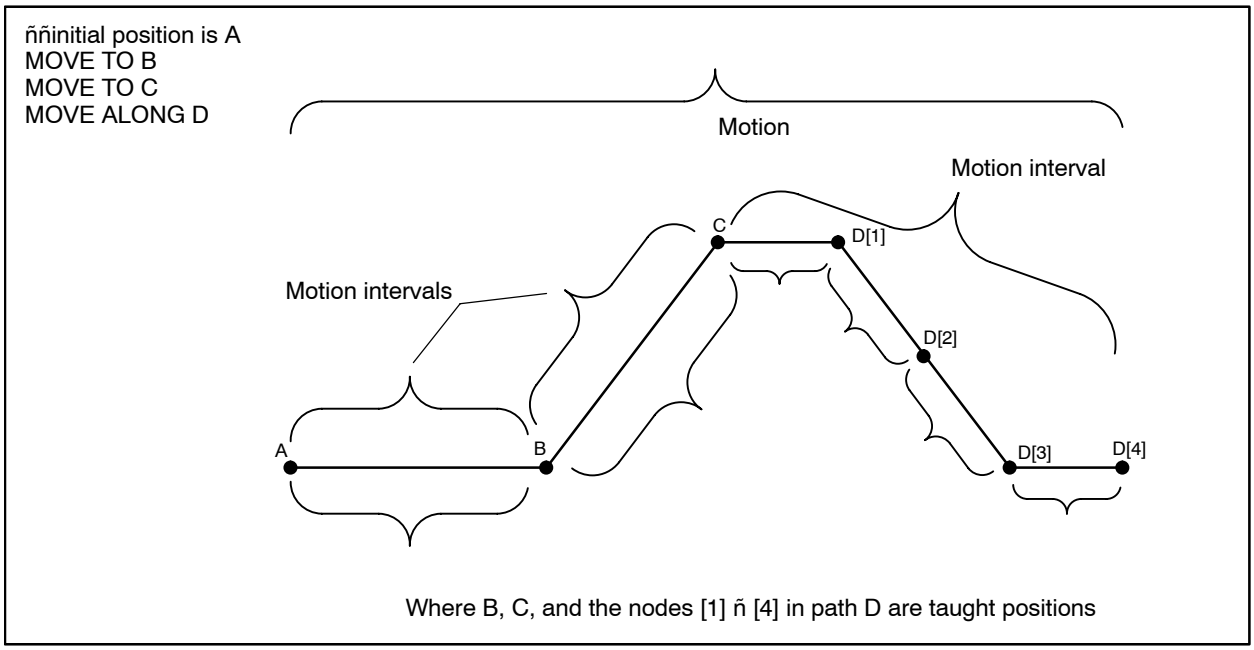
- Program statements are executed by the KAREL interpreter.

- When the interpreter encounters a motion statement, it passes the information to the motion environment, which carries out the motion.
- The motion environment runs in parallel with the interpreter so that, when necessary, motion can be carried out simultaneously with the execution of other program statements.

The following terms, which are illustrated in Figure 8–2 , help clarify the relationship between a motion statement and how it is carried out by the motion environment:

- **Motion** - The physical movement of the robot from the time it starts moving to the time it stops. During continuous path motion, several motion statements executed sequentially can compose a single motion.
- **Motion Interval** - The motion generated by a single motion statement, for example, a MOVE TO or a MOVE ALONG statement.
- **Taught Position -** A position you teach or calculate in a program. It can be a destination for a MOVE TO statement, an intermediate position for a MOVE ALONG statement, or any other position that is used in a motion statement.
- **Motion Segment -** The part of a motion between two taught positions. A motion interval can be composed of a single motion segment, or several motion segments can be combined into one motion interval in which the robot moves near or through taught positions without stopping.

Figure 8–2. Motion Terms



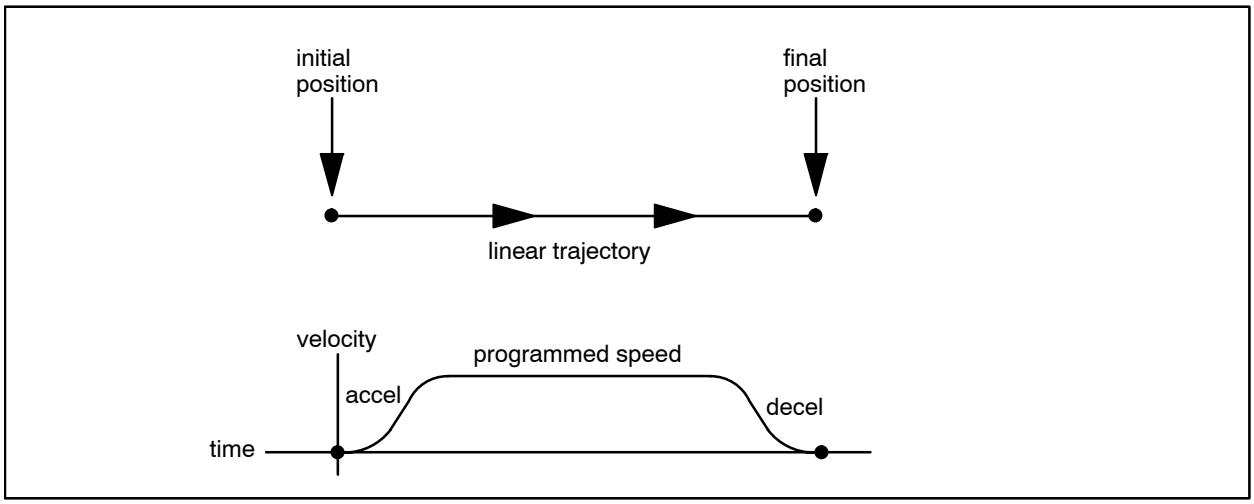
Several characteristics of a motion are controlled by the motion environment and can be specified by changing the appropriate system variables. They are illustrated in Figure 8–3 and can be categorized as follows:

- **Trajectory** The path of the TCP as the robot moves from its initial to final position. The trajectory includes orientation as well as location of the TCP.
- **Acceleration/Deceleration** Acceleration is the initial phase of a motion during which the speed of the robot increases to the programmed speed. At the end of a motion, the robot decelerates to a stop.

  The programmed segment time specified in the KAREL program, which defines the time required to finish the motion segment, does not include deceleration time.

  During continuous path motion, which includes multiple segments, acceleration and deceleration might occur at the taught positions as the robot changes speed and direction of motion.
- **Programmed Speed** The speed is designated in the KAREL program (or by the teach pendant for manual motion). In between acceleration and deceleration the robot moves at the programmed speed.
- **Motion Interval Termination** The criterion by which the motion environment determines when a motion interval is complete. Motion interval termination is important in synchronizing program statements with the actual motion.

Figure 8–3. Motion Characteristics



8.5.1 Motion Trajectory

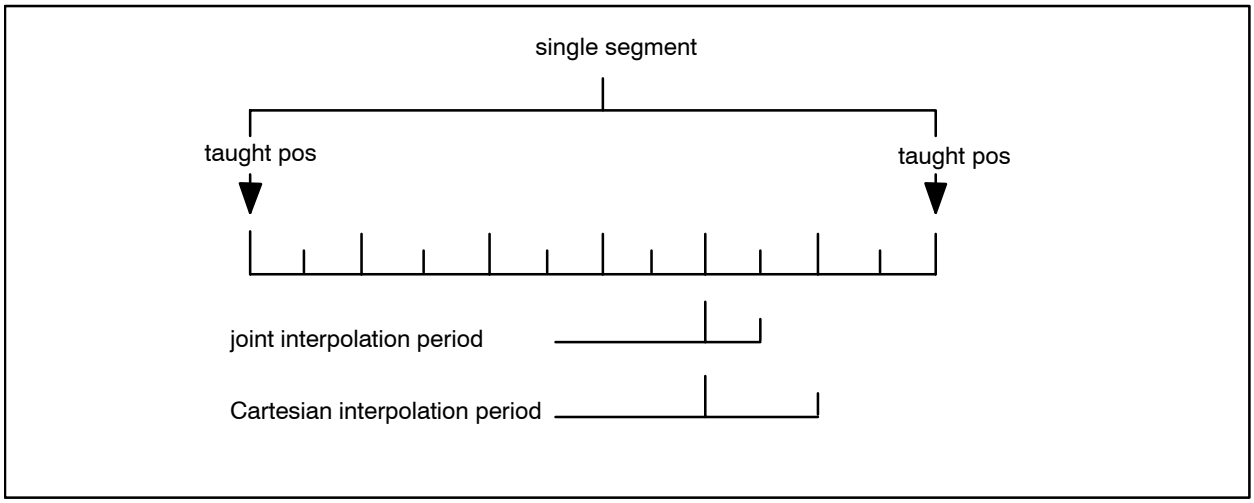
The motion trajectory between two taught positions is generated by interpolating various sets of variables from their initial values at the start position to their final values at the destination position.

The two basic interpolation methods are joint interpolation and Cartesian interpolation.

- During **joint interpolation** , the joint angles of the robot are linearly interpolated from their initial to final values.
- **Cartesian interpolation** is categorized into linear and circular interpolation of the location of the TCP and, for each of these, there are several possible schemes for interpolating the orientation of the TCP. See Figure 8–4 .

  Both location and orientation are interpolated during all robot motions. The system variable, $MOTYPE, governs the basic motion type or how the location of the TCP is interpolated during a motion interval.

Figure 8–4. Interpolation Rates



Location Interpolation

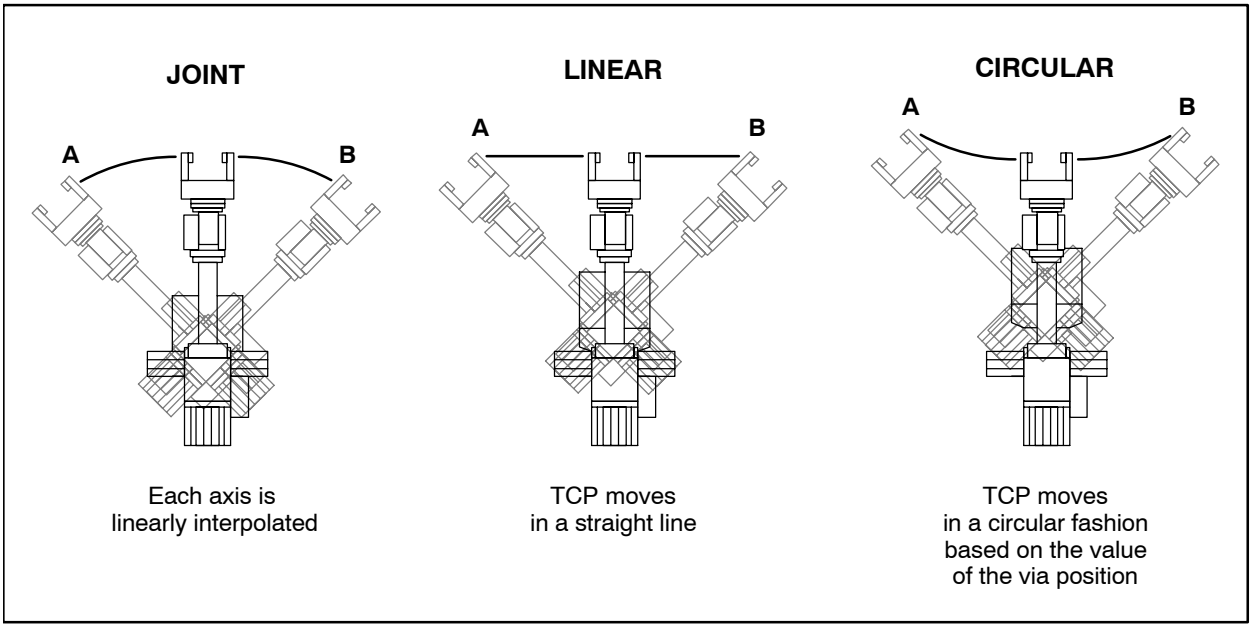
$MOTYPE has three possible enumerated values:

- JOINT (6)
- LINEAR (7)
- CIRCULAR (8)

The value of $MOTYPE can be assigned using the teach pendant, CRT/KB, or by issuing a KAREL assignment statement. Each time a KAREL program is executed, $MOTYPE is initialized to JOINT.

Figure 8–5 shows the difference between the three values for $MOTYPE.

Figure 8–5. Location Interpolation of the TCP



- **JOINT Interpolated Motion**

  The following rules apply to joint interpolated motion:

  — All axes start moving at the same time and reach the beginning of the deceleration at the same time.

  — The trajectory is not a simple geometric shape such as a straight line. However, the path is repeatable.

  — The motion is defined by computing the time for each axis to move from its current position to its final position at the programmed speed. The longest time among all axes is used as the segment time, and each axis begins and ends its motion in this amount of time.

  The axis with the longest time, called the limiting axis, moves at its programmed speed. While the other axes move slower than their programmed speeds, using the same segment time for all axes allows them to arrive at the destination in the correct amount of time.

- **LINEAR Interpolated Motion**

  The following rules apply to linear interpolated motion:

  — The TCP moves in a straight line, from the initial position to the final position, at the programmed speed.

  — The orientation of the tool is changed smoothly from the orientation at the initial position to the orientation at the destination.

See Also: "Orientation Interpolation" for more information on these methods

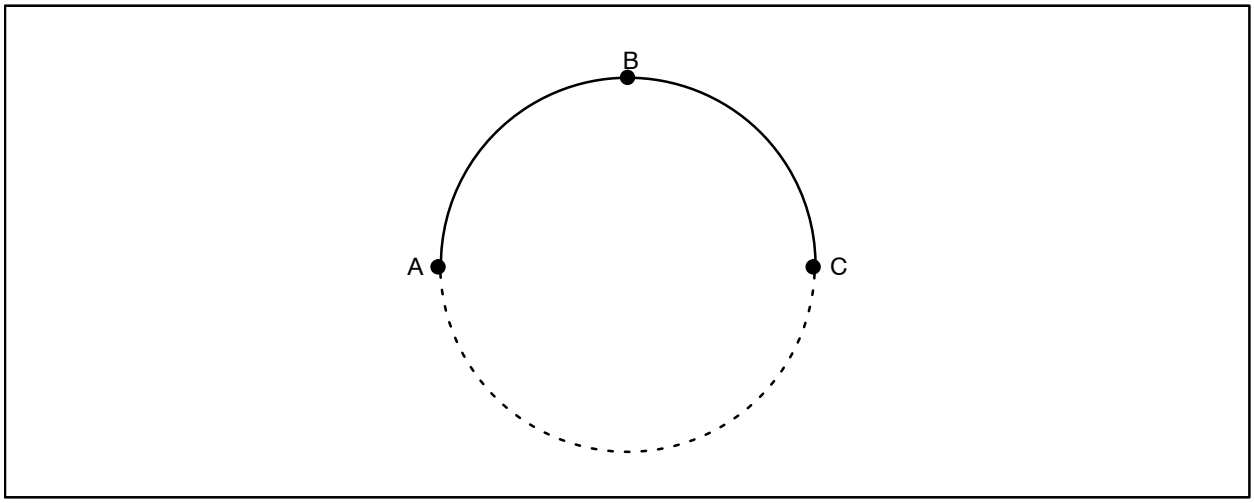
- **CIRCULAR Interpolated Motion**

  The following rules apply to circular interpolated motion.

  — The TCP follows a circular arc from the initial position to the destination.

  — An additional position, called the VIA position, must be specified in order for the motion environment to define the arc. See Figure 8–6 .

Figure 8–6. CIRCULAR Interpolated Motion



— The VIA position is specified with a VIA clause in a MOVE TO statement. If a VIA clause is not included with a MOVE TO statement that uses CIRCULAR interpolation, an error occurs and the program aborts.

For example, the following statements move the TCP from position A to position C, via position B, as shown in Figure 8–6 :

$MOTYPE = CIRCULAR MOVE TO C VIA B -- A is the current position

— Using CIRCULAR interpolation in conjunction with a MOVE ALONG statement is not supported.

— The three-angle method of orientation interpolation is always used. Refer to the section on "Orientation Interpolation" below.

See Also: MOVE TO and MOVE ALONG Statements, Appendix A .

Orientation Interpolation

The KAREL system supports three methods of orientation interpolation:

- Two-Angle Method (RSWORLD)
- Three-Angle Method (AESWORLD)
- Wrist-Joint Method (WRISTJOINT)

The system variable $ORIENT_TYPE uses the predefined constants RSWORLD, AESWORLD, and WRISTJOINT to indicate the type of interpolation used to move from one orientation to another during a LINEAR motion. By default, the two-angle method (RSWORLD) is used.

If the motion is CIRCULAR, the three-angle method or the wrist joint method can be used.

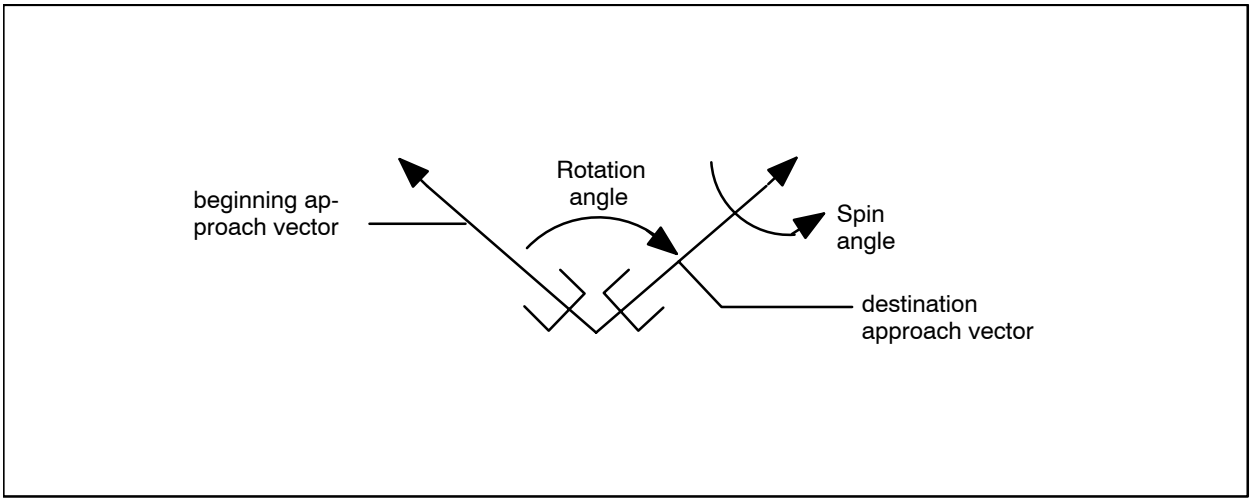
The three methods of orientation interpolation are described as follows:

- **Two-Angle Method (RSWORLD)**

  For the two-angle method (RSWORLD), orientation interpolation is done by linearly interpolating the values of two rotation angles, tool rotation and tool spin, which are defined for each LINEAR motion segment.

  The tool rotation angle is the angle about the common normal between the beginning tool approach vector and the destination approach vector. The tool spin angle is the angle about the approach vector from the beginning position to the destination position. See Figure 8–7 .

Figure 8–7. Two-Angle Orientation Control

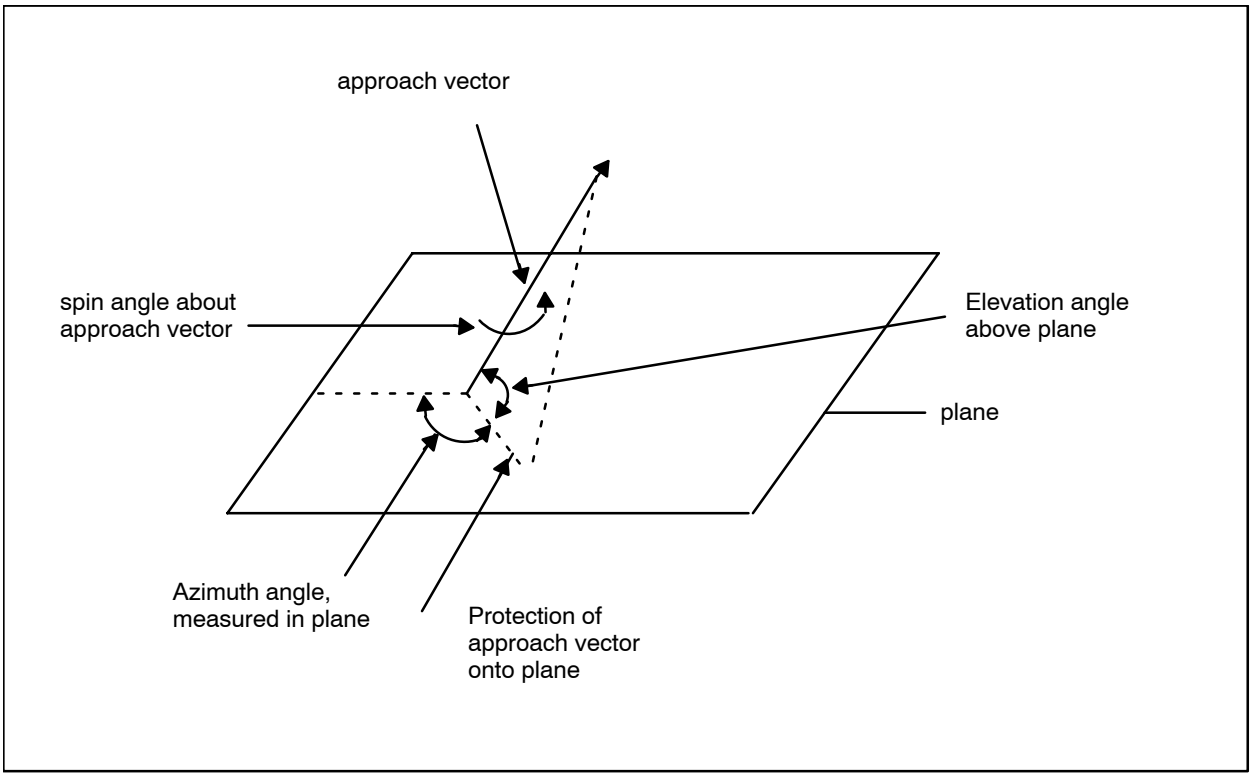


- **Three-Angle Method (AESWORLD)**

  For the three-angle method (AESWORLD), orientation interpolation is done by linearly interpolating the values of three rotation angles: *azimuth* , *elevation* , and *spin* .

For LINEAR motions, elevation and azimuth are defined with respect to the world coordinate horizontal plane. That is, elevation is the elevation angle of the tool approach vector above the horizontal, and azimuth is the angle of the projected approach vector in the horizontal plane. Spin is the rotation angle about the approach vector. See Figure 8–8 .

Figure 8–8. Three-Angle Orientation Control



For CIRCULAR interpolation, elevation and azimuth are defined with respect to the plane of the circle being interpolated.

- **Wrist-Joint Method (WRISTJOINT)**

  For the WRISTJOINT method of orientation interpolation, the three wrist joints are joint interpolated. The remaining joints are interpolated so that the TCP moves in a straight line. Note that the starting and ending orientation will be used as taught, but because of the joint interpolation, the orientation during the move is not predictable, although it is repeatable.

Orientation Trajectory

Regardless of the orientation interpolation method used for Cartesian moves, there are usually at least two possible orientation trajectories between two taught positions-one in a positive direction and one in a negative direction.

For example, during a move in which the azimuth of the tool approach vector is 0° at the initial position and 50° at the destination position and the TCP moves along a straight line, azimuth can change in a negative direction by 310° or in a positive direction by 50°.

- For calculating LINEAR interpolation, the shortest distance for each interpolated variable is always used. That is, for the two-angle method, the smallest change in both spin and rotation will be used, and, for the three-angle method, the smallest change in all three angles will be used.
- For CIRCULAR interpolation, keeping the orientation of the TCP fixed with respect to the path is often more important than the distance traveled while changing orientation.

  For example, during a move in which the TCP follows a complete circle with the tool approach vector pointing toward the center of the circle throughout the entire move, the azimuth angle changes by 360°. If the shortest distance, 0°, is used for the move instead, the tool approach vector will be pointing toward the inside of the circle sometimes and toward the outside at other times during the move.
- In general, when the tool approach vector points from outside the circle toward the inside, the tool approach vector is ‘‘outside’’ the circle, while ‘‘inside’’ the circle means that the approach vector points from the inside toward the outside.
- The following rules are used to determine orientation trajectories for CIRCULAR interpolation:
  - — If all the initial, via, and final approach vectors are outside, then the approach vector will remain outside for the entire segment.
  - — If all the initial, via, and final approach vectors are inside, then the approach vector will remain inside for the entire segment.
  - — If the initial and final approach vectors are on opposite sides, then the shortest change in azimuth will be executed.

    In the following cases very small changes in the orientation of a taught position will make a very large difference in the orientation trajectory:
  - — The approach vector at a taught position is tangent to the circle. This is the point between ‘‘inside’’ and ‘‘outside.’’
  - — The approach vector is perpendicular to the plane of the circle. In this case, the azimuth angle is taken as 0°.
  - — The circle degenerates into a straight line. In this case, the reference frame for three-angle control is computed as follows:
    1. The x-axis is measured along the direction of the motion.
    2. The y-axis is the cross-product of the x-axis and the world z-axis.
    3. Elevation is computed with respect to the xy-plane.
    4. Azimuth is computed with respect to the x-axis.

    The VIA position is used to determine the location trajectory, and also for orientation trajectory interpolation. The benefit of using a VIA position is that a circular motion

will go through the VIA position as it is taught or programmed. This allows the user more control over the tool orientation throughout a circular motion.

It is important to maintain uniform speed along the location trajectory. Circular interpolation maintains a uniform location speed throughout the starting arc (initial to VIA position) and the ending arc (VIA to final position.) However, orientation speeds for the two arcs might be different.

Typically, the location movement of a circular motion dominates that of the orientation movement. The segment time is determined by the location movement and the location speed. The same time will be used for orientation trajectory interpolation. However, in cases where the orientation motion dominates that of the location motion, the programmed location speed might not be maintained. In this case, the system posts the following warning "Speed limits used."

Configuration

- In JOINT interpolated motion, the Boolean value of the system variable $USE_TURNS indicates whether the turn numbers of the initial and destination positions are used in determining the joint distance.
  - — If $USE_TURNS is TRUE, the turn numbers are used. In this case, it is possible for a single segment to turn a joint through several revolutions if that is what the turn numbers specify.
  - — If $USE_TURNS is FALSE, the turn numbers are ignored. This means that the shortest distance between the initial and destination joint positions will be used.
- In CARTESIAN interpolated motion, the robot cannot move along the interpolated location trajectory, maintain control of orientation, and change the configuration. However, if orientation control is not important to the application, the WRISTJOINT method of interpolation can be used. WRISTJOINT is useful if changing configuration is required, while maintaining the location trajectory. The use of the turn numbers of the wrist joints are determined as follows:
  - — If $USE_WJTURNS is TRUE, the turn numbers of the wrist joints are used in determining the wrist joint distances.
  - — If $USE_WJTURNS is FALSE, the turn numbers are ignored and the shortest wrist joint distances are used.
- The Boolean value of the system variable $USE_CONFIG indicates how this physical restriction is handled if you are not using the WRISTJOINT method of orientation interpolation:
  - — If $USE_CONFIG is TRUE, different configurations are not allowed. An error condition that pauses the program occurs if different configurations are specified.
  - — If $USE_CONFIG is FALSE, the stored configuration for the destination position is ignored and the initial configuration is maintained.
  - — The configuration contains both the configuration for joint placement (flip/noflip) and turn number. If $USE_CONFIG is TRUE, the turn number from the taught position will be used to check the joint limit. If $USE_CONFIG is FALSE, the turn number from the taught point will be ignored.

- The physical requirements of executing a Cartesian path also limit the joint motions to±180° from the starting position of that joint. This makes it necessary to ignore the destination turn numbers specified in the taught data. Multiple turn joints, however, always can be returned to their taught positions by executing joint interpolated motions with $USETURNS being TRUE.

8.5.2 Motion Trajectories with Extended Axes

Extended Axes are linear or rotary axes in addition to the robot axes. There are two kinds of extended axes: integrated and non-integrated.

Integrated Extended Axes

- Extended axes are said to be integrated when the positions of the auxiliary axes are integrated into the calculations of the robot TCP position. This includes trajectory calculations of the TCP for Cartesian moves, as well as calculations of the TCP position displayed from the teach pendant or the CRT/KB. In particular, the world coordinate system is moved from the base of the robot to the zero position of the extended axis. Up to three auxiliary axes can be integrated.

  For example, if a robot is mounted on top of an extended axis, such as a rail, you would want to have the extended axis integrated with the robot axes. Once integrated, the world position of the TCP changes as the rail moves, such as during joint jogging of the rail axis. This change occurs even when the robot axes are not moving. You can observe the change in the current robot TCP position in the world coordinate, from the teach pendant.

Non-Integrated Extended Axes

- Non-Integrated extended axes are also called auxiliary axes. The position of these auxiliary axes has no effect on the robot TCP position.

  Robot axis numbers begin at 1 and extended axis numbers begin at a number one more than the last robot axis. The number of robot axes is indicated by the value of the system variable $SCR_GRP[ ].$num_rob_axs. The highest extended axis number is indicated by the value of the system variable $SCR_GRP[ ].$num_axes.

  Regardless of whether the extended axes are integrated or not, the extended axes motion is always joint interpolated. This is true even in integrated extended axes, when the TCP might be moving simultaneously under Cartesian interpolation. For example, if a LINEAR motion is specified for the TCP, the TCP will move along a straight line while the integrated extended axes are joint interpolated from their initial to final locations.

  For more information on setting up extended axes, refer to the *FANUC Robotics SYSTEM R-J3iC Controller Auxiliary Axis Connection and Maintenance Manual* .

8.5.3 Acceleration and Deceleration

During a single segment motion, the robot accelerates from rest at the initial position and decelerates to rest at the destination position.

For motions long enough to reach the programmed speed before deceleration must begin, the acceleration time is always the same regardless of the programmed speed. Therefore, because the acceleration time is fixed, the average acceleration value is proportional to the programmed speed.

Fast Acceleration

KAREL uses fixed acceleration times to generate the acceleration and deceleration profile regardless of the program speed. However, you can reduce the acceleration time linearly based on the program speed by setting the system variable $GROUP[ ].$usemaxaccel. If $GROUP[ ].$usemaxaccel is TRUE, the required acceleration/deceleration time will be adjusted and it will improve corner rounding and cycle time percentages.

- Setting the system variable $GROUP[ ].$usemaxaccel to TRUE causes the acceleration time to be reduced based on the program speed. Therefore, the rate of acceleration is kept constant and the acceleration time changes.
- For short motions, where the programmed speed cannot be reached, the acceleration time is reduced to permit faster short motions.
- A two-stage acceleration/deceleration algorithm is used to produce a second order velocity profile during acceleration and deceleration. This second order method produces smoother derivatives than, for example, a first order method. Therefore, it induces less structural vibration on the robot during acceleration and deceleration.
- For Cartesian motions, the acceleration times are the same for all axes, and are determined by the system variables, $PARAM_GROUP[ ].$cart_accel1 and $PARAM_GROUP[ ].$cart_accel2, which are integers representing the times in milliseconds of each stage of the acceleration/deceleration algorithm.
- For joint interpolated motions, the acceleration times for each joint are permitted to be different. These times are determined by two arrays, $PARAM_GROUP[ ].$accel_time1[ ] and $PARAM_GROUP[ ].$accel_time2[ ], with each array having one element for each robot or extended axis. The values of each array represents the lengths, in milliseconds, of each stage of the acceleration/deceleration algorithm.
- By varying the ratio of the two stage lengths, various profiles can be achieved. A first order profile is achieved when either of the two stages is zero length. A purely second order profile is achieved when the two stages have the same length.
- With any other ratio, a mixed profile is achieved, with a portion of the acceleration being first order and the remainder, second order. This approach makes it possible to achieve profiles with both low peak torque and smooth higher order derivatives.

Figure 8–9 , Figure 8–10 , and Figure 8–11 show the effect of varying the relative lengths of the two stages.

See Also: "Short Motions"

In Figure 8–9 both stages are the same length, producing a second order profile over the entire acceleration profile. In Figure 8–10 , the second stage is zero length, producing a first order profile over the entire acceleration period. The peak acceleration in Figure 8–9 is twice that in Figure 8–10 for a given total acceleration time.

Figure 8–9. Acceleration and Velocity Profile with Stage_1 = Stage_2

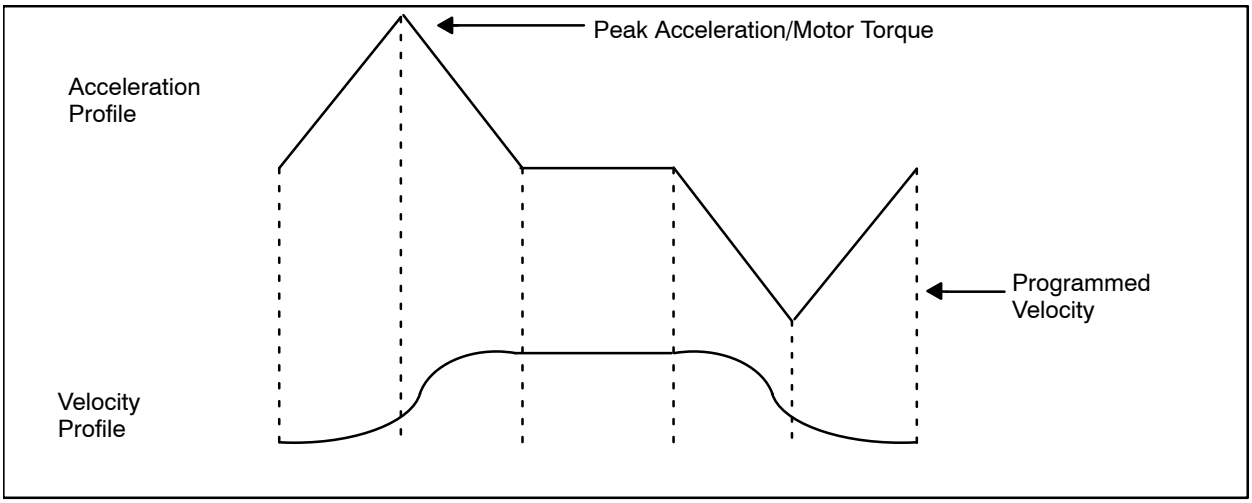


Figure 8–10. Acceleration and Velocity Profile with Stage_2 = 0

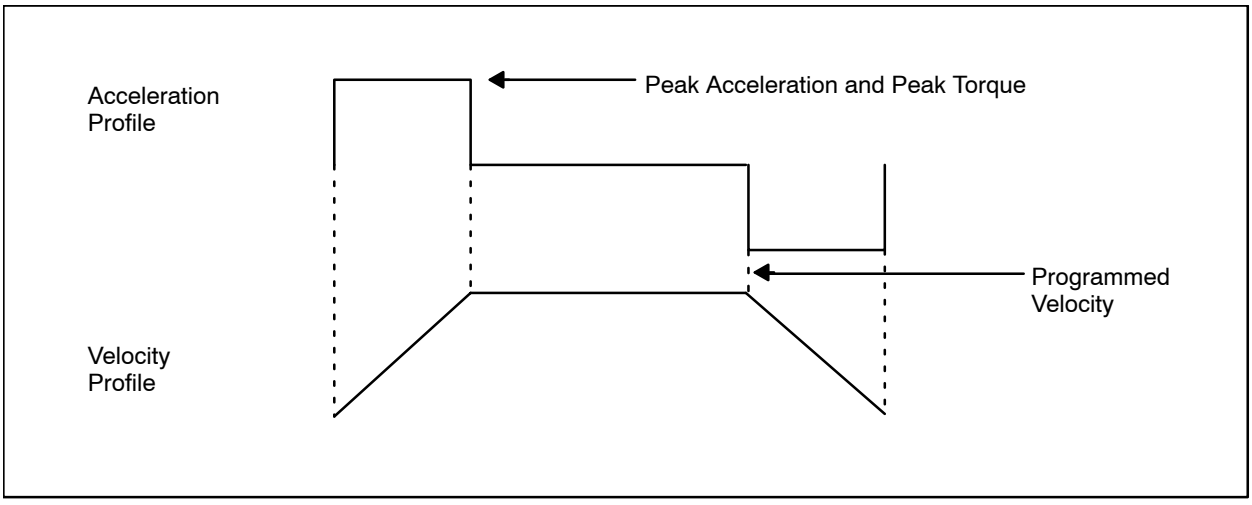
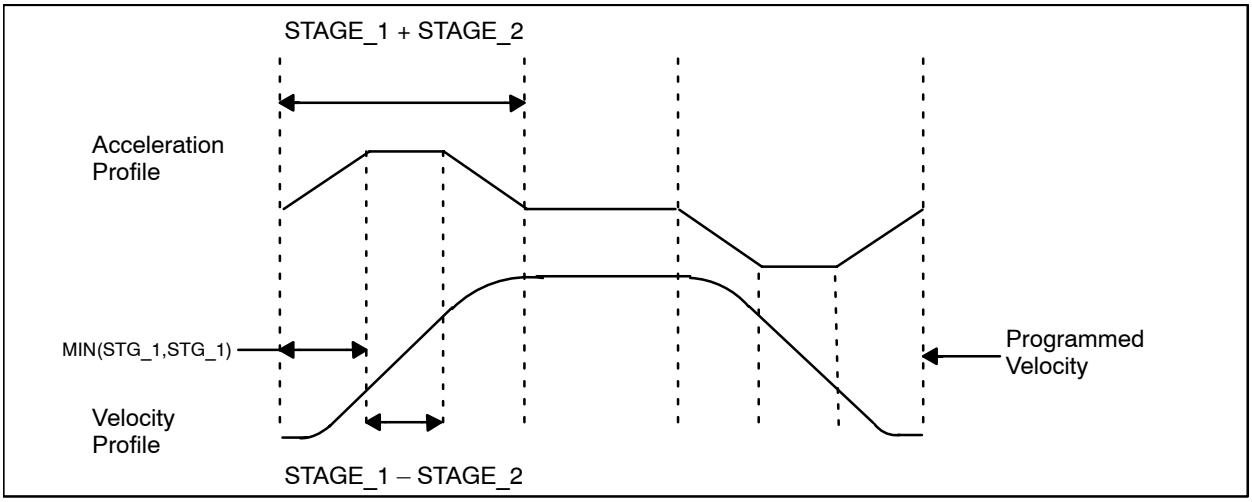


Figure 8–11 shows a desirable compromise between the profiles shown in Figure 8–9 and Figure 8–10 . The first stage is two times the length of the second stage, reducing the peak acceleration, while still maintaining a second order profile over the beginning and end of the acceleration period.

Figure 8–11. Acceleration and Velocity Profile with Stage_1 = 2* Stage_2



For most FANUC Robotics robot models, the default values of the first and second stages of the acceleration/deceleration algorithm are established so that the first stage is twice the second stage in length, but this can vary from model to model. The sum of the two stages is determined so that the maximum acceleration capability is achieved when maximum speed is programmed.

See Also: *FANUC Robotics SYSTEM R-J3iC Controller Software Reference Manual* for system variable descriptions

Acceleration and Deceleration Times

In Figure 8–10 , the velocity profile changes from second order to first order and back to second order during the acceleration period. The time of the straight line portion is the absolute difference in the lengths of the two stages. The times of the curved portions of the profile are each equal to the shorter of the two stage lengths. Acceleration and deceleration times can be calculated using the following:

Total Time = (Stage_1 + Stage_2) (1)

Straight - part Time = (|Stage_1 - Stage_2|) (2)

Curved - part Time = MIN(Stage_1, Stage_2) (3)

(For Cartesian motion, the stage lengths are $GROUP_PARAM[ ].$cart_accel1 and $GROUP_PARAM[ ].$cart_accel2. For joint interpolated motions, the stage lengths are $GROUP_PARAM[ ].$accel_time1[i] and $GROUP_PARAM[ ].$accel_time2[i].)

Peak Acceleration Times

The example in Figure 8–10 , where Stage_2 = 0, is referred to as the constant acceleration case. This also represents the average acceleration of the general case.

The value of the average acceleration is calculated by dividing programmed velocity by total acceleration time:

(4) where A represents average acceleration.

$$A = \frac{\$GROUP[].\$speed}{(Stage_1 + Stage_2)}$$

The average acceleration, ‘‘A’’, can then be multiplied by a ‘‘peak constant’’, Kp, to determine the peak acceleration. Refer to Figure 8–4 .

peak acceleration = Kp * A (5)(6)

$$Kp = \frac{(Stage_1 + Stage_2)}{MAX(Stage_1,\ Stage_2)}$$

For example, if Stage_1 = Stage_2 (Figure 8–9), peak acceleration is double the constant acceleration value or twice the average acceleration. If Stage_1 is two times Stage_2 (Figure 8–11), then peak acceleration is 3/2, or 1.5, times the average acceleration.

8.5.4 Motion Speed

System variables determine the speed of robot motion.

- Speed overrides are scaling constants that allow motion to be executed at slower than programmed speeds.
- For manual motion, the speed is a percentage of a maximum value that is dependent on the robot model.
- For programmed motion, the speed is generally specified in millimeters per second for Cartesian motions and a scaled percent of maximum for joint interpolated motions.
- For Cartesian motion, additional variables are also used to impose limits on the rotational speed for the tool. Rotational speed refers to how fast the TCP rotates and spins (in degrees per second) in order to control the orientation.

Speed Override

For testing or fine tuning a process, speed overrides allow a motion to be executed at a slower speed than the programmed speed without changing the program. Speed overrides are scaling constants that scale all speed values by a percentage.

The system variables $MCR[],$genoverride (general override) and $MCR[],$prgoverride (program override) are both speed overrides. $MCR[],$genoverride can be altered from the teach pendant and from the CRT/KB, but affects both programmed and manual motion. $MCR[],$prgoverride can be altered from a KAREL program, the teach pendant, and from the CRT, and only affects programmed motion.

The two variables are multiplied together to achieve an overall override percentage for programmed motion.

The path value of $CNSTNT_PATH can also affect the execution of a programmed path. When $CNSTNT_PATH is FALSE the filter length is not adjusted meaning the path will vary with the speed override value ($MCR[],$genoverride or $MCR[],$prgoverride.) If $CNSTNT_PATH is TRUE the programmed motion will not be affect by the speed override value.

Manual Motion Speed

The formulas for calculating manual motion speed are different than those used for calculating programmed motion speed.

- Manual motion speed is calculated by multiplying a maximum speed value by the scaling factor $MCR[].$genoverride.
- The maximum speed for each joint for joint interpolation is represented by the array $PARAM_GROUP[].speedlimjnt, multiplied by a limiting factor $SCR_GRP[].$joglim_jnt.
- The maximum speed for Cartesian interpolation is represented by $PARAM_GROUP[].$speedlim multiplied by $MCR[].$genoverride.

The following equations are used to calculate manual motion speed:

Joint Speed (in joint units) equals: (7)

$$\$PARAM_GROUP[i].\$SPEEDLIMJNT * \frac{\$MCR[].\$GENOVERRIDE}{100} * \frac{\$SCR_GRP[i].\$JOGLIM_JNT}{100}$$

Cartesian Translational Speed (in mm/sec) equals: (8)

$$\$PARAM_GROUP[i].SPEEDLIM * \frac{\$MCR[].\$GENOVERRIDE}{100} * \frac{\$SCR_GRP[i].\$JOGLIM}{100}$$

Cartesian Rotational Speed (in mm/sec) equals: (9)

$$\$PARAM_GROUP[i].ROTSPEEDLIM * \frac{\$MCR[].\$GENOVERRIDE}{100} * \frac{\$SCR_GRP[i].\$JOGLIMROT}{100}$$

Programmed Motion Speed

The system variable $GROUP[].$speed governs the translational speed of all programmed motions.

- For Cartesian interpolation, the value of $GROUP[].$speed is the speed of the TCP in millimeters per second. The system variable $PARAM_GROUP[].$speedlim determines the maximum value that can be used for $GROUP[].$speed for Cartesian motions.
- For a single segment motion, the robot accelerates, moves at the programmed speed, $GROUP.$speed, then decelerates to a stop. The average speed of the motion, therefore, is less than the programmed speed.
- In some arm configurations, limits on joint and motor speeds will inhibit the robot from reaching the programmed speed in a Cartesian move. This can also result in the TCP varying from the expected path trajectory.
- For joint interpolation, the value of the system variable $GROUP[].$speed is converted by a conversion constant to a fraction of maximum joint speeds. The conversion constant is $PARAM_GROUP[].$speedlimjnt.
- $PARAM_GROUP[].$speedlimjnt is set so that the average speed of the TCP is approximately the same as the Cartesian speed would be near the center of the working range of the major axis. This conversion constant permits you to assign one value for $SPEED that can be used for both Cartesian and joint motions.
- $PARAM_GROUP[].$speedlimjnt is also the maximum value of $GROUP[].$speed for joint interpolated motions. That is, there is a different maximum value for Cartesian motions than for joint interpolated motions for most robot models, ($PARAM_GROUP[].$speedlim <> $PARAM_GROUP[].$speedlimjnt).

  Consequently, if you always want to move the robot at maximum speeds regardless of motion type, you need to use different values of $SPEED for different motion types.

  For example, the KAREL statement, $GROUP[].$speed = $PARAM_GROUP[].$speedlim, causes all Cartesian motions to run at maximum speed, and the KAREL statement, $GROUP[].$speed = $PARAM_GROUP[].$speedlimjnt, causes all joint motions to run at maximum speed.
- $PARAM_GROUP[].$speedlimjnt can be changed when the robot is installed to be equal to $PARAM_GROUP[].$speedlim so that one value for $SPEED may be used to achieve maximum speed for either joint or Cartesian motions. ($PARAM_GROUP[].$speedlimjnt should not be changed after programs have been written for the system.)
- $PARAM_GROUP[].$speedlimjnt is only a scale factor and consequently has no effect on ultimate joint speed limits. These are determined by $PARAM_GROUP[].$jntvellim, which should not be changed.

  You might also want to change $PARAM_GROUP[].$speedlimjnt so that $GROUP[].$speed is a percent of maximum. This can be achieved by setting $PARAM_GROUP[].$speedlimjnt to 100. However, you should be aware that this will cause drastically different motion speeds for Cartesian and joint motions that use the same value for $GROUP[].$speed.

The following equations are used to calculate programmed motion speed:

Joint Speed equals: (10)

$$\frac{\$GROUP.\$SPEED}{\$PARAM_GROUP.\$SPEEDLIMJNT} * \frac{\$MCR.\$GENOVERRIDE}{100} * \frac{\$MCR.\$PRGOVERRIDE}{100} * PARAM_GROUP.\$JNTVELLIM[i]$$

Cartesian Translational Speed (in mm/sec) equals: (11)

$$\$GROUP.\$SPEED * \frac{\$MCR.\$GENOVERRIDE}{100} * \frac{\$MCR.\$PRGOVERRIDE}{100}$$

Rotational Speed

Normally you are interested in the translation speed of the TCP. However, some motions involve a rotation of the TCP about some fixed point or line, and some motions involve both translation and rotation.

- For Cartesian motion with rotation only, $GROUP[].$speed has little meaning. Because there is no translation, it would theoretically take zero time to move the TCP zero distance regardless of the programmed speed. With no other restrictions, the motion environment would attempt to move the joints infinitely fast.
- For two-angle orientation control, system variable $GROUP[].$rotspeed is defined to limit the ‘‘ROTation’’ speed of the tool around the common normal between the beginning approach vector and the destination approach vector and the ‘‘SPIN’’ speed of the tool around the approach vector during interpolation.
- For three-angle orientation control, the system variable $GROUP[].$rotspeed is used for all three angular speed limits.
- For a Cartesian motion, two speed variables are used, $GROUP[].$speed and $GROUP[].$rotspeed. In the planning for each motion, a segment time is computed based on each of these speeds. The longest time is used as the segment time.
- The system variable $PARAM_GROUP[].$rotspeedlim determines the maximum values that can be used for $GROUP[].$rotspeed.
- If $GROUP[].$rotspeed is set to the same value as $PARAM_GROUP.$rotspeedlim, and if the segment time is determined by this speed value, the following error message will be displayed, "MOTN-056 Speed limits used."
- The two speed values, translational speed $GROUP.$speed and rotational speed, $GROUP.$rotspeed, are both used for the calculation of segment time. The speed which results in the longest segment time determines the dominant motion and that time will be used for the final segment time. This can have the effect of causing one of the speeds ($SPEED or $ROTSPEED) to not be attained. Also, the transitional speed will not be attained in the case of dominant rotational motion.
- The warning "MOTN-056 Speed limits used" is displayed as an indication that the rotational speed is dominant even though the command speed is at the maximum value. This warning is also displayed independent of rotspeed values if time based motion (segtime) is used and the time value would exceed the limit of $PARAM_GROUP.$speedlim or $PARAM_GROUP.$speedlimjnt.

Extended Axis Speed Control

In KAREL extended axes and robot axes move simultaneously, meaning they both start and end at the same time for each motion segment.

The system variable $GROUP[].$ext_speed controls extended axis motion speed control.

- A non-zero value indicates the percentage of maximum extended axis speed to be used for extended axes segment time computation. The default is 100.
- In order to achieve simultaneous motion, the robot motion time is compared with the extended axis segment time during planning. The longer time is used, for both the robot and the extended axis, so that they both reach the destination at the same time.
- If robot motion time is longer than extended axis motion time, the actual extended axes speed will be lower than its programmed value so that robot motion speed is maintained.
- If extended axis motion time is longer than robot motion time, the actual robot speed will be lower than its programmed speed in order to maintain simultaneous motion.
- If there is only extended axis motion but no robot motion, the programmed extended axis speed will be used as specified, even if it could be the default maximum speed.

Other Speed Limits

In Cartesian motions, the TCP moves at a constant speed, meaning the individual joint speeds can vary. During execution of a Cartesian motion, speed limits might be encountered if a particular joint attempts to move too fast, exceeding its speed limits. For example, when moving in a straight line through a singularity point, some axes of a robot move rapidly in an attempt to maintain the straight line.

- Two types of speed limits can be encountered,
  - — Joint speed limits
  - — Motor speed limits
- The values of joint speed limits are stored in the system variable $PARAM_GROUP[].$jntvellim and the values of motor speed limits are stored in $PARAM_GROUP[].$mot_spd_lim.
- The system variable $MCR[].$chk_jnt_spd determines whether or not joint speed limits are used. By default, $MCR[].$chk_jnt_spd is set to TRUE, meaning the joint speeds are checked against the value of $PARAM_GROUP[].$jntvellim.
- If a joint speed limit is encountered, the motion will be slowed down at the point where the limit is reached. All joint speeds are scaled at this point so that the original trajectory is maintained, and the warning message, ‘‘JOINT SPEED LIMIT USED,’’ is issued. The TCP will return to the programmed speed after the joint rate has slowed to below its limit providing that the programmed speed is not so high that the limit is encountered again.
- If a joint speed limit is encountered, the cycle time will be longer than expected, because the motion is slowed down. For programs that are dependent on cycle time, reteaching positions might allow you to avoid the joint speed limits.

- If a motor speed limit is encountered, cycle time is not changed. The motion will be slowed down and the warning message, ‘‘MOTOR SPEED LIMIT USED,’’ will be issued. However, after the motor rate slows to below its limit, the motion speeds up faster than programmed speed to maintain the original cycle time.

Fixed Segment Time

- The $GROUP[].$seg_time system variable can be used to specify a fixed segment time for any motion instead of specifying a program speed. If the value is greater than 0, it will be used as the segment time. If the value is less than or equal to zero, the value of the system variable $GROUP[].$speed will be used to compute the segment time.

  If the speed, that is computed based on the value of $GROUP[].$seg_time, exceeds the maximum speed, a warning message, ‘‘Segment time too short,’’ is displayed and the maximum speed is used. If $GROUP[].$seg_time is specified in a MOVE ALONG path statement, $GROUP[].$speed will control the motion speed to the first node of the path. All subsequent motion segments will be controlled by $GROUP[].$seg_time.

8.5.5 Motion Termination

- Motion termination involves two critical relationships:
  - — One between the motion interval and the actual motion of the robot
  - — One between the motion interval and the program statement that caused that interval
- The motion ‘‘interval’’ is defined to be that part of the motion generated by a single motion statement. The interval, in the absence of any other motion statements, will correspond closely to the actual motion. That is, the robot will start moving at the beginning of the interval, and it will stop moving at or about the same time that the interval terminates. However, several motion statements can be combined to produce one continuous motion. In that case, it is not obvious where one interval ends and the next one begins.
- Interval termination is important to both the program environment and to the motion environment.

  The program environment uses interval termination as the criterion to continue program execution. That is, the interpreter normally will wait at each motion statement for the interval generated by that statement to be completed before going on to the next statement.
- If the NOWAIT clause is used in a motion statement, the interpreter will continue program execution at the beginning of the interval instead of at the end. The motion environment uses interval termination as the criterion for beginning interpolation of the next interval.
- Normally the motion environment determines when a motion interval will be terminated based on the proximity of the robot to its destination position. That is, termination of the actual motion will cause termination of the interval. This is referred to as ‘‘termination based on position.’’

- In some cases, however, a signal from outside the motion environment will cause early or abnormal interval termination. In these cases termination of the interval causes the motion to be terminated. The termination in these cases is referred to as ‘‘abnormal termination.’’

See Also: Section 8.5.6 , ‘‘Multiple Segment Motion’’

Termination Based on Position

When position is used as the criterion for terminating motion, the system variable $TERMTYPE is used to determine when the interval will be terminated based on how close the robot must be to its destination.

- Values for $TERMTYPE are:

  FINE - robot moves to path node and stops before beginning next motion

  COARSE - robot moves to path node and stops before beginning next motion

  NOSETTLE - robot moves close to path node but does not stop before beginning next motion

  NODECEL - robot moves past the path node on its way to next path node without deceleration

  VARDECEL - robot approaches the node and then, at the distance from the path node determined by the value of the deceleration tolerance specified in $DECELTOL, the robot decelerates

- The value can be assigned at the CRT/KB or by executing a KAREL assignment statement. Each time a KAREL program is executed, $TERMTYPE is initialized to COARSE. $TERMTYPE has no effect on manual motions.

  Each value for $TERMTYPE is described briefly in the following list.

  — **COARSE and FINE Tolerances**

    COARSE and FINE are specified as detector pulses in the system variable array $PARAM_GROUP[ ].$stoptol. That is, when all axes are within the specified number of detector pulses from the destination position, the motion environment signals motion interval completion. The effect for both termination types is the same.

  — **NOSETTLE**

    NOSETTLE causes the motion environment to signal interval completion as soon as the deceleration profile is complete. In this case, there is no settling time incurred waiting for the robot to position itself precisely within the FINE or COARSE tolerance.

    You can use this value for $TERMTYPE when it is not important that the robot be precisely in position before subsequent actions are acted upon or motion statements are executed.

  — **NODECEL**

NODECEL is used to permit continuous motion near taught positions. In this case motion interval termination is signaled to the interpreter as soon as the axes begin to decelerate.

— **VARDECEL**

VARDECEL is used to permit variable deceleration. When VARDECEL is specified, you can select a value between NODECEL and NOSETTLE for a deceleration tolerance. When the robot is within the selected deceleration tolerance of the taught position, acceleration toward the next position can begin.

The $GROUP[].$deceltol system variable represents a percentage of the distance to the destination position at the time deceleration begins. $DECELTOL percentages can be set to values from 1 to 99. Any value outside of the range 1 to 99, uses the value in $GROUP[].$deceltol.

Abnormal Interval Termination

A CANCEL operation might be issued to the motion environment when a local condition handler, such as a MOVE statement with an UNTIL clause, is executed and the condition specified in the handler occurs. In this case, the interval is considered completed immediately. The motion environment immediately signals the interpreter and the MOVE statement is terminated.

At the same time, the robot begins to decelerate. Note that in this case the value of $TERMTYPE has no effect on interval termination.

- Motions can be canceled by many conditions including error conditions and those governed by local condition handlers and global condition handlers as well as by the CANCEL statement.
- Two types of CANCEL conditions can occur:
  - Local CANCEL - caused by a local condition handler
  - Global CANCEL - caused by a global condition handler or a CANCEL statement
- The difference between a local CANCEL operation and global CANCEL operation is that pending motion intervals are also canceled by global CANCEL operations, while only the current interval is canceled by a local CANCEL.

Stopping a Motion

STOP causes the motion of the axes to stop. However, it does not cause interval termination. For example, a MOVE statement waiting for interval termination continues to wait. STOP causes the robot to stop moving, but in this case the motion can be resumed. The interval will not terminate until the motion has been resumed and terminated normally.

In this special case it is possible for intervals caused by an interrupt service routine to be processed in the middle of a stopped interval.

A STOP operation can be caused by a STOP statement, STOP action, or an error with STOP or SVAL severity.

8.5.6 Multiple Segment Motion

Multiple segment motion occurs when the robot continues moving as it passes near or through taught positions, thus extending a motion through multiple segments.

For example, continuous path operations such as sealing, arc welding, and painting require this multiple segment motion.

Two primary methods are used for multiple segment motion in the KAREL system:

- **PATH Data Type and MOVE ALONG Statement**

  One method is by using the PATH data type in a MOVE ALONG path statement. In this case, several taught positions can be stored in a single PATH variable. When the MOVE ALONG statement is executed, the motion interval extends over the entire path, which is made up of motion segments joining each of the taught positions.

  See Also: Section 8.5.7 , ‘‘Path Motion,’’ for more information on this method

- **MOVE TO Statements with NODECEL or VARDECEL**

  The second method is by using a sequence of MOVE TO statements with the NODECEL or VARDECEL value for $TERMTYPE. In this case, the interval is terminated as the robot decelerates to the destination position designated in a MOVE TO statement.

  Because interval termination has been signaled to the interpreter, the next motion statement can be immediately executed, and acceleration towards the next taught position begins. That is, deceleration for one segment is overlapped with acceleration for the next segment.

- When multiple segment motion is used, the robot does not pass through the taught positions but passes near them, rounding the corners near the taught positions. The amount by which the taught position is missed depends on the angle between the trajectories of the connecting motion segments and on the programmed speed, $GROUP[].$speed.
- If VARDECEL is used, this amount also depends on the deceleration tolerance specified by $DECELTOL. The VARDECEL termination type is provided so that you can control the distance by which a taught position is missed (at the expense of increased cycle time).
- It is important to remember that with either NODECEL or VARDECEL termination types, the amount of corner rounding is dependent on programmed speed.

Effect of NOWAIT

Using the NOWAIT clause with a motion statement allows you to take advantage of the fact that the motion environment and program interpreter run in parallel.

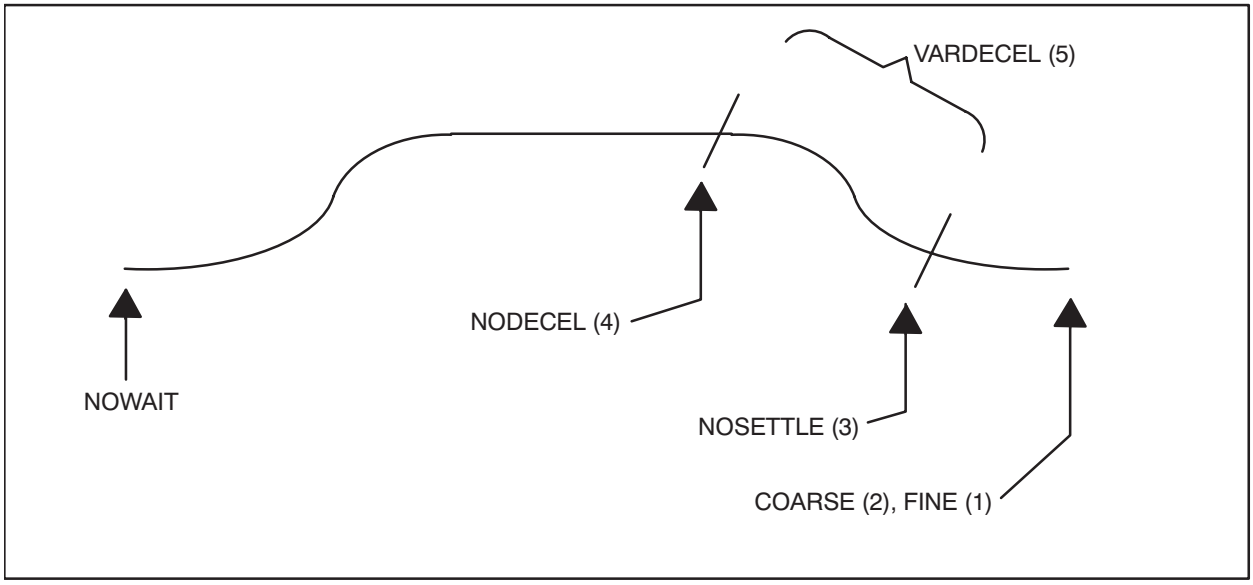
- If you do not use NOWAIT, which is the normal case for simple programs, the interpreter waits at each motion statement for the motion interval for that statement to be completed.

- If you use NOWAIT, the interpreter can continue program execution beyond the current motion statement while the motion environment carries out the motion. The interpreter is permitted to continue at the beginning of the interval instead of at the end of the interval. Because the interpreter waits for each interval to begin, it can execute a motion ahead by at most one motion statement.
- The NOWAIT clause has no effect on how a motion is executed by the motion environment. However, because it has an effect on the timing of subsequent motion statements, NOWAIT can affect the start of planning for succeeding motions and, thus, can have an indirect effect on continuous path motions, as the following paragraphs explain.
- There is always a slight delay between the time the interval completion is signaled and the time that the motion environment can plan and begin executing the next segment. There is also a deceleration in this case before acceleration to the next segment begins.
- If the NOWAIT clause is used in conjunction with the NODECEL termination type, the next motion statement will already have been executed and the next segment planned when the current interval is terminated. Thus, motion along the next segment can begin with no deceleration between intervals. See Figure 8–13 .

Effect of $TERMTYPE on Trajectory

Figure 8–12 shows a motion where the robot is initially stationary, accelerates up to the programmed velocity, and decelerates to a stop. The times in this cycle at which the various termination types ($TERMTYPE) are satisfied are also indicated.

Figure 8–12. Effect of $TERMTYPE on Timing



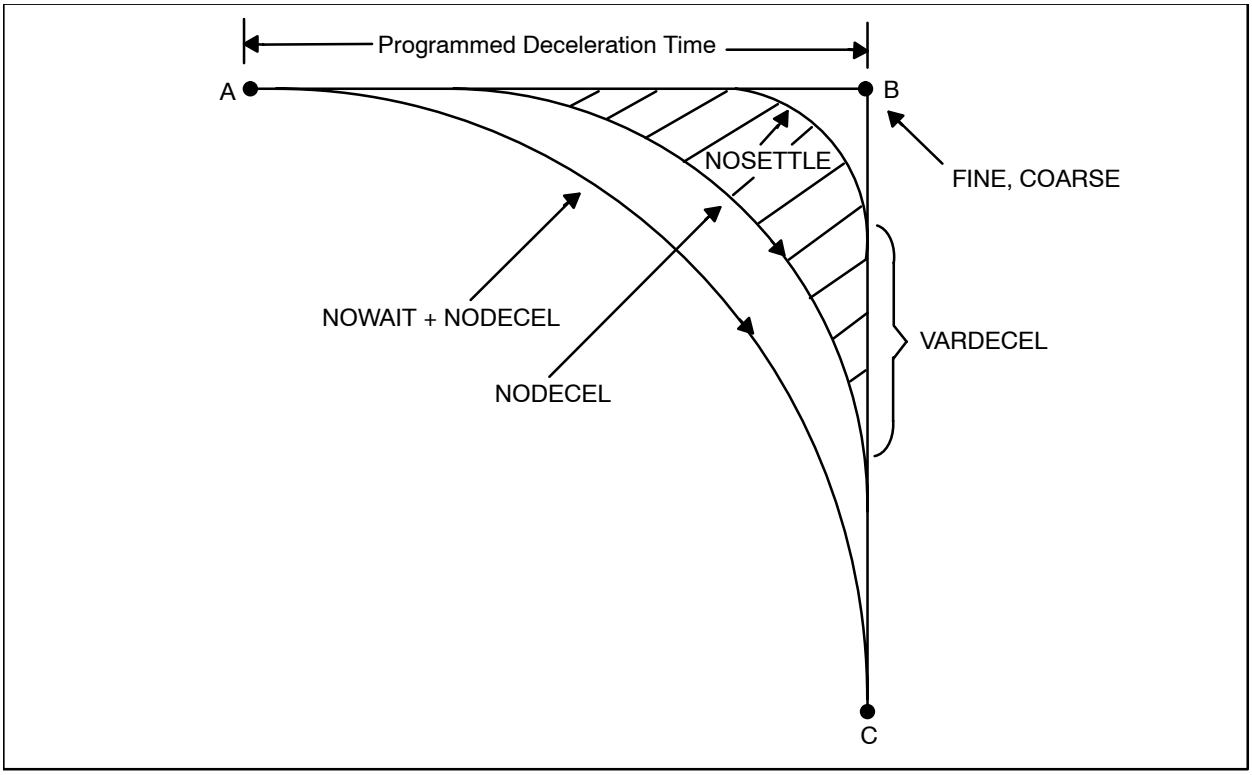
- NOWAIT is not a termination type but indicates the point in the segment at which the interpreter is permitted to continue.

- The following is a section of a test program in which the termination type is set and two consecutive LINEAR moves are made. The motion segments, from the initial position to B and from B to C, are at 90 degrees to each other.

```
$TERMTYPE = ?
-- (FINE | COARSE | NOSETTLE | NODECEL | VARDECEL)
$MOTYPE = LINEAR
MOVE TO B -- add NOWAIT for NOWAIT case
MOVE TO C
```

- This section explains the different values for $TERMTYPE and the uses of the NOWAIT clauses which are also shown in Figure 8–13 .

Figure 8–13. Effect of $TERMTYPE on Path



- For termination types of COARSE and FINE, not only has the deceleration profile been completed but also all axes are within a specified number of detector pulse counts of their destination. The distance corresponding to these pulse counts depends on the type of robot.
- If the termination type is NOSETTLE, the complete deceleration profile will be generated by the software but there still is some lag due to the servo system. The robot will be very close to point B before the MOVE TO C is processed by the interpreter.

- In the case of NODECEL, the interpreter can process the MOVE TO C as soon as deceleration to B starts. There will be a slight delay (from 30 ms to 100 ms depending on robot model) for the next statement to be processed and the interval to begin, but this is small compared to the times required for many FANUC robots to decelerate.
- Some deceleration will occur during this time. This small deceleration will be eliminated if the NOWAIT clause is used with the MOVE TO B statement, as the succeeding statement will be processed and the next segment planned before deceleration begins. The next segment would then begin immediately.

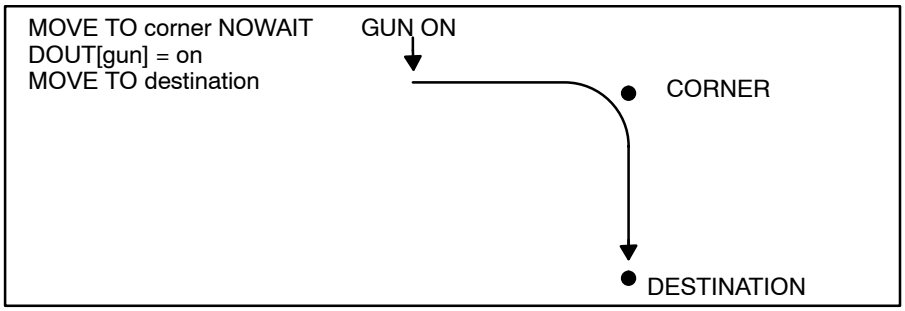
  Figure 8–13 shows that using NODECEL along with NOWAIT will produce maximum corner rounding. Slightly less rounding results if NOWAIT is not used.
- If the termination type VARDECEL is used, corner rounding depends on the value of the system variable $DECELTOL. If a value of 1 is used, the rounding will be nearly equivalent to NODECEL. If a value of 99 is used, the rounding will be nearly equivalent to NOSETTLE. Values in between will yield a trajectory in between those two cases, as indicated by the shaded area in Figure 8–13 .

Program Synchronization

Figure 8–14 , Figure 8–15 and Figure 8–16 show how program synchronization, including digital I/O signals, is affected by termination type, the NOWAIT clause, and local condition handlers.

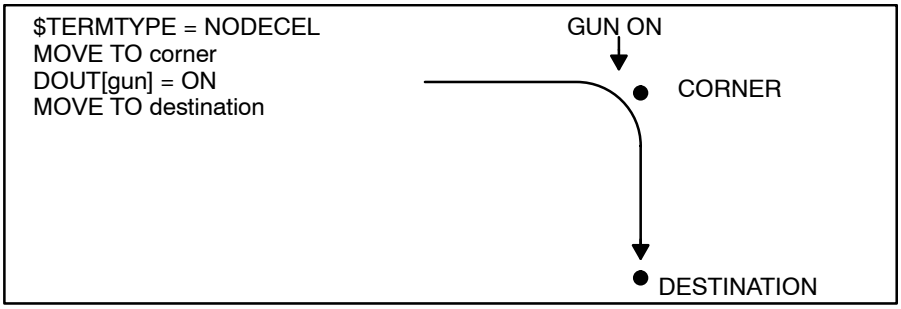
- In Figure 8–14 , because NOWAIT is used, the digital output turns on at the beginning of the motion, even though the digital output statement is placed after the motion statement.

Figure 8–14. NOWAIT Example



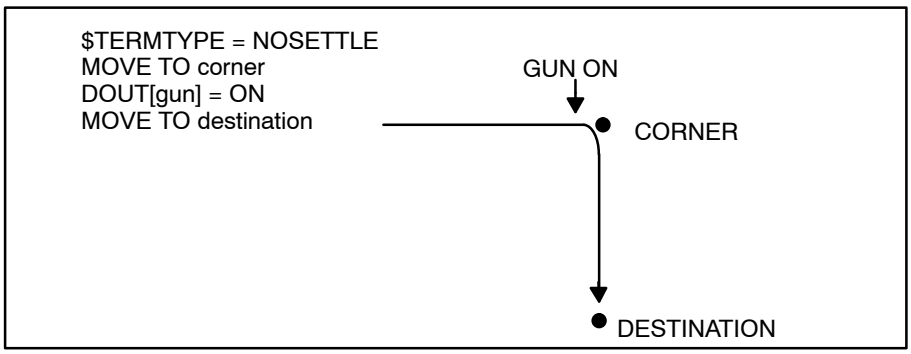
- In Figure 8–15 , the interpreter waits until the interval is terminated before going ahead. With NODECEL, the gun turns on at the beginning of the motion towards DESTINATION, which still occurs well before the robot reaches CORNER.

Figure 8–15. NODECEL Example



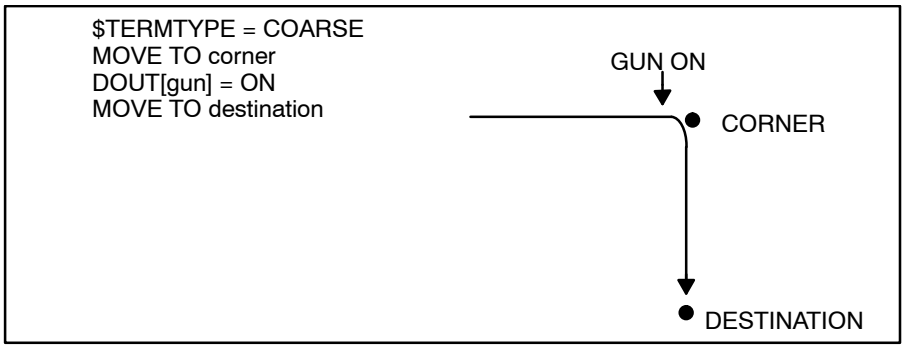
- If VARDECEL is used, the digital output turns on as soon as the deceleration tolerance specified in $DECELTOL is satisfied-somewhere between the NODECEL case of Figure 8–15 and the NOSETTLE case of Figure 8–16 .
- For the NOSETTLE case, the digital output turns on as soon as the controller has finished generating the deceleration profile, and the robot is only the ‘‘servo lag’’ distance from CORNER.

Figure 8–16. NOSETTLE Example



- In Figure 8–17 , the digital output turns on as soon as the controller has finished generating the deceleration profile and all axes are within the COARSE tolerance of being in position.

Figure 8–17. COARSE Example

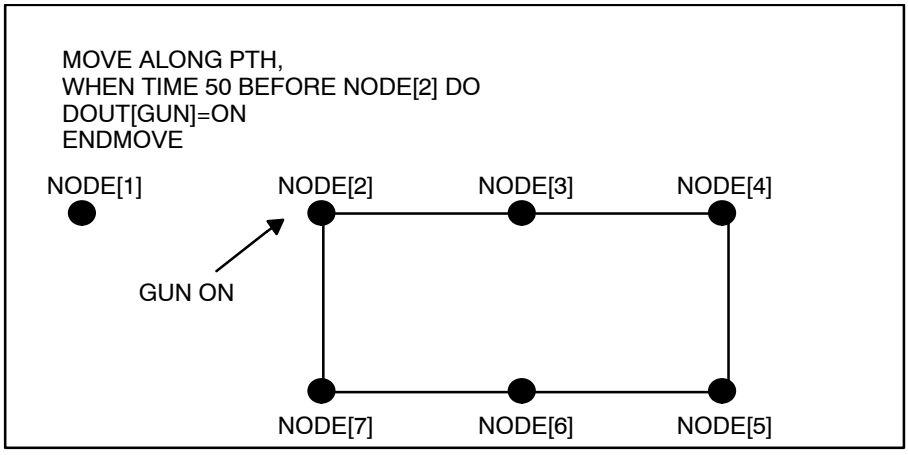


- For the FINE case, all axes are within the FINE tolerance of being in position before the digital output turns on (the closest possible control).

Figure 8–18 shows how to affect program synchronization using local condition handlers.

In Figure 8–18 , the digital output turns on 50 milliseconds before node 2 is reached.

Figure 8–18. Local Condition Handler When Timer Before Example

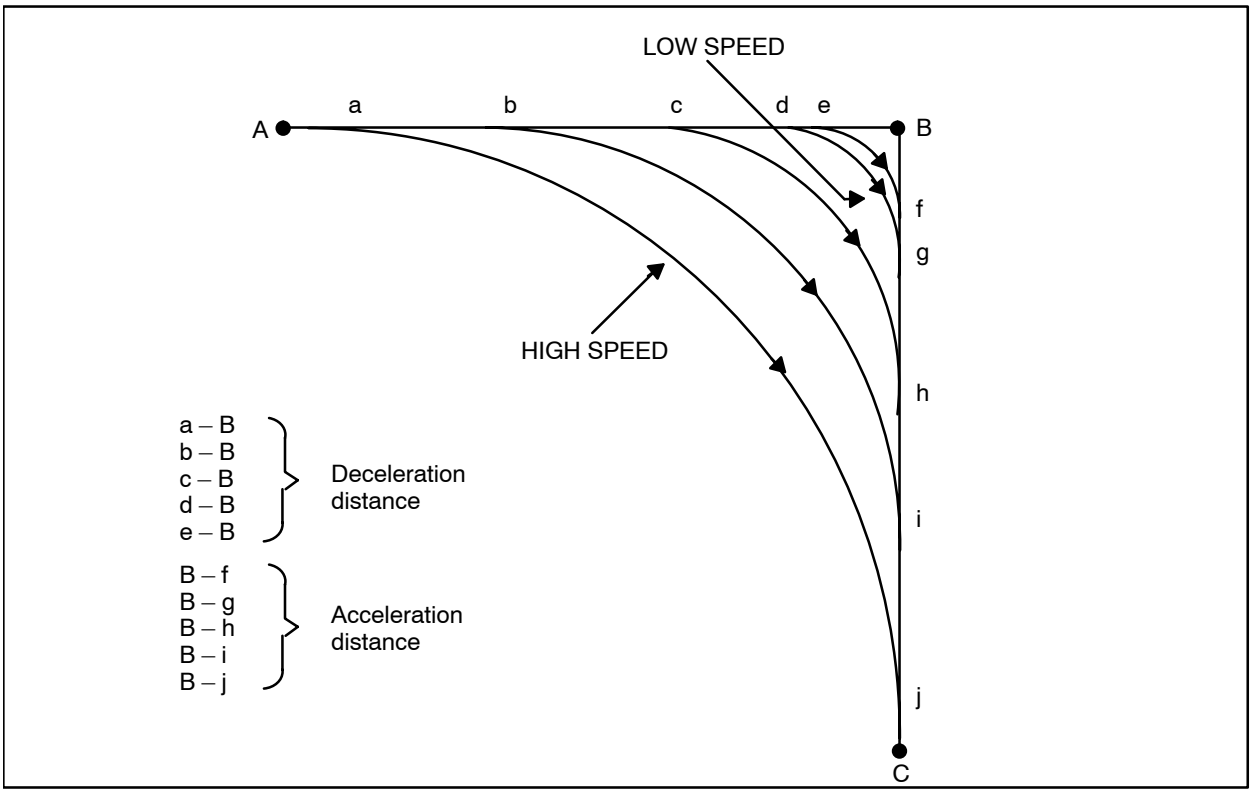


Effect of Motion Speed and Overrides

The main concern with continuous path motion is not that the taught position is missed as a result of the cornering, but that the path taken near the taught position will vary with the programmed speed.

This variation is because the time for acceleration and deceleration between the two segments is constant while the total segment time of the two-segment motion varies with speed. See Figure 8–19 .

Figure 8–19. Effect of Speed on Path



- It is sometimes difficult to teach continuous path positions, because the path generated at production speed is different than the one generated at low speed, making it impossible to see the actual path.
- The speed override feature of KAREL makes this possible, because for speed override, the acceleration times are changed to make acceleration distance constant. This allows you to see the path that will be generated at production speed, while running the robot at reduced speed.
- For special applications, the constant path can be disabled by setting the system variable $CNSTNT_PATH to FALSE.
- When the HOLD key is pressed during playback with speed override, the deceleration distance again is kept constant, keeping the path the same as it would be at production speed. Therefore, the time required to stop the robot is also extended.
- EMERGENCY STOP time is not affected by speed override.

8.5.7 Path Motion

A PATH variable is a varying-length list of elements called path nodes. A path node consists of a position, called NODEPOS, and any associated data.

There are two primary uses of PATH variables:

- As a bookkeeping aid in programming
- For improved performance in continuous path motions

You can define a single PATH variable to include several positions instead of teaching several POSITION variables by name. Then, instead of using a separate MOVE TO statement for each position, a single MOVE TO statement can be used in a loop that indexes through the path nodes.

The following KAREL program statements illustrate the use of a path variable as a bookkeeping aid:

VAR path1 : PATH...FOR i = 1 TO PATH_LEN(path1) MOVE TO path1[i] ENDFOR

- This use of PATH variables saves memory space both because programs can be made shorter and because a single variable name is used instead of many. In addition, it enhances the separation of code and data because positions can be inserted, deleted, and appended without modifying the program.
- For improved performance in continuous path motions, a single PATH variable can be used to create a multiple segment motion in a single MOVE ALONG statement. The motion environment will plan several segments ahead of the current motion of the robot. Any delay between segments is thus minimized and taught position throughput is maximized.
- The MOVE ALONG path statement causes the motion environment to generate a continuous motion through (or near) all the positions in the path by creating a multiple segment motion interval. The beginning of the interval is at the start of the first segment in the path, and the end of the interval is determined by the termination of the last segment of the path.
- The motion type of each segment is controlled by the associated data for the path node. By default, the motion type specified by $MOTYPE is used.
- The termination type for each segment is specified by the SEGTERMTYPE associated data field. The termination type for the last segment is always determined by $TERMTYPE regardless of the value of SEGTERMTYPE.
- A segment termination type, $SEGTERMTYPE, is also defined for paths. This system variable can take on the same values as $TERMTYPE, namely FINE, COARSE, NOSETTLE, NODECEL, and VARDECEL. However, unlike $TERMTYPE, $SEGTERMTYPE is used only by the motion environment to determine when acceleration into the next segment should begin. It has no effect on statement termination.
- With $SEGTERMTYPE set to its default, NODECEL, the path is executed in the same way as one executed by a series of MOVE TO instructions with NOWAIT and NODECEL, with the improvement that taught positions can be spaced more closely without any deceleration near the taught positions.

This improvement is possible because the interpreter does not have to execute intermediate motion statements and the motion environment can plan further ahead.

However, the same continuous path anomalies also exist. Changing program speed will change the path near the taught positions. Circular interpolation with paths can be used to overcome some of these anomalies, as discussed in the following section.

- In a MOVE ALONG statement, either the path name or the path name with an index value of [n..m] can be specified. When the path name is specified, the motion environment executes the entire path from node[1] to node[n]. If a range of nodes is specified, the robot will move along the path from node[n] to node[m].

  If n < m, the robot will move along the path in ascending order. The SEGTERMTYPE and SEGMOTYPE associated data fields from node[i] is used (if other than the default value) for the motion segment toward node[i].

Associated Data

A path node includes other information besides the taught position. This additional information is called *associated data* and is intended to permit teaching additional information which might change at each node without having to program such changes explicitly.

There are two kinds of associated data:

- Group
- Common

The following rules apply to associated data:

- All associated data fields are referenced by name.
- The teach pendant is used to define the names and types of user-defined fields.
- Each node of every path on the system must have the same field definitions. You can then reference these fields by using built-in routines in a KAREL program, using the teach pendant, or by KCL.

The names of the standard fields are listed below.

See Also: The application-specific *FANUC Robotics SYSTEM R-J3iC Controller Setup and Operations Manual* for more information on setting standard and user-defined associated data

Group Associated Data

- Each path node contains a position and at least four fields of group associated data. These fields are used by the motion environment to permit various motion characteristics to be changed at each segment of a path. Each group associated data is group-based.
- These fields are used only during the execution of a path using the MOVE ALONG statement. They are not used when using MOVE TO for individual path nodes.

— SEGRELSPEED allows you to override the SPEED, both higher or lower.

The SEGRELSPEED field is an INTEGER field, representing percentage, with a range of 0 to 4000 (400.0%) that permits a relative multiplier to be applied to the programmed speed for each segment.

For example, if $SPEED were set to 200 mm per second and SEGRELSPEED were set to 500 (50.0%) for node 3 of a path, then the robot would slow down to 50 percent of its set speed or 100 mm per second for the segment toward node 3. Likewise, if SEGRELSPEED were set to 1500 (150.0%) for node 3 of a path, then the robot would speed up 150 percent of its set speed or 300 mm per second for the segment toward node 3.

Even though a maximum of 4000 percent (400.0%) is permitted, the absolute maximums discussed in Section 8.5.4 still apply. Thus if $SPEEDLIM is 1500 for a particular robot and $SPEED is set to 1500, any value larger than 1000 (100.0%) used for SEGRELSPEED will cause a planning error.

The default value of SEGRELSPEED is 0 which is interpreted to mean the same as a value of 1000.

— SEGMOTYPE

The SEGMOTYPE field permits you to change the motion type at each node of a path. This field can be set to the enumerated values JOINT (6), LINEAR (7), or CIRCULAR (8).

The default value will be the value of the system variable, $MOTYPE, which determines the motion type for the overall motion.

See Also: Section 8.5.1 .

— SEGORIENTYPE

The SEGORIENTYPE field indicates the type of orientation control to be used when the LINEAR motion interpolation type is used between segments. It can be assigned the same values that are used for $ORIENT_TYPE. By default, SEGORIENTYPE is set to RSWORLD.

This field can be set to the enumerated values: RSWORLD (1), AESWORLD (2), WRISTJOINT (3).

See Also: Section 8.5.1 .

— SEGBREAK The SEGBREAK field functionality is not yet implemented. If this field is set, it will be ignored.

Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly, personnel could be injured, and equipment could be damaged.

Common Associated Data

- In addition to group associated data, KAREL paths also support common associated data fields. Two common associated data fields are supported. Each field of common associated data applies to all groups.
  - — SEGTERMTYPE

    The SEGTERMTYPE field permits you to change the termination condition for each segment of a path. This field may be set to FINE (1), COARSE (2), NOSETTLE (3), NODECEL (4), or VARDECEL (5), or it may be left uninitialized, which will cause a default value to be used.

    The default value will be the value of the system variable, $SEGTERMTYPE, which is normally NODECEL. The termination type for each segment is specified by the SEGTERMTYPE associated data field. The termination type for the last segment is always determined by $TERMTYPE regardless of the value of SEGTERMTYPE.

    See Also: Section 8.5.5 , "Motion Termination"
  - — SEGDECELTOL

    When the value of the SEGTERMTYPE field is VARDECEL, the SEGDECELTOL field specifies a deceleration tolerance for the segment, within a range of 1 to 99. If it is set to 0, which is the default value, the value of the system variable $DECELTOL is used.
  - — SEGRELACCEL The SEGRELACCEL field functionality is not yet implemented. If this field is set, it will be ignored.
  - — SEGTIMESHFT The SEGTIMESHFT field functionality is not yet implemented. If this field is set, it will be ignored.

8.5.8 Motion Times

To estimate the cycle time of a particular application before actual implementation, you can use the following tables and formulas.

- The formulas can be used for either single or multiple segment motions. Generally, the cycle time for a motion is the sum of all computed segment times plus the time to decelerate at the end of

the motion, plus any settling time. (You can think of the time to accelerate at the beginning of a motion as being part of the computed segment time.)

- The formulas assume that there is no deceleration between segments in multiple segment motions and that FINE or COARSE is used at the end of the motion. If necessary, appropriate adjustments can be made in the formulas.

  For example, if you use NOSETTLE for $TERMTYPE, then there would be no settling time between motions. If you use something other than NODECEL for $SEGTERMTYPE when using paths, then treat each segment as a separate motion.

- The value to use for settling time at the end of a motion depends on many robot dependent variables, but a worst case value of 100 ms would be a conservative estimate for large robots under heavy load.

Table 8–2 defines the symbols that are used in the following formulas. For estimating motion times, values of 100% are assumed for all override and relative speed variables.

Table 8–2. Motion Time Symbols

SYMBOL	MEANING
Ts	Calculated segment time
Tm	Actual motion time
Taccdec	Acceleration or deceleration time (accel + decel = 2 * Taccdec)
Tsettle	Settling time after servo reference is stable
D	Cartesian distance between initial and final position
ROT	Rotation angle of approach vector (two-angle method); rotation angle of all three angles (three-angle method)
SPIN	Spin angle about approach vector
J *i*	Change in angle for *ith* axis from initial to final position

For Cartesian motion: (11)

$$Ts = MAX \left(\frac{D}{\$GROUP.\$SPEED}, \frac{ROT}{\$GROUP.\$ROTSPEED}, \frac{SPIN}{\$GROUP.\$ROTSPEED} \right)$$

For Joint motion: (12)

$$Ts = MAX \left(\frac{Ji}{(\$PARAM_GROUP.\$JNTVELLIM[i] * \frac{\$GROUP.\$SPEED}{\$PARAM_GROUP.\$SPEEDLIMJNT})} \right)$$

For all motions: $Tm = SUM\ (Ts\ for\ all\ segments) + Taccdec + Tsettle$ (13)

Formula 13 indicates that regardless of the distance of a motion, the time to execute that motion is at least Taccdec (not 2 * Taccdec which you might expect), which is normally determined by the times set in the system variables $PARAM_GROUP[].$accel_time1 and $PARAM_GROUP[].$accel_time2.

If a fixed time algorithm were always used for acceleration and deceleration, the minimum motion time would be the fixed acceleration/deceleration time plus the settling time. However, a different algorithm is used for computing Taccdec for short motions.

Short Motions

A short motion is defined as one which is so short that the programmed speed cannot be reached before deceleration must begin. That is, a constant speed is never reached because the robot accelerates, then immediately decelerates.

With the normal constant time acceleration algorithm used in KAREL, as the planned segment time approaches 0, the total motion time approaches a constant equal to that acceleration time. (Refer to Formula 12.)

An ideal algorithm would permit the total motion time to approach 0 as the distance to move approaches 0. This requires a different acceleration algorithm for short motions.

Figure 8–20 indicates the approach taken for short motions. Note that, for the sake of simplicity, the diagrams show first order velocity profiles, when in actuality the second order approach is used for short motions.

Figure 8–20. Short Motions and Long Motions

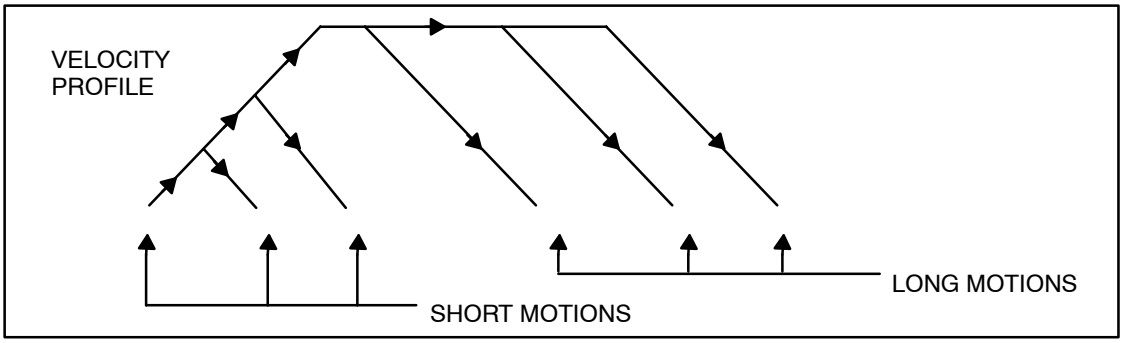


Figure 8–20 indicates that as motions get shorter, the total time gets shorter, which is the general objective.

However, as motion times get shorter, the reference wave forms that drive the robot begin to look like sine waves of higher and higher frequencies. These short pulses begin to excite resonance in the mechanical structure of the robot, in turn causing vibrations.

For this reason, a minimum motion time is imposed. That is, acceleration times get shorter with shorter moves, as the diagram indicates, but only down to a limit. This limit is represented as a minimum acceleration time, kept in the system variable $PARAM_GROUP[ ].$min_acctime[].

As the diagram indicates, the total actual motion time for short motions is twice the computed acceleration time.

Another way of looking at it is that the acceleration and deceleration times are shortened from their fixed time values to be the same as the computed segment time Ts. The short motion algorithm is imposed when Ts is less than the fixed time acceleration/deceleration times.

The formulas for calculating Short Motion Times are as follows:

For short motion: *Ts = (same computations as long motion)* (14)

However, Ts is no shorter than dictated by $PARAM_GROUP[ ].$min_acctime[]

(Ts>$PARAM_GROUP[].$min_acctime[] (15)

Taccdec = Ts (16)

Tm = Ts+ Taccdec + Tsettle) (17)

(same formula as long motion) or

*Tm = (2*Ts) + Tsettle* (18)

Note that the value of $PARAM_GROUP[].$min_acctime[] is a ‘‘total acceleration time.’’ For long motions, the total acceleration time is the sum of $PARAM_GROUP[].$accel_time1[] and $PARAM_GROUP[].$accel_time2[], as discussed earlier. In general then, the value of $PARAM_GROUP[].$min_acctime[] is less than the sum of $PARAM_GROUP[].$accel_time1[] and $PARAM_GROUP[].$accel_time2[]. in no case should it ever be greater than the sum.

8.5.9 Correspondence Between Teach Pendant Program Motion and KAREL Program Motion

The motion control functions that are supported both in the $GROUP system variable and in the teach pendant motion instruction use the value that is specified in the teach pendant motion instruction. Table 8–3 shows the relationship between the $GROUP system variables used for KAREL program motion and the teach pendant motion instruction.

Table 8–3. Correspondence between $GROUP System Variables and Teach Pendant Motion Instructions

KAREL System Variable	Teach Pendant Motion Instruction
$GROUP.$motype	Motion type
$GROUP.$speed	Speed - mm/sec, cm/min, inch/min
$GROUP.$rotspeed	Speed - deg/sec
$GROUP.$seg_time	Speed - sec
$GROUP.$termtype	Termination type
$GROUP.$orient_type	Wrist joint motion option
$GROUP.$accel_ovrd	Acceleration override (ACC) motion option
$GROUP.$ext_indep	Simultaneous/independent EV motion option
$GROUP.$ext_speed	Simultaneous/independent EV motion option
$GROUP.$cnt_shortmo	PTH motion option

The single value of the speed field in the teach pendant motion instruction can take on the function of three system variables:

- If **translational speed (mm/sec, cm/min, inch/min)** is specified, then the rotational speed ($GROUP.$rotspeed) is set to $PARAM_GROUP.$rotspeedlim. The resulting motion is limited first by the command translational speed and second by the rotational speed limit.
- If **rotational speed (deg/sec)** is specified, then the translational speed ($GROUP.$speed) is set to $PARAM_GROUP.$speedlim. The resulting motion is limited first by the command rotational speed and second by the translational speed limit.
- If **time-based motion (sec)** is specified, then the translational speed limit uses $PARAM_GROUP.$speedlim (or $PARAM_GROUP.$jntvellim for joint motion) and $PARAM_GROUP.$rotspeedlim as speed limits. This is similar to how KAREL programs handle time-based motion.

Refer to the *SYSTEM R-J3iC Controller Software Reference Manual* for more detailed information on system variables.

Chapter 9

FILE SYSTEM

Contents

Chapter 9	FILE SYSTEM	9–1
9.1	OVERVIEW	9–2
9.2	FILE SPECIFICATION	9–3
9.2.1	Device Name	9–3
9.2.2	File Name	9–4
9.2.3	File Type	9–5
9.3	STORAGE DEVICE ACCESS	9–6
9.3.1	Overview	9–7
9.3.2	Memory File Devices	9–13
9.3.3	Virtual Devices	9–14
9.3.4	File Pipes	9–15
9.4	FILE ACCESS	9–20
9.5	FORMATTING XML INPUT	9–20
9.5.1	Overview	9–20
9.5.2	Installation Sequence	9–21
9.5.3	Example XML File	9–21
9.5.4	Example KAREL Program Referencing an XML File	9–22
9.5.5	Parse Errors	9–24
9.6	MEMORY DEVICE	9–25

9.1 OVERVIEW

The file system provides a means of storing data on CMOS RAM, FROM, or external storage devices. The data is grouped into units, with each unit representing a file. For example, a file can contain the following:

- Source code statements for a KAREL program
- A sequence of KCL commands for a command procedure
- Variable data for a program

Files are identified by file specifications that include the following:

- The name of the device on which the file is stored
- The name of the file
- The type of data included in the file

The KAREL system includes five types of storage devices where files can be stored:

- RAM Disk
- FROM Disk
- IBM PC
- Memory Card
- USB Memory Stick Device

RAM Disk is a portion of SRAM (formerly CMOS RAM) or DRAM memory that functions as a separate storage device. Any file can be stored on the RAM Disk. RAM Disk files should be copied to disks for permanent storage.

FROM Disk is a portion of FROM memory that functions as a separate storage device. Any file can be stored on the F-ROM disk. However, the hardware supports a limited number of read and write cycles. Therefore, if a file needs to store dynamically changing data, the RAM disk should be used instead.

IBM PC or compatible computers can be used to store files off-line. You can use OLPC, the FANUC Robotics off-line storage software for the PC, to store files on an external storage device. The files on these storage devices are accessible in the following ways:

- Through the FILE menu on the teach pendant and CRT/KB
- Through KAREL programs

Memory Card refers to the ATA Flash File storage. The memory card interface is located on the MAIN CPU.

For more information on storage devices and memory, refer to Section 9.3.1 .

USB Memory Stick Device supports a USB 1.1 interface. The USB Organization specifies standards for USB 1.1 and 2.0. Most memory stick devices conform to the USB 2.0 specification for operation and electrical standards. USB 2.0 devices as defined by the USB Specification must be backward compatible with USB 1.1 devices.

However, FANUC Robotics does not support any security or encryption features on USB memory sticks. The controller supports most widely-available USB Flash memory sticks from 32MB up to 1GB in size. The USB interface is located on the controller operator panel.

9.2 FILE SPECIFICATION

File specifications identify files. The specification indicates:

- The name of the device on which the file is stored, refer to Section 9.2.1 .
- The name of the file, refer to Section 9.2.2 .
- The type of data the file contains, refer to Section 9.2.3 .

The general form of a file specification is:

device_name:file_name.file_type

9.2.1 Device Name

A device name consists of at least two characters that indicate the device on which a file is stored. Files can be stored on RAM disk, F-ROM disk, disk drive units, off-line on a PC, Memory Card, or PATH Composite Device. The device name always ends with a colon (:). The following is a list of valid storage devices.

- **RD: (RAM Disk)**

  The RD: device name refers to files stored on the RAM Disk of the controller. RD: is used as the default device name.

- **FR: (F-ROM Disk)**

  The FR: device name refers to files stored on the F-ROM disk of the controller.

- **MC: (Memory Card Device)**

  The memory card can be formatted and used as an MS-DOS file system. It can be read from and written to on the controller and an IBM PC equipped with the proper hardware and software. If the memory card is used as an MS-DOS file system, it should be formatted only on the R-J3iC controller. Refer to the application-specific *FANUC Robotics SYSTEM R-J3iC Controller Setup and Operations Manual* for information on formatting the memory card on the R-J3iC controller.

- **UD1: (USB Memory Stick Device)**

  The USB memory stick can be formatted and used as an MS-DOS file system. It can be read from and written to on the controller and an IBM PC equipped with the proper hardware and software. If the USB memory stick is used as an MS-DOS file system, it should be formatted only on the R-J3iC controller. Refer to the application-specific *FANUC Robotics SYSTEM R-J3iC Controller Setup and Operations Manual* for information on formatting the USB memory stick on the R-J3iC controller.

- **MD: (Memory Device)**

  The memory device treats the controller's program memory as if it were a file device. You can access all teach pendant programs, KAREL programs, KAREL variables, system variables, and error logs that are loaded in the controller. See Section 9.6 for further details.

- **MDB: (Memory Device Backup)**

  The memory device backup device (MDB:) allows the user to copy the same files as provided by the Backup function on the File Menu. This allows the user to back up the controller remotely.

- **CONS: (Console Device)**

  The console device provides access to the console log text files CONSLOG.LS and CONSTAIL.LS. It is used for diagnostic and debug purposes and not as a storage device.

- **MF: (Memory File Device)**

  The MF: device name refers to files stored on both the RAM and F-ROM disks. Since a file cannot be on both disks at the same time, there will be no duplicate file names.

- **PATH: (Composite Device)**

  The PATH: device is a read-only device that searches the F-ROM disk (FD:), memory card (MC:0, and floppy disk (FLPY:) in that order, for a specified file. The PATH: device eliminates the user's need to know on which storage device the specified file exists.

- **PIP: (File Pipe Device)**

  The PIP: device provides a way to write data from one application and, at the same time, read it from another application. The PIP: device also allows the last set of data written to be retained for analysis. The PIP: device allows you to access any number of pipe files. This access is to files that are in the controller's memory. This means that the access to these files is very efficient. The size of the files and number of files are limited by available controller memory. This means that the best use of a file pipe is to buffer data or temporarily hold it.

9.2.2 File Name

A file name is an identifier that you choose to represent the contents of a file.

The following rules apply to file names:

- File names are limited to eight characters.
- Files should be named according to the rules defined in Section 2.1.4 .

9.2.3 File Type

A file type consists of two characters that indicate what type of data a file contains. A file type always begins with a period (.). Table 9–1 is an alphabetical list of each available file type and its function.

Table 9–1. File Type Descriptions

File Type	Description
.BMP	**Bit map files** contain bit map images used in robot vision systems.
.CF	**KCL command files** are ASCII files that contain a sequence of KCL commands for a command procedure.
.CH	**Condition handler files** are used as part of the condition monitor feature.
.DF	**Default file** are binary files that contain the default motion instructions for each teach pendant programming.
.DG	**Diagnostic files** are ASCII files that provide status or diagnostic information about various functions of the controller.
.DT	**KAREL data file** An ASCII or binary file that can contain any data that is needed by the user.
.IO	**Binary files** that contain I/O configuration data - generated when an I/O screen is displayed and the data is saved.
.KL	**KAREL source code files** are ASCII files that contain the KAREL language statements for a KAREL program.
.LS	**KAREL listing files** are ASCII files that contain the listing of a KAREL language program and line number for each KAREL statement.
.MN	**Mnemonic** program files are supported in previous version s of KAREL.
.ML	**Part model files** contain part model information used in robot vision systems.
.PC	**KAREL p-code files** are binary files that contain the p-code produced by the translator upon translation of a .KL file.

Table 9–1. File Type Descriptions (Cont'd)

File Type	Description
.SV	**System files** are binary files that contain data for tool and user frames (SYSFRAME.SV), system variables (SYSVARS.SV), mastering (SYSMAST.SV), servo parameters (SYSSERVO.SV), and macros (SYSMACRO.SV).
.TP	**Teach pendant program files** are binary files that contain instructions for teach pendant programs.
.TX	**Text files** are ASCII files that can contain system-defined text or user-defined text.
.VR	**Program variable files** are binary files that contain variable data for a KAREL program.
.VA	**ASCII variable files** are contain the listing of a variable file with variable names, types, and contents.
.LS	**Listing files** are teach pendant programs, error logs, and description histories in ASCII format.

9.3 STORAGE DEVICE ACCESS

The KAREL system can access only those storage devices that have been formatted and mounted. These procedures are performed when the devices are first installed on the KAREL system.

The following rules apply when accessing storage devices:

- Formatting a device
  - — Deletes any existing data on the device. For example, if you format RD2:, you will also reformat any data existing on RD: thru RD7:.
  - — Records a directory on the device
  - — Records other data required by the KAREL system
  - — Assigns a volume name to the device

For more information on formatting a device, refer to the FORMAT_DEV Built-in in Appendix A , "KAREL Language Alphabetical Description" or the FORMAT Command in Appendix C , "KCL Command Alphabetical Description."

9.3.1 Overview

The following kinds of storage devices can be used to store programs and files:

- Memory Card (MC:)
- USB Memory Stick Device (UD1:)
- Flash File Storage disk (FR:)
- RAM Disk (RD:) (Not for SpotTool+)
- Ethernet Device (optional)
- Memory Device (MD:)
- Memory Device Binary (MDB:)
- MF Device (MF:)
- Filtered Memory Device (FMD:)

This section describes how to set up storage devices for use. Depending on the storage device, this can include

- Setting up a port on the controller
- Connecting the device to the controller
- Formatting a device

Memory Card (MC:)

The controller supports memory cards. Memory cards support various sizes 8MB or higher. Compact Flash PC cards are also supported if used with a suitable compact adapter. The memory card requires a memory card interface which is standard on Main CPU inside the controller.

Note The controller supports loading software from memory cards.



Warning

Lethal voltage is present in the controller WHENEVER IT IS CONNECTED to a power source. Be extremely careful to avoid electrical shock. HIGH VOLTAGE IS PRESENT at the input side whenever the controller is connected to a power source. Turning the disconnect or circuit breaker to the OFF position removes power from the output side of the device only.

Warning

The memory card interface is located on the Main CPU on an R-J3*i*C controller cabinet. When the power disconnect circuit breaker is OFF, power is still present inside the controller. Turn off the power disconnect circuit breaker before you insert a memory card into the memory card interface; otherwise, you could injure personnel.

Caution

Do not remove the memory card when the controller is reading or writing to it. Doing so could damage the card and lose all information stored on it.

The memory card can be formatted on the controller, and can be used as a load device to install software.

Note Data on all internal file devices such as FR:, RD:, and MD: should be backed up to external file device such as ATA Flash PC card.

Note FANUC Robotics recommends that you use a memory card formatted on an R-J3*i*C controller. The controller formats the card with a sector size of 512 bytes. A PC will also format with a sector size of 2048 bytes if it has the proper driver defaults.

The memory card can be formatted and used as an MS-DOS file system. It can be read from and written to the controller and an IBM PC equipped with the proper hardware and software. If the memory card is used as an MS-DOS file system, it should be formatted on the R-J3*i*C controller.

The controller can read and write memory cards that are formatted with FAT or FAT32 type of formatting (File Access Tables). When a memory card is formatted on the Controller it is formatted as FAT type.

The FAT32 format (32 Bit FAT) removes a few limitations that are included with FAT. One of these is the limitation that only 512 files can be created in the Root directory. Another is that FAT format type only supports memory cards up to 2 GB in size. This feature is included in the controller to increase the compatibility of the Robot Controller with other computer systems.

USB Memory Stick Device (UD1:)

The R-J3*i*C Controller USB memory stick interface supports a USB 1.1 interface. The USB Organization specifies standards for USB 1.1 and 2.0. Most memory stick devices conform to the USB 2.0 specification for operation and electrical standards. USB 2.0 devices as defined by the USB Specification must be backward compatible with USB 1.1 devices. However, FANUC Robotics does not support any security or encryption features on USB memory sticks. The controller supports most widely-available USB Flash memory sticks from 32MB up to 1GB in size.

Note Generally the larger the size of the device such as a USB memory stick, the slower the access speed and device performance.

The USB Memory Stick Device requires a USB interface which is standard on the controller.

The USB memory stick device can be formatted on the controller, and can be used as a load device to install software.



Caution

Do not remove the memory stick when the controller is reading or writing to it. Doing so could damage the memory stick and lose all information stored on it.

Flash File Storage Disk (FR:)

Flash File Storage Disk is a portion of FROM memory that functions as a separate storage device. Flash file storage disk (FR:) does not require battery backup for information to be retained. You can store the following information on Flash file storage disk:

- Programs
- System variables
- Anything you can save as a file

You can format the Flash file storage disk. The size of the Flash file storage disk is set by the system at software installation. Due to the nature of FROM, each time you copy or save a file to the FR: there will be a drop in available FR: memory, even if you are working with the same file. Periodic purging will recover the lost space.

RAM Disk (Not for SpotTool+)

RAM Disk is a portion of Static RAM (SRAM) or DRAM memory that functions as a separate storage device. Any file can be stored on the RAM Disk. RAM Disk files should be copied to disks for permanent storage.

The location and size of the RAM disk (RD:) depends on the value of the system variable $FILE_MAXSEC. The default value of $FILE_MAXSEC depends on the options and tool packages that are installed.

The value in $FILE_MAXSEC represents the memory size allocated for RD: in 512 byte sectors. For example, a value of -128 means that 64K of memory is allocated in DRAM for RD:.

- If **$FILE_MAXSEC > 0** , then RAM disk is defined to be in the PERM pool of SRAM. Because RAM disk is a portion of SRAM, copy all RAM disk files to magnetic disks for permanent storage to prevent losing information due to loss of battery power or system software loading.

SRAM is battery-backed volatile memory. This means that all information in SRAM, including programs, requires battery backup for information to be retained when the controller is turned off and then on again. Teach pendant programs are automatically stored in the TPP pool of SRAM when you write a program.

> **Caution**
>
> Data in SRAM can be lost if the battery is removed or loses its charge, or if new system software is loaded on the controller. To prevent loss of data, back up or copy all files to permanent storage devices such as FR: or ATA Flash PC memory cards.

- If **$FILE_MAXSEC < 0** , then RAM disk is defined to be in DRAM.

  DRAM is non-battery-backed volatile memory. This means that all information in DRAM disappears between power cycles. In effect, DRAM is a temporary device. Information stored in DRAM is lost when you turn off the controller.

> **Caution**
>
> Data in DRAM will be lost if you turn off the controller or if the controller loses power. Do not store anything you want to save beyond the next controller power cycle in DRAM, otherwise, you will lose it.

Note Volatile means the memory is lost when power is disconnected. Non-volatile memory does not require battery power to retain.

You can store anything that is a file on the RAM Disk. The RAM disk is already formatted for you.

Information stored on RAM disk can be stored as compressed or uncompressed. By default, information is compressed. If you want information to remain uncompressed, you must use the **RDU:** device designation to indicate that information will be saved to that device in an uncompressed file format.

FTP Ethernet Device

FTP Ethernet devices are used to copy files from the controller to the network PC or workstation if the FTP option is installed. The client devices displayed are the client devices that have been defined and started. Refer to the *SYSTEM R-J3iC Internet Options Setup and Operations Manual* for more information.

Memory Device (MD:)

The memory device (MD:) treats the controller's program memory as if it were a file device. You can access all teach pendant programs, KAREL programs, and KAREL variables loaded in the controller.

The Memory Device is a group of devices (MD:, MDB:, and optionally FMD:) that provide the following :

- MD: provides access to ASCII and binary versions of user setup and programs
- MDB: provides access to binary versions of user setup and programs (similar to "backup - all of the above" on the teach pendant file menu)
- FMD: provides access to ASCII versions of user setup and programs filtered to include only user settable information (eg. internal timers or time system variables changed by the system are not included) making these files useful for detecting user changes.

Memory Device Binary (MDB:)

The memory device binary device (MDB:) allows you to copy the same files as provided by the Backup function on the File Menu. This allows you to back up the controller remotely such as from SMON, FTP, or KCL. For example, you could use the MDB: device to copy all teach pendant files (including invisible files) to the memory card (KCL>copy MDB:*.tp TO mc:).

MF Device (MF:)

MF: is a composite device that will search the RAM Disk (RD:) and flash file storage disk (FR:) devices, in that order, for a specified file. MF: eliminates your need to know the name of the device that contains the file you specify. For example, "DIR MF:file.ext" will search for the file first on RD:. If it is not found, it will search for the file on FR:. Also, "COPY MC:file.ext to MF" will place the file on RD:.

When files are copied to the MF: device, the RAM Disk is used by default if RD: is in SRAM($FILE_MAXSEC > 0). The Flash ROM disk is used by default if RD: is in DRAM ($FILE_MAXSEC < 0).

Note When you are backing up files, the MF: device will prompt you to select either FR: or the RD: device. The files will be copied to the device that you selected even if RD: is in DRAM.

Filtered Memory Device (FMD:)

The Filtered Memory Device option generates text versions of all backup files of user programs and variables that have been changed manually. Included are system and KAREL variables, position and data registers, teach pendant programs, and I/O configuration data.

When logging into the robot FTP server from a remote client you are defaulted into the MD: device. You can navigate to other robot file devices (FR:, RD:, MC:, MDB:, FMD:) using the change directory

service in your remote FTP client. At a command line using the *cd* command where in this example fmd: is the device being used, this might look like :

```
D:\temp>ftp pderob029
Connected to pderob029.frc.com
220 R-J3 FTP server ready.  [PaintTool V6.22-1L]
User <pderob029.frc.com:<none>>:
230 User logged in [NORM].
ftp>cd fmd:
250 CWD command successful.
ftp>
```

You can compare these files with previous versions to determine what users or operators have changed. Variables and programs that change without user input are filtered out, and will appear in filter exclusion files.

After the option is installed, it will run automatically whenever you perform an Ethernet backup of the controller from the FMD: device. After you install the Filtered Memory Device option, any of the following filter exclusion files could appear on the FR: device.



Caution

Do not delete these files, or filter exclusion data will be lost.

- FR:SVAREEG.DT
- FR:KVAREEG.DT
- FR:POSREEG.DT
- FR:REGEEG.DT
- FR:TPLINEEG.DT

You can view program, variable, or filter exclusion files via KCL. For example:

```
KCL> DIR FMD:*.*.
```

Note Computer systems that perform periodic backups could be modified to use the FMD: device instead of the MD: device for some compare operations, for example. Contact FANUC Robotics for more information.

9.3.2 Memory File Devices

The RAM and F-ROM disks allocate files using blocks. Each block is 512 bytes.

The system variable $FILE_MAXSEC specifies the number of blocks to allocate for the RAM disk. If the specified number is less than zero, the RAM disk is allocated from DRAM. If it is greater than zero, RAM disk is allocated from CMOS RAM. To change the number of blocks to allocate for the RAM disk, perform the following steps from the KCL prompt:

1. Backup all files on the RAM disk. For more information on how to back up files, refer to Chapter 8, "Program and File Manipulation" in the appropriate application-specific *FANUC Robotics SYSTEM R-J3iC Controller HandlingTool Setup and Operations Manual* .
2. Enter DISMOUNT RD:

```
KCL>DISMOUNT RD:
```

3. Enter SET VAR $FILE_MAXSEC

```
KCL>SET VAR
$FILE_MAXSEC = <new value>
```

4. Enter FORMAT RD:

```
KCL>FORMAT RD:
```

   All files will be removed from the RAM Disk when the format is performed.

5. Enter MOUNT RD:

```
KCL>MOUNT RD:
```

The RAM disk will be reformatted automatically on INIT start.

The F-ROM disk can only be formatted from the BootROM because the system software also resides on F-ROM. The number of blocks available is set by the system. The hardware supports a limited number of read and write cycles, so while the F-ROM disk will function similar to the RAM disk, it does not erase files that have been deleted or overwritten.

After some use, the F-ROM disk will have used up all blocks. At that time, a purge is required to erase the F-ROM blocks which are no longer needed. For more information on purging, refer to the PURGE_DEV Built-in in Appendix A , "KAREL Language Alphabetical Descriptions" or the PURGE Command in Appendix C , "KCL Command Alphabetical Description."

For more information on memory, refer to Section 1.4.1 .

9.3.3 Virtual Devices

KAREL Virtual Devices are similar to DOS subdirectories. For example

- In DOS, to access a file in a subdirectory, you would view **FR:\FR1:\>test.kl** .
- In KAREL, to access the same file in a virtual device, you would view **FR1:test.kl** .

The controller supports 7 virtual devices. A number, which identifies the virtual device, is appended to the device name (FR **1** :). Table 9–2 shows some of the valid virtual devices available.

Table 9–2. Virtual Devices

Device Name	Actual Storage
RD:	RAM disk
FR:	F-ROM disk - compressed and uncompressed files
MF:	Refers to files on both RD: and FR:
RD1: - RD7:	RAM disk - compressed and uncompressed files
FR1: - FR7:	F-ROM disk - compressed and uncompressed files
MF1: - MF7:	Refers to files on both the RAM disk and F-ROM disk of the respective virtual device

Rules for Virtual Devices

The following rules apply to virtual devices.

- A file name on a virtual device is unique. A file could exist on either the RAM or F-ROM disks, but not both. For example: RD:test.kl and FR:test.kl could not both exist.
- A file name could be duplicated across virtual devices. For example: RD:test.kl, RD1:test.kl, and FR2:test.kl could all exist.
- The MF: device name could be used in any file operation to find a file on a virtual device, when the actual storage device is unknown. For example: MF:test.kl finds either RD:test.kl or FR:test.kl.
- When you use the MF: device as a storage device, the RAM disk is used by default when RD: is in CMOS and $FILE_MAXSEC > 0. The F-ROM disk is used by default when RD: is in

DRAM and $FILE_MAXSEC < 0. For example: KCL>COPY FILE FLPY:test.kl to MF2 **:** The file will actually exist on RD2:

- When listing the MF: device directory, all files on the RAM and F-ROM disks are listed. However, only the files in the specified virtual device are displayed.
- If the RD5: directory is specified instead of MF5:, only those files on the RAM disk in virtual device 5 are listed. If the FR3: directory is specified, only those files on the F-ROM disk in virtual device 3 are listed. For example: KCL>DIR RD5:
- A file could be copied from one virtual device to another virtual device. A file could also be copied from the RAM disk to the F-ROM disk, and vice versa, if the virtual device is different. For example: KCL>COPY RD1:test.kl to FR3:
- A file could be renamed only within a virtual device and only on the same device. For example: KCL>RENAME FR2:test.kl FR2:example.kl
- A file could be moved within a virtual device from the RAM disk to the F-ROM disk and vice versa, using a special command which is different from copy. For example: KCL>MOVE MF1:test.kl moves test.kl from the F-ROM disk to the RAM disk. KCL>COPY FR1:test.kl TO RD1:test.kl will also move the file from the F-ROM Disk to the RAM Disk. This is because unique file names can only exist on one device. For more information on moving files, refer to the MOVE_FILE Built-in in Appendix A , "KAREL Language Alphabetical Descriptions" or the MOVE FILE Command in Appendix C , "KCL Command Alphabetical Description."
- Formatting the RAM disk, RD: or MF:, clears all the RAM disk files on all the virtual devices. The files on the F-ROM disk remain intact. For example: **KCL>FORMAT RD1:** reformats all RAM disk virtual devices (RD: through RD7:). Reformatting will cause existing data to be removed.
- Purge erases all blocks that are no longer needed for all the virtual devices. For more information on purging, refer to the PURGE_DEV Built-in in Appendix A , "KAREL Language Alphabetical Description" or the PURGE Command in Appendix C , "KCL Command Alphabetical Description."

9.3.4 File Pipes

The PIP: device allows you to access any number of pipe files. This access is to files that are in the controller's memory. This means that the access to these files is very efficient. The size of the files and number of files are limited by available controller memory. This means that the best use of a file pipe is to buffer data or temporarily hold it.

The file resembles a water pipe where data is poured into one end by the writing task and the data flows out the other end into the reading task. This is why the term used is a pipe. This concept is very similar to pipe devices implemented on UNIX, Windows and Linux.

Files on the pipe device have a limited size but the data is arranged in a circular buffer. This is also called a circular queue. This means that a file pipe of size 8kbytes (this is the default size) will contain the last 8k of data written to the pipe. When the user writes the ninth kilobyte of data to the pipe, the first kilobyte will be overwritten.

Since a pipe is really used to transfer data from one place to another some application will be reading the data out of the pipe. In the default mode, the reader will WAIT until information has been written. Once the data is available in the pipe the read will complete. A KAREL application might use BYTES_AHEAD to query the pipe for the amount of data available to read. This is the default read mode.

A second read mode is provided which is called "snapshot." In this mode the reader will read out the current content of the pipe. Once the current content is read the reader receives an end of the file. This can be applied in an application like a "flight recorder". This allows you to record information leading up to an event (such as an error) and then retrieve the last set of debug information written to the pipe. Snapshot mode is a read attribute. It is configured using SET_FILE_ATTR builtin. By default, the read operation is not in snapshot mode.

Typical pipe applications involve one process writing data to a pipe. The data can debug information, process parameters or robot positions. The data can then be read out of the pipe by another application. The reading application can be a KAREL program which is analyzing the data coming out of the pipe or it can be KCL or the web server reading the data out and displaying it to the user in ASCII form.

KAREL Examples

The following apply to KAREL examples.

- Two KAREL tasks can share data through a pipe. One KAREL task can write data to the pipe while a second KAREL task reads from the pipe. In this case the file attribute ATR_PIPWAIT can be used for the task that is reading from the pipe. In this case the reading KAREL task will wait on the read function until the write task has finished writing the data. The default operation of the pipe is to return an end of file when there is no data to be read from the pipe.
- A KAREL application might be executing condition handlers at a very fast data rate. In this case it might not be feasible for the condition handler routine to write data out to the teach pendant display screen because this would interfere with the performance of the condition handler. In this case you could write the data to the PIP: device from the condition handler routine. Another KAREL task might read the data from the PIP: device and display it to the teach pendant. In this case the teach pendant display would not be strictly real time. The PIP: device acts as a buffer in this case so that the condition handler can move on to its primary function without waiting for the display to complete. You can also type the file from KCL at the same time the application is writing to it.

PIP: devices are similar to other devices in the following ways:

- The pipe device is similar in some ways to the RD: device. The RD: device also puts the file content in the system memory. The PIP device is different primarily because the pipe file can be opened simultaneously for read and write.
- Similarly to MC: and FR: devices, the PIP: device is used when you want to debug or diagnose real time software. This allows you to output debug information that you can easily view without interfering with the operation that is writing the debug data. This also allows one task to write information that another task can read.

- The function of the PIP: device is similar to all other devices on the controller. This means that all file I/O operations are supported on this device. All I/O functions are supported and work the same except the following: Chdir, Mkdir, and Rmdir.
- The PIP: device is similar to writing directly to a memory card. However, writing to a memory card will delay the writing task while the delay to the PIP: device is much smaller. This means that any code on the controller can use this device. It also has the ability to retain data through a power cycle.

Rules for PIP: Devices

The following rules apply to PIP: devices:

- The PIP: device can be used by any application or you can specify an associated common option such as KAREL.
- The device is configurable. You can configure how much memory it uses and whether that memory is CMOS (retained) or DRAM (not retained). You are also able to configure the format of the data in order to read out formatted ASCII type data. The device is configured via the PIPE_CONFIG built-in.

Installation, Setup and Operation Sequence

In general the PIP: device operates like any other device. A typical operation sequence includes:

```
OPEN myfile ('PIP:/myfile.dat', 'RW',)
Write myfile ('Data that I am logging', CR)
Close myfile
```

If you want to be able to access myfile.dat from the Web server, put a link to it on the diagnostic Web page.

The files on the PIP: device are configurable. By default the pipe configuration is specified in the $PIPE_CONFIG system variable. The fields listed in Table 9–3 have the following meanings:

Table 9–3. System Variable Field Descriptions

FIELD	DEFAULT	DEFINITION
$sectors	8	Number of 1024 byte sectors in the pipe.
$filedata		Pointer to the actual pipe data (not accessible).
$recordsize	0	Binary record size, zero means its not tracked.
$auxword	0	Dictionary element if dictionary format or type checksum.

Table 9–3. System Variable Field Descriptions (Cont'd)

$memtyp	0	If non zero use CMOS.
$format	Undefined	Formatting mode: undefined, function, format string or KAREL type.
$formatter		Function pointer, "C" format specifier pointer or type code depending on $format.

Each pipe file can be configured via the pipe_config built-in. The pipe_config built-in will be called before the pipe file is opened for writing. Refer to Section A.17 , "pipe_config built-in" for more details.

Operational Examples

The following example writes data from one KAREL routine into a pipe and then reads it back from another routine. These routines can be called from separate tasks so that one task was writing the data and another task can read the data.

Program

```
program pipuform
%nolockgroup
var
     pipe, in_file, mcfile, console:file
     record: string[80]
     status: integer
     parm1, parm2: integer
     msg: string[127]
     cmos_flag: boolean
     n_sectors: integer
     record_size: integer
     form_dict: string[4]
     form_ele: integer
--
--initialize file attributes
routine file_init (att_file :FILE)
begin
 set_file_atr(att_file, ATR_IA)    --force reads to completion
 set_file_atr(att_file, ATR_FIELD)  --force write to completion
 set_file_atr(att_file, ATR_PASSALL) --ignore cr
 set_file_atr(att_file, ATR_UF)    --binary
end file_init
routine write_pipe
begin
 --file is opened
 file_init (pipe)
```

```
 open file pipe ('rw', 'pip:example.dat')
 status = io_status(pipe)
 write console ('Open pipe status:',status,cr)
--  write extra parameters to pipe
 write pipe (msg::8)
 status = io_status(pipe)
end write_pipe
routine read_pipe
var
      record: string[128]
      status: integer
      entry: integer
      num_bytes: integer
begin
 file_init (in_file)
 open file in_file ('ro', 'pip:example.dat')
 BYTES_AHEAD(in_file, entry, status)
 status = 0
 read in_file (parm1::4)
 status = IO_STATUS(in_file)
 write console ('parm1 read',status,cr)
 write console ('parm1',parm1,cr)
 read in_file (parm2::4)
 status = IO_STATUS(in_file)
 write console ('parm2 read',parm2,status,cr)
end read_pipe
begin
      SET_FILE_ATR(console, atr_ia, 0) --ATR_IA is defined in flbt.ke
      OPEN FILE console ('RW','CONS:')
      if(uninit(msg)) then
        msg = 'Example'
      endif
      if(uninit(n_sectors)) then
      cmos_flag = true
      n_sectors = 16
      record_size = 128
      form_dict = 'test'
      form_ele = 1
     endif
     --          [in] pipe_name: STRING;name of tag
     --          [in] cmos_flag: boolean;
     --          [in] n_sectors: integer;
     --          [in] record_size: integer;
     --          [in] form_dict: string;
     --          [in] form_ele: integer;
     --          [out] status: INTEGER
     pipe_config('pip:example.dat',cmos_flag, n_sectors,
```

```
            record_size,form_dict,form_ele,status)
    write_pipe
    read_pipe
    close file pipe
    close file in_file
end pipuform
```

9.4 FILE ACCESS

You can access files using the FILE and SELECT screens on the CRT/KB or teach pendant, or by using KAREL language statements. During normal operations, files will be loaded automatically into the controller. However, other functions could need to be performed.

9.5 FORMATTING XML INPUT

9.5.1 Overview

This feature allows KAREL programs to input data via an XML (eXtended Markup Language) formatted text file. The XML rather than binary format allows the file to be manipulated easily on a PC.

The XML files must follow the most basic XML syntax requirements. These requirements are:

- XML files can have ONLY ONE top level element.
- The start tag must have a matching end tag.
- Empty tags can be represented as <tag parameters/>
- Tags cannot contain special characters such as the set of *, $, and [ ]
- They must not contain unprintable characters
- Attributes must be of the form attr=“value”
- Special characters are used for the following (outside of tags):
  - — < is substituted with &lt
  - — < is substituted with &gt
  - — & is substituted with &amp
  - — “ can be substituted with &quot

- This feature provides an XML parser and the means for both KAREL and C programmers to easily extract binary data from the text information in an XML file. It does not require the application program to do any parsing of the XML file.

Note XML files can have only one top level element. For example,

```
<GRID>
  <TPPROG>
  </TPPROG>
</GRID>
```

is legal. It has one top level element (GRID).

```
<GRID>
</GRID>
<TPPROG>
</TPPROG>
```

is not legal. The master tag can be used to distinguish a GRID file from a password configuration file, for example.

9.5.2 Installation Sequence

This feature consists of KAREL built-ins which provide access to this library for KAREL users. The environment file xml.ev must be on the translator path to translate KAREL programs which reference these built-ins. These built-ins are XML_ADDTAG, XML_GETDATA, XML_REMTAG, XML_SCAN, and XML_SETVAR. Refer to the *KAREL Reference Manual* for more information on these built-ins.

9.5.3 Example XML File

```
<?xml version="1.0" ?>
<!--
The order implies the "index" in the ring
  -->
<ROSIPCFG>
  <ROBOTRING count="4" timeslot="400">
    <MEMBER name="frodo"    ipadd="172.22.200.55" />
    <MEMBER name="bilbo"    ipadd="172.22.194.13" />
    <MEMBER name="gandalf"  ipadd="172.22.194.239" />
```

```
    <MEMBER name="sam"      ipadd="172.22.194.238" />
</ROBOTRING>
  <IPENDANTRING count="4">
    <MEMBER name="frodo"    ipadd="172.22.200.55" dspname="leader"
         port_num="1" />
    <MEMBER name="bilbo"    ipadd="172.22.194.13" dspname="follower1"
         port_num="2" focusbg=8388863/>
    <MEMBER name="gandalf"  ipadd="172.22.194.239" dspname="follower2"
         portnum="3" focusbg="2970272" />
    <MEMBER name="sam"      ipadd="172.22.194.238" dspname="follower3"
         port_num="4" focusbg="8388736" />
  </IPENDANTRING>
</ROSIPCFG>
```

9.5.4 Example KAREL Program Referencing an XML File

The example shown in Figure 9–2 parses the XML file shown in Figure 9–1 .

Figure 9–1. XML Program

```
<?xml version="1.0" ?>
-<!—comment
<GRID rows="16" cols="24" scale="80">
  <xmlstrct_t first=”123456” second=”78910” third="1” "fourth=”A String”>
              special characters < > & "</xmlstrct_t>
</GRID>
```

Figure 9–2. KAREL Program

```
PROGRAM xmlparse
%COMMENT = ’XML Parse’
%NOPAUSESHFT
%NOPAUSE = ERROR + TPENABLE + COMMAND
%NOABORT = ERROR + COMMAND
%NOLOCKGROUP
%NOBUSYLAMP
%ENVIRONMENT xml
%include klerxmlf
CONST
MYXML_CONST = 3
TYPE
    xmlstrct_t = STRUCTURE
    first: integer
```

```
    second: real
    third: BOOLEAN
    fourth: string[20]
  ENDSTRUCTURE
VAR
  xml_name    : string[20]
  tag_name    : string[32]
  text        : array[32] of string[128]
  attrnames   : array[32] of string[32]
  attrvalues  : array[32] of string[64]
  xml_file    : FILE
  status      : INTEGER
  xmlstrct:   xmlstrct_t
  tag_ident:  integer
  func_code:  integer
  text_idx:  integer
  numattr:    integer
  textdone:   BOOLEAN
  done:   BOOLEAN
------------------------------------------------------------------------
BEGIN
--  set_file_atr (xml_file, ATR_XML)        -- This is an XML file
  set_file_atr (xml_file, 20)        -- This is an XML file
  OPEN FILE xml_file ('RO', xml_name)     -- Open does new operation
  status = IO_STATUS(xml_file)
  IF status <> 0 THEN
     POST_ERR(status, '', 0, 0)
     abort
  ENDIF
  xml_addtag(xml_file, 'xmlstrct_t', 32, FALSE, MYXML_CONST, status)
  textdone = TRUE
  done = FALSE
  WHILE (done = FALSE) DO
    xml_scan(xml_file, tag_name, tag_ident, func_code, status)
    if(status = 0) THEN
      done= TRUE
    ENDIF
    IF (status = XML_FUNCTION) THEN
      status = 0
      SELECT tag_ident OF
      CASE (MYXML_CONST) :
        SELECT func_code OF
        CASE (XML_END) :
        -- End tag so nothing to be done here
        CASE (XML_START) :
          text_idx = 1
          xml_setvar(xml_file, 'xmlparse', 'xmlstrct', status)
```

```
        -- Already looked at the attribtues get the text
         xml_getdata(xml_file, numattr, attrnames, attrvalues, text[text_idx],
               textdone, status)
        CASE (XML_TXCONT) :
        -- Usually the user will do one or the other but not both of these calls
         text_idx = text_idx + 1
         xml_getdata(xml_file, numattr, attrnames, attrvalues, text[text_idx],
                textdone, status)
        ELSE:
        ENDSELECT
      ELSE:
      ENDSELECT
    ELSE
      IF(status <> XML_SCANLIM) THEN
       POST_ERR(status, '', 0, 0)
       done = TRUE
      ENDIF
    ENDIF -- Good status from xml_parse
  ENDWHILE
  -- This is not required but allows the user to dynamically remove and add tags
  xml_remtag(xml_file, 'xmlstrct_t', status)
  CLOSE FILE xml_file
  status = IO_STATUS(xml_file)
  IF status <> 0 THEN
     POST_ERR(status, '', 0, 0)
  ENDIF
END xmlparse
```

Executing this program will extract the attributes first, second, third, and fourth, and their values from the XML file. These values will be set in the variable xmlstruct that has fields first, second, third, and fourth. The string variables will also be set to KAREL string variables.

The GRID tag is in the XML file but not processed by this example program.

9.5.5 Parse Errors

XML_TAG_SIZE "Tag too long"

XML_ATTR_SIZE "Attribute too long"

XML_NOSLASH "Invalid use of / character"

XML_INVTAG "Invalid character in tag"

XML_ATTRMATCH "No value for attribute"

XML_TAGMATCH "End tag with no matching start"

XML_INVATTR "Invalid character in attribute"

XML_NOFILE "Cannot find file"

XML_TAGNEST "Tag nesting level too deep"

XML_COMMENT "Error in comment"

XML_BADEXCHAR "Unknown character &xxx;”

XML_TAGNFND "Tag not found"

XML_INVEOF "Unexpected end of file"

XML_SCANLIM "Scan limit exceeded"

XML_FUNCTION "Function code return"

9.6 MEMORY DEVICE

The Memory device (MD:) treats controller memory programs and variable memory as if it were a file device. Teach pendant programs, KAREL programs, program variables, SYSTEM variables, and error logs are treated as individual files. This provides expanded functions to communication devices, as well as normal file devices. For example:

1. FTP can load a PC file by copying it to the MD: device.
2. The error log can be retrieved and analyzed remotely by copying from the MD: device.
3. An ASCII listing of teach pendant programs can be obtained by copying ***.LS from the MD: device.
4. An ASCII listing of system variables can be obtained by copying SYSVARS.VA from the MD: device.

Refer to Table 9–4 for listings and descriptions of files available on the MD device.

Table 9–4. File Listings for the MD Device

File Name	Description
ACCNTG.DG	This file shows the system accounting of Operating system tasks.
ACCOFF.DG	This file shows the system accounting is turned off.
AXIS.DG	This file shows the Axis and Servo Status.

Table 9–4. File Listings for the MD Device (Cont'd)

File Name	Description
CONFIG.DG	This file shows a summary of system configuration
CONSLOG.DG	This file is an ASCII listing of the system console log.
CONSTAIL.DG	This file is an ASCII listing of the last lines of the system console log.
CURPOS.DG	This file shows the current robot position.
*.DF	This file contains the TP editor default setting.
DIOCFGSV.IO	This file contains I/O configuration information in binary form.
DIOCFGSV.VA	This file is an ASCII listing of DIOCFGSV.IO.
ERRACT.LS	This file is an ASCII listing of active errors.
ERRALL.LS	This file is an ASCII listing of error logs.
ERRAPP.LS	This file is an ASCII listing of application errors.
ERRCOMM .LS	This file shows communication errors.
ERRCURR.LS	This file is an ASCII listing of system configuration.
ERRHIST.LS	This file is an ASCII listing of system configuration.
ERRMOT.LS	This file is an ASCII listing of motion errors.
ERRPWD.LS	This file is an ASCII listing of password errors.
ERRSYS.LS	This file is an ASCII listing of system errors.
ETHERNET	This file shows the Ethernet Configuration.
FRAME.DG	This file shows Frame assignments.
FRAMEVAR.SV	This file contains system frame and tool variable information in binary form.
FRAMEVAR.VA	This file is an ASCII listing of FRAMEVAR.SV.
HIST.LS	This file shows history register dumps.
HISTE.LS	This file is an ASCII listing of general fault exceptions.
HISTP.LS	This file is an ASCII listing of powerfail exceptions.
HISTS.LS	This file is an ASCII listing of servo exceptions.
IOCONFIG.DG	This file shows IO configuration and assignments.
IOSTATE.DG	This file is an ASCII listing of the state of the I/O points.
IOSTATUS.CM	This file is a system command file used to restore I/O.
LOG CONSTAIL.DG	This file is the last line of Console Log.
NUMREG.VA	This file is an ASCII listing of NUMREG.VR.
NUMREG.VR	This file contains system numeric registers.

Table 9–4. File Listings for the MD Device (Cont'd)

File Name	Description
MACRO.DG	This file shows the Macro Assignment.
MEMORY.DG	This file shows current memory usage.
PORT.DG	This file shows the Serial Port Configuration.
POSREG.VA	This file is an ASCII listing of POSREG.VR.
POSREG.VR	This file contains system position register information.
PRGSTATE.DG	This file is an ASCII listing of the state of the programs.
SFTYSIG.DG	This file is an ASCII listing of the state of the safety signals.
STATUS.DG	This file shows a summary of system status
SUMMARY.DG	This file shows diagnostic summaries
SYCLDINT.VA	This file is an ASCII listing of system variables initialized at a Cold start.
SYMOTN.VA	This file is an ASCII listing of motion system variables.
SYNOSAVE.VA	This file is an ASCII listing of non-saved system variables.
SYSFRAME.SV	This file contains $MNUTOOL, $MNUFRAME, $MNUTOOLNUM, and $MNUFRAMENUM. These variables were in SYSVARS.SV in releases before V7.20.
SYSMACRO.SV	This file is a listing of system macro definitions.
SYSMACRO.VA	This file is an ASCII listing of SYSMACRO.SV.
SYSMAST.SV	This file is a listing of system mastering information.
SYSMAST.VA	This file is an ASCII listing of SYSMAST.SV.
SYSSERVO.SV	This file is a listing of system servo parameters.
SYSSERVO.VA	This file is an ASCII listing of SYSSERVO.SV.
SYSTEM.DG	This file shows a summary of system information
SYSTEM.VA	This file is an ASCII listing of non motion system variables.
SYSVARS.SV	This file is a listing of system variables.
SYSVARS.VA	This file is an ASCII listing of SYSVARS.SV.
SYS****.SV	This file contains application specific system variables.
SYS****.VA	This file is an ASCII listing of SYS****.VA.
TASKLIST.DG	This file shows the system task information.
TESTRUN.DG	This file shows the Testrun Status.
TIMERS.DG	This file shows the System and Program Timer Status.
TPACCN.DG	This file shows TP Accounting Status.

Table 9–4. File Listings for the MD Device (Cont'd)

File Name	Description
VERSION.DG	This file shows System, Software, and Servo Version Information.
***.PC	This file is a KAREL binary program.
***.VA	This file is an ASCII listing of KAREL variables.
***.VR	This file contains KAREL variables in binary form.
***.LS	This file is an ASCII listing of a teach pendant program.
***.TP	This file is a teach pendant binary program.
***.TX	This file is a dictionary files.
***.HTM	This file is an HTML web page.
***.STM	This file is an HTML web page using an *i*Pendant Control or Server Side Include.
***.GIF	This file is a GIF image file.
***.JPG	This file is a JPEG image file.

Refer to Table 9–5 for a listing of restrictions when using the MD: device.

Table 9–5. Testing Restrictions when Using the MD: Device

File Name or Type	READ	WRITE	DELETE	Comments
***.DG	YES	NO	NO	Diagnostic text file.
***.PC	NO	YES	YES	
***.VR	YES	YES	YES	With restriction of no references.
***.LS	YES	NO	NO	
***.TP	YES	YES	YES	
***.LS	YES	NO	NO	
FFF.DF	YES	YES	NO	
SYS***.SV	YES	YES	NO	Write only at CTRL START.
SYS***.VA	YES	NO	NO	
ERR***.LS	YES	NO	NO	
HISTX.LS	YES	NO	NO	
***REG.VR	YES	YES	NO	
***REG.VA	YES	NO	NO	
DIOCFGSV.IO	YES	YES	NO	Write only at CTRL START.
DIOCFGSV.VA	YES	NO	NO	

Chapter 10

DICTIONARIES AND FORMS

Contents

Chapter 10	DICTIONARIES AND FORMS	10–1
10.1	OVERVIEW	10–3
10.2	CREATING USER DICTIONARIES	10–3
10.2.1	Dictionary Syntax	10–3
10.2.2	Dictionary Element Number	10–4
10.2.3	Dictionary Element Name	10–5
10.2.4	Dictionary Cursor Positioning	10–5
10.2.5	Dictionary Element Text	10–6
10.2.6	Dictionary Reserved Word Commands	10–8
10.2.7	Character Codes	10–10
10.2.8	Nesting Dictionary Elements	10–10
10.2.9	Dictionary Comment	10–11
10.2.10	Generating a KAREL Constant File	10–11
10.2.11	Compressing and Loading Dictionaries on the Controller	10–11
10.2.12	Accessing Dictionary Elements from a KAREL Program	10–12
10.3	CREATING USER FORMS	10–13
10.3.1	Form Syntax	10–14
10.3.2	Form Attributes	10–15
10.3.3	Form Title and Menu Label	10–16
10.3.4	Form Menu Text	10–17
10.3.5	Form Selectable Menu Item	10–18
10.3.6	Edit Data Item	10–19
10.3.7	Non-Selectable Text	10–25
10.3.8	Display Only Data Items	10–26
10.3.9	Cursor Position Attributes	10–26
10.3.10	Form Reserved Words and Character Codes	10–26
10.3.11	Form Function Key Element Name or Number	10–28
10.3.12	Form Function Key Using a Variable	10–29
10.3.13	Form Help Element Name or Number	10–30
10.3.14	Teach Pendant Form Screen	10–30

10.3.15 CRT/KB Form Screen 10–31
10.3.16 Form File Naming Convention 10–32
10.3.17 Compressing and Loading Forms on the Controller 10–32
10.3.18 Displaying a Form 10–34

10.1 OVERVIEW

Dictionaries and forms are used to create operator interfaces on the teach pendant and CRT/KB screens with KAREL programs.

This chapter includes information about

- Creating user dictionary files, refer to Section 10.2.
- Creating and using forms, refer to Section 10.3.

In both cases, the text and format of a screen exists outside of the KAREL program. This allows easy modification of screens without altering KAREL programs.

10.2 CREATING USER DICTIONARIES

A *dictionary file* provides a method for customizing displayed text, including the text attributes (blinking, underline, double wide, etc.), and the text location on the screen, without having to re-translate the program.

The following are steps for using dictionaries.

1. Create a formatted ASCII dictionary text file with a .UTX file extension.
2. Compress the dictionary file using the KCL COMPRESS DICT command. This creates a loadable dictionary file with a .TX extension. Once compressed, the .UTX file can be removed from the system. **Only the compressed dictionary (.TX) file is loaded** .
3. Load the compressed dictionary file using the KCL LOAD DICT command or the KAREL ADD_DICT built-in.
4. Use the KAREL dictionary built-ins to display the dictionary text. Refer to Section 10.2.12, "Accessing Dictionary Elements from a KAREL Program," for more information.

Dictionary files are useful for running the same program on different robots, when the text displayed on each robot is slightly different. For example, if a program runs on only one robot, using KAREL WRITE statements is acceptable. However, using dictionary files simplifies the displaying of text on many robots, by allowing the creation of multiple dictionary files which use the same program to display the text.

Note Dictionary files are useful in multi-lingual programs.

10.2.1 Dictionary Syntax

The syntax for a user dictionary consists of one or more dictionary elements. Dictionary elements have the following characteristics:

- **A dictionary element can contain multiple lines of information** , up to a full screen of information. A user dictionary file has the following syntax:

```
<*comment>
   $n<,ele_name><@cursor_pos><&res_word><#chr_code><"Ele_text"><&res_wor d>
   <#chr_code><+nest_ele>
   <*comment>
   <$n+1>
```

  - — Items in brackets < > are optional.
  - — *comment is any item beginning with *. All text to the end of the line is ignored. Refer to Section 10.2.9.
  - — $n specifies the element number. n is a positive integer 0 or greater. Refer to Section 10.2.2.
  - — ,ele_name specifies a comma followed by the element name. Refer to Section 10.2.3.
  - — @cursor_pos specifies a cursor position (two integers separated by a comma.) Cursor positions begin at @1,1. Refer to Section 10.2.4.
  - — &res_word specifies a dictionary reserve word. Refer to Section 10.2.6 .
  - — "Ele_text" specifies the element text to be displayed. Refer to Section 10.2.5.
  - — +nest_ele specifies the next dictionary text. Refer to Section 10.2.8.
- **A dictionary element does not have to reside all on one line** . Insert a carriage return at any place a space is allowed, except within quoted text. Quoted text must begin and end on the same line.
- **Dictionary elements can contain text, position, and display attribute information** . Table 10–2 lists the attributes of a dictionary element.

10.2.2 Dictionary Element Number

A dictionary element number identifies a dictionary element. A dictionary element begins with a ‘‘$’’ followed by the element number. Element numbers have the following characteristics:

- Element numbers begin at 0 and continue in sequential order.
- If element numbers are skipped, the dictionary compressor will add an extra overhead of 5 bytes for each number skipped. Therefore you should not skip a large amount of numbers.
- If you want the dictionary compressor to automatically generate the element numbers sequentially, use a ‘‘-’’ in place of the number. In the following example, the "-’’ is equated to element number 7.

  $1

  $2

$3

$6

$-

10.2.3 Dictionary Element Name

Each dictionary element can have an optional element name. The name is separated from the element number by a comma and zero or more spaces. Element names are case sensitive. Only the first 12 characters are used to distinguish element names.

The following are examples of element names:

$1, KCMN_SH_LANG

$2, KCMN_SH_DICT

Dictionary elements can reference other elements by their name instead of by number. Additionally, element names can be generated as constants in a KAREL include file.

10.2.4 Dictionary Cursor Positioning

Dictionary elements are displayed in the specified window starting from the current position of the cursor. In most cases, move the cursor to a particular position and begin displaying the dictionary element there.

- The cursor position attribute "@" is used to move the cursor on the screen within the window.
- The "@" sign is followed by two numbers separated by a comma. The first number is the window row and the second number is the window column.

  For example, on the teach pendant, the "t_fu" window begins at row 5 of the "t_sc" screen and is 10 rows high and 40 columns wide.

  — Cursor position "@1,1" is the upper left position of the "t_fu" window and is located at the "t_sc" screen row 5 column 1.

  — The lower right position of the "t_fu" window is "@10,40" and is located at the "t_sc" screen row 15 column 40.

  Refer to Section 7.10.1 for more information on the teach pendant screens and windows.

  For example, on the CRT/KB, the "c_fu" window begins at row 5 of the "c_sc" screen and is 17 rows high and 80 columns wide.

— Cursor position ‘‘@1,1’’ is the upper left position of the "c_fu" window and is located at the "c_sc" screen row 5 column.

— The lower right position of the window is "@17,80’’ and is located at the "c_sc" screen row 21, column 80.

Refer to Section 7.10.2 for more information on the CRT/KB screens and windows.

The window size defines the display limits of the dictionary elements.

10.2.5 Dictionary Element Text

Element text, or quoted text, is the information (text) you want to be displayed on the screen.

- The element text must be enclosed in double quote characters ‘‘ ’’.
- To insert a back-slash within the text, use \\ (double back-slash.)
- To insert a double-quote within the text, use \" (back-slash, quote.)
- More than one element text string can reside in a dictionary element, separated by reserve words. Refer to Section 10.2.6 for more information.
- To include the values of KAREL variables in the element text, use the KAREL built-ins. WRITE_DICT_V and READ_DICT_V, to pass the values of the variables.
- To identify the place where you want the KAREL variables to be inserted, use *format specifiers* in the text.
- A format specifier is the character ‘‘%’’ followed by some optional fields and then a conversion character. A format specifier has the following syntax:

```
%<-><+><width><.precision>conversion_character<^argument_numbe r>
```

Format Specifier

- Items enclosed in < > are optional.
- The - sign means left justify the displayed value.
- The + sign means always display the sign if the argument is a number.
- The width field is a number that indicates the minimum number of characters the field should occupy.
- .precision is the . character followed by a number. It has a specific meaning depending upon the conversion character:
- conversion_characters identify the data type of the argument that is being passed. They are listed in Table 10–1.
- ^argument_number is the ^ (up-caret character) followed by a number.

Conversion Character

The conversion character is used to identify the data type of the KAREL variable that was passed. Table 10–1 lists the conversion characters:

Table 10–1. Conversion Characters

Character	Argument Type: Printed As
d	INTEGER; decimal number.
o	INTEGER; unsigned octal notation (without a leading zero).
x, X	INTEGER; unsigned hexadecimal notation (without a leading 0x or 0X), using abcdef or ABCDEF for 10, ..., 15.
u	INTEGER; unsigned decimal notation.
s	STRING; print characters from the string until end of string or the number of characters given by the precision.
f	REAL; decimal notation of the form <->mmm.dddddd, where the number of d's is given by the precision. The default precision is 6; a precision of 0 suppresses the decimal point.
e, E	REAL; decimal notation of the form <->mmm.dddddd, where the number of d's is given by the precision. The default precision is 6; a precision of 0 suppresses the decimal point.
g, G	REAL; %e or %E is used if the exponent is less than -4 or greater than or equal to the precision; otherwise %f is used. Trailing zeros and a trailing decimal pointer are not printed.
%	No argument is converted; print a %.

- The characters **d** , **o** , **x** , **X** , and **u** , can be used with the INTEGER, SHORT, BYTE, and BOOLEAN data types. A BOOLEAN data type is displayed as 0 for FALSE and 1 for TRUE.
- The **f** , **e** , **E** , **g** , and **G** characters can be used with the REAL data type.
- The character **s** is for a STRING data type.



Caution

Make sure you use the correct conversion character for the type of argument passed. If the conversion character and argument types do not match, unexpected results could occur.

Width and Precision

The optional width field is used to fix the minimum number of characters the displayed variable occupies. This is useful for displaying columns of numbers.

Setting a width longer than the largest number aligns the numbers.

- If the displayed number has fewer characters than the width, the number will be padded on the left (or right if the "-" character is used) by spaces.
- If the width number begins with ‘‘0’’, the field is padded with zeros instead.

The precision has the following meaning for the specified conversion character

- **d** , **o** , **x** , **X** , and **u** - The minimum number of digits to be printed. If the displayed integer is less than the precision, leading zeros are padded. This is the same as using a leading zero on the field width.
- **s** - The maximum number of characters to be printed. If the string is longer than the precision, the remaining characters are ignored.
- **f** , **e** , and **E** - The number of digits to be printed after the decimal point.
- **g** and **G** - The number of significant digits.

Argument Ordering

An element text string can contain more than one format specifier. When a dictionary element is displayed, the first format specifier is applied against the first argument, the second specifier for the second argument, and so on. In some instances, you may need to apply a format specifier out of sequence. This can happen if you develop your program for one language, and then translate the dictionary to another language.

To re-arrange the order of the format specifiers, follow the conversion character with the ‘‘^’’ character and the argument number. As an example,

```
$20, file_message "File %s^2 on device %s^1 not found" &new_line
```

means use the second argument for the first specifier and the first argument for the second specifier.



Caution

You cannot re-arrange arguments that are SHORT or BYTE type because these argument are passed differently than other data types. Re-arranging SHORT or BYTE type arguments could cause unexpected results.

10.2.6 Dictionary Reserved Word Commands

Reserve words begin with the ‘‘&’’ character and are used to control the screen. They effect how, and in some cases where, the text is going to be displayed. They provide an easy and self-documenting way of adding control information to the dictionary. Refer to Table 10–2 for a list of the available reserved words.

Table 10–2. Reserved Words

Reserved Word	Function
&bg_black	Background color black
&bg_blue	Background color blue
&bg_cyan	Background color cyan
&bg_dflt	Background color default
&bg_green	Background color green
&bg_magenta	Background color magenta
&bg_red	Background color red
&bg_white	Background color white
&bg_yellow	Background color yellow
&fg_black	Foreground color black
&fg_blue	Foreground color blue
&fg_cyan	Foreground color cyan
&fg_dflt	Foreground color default
&fg_green	Foreground color green
&fg_magenta	Foreground color magenta
&fg_red	Foreground color red
&fg_white	Foreground color white
&fg_yellow	Foreground color yellow
&clear_win	Clear window (#128)
&clear_2_eol	Clear to end of line (#129)
&clear_2_eow	Clear to end of window (#130)
$cr	Carriage return (#132)
$lf	Line feed (#133)
&rev_lf	Reverse line feed (#134)
&new_line	New line (#135)
&bs	Back space (#136)
&home	Home cursor in window (#137)
&blink	Blink video attribute (#138)
&reverse	Reverse video attribute (#139)
&bold	Bold video attribute (#140)

Table 10–2. Reserved Words (Cont'd)

Reserved Word	Function
&under_line	Underline video attribute (#141)
&double_wide	Wide video size (#142) (refer to description below for usage)
&standard	All attributes normal (#143)
&graphics_on	Turn on graphic characters (#146)
&ascii_on	Turn on ASCII characters (#147)
&double_high	High video size (#148) (refer to description below for usage)
&normal_size	Normal video size (#153)
&multi_on	Turn on multi-national characters (#154)

The attributes &normal_size, &double_high, and &double_wide are used to clear data from a line on a screen. However, they are only effective for the line the cursor is currently on. To use these attributes, first position the cursor on the line you want to resize. Then write the attribute, and the text.

- **For the teach pendant,** &double_high means both double high and double wide are active, and &double_wide is the same as &normal_size.
- **For the CRT/KB,** &double_high means both double high and double wide are active, and &double_wide means double wide but normal height.

10.2.7 Character Codes

A character code is the "#" character followed by a number between 0 and 255. It provides a method of inserting special printable characters, that are not represented on your keyboard, into your dictionary. Refer to Appendix D, for a listing of the ASCII character codes.

10.2.8 Nesting Dictionary Elements

The plus "+" attribute allows a dictionary element to reference another dictionary element from the same dictionary, up to a maximum of five levels. These nested elements can be referenced by element name or element number and can be before or after the current element. When nested elements are displayed, all the elements are displayed in their nesting order as if they are one single element.

10.2.9 Dictionary Comment

The asterisk character (*) indicates that all text, to the end of the line, is a comment. All comments are ignored when the dictionary is compressed. A comment can be placed anywhere a space is allowed, except within the element text.

10.2.10 Generating a KAREL Constant File

The element numbers that are assigned an element name in the dictionary can be generated into a KAREL include file for KAREL programming. The include file will contain the CONST declarator and a constant declaration for each named element.

```
 element_name = element_number
```

Your KAREL program can include this file and reference each dictionary element by name instead of number.

To generate a KAREL include file, specify ‘‘.kl’’, followed by the file name, on the first line of the dictionary fie. The KAREL include file is automatically generated when the dictionary is compressed.

The following would create the file kcmn.kl when the dictionary is compressed.

```
.kl kcmn
$-, move_home, "press HOME to move home"
```

The kcmn.kl file would look as follows

```
-- WARNING: This include file generated by dictionary compressor.
--
-- Include File: kcmn.kl
-- Dictionary file: apkcmneg.utx
--CONST
move_home = 0
```

Note If you make a change to your dictionary that causes the element numbers to be re-ordered, you must re-translate your KAREL program to insure that the proper element numbers are used.

10.2.11 Compressing and Loading Dictionaries on the Controller

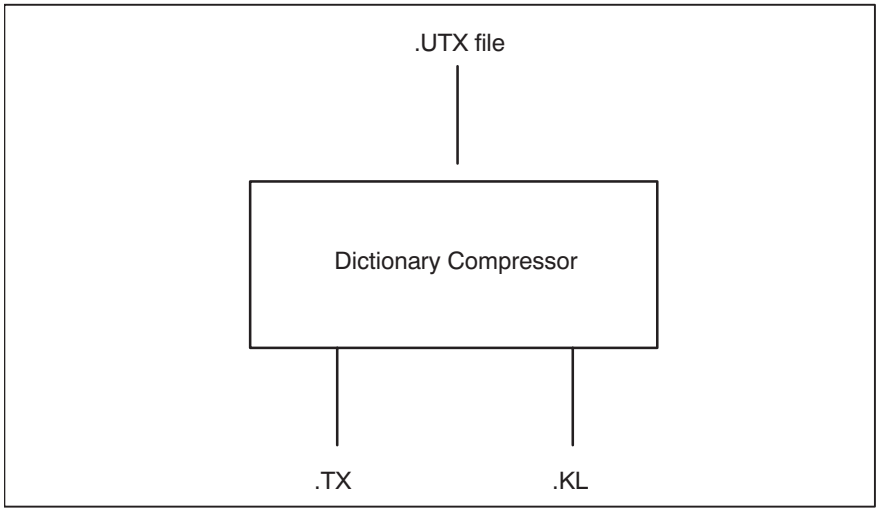
The KAREL editor can be used to create and modify the user dictionary. When you have finished editing the file, you compress it from the KCL command prompt.

```
KCL> COMPRESS DICT filename
```

Do not include the .UTX file type with the file name. If the compressor detects any errors, it will point to the offending word with a brief explanation of what is wrong. Edit the user dictionary and correct the problem before continuing.

A loadable dictionary with the name filename but with a .TX file type will be created. If you used the .kl symbol, a KAREL include file will also be created. Figure 10–1 illustrates the compression process.

Figure 10–1. Dictionary Compressor and User Dictionary File



Before the KAREL program can use a dictionary, the dictionary must be loaded into the controller and given a dictionary name. The dictionary name is a one to four character word that is assigned to the dictionary when it is loaded. Use the KCL LOAD DICT command to load the dictionary.

```
KCL> LOAD DICT filename dictname <lang_name>
```

The optional lang_name allows loading multiple dictionaries with the same dictionary name. The actual dictionary that will be used by your program is determined by the current value of $LANGUAGE. This system variable is set by the KCL SET LANGUAGE command or the SET_LANG KAREL built-in. The allowed languages are ENGLISH, JAPANESE, FRENCH, GERMAN, SPANISH, or DEFAULT.

The KAREL program can also load a dictionary. The KAREL built-in ADD_DICT is used to load a dictionary into a specified language and assign a dictionary name.

10.2.12 Accessing Dictionary Elements from a KAREL Program

Your KAREL program uses either the dictionary name and an element number, or the element name to access a dictionary element. The following KAREL built-ins are used to access dictionary elements:

- ADD_DICT - Add a dictionary to the specified language.

- REMOVE_DICT - Removes a dictionary from the specified language and closes the file or frees the memory it resides in.
- WRITE_DICT - Write a dictionary element to a window.
- WRITE_DICT_V - Write a dictionary element that has format specifiers for a KAREL variable, to a window.
- READ_DICT - Read a dictionary element into a KAREL STRING variable.
- READ_DICT_V - Read a dictionary element that has format specifiers into a STRING variable.
- CHECK_DICT - Check if a dictionary element exists.

10.3 CREATING USER FORMS

A *form* is a type of dictionary file necessary for creating menu interfaces that have the same "look and feel" as the System R-J3iC menu interface.

The following are steps for using forms.

1. Create an ASCII form text file with the .FTX file extension.
2. Compress the form file using the KCL COMPRESS FORM command. This creates a loadable dictionary file with a .TX extension and an associated variable file (.VR).
3. Load the form.
   - **From KCL** , use the KCL LOAD FORM command. This will load the dictionary file (.TX) and the associated variable file (.VR).
   - **From KAREL** , use the ADD_DICT built-in to load the dictionary file (.TX), and the LOAD built-in to load the association variable file (.VR) .
4. Use the KAREL DISCTRL_FORM built-in to display the form text. The DISCTRL_FORM built-in handles all input operations including cursor position, scrolling, paging, input validation, and choice selections. Refer to the DISCTRL_FORM built-in, Appendix A , "KAREL Language Alphabetical Description."

Forms are useful for programs which require the user to enter data. For example, once the user enters the data, the program must test this data to make sure that it is in an acceptable form. Numbers must be entered with the correct character format and within a specified range, text strings must not exceed a certain length and must be a valid selection. If an improper value is entered, the program must notify the user and prompt for a new entry. Forms provide a way to automatically validate entered data. Forms also allow the program to look as if it is integrated into the rest of the system menus, by giving the operator a familiar interface.

Forms must have the USER2 menu selected. Forms use the "t_sc" and "c_sc" screens for teach pendant and CRT/KB respectively. The windows that are predefined by the system are used for displaying the form text. For both screens, this window is 10 rows high and 40 columns wide. This means that the &double_high and &double_wide attributes are used on the CRT/KB and cannot be changed.

10.3.1 Form Syntax

A form defines an operator interface that appears on the teach pendant or CRT/KB screens. A form is a special dictionary element. Many forms can reside in the same dictionary along with other (non-form) dictionary elements.

Note If your program requires a form dictionary file (.FTX), you do not have to create a user dictionary file (.UTX). You may place your user dictionary elements in the same file as your forms.

To distinguish a form from other elements in the dictionary, the symbol ".form" is placed before the element and the symbol ".endform" is placed after the element. The symbols must reside on their own lines. The form symbols are omitted from the compressed dictionary.

The following is the syntax for a form:

Form Syntax

```
.form <form_attributes>
$n, form_name<@cursor_pos><&res_word>"Menu_title"<&res_work>&new_line
     <@cursor_pos><&res_word>"Menu_label"<&res_word>&new_line
     <@cursor_pos><&res_word><"-Selectable_item"<&res_word>&new_line>
     <@cursor_pos><&res_word><"-%Edit_item"<&res_word>&new_line>
     <@cursor_pos><&res_word><"Non_selectable_text"<&res_word>&new_line>
     <@cursor_pos><&res_word><"Display_only_item"<&res_word>&new_line>
     <^function_key &new_line>
     <?help_menu &new_line>
.endform
<$n,function_key
     <"Key_name" &new_line>
     <"Key_name" &new_line>
     <"Key_name" &new_line>
     <"Key_name" &new_line>
     <"help_label" &new_line>
     <"Key_name" &new_line>
     <"Key_name" &new_line>
     <"Key_name" &new_line>
     <"Key_name" &new_line>
     "Key_name"
>
<$n,help_menu
     <"Help_text" &new_line>
     <"Help_text" &new_line>
     "Help_text">
```

Restrictions

- Items in brackets <> are optional.

- Symbols not defined here are standard user dictionary element symbols ($n, @cursor_pos, &res_word, &new_line).
- form_attributes are the key words *unnumber* and *unclear* .
- form_name specifies the element name that identifies the form.
- "Menu_title" and "Menu_label" specify element text that fills the first two lines of the form and are always displayed.
- "- Selectable_item" specifies element text that can be cursored to and selected.
- "-%Editable_item" specifies element text that can be cursored to and edited.
- "Non_selectable_text" specifies element text that is displayed in the form and cannot be cursored to.
- "%Display_only_item" specifies element text using a format specifier. It cannot be cursored to.
- ^function_key defines the labels for the function keys using an element name.
- ?help_menu defines a page of help text that is associated with a form using an element name.
- "Key_name" specifies element text displayed over the function keys.
- "Help_label" is the special label for the function key 5. It can be any label or the special word HELP.
- "Help_text" is element text up to 40 characters long.
- Color attributes can be specified in forms. The *i* Pendant will display the color. The monochrome pendant will ignore the color attributes.

10.3.2 Form Attributes

Normally, a form is displayed with line numbers in front of any item the cursor can move to. To keep a form from generating and displaying line numbers, the symbol ‘‘.form unnumber’’ is used.

To keep a form from clearing any windows before being displayed, the symbol ‘‘.form noclear’’ is used. The symbols ‘‘noclear’’ and ‘‘unnumber’’ can be used in any order.

In the following example, MH_TOOLDEFN is an unnumbered form that does not clear any windows. MH_APPLIO is a numbered form.

```
.form unnumber noclear

$1, MH_TOOLDEFN

.endform

$2, MH_PORT

$3, MH_PORTFKEY
```

```
.form

$6, MH_APPLIO

.endform
```

10.3.3 Form Title and Menu Label

The menu title is the first element of text that follows the form name. The menu label follows the menu title. Each consists of one row of text in a non-scrolling window.

- **On the teach pendant** the first row of the "full" window is used for the menu title. The second row is used for the menu label.
- **On the CRT/KB** the first row of the "cr05" widow is used for the menu title. The second row is used for the menu label.
- The menu title is positioned at row 3, column 1-21.
- The menu label is positioned at row 4, column 1-40.

Unless the "noclear" form attribute is specified both the menu title and menu label will be cleared.

The reserved word &home must be specified before the menu title to insure that the cursor is positioned correctly. The reserved word &reverse should also be specified before the menu title and the reserved word &standard should follow directly after the menu title. These are necessary to insure the menu appears to be consistent with the R-J3iC menu interface. The reserved word &new_line must be specified after both the menu title and menu label to indicate the end of the text. The following is an example menu title and menu label definition.

```
.form

$1, mis_form

&home &reverse "Menu Title" &standard &new_line

"Menu Label" &new_line

.endform
```

If no menu label text is desired, the &new_line can be specified twice after the menu title as in the following example.

```
.form

$1,misc_form

&home &reverse " Menu Title" &standard &new_line &new_line

.endform
```

If the cursor position attribute is specified, it is not necessary to specify the &new_line reserved word. The following example sets the cursor position for the menu title to row 1, column 2, and the menu label to row 2, column 5.

```
.form

$1,misc_form

@1,2 &reverse "Menu Title" &standard

@2,5 "Menu Label"

.endform
```

10.3.4 Form Menu Text

The form menu text follows the menu title and menu label. It consists of an unlimited number of lines that will be displayed in a 10 line scrolling window named ‘‘fscr’’ on the teach pendant and ‘‘ct06’’ on the CRT/KB. This window is positioned at rows 5-14 and columns 1-40. Unless the ‘‘noclear’’ option is specified, all lines will be cleared before displaying the form.

Menu text can consist of the following:

- Selectable menu items
- Edit data items of the following types:

  - — INTEGER
  - — INTEGER port
  - — REAL
  - — SHORT (32768 to 32766)
  - — BYTE (0 to 255)
  - — BOOLEAN
  - — BOOLEAN port
  - — STRING
  - — Program name string
  - — Function key enumeration type
  - — Subwindow enumeration type
  - — Subwindow enumeration type using a variable
  - — Port simulation
- Non-selectable text
- Display only data items with format specifiers
- Cursor position attributes
- Reserve words or ASCII codes
- Function key element name or number
- Help element name or number

Each kind of menu text is explained in the following sections.

10.3.5 Form Selectable Menu Item

Selectable menu items have the following characteristics:

- A selectable menu item is entered in the dictionary as a string enclosed in double quotes.
- The first character in the string must be a dash, '-'. This character will not be printed to the screen. For example,

```
"- Item 1 "
```

- The entire string will be highlighted when the selectable item is the default.
- If a selectable item spans multiple lines, the concatenation character '+' should be used as the last character in the string. The concatenation character will not be printed to the screen. The attribute &new_line is used to signal a new line. For example,

```
"- Item 1, line 1 +" &new_line
```

```
" Item 1, line 2 "
```

- The automatic numbering uses the first three columns and does not shift the form text. Therefore, the text must allow for the three columns by either adding spaces or specifying cursor positions. For example,

```
"- Item 1 " &new_line

"- Item 2 " &new_line

"- Item 3 "
```

or

```
@3,4"- Item 1 "

@4,4"- Item 2 "

@5,4"- Item 3 "
```

- The first line in the scrolling window is defined as row 3 of the form.
- Pressing enter on a selectable menu item will always cause the form processor to exit with the termination character of ky_select, regardless of the termination mask setting. The item number selected will be returned.
- Selecting the item by pressing the ITEM hardkey on the teach pendant will only highlight the item. It does not cause an exit.
- Short-cut number selections are not handled automatically, although they can be specified as a termination mask.

10.3.6 Edit Data Item

You can edit data items that have the following characteristics:

- Data item is entered in the dictionary as a string enclosed in double quotes.
- The first character in the string must be a dash, '-'. This character is not printed to the screen.
- The second character in the string must be a '%'. This character marks the beginning of a format specifier.
- Each format specifier begins with a % and ends with a conversion character. All the characters between these two characters have the same meaning as user dictionary elements.

Note You should provide a field width with each format specifier, otherwise a default will be used. This default might cause your form to be mis-aligned.

Table 10–3 lists the conversion characters for an editable data item.

Table 10–3. Conversion Characters

Character	Argument Type: Printed As
d	INTEGER; decimal number.
o	INTEGER; unsigned octal notation (without a leading zero).
x, X	INTEGER; unsigned hexadecimal notation (without a leading 0x or 0X), using abcdef or ABCDEF for 10, ..., 15.
u	INTEGER; unsigned decimal notation.
pu	INTEGER port; unsigned decimal notation.
px	INTEGER port; unsigned hexadecimal notation (without a leading 0x or 0X), using abcdef or ABCDEF for 10, ..., 15.
f	REAL; decimal notation of the form <->mmm.dddddd, where the number of d's is given by the precision. The default precision is 6; a precision of 0 suppresses the decimal point.
e, E	REAL; decimal notation of the form <->m.dddddde+-xx or <->m.ddddddE+-xx, where the number of d's is given by the precision. The default precision is 6; a precision of 0 suppresses the decimal point.
g, G	REAL; %e or %E is used if the exponent is less than -4 or greater than or equal to the precision; otherwise %f is used. Trailing zeros and a trailing decimal pointer are not printed.
h	SHORT; signed short.
b	BYTE; unsigned byte.
B	BOOLEAN; print characters from boolean enumeration string.
P	BOOLEAN port; print characters from boolean port enumeration string.
S	INTEGER or BOOLEAN port; print characters from port simulation enumeration string.
k	STRING; print characters from KAREL string until end of string or the number of characters given by the precision.
pk	STRING; print program name from KAREL string until end of string or the number of characters given by the precision.
n	INTEGER; print characters from function key enumeration string. Uses dictionary elements to define the enumeration strings.
w	INTEGER; print characters from subwindow enumeration string. Uses dictionary elements to define the enumeration strings.

Table 10–3. Conversion Characters (Cont'd)

Character	Argument Type: Printed As
v	INTEGER; print characters from subwindow enumeration string. Uses a variable to define the enumeration strings.
%	no argument is converted; print a %.

The following is an example of a format specifier:

```
"-%5d" or "-%-10s"
```

The form processor retrieves the values from the input value array and displays them sequentially. **All values are dynamically updated** .

Edit Data Items: INTEGER, INTEGER Ports, REAL, SHORT, BYTE

- You can specify a range of acceptable values by giving each format specifier a minimum and maximum value allowed "(min, max)." If you do not specify a minimum and maximum value, any integer or floating point value will be accepted. For example,

```
"-%3d(1,255)" or "-%10.3f(0.,100000.)"
```

- When an edit data item is selected, the form processor calls the appropriate input routine. The input routine reads the new value (with inverse video active) and uses the minimum and maximum values specified in the dictionary element, to determine whether the new value is within the valid range.
  - — If the new value is out of range, an error message will be written to the prompt line and the current value will not be modified.
  - — If the new value is in the valid range, it will overwrite the current value.

Edit Data Item: BOOLEAN

- The format specifier %B is used for KAREL BOOLEAN values, to display and select menu choice for the F4 and F5 function keys. The name of the dictionary element, that contains the function key labels, is enclosed in parentheses and is specified after the %B. For example,

```
"-%4B(enum_bool)"
```

The dictionary element defining the function keys should define the FALSE value first (F5 label) and the TRUE value second (F4 label). For example,

```
$2,enum_bool

" NO" &new_line

" YES"
```



The form processor will label the function keys when the cursor is moved to the enumerated item. The value shown in the field is the same as the function key label except all leading blanks are removed.

Edit Data Item: BOOLEAN Port

- The format specifier %P is used for KAREL BOOLEAN port values, to display and select menu choices from the F4 and F5 function keys. The name of the dictionary element, that contains the function key labels, is enclosed in parentheses and is specified after the %P. For example,

```
"-%3P(enum_bool)"
```

The dictionary element defining the function keys should define the 0 value first (F5 label) and the 1 value second (F4 label). For example,

```
$2,enum_bool

" OFF" &new_line

" ON"
```



The form processor will label the function keys when the cursor is moved to the enumerated item. The value shown in the field is the same as the function key label except all leading blanks are removed.

Edit Data Item: Port Simulation

- The format specifier %S is used for port simulation, to display and select menu choices from the F4 and F5 function keys. The name of the dictionary element, that contains the function key labels, is enclosed in parentheses and is specified after the %S. For example,

```
"-%1S(sim_fkey)"
```

The dictionary element defining the function keys should define the 0 value first (F5 label) and the 1 value second (F4 label). For example,

```
$-, sim_fkey
" UNSIM " &new_line * F5 key label, port will be unsimulated
"SIMULATE" &new_line * F4 key label, port will be simulated
```

The form processor will label the function keys when the cursor is moved to the enumerated item. The value shown in the field is the same as the function key label except all leading blanks are removed and the value will be truncated to fit in the field width.

Edit Data Item: STRING

- You can choose to clear the contents of a string before editing it. To do this follow the STRING format specifier with the word "clear", enclosed in parentheses. If you do not specify "(clear)", the default is to modify the existing string. For example,

```
"-%10k(clear)"
```

Edit Data Item: Program Name String

- You can use the %pk format specifier to display and select program names from the subwindow. The program types to be displayed are enclosed in parenthesis and specified after %pk. For example,

```
"-%12pk(1)" * specifies TP programs

"-%12pk(2)" * specifies PC programs

"-%12pk(6)" * specifies TP, PC, VR

"-%12pk(16)" * specifies TP & PC
```

All programs that match the specified type and are currently in memory, are displayed in the subwindow. When a program is selected, the string value is copied to the associated variable.

Edit Data Item: Function Key Enumeration

- You can use the format specifier %n (for enumerated integer values) to display and select choices from the function keys. The name of the dictionary element that contains the list of valid choices is enclosed in parentheses and specified after %n. For example,

```
"-%6n(enum_fkey)"
```

The dictionary element defining the function keys should list one function key label per line. If function keys to the left of those specified are not active, they should be set to "". A maximum of 5 function keys can be used. For example,

```
$2,enum_fkey

"" &new_line *Specifies F1 is not active

"JOINT" &new_line *Specifies F2

"LINEAR" &new_line *Specifies F3
```

```
"CIRC" *Specifies F4
```

The form processor will label the appropriate function keys when the enumerated item is selected. When a function key is selected, the value set in the integer is as follows:

```
User presses F1, value = 1

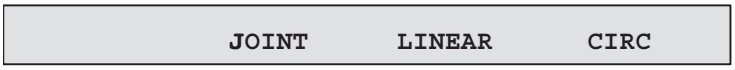
User presses F2, value = 2

User presses F3, value = 3

User presses F4, value = 4

User presses F5, value = 5
```

The value shown in the field is the same as the function key label except all leading blanks are removed.



Edit Data Item: Subwindow Enumeration

- You can use the format specifier %w (for enumerated integer values) to display and select choices from the subwindow. The name of the dictionary element, containing the list of valid choices, is enclosed in parentheses and specified after %w. For example,

```
"-%8w(enum_sub)"
```

One dictionary element is needed to define each choice in the subwindow. 35 choices can be used. If fewer than 35 choices are used, the last choice should be followed by a dictionary element that contains **"\a"** . The choices will be displayed in 2 columns with 7 choices per page. If only 4 or less choices are used, the choices will be displayed in 1 column with a 36 character width. For example,

```
$2,enum_sub "Option 1"

$3 "Option 2"

$4 "Option 3"

$5 "\a"
```

The form processor will label F4 as ‘‘[CHOICE]’’ when the cursor is moved to the enumerated item. When the function key F4, [CHOICE] is selected, it will create the subwindow with the appropriate display. When a choice is selected, the value set in the integer is the number selected. The value shown in the field is the same as the dictionary label except all leading blanks are removed.

Edit Data Item: Subwindow Enumeration using a Variable

- You can also use the format specifier %v (for enumerated integer values) to display and select choices from the subwindow. However, instead of defining the choices in a dictionary they are defined in a variable. The name of the dictionary element, which contains the program and variable name, is enclosed in parentheses and specified after %v. For example,

```
"-%8v(enum_var)"

$-,enum_var

"RUNFORM" &new_line * program name of variable

"CHOICES" &new_line * variable name containing choices
```

[RUNFORM] CHOICES must be defined as a KAREL string array. Each element of the array should define a choice in the subwindow. This format specifier is similar to %w. However, the first element is related to the value 0 and is never used. Value 1 begins at the second element. The last value is either the end of the array or the first uninitialized value.

```
[RUNFORM] CHOICES:ARRAY[6] OF STRING[12] =

[1] *uninit*

[2] 'Red' <= value 1

[3] 'Blue' <= value 2

[4] 'Green' <= value 3

[5] *uninit*

[6] *uninit*
```

10.3.7 Non-Selectable Text

Non-selectable text can be specified in the form. These items have the following characteristics:

- Non-selectable text is entered in the dictionary as a string enclosed in double quotes.
- Non-selectable text can be defined anywhere in the form, but must not exceed the maximum number of columns in the window.

10.3.8 Display Only Data Items

Display only data items can be specified in the form. These items have the following characteristics:

- Display only data items are entered in the dictionary as a string enclosed in double quotes.
- The first character in the string must be a '%'. This character marks the beginning of a format specifier.
- The format specifiers are the same as defined in the previous section for an edit data item.

10.3.9 Cursor Position Attributes

Cursor positioning attributes can be used to define the row and column of any text. The row is always specified first. The dictionary compressor will generate an error if the form tries to backtrack to a previous row or column. The form title and label are on rows 1 and 2. The scrolling window starts on row 3. For example,

```
@3,4 "- Item 1"

@4,4 "- Item 2"

@3,4 "- Item 3" <- backtracking to row 3 not allowed
```

Even though the scrolling window is only 10 lines, a long form can specify row positions that are greater than 12. The form processor keeps track of the current row during scrolling.

10.3.10 Form Reserved Words and Character Codes

Reserved words or character codes can be used. Refer to Table 10–4 for a list of all available reserved words. However, only the reserved words which do not move the cursor are allowed in a scrolling window. Refer to Table 10–5 for a list of available reserved words for a scrolling window.

Table 10–4. Reserved Words

Reserved Word	Function
&bg_black	Background color black
&bg_blue	Background color blue
&bg_cyan	Background color cyan
&bg_dflt	Background color default
&bg_green	Background color green

Table 10–4. Reserved Words (Cont'd)

Reserved Word	Function
&bg_magenta	Background color magenta
&bg_red	Background color red
&bg_white	Background color white
&bg_yellow	Background color yellow
&fg_black	Foreground color black
&fg_blue	Foreground color blue
&fg_cyan	Foreground color cyan
&fg_dflt	Foreground color default
&fg_green	Foreground color green
&fg_magenta	Foreground color magenta
&fg_red	Foreground color red
&fg_white	Foreground color white
&fg_yellow	Foreground color yellow
&clear_win	Clear window (#128)
&clear_2_eol	Clear to end of line (#129)
&clear_2_eow	Clear to end of window (#130)
$cr	Carriage return (#132)
$lf	Line feed (#133)
&rev_lf	Reverse line feed (#134)
&new_line	New line (#135)
&bs	Back space (#136)
&home	Home cursor in window (#137)
&blink	Blink video attribute (#138)
&reverse	Reverse video attribute (#139)
&bold	Bold video attribute (#140)
&under_line	Underline video attribute (#141)
&double_wide	Wide video size (#142) (refer to description below for usage)
&standard	All attributes normal (#143)
&graphics_on	Turn on graphic characters (#146)
&ascii_on	Turn on ASCII characters (#147)

Table 10–4. Reserved Words (Cont'd)

Reserved Word	Function
&double_high	High video size (#148) (refer to description below for usage)
&normal_size	Normal video size (#153)
&multi_on	Turn on multi-national characters (#154)

Table 10–5 lists the reserved words that can be used for a scrolling window.

Table 10–5. Reserved Words for Scrolling Window

Reserved Word	Function
&new_line	New line (#135)
&blink	Blink video attribute (#138)
&reverse	Reverse video attribute (#139)
&bold	Bold video attribute (#140)
&under_line	Underline video attribute (#141)
&standard	All attributes normal (#143)
&graphics_on	Turn on graphic characters (#146)
&ascii_on	Turn on ASCII characters (#147)
&multi_on	Turn on multi-national characters (#154)

10.3.11 Form Function Key Element Name or Number

Each form can have one related function key menu. A function key menu has the following characteristics:

- The function key menu is specified in the dictionary with a caret, ^, immediately followed by the name or number of the function key dictionary element. For example,

```
^misc_fkey
```

- The dictionary element defining the function keys should list one function key label per line. If function keys to the left of those specified are not active, then they should be set to "". A maximum of 10 function keys can be used. For example,

```
$3,misc_fkey

" F1" &new_line
```

```
" F2" &new_line

" F3" &new_line

" F4" &new_line

" HELP >" &new_line

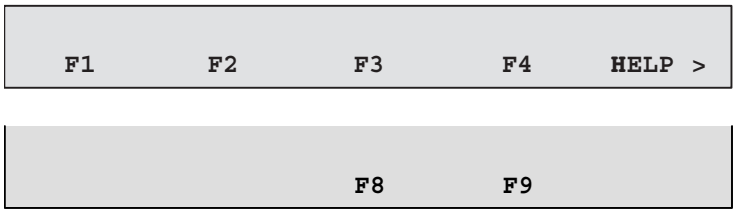
"" &new_line

"" &new_line

" F8" &new_line

" F9" &new_line
```

- The form processor will label the appropriate function keys and return from the routine if a valid key is pressed. The termination character will be set to ky_f1 through ky_f10.
- The function keys will be temporarily inactive if an enumerated data item is using the same function keys.
- If function key F5 is labeled HELP, it will automatically call the form's help menu if one exists.



10.3.12 Form Function Key Using a Variable

A function key menu can also be defined in a variable. The function key dictionary item will contain the program and variable name, prefixed with an asterisk to distinguish it from function key text. For example,

```
* Specify the function keys in a variable
* whose type is an ARRAY[m] of STRING[n].
$3,misc_fkey
  "*RUNFORM"  &new_line * program name of variable
  "*FKEYS"    &new_line * variable name containing function keys
```

[RUNFORM] FKEYS must be defined as a KAREL string array. Each element of the array should define a function key label.

```
[RUNFORM] FKEYS:ARRAY[10] OF STRING[12] =
[1] '   F1'
[2] '   F2'
[3] '   F3'
[4] '   F4'
[5] ' HELP    >'
[6] ''
[7] ''
[8] '   F8'
[9] '   F9'
[10]'         >'
```

10.3.13 Form Help Element Name or Number

Each form can have one related help menu. The help menu has the following characteristics:

- A help element name or number is specified in the dictionary with a question mark, ?, immediately followed by the name or number of the help dictionary element. For example,

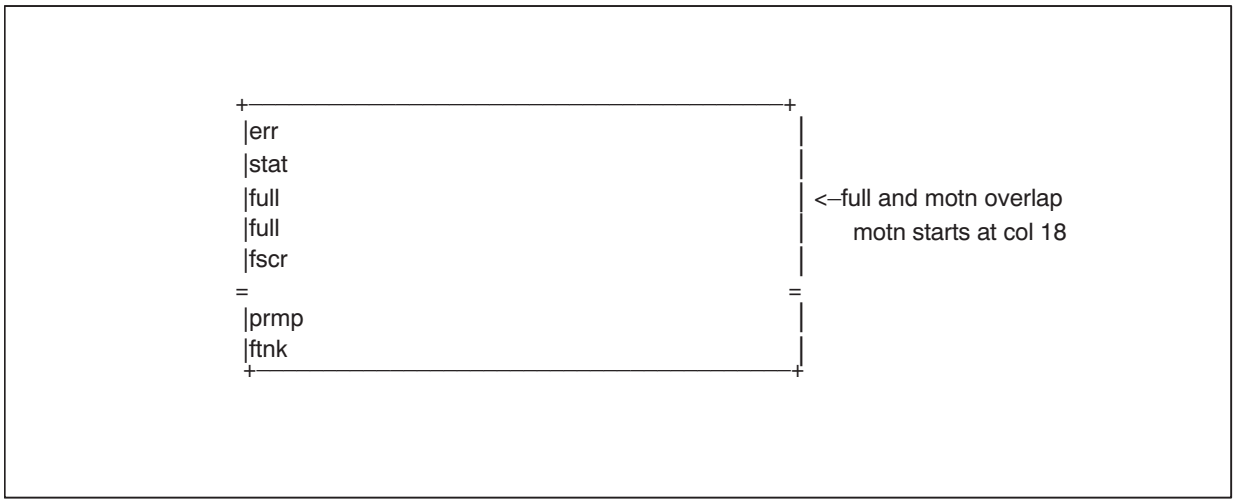
```
?misc_help
```

- The dictionary element defining the help menu is limited to 48 lines of text.
- The form processor will respond to the help key by displaying the help dictionary element in a predefined window. The predefined window is 40 columns wide and occupies rows 3 through 14.
- The help menu responds to the following inputs:
  - — Up or down arrows to scroll up or down 1 line.
  - — Shifted up or down arrows to scroll up or down 3/4 of a page.
  - — Previous, to exit help. The help menu restores the previous screen before returning.

10.3.14 Teach Pendant Form Screen

You can write to other active teach pendant windows while the form is displayed. The screen itself is named "tpsc." Figure 10–2 shows all the windows attached to this screen. Unless the noclear option is specified, ‘‘full,’’ ‘‘fscr,’’ ‘‘prmp,’’ and ‘‘ftnk’’ windows will be cleared before displaying the form.

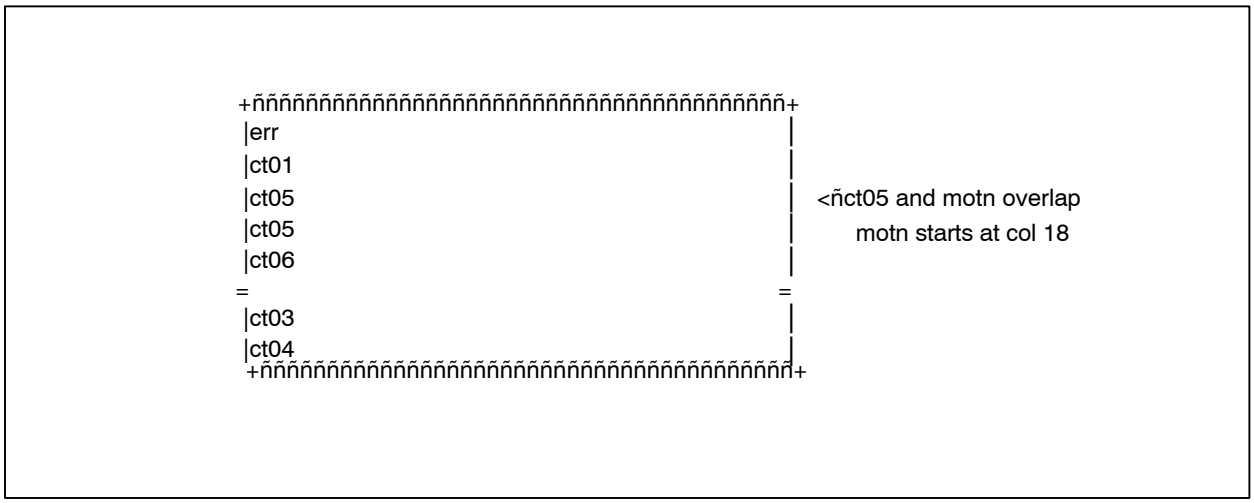
Figure 10–2. Teach Pendant Form Screen



10.3.15 CRT/KB Form Screen

You can write to other active CRT/KB windows while the form is displayed. The screen itself is named ‘‘ctsc.’’ All lines in the screen are set to double high and double wide video size. Figure 10–3 shows all the windows attached to this screen. Unless the ‘‘noclear’’ option is specified, ‘‘ct05,’’ ‘‘ct06,’’ ‘‘ct03,’’ and ‘‘ct04’’ windows will be cleared before displaying the form.

Figure 10–3. CRT/KB Form Screen



10.3.16 Form File Naming Convention

Uncompressed form dictionary files must use the following file name conventions:

- The first two letters in the dictionary file name can be an application prefix.
- If the file name is greater than four characters, the form processor will skip the first two letters when trying to determine the dictionary name.
- The next four letters must be the dictionary name that you use to load the .TX file, otherwise the form processor will not work.
- The last two letters are optional and should be used to identify the language;
  - — "EG" for ENGLISH
  - — "JP" for JAPANESE
  - — "FR" for FRENCH
  - — "GR" for GERMAN
  - — "SP" for SPANISH
- A dictionary file containing form text must have a .FTX file type, otherwise the dictionary compressor will not work. After it is compressed, the same dictionary file will have a .TX file type instead.

The following is an example of an uncompressed form dictionary file name:

```
MHPALTEG.FTX
```

MH stands for Material Handling, PALT is the dictionary name that is used to load the dictionary on the controller, and EG stands for English.

10.3.17 Compressing and Loading Forms on the Controller

The form file can only be compressed on the RAM disk RD:. Compressing a form is similar to compressing a user dictionary. From the KCL command prompt, enter:

```
KCL> COMPRESS FORM filename
```

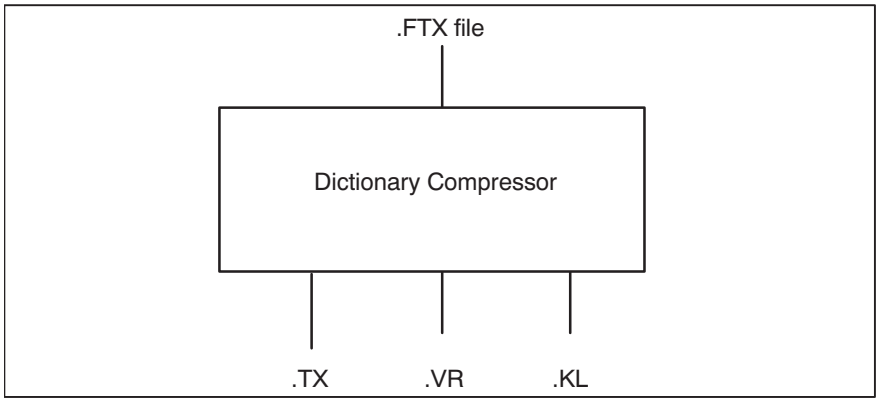
Do not include the .FTX file type. If the compressor detects any errors, it will point to the offending word with a brief explanation of what is wrong. Edit the form and correct the problem before continuing.

Note The form file must be an uncompressed file in order for the errors to point to the correct line.

Two files will be created by the compressor. One is a loadable dictionary file with the name filename but with a .TX file type. The other will be a variable file with a .VR file type but with the four

character dictionary name as the file name. The dictionary name is extracted from filename as described previously. A third file may also be created if you used the ".kl" symbol to generate a KAREL include file. Figure 10–4 illustrates compressing.

Figure 10–4. Dictionary Compressor and Form Dictionary File



Each form will generate three kinds of variables. These variables are used by the form processor. They must be reloaded each time the form dictionary is recompressed. The variables are as follows:

1. Item array variable - The variable name will be the four-character dictionary name, concatenated with the element number, concatenated with _IT.
2. Line array variable - The variable name will be the four-character dictionary name, concatenated with the element number, concatenated with _LN.
3. Miscellaneous variable - The variable name will be the four-character dictionary name, concatenated with the element number, concatenated with _MS.

The data defining the form is generated into KAREL variables. These variables are saved into the variable file and loaded onto the controller. The name of the program is the dictionary name preceded by an asterisk. For example, Dictionary MHPALTEG.FTX contains:

```
.form unnumber

$1, MH_TOOLDEFN

.endform

$2, MH_PORT

$3, MH_PORTFKEY

.form

$6, MH_APPLIO

.endform
```

As explained in the file naming conventions section, the dictionary name extracted from the file name is ‘‘PALT’’. Dictionary elements 1 and 6 are forms. A variable file named PALT.VR is generated with the program name ‘‘*PALT.’’ It contains the following variables:

```
PALT1_IT, PALT1_LN, and PALT1_MS

PALT6_IT, PALT6_LN, and PALT6_MS
```

Note KCL CLEAR ALL will not clear these variables. To show or clear them, you can SET VAR $CRT_DEFPROG = ’*PALT’ and use SHOW VARS and CLEAR VARS.

The form is loaded using the KCL LOAD FORM command.

```
KCL> LOAD FORM filename
```

The name filename is the name of the loadable dictionary file. After this file is loaded, the dictionary name is extracted from filename and is used to load the variable file. This KCL command is equivalent to

```
KCL> LOAD DICT filename dict_name DRAM

KCL> LOAD VARS dict_name
```

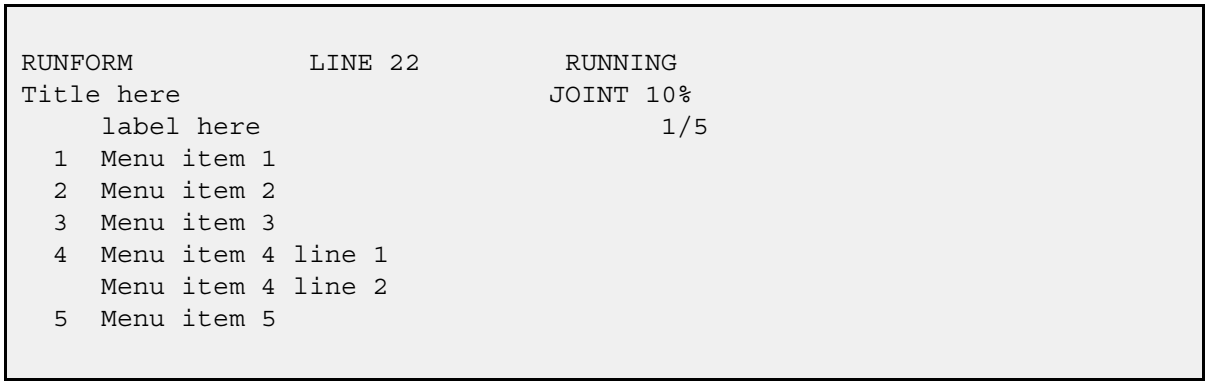
10.3.18 Displaying a Form

The DISCTRL_FORM built-in is used to display and control a form on the teach pendant or CRT/KB screens. All input keys are handled within DISCTRL_FORM. This means that execution of your KAREL program will be suspended until an input key causes DISCTRL_FORM to exit the form. Any condition handlers will remain active while your KAREL program is suspended.

Note DISCTRL_FORM will only display the form if the USER2 menu is the selected menu. Therefore, use FORCE_SPMENU(device_stat, SPI_TPUSER2, 1) before calling DISCTRL_FORM to force the USER2 menu.

The following screen shows the first template in FORM.FTX as displayed on the teach pendant. This example contains four selectable menu items.

Figure 10–5. Example of Selectable Menu Items



The dictionary elements in FORM.FTX, shown in Example Form Dictionary for Selectable Menu Items , were used to create the form shown in Figure 10–5 .

Example Form Dictionary for Selectable Menu Items

```
*     Dictionary Form File: form.ftx
*
*     Generate form.kl which should be included in your KAREL program
.kl form
.form
$-,forml
      &home &reverse "Title here" &standard $new_line
      "    label here " &new_line
      @3,10    "- Menu item 1 "
      @4,10    "- Menu item 2 "
      @5,10    "- Menu item 3 "
      @6,10    "- Menu item 4 line 1 +"
      @7,10    " Menu item 4 line 2 "
      @8,10    "- Menu item 5 "
      * Add as many items as you wish.
      * The form manager will scroll them.
      ^form1_fkey    * specifies element which contains
                     * function key labels
      ?form1_help    * element which contains help
.endform
$-,form1_fkey    * function key labels
      "     F1" &new_line
      "     F2" &new_line
      "     F3" &new_line
      "     F4" &new_line
      "     HELP >" &new_line * help must be on F5
      "     F6" &new_line
      "     F7" &new_line
      "     F8" &new_line
```

```
      "     F9" &new_line
      "     F10 >"
      * you can have a maximum of 10 function keys labeled
$-, form1_help     * help text
      "Help  Line 1" &new_line
      "Help Line 2" &new_line
      "Help Line3" &new_line
      * You can have a maximum of 48 help lines
```

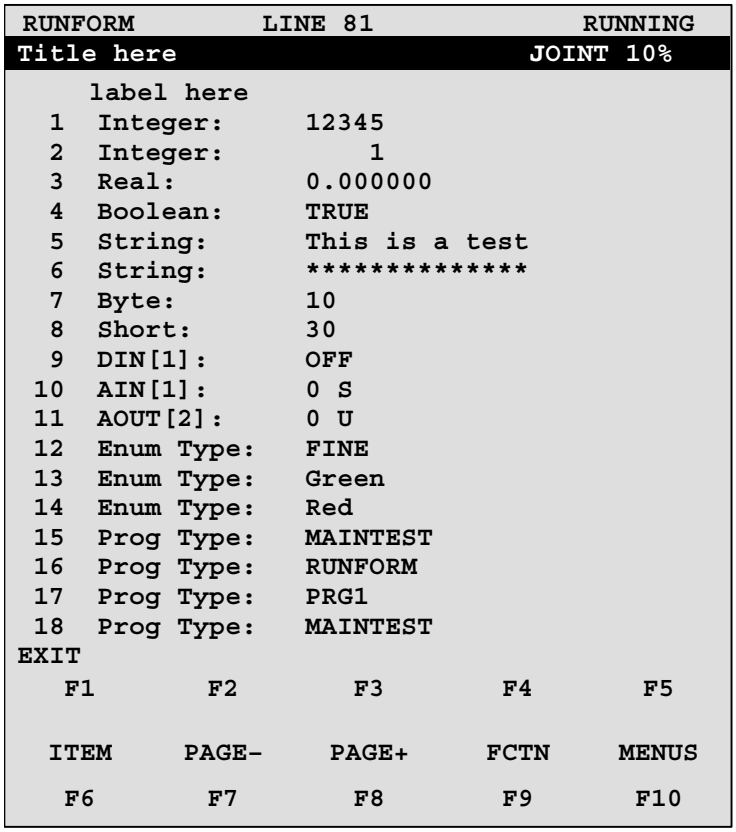
The program shown in Example Program for Selectable Menu Items was used to display the form shown in Figure 10–5 .

Example Program for Selectable Menu Items

```
PROGRAM runform
%NOLOCKGROUP
%INCLUDE form               -- allows you to access form element numbers
%INCLUDE klevccdf
%INCLUDE klevkeys
%INCLUDE klevkmsk
VAR
    device_stat:  INTEGER                   --tp_panel or crt_panel
    value_array:  ARRAY [1] OF STRING [1]   --dummy variable for DISCTRL_FORM
    inact_array:  ARRAY [1] OF BOOLEAN      --not used
    change_array: ARRAY [1] OF BOOLEAN      --not used
    def_item:           INTEGER
    term_char:          INTEGER
    status:             INTEGER
BEGIN
    device_stat = tp_panel
    FORCE_SPMENU (device_stat, SPI_TPUSER2, 1)--forces the TP USER2
menu
    def_item = 1 -- start with menu item 1
    --Displays form named FORM1
    DISCTRL_FORM ("FORM", form1, value_array, inact_array,
           change_array, kc_func_key, def_item, term_char, status)
    WRITE TPERROR (CHR(cc_clear_win))        --clear the TP error
window
    IF term_char = ky_select THEN
          WRITE TPERROR ("Menu item", def_item: :1, 'was selected.')
    ELSE
          WRITE TPERROR ('Func key', term_char: :1, ' was selected.')
    ENDIF
END runform
```

Figure 10–6 shows the second template in FORM.FTX as displayed on the CRT/KB (only 10 numbered lines are shown at one time). This example contains all the edit data types.

Figure 10–6. Example of Edit Data Items



The dictionary elements in FORM.FTX, shown in Example Dictionary for Edit Data Items , were used to create the form shown in Figure 10–6 .

Example Dictionary for Edit Data Items

```
* Dictionary Form File: form.ftx
*
* Generate form.kl which should be included in your KAREL program
.kl form
.form
$-,form2
&home &reverse " Title here" &standard                          &new_line
"    label here     "                                          &new_line
"    Integer:       "    "-%10d"                               &new_line
"    Integer:       "    "-%10d(1,32767)"                      &new_line
```

```
"    Real:          "    "-%12f"                                  &new_line
"    Bolean:        "    "-%10B(bool_fkey)"                       &new_line
"    String:        "    "-%-20k"                                 &new_line
"    String:        "    "-%12k(clear)"                           &new_line
"    Byte:          "    "-%10b"                                  &new_line
"    Short:         "    "-%10h"                                  &new_line
"    DIN[1]:        "    "-%10P(dout_fkey)"                       &new_line
"    AIN[1]:        "    " "-%10pu" " " "-%1S(sim_fkey)"          &new_line
"    AOUT[2]:       "    " "-%10px" " " "-%1S(sim_fkey)"          &new_line
"    Enum Type:     "    "-%8n(enum_fkey)"                        &new_line
"    Enum Type:     "    "-%6w(enum_subwin)"                      &new_line
"    Enum Type:     "    "-%6V(ENUM_VAR)"                         &new_line
"    Prog Type:     "    "-%12pk(1)"                              &new_line
"    Prog Type:     "    "-%12pk(2)"                              &new_line
"    Prog Type:     "    "-%12pk(6)"                              &new_line
"    Prog Type:     "    "-%12pk(16)"                             &new_line
     ^form2_fkey
.endform
$-,form2_fkey
       EXIT" &new_line
*Allows you to specify the labels for F4 and F5 function keys
$-,bool_fkey
"FALSE"    &new_line   *   F5 key label, value will be set FALSE
"TRUE"    &new_line    *   F4 key label, value will be set TRUE
* Allows you to specify the labels for F4 and F5 function keys
$-, dout_fkey
"OFF"      &new_line    *   F5 key label, value will be set OFF
"ON"       &new_line    *   F4 key label, value will be set
ON
*Allows you to specify the labels for F4 and F5 function keys
$-, sim_fkey
" UNSIM "  &new_line    *   F5 key label, port will be unsimulated
"SIMULATE" &new_line    *   F4 key label, port will be simulated
*Allows you to specify the labels for 5 function keys
$-, enum_fkey
"FINE"      &new_line  * F1 key label, value will be set to 1
"COARSE"    &new_line  * F2 key label, value will be set to 2
"NOSETTL"   &new_line  * F3 key label, value will be set to 3
"NODECEL"   &new_line  * F4 key label, value will be set to 4
"VARDECEL"  &new_line  * F5 key label, value will be set to 5
*Allows you to specify a maximum of 35 choices in a subwindow
$-,enum_subwin
"Red"       *      value will be set to 1
$-
"Blue"      *      value will be set to 2
$-
"Green"
```

```
$-
"Yellow"
$-
"\a"          *      specifies end of subwindow list
* Allows you to specify the choices for the subwindow in a
* variable whose type is an ARRAY[m] of STRING[n].
$-,enum_var
"RUNFORM"   &new_line     *    program name of variable
"CHOICES"   &new_line     *    Variable name containing choices
```

The program shown in Example Program for Edit Data Items was used to display the form in Figure 10–6 .

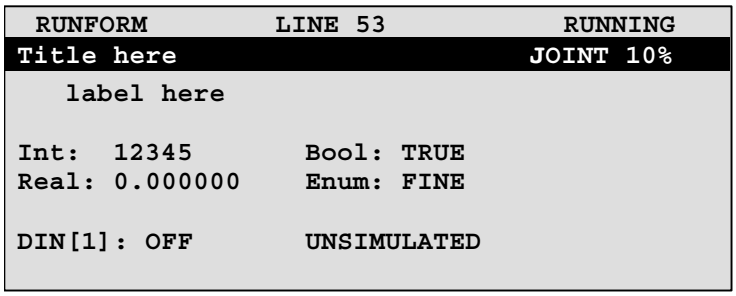
Example Program for Edit Data Items

```
PROGRAM runform
%NOLOCKGROUP
%INCLUDE form     -- allows you to access form element numbers
%INCLUDE klevccdf
%INCLUDE klevkeys
%INCLUDE klevkmsk
TYPE
      mystruc = STRUCTURE
      byte_var1: BYTE
      byte_var2: BYTE
      short_var: SHORT
ENDSTRUCTURE
VAR
      device_stat: INTEGER -- tp_panel or crt_panel
      value_array: ARRAY [20] OF STRING [40]
      inact_array: ARRAY [1] OF BOOLEAN
      change_array: ARRAY[1] OF BOOLEAN
      def_item: INTEGER
      term_char: INTEGER
      status: INTEGER
int_var1: INTEGER
int_var2: INTEGER
real_var: REAL
bool_var: BOOLEAN
str_var1: STRING[20]
str_var2: STRING[12]
struc_var: mystruc
color_sel1: INTEGER
color_sel2: INTEGER
prog_name1: INTEGER[12]
prog_name2: STRING[12]
```

```
Prog_name3: STRING[12]
prog_name4: STRING[12]
choices: ARRAY[5] OF STRING[12]
BEGIN
      value_array [1] = 'int_var1'
      value_array [2] = 'int_var2'
      value_array [3] = 'real_var'
      value_array [4] = 'bool_var'
      value_array [5] = 'str_var1'
      value_array [6] = 'str_var2'
      value_array [7] = 'struc_var.byte_var1'
      value_array [8] = 'struc_var.short_var'
      value_array [9] = 'din[1]'
      value_array [10] = 'ain[1]'
      value_array [11] = 'ain[1]'
      value_array [12] = 'aout[2]'
      value_array [13] = 'aout[2]'
      value_array [14] = '[*system*]$group[1].$termtype'
      value_array [15] = 'color_sel1'
      value_array [16] = 'color_sel2'
      value_array [17] = 'prog_name1'
      value_array [18] = 'prog_name2'
      value_array [19] = 'prog_name3'
      value_array [20] = 'prog_name4'
      choices [1] = ''          --not used
      choices [2] = 'Red'       --corresponds to color_sel12 = 1
      choices [3] = 'Blue'      --corresponds to color_sel12 = 2
      choices [4] = 'Green'     --corresponds to color_sel12 = 3
      choices [5] = 'Yellow'    --corresponds to color_sel12 = 4
-- Initialize variables
int_var1 = 12345
-- int_var2 is purposely left uninitialized
real_var = 0
bool_var = TRUE
str_var1 = 'This is a test'
-- str_var = is purposely left uninitialized
struc_var.byte_var1 = 10
struc_var.short_var = 30
color_sel1 = 3               --corresponds to third item of enum_subwin
color_sel2 = 1
device_stat = crt_panel      --specify the CRT/KB for displaying
form
FORCE_SPMENU(device_stat, SPI_TPUSER2,1)
def_item = 1 -- start with menu item 1
DISCTRL_FORM('FORM', form2, value_array, inact_array,
       change_array, kc_func_key, def_item, term_char, status);
END runform
```

Figure 10–7 shows the third template in FORM.FTX as displayed on the teach pendant. This example contains display only items. It shows how to automatically load the form dictionary file and the variable data file, from a KAREL program.

Figure 10–7. Example of Display Only Data Items



The dictionary elements in FORM.FTX, shown in Example Dictionary for Display Only Data Items , were used to create the form shown in Figure 10–7 .

Example Dictionary for Display Only Data Items

```
*      Dictionary Form File: form.ftx
*
*      Generate form.kl which should be included in your KAREL program
.kl form
.form
$-,form3
      &home &reverse "Title here" &standard    &new_line
      "label here"                             &new_line
                                               &new_line
"Int: " "%-10d" " Bool: " "%-10B(bool_fkey)"   &new_line
"Real: " "%-10f" " Enum: " "%-10n(enum_fkey)"  &new_line
"DIN[""%1d""]: " "%-10P(dout_fkey)" "%-12S(sim2_fkey)"
*You can have as many columns as you wish without exceeding * 40 columns.
*You can specify blank lines too.
.endform
$-,sim2_fkey
  "UNSIMULATED" &new_line  * F5 key label, port will be unsimulated
  "SIMULATED"   &new_line  * F4 key label, port will be simulated
```

The program shown in Example Program for Display Only Data Items was used to display the form shown in Figure 10–7 .

Example Program for Display Only Data Items

```
PROGRAM runform
%NOLOCKGROUP
 %INCLUDE form      -- allows you to access form element numbers
 %INCLUDE klevccdf
 %INCLUDE klevkeys
 %INCLUDE klevkmsk
        device_stat: INTEGER -- tp_panel or crt_panel
        value_array: ARRAY [20] OF STRING [40]
        inact_array: ARRAY [1] OF BOOLEAN -- not used
        change_array: ARRAY[1] OF BOOLEAN -- not used
        def_item: INTEGER
        term_char: INTEGER
        status: INTEGER
        loaded: BOOLEAN
        initialized: BOOLEAN
int_var1: INTEGER
int_var2: INTEGER
real_var: REAL
bool_var: BOOLEAN
BEGIN
-- Make sure 'FORM' dictionary is loaded.
CHECK_DICT('FORM', form3, status)
IF status <> 0 THEN
      WRITE TPPROMPT(CR,'Loading form.....')
      KCL ('CD MF2:',status)            --Use the KCL CD command to
                                        --change directory to MF2:
      KCL ( 'LOAD FORM', status)        --Use the KCL load for command
                                        --to load in the form
      IF status <> 0 THEN
            WRITE TPPROMPT(CR,'loading from failed, STATUS=',status)
            ABORT      --Without the dictionary this program cannot continue.
      ENDIF
ELSE
      WRITE TPPROMPT (CR,'FORM already loaded.')
ENDIF
      value_array [1] = 'int_var1'
      value_array [2] = 'bool_var'
      value_array [3] = 'real_var'
      value_array [4] = '[*system*]$group[1].$termtype'
      value_array [5] = 'int_var2'
      value_array [6] = 'din[1]'
      value_array [7] = 'din[1]'
int_var1 = 12345
bool_var = TRUE
real_var = 0
```

```
int_var2 = 1
device_stat = tp_panel
FORCE_SPMENU(device_stat, SPI_TPUSER2,1)
def_item = 1 -- start with menu item 1
DISCTRL_FORM('FORM', form3, value_array, inact_array,
      change_array, kc_func_key, def_item, term_char, status);
END runform
```

Chapter 11

SYSTEM VARIABLES

Contents

Chapter 11 SYSTEM VARIABLES 11–1
11.1 ACCESS RIGHTS 11–2
11.1.1 System Variables Accessed by KAREL Programs 11–3
11.2 STORAGE 11–4

System variables are variables that are declared as part of the KAREL system software. They have permanently defined variable names that begin with a dollar sign ($). Many system variables are *structure variables* , in which case each field also begins with a dollar sign ($). Many are robot specific, meaning their values depend on the type of robot that is attached to the system.

System variables have the following characteristics:

- They have predefined data types that can be any one of the valid KAREL data types.
- The initial values of the system variables are either internal default values or variables stored in the default system variable file, SYSDEF.SV.
- When loading and saving system variables from the FILE screen or KCL, the system variable file name defaults to SYSVARS.SV.
- Access rights govern whether or not you can examine or change system variables.
- Modified system variables can be saved to reflect the current status of the system.

See Also: Chapter 2 *LANGUAGE ELEMENTS* for more information on the data types available in KAREL

11.1 ACCESS RIGHTS

The following rules apply to system variables:

- If a system variable allows a KAREL program to read its value, you can use that value in the same context as you use program variable values or constant values in KAREL programs.

  For example, these system variables can be used on the right hand side of an assignment statement or as a test condition in a control statement.
- If a system variable allows a KAREL program to write its value, you can use that system variable in any context where you assign values to variables in KAREL programs.

The symbols for the program access rights are listed in Table 11–1 . These symbols are given for each of the system variables in the *FANUC Robotics SYSTEM R-J3iC Controller Software Reference Manual* .

Table 11–1. Access Rights for System Variables

Access	Meaning
NO	No access
RO	Read only
RW	Read and write
FP	Field protection; if it is a structure variable, one of the first three access rights will apply.

See Also: *FANUC Robotics SYSTEM R-J3iC Controller Software Reference Manual* for system variables

11.1.1 System Variables Accessed by KAREL Programs

Many system variables pertaining to motion are defined as an ARRAY[n] or a structure type where "n" is the number of motion groups defined on the controller. The system variable $GROUP is defined in this fashion. The KAREL language recognizes $GROUP as a special system variable and performs a USING $GROUP[def_group] at the beginning of each routine. Therefore, if the $GROUP[n] prefix is not specified, the group specified by the %DEFGROUP directive or 1 is assumed. See Specifying a Motion Group with System Variables for an example.

Specifying a Motion Group with System Variables

```
$GROUP[1].$SPEED = 300
$SPEED = 300 -- same result as above
motion_time = motion_dist / $SPEED
$GROUP[1].$UFRAME = aux_frame_1
```



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly, and injure personnel or damage equipment.

Table 11–2 is a list of the system variables that can be accessed by a KAREL program in the WITH clause of a motion statement.

Table 11–2. System Variables Accessed by Programs

$ACCEL_OVRD	$SEG_TIME
$ACCU_NUM	$SPEED
$CNSTNT_PATH	$TERMTYPE
$CONTAXISVEL	$TIME_SHIFT
$DECELTOL	$UFRAME
$DYN_I_COMP	$USE_CARTACC
$MOTYPE	$USE_CONFIG
$ORIENT_TYPE	$USEMAXACCEL
$REF_POS	$USERELACCEL

Table 11–2. System Variables Accessed by Programs (Cont'd)

$ROTSPEED	$USETIMESHFT
$SEGTERMTYPE	$UTOOL

11.2 STORAGE

System variables are assigned an initial value upon power up based on

- Internal default values
- Values stored in the default system variable file, SYSDEF.SV

Chapter 12

KAREL COMMAND LANGUAGE (KCL)

Contents

Chapter 12	KAREL COMMAND LANGUAGE (KCL)	12–1
12.1	COMMAND FORMAT	12–2
12.1.1	Default Program	12–2
12.1.2	Variables and Data Types	12–3
12.2	MOTION CONTROL COMMANDS	12–3
12.3	ENTERING COMMANDS	12–3
12.3.1	Abbreviations	12–4
12.3.2	Error Messages	12–4
12.3.3	Subdirectories	12–4
12.4	COMMAND PROCEDURES	12–4
12.4.1	Command Procedure Format	12–5
12.4.2	Creating Command Procedures	12–6
12.4.3	Error Processing	12–6
12.4.4	Executing Command Procedures	12–6

The KAREL command language (KCL) environment contains a group of commands that can be used to direct the KAREL system. KCL commands allow you to develop and execute programs, work with files, get information about the system, and perform many other daily operations.

The KCL environment can be displayed on the CRT/KB by pressing MENUS (F10) and selecting KCL from the menu.

In addition to entering commands directly at the KCL prompt, KCL commands can be executed from command files.

12.1 COMMAND FORMAT

A command entry consists of the command keyword and any arguments or parameters that are associated with that command. Some commands also require identifiers specifying the object of the command.

- KCL command keywords are action words such as LOAD, EDIT, and RUN. Command arguments, or parameters, help to define on what object the keyword is supposed to act.
- Many KCL commands have default arguments associated with them. For these commands, you need to enter only the keyword and the system will supply the default arguments.
- KCL supports the use of an asterisk (*) as a wildcard, which allows you to specify a group of objects as a command argument for the following KCL commands:
  - COPY
  - DELETE FILE
  - DIRECTORY
- KCL identifiers follow the same rules as the identifiers in the KAREL programming language.
- All of the data types supported by the KAREL programming language are supported in KCL. Therefore, you can create and set variables in KCL.

See Also: Chapter 2 *LANGUAGE ELEMENTS* , and Chapter 9 *FILE SYSTEM* ,

12.1.1 Default Program

Setting a program name as a default for program name arguments and file name arguments allows you to issue a KCL command without typing the name.

The KCL default program can be set by doing one of the following:

- Using the SET DEFAULT KCL command
- Selecting a program name at the SELECT menu on the CRT/KB

12.1.2 Variables and Data Types

The KCL> CREATE VARIABLE command allows you to declare variables. The KCL> SET VARIABLE command permits you to assign values to declared variables. Assigned values can be INTEGER, REAL, BOOLEAN, and STRING data types. Values can be assigned to particular ARRAY elements or specified PATH nodes. VECTOR variables are assigned as three REAL values, and POSITION variables are assigned as six REAL values.

See Also: CREATE VARIABLE and SET VARIABLE KCL commands in Appendix C , "KCL Command Alphabetical Description"

12.2 MOTION CONTROL COMMANDS

KCL commands can also cause motion, provided the device from which the command is issued has motion control. Refer to the $RMT_MASTER description in the *FANUC Robotics SYSTEM R-J3iC Controller Software Reference Manual* for more information about assigning motion control to a remote device.

Motion commands:

- Immediately cause robot and/or auxiliary axis motion, or have the potential to cause motion
- Can be executed only if a number of conditions are met

The following commands are motion commands:

- CONTINUE
- RUN



Warning

Be sure that the robot work envelope is clear of personnel before issuing a motion command or starting a robot that automatically executes a program at power up. Otherwise, you could injure personnel or damage equipment.

12.3 ENTERING COMMANDS

You can enter KCL commands only from the CRT/KB.

To enter KCL commands:

1. Press MENUS (F10) at the CRT/KB.

2. Select KCL.
3. Enter commands at the KCL prompt.

By entering the first keyword of a KCL command that requires more than one keyword, and by pressing ENTER, a list of all additional KCL keywords will be displayed.

For example, entering **DELETE** at the KCL prompt will display the following list of possible commands: "FILE, NODE, or VARIABLE."

Note The up arrow key can be used to recall any of the last ten commands entered.

12.3.1 Abbreviations

Any KCL command can be abbreviated as long as the abbreviations are unique in KCL. For example, **TRAN** is unique to TRANSLATE and **ED** , to EDIT.

12.3.2 Error Messages

If you enter a KCL command incorrectly, KCL displays the appropriate error message and returns the KCL> prompt, allowing you to reenter the command. An up arrow (^) indicates the offending character or the beginning of the offending word.

12.3.3 Subdirectories

Subdirectories are available on the memory card device. Subdirectories allow both memory cards and Flash disk cards to be formatted on any MS-DOS file system. You can perform all KCL file related commands on subdirectories. You can nest subdirectories up to many levels. However, FANUC Robotics does not recommend nesting subdirectories greater than eight levels.

12.4 COMMAND PROCEDURES

Command procedures are a sequence of KCL commands that are stored in a command file (.CF file type) and can be executed automatically in sequence.

- Command procedures allow you to use a sequence of KCL commands without typing them over and over.
- Command procedures are executed using the RUNCF command.

12.4.1 Command Procedure Format

All KCL commands except RUNCF can be used inside a command procedure. For commands that require confirmation, you can enter either the command and confirmation on one line or KCL will prompt for the confirmation on the input line. Confirmation in a Command Procedure displays **CLEAR ALL** as the KCL command and **YES** as the confirmation.

Confirmation in a Command Procedure

```
Enter command and confirmation on one line:
 CLEAR ALL YES
```

Nesting Command Procedures

Use the following guidelines when nesting command procedures:

- Command procedures can be nested by using %INCLUDE filename inside a command procedure.
- Nesting of command procedures is restricted to four levels.

  If nesting of more than four command procedures is attempted, KCL will detect the error and take the appropriate action based on the system variable $STOP_ON_ERR. Refer to Section 12.4.3 for more information on $STOP_ON_ERR.

See Also: Section 12.4.3 , “Error Processing”

Continuation Character

The KCL continuation character, ampersand (&), allows you to continue a command entry across more than one line in a command procedure.

You can break up KCL commands between keywords or between special characters.

For example, use the ampersand (&) to continue a command across two lines:

```
CREATE VAR [TESTING_PROG.]PICK_UP_PNT &
      :POSITION
```

Comments

Comment lines can be used to document command procedures. The following rules apply to using comments in command procedures:

- Precede comments with two consecutive hyphens (**--**).
- Comments can be placed on a line by themselves or at the end of a command line.

12.4.2 Creating Command Procedures

A command procedure can be created by typing in the list of commands into a command file and saving the file. This can be done using the full screen editor.

See Also: EDIT KCL commands, Appendix C, "KCL Command Alphabetical Description"

12.4.3 Error Processing

If the system detects a KCL error while a command procedure is being executed, the system handles the error in one of two ways, depending on the value of the system variable $STOP_ON_ERR:

- If $STOP_ON_ERR is TRUE when a KCL error is detected, the command procedure terminates and the KCL> prompt returns.
- If $STOP_ON_ERR is FALSE, the system ignores KCL errors and the command procedure runs to completion.

12.4.4 Executing Command Procedures

Each command in a command procedure is displayed as it is executed unless the SET VERIFY OFF command is used. Each command is preceded with the line number from the command file. However, if the file is not on the RD: device, the entire command file is read into memory before execution and line numbers will be omitted from the display.

Command procedures can be executed using the KCL RUNCF command.

Chapter 13

INPUT/OUTPUT SYSTEM

Contents

Chapter 13	INPUT/OUTPUT SYSTEM	13–1
13.1	USER-DEFINED SIGNALS	13–2
13.1.1	DIN and DOUT Signals	13–2
13.1.2	GIN and GOUT Signals	13–3
13.1.3	AIN and AOUT Signals	13–3
13.1.4	Hand Signals	13–5
13.2	SYSTEM-DEFINED SIGNALS	13–5
13.2.1	Robot Digital Input and Output Signals (RDI/RDO)	13–6
13.2.2	Operator Panel Input and Output Signals (OPIN/OPOUT)	13–6
13.2.3	Teach Pendant Input and Output Signals (TPIN/TPOUT)	13–17
13.3	Serial Input/Output	13–21
13.3.1	Serial Input/Output	13–21

The Input/Output (I/O) system provides user access with KAREL to user-defined I/O signals, system-defined I/O signals and communication ports. The user-defined I/O signals are controlled in a KAREL program and allow you to communicate with peripheral devices and the robot end-of-arm tooling. System-defined I/O signals are those that are designated by the KAREL system for specific purposes. Standard and optional communications port configurations also exist.

The number of user-defined I/O signals is dependent on the controller hardware and on the types and number of modules selected.

13.1 USER-DEFINED SIGNALS

User-defined signals are those input and output signals whose meaning is defined by a KAREL program. You have access to user-defined signals through the following predefined port arrays:

- DIN (digital input) and DOUT (digital output)
- GIN (group input) and GOUT (group output)
- AIN (analog input) and AOUT (analog output)

In addition to the port arrays, you have access to robot hand control signals through KAREL OPEN and CLOSE HAND statements.

13.1.1 DIN and DOUT Signals

The DIN and DOUT signals provide access to data on a single input or output line in a KAREL program.

The program treats the data as a BOOLEAN data type. The value is either ON (active) or OFF (inactive). You can define the polarity of the signal as either active-high (ON when voltage is applied) or active-low (ON when voltage is not applied).

Input signals are accessed in a KAREL program by the name DIN[n], where ‘‘n’’ is the signal number.

Evaluating DIN signals causes the system to perform read operations of the input port. Assigning a value to a DIN signal is an invalid operation unless the DIN signal has been simulated. These can never be set in a KAREL program, unless the DIN signal has been simulated.

Evaluating DOUT signals causes the system to return the currently output value from the specified output signal. Assigning a value to a DOUT signal causes the system to set the output signal to ON or OFF.

To turn on a DOUT:

```
DOUT[n] = TRUE or
```

```
DOUT[n] = ON
```

To turn off a DOUT:

```
DOUT[n] = FALSE or
DOUT[n] = OFF
```

You assign digital signals to the ports on I/O devices using teach pendant I/O menus or the KAREL built-in routine SET_PORT_ASG.

13.1.2 GIN and GOUT Signals

The GIN and GOUT signals provide access to DINs and DOUTs as a group of input or output signals in a KAREL program. A group can have a size of 1 to 16 bits, with each bit corresponding to an input or output signal. You define the group size and the DINs or DOUTs associated with a specific group. The first (lowest numbered) port is the least significant bit of the group value.

The program treats the data as an INTEGER data type. The unused bits are interpreted as zeros.

Input signals are accessed in KAREL programs by the name GIN[n], where“n” is the group number.

Evaluating GIN signals causes the system to perform read operations of the input ports. Assigning a value to a GIN signal is an invalid operation unless the GIN signal has been simulated. These can never be set in a KAREL program, unless the GIN signal has been simulated.

Setting GOUT signals causes the system to return the currently output value from the specified output port. Assigning a value to a GOUT signal causes the system to perform an output operation.

To control a group output, the integer value equivalent to the desired binary output is used. For example the command GOUT[n] = 25 will have the following binary result “0000000000011001” where 1 = output on and 0 = output off, least significant bit (LSB) being the first bit on the right.

You assign group signals using teach pendant I/O menus or the KAREL built-in routine SET_PORT_ASG.

13.1.3 AIN and AOUT Signals

The AIN and AOUT signals provide access to analog electrical signals in a KAREL program. For input signals, the analog data is digitized by the system and passed to the KAREL program as a 16 bit binary number, of which 14 bits, 12 bits, or 8 bits are significant depending on the analog module. The program treats the data as an INTEGER data type. For output signals, an analog voltage corresponding to a programmed INTEGER value is output.

Input signals are accessed in KAREL programs by the name AIN[n], where“n” is the signal number.

Evaluating AIN signals causes the system to perform read operations of the input port. Setting an AIN signal at the Teach Pendant is an invalid operation unless the AIN signal has been simulated. These can never be set in a KAREL program, unless the AIN signal has been simulated.

The value displayed on the TP or read by a program from an analog input port are dependent on the voltage supplied to the port and the number of bits of significant data supplied by the analog-to-digital conversion. For positive input voltages, the values read will be in the range from 0 to 2**(N-1) -1, where N is the number of bits of significant data. For 12 bit devices (most FANUC modules), this is 2**11–1, or 2047.

For negative input voltages, the value will be in the range 2**N - 1 to 2**(N-1) as the voltage varies from the smallest detectable negative voltage to the largest negative voltage handled by the device. For 12 bit devices, this is from 4095 to 2048.

An example of the KAREL logic for converting this input to a real value representing the voltage, where the device is a 12 bit device which handles a range from +10v to -10v would be as follows:

Figure 13–1. KAREL Logic for Converting Input to a Real Value Representing the Voltage

```
V: REAL
AINP: INTEGER
AINP = AIN[1]
IF (AINP <= 2047) THEN
V = AINP * 10.0 /2047.0
ELSE
V = (AINP - 4096) * 10.0 / 2047
ENDIF
```

In TPP, the following logic would be used:

```
R[1] = AI[1]
IF (R[1] > 2047) JMP LBL[1]
R[2] = R[1] * 10
R[2] = R[2] / 2047
JMP LBL[2]
LBL[1]:
R[2] = R[1] - 4096
R[2] = R[2] * 10
R[2] = R[2] / 2047
LBL[2]
```

R[2] has the desired voltage.

Evaluating AOUT signals causes the system to return the currently output value from the specified output signal. Assigning a value to an AOUT signal causes the system to perform an output operation.

An AOUT can be turned on in a KAREL program with AOUT[n] = (an integer value). The result will be the output voltage on the AOUT signal line[n] of the integer value specified. For example, AOUT[1] = 1000 will output a +5 V signal on Analog Output line 1 (using an output module with 12 significant bits).

You assign analog signals using teach pendant I/O menus or the KAREL built-in routine SET_PORT_ASG.

13.1.4 Hand Signals

You have access to a special set of robot hand control signals used to control end-of-arm tooling through the KAREL language HAND statements, rather than through port arrays. HAND signals provide a KAREL program with access to two output signals that work in a coordinated manner to control the tool. The signals are designated as the open line and the close line. The system can support up to two HAND signals.

HAND[1] uses the same physical outputs as RDO[1] and RDO[2].

HAND[2] uses the same physical outputs as RDO[3] and RDO[4].

The following KAREL language statements are provided for controlling the signal, where “n” is the signal number.

OPEN HAND n activates open line, and deactivates close line

CLOSE HAND n deactivates open line, and activates close line

RELAX HAND n deactivates both lines

13.2 SYSTEM-DEFINED SIGNALS

System-defined I/O signals are signals designated by the controller software for a specific purpose. Except for certain UOP signals, system-defined I/O cannot be reassigned.

You have access to system-defined I/O signals through the following port arrays:

- Robot digital input (RDI) and robot digital output (RDO)
- Operator panel input (OPIN) and operator panel output (OPOUT)
- Teach pendant input (TPIN) and teach pendant output (TPOUT)

13.2.1 Robot Digital Input and Output Signals (RDI/RDO)

Robot I/O is the input and output signals between the controller and the robot. These signals are sent to the EE (End Effector) connector located on the robot. The number of robot input and output signals (RDI and RDO) varies depending on the number of axes in the system. For more information on configuring Robot I/O, refer to the appropriate application-specific *FANUC Robotics SYSTEM R-J3iC Controller HandlingTool Setup and Operations Manual.*

RDI[1] through RDI[8] are available for tool inputs. All or some of these signals can be used, depending on the robot model. Refer to the Maintenance Manual specific to your robot model, for more information.

RDO[1] through RDO[8] are available for tool control. All or some of these signals can be used, depending on the robot model. Refer to the Maintenance Manual specific to your robot model, for more information.

RDO[1] through RDO[4] are the same signals set using OPEN, CLOSE, and RELAX hand. See Section 13.1.4 .

13.2.2 Operator Panel Input and Output Signals (OPIN/OPOUT)

Operator panel input and output signals are the input and output signals for the standard operator panel (SOP) and for the user operator panel (UOP).

Operator panel input signals are assigned as follows:

- The first 16 signals, OPIN[0] - OPIN[15], are assigned to the standard operator panel.
- The next 18 signals, OPIN[16] - OPIN[33], are assigned to the user operator panel (UOP). If you have a process I/O board, these 18 UOP signals are mapped to the first 18 input ports on the process I/O board.

Operator panel output signals are assigned as follows:

- The first 16 signals, OPOUT[0] - OPOUT[15], are assigned to the standard operator panel.
- The next 20 signals, OPOUT[16] - OPOUT[35], are assigned to the user operator panel (UOP). If you have a process I/O board, these 20 UOP signals are mapped to the first 20 output ports on the process I/O board.

Standard Operator Panel Input and Output Signals

Standard operator panel input and output signals are recognized by the KAREL system as OPIN[0] - OPIN[15] and OPOUT[0] - OPOUT[15] and by the screens on the teach pendant as SI[0] - SI[15] and SO[0] - SO[15]. Table 13–1 lists each standard operator panel input signal. Table 13–2 lists each standard operator panel output signal.

Table 13–1. Standard Operator Panel Input Signals

OPIN[n]	SI[n]	Function	Description
OPIN[0]	SI[0]	NOT USED	-
OPIN[1]	SI[1]	FAULT RESET	This signal is normally turned OFF, indicating that the FAULT RESET button is not being pressed.
OPIN[2]	SI[2]	REMOTE	This signal is normally turned OFF, indicating that the controller is not set to remote.
OPIN[3]	SI[3]	HOLD	This signal is normally turned ON, indicating that the HOLD button is not being pressed.
OPIN[6]	SI[6]	CYCLE START	This signal is normally turned OFF, indicating that the CYCLE START button is not being pressed.
OPIN[7] - OPIN[15]	SI[7], SI[10] - SI[15]	NOT USED	-
	SI[8] SI[9]	CE/CR Select b0 CE/CR Select b1	This signal is two bits and indicates the status of the mode select switch.

Table 13–2. Standard Operator Panel Output Signals

OPOUT[n]	SOI[n]	Function	Description
OPOUT[0]	SO[0]	REMOTE LED	This signal indicates that the controller is set to remote.
OPOUT[1]	SO[1]	CYCLE START	This signal indicates that the CYCLE START button has been pressed or that a program is running.
OPOUT[2]	SO[2]	HOLD	This signal indicates that the HOLD button has been pressed or that a hold condition exists.
OPOUT[3]	SO[3]	FAULT LED	This signal indicates that a fault has occurred.
OPOUT[4]	SO[4]	BATTERY ALARM	This signal indicates that the CMOS battery voltage is low.
OPOUT[5]	SO[5]	USER LED#1 (PURGE COMPLETE for P-series robots)	This signal is user-definable.
OPOUT[6]	SO[6]	USER LED#2	This signal is user-definable.
OPOUT[7]	SO[7]	TEACH PENDANT ENABLED	This signal indicates that the teach pendant is enabled.
OPOUT[8] - OPOUT[15]	SO[8] - SO[15]	NOT USED	-

User Operator Panel Input and Output Signals

User operator panel input and output signals are recognized by the KAREL system as OPIN[16]-OPIN[33] and OPOUT[16]-OPOUT[35] and by the screens on the teach pendant as UI[1]-UI[18] and UO[1]-UO[20]. On the process I/O board, UOP input signals are mapped to the first 18 digital input signals and UOP output signals are mapped to the first 20 digital output signals. Table 13–3 lists and describes each user operator panel input signal. Table 13–4 lists each user operator panel output signal. Figure 13–2 and Figure 13–3 illustrate the timing of the UOP signals.

Table 13–3. User Operator Panel Input Signals

OPIN[n]	UI[n]	Process I/O Number	Function	Description
OPIN[16]	UI[1]	1	*IMSTP Always active	*IMSTP is the immediate stop software signal. *IMSTP is a normally OFF signal held ON that when set to OFF will • Pause a program if running. • Shut off power to the servos. • Immediately stop the robot and applies robot brakes. Error code SRVO-037 *IMSTP Input (Group:i) will be displayed when this signal is lost. This signal is always active. **Warning** ***IMSTP is a software controlled input and cannot be used for safety purposes. Use *IMSTP with EMG1, EMG2, and EMGCOM to use this signal with a hardware controller emergency stop. Refer to the Maintenance Manual, specific to your robot model, for connection information of EMG1, EMG2, and EMGCOM.**
OPIN[17]	UI[2]	2	*HOLD Always active	*HOLD is the external hold signal. *HOLD is a normally OFF signal held ON that when set to OFF will • Pause program execution. • Slow motion to a controlled stop and hold. • Optional Brake on Hold shuts off servo power after the robot stops.

Table 13–3. User Operator Panel Input Signals (Cont'd)

OPIN[n]	UI[n]	Process I/O Number	Function	Description
OPIN[18]	UI[3]	3	*SFSPD Always active	*SFSPD is the safety speed input signal. This signal is usually connected to the safety fence.*SFSPD is a normally OFF signal held ON that when set OFF will • Pause program execution. • Reduce the speed override value to that defined in a system variable. This value cannot be increased while *SFSPD is OFF. • Display error code message MF-0004 Fence Open. • Not allow a REMOTE start condition. Start inputs from UOP or SOP are disabled when *SFSPD is set to OFF.

Table 13–3. User Operator Panel Input Signals (Cont'd)

OPIN[n]	UI[n]	Process I/O Number	Function	Description
OPIN[19]	UI[4]	4	CSTOPI Always active	CSTOPI is the cycle stop input. When CSTOPI becomes TRUE, the system variable $CSTOP is set to TRUE. In addition, if the system variable $SHELL_CONFIG.$shell_name is not TRUE or is uninitialized at power up, CSTOPI functions as follows, depending on the system variable $SHELL_CFG.$USE_ABORT. **If the system variable $SHELL_CFG.$USE_ABORT is set to FALSE** , the CSTOPI input • Clears the queue of programs to be executed that were sent by RSR signals. **Warning** **When $SHELL_CFG.USE_ABORT is FALSE, CSTOPI does not immediately stop automatic program execution.** • Automatic execution will be stopped after the current program has finished executing. **If the system variable $SHELL_CFG.$USE_ABORT is set to TRUE,** the CSTOPI input • Clears the queue of programs to be executed that were sent by RSR signals. • Immediately aborts the currently executing program for programs that were sent to be executed by either RSR or PNS.

Table 13–3. User Operator Panel Input Signals (Cont'd)

OPIN[n]	UI[n]	Process I/O Number	Function	Description
OPIN[20]	UI[5]	5	FAULT_RESET Always active	FAULT_RESET is the external fault reset signal. When this signal is received • Error status is cleared. • Servo power is turned ON. • A paused program **will not be resumed.**
OPIN[21]	UI[6]	6	START Active when the robot is in a remote condition (CMDENBL = ON)	START is the remote start input. How this signal functions depends on the system variable $SHELL_CFG.$CONT_ONLY. **If the system variable $SHELL_CFG.$CONT_ONLY is set to FALSE** , the START input signal will • Resume a paused program. • If a program is not paused, the currently selected program starts from the position of the cursor. **If the system variable $SHELL_CFG.$CONT_ONLY is set to TRUE,** the START input signal will • Resume a paused program only. The PROD_START input must be used to start a program from the beginning.
OPIN[22]	UI[7]	7	HOME Active when the robot is in a remote condition	HOME is the home input. When this signal is received the robot moves to the defined home position.
OPIN[23]	UI[8]	8	ENBL Always active	ENBL is the enable input. This signal must be ON to have motion control ability. When this signal is OFF, robot motion can be done. When ENBL is ON and the REMOTE switch on the operator panel is in the REMOTE position, the robot is in a remote operating condition.

Table 13–3. User Operator Panel Input Signals (Cont'd)

OPIN[n]	UI[n]	Process I/O Number	Function	Description
OPIN[24]-OPIN[31]	UI[9]-UI[16]	9- 126	RSR1/PNS1, RSR2/PNS2, RSR3/PNS3, RSR4/PNS4,RSR5/PNS5, ,RSR6/PNS6, ,RSR7/PNS7, ,RSR8/PNS8 Active when the robot is in a remote condition (CMDENBL = ON)	**RSR1-8** are the robot service request input signals. When one of these signals is received, the corresponding RSR program is executing or, or a program is running currently, stored in a queue for later execution. RSR signals are used for production operation and can be received while an ACK output is being pulsed. See Figure 13–2 . **PNS 1-8** are program number select input signals. PNS selects programs for execution, **but does not execute programs** . Programs that are selected by PNS are executed using the START input or the PROD_START input depending on the value of the system variable $SHELL_CFG.$CONT_ONLY.The PNS number is output by pulsing the SNO signal (selected number output) and the SNACK signal (selected number acknowledge). See Figure 13–3 .
OPIN[32]	UI[17]	17	PNSTROBE Active when the robot is in a remote condition (CMDENBL = ON)	The PNSTROBE input is the program number select strobe input signal. See Figure 13–3 .
OPIN[33]	UI[18]	18	PROD_START Active when the robot is in a remote condition (CMDENBL = ON)	The PROD_START input, when used with PNS, will initiate execution of the selected program from the PNS lines. When used without PNS, PROD_START executes the selected program from the current cursor position. See Figure 13–3 .

Table 13–4. User Operator Panel Output Signals

OPOUT[n]	UO[n]	Process I/O Number	Function	Description
OPOUT[16]	UO[1]	1	CMDENBL	CMDENBL is the command enable output. This output indicates that the robot is in a remote condition. This signal goes ON when the REMOTE switch is turned to ON or when the ENBL input is received. This output only stays on when the robot is not in a fault condition. See Figure 13–2 and Figure 13–3 .
OPOUT[17]	UO[2]	2	SYSRDY	SYSRDY is the system ready output. This output indicates that servos are turned ON.
OPOUT[18]	UO[3]	3	PROGRUN	PROGRUN is the program run output. This output turns on when a program is running. See Figure 13–3 .
OPOUT[19]	UO[4]	4	PAUSED	PAUSED is the paused program output. This output turns on when a program is paused.
OPOUT[20]	UO[5]	5	HELD	HELD is the hold output. This output turns on when the SOP HOLD button has been pressed, or the UOP *HOLD input is OFF.
OPOUT[21]	UO[6]	6	FAULT	FAULT is the error output. This output turns on when a program is in an error condition.
OPOUT[22]	UO[7]	7	ATPERCH	Not supported. Refer to the appropriate application-specific *FANUC Robotics SYSTEM R-J3iC Controller Setup and Operations Manual* , “Reference Position Utility” section.
OPOUT[23]	UO[8]	8	TPENBL	TPENBL is the teach pendant enable output. This output turns on when the teach pendant is on.
OPOUT[24]	UO[9]	9	BATALM	BATALM is the battery alarm output. This output turns on when the CMOS RAM battery voltage goes below 3.6 volts.

Table 13–4. User Operator Panel Output Signals (Cont'd)

OPOUT[n]	UO[n]	Process I/O Number	Function	Description
OPOUT[25]	UO[10]	10	BUSY	BUSY is the processor busy output. This signal turns on when the robot is executing a program or when the processor is busy.
OPOUT[26] OPOUT[33]	UO[11]- UO[18]	11- 18	ACK1/SNO1, ACK2/SNO2, ACK3/SNO3, ACK4/SNO4, ACK5/SNO5, ACK6/SNO6, ACK7/SNO7, ACK8/SNO8	**ACK 1-8** are the acknowledge signals output 1 through 4. These signals turn on when the corresponding RSR signal is received. See Figure 13–2 **SNO 1-8** are the signal number outputs. These signals carry the 8-bit representation of the corresponding PNS selected program number. If the program cannot be represented by an 8-bit number, the signal is set to all zeroes or off. See Figure 13–3 .
OPOUT[34]	UO[19]	19	SNACK	SNACK is the signal number acknowledge output. This output is pulsed if the program is selected by PNS input. See Figure 13–3 .
OPOUT[35]	UO[20]	20	RESERVED	-
OPOUT[36]	UO[21]	21	UNCAL (option)	UNCAL is the uncalibrated output. This output turns on when the robot is not calibrated. The robot is uncalibrated when the controller loses the feedback signals from one or all of the motors. Set $OPWORK.$OPT_OUT = 1 to use this signal.
OPOUT[37]	UO[22]	22	UPENBL (option)	UPENBL is the user panel enable output. This output indicates that the robot is in a remote condition. This signal goes on when the remote switch is turned to ON or when the ENBL input is received. **This output will stay on even if the robot is in a fault condition.** Set $OPWORK.$OPT_OUT = 1 to use this signal.

Table 13–4. User Operator Panel Output Signals (Cont'd)

OPOUT[n]	UO[n]	Process I/O Number	Function	Description
OPOUT[38]	UO[23]	23	LOCKED (option)	-
OPOUT[39]	UO[24]	24	CSTOPO (option)	CSTOPO is the cycle stop output. This output turns on when the CSTOPI input has been received. Set $OPWORK.$OPT_OUT = 1 to use this signal.

Figure 13–2. RSR Timing Diagram

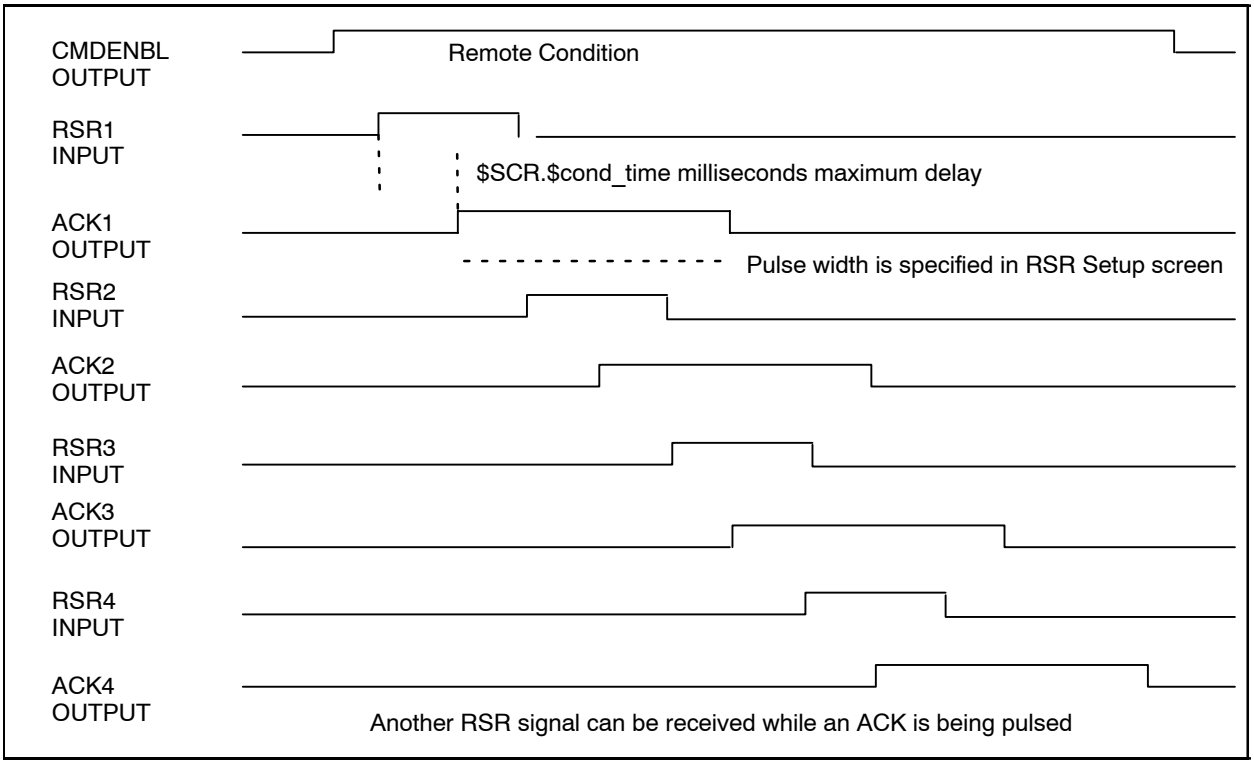
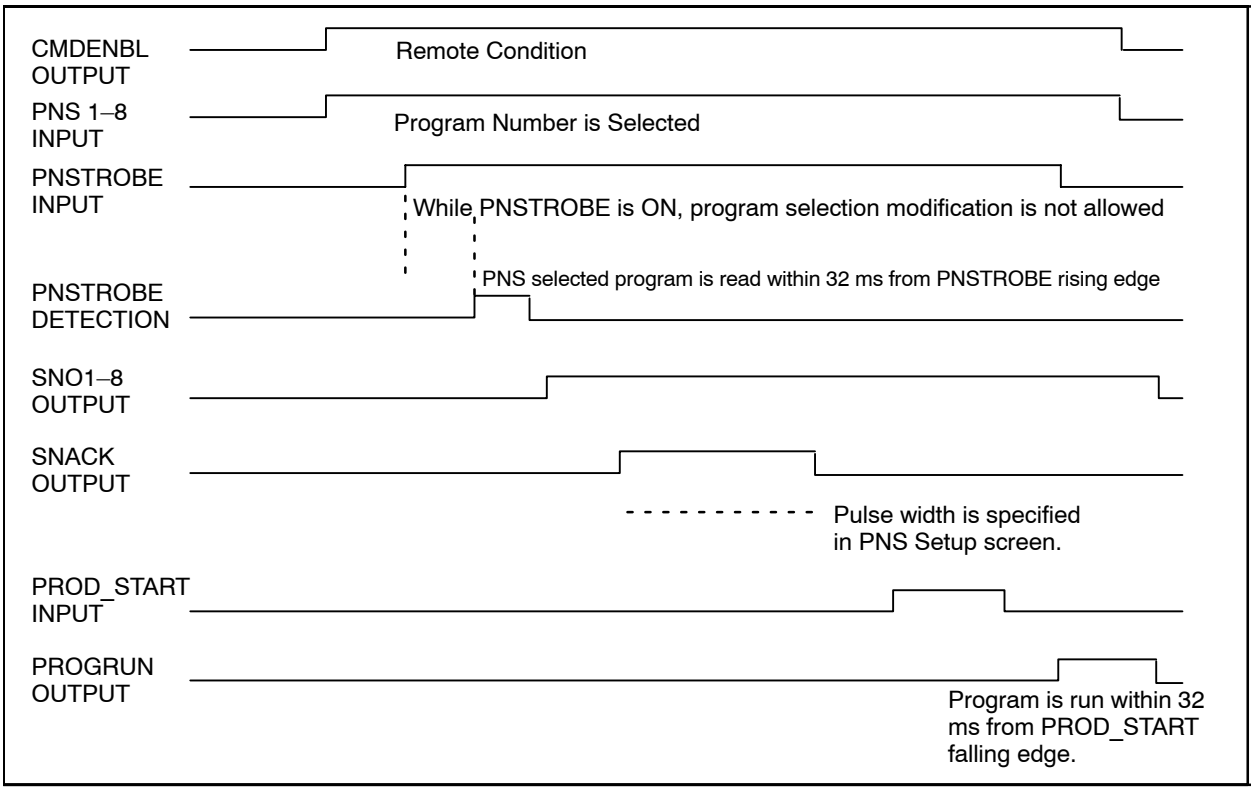


Figure 13–3. PNS Timing Diagram



13.2.3 Teach Pendant Input and Output Signals (TPIN/TPOUT)

The teach pendant input signals (TPIN) provide read access to input signals generated by the teach pendant keys. Teach pendant inputs can be accessed through the TPIN port arrays. A KAREL program treats teach pendant input data as a BOOLEAN data type. The value is either ON (active--the key is pressed) or OFF (inactive--the key is not pressed). TPIN signals are accessed in KAREL programs by the name TPIN[n], where “n” is the signal number, which is assigned internally. Refer to Table 13–5 for teach pendant input signal assignments.

Table 13–5. Teach Pendant Input Signal Assignments

TPIN[n]	Teach Pendant Key
EMERGENCY STOP AND DEADMAN	

Table 13–5. Teach Pendant Input Signal Assignments (Cont'd)

TPIN[n]	Teach Pendant Key
TPIN[250]	EMERGENCY STOP
TPIN[249]	ON/OFF switch
TPIN[247]	Right DEADMAN switch
TPIN[248]	Left DEADMAN switch
Arrow Keys	
TPIN[212]	Up arrow
TPIN[213]	Down arrow
TPIN[208]	Right arrow
TPIN[209]	Left arrow
TPIN[0]	Left and/or right shift
TPIN[204]	Shifted Up arrow
TPIN[205]	Shifted Down arrow
TPIN[206]	Shifted Right arrow
TPIN[207]	Shifted Left arrow
Keypad Keys (shifted or unshifted)	
TPIN[13]	ENTER
TPIN[8]	BACK SPACE
TPIN[48]	0
TPIN[49]	1
TPIN[50]	2
TPIN[51]	3
TPIN[52]	4
TPIN[53]	5
TPIN[54]	6
TPIN[55]	7
TPIN[56]	8
TPIN[57]	9
Function Keys	

Table 13–5. Teach Pendant Input Signal Assignments (Cont'd)

TPIN[n]	Teach Pendant Key
TPIN[128]	PREV
TPIN[129]	F1
TPIN[131]	F2
TPIN[132]	F3
TPIN[133]	F4
TPIN[134]	F5
TPIN[135]	NEXT
TPIN[136]	Shifted PREV
TPIN[137]	Shifted F1
TPIN[138]	Shifted F2
TPIN[139]	Shifted F3
TPIN[140]	Shifted F4
TPIN[141]	Shifted F5
TPIN[142]	Shifted NEXT
Menu Keys	
TPIN[143]	SELECT
TPIN[144]	MENUS
TPIN[145]	EDIT
TPIN[146]	DATA
TPIN[147]	FCTN
TPIN[148]	ITEM
TPIN[149]	+%
TPIN[150]	-%
TPIN[151]	HOLD
TPIN[152]	STEP
TPIN[153]	RESET
TPIN[240]	DISP
TPIN[203]	HELP
TPIN[154]	Shifted ITEM
TPIN[155]	Shifted +%
TPIN[156]	Shifted -%
TPIN[157]	Shifted STEP
TPIN[158]	Shifted HOLD
TPIN[159]	Shifted RESET
TPIN[227]	Shifted DISP
TPIN[239]	Shifted HELP
User Function Keys	

Table 13–5. Teach Pendant Input Signal Assignments (Cont'd)

TPIN[n]	Teach Pendant Key
TPIN[173]	USER KEY 1
TPIN[174]	USER KEY 2
TPIN[175]	USER KEY 3
TPIN[176]	USER KEY 4
TPIN[177]	USER KEY 5
TPIN[178]	USER KEY 6
TPIN[210]	USER KEY 7
TPIN[179]	Shifted USER KEY 1
TPIN[180]	Shifted USER KEY 2
TPIN[181]	Shifted USER KEY 3
TPIN[182]	Shifted USER KEY 4
TPIN[183]	Shifted USER KEY 5
TPIN[184]	Shifted USER KEY 6
TPIN[211]	Shifted USER KEY 7
Motion Keys	
TPIN[185]	FWD
TPIN[186]	BWD
TPIN[187]	COORD
TPIN[188]	+X
TPIN[189]	+Y
TPIN[190]	+Z
TPIN[191]	+X rotation
TPIN[192]	+Y rotation
TPIN[193]	+Z rotation
TPIN[194]	-X
TPIN[195]	-Y
TPIN[196]	-Z
TPIN[197]	-X rotation
TPIN[198]	-Y rotation
TPIN[199]	-Z rotation
TPIN[226]	Shifted FWD
TPIN[207]	Shifted BWD
TPIN[202]	Shifted COORD

Table 13–5. Teach Pendant Input Signal Assignments (Cont'd)

TPIN[n]	Teach Pendant Key
Motion Keys Cont'd	
TPIN[214]	Shifted +X
TPIN[215]	Shifted +Y
TPIN[216]	Shifted +Z
TPIN[217]	Shifted +X rotation
TPIN[218]	Shifted +Y rotation
TPIN[219]	Shifted +Z rotation
TPIN[220]	Shifted -X
TPIN[221]	Shifted -Y
TPIN[222]	Shifted -Z
TPIN[223]	Shifted -X rotation
TPIN[224]	Shifted -Y rotation
TPIN[225]	Shifted -Z rotation

Three teach pendant output signals are available for use:

- TPOUT[6] - controls teach pendant USER LED #1
- TPOUT[7] - controls teach pendant USER LED #2
- TPOUT[8] - controls teach pendant USER LED #3

13.3 Serial Input/Output

13.3.1 Serial Input/Output

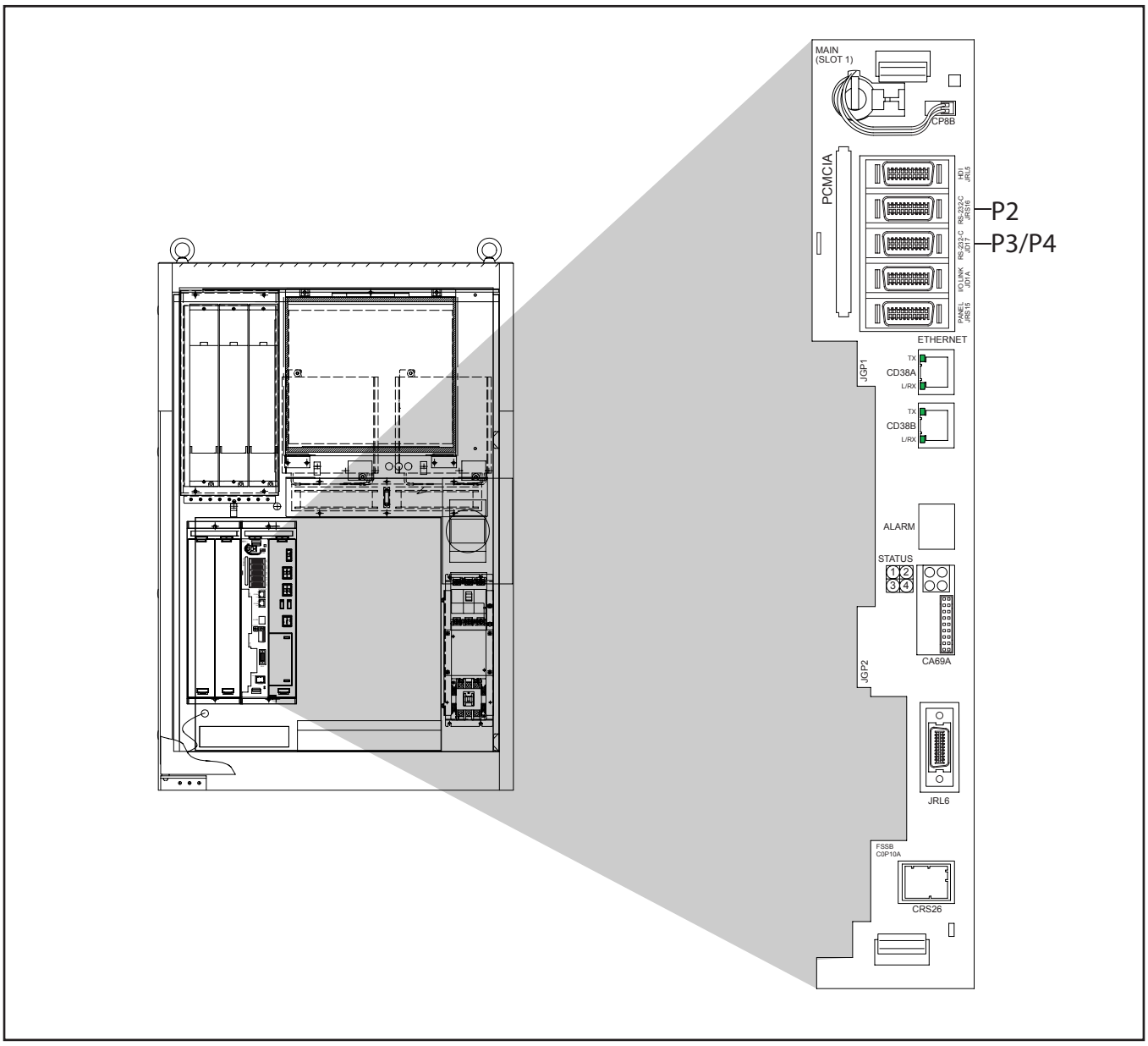
The serial I/O system allows you to communicate with peripheral serial devices connected to the KAREL system. For example, you could use serial I/O to write messages from one of the communications ports to a remote terminal across a cable that connects to the R-J3*i*C controller.

To use serial I/O you must provide a serial device and the appropriate cable. Refer to the Maintenance Manual, specific to your robot model, for electrical specifications.

The communications ports that you use to read and write serial data are defined in the system software. Each software port is associated with physical connectors on the R-J3*i*C controller to which you attach the communications cable.

Figure 13–4 shows the location of the ports on the controller.

Figure 13–4. Location of Ports on the Controller



Ports

Setting up a port means initializing controller serial ports to use specific devices, such as the CRT/KB. Initializing ports involves setting up specific information for a port based on the kind of device that will connect to the port. This is done on the teach pendant PORT INIT screen.

The controller supports up to four serial ports. Several different kinds of devices can be connected to these ports.

Up to four ports are available, P1-P4. Table 13–6 lists the ports. You can set up ports P2 through P4 if you have them, but you cannot set up the teach pendant port, P1.

Table 13–6. Ports P1 - P4

Port	Item Name on Screen	Kind of Port	Use	Default Device
P1	Teach Pendant **Note** This is a dedicated port and cannot be changed.	RS-422	Teach pendant	Teach pendant
P2	JRS16 RS-232–C	RS-232-C	Any device	Maintenance Console
P3	JD17 RS-232–C on Main CPU card	RS-232-C		KCL
P4	JD17 on Main CPU card. This port is displayed on the teach pendant if $RS232_NPORT=4.	RS-422		No use

Devices

You can modify the default communications settings for each port except port 1, which is dedicated to the teach pendant (TP). Table 13–7 lists the default settings for each kind of device you can connect to a port.

Table 13–7. Default Communications Settings for Devices

Device	Speed (baud)	Parity Bit	Stop Bit	Timeout Value (sec)
Sensor*	4800	Odd	1 bit	0
Host Comm.*	4800	Odd	1 bit	0
KCL/CRT	9600	None	1 bit	0
Maintenance Console	9600	None	1 bit	0
Factory Terminal	9600	None	1 bit	0
TP Demo Device	9600	None	1 bit	0
No Use	9600	None	1 bit	0
Current Position (for use with the Current Position option)	9600	None	1 bit	0

Table 13–7. Default Communications Settings for Devices (Cont'd)

Device	Speed (baud)	Parity Bit	Stop Bit	Timeout Value (sec)
PMC Programmer	9600	None	2 bit	0
Modem/PPP	Refer to the *FANUC Robotics Internet Options Setup and Operations Manual* for information on the supported modems.			
HMI Device	19200	Odd	1 bit	0

*You can adjust these settings; however, if you do, they might not function as intended because they are connected to an external device.

After the hardware has been connected and the appropriate port is configured and the external port is connected, you can use KAREL language OPEN FILE, READ, and WRITE statements to communicate with the peripheral device.

Higher levels of communication protocol are supported as an optional feature.

See Also: Appendix A for more information on the statements and built-ins available in KAREL

Refer to the *FANUC Robotics SYSTEM R-J3iC Controller application-specific Setup and Operations Manual* for more information about setting up ports.

Chapter 14

MULTI-TASKING

Contents

Chapter 14 MULTI-TASKING 14–1
14.1 MULTI-TASKING TERMINOLOGY 14–2
14.2 INTERPRETER ASSIGNMENT 14–3
14.3 MOTION CONTROL 14–3
14.4 TASK SCHEDULING 14–4
14.4.1 Priority Scheduling 14–5
14.4.2 Time Slicing 14–6
14.5 STARTING TASKS 14–6
14.5.1 Running Programs from the User Operator Panel (UOP) PNS Signal 14–7
14.5.2 Child Tasks 14–7
14.6 TASK CONTROL AND MONITORING 14–8
14.6.1 From TPP Programs 14–8
14.6.2 From KAREL Programs 14–8
14.6.3 From KCL 14–9
14.7 USING SEMAPHORES AND TASK SYNCHRONIZATION 14–9
14.8 USING QUEUES FOR TASK COMMUNICATIONS 14–14

Multi-tasking allows more than one program to run on the controller on a time-sharing basis, so that multiple programs appear to run simultaneously.

Multi-tasking is especially useful when you are executing several sequences of operations which can generally operate independently of one another, even though there is some interaction between them. For example:

- A process of monitoring input signals and setting output signals.
- A process of generating and transmitting log information to a cell controller and receiving commands or other input data from a cell controller.

It is important to be aware that although multiple tasks seem to operate at the same time, they are sharing use of the same processor, so that at any instant only one task is really being executed. With the exception of interruptible statements, once execution of a statement is started, it must complete before statements from another task can be executed. The following statements are interruptible:

- MOVE
- READ
- DELAY
- WAIT
- WAIT FOR

Refer to Section 14.4, “Task Scheduling” for information on how the system decides which task to execute first.

14.1 MULTI-TASKING TERMINOLOGY

The following terminology and expressions are used in this chapter.

- **Task or User task**

  A task, or user task, is a user program that is running or paused. A task is executed by an "interpreter." A task is created when the program is started and eliminated when the interpreter it is assigned to, becomes assigned to another task.

- **Interpreter**

  An interpreter is a system component that executes user programs. At a cold or controlled start, ($MAXNUMTASKS + 2) interpreters are created. These interpreters are capable of concurrently executing tasks.

- **Task name**

  Task name is the program name specified when the task is created. When you create a task, specify the name of the program to be executed as the task name.

Note The task name does not change once the task is created. Therefore, when an external routine is executing, the current executing program name is not the same as the task name. When you send any requests to the task, use the task name, not the current program name.

- **Motion control**

  Motion control is defined by a bit mask that specifies the motion groups of which a task has control. Only one task at a time can control a motion group. However, different tasks can control different motion groups simultaneously. Refer to Section 14.3 , "Motion Control," for more information.

14.2 INTERPRETER ASSIGNMENT

When a task is started, it is assigned to an interpreter. The interpreter it is assigned to (1, 2, 3, ...) determines its task number. The task number is used in PAUSE PROGRAM, ABORT PROGRAM and CONTINUE PROGRAM condition handler actions. The task number for a task can be determined using the GET_TSK_INFO built-in.

The following are rules for assigning a task to an interpreter:

- If the task is already assigned to an interpreter, it uses the same interpreter.
- A task is assigned to the first available interpreter that currently has no tasks assigned to it.
- If all interpreters are assigned to tasks, a new task will be assigned to the first interpreter that has an aborted task.
- If none of the above can be done, the task cannot be started.

14.3 MOTION CONTROL

An important restriction in multi-tasking is in the control of the various motion groups. Only one task can have control, or use of, a group of axes. A task requires control of the group(s) in the following situations:

- When the task starts, if the controller directive %NOLOCKGROUP is not used. If the %LOCKGROUP directive is not used, the task requires control of all groups by default. If %LOCKGROUP is used, control of the specified groups is required.

  For teach pendant programs, motion control is required when the program starts, unless the DETAIL page from the SELECT screen is used to set the Group Mask to [*,*,*,*,*].
- When a task executes the LOCK_GROUP built-in, it requires the groups specified by the group mask.
- When a task executes a MOVE statement, it requires control of the group.

- When a task calls a ROUTINE or teach pendant program, it requires control of those group(s). The group(s) required by a ROUTINE or TPP+ program are those specified, or implied, by controller directives or in the teach pendant DETAIL setup.

A task will be given control of the required group(s), assuming:

- No other task has control of the group.
- The teach pendant is not enabled, with the exception that motion control can be given to a program when it is started using shift-FWD at the teach pendant or if it has the %TPMOTION directive.
- There are no emergency stops active.
- The servos are ready.
- The UOP signal IMSTP is not asserted.

A task will be paused if it is not able to get control of the required group(s).

After a task gets control of a group, it keeps it until one of the following:

- The task ends (aborts).
- The task executes the UNLOCK_GROUP built-in.
- The task passes control of the group(s) in a RUN_TASK built-in.
- The ROUTINE or teach pendant program returns, and groups were required by a ROUTINE or teach pendant program, but not by the calling program.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly, personnel could be injured, and equipment could be damaged.

14.4 TASK SCHEDULING

A task that is currently running (not aborted or paused) will execute statements until one of the following:

- A hold condition occurs.
- A higher priority program becomes ready to run.
- The task time slice expires.
- The program aborts or pauses.

The following are examples of hold conditions:

- Waiting for a read operation to complete.
- Waiting for a motion to complete.
- Waiting for a WAIT, WAIT FOR, or DELAY statement to complete.

A task is ready to run when it is in running state and has no hold conditions. Only one task is actually executed at a time. There are two rules for determining which task will be executed when more than one task is ready to run:

- Priority - If two or more tasks of different priority are ready to run, the task with higher priority is executed first. Refer to Section 14.4.1 , “Priority Scheduling,” for more information.
- Time-slicing - If two tasks of the same priority are ready to run, execution of the tasks is time-sliced. Refer to Section 14.4.2 , “Time Slicing,” for more information.

14.4.1 Priority Scheduling

If two or more tasks with different priorities are ready to run, the task with the highest priority will run first. The priority of a task is determined by its priority number. Priority numbers must be in the range from -8 to 143. The lower the priority number, the higher the task priority.

For example: if TASK_A has a priority number of 50 and TASK_B has a priority number of 60, and both are ready to run, TASK_A will execute first, as long as it is ready to run.

A task priority can be set in one of the following ways:

- By default, each user task is assigned a priority of 50.
- KAREL programs may contain the %PRIORITY translator directive.
- The SET_TSK_ATTR built-in can be used to set the current priority of any task.

In addition to affecting other user tasks, task priority also affects the priority of the interpreter executing it, relative to that of other system functions. If the user task has a higher priority (lower priority number) than the system function, as long as the user task is ready to run, the system function will be not be executed. The range of user task priorities is restricted at the high priority end. This is done so that the user program cannot interfere with motion interpolation. Motion interpolation refers to the updates required to cause a motion, or path segment, to complete.

The following table indicates the priority of some other system functions.

Table 14–1. System Function Priority Table

Priority	System Function	Effect of Delaying Function
-8	Maximum priority	New motions, or continuation nodes of a MOVE ALONG path statement delayed.
-1	Motion Planner	New motions, or continuation nodes of a MOVE ALONG path statement delayed.
4	TP Jog	Jogging from the Teach Pendant delayed.
54	Error Logger	Update of system error log delayed.
73	KCL	Execution of KCL commands delayed.
82	CRT manager	Processing of CRT soft-keys delayed.
88	TP manager	General teach pendant activity delayed.
143	Lowest priority	Does not delay any of the above.

14.4.2 Time Slicing

If two or more tasks of the same priority are ready to run, they will share the system resources by time-slicing, or alternating use of the system.

A time-slice permits other tasks of the same priority to execute, but not lower priority tasks.

The default time-slice for a task is 256 msec. Other values can be set using the %TIMESLICE directive or the SET_TSK_ATTR built-in.

14.5 STARTING TASKS

There are a number ways to start a task.

- KCL RUN command. Refer to Appendix C ,“KCL Command Alphabetic Descriptions.”
- Operator Panel start key. Refer to the appropriate application- specific *FANUC Robotics SYSTEM R-J3iC Controller HandlingTool Setup and Operations Manual.*
- User operator panel start signal. Refer to the appropriate application-specific *FANUC Robotics SYSTEM R-J3iC Controller HandlingTool Setup and Operations Manual.*
- User operator panel PNS signal. Refer to Section 14.5.1 ,“Running Programs from the User Operator Panel (UOP) PNS Signal,” for more information.
- Teach pendant shift-FWD key. Refer to the appropriate application-specific *FANUC Robotics SYSTEM R-J3iC Controller HandlingTool Setup and Operations Manual* , Chapter on “Testing a Program and Running Production,” for more information.

- Teach pendant program executes a RUN instruction. Refer to Section 14.5.2 , “Child Tasks,” for more information.
- KAREL program executes the RUN_TASK built-in. Refer to Section 14.5.2 , “Child Tasks,” for more information.

In each case, the task will not start running if it requires motion control that is not available.

14.5.1 Running Programs from the User Operator Panel (UOP) PNS Signal

A program is executed:

- If the binary value of the UOP PNS signals is non-zero and the UOP PROGSTART signal is asserted
- If there is currently a program with the name “PNSnnnn,” where nnnn is the decimal value of the PNS signals plus the current value of $SHELLCFG.$jobbase.

A program is not executed:

- If the binary value of the PNS signals is zero.

Multiple programs can be started in this way, as long as there is no motion group overlap.

If the task name determined from the PNS is in a paused state, the PROGSTART signal is interpreted as a CONTINUE signal. If $SHELLCFG.$contonly is TRUE, this is the only function of the PNS/PROGSTART signals.

If $SHELLCFG.$useabort is TRUE, the PNS signals can be used to abort a running task. The name of the task to be aborted is the same as that used with the PROGSTART signal. In this case, abort is triggered by the UOP CSTOPI signal

14.5.2 Child Tasks

A running task can create new tasks. This new task is called a child task. The task requesting creation of the child task is called the parent task. In teach pendant programs, a new task is created by executing a RUN instruction. In KAREL programs a new task can be created using the RUN_TASK built-in.

The parent and child task may not require the same motion group. In the case of RUN_TASK, however, it is possible to release control of motion groups for use by the child task.

> **Warning**
>
> **Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly, and could injure personnel or damage equipment.**

Once a child task is created, it runs independently of its parent task, with the following exception:

- If a parent task is continued and its child task is paused, the child task is also continued.
- If a parent task is put in STEP mode, the child task is also put in STEP mode.

If you want the child task to be completely independent of the parent, a KAREL program can initiate another task using the KCL or KCL_NOWAIT built-ins to issue a KCL>RUN command.

14.6 TASK CONTROL AND MONITORING

There are three environments from which you can control and monitor tasks:

1. Teach Pendant Programs (TPP) - Section 14.6.1
2. KAREL Programs - Section 14.6.2
3. KCL commands - Section 14.6.3

14.6.1 From TPP Programs

The TPP instruction RESUME_PROG can be used to continue a PAUSEd task.

14.6.2 From KAREL Programs

There are a number of built-ins used to control and monitor other tasks. See the description of these built-ins in Appendix A.

- RUN_TASK executes a task.
- CONT_TASK resumes execution of a PAUSEd task.
- PAUSE_TASK pauses a task.
- ABORT_TASK aborts a task.
- CONTINUE condition handler action causes execution of a task.

- ABORT condition handler action causes a task to be aborted.
- PAUSE condition handler action causes a task to be paused.
- GET_TSK_INFO determines whether a specified task is running, paused, or aborted. Also determines what program and line number is being executed, and what, if anything, the task is waiting for.

14.6.3 From KCL

The following KCL commands can be used to control and monitor the status of tasks. Refer to Appendix C , "KCL Command Alphabetic Descriptions," for more information.

- RUN <task_name> starts or continues a task.
- CONT <task_name> continues a task.
- PAUSE <task_name> pauses a task.
- ABORT <task_name> aborts a task.
- SHOW TASK <task_name> displays the status of a task.
- SHOW TASKS displays the status of all tasks.

14.7 USING SEMAPHORES AND TASK SYNCHRONIZATION

Good design dictates that separate tasks be able to operate somewhat independently. However, they should also be able to interact.

The KAREL controller supports counting semaphores. The following operations are permitted on semaphores:

- **Clear a semaphore** (KAREL: CLEAR_SEMA built-in): sets the semaphore count to zero.

  All semaphores are cleared at cold start. It is good practice to clear a semaphore prior to using it. Before several tasks begin sharing a semaphore, one and only one of these task, should clear the semaphore.

- **Post to a semaphore** (KAREL: POST_SEMA built-in): adds one to the semaphore count.

  If the semaphore count is zero or greater, when the post semaphore is issued, the semaphore count will be incremented by one. The next task waiting on the semaphore will decrement the semaphore count and continue execution. Refer to Figure 14–1 .

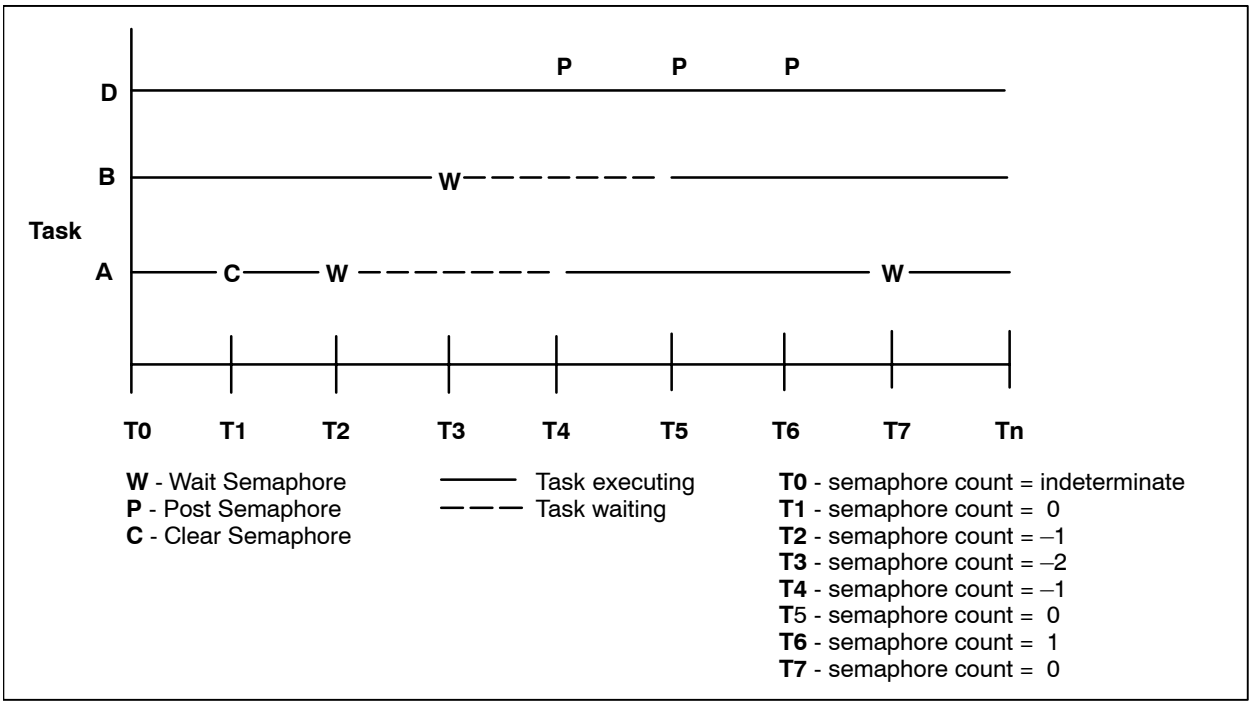
  If the semaphore count is negative, when the post semaphore is issued, the semaphore count will be incremented by one. The task which has been waiting on the semaphore the longest will then continue execution. Refer to Figure 14–1 .

- **Read a semaphore** (KAREL: SEMA_COUNT built-in): returns the current semaphore count.
- **Wait for a semaphore** (KAREL: PEND_SEMA built-in, SIGNAL SEMAPHORE Action):

  If the semaphore count is greater than zero when the wait semaphore is issued, the semaphore count will be decremented and the task will continue execution. Refer to Figure 14–1 .

  If the semaphore count is less than or equal to zero (negative), the wait semaphore will decrement the semaphore count and the task will wait to be released by a post semaphore. Tasks are released on a first-in/first-out basis. For example, if *task A* waits on semaphore 1, then *task B* waits on semaphore 1. When *task D* posts semaphore 1, only *task A* will be released. Refer to Figure 14–1 .

Figure 14–1. Task Synchronization Using a Semaphore



Example: Semaphores can be used to implement a task that acts as a request server. In the following example, the main task waits for the server to complete its operation. Semaphore[4] is used to control access to rqst_param or R[5]. Semaphore[5] is used to signal the server task that service is being requested; semaphore[6] is used by the server to signal that the operation is complete.

The main task would contain the following KAREL:

Main Task

```
--KAREL
CLEAR_SEMA(4)
CLEAR_SEMA(5)
CLEAR_SEMA(6)
RUN TASK('server',0,TRUE,TRUE,1,STATUS)
PEND_SEMA(4,max_time,time_out)
rqst_param=10
POST_SEMA(5)
PEND_SEMA(6,max_time,time_out)
```

The server task would contain the following KAREL code:

Server Task

```
--KAREL
POST_SEMA (4)
WHILE TRUE DO
  PEND_SEMA(5,max_time,time_out)
  IF rqst_param=10 THEN
     do_something
  ENDIF
  POST_SEMA(4)
  POST_SEMA(6)
ENDWHILE
```

Example: The program example in Semaphore and Task Synchronization Program Example - *MAIN TASK* thru Semaphore and Task Synchronization Program Example - *TASK B* shows how semaphores and tasks can be used together for synchronization. *MAIN_TASK.KL* is used to initialize the semaphore (MOTION_CTRL) and then runs both *TASK_A.KL* and *TASK_B.KL*. *MAIN_TASK.KL* then waits for *TASK_A* and *TASK_B* to abort before completing. *TASK_A* waits until you press F1 and then moves the robot to the HOME position. *TASK_B* waits until you press F2 and then moves the robot along a path.

Semaphore and Task Synchronization Program Example - *MAIN TASK*

```
PROGRAM main_task
%nolockgroup
VAR
  motion_ctrl: INTEGER
  tsk_a_done : BOOLEAN
  tsk_b_done : BOOLEAN
  tmr        : INTEGER
  status     : INTEGER
------------------------------------------------
--                                            --
--  INIT_LOCK:  Initialize the semaphore      --
```

```
--              to make sure its count is at  --
--              zero before using it.  Then   --
--              post this semaphore which will--
--              allow the first pend to the   --
--              semaphore to continue         --
--               execution.                   --
-----------------------------------------------
ROUTINE init_lock
BEGIN
 CLEAR_SEMA (motion_ctrl)  -- makes sure semaphore is zero before using it.
 POST_SEMA  (motion_ctrl)  -- makes motion_ctrl available immediately
END init_lock
-----------------------------------------------
--                                           --
--  IS_TSK_DONE : Find out if the specified  --
--                task is running or not.    --
--                If the task is aborted then --
--                return TRUE otherwise FALSE.--
-----------------------------------------------
ROUTINE is_tsk_done (task_name:STRING): BOOLEAN
VAR
 status  : INTEGER    -- The status of the operation of GET_TSK_INFO
 task_no : INTEGER    -- Receives the current task number for task_name
 attr_out: INTEGER    -- Receives the TSK_STATUS output
 dummy   : STRING[2]  -- Does not receive any information
BEGIN
  GET_TSK_INFO (task_name, task_no, TSK_STATUS, attr_out, dummy, status)
  IF (attr_out = PG_ABORTED) THEN
    RETURN (TRUE)  -- If task is aborted then return TRUE
  ENDIF
  RETURN(FALSE)    -- otherwise task is not aborted and return
FALSE
END is_tsk_done
BEGIN
  motion_ctrl = 1  -- Semaphore to allow motion control
  init_lock   -- Make sure this is done just once
  FORCE_SPMENU ( tp_panel, spi_tpuser, 1)  -- Force the Teach Pendant
                                           -- user screen to be seen
   RUN_TASK('task_a', 1, FALSE, FALSE, 1, status)  -- Run task_a
   RUN_TASK('task_b', 1, FALSE, FALSE, 1, status)  -- Run task_b
   REPEAT
     tsk_a_done = is_tsk_done ('task_a')
     tsk_b_done = is_tsk_done ('task_b')
     delay (100)
   UNTIL (tsk_a_done and tsk_b_done)   -- Repeat until both task_a
END main_task    -- and task_b are aborted
```

Semaphore and Task Synchronization Program Example - *TASK A*

```
PROGRAM task_a
%nolockgroup
VAR
  motion_ctrl FROM main_task: INTEGER
  home_pos                  : POSITION
  status                    : INTEGER
-----------------------------------------------
--                                           --
--  RUN_HOME    : Lock the robot motion      --
--                control.  This task is     --
--                moving the robot and must  --
--                 have control.             --
--                                           --
-----------------------------------------------
ROUTINE run_home
VAR
  time_out: BOOLEAN
BEGIN
   PEND_SEMA(motion_ctrl,-1,time_out)-- lock motion_ctrl from other tasks
                                     -- keep other tasks from moving robot
   LOCK_GROUP (1, status)
   MOVE TO home_pos   -- move to the home position
   UNLOCK_GROUP (1, status)
   POST_SEMA(motion_ctrl)   -- unlock motion_ctrl
                            -- allow other task to move robot
END  run_home
BEGIN
   set_cursor (tpfunc, 1, 4, status)
   write tpfunc ('HOME',CR)
   wait for TPIN[129]+     -- wait for F1 to be pressed
   run_home
END task_a
```

Semaphore and Task Synchronization Program Example - *TASK B*

```
PROGRAM task_b
%nolockgroup
VAR
  motion_ctrl FROM main_task : INTEGER
  work_path                  : PATH
  status                     : INTEGER
-----------------------------------------------
--                                           --
--  do_work    :  Lock the robot from other   --
```

```
--                tasks and do work.  This    --
--                task is doing motion and    --
--                must lock motion control so --
--                that another task does not  --
--                try to do motion at the     --
--                 same time.                 --
-----------------------------------------------
ROUTINE do_work
VAR
  time_out: BOOLEAN
BEGIN
   PEND_SEMA (motion_ctrl,-1,time_out) -- lock motion_ctrl from other
                                       -- tasks keep other tasks from
     --  moving robot
   LOCK_GROUP (1, status)
   MOVE ALONG work_path    -- move along the work path
   UNLOCK_GROUP (1, status)
   POST_SEMA(motion_ctrl)    -- unlock motion_ctrl allow
                                          -- other task to move robot
END  do_work
BEGIN
   set_cursor(tpfunc, 1, 10, status)
   write tpfunc('WORK',CR)
   wait for TPIN[131]+     -- wait until F2 is pressed
   do_work
END task_b
```

14.8 USING QUEUES FOR TASK COMMUNICATIONS

Queues are supported only in KAREL. A queue is a first-in/first-out list of integers. They are used to pass information to another task sequentially. A queue consists of a user variable of type QUEUE_TYPE and an ARRAY OF INTEGER. The maximum number of entries in the queue is determined by the size of the array.

The following operations are supported on queues:

- INIT_QUEUE initializes a queue and sets it to empty.
- APPEND_QUEUE adds an integer to the list of entries in the queue.
- GET_QUEUE: reads the oldest (top) entry from the queue and deletes it.

These, and other built-ins related to queues (DELETE_QUEUE, INSERT_QUEUE, COPY_QUEUE) are described in Appendix A.

A QUEUE_TYPE Data Type has one user accessible element, *n_entries* . This is the number of entries that have been added to the queue and not read out. The array of integer used with a queue, is used by the queue built-ins and should not be referenced by the KAREL program.

Example: The following example illustrates a more powerful request server, in which more than one task is posting requests and the requester does not wait for completion of the request.

The requester would contain the following code:

Requester

```
--declarations
VAR
  rqst_queue FROM server: QUEUE_TYPE
  rqst_data FROM server: ARRAY[100] OF INTEGER
  status:  INTEGER
  seq_no:  INTEGER
  -- posting to the queue --
APPEND_QUEUE (req_code, rqst_queue, rqst_data, seq_no, status)
```

The server task would contain the following code:

Server

```
PROGRAM server
VAR
  rqst_queue: QUEUE_TYPE
  rqst_data : ARRAY[100] OF INTEGER
  status    : INTEGER
  seq_no    : INTEGER
  rqst_code : INTEGER
BEGIN
 INIT_QUEUE(rqst_queue)   --initialization
  WHILE TRUE DO             --serving loop
      WAIT FOR rqst_code.n_entries > 0
      GET_QUEUE (rqst_queue, rqst_data, rqst_code, seq_no, status)
      SELECT rqst_code OF
 CASE (1): do_something
      ENDSELECT
  ENDWHILE
END server
```

Appendix A

KAREL LANGUAGE ALPHABETICAL DESCRIPTION

Contents

Appendix A	KAREL LANGUAGE ALPHABETICAL DESCRIPTION	A–1
A.1	OVERVIEW	A–9
A.2	- A - KAREL LANGUAGE DESCRIPTION	A–18
A.2.1	ABORT Action	A–18
A.2.2	ABORT Condition	A–18
A.2.3	ABORT Statement	A–19
A.2.4	ABORT_TASK Built-In Procedure	A–19
A.2.5	ABS Built-In Function	A–20
A.2.6	ACOS Built-In Function	A–21
A.2.7	ACT_SCREEN Built-In Procedure	A–22
A.2.8	ADD_BYNAMEPC Built-In Procedure	A–22
A.2.9	ADD_DICT Built-In Procedure	A–24
A.2.10	ADD_INTPC Built-In Procedure	A–25
A.2.11	ADD_REALPC Built-In Procedure	A–26
A.2.12	ADD_STRINGPC Built-In Procedure	A–27
A.2.13	%ALPHABETIZE Translator Directive	A–29
A.2.14	APPEND_NODE Built-In Procedure	A–29
A.2.15	APPEND_QUEUE Built-In Procedure	A–30
A.2.16	APPROACH Built-In Function	A–31
A.2.17	ARRAY Data Type	A–31
A.2.18	ARRAY_LEN Built-In Function	A–33
A.2.19	ASIN Built-In Function	A–33
A.2.20	Assignment Action	A–34
A.2.21	Assignment Statement	A–35
A.2.22	AT NODE Condition	A–37
A.2.23	ATAN2 Built-In Function	A–37
A.2.24	ATTACH Statement	A–38
A.2.25	ATT_WINDOW_D Built-In Procedure	A–39

A.2.26 ATT_WINDOW_S Built-In Procedure A–40
A.2.27 AVL_POS_NUM Built-In Procedure A–40
A.3 - B - KAREL LANGUAGE DESCRIPTION A–41
A.3.1 BOOLEAN Data Type A–41
A.3.2 BYNAME Built-In Function A–42
A.3.3 BYTE Data Type A–43
A.3.4 BYTES_AHEAD Built-In Procedure A–44
A.3.5 BYTES_LEFT Built-In Function A–45
A.4 - C - KAREL LANGUAGE DESCRIPTION A–47
A.4.1 CALL_PROG Built-In Procedure A–47
A.4.2 CALL_PROGLIN Built-In Procedure A–47
A.4.3 CANCEL Action A–48
A.4.4 CANCEL Statement A–49
A.4.5 CANCEL FILE Statement A–50
A.4.6 CHECK_DICT Built-In Procedure A–51
A.4.7 CHECK_EPOS Built-In Procedure A–52
A.4.8 CHECK_NAME Built-In Procedure A–53
A.4.9 CHR Built-In Function A–53
A.4.10 CLEAR Built-In Procedure A–54
A.4.11 CLEAR_SEMA Built-In Procedure A–55
A.4.12 CLOSE FILE Statement A–55
A.4.13 CLOSE HAND Statement A–56
A.4.14 CLOSE_TPE Built-In Procedure A–57
A.4.15 CLR_IO_STAT Built-In Procedure A–57
A.4.16 CLR_PORT_SIM Built-In Procedure A–58
A.4.17 CLR_POS_REG Built-In Procedure A–58
A.4.18 %CMOSVARS Translator Directive A–59
A.4.19 %CMOS2SHADOW Translator Directive A–59
A.4.20 CNC_DYN_DISB Built-In Procedure A–60
A.4.21 CNC_DYN_DISE Built-In Procedure A–60
A.4.22 CNC_DYN_DISI Built-In Procedure A–61
A.4.23 CNC_DYN_DISP Built-In Procedure A–62
A.4.24 CNC_DYN_DISR Built-In Procedure A–62
A.4.25 CNC_DYN_DISS Built-In Procedure A–63
A.4.26 CNCL_STP_MTN Built-In Procedure A–64
A.4.27 CNV_CONF_STR Built-In Procedure A–65
A.4.28 CNV_INT_STR Built-In Procedure A–65
A.4.29 CNV_JPOS_REL Built-In Procedure A–66
A.4.30 CNV_REAL_STR Built-In Procedure A–67
A.4.31 CNV_REL_JPOS Built-In Procedure A–68
A.4.32 CNV_STR_CONF Built-In Procedure A–69
A.4.33 CNV_STR_INT Built-In Procedure A–69
A.4.34 CNV_STR_REAL Built-In Procedure A–70
A.4.35 CNV_STR_TIME Built-In Procedure A–71
A.4.36 CNV_TIME_STR Built-In Procedure A–71
A.4.37 %COMMENT Translator Directive A–72
A.4.38 COMMON_ASSOC Data Type A–73
A.4.39 CONDITION...ENDCONDITION Statement A–73
A.4.40 CONFIG Data Type A–75
A.4.41 CONNECT TIMER Statement A–76
A.4.42 CONTINUE Action A–77
A.4.43 CONTINUE Condition A–77
A.4.44 CONT_TASK Built-In Procedure A–78
A.4.45 COPY_FILE Built-In Procedure A–79
A.4.46 COPY_PATH Built-In Procedure A–80

A.4.47 COPY_QUEUE Built-In Procedure A–82
A.4.48 COPY_TPE Built-In Procedure A–83
A.4.49 COS Built-In Function A–84
A.4.50 CR Input/Output Item A–84
A.4.51 CREATE_TPE Built-In Procedure A–85
A.4.52 CREATE_VAR Built-In Procedure A–86
A.4.53 %CRTDEVICE A–89
A.4.54 CURJPOS Built-In Function A–89
A.4.55 CURPOS Built-In Function A–90
A.4.56 CURR_PROG Built-In Function A–91

A.5 - D - KAREL LANGUAGE DESCRIPTION A–92
A.5.1 DAQ_CHECKP Built-In Procedure A–92
A.5.2 DAQ_REGPIPE Built-In Procedure A–93
A.5.3 DAQ_START Built-In Procedure A–95
A.5.4 DAQ_STOP Built-In Procedure A–97
A.5.5 DAQ_UNREG Built-In Procedure A–98
A.5.6 DAQ_WRITE Built-In Procedure A–99
A.5.7 %DEFGROUP Translator Directive A–101
A.5.8 DEF_SCREEN Built-In Procedure A–101
A.5.9 DEF_WINDOW Built-In Procedure A–102
A.5.10 %DELAY Translator Directive A–103
A.5.11 DELAY Statement A–104
A.5.12 DELETE_FILE Built-In Procedure A–105
A.5.13 DELETE_NODE Built-In Procedure A–106
A.5.14 DELETE_QUEUE Built-In Procedure A–106
A.5.15 DEL_INST_TPE Built-In Procedure A–107
A.5.16 DET_WINDOW Built-In Procedure A–108
A.5.17 DISABLE CONDITION Action A–108
A.5.18 DISABLE CONDITION Statement A–109
A.5.19 DISCONNECT TIMER Statement A–111
A.5.20 DISCTRL_ALPH Built_In Procedure A–111
A.5.21 DISCTRL_FORM Built_In Procedure A–113
A.5.22 DISCTRL_LIST Built-In Procedure A–116
A.5.23 DISCTRL_PLMN Built-In Procedure A–117
A.5.24 DISCTRL_SBMN Built-In Procedure A–119
A.5.25 DISCTRL_TBL Built-In Procedure A–122
A.5.26 DISMOUNT_DEV Built-In Procedure A–124
A.5.27 DISP_DAT_T Data Type A–125

A.6 - E - KAREL LANGUAGE DESCRIPTION A–126
A.6.1 ENABLE CONDITION Action A–126
A.6.2 ENABLE CONDITION Statement A–127
A.6.3 %ENVIRONMENT Translator Directive A–128
A.6.4 ERR_DATA Built-In Procedure A–129
A.6.5 ERROR Condition A–131
A.6.6 EVAL Clause A–131
A.6.7 EVENT Condition A–132
A.6.8 EXP Built-In Function A–133

A.7 - F - KAREL LANGUAGE DESCRIPTION A–133
A.7.1 FILE Data Type A–133
A.7.2 FILE_LIST Built-In Procedure A–134
A.7.3 FOR...ENDFOR Statement A–135
A.7.4 FORCE_SPMENU Built-In Procedure A–137
A.7.5 FORMAT_DEV Built-In Procedure A–139
A.7.6 FRAME Built-In Function A–140

A.7.7 FROM Clause A–142

A.8 - G - KAREL LANGUAGE DESCRIPTION A–143
A.8.1 GET_ATTR_PRG Built-In Procedure A–143
A.8.2 GET_FILE_POS Built-In Function A–145
A.8.3 GET_JPOS_REG Built-In Function A–146
A.8.4 GET_JPOS_TPE Built-In Function A–146
A.8.5 GET_PORT_ASG Built-in Procedure A–147
A.8.6 GET_PORT_ATR Built-In Function A–149
A.8.7 GET_PORT_CMT Built-In Procedure A–151
A.8.8 GET_PORT_MOD Built-In Procedure A–152
A.8.9 GET_PORT_SIM Built-In Procedure A–154
A.8.10 GET_PORT_VAL Built-In Procedure A–154
A.8.11 GET_POS_FRM Built-In Procedure A–155
A.8.12 GET_POS_REG Built-In Function A–156
A.8.13 GET_POS_TPE Built-In Function A–157
A.8.14 GET_POS_TYP Built-In Procedure A–158
A.8.15 GET_PREG_CMT Built-In-Procedure A–158
A.8.16 GET_QUEUE Built-In Procedure A–159
A.8.17 GET_REG Built-In Procedure A–160
A.8.18 GET_REG_CMT A–161
A.8.19 GET_TIME Built-In Procedure A–161
A.8.20 GET_TPE_CMT Built-in Procedure A–162
A.8.21 GET_TPE_PRM Built-in Procedure A–163
A.8.22 GET_TSK_INFO Built-In Procedure A–165
A.8.23 GET_USEC_SUB Built-In Procedure A–167
A.8.24 GET_USEC_TIM Built-In Function A–168
A.8.25 GET_VAR Built-In Procedure A–169
A.8.26 GO TO Statement A–171
A.8.27 GROUP_ASSOC Data Type A–171

A.9 - H - KAREL LANGUAGE DESCRIPTION A–172
A.9.1 HOLD Action A–172
A.9.2 HOLD Statement A–173

A.10 - I - KAREL LANGUAGE DESCRIPTION A–174
A.10.1 IF ... ENDIF Statement A–174
A.10.2 IN Clause A–176
A.10.3 %INCLUDE Translator Directive A–176
A.10.4 INDEX Built-In Function A–177
A.10.5 INI_DYN_DISB Built-In Procedure A–178
A.10.6 INI_DYN_DISE Built-In Procedure A–180
A.10.7 INI_DYN_DISI Built-In Procedure A–181
A.10.8 INI_DYN_DISP Built-In Procedure A–183
A.10.9 INI_DYN_DISR Built-In Procedure A–184
A.10.10 INI_DYN_DISS Built-In Procedure A–185
A.10.11 INIT_QUEUE Built-In Procedure A–186
A.10.12 INIT_TBL Built-In Procedure A–187
A.10.13 IN_RANGE Built-In Function A–198
A.10.14 INSERT_NODE Built-In Procedure A–199
A.10.15 INSERT_QUEUE Built-In Procedure A–200
A.10.16 INTEGER Data Type A–201
A.10.17 INV Built-In Function A–202
A.10.18 IO_MOD_TYPE Built-In Procedure A–203
A.10.19 IO_STATUS Built-In Function A–204

A.11 - J - KAREL LANGUAGE DESCRIPTION A–205
A.11.1 J_IN_RANGE Built-In Function A–205

A.11.2 JOINTPOS Data Type A–206
A.11.3 JOINT2POS Built-In Function A–206
A.12 - K - KAREL LANGUAGE DESCRIPTION A–208
A.12.1 KCL Built-In Procedure A–208
A.12.2 KCL_NO_WAIT Built-In Procedure A–209
A.12.3 KCL_STATUS Built-In Procedure A–210
A.13 - L - KAREL LANGUAGE DESCRIPTION A–210
A.13.1 LN Built-In Function A–210
A.13.2 LOAD Built-In Procedure A–211
A.13.3 LOAD_STATUS Built-In Procedure A–212
A.13.4 LOCK_GROUP Built-In Procedure A–213
A.13.5 %LOCKGROUP Translator Directive A–214
A.14 - M - KAREL LANGUAGE DESCRIPTION A–215
A.14.1 MIRROR Built-In Function A–215
A.14.2 MODIFY_QUEUE Built-In Procedure A–217
A.14.3 MOTION_CTL Built-In Function A–218
A.14.4 MOUNT_DEV Built-In Procedure A–219
A.14.5 MOVE ABOUT Statement A–219
A.14.6 MOVE ALONG Statement A–221
A.14.7 MOVE AWAY Statement A–222
A.14.8 MOVE AXIS Statement A–224
A.14.9 MOVE_FILE Built-In Procedure A–225
A.14.10 MOVE NEAR Statement A–226
A.14.11 MOVE RELATIVE Statement A–227
A.14.12 MOVE TO Statement A–229
A.14.13 MSG_CONNECT Built-In Procedure A–230
A.14.14 MSG_DISCO Built-In Procedure A–231
A.14.15 MSG_PING A–232
A.15 - N - KAREL LANGUAGE DESCRIPTION A–233
A.15.1 NOABORT Action A–233
A.15.2 %NOABORT Translator Directive A–233
A.15.3 %NOBUSYLAMP Translator Directive A–234
A.15.4 NODE_SIZE Built-In Function A–234
A.15.5 %NOLOCKGROUP Translator Directive A–236
A.15.6 NOMESSAGE Action A–237
A.15.7 NOPAUSE Action A–238
A.15.8 %NOPAUSE Translator Directive A–238
A.15.9 %NOPAUSESHFT Translator Directive A–239
A.15.10 NOWAIT Clause A–239
A.16 - O - KAREL LANGUAGE DESCRIPTION A–240
A.16.1 OPEN FILE Statement A–240
A.16.2 OPEN HAND Statement A–241
A.16.3 OPEN_TPE Built-In Procedure A–241
A.16.4 ORD Built-In Function A–243
A.16.5 ORIENT Built-In Function A–243
A.17 - P - KAREL LANGUAGE DESCRIPTION A–244
A.17.1 PATH Data Type A–244
A.17.2 PATH_LEN Built-In Function A–246
A.17.3 PAUSE Action A–247
A.17.4 PAUSE Condition A–248
A.17.5 PAUSE Statement A–248
A.17.6 PAUSE_TASK Built-In Procedure A–249
A.17.7 PEND_SEMA Built-In Procedure A–250

A.17.8 PIPE_CONFIG Built-In Procedure A–251
A.17.9 POP_KEY_RD Built-In Procedure A–252
A.17.10 Port_Id Action A–253
A.17.11 Port_Id Condition A–253
A.17.12 POS Built-In Function A–254
A.17.13 POS2JOINT Built-In Function A–255
A.17.14 POS_REG_TYPE Built-In Procedure A–256
A.17.15 POSITION Data Type A–258
A.17.16 POST_ERR Built-In Procedure A–259
A.17.17 POST_SEMA Built-In Procedure A–260
A.17.18 PRINT_FILE Built-In Procedure A–260
A.17.19 %PRIORITY Translator Directive A–261
A.17.20 PROG_BACKUP Built-In Procedure A–263
A.17.21 PROG_CLEAR Built-In Procedure A–266
A.17.22 PROG_RESTORE Built-In Procedure A–268
A.17.23 PROG_LIST Built-In Procedure A–270
A.17.24 PROGRAM Statement A–271
A.17.25 PULSE Action A–272
A.17.26 PULSE Statement A–273
A.17.27 PURGE CONDITION Statement A–274
A.17.28 PURGE_DEV Built-In Procedure A–275
A.17.29 PUSH_KEY_RD Built-In Procedure A–276

A.18 - Q - KAREL LANGUAGE DESCRIPTION A–277
A.18.1 QUEUE_TYPE Data Type A–277

A.19 - R - KAREL LANGUAGE DESCRIPTION A–277
A.19.1 READ Statement A–277
A.19.2 READ_DICT Built-In Procedure A–279
A.19.3 READ_DICT_V Built-In-Procedure A–280
A.19.4 READ_KB Built-In Procedure A–281
A.19.5 REAL Data Type A–285
A.19.6 Relational Condition A–287
A.19.7 RELAX HAND Statement A–288
A.19.8 RELEASE Statement A–289
A.19.9 REMOVE_DICT Built-In Procedure A–289
A.19.10 RENAME_FILE Built-In Procedure A–290
A.19.11 RENAME_VAR Built-In Procedure A–291
A.19.12 RENAME_VARS Built-In Procedure A–291
A.19.13 REPEAT ... UNTIL Statement A–292
A.19.14 RESET Built-In Procedure A–293
A.19.15 RESUME Action A–294
A.19.16 RESUME Statement A–294
A.19.17 RETURN Statement A–295
A.19.18 ROUND Built-In Function A–296
A.19.19 ROUTINE Statement A–296
A.19.20 RUN_TASK Built-In Procedure A–298

A.20 - S - KAREL LANGUAGE DESCRIPTION A–299
A.20.1 SAVE Built-In Procedure A–299
A.20.2 SAVE_DRAM Built-In Procedure A–300
A.20.3 SELECT ... ENDSELECT Statement A–301
A.20.4 SELECT_TPE Built-In Procedure A–302
A.20.5 SEMA_COUNT Built-In Function A–302
A.20.6 SEMAPHORE Condition A–303
A.20.7 SEND_DATAPC Built-In Procedure A–303
A.20.8 SEND_EVENTPC Built-In Procedure A–305

A.20.9 SET_ATTR_PRG Built-In Procedure A–305
A.20.10 SET_CURSOR Built-In Procedure A–307
A.20.11 SET_EPOS_REG Built-In Procedure A–308
A.20.12 SET_EPOS_TPE Built-In Procedure A–309
A.20.13 SET_FILE_ATR Built-In Procedure A–310
A.20.14 SET_FILE_POS Built-In Procedure A–310
A.20.15 SET_INT_REG Built-In Procedure A–311
A.20.16 SET_JPOS_REG Built-In Procedure A–312
A.20.17 SET_JPOS_TPE Built-In Procedure A–313
A.20.18 SET_LANG Built-In Procedure A–314
A.20.19 SET_PERCH Built-In Procedure A–315
A.20.20 SET_PORT_ASG Built-In Procedure A–316
A.20.21 SET_PORT_ATR Built-In Function A–317
A.20.22 SET_PORT_CMT Built-In Procedure A–319
A.20.23 SET_PORT_MOD Built-In Procedure A–320
A.20.24 SET_PORT_SIM Built-In Procedure A–321
A.20.25 SET_PORT_VAL Built-In Procedure A–322
A.20.26 SET_POS_REG Built-In Procedure A–323
A.20.27 SET_POS_TPE Built-In Procedure A–324
A.20.28 SET_PREG_CMT Built-In-Procedure A–324
A.20.29 SET_REAL_REG Built-In Procedure A–325
A.20.30 SET_REG_CMT Built-In-Procedure A–325
A.20.31 SET_TIME Built-In Procedure A–326
A.20.32 SET_TPE_CMT Built-In Procedure A–327
A.20.33 SET_TRNS_TPE Built-In Procedure A–328
A.20.34 SET_TSK_ATTR Built-In Procedure A–329
A.20.35 SET_TSK_NAME Built-In Procedure A–330
A.20.36 SET_VAR Built-In Procedure A–330
A.20.37 %SHADOWVARS Translator Directive A–332
A.20.38 SHORT Data Type A–332
A.20.39 SIGNAL EVENT Action A–332
A.20.40 SIGNAL EVENT Statement A–333
A.20.41 SIGNAL SEMAPHORE Action A–333
A.20.42 SIN Built-In Function A–334
A.20.43 SQRT Built-In Function A–334
A.20.44 %STACKSIZE Translator Directive A–335
A.20.45 STD_PTH_NODE Data Type A–335
A.20.46 STOP Action A–336
A.20.47 STOP Statement A–337
A.20.48 STRING Data Type A–338
A.20.49 STR_LEN Built-In Function A–339
A.20.50 STRUCTURE Data Type A–340
A.20.51 SUB_STR Built-In Function A–341

A.21 - T - KAREL LANGUAGE DESCRIPTION A–342
A.21.1 TAN Built-In Function A–342
A.21.2 TIME Condition A–343
A.21.3 %TIMESLICE Translator Directive A–344
A.21.4 %TPMOTION Translator Directive A–344
A.21.5 TRANSLATE Built-In Procedure A–344
A.21.6 TRUNC Built-In Function A–346

A.22 - U - KAREL LANGUAGE DESCRIPTION A–347
A.22.1 UNHOLD Action A–347
A.22.2 UNHOLD Statement A–348
A.22.3 UNINIT Built-In Function A–349
A.22.4 %UNINITVARS Translator Directive A–350

A.22.5 UNLOCK_GROUP Built-In Procedure A–350
A.22.6 UNPAUSE Action A–352
A.22.7 UNPOS Built-In Procedure A–353
A.22.8 UNTIL Clause A–353
A.22.9 USING ... ENDUSING Statement A–354
A.23 - V - KAREL LANGUAGE DESCRIPTION A–355
A.23.1 VAR_INFO Built-In Procedure A–355
A.23.2 VAR_LIST Built-In Procedure A–358
A.23.3 VECTOR Data Type A–360
A.23.4 VIA Clause A–361
A.23.5 VOL_SPACE Built-In Procedure A–361
A.24 - W - KAREL LANGUAGE DESCRIPTION A–363
A.24.1 WAIT FOR Statement A–363
A.24.2 WHEN Clause A–364
A.24.3 WHILE...ENDWHILE Statement A–364
A.24.4 WITH Clause A–365
A.24.5 WRITE Statement A–366
A.24.6 WRITE_DICT Built-In Procedure A–367
A.24.7 WRITE_DICT_V Built-In Procedure A–368
A.25 - X - KAREL LANGUAGE DESCRIPTION A–369
A.25.1 XML_ADDTAG Built-In Procedure A–369
A.25.2 XML_GETDATA Built-In Procedure A–370
A.25.3 XML_REMTAG Built-In Procedure A–371
A.25.4 XML_SCAN Built-In Procedure A–371
A.25.5 XML_SETVAR Built-In Procedure A–373
A.25.6 XYZWPR Data Type A–374
A.25.7 XYZWPREXT Data Type A–375
A.26 - Y - KAREL LANGUAGE DESCRIPTION A–375
A.27 - Z - KAREL LANGUAGE DESCRIPTION A–375

A.1 OVERVIEW

This appendix describes, in alphabetical order, each standard KAREL language element, including:

- Data types
- Executable statements and clauses
- Condition handler conditions and actions
- Built-in routines
- Translator directives

A brief example of a typical use of each element is included in each description.

Note If, during program execution, any uninitialized variables are encountered as arguments for built-in routines, the program pauses and an error is displayed. Either initialize the variable, KCL> SET VARIABLE command, or abort the program, using the KCL> ABORT command.

Conventions

This section describes each standard element of the KAREL language in alphabetical order. Each description includes the following information:

- **Purpose:** Indicates the specific purpose the element serves in the language
- **Syntax:** Describes the proper syntax needed to access the element in KAREL. Table A-1 describes the syntax notation that is used.

Table A–1. Syntax Notation

Syntax	Meaning	Example	Result
< >	Enclosed words are optional	AAA <BBB>	AAA AAA BBB
{ }	Enclosed words are optional and can be repeated	AAA {BBB}	AAA AAA BBB AAA BBB BBB AAA BBB BBB BBB
|	Separates alternatives	AAA | BBB	AAA BBB
< | >	Separates an alternative if only one or none can be used	AAA <BBB | CCC>	AAA AAA BBB AAA CCC
||	Exactly one alternative must be used	AAA || BBB | CCC ||	AAA BBB AAA CCC

Table A–1. Syntax Notation (Cont'd)

Syntax	Meaning	Example	Result
{ | }	Any combination of alternatives can be used	AAA {BBB | CCC}	AAA AAA BBB AAA CCC AAA BBB CCC AAA CCC BBB AAA BBB CCC BBB BBB
< < | > >	Nesting of symbols is allowed. Look at the innermost notation first to see what it describes, then look at the next innermost layer to see what it describes, and so forth.	AAA <BBB <CCC | DDD>	AAA AAA BBB AAA BBB CCC AAA BBB DDD

If the built-in is a function, the following notation is used to identify the data type of the value returned by the function:

```
Function Return Type: data_typ
```

Input and output parameter data types for functions and procedures are identified as:

[in] param_name: data_type

[out] param_name: data_type

where :

[in] specifies the data type of parameters which are passed into the routine

[out] specifies the data type of parameters which are passed back into the program from the routine

%ENVIRONMENT Group specifies the %ENVIRONMENT group for built-in functions and procedures, which is used by the off-line translator. Valid values are: BYNAM, CTDEF, ERRS, FDEV, FLBT, IOSETUP, KCL, MEMO, MIR, MOTN, MULTI, PATHOP, PBQMGR, REGOPE, STRNG, SYSDEF, TIM, TPE, TRANS, UIF, VECTR. The SYSTEM group is automatically used by the off-line translator.

- **Details:** Lists specific rules that apply to the language element. An italics-type font is used to denote keywords input by the user within the syntax of the element.
- **See Also:** Refers the reader to places in the document where more information can be found.

- **Example:** Displays a brief example and explanation of the element. Table A–2 through Table A–8 list the KAREL language elements, described in this appendix, by the type of element. Table A–9 lists these elements in alphabetical order.

Table A–2. Actions

ABORT Action
Assignment Action
CANCEL Action
CONTINUE Action
DISABLE CONDITION Action
ENABLE CONDITION Action
HOLD Action
NOABORT Action
NOMESSAGE Action
NOPAUSE Action
PAUSE Action
Port_Id Action
PULSE Action
RESUME Action
SIGNAL EVENT Action
SIGNAL SEMAPHORE Action
STOP Action
UNHOLD Action
UNPAUSE Action

Table A–3. Clauses

EVAL Clause
FROM Clause
IN Clause
NOWAIT Clause
UNTIL Clause
VIA Clause
WHEN Clause
WITH Clause

Table A–4. Conditions

```
ABORT Condition
AT NODE Condition
CONTINUE Condition
ERROR Condition
EVENT Condition
PAUSE Condition
Port_Id Condition
Relational Condition
SEMAPHORE Condition
TIME Condition
```

Table A–5. Data Types

```
ARRAY Data Type
BOOLEAN Data Type
BYTE Data Type
COMMON_ASSOC Data Type
CONFIG Data Type
DISP_DAT_T Data Type
FILE Data Type
GROUP_ASSOC Data Type
INTEGER Data Type
JOINTPOS Data Type
PATH Data Type
POSITION Data Type
QUEUE_TYPE Data Type
REAL Data Type
SHORT Data Type
STD_PTH_NODE Data Type
STRING Data Type
STRUCTURE Data Type
VECTOR Data Type
XYZWPR Data Type
XYZWPREXT Data Type
```

Table A–6. Directives

```
%ALPHABETIZE
%CMOSVARS
%CMOS2SHADOW
%COMMENT
%CRTDEVICE
%DEFGROUP
%DELAY
%ENVIRONMENT
%INCLUDE
%LOCKGROUP
%NOABORT
%NOBUSYLAMP
%NOLOCKGROUP
%NOPAUSE
%NOPAUSESHFT
%PRIORITY
%SHADOWVARS
%STACKSIZE
%TIMESLICE
%TPMOTION
%UNINITVARS
```

Table A–7. KAREL Built—In Routine Summary

Category	Identifier		
Byname	CALL_PROG CALL_PROGLIN	CURR_PROG FILE_LIST	PROG_LIST VAR_INFO VAR_LIST
Data Acquisition	DAQ_CHECKP DAQ_REGPIPE	DAQ_START DAQ_STOP	DAQ_UNREG DAQ_WRITE
Error Code Handling	ERR_DATA	POST_ERR	
File and Device Operation	CHECK_NAME COPY_FILE DELETE_FILE DISMOUNT_DEV FORMAT_DEV	MOUNT_DEV MOVE_FILE PRINT_FILE PURGE_DEV RENAME_FILE	XML_ADDTAG XML_GETDATA XML_REMTAG XML_SCAN XML_SETVAR

Table A–7. KAREL Built—In Routine Summary (Cont'd)

Category	Identifier		
Serial I/O, File Usage	BYTES_AHEAD BYTES_LEFT CLR_IO_STAT GET_FILE_POS GET_PORT_ATR	IO_STATUS MSG_CONNECT MSG_DISCO MSG_PING PIPE_CONFIG	SET_FILE_ATR SET_FILE_POS SET_PORT_ATR VOL_SPACE
Process I/O Setup	CLR_PORT_SIM GET_PORT_ASG GET_PORT_CMT GET_PORT_MOD GET_PORT_SIM	GET_PORT_VAL IO_MOD_TYPE SET_PORT_ASG	SET_PORT_CMT SET_PORT_MOD SET_PORT_SIM SET_PORT_VAL
KCL Operation	KCL	KCL_NO_WAIT	KCL_STATUS
Memory Operation	CLEAR CREATE_VAR LOAD LOAD_STATUS	PROG_BACKUP PROG_CLEAR PROG_RESTORE RENAME_VAR	RENAME_VARS SAVE SAVE_DRAM
MIRROR	MIRROR		
Program and Motion Control	CNCL_STP_MTN	MOTION_CTL	RESET
Multi-programming	ABORT_TASK CLEAR_SEMA CONT_TASK GET_TSK_INFO LOCK_GROUP	PAUSE_TASK PEND_SEMA POST_SEMA RUN_TASK SEMA_COUNT	SET_TSK_ATTR SET_TSK_NAME UNLOCK_GROUP
Path Operation	APPEND_NODE COPY_PATH DELETE_NODE	INSERT_NODE NODE_SIZE	PATH_LEN
Personal Computer Communications	ADD_BYNAMEPC ADD_INTPC ADD_REALPC	ADD_STRINGPC SEND_DATAPC SEND_EVENTPC	
Position	CHECK_EPOS CNV_JPOS_REL CNV_REL_JPOS CURPOS	CURJPOS FRAME IN_RANGE J_IN_RANGE	JOINT2POS POS POS2JOINT SET_PERCH UNPOS
Register Operation	SET_PREG_CMT	SET_REG_CMT	
Queue Manager	APPEND_QUEUE COPY_QUEUE DELETE_QUEUE	GET_QUEUE INIT_QUEUE INSERT_QUEUE	MODIFY_QUEUE

Table A–7. KAREL Built—In Routine Summary (Cont'd)

Category	Identifier		
Register Operation	CLR_POS_REG GET_JPOS_REG GET_POS_REG GET_PREG_CMT	GET_REG GET_REG_CMT POS_REG_TYPE SET_EPOS_REG	SET_INT_REG SET_JPOS_REG SET_POS_REG SET_REAL_REG
String Operation	CNV_CONF_STR CNV_INT_STR	CNV_REAL_STR CNV_STR_CONF	CNV_STR_INT CNV_STR_REAL
System	ABS ACOS ARRAY_LEN ASIN ATAN2 BYNAME CHR COS	EXP GET_VAR INDEX INV LN ORD ROUND SET_VAR	SIN SQRT STR_LEN SUB_STR TAN TRUNC UNINIT
Time-of-Day Operation	CNV_STR_TIME CNV_TIME_STR	GET_TIME GET_USEC_SUB	GET_USEC_TIM SET_TIME
TPE Program	AVL_POS_NUM CLOSE_TPE COPY_TPE CREATE_TPE DEL_INST_TPE GET_ATTR_PRG	GET_JPOS_TPE GET_POS_FRM GET_POS_TPE GET_POS_TYP GET_TPE_CMT GET_TPE_PRM OPEN_TPE SELECT_TPE	SET_ATTR_PRG SET_EPOS_TPE SET_JPOS_TPE SET_POS_TPE SET_TPE_CMT SET_TRNS_TPE
Translate	TRANSLATE		

Table A–7. KAREL Built—In Routine Summary (Cont'd)

Category	Identifier		
User Interface	ACT_SCREEN ADD_DICT ATT_WINDOW_D ATT_WINDOW_S CHECK_DICT CNC_DYN_DISB CNC_DYN_DISE CNC_DYN_DISI CNC_DYN_DISP CNC_DYN_DISR CNC_DYN_DISS DEF_SCREEN	DEF_WINDOW DET_WINDOW DISCTRL_ALPH DISCTRL_FORM DISCTRL_LIST DISCTRL_PLMN DISCTRL_SBMN DISCTRL_TBL FORCE_SPMENU INI_DYN_DISB INI_DYN_DISE INI_DYN_DISI INI_DYN_DISP INI_DYN_DISR INI_DYN_DISS POP_KEY_RD	PUSH_KEY_RD READ_DICT READ_DICT_V READ_KB REMOVE_DICT SET_CURSOR SET_LANG WRITE_DICT WRITE_DICT_V
Vector	APPROACH	ORIENT	

Table A–8. Items

CR Input/Output Item

Table A–9. Statements

ABORT Statement
Assignment Statement
ATTACH Statement
CANCEL Statement
CANCEL FILE Statement
CLOSE FILE Statement
CLOSE HAND Statement
CONDITION..ENDCONDITION Statement
CONNECT TIMER Statement
DELAY Statement
DISABLE CONDITION Statement
DISCONNECT TIMER Statement
ENABLE CONDITION Statement
FOR..ENDFOR Statement
GO TO Statement
HOLD Statement
IF..ENDIF Statement
MOVE ABOUT Statement
MOVE ALONG Statement
MOVE AWAY Statement
MOVE AXIS Statement
MOVE NEAR Statement
MOVE RELATIVE Statement
MOVE TO Statement
OPEN FILE Statement
OPEN HAND Statement
PAUSE Statement
PROGRAM Statement
PULSE Statement
PURGE CONDITION Statement
READ Statement
RELAX HAND Statement
RELEASE Statement
REPEAT...UNTIL Statement
RESUME Statement
RETURN Statement
ROUTINE Statement
SELECT..ENDSELECT Statement
SIGNAL EVENT Statement
STOP Statement
UNHOLD Statement
USING..ENDUSING Statement
WAIT FOR Statement
WHILE..ENDWHILE Statement
WRITE Statement

A.2 - A - KAREL LANGUAGE DESCRIPTION

A.2.1 ABORT Action

Purpose: Aborts execution of a running or paused task

Syntax : ABORT <PROGRAM[n]>

Details:

- If task execution is running or paused, the ABORT action will abort task execution.
- The ABORT action can be followed by the clause PROGRAM[n], where **n** is the task number to be aborted. Use GET_TASK_INFO to get a task number.
- If PROGRAM[n] is not specified, the current task execution is aborted.

See Also: GET_TSK_INFO Built-in

Chapter 6 *CONDITION HANDLERS*

Example: Refer to Section B.6, "Path Variables and Condition Handlers Program (PTH_MOVE.KL)," for a detailed program example.

A.2.2 ABORT Condition

Purpose: Monitors the aborting of task execution

Syntax : ABORT <PROGRAM[n]>

- The ABORT condition is satisfied when the task is aborted. The actions specified by the condition handler will be performed.
- If PROGRAM [n] is not specified, the current task number is used.
- Actions that are routine calls will not be executed if task execution is aborted.
- The ABORT condition can be followed by the clause PROGRAM[n], where n is the task number to be monitored. Use GET_TSK_INFO to get a task number.

See Also: CONDITION ... ENDCONDITION Statement, GET_TSK_INFO Built-in, Chapter 6 *CONDITION HANDLERS* , Appendix E, “Syntax Diagrams,” for additional syntax information

Example: Refer to the following sections for detailed program examples:

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

A.2.3 ABORT Statement

Purpose: Terminates task execution and cancels any motion in progress (or pending)

Syntax : ABORT <PROGRAM[n]>

- After an ABORT, the program cannot be resumed. It must be restarted.
- The statement can be followed by the clause PROGRAM[n], where n is the task number to be aborted.

See Also: , “Syntax Diagrams,” for additional syntax information

Example: Refer to the following sections for detailed program examples:

Section B.2, "Copying Path Variables" (CPY_PTH.KL)

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL)

Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.2.4 ABORT_TASK Built-In Procedure

Purpose: Aborts the specified running or paused task

Syntax : ABORT_TASK(task_name, force_sw, cancel_mtn_sw, status)

Input/Output Parameters:

[in] task_name :STRING

[in] force_sw :BOOLEAN

[in] cancel_mtn_sw :BOOLEAN

[out] status :INTEGER

%ENVIRONMENT Group :MULTI

Details:

- *task_name* is the name of the task to be aborted. If task name is '*ALL*', all executing or paused tasks are aborted except the tasks that have the ''ignore abort request'' attribute set.
- *force_sw* , if true, specifies to abort a task even if the task has the ''ignore abort request'' set. *force_sw* is ignored if task_name is '*ALL*'.
- *cancel_mtn_sw* specifies whether motion is canceled for all groups belonging to the specified task.

Note Do not use more than one motion group in a KAREL program. If you need to use more than one motion group, you must use a teach pendant program.



Warning

Do not run a KAREL program that includes more than one motion group. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: CONT_TASK, RUN_TASK, PAUSE_TASK Built-In Procedures, NO_ABORT Action, %NO_ABORT Translator Directive, Chapter 14 *MULTI-TASKING*

Example: Refer to Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL), for a detailed program example.

A.2.5 ABS Built-In Function

Purpose: Returns the absolute value of the argument x, which can be an INTEGER or REAL expression

Syntax : ABS(x)

Function Return Type :INTEGER or REAL

Input/Output Parameters :

[in] x :INTEGER or REAL expression

%ENVIRONMENT Group :SYSTEM

Details:

- Returns the absolute value of x, with the same data type as x.

Example: Refer to Section B.7, "Listing Files and Programs and Manipulating Strings (LIST_EX.KL)," for a detailed program example.

A.2.6 ACOS Built-In Function

Purpose: Returns the arc cosine (cos-1) in degrees of the specified argument

Syntax : ACOS(x)

Function Return Type :REAL

Input/Output Parameters :

[in] x :REAL

%ENVIRONMENT Group :SYSTEM

Details:

- x must be between -1.0 and 1.0; otherwise the program will abort with an error.
- Returns the arccosine of x.

Example: The following example sets ans_r to the arccosine of -1 and writes this value to the screen. The output for the following example is 180 degrees.

ACOS Built-In Function

```
routine take_acos
var
  ans_r:  real
begin
  ans_r = acos (-1)
  WRITE ('acos -1 ', ans_r, CR)
END take_acos
```

The second example causes the program to abort since the input value is less than -1 and not within the valid range.

ACOS Built-In Function

```
routine take_acos
var
  ans_r:  real
begin
  ans_r = acos (-1.5) -- causes program to abort
  WRITE ('acos -1.5 ', ans_r, CR)
END take_acos
```

A.2.7 ACT_SCREEN Built-In Procedure

Purpose: Activates a screen

Syntax : ACT_SCREEN

Input/Output Parameters :

[in] screen_name :STRING

[out] old_screen_n :STRING

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- Causes the display device associated with the screen to be cleared and all windows attached to the screen to be displayed.
- *screen_name* must be a string containing the name of a previously defined screen, see DEF_SCREEN Built-in.
- The name of the screen that this replaces is returned in *old_screen_n* .
- Requires the USER or USER2 menu to be selected before activating the new screen, otherwise the status will be set to 9093.
  - — To force the selection of the teach pendant user menu before activating the screen, use FORCE_SPMENU (tp_panel, SPI_TPUSER, 1).
  - — To force the selection of the CRT/KB user menu before activating the screen, use FORCE_SPMENU (crt_panel, SPI_TPUSER, 1).
- If the USER menu is exited and re-entered, your screen will be reactivated as long as the KAREL task which called ACT_SCREEN continues to run. When the KAREL task is aborted, the system's user screen will be re-activated. Refer to Section 7.10 for details on the system's user screen.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: DEF_SCREEN Built-In Procedure

Example: Refer to the following sections for detailed program examples:

Section B.12 , "Displaying a List From a Dictionary File" (DCLST_EX.KL)

A.2.8 ADD_BYNAMEPC Built-In Procedure

Purpose: To add an integer, real, or string value into a KAREL byte given a data buffer.

Syntax : ADD_BYNAMEPC(dat_buffer, dat_index, prog_name, var_name, status)

Input/Output Parameters :

[in] dat_buffer :ARRAY OF BYTE

[in,out] dat_index :INTEGER

[in] prog_name :STRING

[in] var_name :STRING

[out] status :INTEGER

%ENVIRONMENT Group :PC

Details:

- *dat_buffer* - an array of up to 244 bytes.
- *dat_index* - the starting byte number to place the string value.
- *prog_name* - specifies the name of the program that contains the specified variable.
- *var_name* - refers to a static program variable. This is only supported by an integer, real, or string variable (arrays and structures are not supported).
- *status* - the status of the attempted operation. If not 0, then an error occurred and data was not placed into the buffer.

The ADD_BYNAMEPC built-in adds integer, real, and string values to the data buffer in the same manner as the KAREL built-ins ADD_INTPC, ADD_REALPC, and ADD_STRINGPC.

See Also: ADD_BYNAMEPC, ADD_INTPC, ADD_REALPC, ADD_STRINGPC

Example: See the following for an example of the ADD_BYNAMEPC built-in.

ADD_BYNAMEPC Built-In Procedure

```
PROGRAM TESTBYNM
%ENVIRONMENT PC
CONST
  er_abort = 2
VAR
  dat_buffer:  ARRAY[100] OF BYTE
  index:       INTEGER
  status:      INTEGER
BEGIN
  index = 1
  ADD_BYNAMEPC(dat_buffer,index, 'TESTDATA','INDEX',status)
  IF status<>0 THEN
```

```
    POST_ERR(status,'',0,er_abort)
  ENDIF
END testbynm
```

A.2.9 ADD_DICT Built-In Procedure

Purpose: Adds the specified dictionary to the specified language.

Syntax : ADD_DICT(file_name, dict_name, lang_name, add_option, status)

Input/Output Parameters :

[in] file_name :STRING

[in] dict_name :STRING

[in] lang_name :STRING

[in] add_option :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *file_name* specifies the device, path, and file name of the dictionary file to add. The file type is assumed to be '.TX' (text file).
- *dict_name* specifies the name of the dictionary to use when reading and writing dictionary elements. Only 4 characters are used.
- *lang_name* specifies to which language the dictionary will be added. One of the following pre-defined constants should be used:

  dp_default

  dp_english

  dp_japanese

  dp_french

  dp_german

  dp_spanish

- The default language should be used unless more than one language is required.
- *add_option* should be the following:

  dp_dram Dictionary will be loaded to DRAM memory and retained until the next INIT START.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred adding the dictionary file.

See Also: READ_DICT, WRITE_DICT, REMOVE_DICT Built-In Procedures, Chapter 10 *DICTIONARIES AND FORMS*

Example: Refer to the following sections for detailed program examples:

Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL)

Section B.12, "Dictionary Files" (DCALPHEG.UTX)

A.2.10 ADD_INTPC Built-In Procedure

Purpose: To add an INTEGER value (type 16 - 10 HEX) into a KAREL byte data buffer.

Syntax : ADD_INTPC(dat_buffer, dat_index, number, status)

Input/Output Parameters :

[in] dat_buffer :ARRAY OF BYTE

[in,out] dat_index :INTEGER

[in] number :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PC

Details:

- *dat_buffer* - an array of up to 244 bytes.
- *dat_index* - the starting byte number to place the integer value.
- *number* - the integer value to place into the buffer.
- *status* - the status of the attempted operation. If not 0, then an error occurred and data was not put into the buffer.

The KAREL built-ins ADD_BYNAMEPC, ADD_INTPC, ADD_REALPC, and ADD_STRINGPC can be used to format a KAREL byte buffer in the following way: INTEGER data is added to the buffer as follows (buffer bytes are displayed in HEX):

beginning index = dat_index

2 bytes - variable type

4 bytes - the number

2 bytes of zero (0) - end of buffer marker

The following is an example of an INTEGER placed into a KAREL array of bytes starting at index = 1:

0 10 0 0 0 5 0 0

where:

0 10 = INTEGER variable type

0 0 0 5 = integer number 5

0 0 = end of data in the buffer

On return from the built-in, index = 7.

See Also: ADD_BYNAMEPC, ADD_INTPC, ADD_REALPC, ADD_STRINGPC

Example: Refer to the TESTDATA example in the built-in function SEND_DATAPC.

A.2.11 ADD_REALPC Built-In Procedure

Purpose: To add a REAL value (type 17 - 11 HEX) into a KAREL byte data buffer.

Syntax : ADD_REALPC(dat_buffer, dat_index, number, status)

Input/Output Parameters :

[in] dat_buffer :ARRAY OF BYTE

[in,out] dat_index :INTEGER

[in] number :REAL

[out] status :INTEGER

%ENVIRONMENT Group :PC

Details:

- *dat_buffer* - an array of up to 244 bytes.
- *dat_index* - the starting byte number to place the real value.
- *number* - the real value to place into the buffer.
- *status* - the status of the attempted operation. If not 0, then an error occurred and data was not placed into the buffer.

The KAREL built-ins ADD_BYNAMEPC, ADD_INTPC, ADD_REALPC, and ADD_STRINGPC can be used to format a KAREL byte buffer in the following way:

REAL data is added to the buffer as follows (buffer bytes are displayed in HEX):

beginning index = dat_index

2 bytes - variable type

4 bytes - the number

2 bytes of zero (0) - end of buffer marker

The following is an example of an REAL placed into a KAREL array of bytes starting at index = 1:

0 11 43 AC CC CD 0 0

where:

0 11 = REAL variable type

43 AC CC CD = real number 345.600006

0 0 = end of data in the buffer

On return from the built-in, index = 7.

See Also: ADD_BYNAMEPC, ADD_INTPC, ADD_REALPC, ADD_STRINGPC

Example: Refer to the TESTDATA example in the built-in function SEND_DATAPC.

A.2.12 ADD_STRINGPC Built-In Procedure

Purpose: To add a string value (type 209 - D1 HEX) into a KAREL byte data buffer.

Syntax : ADD_STRINGPC(dat_buffer, dat_index, item, status)

Input/Output Parameters :

[in] dat_buffer :ARRAY OF BYTE

[in,out] dat_index :INTEGER

[in] item :string

[out] status :INTEGER

%ENVIRONMENT Group :PC

Details:

- *dat_buffer* - an array of up to 244 bytes.
- *dat_index* - the starting byte number to place the string value.
- *item* - the string value to place into the buffer.
- *status* - the status of the attempted operation. If not 0, then an error occurred and data was not placed into the buffer.

The KAREL built-ins ADD_BYNAMEPC, ADD_INTPC, ADD_REALPC, and ADD_STRINGPC can be used to format a KAREL byte buffer in the following way:

STRING data is added to the buffer as follows:

beginning index = dat_index

2 bytes - variable type

1 byte - length of text string

text bytes

2 bytes of zero (0) - end of buffer marker

The following is an example of an STRING placed into a KAREL array of bytes starting at index = 1:

0 D1 7 4D 48 53 48 45 4C 4C 0 0 0

where:

0 D1 = STRING variable type

7 = there are 7 characters in string 'MHSHELL'

4D 48 53 48 45 4C 4C 0 = 'MHSHELL' with end of string 0

0 0 = end of data in the buffer

On return from the built-in, index = 12.

See Also: ADD_BYNAMEPC, ADD_INTPC, ADD_REALPC, ADD_STRINGPC

Example: Refer to the TESTDATA example in the built-in function SEND_DATAPC.

A.2.13 %ALPHABETIZE Translator Directive

Purpose: Specifies that static variables will be created in alphabetical order when p-code is loaded.

Syntax : %ALPHABETIZE

Details:

- Static variables can be declared in any order in a KAREL program and %ALPHABETIZE will cause them to be displayed in alphabetical order in the DATA menu or KCL> SHOW VARS listing.

  Example: Refer to the following sections for detailed program examples:

Section B.2, "Copying Path Variables" (CPY_PTH.KL)

Section B.5,"Using Register Built-ins" (REG_EX.KL)

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL)

A.2.14 APPEND_NODE Built-In Procedure

Purpose: Adds an uninitialized node to the end of the PATH argument

Syntax : APPEND_NODE(path_var, status)

Input/Output Parameters :

[in] path_ var :PATH

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *path_var* is the path variable to which the node is appended.
- The appended PATH node is uninitialized. The node can be assigned values by directly referencing its NODEDATA structure.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: DELETE_NODE, INSERT_NODE Built-In Procedures

Example: Refer to Section B.2, "Copying Path Variables" (CPY_PTH.KL), for a detailed program example.

A.2.15 APPEND_QUEUE Built-In Procedure

Purpose: Appends an entry to a queue if the queue is not full

Syntax : APPEND_QUEUE(value, queue, queue_data, sequence_no, status)

Input/Output Parameters :

[in] value :INTEGER

[in,out] queue :QUEUE_TYPE

[in,out] queue_data :ARRAY OF INTEGER

[out] sequence_no :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBQMGR

Details:

- *value* specifies the value to be appended to the queue.
- *queue* specifies the queue variable for the queue.
- *queue_data* specifies the array used to hold the data in the queue. The length of this array determines the maximum number of entries in the queue.
- *sequence_no* is returned with the sequence number of the entry just appended.
- *status* is returned with the zero if an entry can be appended to the queue. Otherwise it is returned with 61001, ‘‘Queue is full.’’

See Also: DELETE_QUEUE, INSERT_QUEUE Built-In Procedures. Refer to Section 14.8, "Using Queues for Task Communication," for more information and an example.

A.2.16 APPROACH Built-In Function

Purpose: Returns a unit VECTOR representing the z-axis of a POSITION argument

Syntax : APPROACH(posn)

Function Return Type :VECTOR

Input/Output Parameters :

[in] posn :POSITION

%ENVIRONMENT Group :VECTR

Details:

- Returns a VECTOR consisting of the approach vector (positive z-axis) of the argument *posn* .

Example: This program allows you to move the TCP to a position that is 500 mm away from another position along the z-axis.

APPROACH Function

```
PROGRAM p_approach
VAR
  start_pos  : POSITION
  app_vector : VECTOR
BEGIN
  MOVE TO start_pos
  app_vector = APPROACH (start_pos)  --sets app_vector equal to the
                                     --z-axis of start_pos
 start_pos.location = start_pos.location + app_vector *500
                                   --moves start_pos + 500 mm
                                   --in z direction
  WITH $MOTYPE = LINEAR, MOVE TO start_pos
END p_approach
```

Note Approach has been left in for older versions of KAREL. You should now directly access the vectors of a POSITION (i.e., posn. approach.)

A.2.17 ARRAY Data Type

Purpose: Defines a variable, function return type, or routine parameter as ARRAY data type

Syntax : ARRAY<[size{,size}]> OF data_type

where:

size : an INTEGER literal or constant

data_type : any type except PATH

Details:

- *size* indicates the number of elements in an ARRAY variable.
- *size* must be in the range 1 through 32767 and must be specified in a normal ARRAY variable declaration. The amount of available memory in your controller might restrict the maximum size of an ARRAY.
- Individual elements are referenced by the ARRAY name and the subscript *size* . For example, table[1] refers to the first element in the ARRAY table.
- An entire ARRAY can be used only in assignment statements or as an argument in routine calls. In an assignment statement, both ARRAY variables must be of the same *size* and *data_type* . If *size* is different, the program will be translated successfully but will be aborted during execution, with error 12304, "Array Length Mismatch."
- *size* is not specified when declaring ARRAY routine parameters; an ARRAY of any size can be passed as an ARRAY parameter to a routine.
- *size* is not used when declaring an ARRAY return type for a function. However, the returned ARRAY must be of the same size as the ARRAY to which it is assigned in the function call.
- Each element is of the same type designated by *data_type* .
- Valid ARRAY operators correspond to the valid operators of the individual elements in the ARRAY.
- Individual elements of an array can be read or written only in the format that corresponds to the data type of the ARRAY.
- Arrays of multiple dimensions can be defined. Refer to Chapter 2 for more information.
- Variable-sized arrays can be defined. Refer to Chapter 2 for more information.

See Also: ARRAY_LEN Built-In Function, Chapter 5 *ROUTINES* , for information on passing ARRAY variables as arguments in routine calls Chapter 7 *FILE INPUT/OUTPUT OPERATIONS*

Example: Refer to the following sections for detailed program examples:

Section B.2, "Copying Path Variables" (CPY_PTH.KL)

Section B.8, "Generating and Moving Along a Hexagon Path" (GEN_HEX.KL)

Section B.9, "Using the File and Device Built-ins" (FILE_EX.KL)

Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL)

Section B.14, "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

A.2.18 ARRAY_LEN Built-In Function

Purpose: Returns the number of elements contained in the specified array argument

Syntax : ARRAY_LEN(ary_var)

Function Return Type :INTEGER

Input/Output Parameters :

[in] ary_var :ARRAY

%ENVIRONMENT Group :SYSTEM

- The returned value is the number of elements declared for *ary_var* , not the number of elements that have been initialized in *ary_var* .

Example: Refer to Section B.7, "Listing Files and Programs and Manipulating Strings" (LIST_EX.KL), for a detailed program example.

A.2.19 ASIN Built-In Function

Purpose: Returns arcsine (sin-1) in degrees of the specified argument

Syntax : ASIN(x)

Function Return Type :REAL

Input/Output Parameters :

[in] x :REAL

%ENVIRONMENT Group :SYSTEM

Details:

- Returns the arcsine of x.
- x must be between -1 and 1, otherwise the program will abort with an error.

Example: The following example sets ans_r to the arcsine of -1 and writes this value to the screen. The output for the following example is -90 degrees.

ASIN Built-In Function

```
ROUTINE take_asin
VAR
  ans_r:  REAL
BEGIN
  ans_r = ASIN (-1)
  WRITE ('asin -1 ', ans_r, CR)
END take_asin
```

The second example causes the program to abort since the input value is less than -1 and not within the valid range.

ASIN Built-In Function

```
ROUTINE take_asin
VAR
  ans_r:  REAL
BEGIN
  ans_r = ASIN (-1.5) -- causes program to abort
  WRITE ('asin -1.5 ', ans_r, CR)
END take_asin
```

A.2.20 Assignment Action

Purpose: Sets the value of a variable to the result of an evaluated expression

Syntax : variable {[subscript{,subscript}]| . field} = expn

where:

variable : any KAREL variable

subscript : an INTEGER expression

expn : a valid KAREL expression

field : any field from a structured variable

Details:

- *variable* can be any user-defined variable, system variable with write access, or output port array with write access.
- *subscript* is used to access elements of an array.
- *field* is used to access fields in a structure.

- *expn* must be of the same type as the variable or element of *variable* .
- An exception is that an INTEGER expression can be assigned to a REAL. Any positional types can be assigned to each other.
- Only system variables with write access (listed as RW in Table 11-3, “System Variables Summary”) can be used on the left side of an assignment statement. System variables with read only (RO) or read write (RW) access can be used on the right side.
- Input port arrays cannot be used on the left side of an assignment statement.

See Also: Chapter 3 *USE OF OPERATORS* , for detailed information about expressions and their evaluation Chapter 6 *CONDITION HANDLERS* , for more information about using assignment actions.

Example: The following example uses the assignment action to turn DOUT[1] off and set **port_var** equal to DOUT[2] when EVENT[1] turns on.

Assignment Action

```
CONDITION[1]:
  WHEN EVENT[1] DO
    DOUT[1] = OFF
    port_var = DOUT[2]
ENDCONDITION
```

A.2.21 Assignment Statement

Purpose: Sets the value of a variable to the result of an evaluated expression

Syntax : variable {[subscript{,subscript}]| . field} = expn

where:

variable : any KAREL variable

subscript : an INTEGER expression

expn : a valid KAREL expression

field : any field from a structured variable

Details:

- *variable* can be any user-defined variable, system variable with write access, or output port array with write access.
- *subscript* is used to access elements of an array.

- *field* is used to access fields in a structure.
- *expn* must be of the same type as the variable or element of *variable* .
- An exception is that an INTEGER expression can be assigned to a REAL. Any positional types can be assigned to each other. INTEGER, SHORT, and BYTE can be assigned to each other.
- If *variable* is of type ARRAY, and no subscript is supplied, the expression must be an ARRAY of the same type and size. A type mismatch will be detected during translation. A size mismatch will be detected during execution and causes the program to abort with error 12304, "Array Length Mismatch."
- If *variable* is a user-defined structure, and no field is supplied, the expression must be a structure of the same type.
- Only system variables with write access (listed as RW in Table 11-3, ‘‘System Variables Summary’’) can be used on the left side of an assignment statement. System variables with read only (RO) or read write (RW) access can be used on the right side.

  If read only system variables are passed as parameters to a routine, they are passed by value, so any attempt to modify them (with an assignment statement) through the parameter in the routine has no effect.
- Input port arrays cannot be used on the left side of an assignment statement.

See Also: Chapter 3 *USE OF OPERATORS* , for detailed information about expressions and their evaluation, Chapter 2 *LANGUAGE ELEMENTS* . Refer to Appendix B, "KAREL Example Programs," for more detailed program examples.

Example: The following example assigns an INTEGER literal to an INTEGER variable and then increments that variable by a literal and value.

Assignment Statement

```
int_var = 5
  int_var = 5 + int_var
```

Example: The next example multiplies the system variable $SPEED by a REAL value. It is then used to assign the ARRAY variable **array_1** , element loop_count to the new value of the system variable $SPEED.

Assignment Statement

```
$SPEED = $SPEED * .25
  array_1[loop_count] = $SPEED
```

Example: The last example assigns all the elements of the ARRAY **array_1** to those of ARRAY **array_2** , and all the fields of structure **struc_var_1** to those of **struc_var_2** .

Assignment Statement

```
array_2 = array_1
```

```
struc_var_2 = struc_var_1
```

A.2.22 AT NODE Condition

Purpose: Condition is satisfied when a specified PATH node or position has been reached

Syntax : AT NODE[n]

where:

n :an INTEGER expression or * (asterisk)

Details:

- The AT NODE condition can be used only in local condition handlers.
- If the move is along a PATH or to a path node, *n* specifies the path node. If *n* is a wildcard (*) or negative one (-1), any node will satisfy the AT NODE condition.
- If the move is to a position, *n = 1* (node 1) can be used to indicate the destination.
- If *n* is greater than the length of the path (or greater than 1 if the move is to a position), the condition is never satisfied.
- If *n* is less than zero or greater than 1000, the program is aborted with an error.

See Also: Chapter 6 *CONDITION HANDLERS* , for more information on synchronizing local condition handlers with the motion environment. PATH_LEN Built-In Function

Example: Refer to Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.2.23 ATAN2 Built-In Function

Purpose: Returns a REAL angle, measured counterclockwise in degrees, from the positive x-axis to a line connecting the origin and a point whose x- and y- coordinates are specified as the x- and y-arguments

Syntax : ATAN2(x1, y1)

Function Return Type :REAL

Input/Output Parameters :

[in] x1 :REAL

[in] y1 :REAL

%ENVIRONMENT Group :SYSTEM

Details:

- *x1* and *y1* specify the x and y coordinates of the point.
- If *x1* and *y1* are both zero, the interpreter will abort the program.

Example: The following example uses the values 100, 200, and 300 respectively for **x, y,** and **z** to compute the orientation component **direction** . The position, **p1** is then defined to be a position with **direction** as its orientation component.

ATAN2 Built-In Function

```
PROGRAM p_atan2
VAR
  p1 : POSITION
  x, y, z, direction : REAL
BEGIN
  x = 100  --  use appropriate values
  y = 200  --    for x,y,z on
  z = 300  --    your robot
  direction = ATAN2(x, y)
  p1 = POS(x, y, z, 0, 0, direction, 'n') --r orientation component
  MOVE TO p1                              --of POS equals angle
END p_atan2                               --returned by ATAN2(100,200)
```

A.2.24 ATTACH Statement

Purpose: Gives the KAREL program control of motion for the robot arm and auxiliary and extended axes

Syntax : ATTACH

Details:

- Used with the RELEASE statement. If motion control is not currently released from program control, the ATTACH statement has no effect.
- If the teach pendant is still enabled, execution of the KAREL program is delayed until the teach pendant is disabled. The task status will show a hold of "attach done."
- Stopped motions can only be resumed following execution of the ATTACH statement.

See Also: RELEASE Statement, Chapter 8 *MOTION* , for more information on motion control, Appendix E, “Syntax Diagrams,” for additional syntax information.

Example: Refer to Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.2.25 ATT_WINDOW_D Built-In Procedure

Purpose: Attach a window to the screen on a display device

Syntax : ATT_WINDOW_D(window_name, disp_dev_nam, row, col, screen_name, status)

Input/Output Parameters :

[in] window_name :STRING

[in] disp_dev_nam :STRING

[in] row :INTEGER

[in] col :INTEGER

[out] screen_name :STRING

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- Causes data in the specified window to be displayed or attached to the screen currently active on the specified display device.
- *window_name* must be a previously defined window.
- *disp_dev_nam* must be one of the display devices already defined:

  'CRT' CRT Device

  'TP' Teach Pendant Device
- *row* and *col* indicate the position in the screen. Row 1 indicates the top row; col 1 indicates the left-most column. The entire window must be visible in the screen where positioned. For example, if the screen is 24 rows by 80 columns (as defined by its associated display device) and the window is 2 rows by 80 columns, *row* must be in the range 1-23; *col* must be 1.
- The name of the active screen is returned in *screen_name* . This can be used to detach the window later.
- It is an error if the window is already attached to the screen.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

A.2.26 ATT_WINDOW_S Built-In Procedure

Purpose: Attach a window to a screen

Syntax : ATT_WINDOW_S(window_name, screen_name, row, col, status)

Input/Output Parameters :

[in] window_name :STRING

[in] screen_name :STRING

[in] row :INTEGER

[in] col :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- Causes data in the specified window to be displayed or attached to the specified screen at a specified row and column.
- *window_name* and *screen_name* must be previously defined window and screen names.
- *row* and *col* indicate the position in the screen. Row 1 indicates the top row; col 1 indicates the left-most column. The entire window must be visible in the screen as positioned. For example, if the screen is 24 rows by 80 columns (as defined by its associated display device) and the window is 2 rows by 80 columns, row must be in the range 1-23; col must be 1.
- If the screen is currently active, the data will immediately be displayed on the device. Otherwise, there is no change in the displayed data.
- It is an error if the window is already attached to the screen.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: Section 7.10, "User Interface Tips," DET_WINDOW Built-In

Example: Refer to Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL), for a detailed program example.

A.2.27 AVL_POS_NUM Built-In Procedure

Purpose: Returns the first available position number in a teach pendant program

Syntax : AVL_POS_NUM(open_id, pos_num, status)

Input/Output Parameters :

[in] open_id :INTEGER

[out] pos_num : INTEGER

[out] status : INTEGER

%ENVIRONMENT Group :TPE

Details:

- *open_id* specifies the opened teach pendant program. A program must be opened before calling this built-in.
- *pos_num* is set to the first available position number.
- *status* explains the status of the attempted operation. If not equal to 0, then an error has occurred.

Example: Refer to Section B.14, "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL), for a detailed program example.

A.3 - B - KAREL LANGUAGE DESCRIPTION

A.3.1 BOOLEAN Data Type

Purpose: Defines a variable, function return type, or routine parameter as a BOOLEAN data type

Syntax : BOOLEAN

Details:

- The BOOLEAN data type represents the BOOLEAN predefined constants TRUE, FALSE, ON, and OFF.

  Table A–10 lists some examples of valid and invalid BOOLEAN values used to represent the Boolean predefined constants.

Table A–10. Valid and Invalid BOOLEAN Values

VALID	INVALID	REASON
TRUE	T	Must use entire word
ON	1	Cannot use INTEGER values

- TRUE and FALSE typically represent logical flags, and ON and OFF typically represent signal states. TRUE and ON are equivalent, as are FALSE and OFF.

- Valid BOOLEAN operators are
  - AND, OR, and NOT
  - Relational operators (>, >=, =, <>, <, and <=)
- The following have BOOLEAN values:
  - BOOLEAN constants, whether predefined or user-defined (for example, ON is a predefined constant)
  - BOOLEAN variables and BOOLEAN fields in a structure
  - ARRAY OF BOOLEAN elements
  - Values returned by BOOLEAN functions, whether user-defined or built-in (for example, IN_RANGE(pos_var))
  - Values resulting from expressions that use relational or BOOLEAN operators (for example, x > 5.0)
  - Values of digital ports (for example, DIN[2])
- Only BOOLEAN expressions can be assigned to BOOLEAN variables, returned from BOOLEAN function routines, or passed as arguments to BOOLEAN parameters.

Example: Refer to the following sections for detailed program examples:

Section B.2, "Copying Path Variables" (CPY_PTH.KL)

Section B.3, "Saving Data to the Default Device" (SAVE_VR.KL)

Section B.5, "Using Register Built-ins" (REG_EX.KL)

Section B.7, "Listing Files and Programs and Manipulating Strings" (LIST_EX.KL)

Section B.9 , "Using the File and Device Built-ins" (FILE_EX.KL)

Section B.10 , "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.12 , "Displaying a List From a Dictionary File" (DCLST_EX.KL)

Section B.14 , "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.3.2 BYNAME Built-In Function

Purpose: Allows a KAREL program to pass a variable, whose name is contained in a STRING, as a parameter to a KAREL routine. This means the programmer does not have to determine the variable name during program creation and translation.

Syntax : BYNAME (prog_name, var_name, entry)

Input/Output Parameters :

[in] prog_name :STRING

[in] var_name :STRING

[in,out] entry :INTEGER

%ENVIRONMENT Group :system

Details:

- This built-in can be used only to pass a parameter to a KAREL routine.
- *entry* returns the entry number in the variable data table where *var_name* is located. This variable does not need to be initialized and should not be modified.
- *prog_name* specifies the name of the program that contains the specified variable. If *prog_name* is equal to ’’ (double quotes), then the routine defaults to the task name being executed.
- *var_name* must refer to a static, program variable.
- If *var_name* does not contain a valid variable name or if the variable is not of the type expected as a routine parameter, the program is aborted.
- System variables cannot be passed using BYNAME.
- The PATH data type cannot be passed using BYNAME. However, a user-defined type that is a PATH can be used instead.

Example: Refer to Section B.2 , "Copying Path Variables" (CPY_PTH.KL), for a detailed program example.

A.3.3 BYTE Data Type

Purpose: Defines a variable as a BYTE data type

Syntax : BYTE

Details:

- BYTE has a range of ($0 \leq n \geq 255$). No uninitialized checking is done on bytes.
- BYTEs are allowed only within an array or within a structure.
- BYTEs can be assigned to SHORTs and INTEGERs, and SHORTs and INTEGERs can be assigned to BYTEs. An assigned value outside the BYTE range will be detected during execution and cause the program to abort.

Example: The following example defines an array of BYTE and a structure containing BYTEs.

BYTE Data Type

```
PROGRAM byte_ex
%NOLOCKGROUP
  TYPE
    mystruct = STRUCTURE
      param1: BYTE
      param2: BYTE
      param3: SHORT
    ENDSTRUCTURE
  VAR
    array_byte: ARRAY[10] OF BYTE
    myvar: mystruct
  BEGIN
    array_byte[1] = 254
    myvar.param1 = array_byte[1]
END byte_ex
```

A.3.4 BYTES_AHEAD Built-In Procedure

Purpose: Returns the number of bytes of input data presently in the read-ahead buffer for a KAREL file. Allows KAREL programs to check instantly if data has been received from a serial port and is available to be read by the program. BYTES_AHEAD is also supported on socket messaging and pipes.

Syntax : BYTES_AHEAD(file_id, n_bytes, status)

Input/Output Parameters :

[in] file_id :FILE

[out] n_bytes :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :FLBT

Details:

- *file_id* specifies the file that was opened.
- The *file_id* must be opened with the ATR_READAHD attribute set greater than zero.
- *n_byte* is the number of bytes in the read_ahead buffer.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

- A non-zero status will be returned for non-serial devices such as files.

See Also: Section 7.3.1 , “File Attributes”

Example: The following example will clear Port 2 (FLPY:) from any bytes still remaining to be read.

BYTES_AHEAD Built-In Procedure

```
ROUTINE purge_port
VAR
     s1         :  STRING[1]
     n_try      :  INTEGER
     n_bytes    :  INTEGER
     stat       :  INTEGER
BEGIN
  stat=SET_PORT_ATR (port_2, ATR_READAHD, 1) -- sets FLPY: to have a read
                                    -- ahead buffer of 128 bytes
  OPEN FILE fi('RO', 'rdahd.tst')
  REPEAT
     BYTES_AHEAD (fi, n_bytes, stat)
                              --Get number of bytes ready
                              --to be read
    if (n_bytes = 0) then     --if there are no bytes then set stat
       stat = 282
    endif
    if (n_bytes >= 1_) then   --there are bytes to be read
       read fi(s1::1)         --read in one byte at a time
       stat=io_status (fi)    --get the status of the read operation
    endif
  UNTIL stat <> 0             --continue until no more bytes are left
END purge_port
BEGIN
-- main program text here
END bytes_ahd
```

A.3.5 BYTES_LEFT Built-In Function

Purpose: Returns the number of bytes remaining in the current input data record

Syntax : BYTES_LEFT(file_id)

Function Return Type :INTEGER

Input/Output Parameters :

[in] file_id :FILE

%ENVIRONMENT Group :FLBT

Details:

- *file_id* specifies the file that was opened.
- If no read or write operations have been done or the last operation was a READ file_id (CR), a zero is returned.
- If *file_id* does not correspond to an opened file or one of the pre-defined ‘‘files’’ opened to the respective CRT/KB, teach pendant, and vision windows, the program is aborted.

  Note An infeed character (LF) is created when the ENTER key is pressed, and is counted by BYTES_LEFT.

- This function will return a non-zero value only when data is input from a keyboard (teach pendant or CRT/KB), not from files or ports.



Warning

This function is used exclusively for reading from a window to determine if more data has been entered. Do not use this function with any other file device. Otherwise, you could injure personnel or damage equipment.

See Also: Section 7.10.1 , "User Menu on the Teach Pendant," Section 7.10.2 , "User Menu on the CRT/KB"

Example: The following example reads the first number, **qd_field** , and then uses BYTES_LEFT to determine if the user entered any additional numbers. If so, these numbers are then read.

BYTES_LEFT Built-In Function

```
PROGRAM p_bytesleft
%NOLOCKGROUP
%ENVIRONMENT flbt
CONST
  default_1 = 0
  default_2 = -1
VAR rqd_field, opt_field_1, opt_field_2: INTEGER
BEGIN
  WRITE('Enter integer field(s): ')
  READ(rqd_field)
  IF BYTES_LEFT(TPDISPLAY) > 0 THEN
    READ(opt_field_1)
  ELSE
    opt_field_1 = default_1
  ENDIF
IF BYTES_LEFT(TPDISPLAY) > 0 THEN
```

```
    READ(opt_field_2)
  ELSE
    opt_field_2 = default_2
  ENDIF
END p_bytesleft
```

A.4 - C - KAREL LANGUAGE DESCRIPTION

A.4.1 CALL_PROG Built-In Procedure

Purpose: Allows a KAREL program to call an external KAREL or teach pendant program. This means that the programmer does not have to determine the program to be called until run time.

Syntax : CALL_PROG(prog_name, prog_index)

Input/Output Parameters :

[in] prog_name :STRING

[in,out] prog_index :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *prog_name* is the name of the program to be executed, in the current calling task.
- *prog_index* returns the entry number in the program table where *prog_name* is located. This variable does not need to be initialized and should not be modified.
- CALL_PROG cannot be used to run internal or external routines.

See Also: CURR_PROG and CALL_PROGLIN Built-In Functions

Example: Refer to Section B.2 , "Copying Path Variables" (CPY_PTH.KL), for a detailed program example.

A.4.2 CALL_PROGLIN Built-In Procedure

Purpose: Allows a KAREL program to call an external KAREL or teach pendant program, beginning at a specified line. This means that the programmer does not need to know, at creation and translation, what program will be called. The programmer can decide this at run time.

Syntax : CALL_PROGLIN(prog_name, prog_line, prog_index, pause_entry)

Input/Output Parameters :

[in] prog_name :STRING

[in] prog_line :INTEGER

[in,out] prog_index :INTEGER

[in] pause_entry :BOOLEAN

%ENVIRONMENT Group :BYNAM

Details:

- *prog_name* is the name of the program to be executed, in the current calling task.
- *prog_line* specifies the line at which to begin execution for a teach pendant program. 0 or 1 is used for the beginning of the program.
- KAREL programs always execute at the beginning of the program.
- *prog_index* returns the entry number in the program table where *prog_name* is located. This variable does not need to be initialized and should not be modified.
- *pause_entry* specifies whether to pause program execution upon entry of the program.
- CALL_PROGLIN cannot be used to run internal or external routines.

See Also: CURR_PROG and CALL_PROG Built-In Function

Example: Refer to Section B.5 ,"Using Register Built-ins" (REG_EX.KL), for a detailed program example.

A.4.3 CANCEL Action

Purpose: Terminates any motion in progress

Syntax : CANCEL <GROUP[n{,n}]>

Details:

- Cancels a motion currently in progress or pending (but not stopped) for one or more groups.
- CANCEL does not cancel motions that are already stopped. To cancel a motion that is already stopped, use the CNCL_STP_MTN built-in routine.
- If the group clause is not present, all groups for which the task has control (when the condition is defined) will be canceled. In particular, if the program containing the condition handler definition contains the %NOLOCKGROUP directive, the CANCEL action will not cancel motion in any group.

- If a motion that is canceled and is part of a SIMULTANEOUS or COORDINATED motion with other groups, the motions for all groups are canceled.
- The robot and auxiliary or extended axes decelerate smoothly to a stop. The remainder of the motion is canceled.
- Canceled motions are treated as completed and cannot be resumed.
- The CANCEL action in a global condition handler also cancels any pending motions.
- The CANCEL action in a local condition handler cancels only the motion in progress, permitting any pending motions to start.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

Example: The following example uses a local condition handler to cancel only the current motion in progress.

CANCEL Action

```
MOVE ALONG some_path,
  WHEN AT NODE[n] DO
    CANCEL
ENDMOVE
```

A.4.4 CANCEL Statement

Purpose: Terminates any motion in progress.

Syntax : CANCEL <GROUP[n{,n}]>

Details:

- Cancels a motion currently in progress or pending (but not stopped) for one or more groups.
- CANCEL does not cancel motions that are already stopped. To cancel a motion that is already stopped, use the CNCL_STP_MTN built-in routine.
- If the group clause is not present, all groups for which the task has control will be canceled. In particular, if the program using the CANCEL statement contains the %NOLOCKGROUP directive, the CANCEL statement will not cancel motion in any group.

- If a motion that is canceled is part of a SIMULTANEOUS or COORDINATED motion with other groups, the motions for all groups are canceled.
- The robot and auxiliary axes decelerate smoothly to a stop. The remainder of the motion is canceled.
- Canceled motions are treated as completed and cannot be resumed.
- CANCEL does not affect stopped motions. Stopped motions can be resumed.
- If an interrupt routine executes a CANCEL statement and the interrupted statement was a motion statement, when the interrupted program resumes, execution normally resumes with the statement following the motion statement.
- CANCEL might not work as expected if it is used in a routine called by a condition handler. The motion might already be put on the stopped motion queue before the routine is called. Use a CANCEL action directly in the condition handler to be sure the motion is canceled.
- Motion cannot be cancelled for a different task.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: Appendix E , "Syntax Diagrams," for additional syntax information

Example: The following example cancels the current motion if DIN[1] is ON.

CANCEL Statement

```
MOVE ALONG some_path NOWAIT
  IF DIN[1] THEN
    WRITE ('Motion canceled',CR)
    CANCEL
  ENDIF
```

A.4.5 CANCEL FILE Statement

Purpose: Cancels a READ or WRITE statement that is in progress.

Syntax : CANCEL FILE [file_var]

where:

file_var :a FILE variable

Details:

- Used to cancel input or output on a specified file
- The built-in function IO_STATUS can be used to determine if a CANCEL FILE operation was successful or, if it failed to determine the reason for the failure.

See Also: IO_STATUS Built-In Function, Chapter 7 *FILE INPUT/OUTPUT OPERATIONS* , Appendix E, "Syntax Diagrams," for additional syntax information

Example: The following example reads an integer, but cancels the read if the F1 key is pressed.

CANCEL FILE Statement

```
PROGRAM can_file_ex
%ENVIRONMENT FLBT
%ENVIRONMENT UIF
%NOLOCKGROUP
  VAR
    int_var: INTEGER
  ROUTINE cancel_read
    BEGIN
      CANCEL FILE TPDISPLAY
    END cancel_read
  BEGIN
    CONDITION[1]:
      WHEN TPIN[ky_f1]+ DO
        cancel_read
      ENABLE CONDITION[1]
    ENDCONDITION

    ENABLE CONDITION[1]
    REPEAT
      -- Read an integer, but cancel if F1 pressed
      CLR_IO_STAT(TPDISPLAY)
      WRITE(CR, 'Enter an integer: ')
      READ(int_var)
    UNTIL FALSE
end can_file_ex
```

A.4.6 CHECK_DICT Built-In Procedure

Purpose: Checks the specified dictionary for a specified element

Syntax : CHECK_DICT(dict_name, element_no, status)

Input/Output Parameters :

[in] dict_name :STRING

[in] element_no :STRING

[out] status :INTEGER

%ENVIRONMENT Group :UIF

Details:

- *dict_name* is the name of the dictionary to check.
- *element_no* is the element number within the dictionary.
- *status* explains the status of the attempted operation. If not equal to 0, then the element could not be found.

See Also: ADD_DICT, READ_DICT, WRITE_DICT, REMOVE_DICT Built-In Procedures. Refer to the program example for the DISCTRL_LIST Built-In Procedure and Chapter 10 *DICTIONARIES AND FORMS*

Example: Refer to Section B.12 , "Displaying a List From a Dictionary File" (DCLST_EX.KL), for a detailed program example.

A.4.7 CHECK_EPOS Built-In Procedure

Purpose: Checks that the specified position is valid and that no motion errors will be generated when moving to this position

Syntax : CHECK_EPOS (eposn, uframe, utool, status <, group_no>)

Input/Output Parameters :

[in] eposn :XYZWPREXT

[in] uframe :POSITION

[in] utool :POSITION

[out] status :INTEGER

[in] group_no :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *eposn* is the XYZWPREXT position to be checked.
- *uframe* specifies the uframe position to use with *eposn.*
- *utool* specifies the utool position to use with *eposn.*
- *status* explains the status of the check. If the position is reachable, the status will be 0.
- *group_no* is optional, but if specified will be the group number for *eposn* . If not specified the default group of the program is used.

See Also: GET_POS_FRM

Example: Refer to Section B.8 (GEN_HEX.KL)

A.4.8 CHECK_NAME Built-In Procedure

Purpose: Checks a specified file or program name for illegal characters.

Syntax : CHECK_NAME (name_spec, status)

Input/Output Parameters :

[in] name_spec :STRING

[out] status :INTEGER

%ENVIRONMENT Group :FDEV

Details:

- Name_spec specifies the string to check for illegal characters. The string can be the file name or program name. It should not include the extension of the file or the program. This built-in does not handle special system names such as *SYSTEM*.

A.4.9 CHR Built-In Function

Purpose: Returns the character that corresponds to a numeric code

Syntax : CHR (code)

Function Return Type :STRING

Input/Output Parameters :

[in] code :INTEGER

%ENVIRONMENT Group :SYSTEM

Details:

- *code* represents the numeric code of the character for either the ASCII, Graphic, or Multinational character set.
- Returns a single character string that is assigned the value of *code* .

See Also: Appendix D,“ASCII Character Codes”

Example: Refer to the following sections for detailed program examples:

Section B.4,"Standard Routines" (ROUT_EX.KL)

Section B.5,"Using Register Built-ins" (REG_EX.KL)

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.13, "Using the DISCTRL_ALPHA Built-in" (DCALP_EX.KL)

Section B.14, "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.4.10 CLEAR Built-In Procedure

Purpose: Clears the specified program and/or variables from memory

Syntax : CLEAR(file_spec, status)

Input/Output Parameters :

[in] file_spec :STRING

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *file_spec* specifies the program name and type of data to clear. The following types are valid:

  no ext :KAREL or Teach Pendant program and variables.TP :Teach Pendant program.PC :KAREL program.VR :KAREL variables

- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

Example: The following example clears a KAREL program, clears the variables for a program, and clears a teach pendant program.

CLEAR Built-In Procedure

```
-- Clear KAREL program
  CLEAR('test1.pc', status)
  -- Clear KAREL variables
  CLEAR('testvars.vr', status)
  -- Clear Teach Pendant program
  CLEAR('prg1.tp', status)
```

A.4.11 CLEAR_SEMA Built-In Procedure

Purpose: Clear the indicated semaphore by setting the count to zero

Syntax : CLEAR_SEMA(semaphore_no)

Input/Output Parameters :

[in] semaphore_no :INTEGER

%ENVIRONMENT Group :MULTI

Details:

- The semaphore indicated by *semaphore_no* is cleared.
- *semaphore_no* must be in the range of 1 to the number of semaphores defined on the controller.
- All semaphores are cleared at COLD start. It is good practice to clear a semaphore prior to using it. Before several tasks begin sharing a semaphore, one and only one of these task, should clear the semaphore.

See Also: POST_SEMA, PEND_SEMA Built-In Procedures, SEMA_COUNT Built-In Function, examples in Chapter 14, "Multi-Tasking"

A.4.12 CLOSE FILE Statement

Purpose: Breaks the association between a FILE variable and a data file or communication port

Syntax : CLOSE FILE file_var

where:

file_var :a FILE variable

Details:

- *file_var* must be a static variable that was used in the OPEN FILE statement.
- Any buffered data associated with the *file_var* is written to the file or port.
- The built-in function IO_STATUS will always return zero.

See Also: IO_STATUS Built-In Function, Chapter 7 *FILE INPUT/OUTPUT OPERATIONS* , Appendix E , "Syntax Diagrams," for additional syntax information

Example: Refer to Section B.12 , "Displaying a List From a Dictionary File" (DCLST_EX.KL), for a detailed program example.

A.4.13 CLOSE HAND Statement

Purpose: Causes the specified hand to close

Syntax : CLOSE HAND hand_num

where:

hand_num :an INTEGER expression

Details:

- The actual effect of the statement depends on how the HAND signals are set up in I/O system.
- The valid range of values for *hand_num* is 1-2. Otherwise, the program is aborted with an error.
- The statement has no effect if the value of *hand_num* is in range but the hand is not connected.
- The program is aborted with an error if the value of *hand_num* is in range but the HAND signal represented by that value has not been assigned.

See Also: Chapter 13 *INPUT/OUTPUT SYSTEM* , for more information on hand signals, Appendix E, "Syntax Diagrams," for additional syntax information

Example: The following example moves the robot to the first position and closes the hand specified by **hand_num** .

CLOSE HAND Statement

```
MOVE TO p1
  CLOSE HAND hand_num
```

A.4.14 CLOSE_TPE Built-In Procedure

Purpose: Closes the specified teach pendant program

Syntax : CLOSE_TPE(open_id, status)

Input/Output Parameters :

[in] open_id :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *open_id* indicates the teach pendant program to close. All teach pendant programs that are opened must be closed before they can be executed. Any unclosed programs remain opened until the KAREL program which opened it is aborted or runs to completion.
- *status* explains the status of the attempted operation. If not equal to 0, then an error has occurred.

See Also: OPEN_TPE Built-In Procedure

Example: Refer to Section B.14 , "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL), for a detailed program example.

A.4.15 CLR_IO_STAT Built-In Procedure

Purpose: Clear the results of the last operation on the file argument

Syntax : CLR_IO_STAT(file_id)

Input/Output Parameters :

[in] file_id :FILE

%ENVIRONMENT Group :PBCORE

Details:

- Causes the last operation result on *file_id* , which is returned by IO_STATUS, to be cleared to zero.

See Also: I/O-STATUS Built-In Function

Example: Refer to Section B.12 , "Displaying a List From a Dictionary File" (DCLST_EX.KL), for a detailed program example.

A.4.16 CLR_PORT_SIM Built-In Procedure

Purpose: Sets the specified port to be unsimulated

Syntax : CLR_PORT_SIM(port_type, port_no, status)

Input/Output Parameters :

[in] port_type :INTEGER

[in] port_no :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :iosetup

Details:

- *port_type* specifies the code for the type of port to unsimulate. Codes are defined in FR:KLIOTYPS.KL.
- *port_no* specifies the port number to unsimulate.
- *status* is returned with zero if parameters are valid and the simulation of the specified port is cleared.

See Also: GET_PORT_SIM, SET_PORT_SIM Built-In Procedures

A.4.17 CLR_POS_REG Built-In Procedure

Purpose: Removes all data for the specified group in the specified position register

Syntax : CLR_POS_REG(register_no, group_no, status)

Input/Output Parameters :

[in] register_no :INTEGER

[in] group_no :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :REGOPE

Details:

- *register_no* specifies the register number whose data should be cleared.

- If *group_no* is zero, data for all groups is cleared.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: SET_POS_REG Built-In Procedure, GET_POS_REG Built-In Function

Example: The following example clears the first 100 position registers.

CLR_POS_REG Built-In Procedure

```
FOR register_no = 1 to 100 DO
    CLR_POS_REG(register_no, 0, status)
  ENDFOR
```

A.4.18 %CMOSVARS Translator Directive

Purpose: Specifies the default storage for KAREL variables is permanent memory

Syntax : %CMOSVARS

Details:

- If %CMOSVARS is specified in the program, then all static variables by default will be created in permanent memory.
- If %CMOSVARS is not specified, then all static variables by default will be created in temporary memory.
- If a program specifies %CMOSVARS, but not all static variables need to be created in permanent memory, the IN DRAM clause can be used on selected variables.

See Also: Section A.10.2 IN DRAM Clause

Example: Refer to the following sections for detailed program examples:

Section B.10 , "Using Dynamic Display Built-ins" (DCLST_EX.KL)

Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.4.19 %CMOS2SHADOW Translator Directive

Purpose: Instructs the translator to put all CMOS variables in Shadow memory

Syntax : %CMOS2SHADOW

A.4.20 CNC_DYN_DISB Built-In Procedure

Purpose: Cancels the dynamic display based on the value of a BOOLEAN variable in a specified window.

Syntax : CNC_DYN_DISB (b_var, window_name, status)

Input/Output Parameters :

[in] b_var :BOOLEAN

[in] window_name :STRING

[out] status :INTEGER

%ENVIRONMENT Group :UIF

Details:

- *b_var* is the boolean variable whose dynamic display is to be canceled.
- *window_name* must be a previously defined window name. See Section 7.10.1. and Section 7.10.2 for predefined window names.
- If there is more than one display active for this variable in this window, all the displays are canceled.
- *status* returns an error if there is no dynamic display active specifying this variable and window. If not equal to 0, then an error occurred.

See Also: INI_DYN_DISB Built-In Procedure

Example: Refer to the following sections for detailed program examples:

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.11, "Manipulating Values of Dynamically Displayed Variables" (CHG_DATA.KL)

A.4.21 CNC_DYN_DISE Built-In Procedure

Purpose: Cancels the dynamic display based on the value of an INTEGER variable in a specified window.

Syntax : CNC_DYN_DISe (e_var, window_name, status)

Input/Output Parameters :

[in] e_var :INTEGER

[in] window_name :STRING

[out] status :INTEGER

%ENVIRONMENT Group :UIF

Details:

- *e_var* is the integer variable whose dynamic display is to be canceled.
- Refer to the CNC_DYN_DISB built-in procedure for a description of the other parameters listed above.

See Also: INI_DYN_DISE Built-In Procedure

Example: Refer to the following sections for detailed program examples:

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.11 , "Manipulating Values of Dynamically Displayed Variables" (CHG_DATA.KL)

A.4.22 CNC_DYN_DISI Built-In Procedure

Purpose: Cancels the dynamic display of an INTEGER variable in a specified window.

Syntax : CNC_DYN_DISI(int_var, window_name, status)

Input/Output Parameters :

[in] int_var :INTEGER

[in] window_name :STRING

[out] status :INTEGER

%ENVIRONMENT Group :UIF

Details:

- *int_var* is the integer variable whose dynamic display is to be canceled.
- Refer to the CNC_DYN_DISB built-in procedure for a description of the other parameters listed above.

See Also: INI_DYN_DISI Built-In Procedure

Example: Refer to the following sections for detailed program examples:

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.11, "Manipulating Values of Dynamically Displayed Variables" (CHG_DATA.KL)

A.4.23 CNC_DYN_DISP Built-In Procedure

Purpose: Cancels the dynamic display based on the value of a port in a specified window.

Syntax : CNC_DYN_DISP(port_type, port_no, window_name, status)

Input/Output Parameters :

[in] port_type :INTEGER

[in] port_no :INTEGER

[in] window_name :STRING

[out] status :INTEGER

%ENVIRONMENT Group :UIF

Details:

- *port_type* and *port_no* are integer values specifying the port whose dynamic display is to be canceled.
- Refer to the CNC_DYN_DISB built-in procedure for a description of the other parameters listed above.

See Also: INI_DYN_DISP Built-In Procedure for information on *port_type* codes.

Example: Refer to the following sections for detailed program examples:

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.11, "Manipulating Values of Dynamically Displayed Variables" (CHG_DATA.KL)

A.4.24 CNC_DYN_DISR Built-In Procedure

Purpose: Cancels the dynamic display of a REAL number variable in a specified window.

Syntax : CNC_DYN_DISR(real_var, window_name, status)

Input/Output Parameters :

[in] real_var :REAL

[in] window_name :STRING

[out] status :INTEGER

%ENVIRONMENT Group :UIF

Details:

- *real_var* is the REAL variable whose dynamic display is to be canceled.
- Refer to the CNC_DYN_DISB built-in procedure for a description of the other parameters listed above.

See Also: INI_DYN_DISR Built-In Procedure

Example: Refer to the following sections for detailed program examples:

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.11, "Manipulating Values of Dynamically Displayed Variables" (CHG_DATA.KL)

A.4.25 CNC_DYN_DISS Built-In Procedure

Purpose: Cancels the dynamic display of a STRING variable in a specified window.

Syntax : CNC_DYN_DISS(str_var, window_name, status)

Input/Output Parameters :

[in] str_var :STRING

[in] window_name :STRING

[out] status :INTEGER

%ENVIRONMENT Group :UIF

Details:

- *str_var* is the STRING variable whose dynamic display is to be canceled.
- Refer to the CNC_DYN_DISB built-in procedure for a description of the other parameters listed above.

See Also: INI_DYN_DISS Built-In Procedure

Example: Refer to the following sections for detailed program examples:

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.11, "Manipulating Values of Dynamically Displayed Variables" (CHG_DATA.KL)

A.4.26 CNCL_STP_MTN Built-In Procedure

Purpose: Cancels all stopped motions

Syntax : CNCL_STP_MTN

%ENVIRONMENT Group :motn

- All stopped motions will be canceled for all groups that the program controls.
- The statements following the motion statements will be executed.
- CNCL_STP_MTN will have no effect if no motions are currently stopped.
- Motion cannot be cancelled for a different task.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

Example: The following example will cancel all stopped motions for all groups that the program controls after an emergency stop has occurred.

CNCL_STP_MTN Built-In Procedure

```
ROUTINE e_stop_hndlr
  BEGIN
  CNCL_STP_MTN
END e_stop_hndlr
CONDITION[100]:
  WHEN ERROR[estop] DO
    UNPAUSE
    ENABLE CONDITION[100]
    e_stop_hndlr
END CONDITION
ENABLE CONDITION[100]
```

A.4.27 CNV_CONF_STR Built-In Procedure

Purpose: Converts the specified CONFIG into a STRING

Syntax : CNV_CONF_STR(source, target)

Input/Output Parameters :

[in] source :CONFIG

[out] target :STRING

%ENVIRONMENT Group :STRNG

Details:

- *target* receives the STRING form of the configuration specified by *source* .
- *target* must be long enough to accept a valid configuration string for the robot arm attached to the controller. Otherwise, the program will be aborted with an error.

  Using a length of 25 is generally adequate because the longest configuration string of any robot is 25 characters long.

See Also: CNV_STR_CONF Built-In Procedure

Example: The following example converts the configuration from position **posn** into a STRING and puts it into **config_string** . The string is then displayed on the screen.

CNV_CONF_STR Built-In Procedure

```
CNV_CONF_STR(posn.pos_config, config_string)
 WRITE('Configuration of posn: ', config_string, cr)
```

A.4.28 CNV_INT_STR Built-In Procedure

Purpose: Formats the specified INTEGER into a STRING

Syntax : CNV_INT_STR(source, length, base, target)

Input/Output Parameters :

[in] source :INTEGER expression

[in] length :INTEGER expression

[in] base :INTEGER expression

[out] target :STRING expression

%ENVIRONMENT Group :PBCORE

Details:

- *source* is the INTEGER to be formatted into a STRING.
- *length* specifies the minimum length of the *target* . The actual length of *target* may be greater if required to contain the contents of *source* and at least one leading blank.
- *base* indicates the number system in which the number is to be represented. *base* must be in the range 2-16 or 0 (zero) indicating base 10.
- If the values of *length* or *base* are invalid, *target* is returned uninitialized.
- If *target* is not declared long enough to contain *source* and at least one leading blank, it is returned with one blank and the rest of its declared length filled with ‘‘*".

See Also: CNV_STR_INT Built-In Procedure

Example: Refer to the following section for detailed program examples:

Section B.7 , "Listing Files and Programs and Manipulating Strings" (LIST_EX.KL)

A.4.29 CNV_JPOS_REL Built-In Procedure

Purpose: Allows a KAREL program to examine individual joint angles as REAL values

Syntax : CNV_JPOS_REL(jointpos, real_array, status)

Input/Output Parameters :

[in] joint_pos :JOINTPOS

[out] real_array :ARRAY [num_joints] OF REAL

[out] status :INTEGER

%ENVIRONMENT Group :SYSTEM

Details:

- *joint_pos* is one of the KAREL joint position data types: JOINTPOS, or JOINTPOS1 through JOINTPOS9.
- *num_joints* can be smaller than the number of joints in the system. A value of nine can be used if the actual number of joints is unknown. Joint number one will be stored in *real_array* element number one, etc. Excess array elements will be ignored.

- The measurement of the *real_array* elements is in degrees.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: CNV_REL_JPOS Built-In Procedure

Example: Refer to Section B.14 , "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL), for a detailed program example.

A.4.30 CNV_REAL_STR Built-In Procedure

Purpose: Formats the specified REAL value into a STRING

Syntax : CNV_REAL_STR(source, length, num_digits, target)

Input/Output Parameters :

[in] source :REAL expression

[in] length :INTEGER expression

[in] num_digits :INTEGER expression

[out] target :STRING

%ENVIRONMENT Group :STRNG

Details:

- *source* is the REAL value to be formatted.
- *length* specifies the minimum length of the *target* . The actual length of *target* may be greater if required to contain the contents of *source* and at least one leading blank.
- *num_digits* specifies the number of digits displayed to the right of the decimal point. If *num_digits* is a negative number, *source* will be formatted in scientific notation (where the ABS(*num_digits*) represents the number of digits to the right of the decimal point.) If *num_digits* is 0, the decimal point is suppressed.
- If *length* or *num_digits* are invalid, *target* is returned uninitialized.
- If the declared length of *target* is not large enough to contain *source* with one leading blank, *target* is returned with one leading blank and the rest of its declared length filled with "*"s (asterisks).

See Also: CNV_STR_REAL Built-In Procedure

Example: The following example converts the REAL number in **cur_volts** into a STRING and puts it into **volt_string** . The minimum length of **cur_volts** is specified to be seven characters with two characters after the decimal point. The contents of **volt_string** is then displayed on the screen.

CNV_REAL_STR Built-In Procedure

```
cur_volts = AIN[2]
CNV_REAL_STR(cur_volts, 7, 2, volt_string)
WRITE('Voltage=',volt_string,CR)
```

A.4.31 CNV_REL_JPOS Built-In Procedure

Purpose: Allows a KAREL program to manipulate individual angles of a joint position

Syntax : CNV_REL_JPOS(real_array, joint_pos, status)

Input/Output Parameters :

[in] real_array :ARRAY [num_joints] OF REAL

[out] joint_pos :JOINTPOS

[out] status :INTEGER

%ENVIRONMENT Group :SYSTEM

Details:

- *real_array* must have a declared size, equal to or greater than, the number of joints in the system. A value of nine can be used for *num_joints,* if the actual number of joints is unknown. Array element number one will be stored in joint number one, and so forth. Excess array elements will be ignored. If the array is not large enough the program will abort with an invalid argument error.
- If any of the elements of *real_array* that correspond to a joint angle are uninitialized, the program will be paused with an uninitialized variable error.
- The measurement of the *real_array* elements is degrees.
- *joint_pos* is one of the KAREL joint position types: JOINTPOS, or JOINTPOS1 through JOINTPOS9.
- *joint_pos* receives the joint position form of real_array.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

Example: Refer to the following sections for detailed program examples:

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.8, "Generating and Moving Along a Hexagon Path" (GEN_HEX.KL)

Section B.14, "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

A.4.32 CNV_STR_CONF Built-In Procedure

Purpose: Converts the specified configuration string into a CONFIG data type

Syntax : CNV_STR_CONF(source, target, status)

Input/Output Parameters :

[in] source :STRING

[out] target :CONFIG

[out] status :INTEGER

%ENVIRONMENT Group :STRNG

Details:

- *target* receives the CONFIG form of the configuration string specified by *source* .
- *source* must be a valid configuration string for the robot arm attached to the controller.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: CNV_CONF_STR Built-In Procedure

Example: The following example sets the configuration of position **posn** to the configuration specified by **config_string** and then moves the TCP to that position.

CNV_STR_CONF Built-In Procedure

```
CNV_STR_CONF(config_string, posn.pos_config, status)
 MOVE TO posn
```

A.4.33 CNV_STR_INT Built-In Procedure

Purpose: Converts the specified STRING into an INTEGER

Syntax : CNV_STR_INT(source, target)

Input/Output Parameters :

[in] source :STRING

[out] target :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *source* is converted into an INTEGER and stored in *target* .
- If *source* does not contain a valid representation of an INTEGER, *target* is set uninitialized.

See Also: CNV_INT_STR Built-In Procedure

Example: Refer to the following sections for detailed program examples:

Section B.2 , "Copying Path Variables" (CPY_PTH.KL)

Section B.12 , "Displaying a List From a Dictionary File" (DCLST_EX.KL)

A.4.34 CNV_STR_REAL Built-In Procedure

Purpose: Converts the specified STRING into a REAL

Syntax : CNV_STR_REAL(source, target)

Input/Output Parameters :

[in] source :STRING

[out] target :REAL

%ENVIRONMENT Group :PBCORE

Details:

- Converts *source* to a REAL number and stores the result in *target* .
- If *source* is not a valid decimal representation of a REAL number, *target* will be set uninitialized. *source* may contain scientific notation of the form *nn.nnEsnn* where *s* is a + or - sign.

See Also: CNV_REAL_STR Built-In Procedure

Example: The following example converts the STRING **str** into a REAL and puts it into **rate** .

CNV_STR_REAL Built-In Procedure

```
REPEAT
 WRITE('Enter rate:')
 READ(str)
 CNV_STR_REAL(str, rate)
UNTIL NOT UNINIT(rate)
```

A.4.35 CNV_STR_TIME Built-In Procedure

Purpose: Converts a string representation of time to an integer representation of time.

Syntax : CNV_STR_TIME(source, target)

Input/Output Parameters :

[in] source :STRING

[out] target :INTEGER

%ENVIRONMENT Group :TIM

Details:

- The size of the string parameter, *source* , is STRING[20].
- *source* must be entered using ‘‘DD-MMM-YYY HH:MM:SS’’ format. The seconds specifier, ‘‘SS,’’ is optional. A value of zero (0) is used if seconds is not specified. If *source* is invalid, *target* will be set to 0.
- *target* can be used with the SET_TIME Built-In Procedure to reset the time on the system. If *target* is 0, the time on the system will not be changed.

See Also: SET_TIME Built-In Procedure

Example: The following example converts the STRING variable **str_time** , input by the user in ‘‘DD-MMM-YYY HH:MM:SS’’ format, to the INTEGER representation of time **int_time** using the CNV_STR_TIME procedure. SET_TIME is then used to set the time within the KAREL system to the time specified by **int_time** .

CNV_STR_TIME Built-In Procedure

```
WRITE('Enter the new time : ')
READ(str_time)
CNV_STR_TIME(str_time,int_time)
SET_TIME(int_time)
```

A.4.36 CNV_TIME_STR Built-In Procedure

Purpose: Converts an INTEGER representation of time to a STRING

Syntax : CNV_TIME_STR(source, target)

Input/Output Parameters :

[in] source :INTEGER

[out] target :STRING

%ENVIRONMENT Group :TIM

Details:

- The GET_TIME Built-In Procedure is used to determine the INTEGER representation of time. CNV_TIME_STR is used to convert *source* to *target* , which will be displayed in ‘‘DD-MMM-YYY HH:MM:’’ format.

See Also: GET_TIME Built-In Procedure

Example: Refer to Section B.9 , "Using the File and Device Built-ins" (FILE_EX.KL), for a detailed program example.

A.4.37 %COMMENT Translator Directive

Purpose: Specifies a comment of up to 16 characters

Syntax : %COMMENT = ’sssssssssssssss’

where sssssssssssssss = space

Details:

- The comment can be up to 16 characters long.
- During load time, the comment will be stored as a program attribute and can be displayed on the teach pendant or CRT/KB.
- %COMMENT must be used after the PROGRAM statement, but before any CONST, TYPE, or VAR sections.

See Also: SET_ATTR_PRG and GET_ATTR_PRG Built-In Procedures

Example: Refer to the following sections for detailed program examples:

Section B.2, "Copying Path Variables" (CPY_PTH.KL)

Section B.3,"Saving Data to the Default Device" (SAVE_VR.KL)

Section B.5,"Using Register Built-ins" (REG_EX.KL)

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.9, "Using the File and Device Built-ins" (FILE_EX.KL)

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL)

Section B.13, "Using the DISCTRL_ALPHA Built-in" (DCALP_EX.KL)

Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.4.38 COMMON_ASSOC Data Type

Purpose: Defines a variable or structure field as a COMMON_ASSOC data type

Syntax : COMMON_ASSOC

Details:

- COMMON_ASSOC consists of a record containing standard associated data common for all motion groups. It contains the following predefined fields, all INTEGERs:
  - SEGTERMTYPE :termination type
  - SEGDECELTOL :deceleration tolerance
  - SEGRELACCEL :not implemented
  - SEGTIMESHFT :not implemented
- Variables and fields of structures can be declared as COMMON_ASSOC.
- Subfields of this structure can be accessed and set using the usual structure field notation.
- Variables and fields declared COMMON_ASSOC can be:
  - Passed as parameters.
  - Written to and read from unformatted files.
  - Assigned to one another.
- Each subfield of a COMMON_ASSOC variable or structure field can be passed as a parameter to a routine, but is always passed by value.

See Also: Section 8.5.7 , "Path Motion," for default values, Section 2.1.6 , "Predefined Identifiers"

Example: Refer to Section B.2 , "Copying Path Variables" (CPY_PTH.KL), for a detailed program example.

A.4.39 CONDITION...ENDCONDITION Statement

Purpose: Defines a global condition handler

Syntax : CONDITION[cond_hand_no]: [with_list]

WHEN cond_list DO action_list

{WHEN cond_list DO action_list}

ENDCONDITION

Details:

- *cond_hand_no* specifies the number associated with the condition handler and must be in the range of 1-1000. The program is aborted with an error if it is outside this range.
- If a condition handler with the specified number already exists, the old one is replaced with the new one.
- The optional [with_list] can be used to specify condition handler qualifiers. See the WITH clause for more information.
- All of the conditions listed in a single WHEN clause must be satisfied simultaneously for the condition handler to be triggered.
- Multiple conditions must all be separated by the AND operator or the OR operator. Mixing of AND and OR is not allowed.
- The actions listed after DO are to be taken when the corresponding conditions of a WHEN clause are satisfied simultaneously.
- Multiple actions are separated by a comma or on a new line.
- Calls to function routines are not allowed in a CONDITION statement.
- The condition handler is initially disabled and is disabled again whenever it is triggered. Use the ENABLE statement or action, specifying the condition handler number, to enable it.
- Use the DISABLE statement or action to deactivate a condition handler.
- The condition handler remains defined and can subsequently be reactivated by the ENABLE statement or action.
- The PURGE statement can be used to delete the definition of a condition handler.
- Condition handlers are known only to the task which defines them. Two different tasks can use the same *cond_hand_no* even though they specify different conditions.

See Also: Chapter 6 *CONDITION HANDLERS* , Appendix E, ‘‘Syntax Diagrams,’’ for additional syntax information

Example: Refer to the following sections for detailed program examples:

Section B.6 , "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.4.40 CONFIG Data Type

Purpose: Defines a variable or structure field as a CONFIG data type

Syntax : CONFIG

Details:

- CONFIG defines a variable or structure field as a highly compact structure consisting of fields defining a robot configuration.
- CONFIG contains the following predefined fields:
  - CFG_TURN_NO1 :INTEGER
  - CFG_TURN_NO2 :INTEGER
  - CFG_TURN_NO3 :INTEGER
  - CFG_FLIP :BOOLEAN
  - CFG_LEFT :BOOLEAN
  - CFG_UP :BOOLEAN
  - CFG_FRONT :BOOLEAN
- Variables and fields of structures can be declared as CONFIG.
- Subfields of CONFIG data type can be accessed and set using the usual structure field notation.
- Variables and fields declared as CONFIG can be
  - Assigned to one another.
  - Passed as parameters.
  - Written to and read from unformatted files.
- Each subfield of a CONFIG variable or structure field can be passed as a parameter to a routine, but is always passed by value.
- A CONFIG field is part of every POSITION and XYZWPR variable and field.
- An attempt to assign a value to a CONFIG subfield that is too large for the field results in an abort error.

Example: The following example shows how subfields of the CONFIG structure can be accessed and set using the usual structure.field notation.

CONFIG Data Type

```
VAR
 config_var1  config_var2:  CONFIG
 pos_var:  POSITION
 seam_path:  PATH
 i:  INTEGER
```

```
BEGIN
 config_var1 = pos_var.config_data
 config_var1 = config_var2
 config_var1.cfg_turn_no1 = 0
 IF pos_var.pos_config_data.cfg_flip THEN...
 FOR i = 1 TO PATH_LEN(seam_path) DO
 seam_path[i].node_pos.pos_config = config_ar1
 ENDFOR
```

A.4.41 CONNECT TIMER Statement

Purpose: Causes an INTEGER variable to start being updated as a millisecond clock

Syntax : CONNECT TIMER TO clock_var

where:

clock_var :a static, user-defined INTEGER variable

Details:

- *clock_var* is presently incremented by the value of the system variable $SCR.$COND_TIME every $SCR.$COND_TIME milliseconds as long as the program is running or paused and continues until the program disconnects the timer, ends, or aborts. For example, if $SCR.$COND_TIM E=32 then *clock_var* will be incremented by 32 every 32 milliseconds.
- You should initialize *clock_var* before using the CONNECT TIMER statement to ensure a proper starting value.
- If the variable is uninitialized, it will remain so for a short period of time (up to 32 milliseconds) and then it will be set to a very large negative value (-2.0E31 + 32 milliseconds) and incremented from that value.
- The program can reset the *clock_var* to any value while it is connected.
- A *clock_var* initialized at zero wraps around from approximately two billion to approximately minus two billion after about 23 days.
- If *clock_var* is a system variable or a local variable in a routine, the program cannot be translated.

Note If two CONNECT TIMER statements using the same variable, are executed in two different tasks, the timer will advance twice as fast. For example, the timer will be incremented by 2 * $SCR.$COND_TIME every $SCR.$COND_TIME ms. However, this does not occur if two or more CONNECT TIMER statements using the same variable, are executed in the same task.

See Also: Appendix E for additional syntax information, DISCONNECT TIMER Statement

Example: Refer to the following sections for detailed program examples:

Section B.8 , "Generating and Moving Along a Hexagon Path" (GEN_HEX.KL)

Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.4.42 CONTINUE Action

Purpose: Continues execution of a paused task

Syntax : CONTINUE <PROGRAM[n]>

Details:

- The CONTINUE action will not resume stopped motions.
- If program execution is paused, the CONTINUE action will continue program execution.
- The CONTINUE action can be followed by the clause PROGRAM[n], where n is the task number to be continued. Use GET_TSK_INFO to get a task number for a specified task name.
- A task can be in an interrupt routine when CONTINUE is executed. However, you should be aware of the following circumstances because CONTINUE only affects the current interrupt level, and interrupt levels of a task might be independently paused or running.
  - — If the interrupt routine and the task are both paused, CONTINUE will continue the interrupt routine but the task will remain paused.
  - — If the interrupt routine is running and the task is paused, CONTINUE will appear to have no effect because it will try to continue the running interrupt routine.
  - — If the interrupt routine is paused and the task is running, CONTINUE will continue the interrupt routine.

Example: Refer to Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.4.43 CONTINUE Condition

Purpose: Condition that is satisfied when program execution is continued

Syntax : CONTINUE <PROGRAM[n]>

Details:

- The CONTINUE condition monitors program execution.

  If program execution is paused, the CONTINUE action, issuing CONTINUE from the CRT/KB or a CYCLE START from the operator panel, will continue program execution and satisfy the CONTINUE condition.

- The CONTINUE condition can be followed by the clause PROGRAM[n], where n is the task number to be continued. Use GET_TSK_INFO to get the task number of a specified task name.

Example: In the following example, program execution is being monitored. When the program is continued, a digital output will be turned on.

CONTINUE Condition

```
CONDITION[1]:
  WHEN CONTINUE DO DOUT[1] = ON
ENDCONDITION
```

A.4.44 CONT_TASK Built-In Procedure

Purpose: Continues the specified task

Syntax : CONT_TASK(task_name, status)

Input/Output Parameters :

[in] task_name :STRING

[out] status :INTEGER

%ENVIRONMENT Group :MULTI

Details:

- *task_name* is the name of the task to be continued. If the task was not paused, an error is returned in *status*.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.
- A task can be in an interrupt routine when CONT_TASK is executed. However, you should be aware of the following circumstances because CONT_TASK only affects the current interrupt level, and interrupt levels of a task might be independently paused or running.
  - — If the interrupt routine and the task are both paused, CONT_TASK will continue the interrupt routine but the task will remain paused.
  - — If the interrupt routine is running and the task is paused, CONT_TASK will appear to have no effect because it will try to continue the running interrupt routine.
  - — If the interrupt routine is paused and the task is running, CONT_TASK will continue the interrupt routine.

See Also: RUN_TASK, ABORT_TASK, PAUSE_TASK Built-In Procedures, Chapter 14 *MULTI-TASKING*

Example: The following example prompts the user for the task name and continues the task execution. Refer to Chapter 14 *MULTI-TASKING* , for more examples.

CONT_TASK Built-In Procedure

```
PROGRAM cont_task_ex
   %ENVIRONMENT MULTI
     VAR
       task_str: STRING[12]
       status: INTEGER
     BEGIN
       WRITE('Enter task name to continue:')
       READ(task_str)
       CONT_TASK(task_str, status)
   END cont_task_ex
```

A.4.45 COPY_FILE Built-In Procedure

Purpose: Copies the contents of one file to another with the overwrite option

Syntax : COPY_FILE(from_file, to_file, overwrite_sw, nowait_sw, status)

Input/Output Parameters :

[in] from_file :STRING

[in] to_file :STRING

[in] overwrite_sw :BOOLEAN

[in] nowait_sw :BOOLEAN

[out] status :INTEGER

%ENVIRONMENT Group :FDEV

Details:

- *from_file* specifies the device, name, and type of the file from which to copy. *from_file* can be specified using the wildcard (*) character. If no device is specified, the default device is used. You must specify both a name and type. However, these can be a wildcard (*) character.
- *to_file* specifies the device, name, and type of the file to which to copy. *to_file* can be specified using the wildcard (*) character. If no device is specified, the default device is used.
- *overwrite_sw* specifies that the file(s) should be overwritten if they exist.

- If *nowait_sw* is TRUE, execution of the program continues while the command is executing. If it is FALSE, the program stops, including condition handlers, until the operation is complete. If you have time critical condition handlers in the program, put them in another program that executes as a separate task.
- If the program is aborted during the copy, the copy will completed before aborting.
- If the device you are copying to becomes full during the copy, an error will be returned.

  Note *nowait_sw* is not available in this release and should be set to FALSE.

- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: RENAME_FILE, DELETE_FILE Built-In Procedures

Example: Refer to Section B.9 , "Using the File and Device Built-ins" (FILE_EX.KL), for a detailed program example.

A.4.46 COPY_PATH Built-In Procedure

Purpose: Copies a complete path, part of a path, or a path in reverse node order (including associated data), to another identical type path variable.

Syntax : COPY_PATH (source_path, start_node, end_node, dest_path, status)

Input/Output Parameters :

[in] source_path :PATH

[in] start_node :INTEGER

[in] end_node :INTEGER

[in] dest_path :PATH

[out] status :INTEGER

%ENVIRONMENT Group :pathop

Details:

- *source_path* specifies the source path to copy from. This path can be a standard path or a user defined path.
- *start_node* specifies the number of the first node to copy. A value of 0 will copy the complete path, including header information. The *start_node* number must be between 0 and the highest node number in the source path. Otherwise, error status will be returned.

- *end_node* specifies the number of the last node to copy. A value of 0 will copy the complete path, including header information. The *end_node* number must be between 0 and the highest node number of the source path. Otherwise, error status will be returned.
- *dest_path* specifies the destination path to copy to. This path can be a standard path or a user defined path. However, the *dest_path* type must be identical to the *source_path* type. If they are not identical, an error status will be returned.
- *status* of 0 is returned if the parameters are valid and the COPY_PATH operation was successful. Non-zero status indicates the COPY_PATH operation was unsuccessful.

  Note To copy a complete path from one path variable to another identical path variable, set the *start_node* and *end_node* parameters to 0 (zero).

An example of a **partial path** copy to a destination path.

Executing the COPY_PATH(P1, 2, 5, P2) command will copy node 2 through node 5 (inclusive) of path P1 to node 1 through 4 of Path P2, provided the path length of P1 is greater than or equal to 5. The destination path P2 will become a 4 node path. The original destination path is completely overwritten.

An example of a **source path copy in reverse order** to a destination path.

Executing the COPY_PATH(P1, 5, 2, P2) command will copy node 5 through node 2 (inclusive) of path P1 to node 1 through 4 of Path P2, provided the path length of P1 is greater than or equal to 5. The destination path P2 will become a 4 node path. The original destination path is completely overwritten.

Specifically, the above command will copy node 5 of P1 to node 1 of P2, node 4 of P1 to node 2 of P2, and so forth (including the common and group associated data for each node). Because of the reverse node-to-node copy of associated data, the trajectory of the destination path might not represent the expected reverse trajectory of the source path. This is caused by the change in relative position of the segmotype and segtermtype contained in the associated data.



Warning

When you execute a reverse node copy operation, the associated data of the source path can cause an unexpected reverse path trajectory in the destination path. Be sure personnel and equipment are out of the way before you test the destination path. Otherwise, you could damage equipment or injure personnel.

Example: Refer to Section B.2 , "Copying Path Variables " (CPY_PTH.KL), for a detailed program example.

A.4.47 COPY_QUEUE Built-In Procedure

Purpose: Copies one or more consecutive entries from a queue into an array of integers. The entries are not removed but are copied, starting with the oldest and proceeding to the newest, or until the output array, or integers, are full. A parameter specifies the number of entries at the head of the list (oldest entries) to be skipped.

Syntax : COPY_QUEUE(queue, queue_data, sequence_no, n_skip, out_data, n_got, status)

Input/Output Parameters :

[in] queue_t :QUEUE_TYPE

[in] queue_data :ARRAY OF INTEGER

[in] n_skip :INTEGER

[in] sequence_no :integer

[out] out_data :ARRAY OF INTEGER

[out] n_got :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBQMGR

Details:

- *queue_t* specifies the queue variable for the queue from which the values are to be read.
- *queue_data* specifies the array variable for the queue from which the values are to be read.
- *sequence_no* specifies the sequence number of the oldest entry to be copied. If the *sequence_no* is zero, the starting point for the copy is determined by the *n_skip* parameter.
- *n_skip* specifies the number of oldest entries to be skipped. A value of zero indicates to return the oldest entries.
- *out_data* is an integer array into which the values are to be copied; the size of the array is the maximum number of values returned.
- *n_got* is returned with the number of entries returned. This will be one of the following:
  - Zero if there are *n_skip* or fewer entries in the queue.
  - *(queue_to n_entries_skip*) if this is less than ARRAY_LEN(out_data)
  - ARRAY_LEN(out_data) if this is less than or equal to queue.n_entries - n_skip
- *status* is returned with zero

See Also: APPEND_QUEUE, DELETE_QUEUE, INSERT_QUEUE Built-In Procedures, Section 14.8 , "Using Queues for Task Communication"

Example: The following example gets one ‘‘page’’ of a job queue and calls a routine, disp_queue, to display this. If there are no entries for the page, the routine returns FALSE; otherwise the routine returns TRUE.

COPY_QUEUE Built-In Procedure

```
PROGRAM copy_queue_x
%environment PBQMGR
VAR
  job_queue FROM global_vars: QUEUE_TYPE
  job_data FROM global_vars: ARRAY[100] OF INTEGER
ROUTINE disp_queue(data: ARRAY OF INTEGER;
                   n_disp: INTEGER) FROM disp_prog
ROUTINE disp_page(data_array: ARRAY OF INTEGER;
                  page_no: INTEGER): BOOLEAN
VAR
  status: INTEGER
  n_got: INTEGER
BEGIN
  COPY_QUEUE(job_queue, job_data,
             (page_no - 1) * ARRAY_LEN(data_array), 0,
             data_array, n_got, status)
  IF (n_got = 0) THEN
    RETURN (FALSE)
  ELSE
    disp_queue(data_array, n_got)
    RETURN (TRUE)
  ENDIF
END disp_page
BEGIN
END copy_queue_x
```

A.4.48 COPY_TPE Built-In Procedure

Purpose: Copies one teach pendant program to another teach pendant program.

Syntax : COPY_TPE(from_prog, to_prog, overwrite_sw, status)

Input/Output Parameters :

[in] from_prog :STRING

[in] to_prog :STRING

[in] overwrite_sw :BOOLEAN

[out] status :INTEGER

%ENVIRONMENT Group :TPE

Details:

- *from_prog* specifies the teach pendant program name, without the .tp extension, to be copied.
- *to_prog* specifies the new teach pendant program name, without the .tp extension, that *from_prog* will be copied to.
- *overwrite_sw* , if set to TRUE, will automatically overwrite the *to_prog* if it already exists and it is not currently selected. If set to FALSE, the *to_prog* will not be overwritten if it already exists.
- *status* explains the status of the attempted operation. If not equal to 0, the copy did not occur.

See Also: CREATE_TPE Built-in Procedure

Example: Refer to Section B.14, "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL), for a detailed program example.

A.4.49 COS Built-In Function

Purpose: Returns the REAL cosine of the REAL angle argument, specified in degrees

Syntax : COS(angle) Function Return Type :REAL

Input/Output Parameters :

[in] angle :REAL expression

%ENVIRONMENT Group :SYSTEM

Details:

- *angle* is an angle specified in the range of ±18000 degrees. Otherwise, the program will be aborted with an error.

Example: Refer to Section B.8, "Generating and Moving Along a Hexagon Path" (GEN_HEX.KL), for a detailed program example.

A.4.50 CR Input/Output Item

Purpose: Can be used as a data item in a READ or WRITE statement to specify a carriage return

Syntax : CR

Details:

- When CR is used as a data item in a READ statement, it specifies that any remaining data in the current input line is to be ignored.

  The next data item will be read from the start of the next input line.
- When CR is used as a data item in a WRITE statement, it specifies that subsequent output to the same file will appear on a new line.

See Also: Appendix E , ‘‘Syntax Diagrams,’’ for additional syntax information

Example: Refer to the following sections for detailed program examples:

Section B.3 ,"Saving Data to the Default Device" (SAVE_VR.KL)

Section B.4 ,"Standard Routines" (ROUT_EX.KL)

Section B.5 ,"Using Register Built-ins" (REG_EX.KL)

Section B.6 , "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.7 , "Listing Files and Programs and Manipulating Strings" (LIST_EX.KL)

Section B.8 , "Generating and Moving Along a Hexagon Path" (GEN_HEX.KL)

Section B.9 , "Using the File and Device Built-ins" (FILE_EX.KL)

Section B.10 , "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.12 , "Displaying a List From a Dictionary File" (DCLST_EX.KL)

Section B.13 , "Using the DISCTRL_ALPHA Built-in" (DCALP_EX.KL)

Section B.14 , "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.4.51 CREATE_TPE Built-In Procedure

Purpose: Creates a teach pendant program of the specified name

Syntax : CREATE_TPE(prog_name, prog_type, status)

Input/Output Parameters :

[in] prog_name :STRING

[in] prog_type :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :TPE

Details:

- *prog_name* specifies the name of the program to be created.
- *prog_type* specifies the type of the program to be created. The following constants are valid for program type: PT_MNE_UNDEF :TPE program of undefined sub type PT_MNE_JOB :TPE job PT_MNE_PROC :TPE process PT_MNE_MACRO :TPE macro
- *status* explains the status of the attempted operation. If it is not equal to 0, then an error occurred. Some of the possible errors are as follows:

  7015 Specified program exist

  9030 Program name is NULL

  9031 Remove num from top of Program name

  9032 Remove space from Program name

  9036 Memory is not enough

  9038 Invalid character in program name
- The program is created to reference all motion groups on the system. The program is created without any comment or any other program attributes. Once the program is created, SET_ATTR_PRG can be used to specify program attributes.

See Also: SET_ATTR_PRG Built-In Procedure

A.4.52 CREATE_VAR Built-In Procedure

Purpose: Creates the specified KAREL variable

Syntax : CREATE_VAR(var_prog_nam, var_nam, typ_prog_nam, type_nam, group_num, inner_dim, mid_dim, outer_dim, status, <mem_pool>)

Input/Output Parameters :

[in] var_prog_nam :STRING

[in] var_nam :STRING

[in] typ_prog_nam :STRING

[in] type_nam :STRING

[in] group_num :INTEGER

[in] inner_dim :INTEGER

[in] mid_dim :INTEGER

[in] outer_dim :INTEGER

[out] status :INTEGER

[in] mem_pool :INTEGER

%ENVIRONMENT Group :MEMO

Details:

- *var_prog_nam* specifies the program name that the variable should be created in. If var_prog_nam is ' ', the default, which is the name of the program currently executing, is used.
- *var_nam* specifies the variable name that will be created.
- If a variable is to be created as a user-defined type, the user-defined type must already be created in the system. *typ_prog_nam* specifies the program name of the user-defined type. If typ_prog_nam is ' ', the default, which is the name of the program currently executing, is used.
- *type_nam* specifies the type name of the variable to be created. The following type names are valid:

  'ARRAY OF BYTE'

  'ARRAY OF SHORT'

  'BOOLEAN'

  'CAM_SETUP'

  'COMMON_ASSOC'

  'CONFIG'

  'FILE'

  'GROUP_ASSOC'

'INTEGER'

'JOINTPOS'

'JOINTPOS1'

'JOINTPOS2'

'JOINTPOS3'

'JOINTPOS4'

'JOINTPOS5'

'JOINTPOS6'

'JOINTPOS7'

'JOINTPOS8'

'JOINTPOS9'

'MODEL'

'POSITION'

'REAL'

'STRING[n]', where n is the string length; the default is 12 if not specified.

'VECTOR'

'VIS_PROCESS'

'XYZWPR'

'XYZWPREXT'

Any other type names are considered user-defined types.

- *group_num* specifies the group number to be used for positional data types.
- *inner_dim* specifies the dimensions of the innermost array. For example, *inner_dim* = 30 for ARRAY[10,20,30] OF INTEGER. *inner_dim* should be set to 0 if the variable is not an array.
- *mid_dim* specifies the dimensions of the middle array. For example, *mid_dim* = 20 for ARRAY[10,20,30] OF INTEGER. *mid_dim* should be set to 0 if the variable is not a 2-D array.
- *outer_dim* specifies the dimensions of the outermost array. For example, *outer_dim* = 10 for ARRAY[10,20,30] OF INTEGER. *outer_dim* should be set to 0 if the variable is not a 3-D array.

- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.
- *mem_pool* is an optional parameter that specifies the memory pool from which the variable is created. If not specified, then the variable is created in DRAM which is temporary memory. The DRAM variable must be recreated at every power up and the value is always reset to uninitialized.
- If *mem_pool* = -1, then the variable is created in CMOS RAM which is permanent memory.

See Also: CLEAR, RENAME_VAR Built-In Procedures

Example: Refer to Section B.2 , "Copying Path Variables" (CPY_PTH.KL), for a detailed program example.

A.4.53 %CRTDEVICE

Purpose: Specifies that the CRT/KB device is the default device

Syntax : %CRTDEVICE

Details:

- Specifies that the INPUT/OUTPUT window will be the default in the READ and WRITE statements instead of the TPDISPLAY window.

Example: Refer to Section B.2 , "Copying Path Variables" (CPY_PTH.KL), for a detailed program example showing how to use this device.

A.4.54 CURJPOS Built-In Function

Purpose: Returns the current joint position of the tool center point (TCP) for the specified group of axes, even if one of the axes is in an overtravel

Syntax : CURJPOS(axs_lim_mask, ovr_trv_mask <,group_no>)

Function Return Type :JOINTPOS

Input/Output Parameters :

[out] axs_lim_mask :INTEGER

[out] ovr_trv_mask :INTEGER

[in] group_no :INTEGER

%ENVIRONMENT Group :SYSTEM

Details:

- If *group_no* is omitted, the default group for the program is assumed.
- If *group_no* is specified, it must be in the range of 1 to the total number of groups defined on the controller.
- *axs_lim_mask* specifies which axes are outside the axis limits.
- *ovr_trv_mask* specifies which axes are in overtravel.

Note *axis_limit_mask* and *ovr_trv_mask* are not available in this release and can be set to 0.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: CURPOS Built-In Function, Chapter 8 *MOTION*

Example: The following example gets the current joint position of the robot.

CURJPOS Built-In Function

```
PROGRAM getpos
VAR
 jnt: JOINTPOS
BEGIN
 jnt=CURJPOS(0,0)
END getpos
```

A.4.55 CURPOS Built-In Function

Purpose: Returns the current Cartesian position of the tool center point (TCP) for the specified group of axes even if one of the axes is in an overtravel

Syntax : CURPOS(axis_limit_mask, ovr_trv_mask <,group_no>)

Function Return Type :XYZWPREXT

Input/Output Parameters :

[out] axis_limit_mask :INTEGER

[out] ovr_trv_mask :INTEGER

[in] group_no :INTEGER

%ENVIRONMENT Group :SYSTEM

Details:

- If *group_no* is omitted, the default group for the program is assumed.
- If *group_no* is specified, it must be in the range of 1 to the total number of groups defined on the controller.
- The group must be kinematic.
- Returns the current position of the tool center point (TCP) relative to the current value of the system variable $UFRAME for the specified group.
- *axis_limit_mask* specifies which axes are outside the axis limits.
- *ovr_trv_mask* specifies which axes are in overtravel.

Note *axis_limit_mask* and *ovr_trv_mask* are not available in this release and will be ignored if set.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: Chapter 8 *MOTION*

Example: Refer to Section B.5 ,"Using Register Built-ins," for a detailed program example.

Section B.5,"Using Register Built-ins" (REG_EX.KL)

Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.4.56 CURR_PROG Built-In Function

Purpose: Returns the name of the program currently being executed

Syntax : CURR_PROG

Function Return Type :STRING[12]

%ENVIRONMENT Group :BYNAM

Details:

- The variable assigned to CURR_PROG must be declared with a string variable length ≥12

Example: Refer to Section B.2 , "Copying Path Variables" (CPY_PTH.KL), for a detailed program example.

A.5 - D - KAREL LANGUAGE DESCRIPTION

A.5.1 DAQ_CHECKP Built-In Procedure

Purpose: To check the status of a pipe and the number of bytes available to be read from the pipe.

Syntax : DAQ_CHECKP(pipe_num, pipe_stat, bytes_avail)

Input/Output Parameters :

[in] pipe_num :INTEGER

[out] pipe_stat :INTEGER

[out] bytes_avail :INTEGER

Details:

- *pipe_num* is the number of the pipe (1 - 5) to check.
- *pipe_stat* is the status of the pipe returned. The status is a combination of the following flags:
  - — DAQ_PIPREG is when the pipe is registered (value = 1).
  - — DAQ_ACTIVE is when the pipe is active, i.e., has been started (value = 2).
  - — DAQ_CREATD is when the pipe is created (value = 4).
  - — DAQ_SNAPSH is when the pipe is in snapshot mode (value = 8).
  - — DAQ_1STRD is when the pipe has been read for the first time (value = 16).
  - — DAQ_OVFLOW is when the pipe is overflowed (value = 32).
  - — DAQ_FLUSH is when the pipe is being flushed (value = 64).
- *bytes_avail* is the number of bytes that are available to be read from the pipe.

DAQ_CHECKP Built-In Procedure

```
The pipe_stat returned parameter can be AND'ed with the
above flag constants to determine whether the pipe is
registered, is active, and so forth.  For example, you must check
```

```
to see if the pipe is active before writing to it.
```

DAQ_CHECKP Built-In Procedure

```
The DAQ_OVFLOW flag will never be set for the task that
writes to the pipe when it calls DAQ_CHECKP.  This
flag applies only to tasks that read from the pipe.
```

See Also: DAQ_WRITE Built-In.

Example: Refer to the DAQWRITE example in the built-in function DAQ_WRITE.

Note This built-in is only available when DAQ or data monitor options are loaded.

A.5.2 DAQ_REGPIPE Built-In Procedure

Purpose: To register a pipe for use in KAREL.

Syntax : DAQ_REGPIPE(pipe_num, mem_type, pipe_size, prog_name, var_name, pipe_name, stream_size, and status)

Input/Output Parameters :

[in] pipe_num :INTEGER

[in] mem_type :INTEGER

[in] pipe_size :INTEGER

[in] prog_name :STRING

[in] var_name :STRING

[in] pipe_name :STRING

[in] stream_size :INTEGER

[out] status :INTEGER

Details:

- *pipe_num* is the number of the pipe (1-5) to be registered.

- *mem_type* allows you to allocate the memory to be used for the pipe. The following constants can be used:
  - — DAQ_DRAM allows you to allocate DRAM memory.
  - — DAQ_CMOS allows you to allocate CMOS memory.
- *pipe_size* is the size of the pipe, is expressed as the number of data records that it can hold. The data record size itself is determined by the data type of var_name.
- *prog_name* is the name of the program containing the variable to be used for writing to the pipe. If passed as an empty string, the name of the current program is used.
- *var_name* is the name of the variable that defines the data type to be used for writing to the pipe. Once registered, you can write any variable of this data type to the pipe.
- *pipe_name* is the name of the pipe file. For example, if the pipe name is passed as 'foo.dat', the pipe will be accessible using the file string 'PIP:FOO.DAT'. A unique file name with an extension is required even if the pipe is being used only for sending to the PC.
- *stream_size* is the number of records to automatically stream to an output file, if the pipe is started as a streamed pipe. A single write of the specified variable constitutes a single record in the pipe. If stream size is set to zero, the pipe will not automatically stream records to a file device; all data will be kept in the pipe until the pipe is read. Use stream_size to help optimize network loading when the pipe is used to send data to the PC. If it is zero or one, the monitoring task will send each data record as soon as it is seen in the pipe. If the number is two or more, the monitor will wait until there are that many data records in the pipe before sending them all to the PC. In this manner, the overhead of sending network packets can be minimized. Data will not stay in the pipe longer than the time specified by the FlushTime argument supplied with the FRCPipe.StartMonitor Method.
- *status* is the status of the attempted operation. If not 0, then an error occurred and the pipe was not registered.

See Also: DAQ_UNREG Built-In.

DAQ_REGPIPE Built-In Procedure

```
Pipes must be registered before they can be started and to which data
is written.  The registration operation tells
the system how to configure the pipe when it is to be used.  After
it is registered, a pipe is configured to accept the
writing of a certain amount of data per record, as governed by the
size of the specified variable.  In order to
change the configuration of a pipe, the pipe must first be unregistered
using DAQ_UNREG, and then
re-registered.
```

Example: The following example registers KAREL pipe 1 to write a variable in the program.

DAQ_REGPIPE Built-In Procedure

```
PROGRAM DAQREG
```

```
%ENVIRONMENT DAQ
CONST
  er_abort = 2
VAR
  status:  INTEGER
  datavar: INTEGER
BEGIN
  -- Register pipe 1 DRAM as kldaq.dat
  -- It can hold 100 copies of the datavar variable
  -- before the pipe overflows
  DAQ_REGPIPE(1, DAQ_DRAM, 100, '', 'datavar', &
              'kldaq.dat', 0, status)
  IF status<>0 THEN
    POST_ERR(status,' ',0,er_abort)
  ENDIF
END DAQREG
```

Note This built-in is only available when DAQ or data monitor options are loaded.

A.5.3 DAQ_START Built-In Procedure

Purpose: To activate a KAREL pipe for writing.

Syntax : DAQ_START(pipe_num, pipe_mode, stream_dev, status)

Input/Output Parameters :

[in] pipe_num :INTEGER

[in] pipe_mode :INTEGER

[in] stream_dev :STRING

[out] status :INTEGER

Details:

- *pipe_num* is the number of the pipe (1 - 5) to be started. The pipe must have been previously registered
- *pipe_mode* is the output mode to be used for the pipe. The following constants are used:
  - — DAQ_SNAPSHT is the snapshot mode (each read of the pipe will result in all of the pipe's contents).
  - — DAQ_STREAM is the stream mode (each read from the same pipe file will result in data written since the previous read).

- *stream_dev* is the device to which records will be automatically streamed. This parameter is ignored if the stream size was set to 0 during registration.
- *status* is the status of the attempted operation. If not 0, then an error occurred and the pipe was not unregistered.

See Also: DAQ_REGPIPE Built-In and DAQ_STOP Built-In,

DAQ_START Built-In Procedure

```
This built-in call can be made either from the same task/program as
the writing task, or from a separate
activate/deactivate task.  The writing task can lie dormant until
the pipe is started, at which point it begins to write
data.
```

DAQ_START Built-In Procedure

```
A pipe is automatically started when a PC application issues the FRCPipe.
StartMonitor method.  In this case,
there is no need for the KAREL application to call DAQ_START to activate
the pipe..
```

DAQ_START Built-In Procedure

```
Starting and stopping a pipe is tracked using a reference counting
scheme.  That is, any combination of two
DAQ_START and FRCPipe.StartMonitor calls requires any comb
```

Example: The following example starts KAREL pipe 1 in streaming mode.

DAQ_START Built-In Procedure

```
PROGRAM PIPONOFF
%ENVIRONMENT DAQ
CONST
  er_abort = 2
VAR
  status:  INTEGER
  tpinput: STRING[1]
BEGIN
  -- prompt to turn on pipe
  WRITE('Press 1 to start pipe')
  READ (tpinput)
  IF tpinput = '1' THEN
    -- start pipe 1
    DAQ_START(1, DAQ_STREAM, 'RD:', status)
    IF status<>0 THEN
      POST_ERR(status,' ',0,er_abort)
```

```
    ELSE
      -- prompt to turn off pipe
      WRITE('Press any key to stop pipe')
      READ (tpinput)
      -- stop pipe 1
      DAQ_STOP(1, FALSE, status)
      IF status<>0 THEN
        POST_ERR(status,' ',0,er_abort)
      ENDIF
    ENDIF
  ENDIF
END PIPONOFF
```

Note This built-in is only available when DAQ or data monitor options are loaded.

A.5.4 DAQ_STOP Built-In Procedure

Purpose: To stop a KAREL pipe for writing.

Syntax : DAQ_STOP(pipe_num, force_off, status)

Input/Output Parameters :

[in] pipe_num :INTEGER

[in] force_off :BOOLEAN

[out] status :INTEGER

Details:

- *pipe_num* is the number of the pipe (1 - 5) to be stopped.
- *force_off* occurs if TRUE force the pipe to be turned off, even if another application made a start request on the pipe. If set FALSE, if all start requests have been accounted for with stop requests, the pipe is turned off, else it remains on.
- *status* is the status of the attempted operation. If not 0, then an error occurred and the pipe was not stopped.

See Also: DAQ_START Built-In.

DAQ_STOP Built-In Procedure

```
The start/stop mechanism on each pipe works on a reference count.
The pipe is started on the first start request,
and each subsequent start request is counted.  If a stop request is
```

```
received for the pipe, the count is decremented.
```

DAQ_STOP Built-In Procedure

```
If the pipe is not forced off, and the count is not zero, the pipe
stays on.  By setting the force_off flag to TRUE,
the pipe is turned off regardless of the count.  The count is reset.
```

DAQ_STOP Built-In Procedure

```
FRCPipe.StopMonitor method issued by a PC application is equivalent
to a call to DAQ_STOP.
```

Example: Refer to the PIPONOFF example in the built-in function DAQ_START.

Note This built-in is only available when DAQ or data monitor options are loaded.

A.5.5 DAQ_UNREG Built-In Procedure

Purpose: To unregister a previously-registered KAREL pipe, so that it may be used for other data.

Syntax : DAQ_UNREG(pipe_num, status)

Input/Output Parameters :

[in] pipe_num :INTEGER

[out] status :INTEGER

Details:

- *pipe_num* is the number of the pipe (1 - 5) to be unregistered.
- *status* is the status of the attempted operation. If not 0, then an error occurred and the pipe was not unregistered.

See Also: DAQ_REGPIPE Built-In.

DAQ_UNREG Built-In Procedure

```
Unregistering a pipe allows the pipe to be re-configured for a different
data size, pipe size, pipe name, and so
forth.  You must un-register the pipe before re-registering using
DAQ_REGPIPE.
```

Example: The following example unregisters KAREL pipe 1.

DAQ_UNREG Built-In Procedure

```
PROGRAM DAQUNREG
%ENVIRONMENT DAQ
CONST
  er_abort = 2
VAR
  status:  INTEGER
BEGIN
  -- unregister pipe 1
  DAQ_UNREG(1, status)
  IF status<>0 THEN
    POST_ERR(status,' ',0,er_abort)
  ENDIF
END DAQUNREG
```

Note This built-in is only available when DAQ or data monitor options are loaded.

A.5.6 DAQ_WRITE Built-In Procedure

Purpose: To write data to a KAREL pipe.

Syntax : DAQ_WRITE(pipe_num, prog_name, var_name, status)

Input/Output Parameters :

[in] pipe_num :INTEGER

[in] prog_name :STRING

[in] var_name :STRING

[out] status :INTEGER

Details:

- *pipe_num* is the number of the pipe (1 - 5) to which data is written.
- *prog_name* is the name of the program containing the variable to be written. If passed as an empty string, the name of the current program is used.
- *var_name* is the name of the variable to be written.
- *status* is the status of the attempted operation. If not 0, then an error occurred and the data was not written.

See Also: DAQ_REGPIPE and DAQ_CHECKP.

DAQ_WRITE Built-In Procedure

You do not have to use the same variable for writing data to the pipe that was used to register the pipe. The only requirement is that the data type of the variable written matches the type of the variable used to register the pipe.

DAQ_WRITE Built-In Procedure

If a PC application is monitoring the pipe, each call to DAQ_WRITE will result in an FRCPipe_Receive Event.

Example: The following example registers KAREL pipe 2 and writes to it when the pipe is active.

DAQ_WRITE Built-In Procedure

```
PROGRAM DAQWRITE
%ENVIRONMENT DAQ
%ENVIRONMENT SYSDEF
CONST
  er_abort = 2
TYPE
  daq_data_t = STRUCTURE
    count: INTEGER
    dataval: INTEGER
  ENDSTRUCTURE
VAR
  status:  INTEGER
  pipestat: INTEGER
  numbytes: INTEGER
  datavar: daq_data_t
BEGIN
  -- register 10KB pipe 2 in DRAM as kldaq.dat
  DAQ_REGPIPE(2, DAQ_DRAM, 100, '', 'datavar', &
              'kldaq.dat', 1, status)
  IF status<>0 THEN
    POST_ERR(status,' ',0,er_abort)
  ENDIF
  -- use DAQ_CHECKP to monitor status of pipe
  DAQ_CHECKP(2, pipestat, numbytes)
  datavar.count = 0
  WHILE (pipestat AND DAQ_PIPREG) > 0 DO  -- do while registered
    -- update data variable
    datavar.count = datavar.count + 1
    datavar.dataval = $FAST_CLOCK
    -- check if pipe is active
    IF (pipestat AND DAQ_ACTIVE) > 0 THEN
      -- write to pipe
```

```
      DAQ_WRITE(2, '', datavar, status)
      IF status<>0 THEN
        POST_ERR(status,' ',0,er_abort)
      ENDIF
    ENDIF
    -- put in delay to reduce loading
    DELAY(200)
    DAQ_CHECKP(2, pipestat, numbytes)
  ENDWHILE
END DAQWRITE
```

Note This built-in is only available when DAQ or data monitor options are loaded.

A.5.7 %DEFGROUP Translator Directive

Purpose: Specifies the default motion group to be used by the translator

Syntax : %DEFGROUP = n

Details:

- *n* is the number of the motion group.
- The range is 1 to the number of groups on the controller.
- If %DEFGROUP is not specified, group 1 is used.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

A.5.8 DEF_SCREEN Built-In Procedure

Purpose: Defines a screen

Syntax : DEF_SCREEN(screen_name, disp_dev_name, status)

Input/Output Parameters :

[in] screen_name :STRING

[in] disp_dev_name :STRING

[out] status :INTEGER

%ENVIRONMENT Group :UIF

Details:

- Define a screen, associated with a specified display device, to which windows could be attached and be activated (displayed).
- *screen_name* must be a unique, valid name (string), one to four characters long.
- *disp_dev_name* must be one of the display devices already defined, otherwise an error is returned. The following are the predefined display devices:

  'TP' Teach Pendant Device'CRT' CRT/KB Device
- *status* explains the status of the attempted operation. (If not equal to 0, then an error occurred.)

See Also: ACT_SCREEN Built-In Procedure

Example: Refer to Section B.12 , "Displaying a List From a Dictionary File" (DCLST_EX.KL), for a detailed program example.

A.5.9 DEF_WINDOW Built-In Procedure

Purpose: Define a window

Syntax : DEF_WINDOW(window_name, n_rows, n_cols, options, status)

Input/Output Parameters :

[in] window_name :STRING

[in] n_rows :INTEGER

[in] n_cols :INTEGER

[in] options :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- Define a window that can be attached subsequently to a screen, have files opened to it, be written or have input echoed to it, and have information dynamically displayed in it.
- *window_name* must be a valid name string, one to four characters long, and must not duplicate a window with the same name.
- *n_rows* and *n_cols* specify the size of the window in standard-sized characters. Any line containing double-wide or double-wide-double-high characters will contain only half this many characters. The first row and column begin at 1.
- *options* must be one of the following:

  0 :No option

  wd_com_cursr :Common cursor

  wd_scrolled :Vertical scrolling

  wd_com_cursr + wd_scrolled :Common cursor + Vertical scrolling
- If common cursor is specified, wherever a write leaves the cursor is where the next write will go, regardless of the file variable used. Also, any display attributes set for any file variable associated with this window will apply to all file variables associated with the window. If this is not specified, the cursor position and display attributes (except character size attributes, which always apply to the current line of a window) are maintained separately for each file variable open to the window. The common-cursor attribute is useful for windows that can be written to by more than one task and where these writes are to appear end-to-end. An example might be a log display.
- If vertical scrolling is specified and a line-feed, new-line, or index-down character is received and the cursor is in the bottom line of the window, all lines except the top line are moved up and the bottom line is cleared. If an index-up character is written, all lines except the bottom line are moved down and the top line is cleared. If this is not specified, the bottom or top line is cleared, but the rest of the window is unaffected.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: ATT _WINDOW_D, ATT_WINDOW_S Built-In Procedures

A.5.10 %DELAY Translator Directive

Purpose: Sets the amount of time program execution will be delayed every 250 milliseconds. Each program is delayed 8ms every 250ms by default. This allows the CPU to perform other functions such as servicing the CRT/KB and Teach Pendant user interfaces. %DELAY provides a way to change from the default and allow more CPU for system tasks such as user interface.

Syntax : %DELAY = n

Details:

- *n* is the delay time in milliseconds.
- The default delay time is 8 ms, if no DELAY is specified
- If *n* is set to 0, the program will attempt to use 100% of the available CPU time. This could result in the teach pendant and CRT/KB becoming inoperative since their priority is lower. A delay of 0 is acceptable if the program will be waiting for motion or I/O.
- While one program is being displayed, other programs are prohibited from executing. Interrupt routines (routines called from condition handlers) will also be delayed.
- Very large delay values will severely inhibit the running of all programs.
- To delay one program in favor of another, use the DELAY Statement instead of %DELAY.

A.5.11 DELAY Statement

Purpose: Causes execution of the program to be suspended for a specified number of milliseconds

Syntax : DELAY time_in_ms

where:

time_in_ms :an INTEGER expression

Details:

- If motion is active at the time of the delay, the motion continues.
- *time_in_ms* is the time in milliseconds. The actual delay will be from zero to $SCR.$cond_time milliseconds less than the rounded time.
- A time specification of zero has no effect.
- If a program is paused while a delay is in progress, the delay will continue to be timed.
- If the delay time in a paused program expires while the program is still paused, the program, upon resuming and with no further delay, will continue execution with the statement following the delay. Otherwise, upon resumption, the program will finish the delay time before continuing execution.
- Aborting a program, or issuing RUN from the CRT/KB when a program is paused, terminates any delays in progress.
- While a program is awaiting expiration of a delay, the KCL> SHOW TASK command will show a hold of DELAY.
- A time value greater than one day or less than zero will cause the program to be aborted with an error.

See Also: Appendix E , ‘‘Syntax Diagrams,’’ for additional syntax information

Example: Refer to the following sections for detailed program examples:

Section B.11, "Manipulating Values of Dynamically Displayed Variables" (CHG_DATA.KL)

Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.5.12 DELETE_FILE Built-In Procedure

Purpose: Deletes the specified file

Syntax : DELETE_FILE(file_spec, nowait_sw, status)

Input/Output Parameters :

[in] file_spec :STRING

[in] nowait_sw :BOOLEAN

[out] status :INTEGER

%ENVIRONMENT Group :FDEV

Details:

- *file_spec* specifies the device, name, and type of the file to delete. *file_spec* can be specified using the wildcard (*) character. If no device name is specified, the default device is used.
- If *nowait_sw* is TRUE, execution of the program continues while the command is executing. If it is FALSE, the program stops, including condition handlers, until the operation is complete. If you have time critical condition handlers in the program, put them in another program that executes as a separate task.

  Note *nowait_sw* is not available in this release and should be set to FALSE.

- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: COPY_FILE, RENAME_FILE Built-In Procedures

Example: Refer to Section B.3 ,"Saving Data to the Default Device" (SAVE_VRS.KL), for a detailed program example.

A.5.13 DELETE_NODE Built-In Procedure

Purpose: Deletes a path node from a PATH

Syntax : DELETE_NODE(path_var, node_num, status)

Input/Output Parameters :

[in] path_var :PATH

[in] node_num :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PATHOP

Details:

- *node_num* specifies the node to be deleted from the PATH specified by *path_var* .
- All nodes past the deleted node will be renumbered.
- *node_num* must be in the range from one to PATH_LEN(path_var). If it is outside this range, the status is returned with an error.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: APPEND_NODE, INSERT_NODE Built-In Procedures

Example: Refer to Section B.2 , "Copying Path Variables" (CPY_PTH.KL), for a detailed program example.

A.5.14 DELETE_QUEUE Built-In Procedure

Purpose: Deletes an entry from a queue

Syntax : DELETE_QUEUE(sequence_no, queue, queue_data, status)

Input/Output Parameters :

[in] sequence_no :INTEGER

[in,out] queue_t :QUEUE_TYPE

[in,out] queue_data :ARRAY OF INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBQMGR

Details:

- Use COPY_QUEUE to get a list of the sequence numbers.
- *sequence_no* specifies the sequence number of the entry to be deleted. Use COPY_QUEUE to get a list of the sequence numbers.
- *queue_t* specifies the queue variable for the queue.
- *queue_data* specifies the array used to hold the data in the queue. The length of this array determines the maximum number of entries in the queue.
- *status* returns 61003, ‘‘Bad sequence no,’’ if the specified sequence number is not in the queue.

See Also: APPEND_QUEUE, COPY_QUEUE, INSERT_QUEUE Built-In Procedures, Section 14.8 , "Using Queues for Task Communication"

A.5.15 DEL_INST_TPE Built-In Procedure

Purpose: Deletes the specified instruction in the specified teach pendant program

Syntax : DEL_INST_TPE(open_id, lin_num, status)

Input/Output Parameters :

[in] open_id :INTEGER

[in] lin_num :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :TPE

Details:

- *open_id* specifies the opened teach pendant program. A program must be opened with read/write access, using the OPEN_TPE built-in, before calling the DEL_INST_TPE built-in.
- *lin_num* specifies the line number of the instruction to be deleted.
- *status* explains the status of the attempted operation. If not equal to 0, then an error has occurred.

See Also: CREATE_TPE, CLOSE_TPE, COPY_TPE, OPEN_TPE, SELECT_TPE Built-In Procedures

A.5.16 DET_WINDOW Built-In Procedure

Purpose: Detach a window from a screen

Syntax : DET_WINDOW(window_name, screen_name, status)

Input/Output Parameters :

[in] window_name :STRING

[in] screen_name :STRING

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- Removes the specified window from the specified screen.
- *window_name* and *screen_name* must be valid and already defined.
- The areas of other window(s) hidden by this window are redisplayed. Any area occupied by this window and not by any other window is cleared.
- An error occurs if the window is not attached to the screen.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: DEF_WINDOW, ATT_WINDOW_S, ATT_WINDOW_D Built-In Procedures

Example: Refer to Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL), for a detailed program example.

A.5.17 DISABLE CONDITION Action

Purpose: Used within a condition handler to disable the specified condition handler

Syntax : DISABLE CONDITION [cond_hand_no]

where:

cond_hand_no :an INTEGER expression

Details:

- If the condition handler is not defined, DISABLE CONDITION has no effect.
- If the condition handler is defined but not currently enabled, DISABLE CONDITION has no effect.
- When a condition handler is disabled, its conditions are not tested. Thus, if it is activated again, the conditions must be satisfied after the activation.
- Use the ENABLE CONDITION statement or action to reactivate a condition handler that has been disabled.
- *cond_hand_no* must be in the range of 1-1000. Otherwise, the program will be aborted with an error.

See Also: Chapter 6, ‘‘Condition Handlers,’’ for more information on using DISABLE CONDITION in condition handlers

Example: The following example disables condition handler number 2 when condition number 1 is triggered.

DISABLE CONDITION Action

```
CONDITION[1]:
  WHEN EVENT[1] DO
  DISABLE CONDITION[2]
ENDCONDITION
```

A.5.18 DISABLE CONDITION Statement

Purpose: Disables the specified condition handler

Syntax : DISABLE CONDITION [cond_hand_no]

where:

cond_hand_no :an INTEGER expression

Details:

- If the condition handler is not defined, DISABLE CONDITION has no effect.
- If the condition handler is defined but not currently enabled, DISABLE CONDITION has no effect.

- When a condition handler is disabled, its conditions are not tested. Thus, if it is activated again, the conditions must be satisfied after the activation.
- Use the ENABLE CONDITION statement or action to reactivate a condition handler that has been disabled.
- *cond_hand_no* must be in the range of 1-1000. Otherwise, the program will be aborted with an error.

See Also: Chapter 6 *CONDITION HANDLERS* , for more information on using DISABLE CONDITION in condition handlers, Appendix E, "Syntax Diagrams," for additional syntax information

Example: The following example allows the operator to choose whether or not to see **count** .

DISABLE CONDITION Statement

```
PROGRAM p_disable
VAR
  count    : INTEGER
  answer   : STRING[1]
ROUTINE showcount
BEGIN
  WRITE ('count = ',count::10,CR)
END showcount
BEGIN
  CONDITION[1]:
    WHEN EVENT[1] DO            -- Condition[1] shows count
       showcount
    ENABLE CONDITION[1]
  ENDCONDITION
  ENABLE CONDITION[1]
  count = 0
  WRITE ('do you want to see count?')
  READ (answer,CR)
  IF answer = 'n'
    THEN DISABLE CONDITION[1]   -- Disables condition[1]
  ENDIF                         -- Count will not be shown
  FOR count = 1 TO 13 DO
    SIGNAL EVENT[1]
  ENDFOR
END p_disable
```

A.5.19 DISCONNECT TIMER Statement

Purpose: Stops updating a clock variable previously connected as a timer

Syntax : DISCONNECT TIMER timer_var

where:

timer_var :a static, user-defined INTEGER variable

Details:

- If *timer_var* is not currently connected as a timer, the DISCONNECT TIMER statement has no effect.
- If *timer_var* is a system or local variable, the program will not be translated.

See Also: Appendix E, "Syntax Diagrams," for additional syntax information, CONNECT TIMER Statement

Example: The following example moves the TCP to the initial POSITION variable **p1** , sets the INTEGER variable **timevar** to 0 and connects the timer. After moving to the destination position **p2** , the timer is disconnected.

DISCONNECT TIMER Statement

```
MOVE TO p1
  timevar = 0
  CONNECT TIMER TO timevar

  MOVE TO p2
  DISCONNECT TIMER timevar
```

A.5.20 DISCTRL_ALPH Built_In Procedure

Purpose: Displays and controls alphanumeric string entry in a specified window.

Syntax : DISCTRL_ALPH(window_name, row, col, str, dict_name, dict_ele, term_char, status)

Input/Output Parameters :

[in] window_name :STRING

[in] row :INTEGER

[in] col :INTEGER

[in,out] str :STRING

[in] dict_name :STRING

[in] dict_ele :INTEGER

[out] term_char :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :UIF

Details:

- *window_name* identifies the window where the *str* is currently displayed. See also Section 7.10.1 or Section 7.10.2 for a listing of windows that may be used for *window_name.*
- *row* specifies the row number where the *str* is displayed.
- *col* specifies the column number where the *str* is displayed.
- *str* specifies the KAREL string to be modified, which is currently displayed on the *window_name* at position *row* and *col.*
- *dict_name* specifies the dictionary that contains the words that can be entered. *dict_name* can also be set to one of the following predefined values.

  'PROG' :program name entry

  'COMM' :comment entry
- *dict_ele* specifies the dictionary element number for the words. *dict_ele* can contain a maximum of 5 lines with no "&new_line" accepted on the last line. See the example below.
- If a predefined value for *dict_name* is used, then *dict_ele* is ignored.
- *term_char* receives a code indicating the character that terminated the menu. The code for key terminating conditions are defined in the include file FR:KLEVKEYS.KL. The following predefined constants are keys that are normally returned:

  ky_enter

  ky_prev

ky_new_menu

- DISCTRL_ALPH will display and control string entry from the teach pendant device. To display and control string entry from the CRT/KB device, you must create an INTEGER variable, device_stat, and set it to crt_panel. To set control to the teach pendant device, set device_stat to tp_panel. Refer to the example below.
- *status* explains the status of an attempted operation. If not equal to 0, then an error occurred.

Note DISCTRL_ALPH will only display and control string entry if the USER or USER2 menu is the selected menu. Therefore, use FORCE_SPMENU(device_stat, SPI_TPUSER, 1) before calling DISCTRL_ALPH to force the USER menu.

See Also: ACT_SCREEN, DISCTRL_LIST Built-In Procedures

Example: Refer to Section B.13 , "Using the DISCTRL_ALPHA Built-in" (DCLAP_EX.KL), for a detailed program example.

A.5.21 DISCTRL_FORM Built_In Procedure

Purpose: Displays and controls a form on the teach pendant or CRT/KB screen

Syntax : DISCTRL_FORM(dict_name, ele_number, value_array, inact_array, change_array, term_mask, def_item, term_char, status)

Input/Output Parameters :

[in] dict_name : STRING

[in] ele_number : INTEGER

[in] value_array : ARRAY OF STRING

[in] inactive_array : ARRAY OF BOOLEAN

[out] change_array : ARRAY OF BOOLEAN

[in] term_mask : INTEGER

[in,out] def_item : INTEGER

[out] term_char : INTEGER

[out] status : INTEGER

%ENVIRONMENT Group :PBcore

Details:

- *dict_name* is the four-character name of the dictionary containing the form.
- *ele_number* is the element number of the form.
- *value_array* is an array of variable names that corresponds to each edit or display only data item in the form. Each variable name can be specified as a '[prog_name]var_name'.
  - *[prog_name]* is the name of the program that contains the specified variable. If [prog_name] is not specified, the current program being executed is used. '[*SYSTEM*]' should be used for system variables.
  - *var_name* must refer to a static, global program variable.
  - *var_name* can contain node numbers, field names, and/or subscripts.
  - *var_name* can also specify a port variable with index. For example, 'DIN[1]'.
- *inactive_array* is an array of booleans that corresponds to each item in the form.
  - Each boolean defaults to FALSE, indicating it is active.
  - You can set any boolean to TRUE which will make that item inactive and non-selectable.
  - The array size can be greater than or less than the number of items in the form.
  - If an inactive_array is not used, then an array size of 1 can be used. The array does not need to be initialized.
- *change_array* is an array of booleans that corresponds to each edit or display only data item in the form.
  - If the corresponding value is set, then the boolean will be set to TRUE, otherwise it is set to FALSE. You do not need to initialize the array.
  - The array size can be greater than or less than the number of data items in the form.
  - If change_array is not used, an array size of 1 can be used.
- *term_mask* is a bit-wise mask indicating conditions that will terminate the form. This should be an OR of the constants defined in the include file klevkmsk.kl.

  kc_func_key — Function keys

  kc_enter_key — Enter and Return keys

  kc_prev_key — PREV key

If either a selectable item or a new menu is selected, the form will always terminate, regardless of *term_mask.*

- For version 6.20 and 6.21, *def_item* receives the item you want to be highlighted when the form is entered. *def_item* returns the item that was currently highlighted when the termination character was pressed.
- For version 6.22 and later, *def_item* receives the item you want to be highlighted when the form is entered. *def_item* is continuously updated while the form is displayed and contains the number of the item that is currently highlighted
- *term_char* receives a code indicating the character or other condition that terminated the form. The codes for key terminating conditions are defined in the include file klevkeys.kl. Keys normally returned are pre-defined constants as follows:

  ky_undef — No termination character was pressed

  ky_select — A selectable item was selected

  ky_new_menu — A new menu was selected

  ky_f1 — Function key 1 was selected

  ky_f2 — Function key 2 was selected

  ky_f3 — Function key 3 was selected

  ky_f4 — Function key 4 was selected

  ky_f5 — Function key 5 was selected

  ky_f6 — Function key 6 was selected

  ky_f7 — Function key 7 was selected

  ky_f8 — Function key 8 was selected

  ky_f9 — Function key 9 was selected

  ky_f10 — Function key 10 was selected
- DISCTRL_FORM will display the form on the teach pendant device. To display the form on the CRT/KB device, you must create an INTEGER variable, *device_stat* , and set it to *crt_panel* . To set control to the teach pendant device, set *device_stat* to *tp_panel.*

- *status* explains the status of the attempted operation. If *status* returns a value other than 0, an error has occurred.

  Note DISCTRL_FORM will only display the form if the USER2 menu is the selected menu. Therefore, use FORCE_SPMENU(device_stat, SPI_TPUSER2, 1) before calling DISCTRL_FORM to force the USER2 menu.

See Also: Chapter 10 *DICTIONARIES AND FORMS* , for more details and examples.

A.5.22 DISCTRL_LIST Built-In Procedure

Purpose: Displays and controls cursor movement and selection in a list in a specified window

Syntax : DISCTRL_LIST(file_var, display_data, list_data, action, status)

Input/Output Parameters :

[in] file_ var :FILE

[in,out] display_data :DISP_DAT_T

[in] list_data :ARRAY OF STRING

[in] action :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *file_var* must be opened to the window where the list data is to appear.
- *display_data* is used to display the list. Refer to the DISP_DAT_T data type for details.
- *list_data* contains the list of data to display.
- *action* must be one of the following:

  dc_disp : Positions cursor as defined in display_data

  dc_up : Moves cursor up one row

  dc_dn : Moves cursor down one row

dc_lf : Moves cursor left one field

dc_rt : Moves cursor right one field

- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.
- Using DISCTRL_FORM is the preferred method for displaying and controlling information in a window.

See Also: DISCTRL_FORM Built-In Procedure, Section 7.10.1 , "User Menu on the Teach Pendant," Section 7.10.2 , "User Menu on the CRT/KB," Chapter 10 *DICTIONARIES AND FORMS*

Example: Refer to Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL), for a detailed program example.



Caution

The input parameters are not checked for validity. You must make sure the input parameters are valid; otherwise, the built-in might not work properly.

A.5.23 DISCTRL_PLMN Built-In Procedure

Purpose: Creates and controls cursor movement and selection in a pull-up menu

Syntax : DISCTRL_PLMN(dict_name, element_no, ftn_key_no, def_item, term_char, status)

Input/Output Parameters :

[in] dict_name :STRING

[in] element_no :INTEGER

[in] ftn_key_num :INTEGER

[in,out] def_item :INTEGER

[out] term_char :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group : UIF

Details:

- The menu data in the dictionary consists of a list of enumerated values that are displayed and

selected from a pull-up menu on the teach pendant device. A maximum of 9 values should be used. Each value is a string of up to 12 characters.

A sequence of consecutive dictionary elements, starting with *element_no* , define the values. Each value must be put in a separate element, and must not end with &new_line. The characters are assigned the numeric values 1..9 in sequence. The last dictionary element must be "".

- *dict_name* specifies the name of the dictionary that contains the menu data.
- *element_no* is the element number of the first menu item within the dictionary.
- *ftn_key_num* is the function key where the pull-up menu should be displayed.
- *def_item* is the item that should be highlighted when the menu is entered. 1 specifies the first item. On return, *def_item* is the item that was currently highlighted when the termination character was pressed.
- *term_char* receives a code indicating the character that terminated the menu. The codes for key terminating conditions are defined in the include file FROM:KLEVKEYS.KL. Keys normally returned are pre-defined constants as follows:

  ky_enter — A menu item was selected

  ky_prev — A menu item was not selected

  ky_new_menu — A new menu was selected

  ky_f1

  ky_f2

  ky_f3

  ky_f4

  ky_f5
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

Example: In this example, dictionary file TPEXAMEG.TX is loaded as **'EXAM'** on the controller. TPPLMN.KL calls DISCTRL_PLMN to display and process the pull-up menu above function key 3.

DISCTRL_PLMN Built-In Procedure

```
-----------------------------------------------
TPEXAMEG.TX
-----------------------------------------------
$subwin_menu
"Option 1"
$
```

```
"Option 2"
$
"Option 3"
$
"Option 4"
$
"Option 5"
$
"......"
-----------------------------------------------
TPPLMN.KL
-----------------------------------------------
PROGRAM tpplmn
%ENVIRONMENT uif
VAR
  def_item: INTEGER
  term_char: INTEGER
  status: INTEGER
BEGIN
  def_item = 1
  DISCTRL_PLMN('EXAM', 0, 3, def_item, term_char, status)
  IF term_char = ky_enter THEN
    WRITE (CR, def_item, ' was selected')
  ENDIF
END tpplmn
```

A.5.24 DISCTRL_SBMN Built-In Procedure

Purpose: Creates and controls cursor movement and selection in a sub-window menu

Syntax : DISCTRL_SBMN(dict_name, element_no, def_item, term_char, status)

Input/Output Parameters :

[in] dict_name :STRING

[in] element_no :INTEGER

[in,out] def_item :INTEGER

[out] term_char :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group : UIF

Details:

- The menu data in the dictionary consists of a list of enumerated values that are displayed and selected from the 'subm' subwindow on the Teach Pendant device. There can be up to 5 subwindow pages, for a maximum of 35 values. Each value is a string of up to 16 characters. If 4 or less enumerated values are used, then each string can be up to 40 characters.

  A sequence of consecutive dictionary elements, starting with *element_no* , define the values. Each value must be put in a separate element, and must not end with &new_line. The characters are assigned the numeric values 1..35 in sequence. The last dictionary element must be "".
- *dict_name* specifies the name of the dictionary that contains the menu data.
- *element_no* is the element number of the first menu item within the dictionary.
- *def_item* is the item that should be highlighted when the menu is entered. 1 specifies the first item. On return, *def_item* is the item that was currently highlighted when the termination character was pressed.
- *term_char* receives a code indicating the character that terminated the menu. The codes for key terminating conditions are defined in the include file FROM:KLEVKEYS.KL. Keys normally returned are pre-defined constants as follows:

  ky_enter — A menu item was selected

  ky_prev — A menu item was not selected

  ky_new_menu — A new menu was selected

  ky_f1

  ky_f2

  ky_f3

  ky_f4

  ky_f5
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

Example: In this example, dictionary file TPEXAMEG.TX is loaded as **'EXAM'** on the controller. TPSBMN.KL calls DISCTRL_SBMN to display and process the subwindow menu.

DISCTRL_SBMN Built-In Procedure

```
-----------------------------------------------
TPEXAMEG.TX
-----------------------------------------------
$subwin_menu
"Red"
$
```

```
"Blue"
$
"Green"
$
"Yellow"
$
"Brown"
$
"Pink"
$
"Mauve"
$
"Black"
$
"Lime"
$
"Lemon"
$
"Beige"
$
"Blue"
$
"Green"
$
"Yellow"
$
"Brown"
$
"\a"
-----------------------------------------------
TPSBMN.KL
-----------------------------------------------
PROGRAM tpsbmn
%ENVIRONMENT uif
VAR
  def_item: INTEGER
  term_char: INTEGER
  status: INTEGER
BEGIN
  def_item = 1
  DISCTRL_SBMN('EXAM', 0, def_item, term_char, status)
  IF term_char = ky_enter THEN
    WRITE (CR, def_item, ' was selected')
  ENDIF
END tpsbmn
```

A.5.25 DISCTRL_TBL Built-In Procedure

Purpose: Displays and controls a table on the teach pendant

Syntax : DISCTRL_TBL(dict_name, ele_number, num_rows, num_columns, col_data, inact_array, change_array, def_item, term_char, term_mask, value_array, attach_wind, status)

Input/Output Parameters :

[in] dict_name :STRING

[in] ele_number :INTEGER

[in] num_rows :INTEGER

[in] num_columns :INTEGER

[in] col_data :ARRAY OF COL_DESC_T

[in] inact_array :ARRAY OF BOOLEAN

[out] change_array :ARRAY OF BOOLEAN

[in,out] def_item :INTEGER

[out] term_char :INTEGER

[in] term_mask :INTEGER

[in] value_array :ARRAY OF STRING

[in] attach_wind :BOOLEAN

[out] status :INTEGER

%ENVIRONMENT Group : UIF

Details:

- DISCTRL_TBL is similar to the INIT_TBL and ACT_TBL Built-In routines and should be used if no special processing needs to be done with each keystroke.
- *dict_name* is the four-character name of the dictionary containing the table header.
- *ele_number* is the element number of the table header.
- *num_rows* is the number of rows in the table.
- *num_columns* is the number of columns in the table.

- *col_data* is an array of column descriptor structures, one for each column in the table. For a complete description, refer to the INIT_TBL Built-In routine in this appendix.
- *inact_array* is an array of booleans that corresponds to each column in the table.
  - — You can set each boolean to TRUE which will make that column inactive. This means the you cannot move the cursor to this column.
  - — The array size can be less than or greater than the number of items in the table.
  - — If *inact_array* is not used, then an array size of 1 can be used, and the array does not need to be initialized.
- *change_array* is a two dimensional array of BOOLEANs that corresponds to formatted data items in the table.
  - — If the corresponding value is set, then the boolean will be set to TRUE, otherwise it is set to FALSE. You do not need to initialize the array.
  - — The array size can be less than or greater than the number of data items in the table.
  - — If *change_array* is not used, then an array size of 1 can be used.
- *def_item* is the row containing the item you want to be highlighted when the table is entered. On return, *def_item* is the row containing the item that was currently highlighted when the termination character was pressed.
- *term_char* receives a code indicating the character or other condition that terminated the table. The codes for key terminating conditions are defined in the include file FROM:KLEVKEYS.KL. Keys normally returned are pre-defined constants as follows:

  ky_undef — No termination character was pressed

  ky_select — A selectable item as selected

  ky_new_menu — A new menu was selected

  ky_f1 — Function key 1 was selected

  ky_f2 — Function key 2 was selected

  ky_f3 — Function key 3 was selected

  ky_f4 — Function key 4 was selected

  ky_f5 — Function key 5 was selected

  ky_f6 — Function key 6 was selected

  ky_f7 — Function key 7 was selected

  ky_f8 — Function key 8 was selected

ky_f9 — Function key 9 was selected

ky_f10 — Function key 10 was selected

- *term_mask* is a bit-wise mask indicating conditions that will terminate the request. This should be an OR of the constants defined in the include file FROM:KLEVKMSK.KL.

  kc_display — Displayable keys

  kc_func_key — Function keys

  kc_keypad — Key-pad and Edit keys

  kc_enter_key — Enter and Return keys

  kc_delete — Delete and Backspace keys

  kc_lr_arw — Left and Right Arrow keys

  kc_ud_arw — Up and Down Arrow keys

  kc_other — Other keys (such as Prev)

- *value_array* is an array of variable names that corresponds to each column of data item in the table. Each variable name can be specified as '[prog_name]var_name'.
  - — *[prog_name]* specifies the name of the program that contains the specified variable. If [prog_name] is not specified, then the current program being executed is used.
  - — *var_name* must refer to a static, global program variable.
  - — *var_name* can contain node numbers, field names, and/or subscripts.
- *attach_wind* should be set to 1 if the table manager window needs to be attached to the display device. If it is already attached, this parameter can be set to 0.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

Example: Refer to the INIT_TBL Built-In routine for an example of setting up the dictionary text and initializing the parameters.

A.5.26 DISMOUNT_DEV Built-In Procedure

Purpose: Dismounts the specified device.

Syntax : DISMOUNT_DEV (device, status)

Input/Output Parameters :

[in] device :STRING

[out] status :INTEGER

%ENVIRONMENT Group :FDEV

Details:

- *device* specifies the device to be dismounted.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: MOUNT_DEV, FORMAT_DEV Built-In Procedures

Example: Refer to Section B.9, "Using the File and Device Built-ins" (FILE_EX.KL), for a detailed program example.

A.5.27 DISP_DAT_T Data Type

Purpose: Defines data type for use in DISCTRL_LIST Built-In

Syntax :

disp_dat_t = STRUCTURE

win_start : ARRAY [4] OF SHORT

win_end : ARRAY [4] OF SHORT

curr_win : SHORT

cursor_row : SHORT

lins_per_pg : SHORT

curs_st_col : ARRAY [10] OF SHORT

curs_en_col : ARRAY [10] OF SHORT

curr_field : SHORT

last_field : SHORT

curr_it_num : SHORT

sob_it_num : SHORT

eob_it_num : SHORT

last_it_num : SHORT

menu_id : SHORT

ENDSTRUCTURE

Details:

- *disp_dat_t* can be used to display a list in four different windows. The list can contain up to 10 fields. Left and right arrows move between fields. Up and down arrows move within a field.
- *win_start* is the starting row for each window.
- *win_end* is the ending row for each window.
- *curr_win* defines the window to display. The count begins at zero (0 will display the first window).
- *cursor_row* is the current cursor row.
- *lins_per_pg* is the number of lines per page for paging up and down.
- *curs_st_col* is the cursor starting column for each field. The range is 0-39 for the teach pendant.
- *curs_en_col* is the cursor ending column for each field. The range is 0-39 for the teach pendant.
- *curr_field* is the current field in which the cursor is located. The count begins at zero (0 will set the cursor to the first field).
- *last_field* is the last field in the list.
- *curr_it_num* is the item number the cursor is on.
- *sob_it_num* is the item number of the first item in the array.
- *eob_it_num* is the item number of the last item in the array.
- *last_it_num* is the item number of the last item in the list.
- *menu_id* is the current menu identifier. Not implemented. May be left uninitialized.

Example: Refer to Section B.12, "Displaying a List From a Dictionary File" (DCLIST_EX.KL), for a detailed program example.

A.6 - E - KAREL LANGUAGE DESCRIPTION

A.6.1 ENABLE CONDITION Action

Purpose: Enables the specified condition handler

Syntax : ENABLE CONDITION [cond_hand_no]

where:

cond_hand_no :an INTEGER expression

Details:

- ENABLE CONDITION has no effect when
  - — The condition handler is not defined
  - — The condition handler is defined but is already enabled
- *cond_hand_no* must be in the range of 1-1000. Otherwise, the program will be aborted with an error.
- When a condition handler is enabled, its conditions are tested each time the condition handler is scanned. If the conditions are satisfied, the corresponding actions are performed and the condition handler is deactivated. Issue an ENABLE CONDITION statement or action to reactivate it.
- Use the DISABLE CONDITION statement or action to deactivate a condition handler that has been enabled.
- Condition handlers are known only to the task which defines them. One task cannot enable another tasks condition.

See Also: DISABLE CONDITION Action, Chapter 6 *CONDITION HANDLERS*

Example: Refer to Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.6.2 ENABLE CONDITION Statement

Purpose: Enables the specified condition handler

Syntax : ENABLE CONDITION [cond_hand_no]

where:

cond_hand_no :an INTEGER expression

Details:

- ENABLE CONDITION has no effect when
  - — The condition handler is not defined
  - — The condition handler is defined but is already enabled
- *cond_hand_no* must be in the range of 1-1000. Otherwise, the program will be aborted with an error.

- When a condition handler is enabled, its conditions are tested each time the condition handler is scanned. If the conditions are satisfied, the corresponding actions are performed and the condition handler is deactivated. Issue an ENABLE CONDITION statement or action to reactivate it.
- Use the DISABLE CONDITION statement or action to deactivate a condition handler that has been enabled.
- Condition handlers are known only to the task which defines them. One task cannot enable another tasks condition.

See Also: DISABLE CONDITION Statement, Chapter 6 *CONDITION HANDLERS* , Appendix E, ‘‘Syntax Diagrams,’’ for additional syntax information

Example: Refer to the following sections for detailed program examples.

Section B.6 , "Path Variables and Condition Handlers Program" (PTH_MOV.KL)

Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.6.3 %ENVIRONMENT Translator Directive

Purpose: Loads environment file.

Syntax : %ENVIRONMENT path_name

- Used by the off-line translator to specify that the binary file, path_name.ev, should be loaded. Environment files contain definitions for predefined constants, ports, types, system variables, and built-ins.
- All .EV files are loaded upon installation of the controller software. Therefore, the controller’s translator will ignore %ENVIRONMENT statements since it already has the .EV files loaded.
- *path_name* can be one of the following:
  - BYNAM
  - CTDEF (allows program access to CRT/KB system variables)
  - ERRS
  - FDEV
  - FLBT
  - IOSETUP
  - KCLOP
  - MEMO
  - MIR
  - MOTN

— MULTI
— PATHOP
— PBCORE
— PBQMGR
— REGOPE
— STRNG
— SYSDEF (allows program access to most system variables)
— SYSTEM
— TIM
— TPE
— TRANS
— UIF
— VECTR

- If no %ENVIRONMENT statements are specified in your KAREL program, the off-line translator will load all the .EV files specified in TRMNEG.TX. The translator must be able to find these files in the current directory or in one of the PATH directories.
- If at least one %ENVIRONMENT statement is specified, the off-line translator will only load the files you specify in your KAREL program. Specifying your own %ENVIRONMENT statements will reduce the amount of memory required to translate and will be faster, especially if you do not require system variables since SYSDEF.EV is the largest file.
- SYSTEM.EV and PBCORE.EV are automatically loaded by the translator and should not be specified in your KAREL program. The off-line translator will print the message "Continuing without system defined symbols" if it cannot find SYSTEM.EV. Do not ignore this message. Make sure the SYSTEM.EV file is loaded.

Example: Refer to the following sections for detailed program examples:

Section B.3,"Saving Data to the Default Device" (SAVE_VR.KL)

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.14, "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

A.6.4 ERR_DATA Built-In Procedure

Purpose: Reads the requested error from the error history and returns the error

Syntax : ERR_DATA(seq_num, error_code, error_string, cause_code, cause_string, time_int, severity, prog_nam)

Input/Output Parameters :

[in,out] seq_num :INTEGER

[out] error_code :INTEGER

[out] error_string :STRING

[out] cause_code :INTEGER

[out] cause_string :STRING

[out] time_int :INTEGER

[out] severity :INTEGER

[out] prog_nam :STRING

%ENVIRONMENT Group :ERRS

- *seq_num* is the sequence number of the previous error requested. *seq_num* should be set to 0 if the oldest error in the history is desired. *seq_num* should be set to MAXINT if the most recent error is desired.
- *seq_num* is set to the sequence number of the error that is returned.
  - — If the initial value of *seq_num* is greater than the sequence number of the newest error in the log, *seq_num* is returned as zero and no other data is returned.
  - — If the initial value of *seq_num* is less than the sequence number of the oldest error in the log, the oldest error is returned.
- *error_code* returns the error code and *error_string* returns the error message. *error_string* must be at least 40 characters long or the program will abort with an error.
- *cause_code* returns the reason code if it exists and *cause_string* returns the message. *cause_string* must be at least 40 characters long or the program will abort with an error.
- *error_code* and *cause_code* are in the following format:

  ffccc (decimal)

  where ff represents the facility code of the error.

  ccc represents the error code within the specified facility.

  Refer to Chapter 6, "Condition Handlers," for the error facility codes.
- *time_int* returns the time that *error_code* was posted. The time is in encoded format, and CNV_TIME_STR Built-In should be used to get the date-and-time string.
- *severity* returns one of the following *error_codes:* 0 :WARNING1 :PAUSE2 :ABORT

- If the error occurs in the execution of a program, *prog_nam* specifies the name of the program in which the error occurred.
- If the error is posted by POST_ERR, or if the error is not associated with a particular program (e.g., E-STOP), *prog_nam* is returned as ‘ "" ’.
- Calling ERR_DATA immediately after POST_ERR may not return the error just posted since POST_ERR returns before the error is actually in the error log.

See Also: POST_ERR Built-In Procedure

A.6.5 ERROR Condition

Purpose: Specifies an error as a condition

Syntax : ERROR[n]

where:

n :an INTEGER expression or asterisk (*)

Details:

- If *n* is an INTEGER, it represents an error code number. The condition is satisfied when the specified error occurs.
- If *n* is an asterisk (*), it represents a wildcard. The condition is satisfied when any error occurs.
- The condition is an event condition, meaning it is satisfied only for the scan performed when the error was detected. The error is not remembered on subsequent scans.

See Also: Chapter 6 *CONDITION HANDLERS* , for more information on using conditions. The appropriate application-specific *FANUC Robotics SYSTEM R-J3iC Controller Setup and Operations Manual* for a list of all error codes

Example: Refer to Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.6.6 EVAL Clause

Purpose: Allows expressions to be evaluated in a condition handler definition

Syntax : EVAL(expression)

where:

expression :a valid KAREL expression

Details:

- *expression* is evaluated when the condition handler is defined, rather than dynamically during scanning.
- *expression* can be any valid expression that does not contain a function call.

See Also: Chapter 6 *CONDITION HANDLERS* „ for more information on using conditions

Example: The following example uses a local condition handler to move to the position **far_pos** until AIN[**force**] is greater than the evaluated expression (10 * **f_scale**).

EVAL Clause

```
WRITE ('Enter force scale: ')
  READ (f_scale)
  MOVE TO far_pos,
    UNTIL AIN[force] > EVAL(10 * f_scale)
  ENDMOVE
```

A.6.7 EVENT Condition

Purpose: Specifies the number of an event that satisfies a condition when a SIGNAL EVENT statement or action with that event number is executed

Syntax : EVENT[event_no]

where:

event_no :is an INTEGER expression

Details:

- Events can be used as user-defined event codes that become TRUE when signaled.
- The SIGNAL EVENT statement or action is used to signal that an event has occurred.
- *event_no* must be in the range of -32768 to 32767.

See Also: SIGNAL EVENT Action, and CONDITION or SIGNAL EVENT Statement

Example: Refer to Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.6.8 EXP Built-In Function

Purpose: Returns a REAL value equal to e (approximately 2.71828) raised to the power specified by a REAL argument

Syntax : EXP(x)

Function Return Type :REAL

Input/Output Parameters :

[in] x :REAL

%ENVIRONMENT Group :SYSTEM

Details:

- EXP returns e (base of the natural logarithm) raised to the power *x* .
- *x* must be less than 80. Otherwise, the program will be paused with an error.

Example: The following example uses the EXP Built-In to evaluate the exponent of the expression **(-6.44 + timevar/(timevar + 20))** .

EXP Built-In Function

```
WRITE (CR, 'Enter time needed for move:')
  READ (timevar)
  distance = timevar *
             EXP(-6.44 + timevar/(timevar + 20))
  WRITE (CR, CR, 'Distance for move:', distance::10::3)
```

A.7 - F - KAREL LANGUAGE DESCRIPTION

A.7.1 FILE Data Type

Purpose: Defines a variable as FILE data type

Syntax : file

Details:

- FILE allows you to declare a static variable as a file.
- You must use a FILE variable in OPEN FILE, READ, WRITE, CANCEL FILE, and CLOSE FILE statements.

- You can pass a FILE variable as a parameter to a routine.
- Several built-in routines require a FILE variable as a parameter, such as BYTES_LEFT, CLR_IO_STAT, GET_FILE_POS, IO_STATUS, SET_FILE_POS.
- FILE variables have these restrictions:
  - FILE variables must be a static variable.
  - FILE variables are never saved.
  - FILE variables cannot be function return values.
  - FILE types are not allowed in structures, but are allowed in arrays.
  - No other use of this variable data type, including assignment to one another, is permitted.

Example: Refer to the following sections for detailed program examples:

Section B.2 , "Copying Path Variables" (CPY_PTH.KL)

Section B.12 , "Displaying a List From a Dictionary File" (DCLST_EX.KL)

A.7.2 FILE_LIST Built-In Procedure

Purpose: Generates a list of files with the specified name and type on the specified device.

Syntax: FILE_LIST(file_spec, n_skip, format, ary_nam, n_files, status)

Input/Output Parameters :

[in] file_spec :STRING

[in] n_skip :INTEGER

[in] format :INTEGER

[out] ary_nam :ARRAY of STRING

[out] n_files :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :BYNAM

Details:

- *file_spec* specifies the device, name, and type of the list of files to be found. *file_spec* can be specified using the wildcard (*) character.

- *n_skip* is used when more files exist than the declared length of *ary_nam* . Set *n_skip* to 0 the first time you use FILE_LIST. If *ary_nam* is completely filled with variable names, copy the array to another ARRAY of STRINGs and execute the FILE_LIST again with *n_skip* equal to *n_files* . The second call to FILE_LIST will skip the files found in the first pass and only locate the remaining files.
- *format* specifies the format of the file name and file type. The following values are valid for *format* :

  1 **file_name** only, no blanks 2 **file_type** only, no blanks3 **file_name.file_type** , no blanks4 **filename.ext size date time** The total length is 40 characters.

  — The **file_name** starts with character 1.

  — The **file_type** (extension) starts with character 10.

  — The **size** starts with character 21.

  — The **date** starts with character 26.

  — The **time** starts with character 36.

  Date and time are only returned if the device supports time stamping; otherwise just the filename.ext size is stored.
- *ary_nam* is an ARRAY of STRINGs to store the file names. If the string length of ary_nam is not large enough to store the formatted information, an error will be returned.
- *n_files* is the number of files stored in *ary_name* .
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: VAR_LIST, PROG_LIST Built-In Procedures

Example: Refer to Section B.7 , "Listing Files and Programs and Manipulating Strings" (LIST_EX.KL), for a detailed program example.

A.7.3 FOR...ENDFOR Statement

Purpose: Looping construct based on an INTEGER counter

Syntax : FOR count = initial || TO | DOWNTO || final

DO{stmnt} ENDFOR

where:

[in]count :INTEGER variable

[in]initial :INTEGER expression

[in]final :INTEGER expression

[in]stmnt :executable KAREL statement

Details:

- Initially, *count* is set to the value of *initial* and *final* is evaluated. For each iteration, *count* is compared to *final.*
- If TO is used, *count* is incremented for each loop iteration.
- If DOWNTO is used, *count* is decremented for each loop iteration.
- If *count* is greater than *final* using TO, *stmnt* is never executed.
- If *count* is less than *final* using DOWNTO, *stmnt* is never executed on the first iteration.
- If the comparison does not fail on the first iteration, the FOR loop will be executed for the number of times that equals ABS(*final* - *initial* l) + 1.
- If *final* = *initial* , the loop is executed once.
- *initial* is evaluated prior to entering the loop. Therefore, changing the values of *initial* and *final* during loop execution has no effect on the number of iterations performed.
- The value of *count* on exit from the loop is uninitialized.
- Never issue a GO TO statement in a FOR loop. If a GO TO statement causes the program to exit a FOR loop, the program might be aborted with a ‘‘Run time stack overflow’’ error.
- Never include a GO TO label in a FOR loop. Entering a FOR loop by a GO TO statement usually causes the program to be aborted with a ‘‘Run time stack underflow’’ error when the ENDFOR statement is encountered.
- The program will not be translated if *count* is a system variable or ARRAY element.

See Also: Appendix E , ‘‘Syntax Diagrams,’’ for additional syntax information.

Example: Refer to the following sections for detailed program examples:

Section B.2, "Copying Path Variables" (CPY_PTH.KL)

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.7, "Listing Files and Programs and Manipulating Strings" (LIST_EX.KL)

Section B.11, "Manipulating Values of Dynamically Displayed Variables" (CHG_DATA.KL)

Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL)

Section B.14, "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.7.4 FORCE_SPMENU Built-In Procedure

Purpose: Forces the display of the specified menu

Syntax : FORCE_SPMENU(device_code, spmenu_id, screen_no)

Input/Output Parameters :

[in] device_code :INTEGER

[in] spmenu_id :INTEGER

[in] screen_no :INTEGER

%ENVIRONMENT Group :pbcore

Details:

- *device_code* specifies the device and should be one of the following predefined constants:

  tp_panel Teach pendant device

  crt_panel CRT device

- *spmenu_id* and *screen_no* specify the menu to force. The predefined constants beginning with SPI_ define the *spmenu_id* and the predefined constants beginning with SCR_ define the *screen_no* . If no SCR_ is listed, use 1.

  SPI_TPHINTS — UTILITIES Hints

  SPI_TPPRGADJ — UTILITIES Prog Adjust

  SPI_TPMIRROR — UTILITIES Mirror Image

  SPI_TPSHIFT — UTILITIES Program Shift

  SPI_TPTSTRUN — TEST CYCLE

  SPI_TPMANUAL, SCR_MACMAN — MANUAL Macros

  SPI_TPOTREL — MANUAL OT Release

  SPI_TPALARM, SCR_ALM_ALL — ALARM Alarm Log

  SPI_TPALARM, SCR_ALM_MOT — ALARM Motion Log

  SPI_TPALARM, SCR_ALM_SYS — ALARM System Log

  SPI_TPALARM, SCR_ALM_APPL — ALARM Appl Log

SPI_TPDIGIO — I/O Digital

SPI_TPANAIO — I/O Analog

SPI_TPGRPIO — I/O Group

SPI_TPROBIO — I/O Robot

SPI_TPUOPIO — I/O UOP

SPI_TPSOPIO — I/O SOP

SPI_TPPLCIO — I/O PLC

SPI_TPSETGEN — SETUP General

SPI_TPFRAM — SETUP Frames

SPI_TPPORT — SETUP Port Init

SPI_TPMMACRO, SCR_MACSETUP — SETUP Macro

SPI_TPREFPOS — SETUP Ref Position

SPI_TPPWORD — SETUP Passwords

SPI_TPHCCOMM — SETUP Host Comm

SPI_TPSYRSR — SETUP RSR/PNS

SPI_TPFILS — FILE

SPI_TPSTATUS, SCR_AXIS — STATUS Axis

SPI_TPMEMORY — STATUS Memory

SPI_TPVERSN — STATUS Version ID

SPI_TPPRGSTS — STATUS Program

SPI_TPSFTY — STATUS Safety Signals

SPI_TPUSER — USER

SPI_TPSELECT — SELECT

SPI_TPTCH — EDIT

SPI_TPREGIS, SCR_NUMREG — DATA Registers

SPI_SFMPREG, SCR_POSREG — DATA Position Reg

SPI_TPSYSV, SCR_NUMVAR — DATA KAREL Vars

SPI_TPSYSV, SCR_POSVAR — DATA KAREL Posns

SPI_TPPOSN — POSITION

SPI_TPSYSV, SCR_CLOCK — SYSTEM Clock

SPI_TPSYSV, SCR_SYSVAR — SYSTEM Variables

SPI_TPMASCAL — SYSTEM Master/Cal

SPI_TPBRKCTR — SYSTEM Brake Cntrl

SPI_TPAXLM — SYSTEM Axis Limits

SPI_CRTKCL, SCR_KCL — KCL> (crt_panel only)

SPI_CRTKCL, SCR_CRT — KAREL EDITOR (crt_panel only)

SPI_TPUSER2 — Menu for form/table managers

See Also: ACT_SCREEN Built-In Procedure

Example: Refer to the following sections for detailed program examples:

Section B.4 , "Standard Routines" (ROUT_EX.KL)

Section B.5 , "Using Register Built-ins" (REG_EX.KL)

Section B.12 , "Dictionary Files" (DCLISTEG.UTX)

Section B.13 , "Using the DISCTRL_ALPHA Built-in" (DCALP_EX.KL)

Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.7.5 FORMAT_DEV Built-In Procedure

Purpose: Deletes any existing information and records a directory and other internal information on the specified device.

Syntax : FORMAT_DEV(device, volume_name, nowait_sw, status)

Input/Output Parameters :

[in] device :STRING

[in] volume_name :STRING

[in] nowait_sw :BOOLEAN

[out] status :INTEGER

%ENVIRONMENT Group :FDEV

Details:

- *device* specifies the device to initialize.
- *volume_name* acts as a label for a particular unit of storage media. *volume_name* can be a maximum of 11 characters and will be truncated to 11 characters if more are specified.
- If *nowait_sw* is TRUE, execution of the program continues while the command is executing. If it is FALSE, the program stops, including condition handlers, until the operation is complete. If you have time critical condition handlers in the program, put them in another program that executes as a separate task.

  Note *nowait_sw* is not available in this release and should be set to FALSE.

- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: MOUNT_DEV, DISMOUNT_DEV Built-In Procedures

Example: Refer to Section B.9 , "Using the File and Device Built-ins" (FILE_EX.KL), for a detailed program example.

A.7.6 FRAME Built-In Function

Purpose: Returns a frame with a POSITION data type representing the transformation to the coordinate frame specified by three (or four) POSITION arguments.

Syntax : FRAME(pos1, pos2, pos3 <,pos4>)

Function Return Type :Position

Input/Output Parameters :

[in]pos1 :POSITION

[in]pos2 :POSITION

[in]pos3 :POSITION

[in]pos4 :POSITION

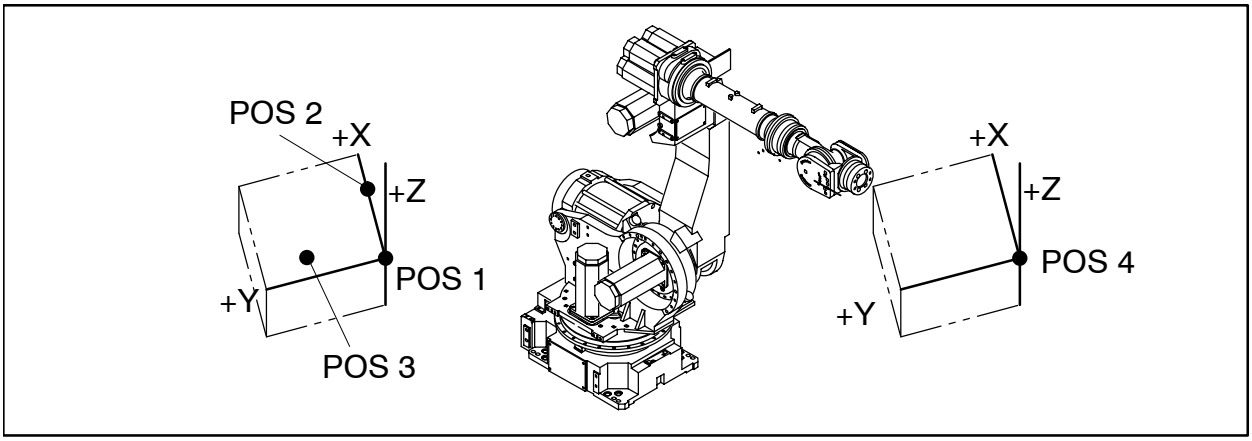
%ENVIRONMENT Group :SYSTEM

Details:

- The returned value is computed as follows:
  - — *pos1* is assumed to be the origin unless a *pos4* argument is supplied. See Figure A–1 .
  - — If *pos4* is supplied, the origin is shifted to *pos4* , and the new coordinate frame retains the same orientation in space as the first coordinate frame. See Figure A–1 .
  - — The x-axis is parallel to a line from *pos1* to *pos2* .
  - — The xy-plane is defined to be that plane containing *pos1* , *pos2* , and *pos3* , with *pos3* in the positive half of the plane.
  - — The y-axis is perpendicular to the x-axis and in the xy-plane.
  - — The z-axis is through pos1 and perpendicular to the xy-plane. The positive direction is determined by the right hand rule.
  - — The configuration of the result is set to that of *pos1* , or *pos4* if it is supplied.
- *pos1* and *pos2* arguments must be at least 10 millimeters apart and *pos3* must be at least 10 millimeters away from the line connecting *pos1* and *pos2* .

If either condition is not met, the program is paused with an error.

Figure A–1. FRAME Built-In Function



Example: The following example allows the operator to set a frame to a pallet so that a palletizing routine will be able to move the TCP along the x, y, z direction in the pallet's coordinate frame.

FRAME Built-In Function

```
WRITE('Teach corner_1, corner_2, corner_3',CR)
  RELEASE --Allows operator to turn on teach pendant
          --and teach positions
  ATTACH  --Returns motion control to program
  $UFRAME = FRAME (corner_1, corner_2, corner_3)
```

A.7.7 FROM Clause

Purpose: Indicates a variable or routine that is external to the program, allowing data and/or routines to be shared among programs

Syntax : FROM prog_name

where:

prog_name : any KAREL program identifier

Details:

- The FROM clause can be part of a type, variable, or routine declaration.
- The type, variable, or routine belongs to the program specified by *prog_name* .
- In a FROM clause, *prog_name* can be the name of any program, including the program in which the type, variable, or routine is declared.
- If the FROM clause is used in a routine declaration and is called during program execution, the body of the declaration must appear in the specified program and that program must be loaded.
- The FROM clause cannot be used when declaring variables in the declaration section of a routine.

Example: Refer to the following sections for detailed program examples:

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.7, "Listing Files and Programs and Manipulating Strings" (LIST_EX.KL)

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.11, "Manipulating Values of Dynamically Displayed Variables" (CHG_DATA.KL)

Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL)

Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.8 - G - KAREL LANGUAGE DESCRIPTION

A.8.1 GET_ATTR_PRG Built-In Procedure

Purpose: Gets attribute data from the specified teach pendant or KAREL program

Syntax : GET_ATTR_PRG(program_name, attr_number, int_value, string_value, status)

Input/Output Parameters :

[in] program_name :STRING

[in] attr_number :INTEGER

[out] int_value :INTEGER

[out] string_value :STRING

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *program_name* specifies the program from which to get attribute.
- *attr_number* is the attribute whose value is to be returned. The following attributes are valid:

  AT_PROG_TYPE : Program type

  AT_PROG_NAME : Program name (String[12])

  AT_OWNER : Owner (String[8])

  AT_COMMENT : Comment (String[16])

  AT_PROG_SIZE : Size of program

  AT_ALLC_SIZE : Size of allocated memory

  AT_NUM_LINE : Number of lines

  AT_CRE_TIME : Created (loaded) time

  AT_MDFY_TIME : Modified time

  AT_SRC_NAME : Source file (or original file) name (String[128])

AT_SRC_VRSN : Source file versionA

AT_DEF_GROUP : Default motion group mask (for task attribute). See Table A–16 .

AT_PROTECT : Protection code; 1 :Protection OFF ; 2 :Protection ON

AT_STK_SIZE : Stack size (for task attribute)

AT_TASK_PRI : Task priority (for task attribute)

AT_DURATION : Time slice duration (for task attribute)

AT_BUSY_OFF : Busy lamp off (for task attribute)

AT_IGNR_ABRT : Ignore abort request (for task attribute)

AT_IGNR_PAUS : Ignore pause request (for task attribute)

AT_CONTROL : Control code (for task attribute)

- The program type returned for AT_PROG_TYPE will be one of the following constants:

  PT_KRLPRG : Karel program

  PT_MNE_UNDEF : Teach pendant program of undefined sub type

  PT_MNE_JOB : Teach pendant job

  PT_MNE_PROC : Teach pendant process

  PT_MNE_MACRO : Teach pendant macro

- If the attribute data is a number, it is returned in *int_value* and *string_value* is not modified.
- If the attribute data is a string, it is returned in *string_value* and *int_value* is not modified.
- *status* explains the status of the attempted operation. If it is not equal to 0, then an error has occurred. Some of the errors which could occur are:

  7073 The program specified in *program_name* does not exist

  17027 *string_value* is not large enough to contain the attribute string. The value has been truncated to fit.

  17033 *attr_number* has an illegal value

See Also: SET_ATTR_PRG, GET_TSK_INFO, SET_TSK_ATTR Built-In Procedures

A.8.2 GET_FILE_POS Built-In Function

Purpose: Returns the current file position (where the next READ or WRITE operation will take place) in the specified file

Syntax : GET_FILE_POS(file_id)

Function Return Type :INTEGER

Input/Output Parameters :

[in] file_id :FILE

%ENVIRONMENT Group :FLBT

Details:

- GET_FILE_POS returns the number of bytes before the next byte to be read or written in the file.
- Line terminators are counted in the value returned.
- The file associated with *file_id* must be open. Otherwise, the program is aborted with an error.
- If the file associated with *file_id* is open for read-only, it cannot be on the FROM or RAM disks as a compressed file.



Warning

GET_FILE_POS is only supported for files opened on the RAM Disk device. Do not use GET_FILE_POS on another device; otherwise, you could injure personnel and damage equipment.

Example: The following example opens the **filepos.dt** data file, stores the positions in **my_path** in a file, and builds a directory to access them.

GET_FILE_POS Built-In Function

```
OPEN FILE file_id ('RW','filepos.dt')
  FOR i = 1 TO PATH_LEN(my_path) DO
    temp_pos = my_path[i].node_pos
    pos_dir[i] = GET_FILE_POS(file_id)
    WRITE file_id (temp_pos)
  ENDFOR
```

A.8.3 GET_JPOS_REG Built-In Function

Purpose: Gets a JOINTPOS value from the specified register

Syntax : GET_JPOS_REG(register_no, status <,group_no>)

Function Return Type :REGOPE

Input/Output Parameters :

[in] register_no :INTEGER

[out] status :INTEGER

[in] group_no :INTEGER

%ENVIRONMENT Group :REGOPE

Details:

- *register_no* specifies the position register to get.
- If *group_no* is omitted, the default group for the program is assumed.
- If *group_no* is specified, it must be in the range of 1 to the total number of groups defined on the controller.
- GET_JPOS_REG returns the position in JOINTPOS format. Use POS_REG_TYPE to determine the position representation.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: GET_POS_REG, SET_JPOS_REG, SET_POS_REG Built-in Procedures

Example: Refer to Section B.5, "Using Register Built-ins" (REG_EX.KL) for a detailed program example.

A.8.4 GET_JPOS_TPE Built-In Function

Purpose: Gets a JOINTPOS value from the specified position in the specified teach pendant program

Syntax : GET_JPOS_TPE(open_id, position_no, status <, group_no>)

Function Return Type :JOINTPOS

Input/Output Parameters :

[in] open_id :INTEGER

[in] position_no :INTEGER

[out] status :INTEGER

[in] group_no :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *open_id* specifies the teach pendant program. A program must be opened before calling this built-in.
- *position_no* specifies the position in the program to get.
- If *group_no* is omitted, the default group for the program is assumed.
- If *group_no* is specified, it must be in the range of 1 to the total number of groups defined on the controller.
- No conversion is done for the position representation. The position data must be in JOINTPOS format. If the stored position is not in JOINTPOS, an error status is returned. Use GET_POS_TYP to get the position representation.
- If the specified position in the program is uninitialized, the returned JOINTPOS value is uninitialized and the status is set to 17038, "Uninitialized TPE position".
- *status* explains the status of the attempted operation. If not equal to 0, then an error has occurred.

See Also: SET_JPOS_TPE, GET_POS_TPE, SET_POS_TPE Built-ins

Example: Refer to Section B.14 , "Applying Offsets to a Copied Teach Pendant Program" (CPY_TPE.KL), for a detailed program example.

A.8.5 GET_PORT_ASG Built-in Procedure

Purpose: Allows a KAREL program to determine the physical port(s) to which a specified logical port is assigned.

Syntax : GET_PORT_ASG(log_port_type, log_port_no, rack_no, slot_no, phy_port_type, phy_port_no, n_ports, status)

Input/Output Parameters :

[in] log_port_type :INTEGER

[in] log_port_no :INTEGER

[out] rack_no :INTEGER

[out] slot_no :INTEGER

[out] phy_port_type :INTEGER

[out] phy_port_no :INTEGER

[out] n_ports :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :IOSETUP

Details:

- *log_port_type* specifies the code for the type of port whose assignment is being accessed. Codes are defined in FR:KLIOTYPS.KL.
- *log_port_no* specifies the number of the port whose assignment is being accessed.
- *rack_no* is returned with the rack containing the port module. For process I/O boards, memory-image, and dummy ports, this is zero; for Allen-Bradley ports, this is 16.
- *phy_port_type* is returned with the type of port assigned to. Often this will be the same as log_port_type. Exceptions are if log_port_type is a group type (io_gpin or io_gpout) or a port is assigned to memory-image or dummy ports.
- *phy_port_no* is returned with the number of the port assigned to. If log_port_type is a group, this is the port number for the least-significant bit of the group.
- *n_ports* is returned with the number of physical ports assigned to the logical port. This will be 1 in all cases except when log_port_type is a group type. In this case, n_ports indicates the number of bits in the group.
- *status* is returned with zero if the parameters are valid and the specified port is assigned. Otherwise, it is returned with an error code.

Example: The following example returns to the caller the module rack and slot number, port_number, and number of bits assigned to a specified group input port. A boolean is returned indicating whether the port is assigned to a DIN port. If the port is not assigned, a non-zero status is returned.

GET_PORT_ASG Built-In Procedure

```
PROGRAM getasgprog
```

```
%ENVIRONMENT IOSETUP
%INCLUDE FR:\kliotyps
   ROUTINE get_gin_asg(gin_port_no: INTEGER;
                       rack_no: INTEGER;
                       slot_no: INTEGER;
                       frst_port_no: INTEGER;
                       n_ports: INTEGER;
                       asgd_to_din: BOOLEAN): INTEGER
     VAR
       phy_port_typ: INTEGER
       status: INTEGER

     BEGIN
     GET_PORT_ASG(io_gpin, gin_port_no, rack_no, slot_no,
                  phy_port_typ, frst_port_no, n_ports, status)
     IF status <> 0 THEN
       RETURN (status)
     ENDIF
     asgd_to_din = (phy_port_typ = io_din)
     END get_gin_asg
BEGIN
END getasgprog
```

A.8.6 GET_PORT_ATR Built-In Function

Purpose: Gets an attribute from the specified port

Syntax : GET_PORT_ATR(port_id, atr_type, atr_value)

Function Return Type :INTEGER

Input/Output Parameters :

[in] port_id :INTEGER

[in] atr_type :INTEGER

[out] atr_value :INTEGER

%ENVIRONMENT Group :FLBT

Details:

- *port_id* specifies which port is to be queried. Use one of the following predefined constants:

port_1

port_2

port_3

port_4

port_5

- *atr_type* specifies the attribute whose current setting is to be returned. Use one of the following predefined constants:

  atr_readahd :Read ahead buffer

  atr_baud :Baud rate

  atr_parity :Parity

  atr_sbits :Stop bit

  atr_dbits :Data length

  atr_xonoff :Xon/Xoff

  atr_eol :End of line

  atr_modem :Modem line

- *atr_value* receives the current value for the specified attribute.
- GET_PORT_ATR returns the status of this action to the port.

See Also: SET_PORT_ATR Built-In Function, Chapter 7 *FILE INPUT/OUTPUT OPERATIONS*

Example: The following example sets up the port to a desired configuration, if it is not already set to the specified configuration.

GET_PORT_ATR Built-In Function

```
PROGRAM port_atr
%ENVIRONMENT FLBT
VAR
 stat:   INTEGER
 atr_value: INTEGER
BEGIN
-- sets read ahead buffer to desired value, if not already correct
 stat=GET_PORT_ATR(port_2,atr_readahd,atr_value)
 IF(atr_value <> 2) THEN
  stat=SET_PORT_ATR(port_2,atr_readahd,2) --set to 256 bytes
 ENDIF
```

```
-- sets the baud rate to 9600, if not already set
 stat=GET_PORT_ATR(port_2,atr_baud,atr_value)
 IF(atr_value <> BAUD_9600) THEN
  stat=SET_PORT_ATR(port_2,atr_baud,baud_9600)
 ENDIF
-- sets parity to even, if not already set
 stat=GET_PORT_ATR(port_2,atr_parity,atr_value)
 IF(atr_value <> PARITY_EVEN) THEN
  stat=SET_PORT_ATR(port_2,atr_parity,PARITY_EVEN)
 ENDIF
-- sets the stop bit to 1, if not already set
 stat=GET_PORT_ATR(port_2,atr_sbits,atr_value)
 IF(atr_value <> SBITS_1) THEN
  stat=SET_PORT_ATR(port_2,atr_sbits,SBITS_1)
 ENDIF
-- sets the data bit to 5, if not already set
 stat=GET_PORT_ATR(port_2,atr_dbits,atr_value)
 IF(atr_value <> DBITS_5) THEN
  stat=SET_PORT_ATR(port_2,atr_dbits,DBITS_5)
 ENDIF
-- sets xonoff to not used, if not already set
 stat=GET_PORT_ATR(port_2,atr_xonoff,atr_value)
 IF(atr_value <> xf_not_used) THEN
  stat=SET_PORT_ATR(port_2,atr_xonoff,xf_not_used)
 ENDIF
-- sets end of line marker, if not already set
 stat=GET_PORT_ATR(port_2,atr_eol,atr_value)
 IF(atr_value <> 65) THEN
  stat=SET_PORT_ATR(port_2,atr_eol,65)
 ENDIF
END port_atr
```

A.8.7 GET_PORT_CMT Built-In Procedure

Purpose: Allows a KAREL program to determine the comment that is set for a specified logical port

Syntax : GET_PORT_CMT(port_type, port_no, comment_str, status)

Input/Output Parameters :

[in] port_type :INTEGER

[in] port_no :INTEGER

[out] comment_str :STRING

[out] status :INTEGER

%ENVIRONMENT Group :IOSETUP

Details:

- *port_type* specifies the code for the type of port whose comment is being returned. Codes are defined in FR:KLIOTYPS.KL.
- *port_no* specifies the port number whose comment is being set.
- *comment_str* is returned with the comment for the specified port. This should be declared as a STRING with a length of at least 16 characters.
- *status* is returned with zero if the parameters are valid and the comment is returned for the specified port.

See Also: GET_PORT_VAL, GET_PORT_MOD, SET_PORT_CMT, SET_PORT_VAL, SET_PORT_MOD Built-in Procedures.

A.8.8 GET_PORT_MOD Built-In Procedure

Purpose: Allows a KAREL program to determine what special port modes are set for a specified logical port

Syntax : GET_PORT_MOD(port_type, port_no, mode_mask, status)

Input/Output Parameters :

[in] port_type :INTEGER

[in] port_no :INTEGER

[out] mode_mask :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :IOSETUP

Details:

- *port_type* specifies the code for the type of port whose mode is being returned. Codes are defined in FR:KLIOTYPS.KL.
- *port_no* specifies the port number whose mode is being set.
- *mode_mask* is returned with a mask specifying which modes are turned on. The following modes are defined:

1 :reverse mode

Sense of the port is reversed; if the port is set to TRUE, the physical output is set to FALSE. If the port is set to FALSE, the physical output is set to TRUE. If a physical input is TRUE, when the port is read, FALSE is returned. If a physical input is FALSE, when the port is read, TRUE is returned.

2 :complementary mode

The logical port is assigned to two physical ports whose values are complementary. In this case, port_no must be an odd number. If port n is set to TRUE, then port n is set to TRUE and port n + 1 is set to FALSE. If port n is set to FALSE, then port n is set to FALSE and port n + 1 is set to TRUE. This is effective only for output ports.

- *status* is returned with zero if the parameters are valid and the specified mode is returned for the specified port.

Example: The following example gets the mode(s) for a specified port.

GET_PORT_MOD_Built-In Procedure

```
PROGRAM getmodprog
%ENVIRONMENT IOSETUP
%INCLUDE FR:\kliotyps
 ROUTINE get_mode( port_type:  INTEGER;
       port_no:   INTEGER;
       reverse:   BOOLEAN;
       complementary: BOOLEAN): INTEGER
  VAR
   mode:  INTEGER
   status: INTEGER
  BEGIN
   GET_PORT_MOD(port_type, port_no, mode, status)
   IF (status <>0) THEN
    RETURN (status)
   ENDIF
   IF (mode AND 1) <> 0 THEN
    reverse = TRUE
   ELSE
    reverse = FALSE
   ENDIF
   IF (mode AND 2) <> 0 THEN
    complementary = TRUE
   ELSE
    complementary = FALSE
   ENDIF
   RETURN (status)
  END get_mode
 BEGIN
 END getmodprog
```

A.8.9 GET_PORT_SIM Built-In Procedure

Purpose: Gets port simulation status

Syntax : GET_PORT_SIM(port_type, port_no, simulated, status)

Input/Output Parameters:

[in] port_type :INTEGER

[in] port_no :INTEGER

[out] simulated :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :IOSETUP

Details:

- *port_type* specifies the code for the type of port to get. Codes are defined in FRS:KLIOTYPS.KL.
- *port_no* specifies the number of the port whose simulation status is being returned.
- *simulated* returns TRUE if the port is being simulated, FALSE otherwise.
- *status* is returned with zero if the port is valid.

See Also: GET_PORT_MOD, SET_PORT_SIM, SET_PORT_MOD Built-in Procedures.

A.8.10 GET_PORT_VAL Built-In Procedure

Purpose: Allows a KAREL program to determine the current value of a specified logical port

Syntax : GET_PORT_VAL(port_type, port_no, value, status)

Input/Output Parameters :

[in] port_type :INTEGER

[in] port_no :INTEGER

[out] value :STRING

[out] status :INTEGER

%ENVIRONMENT Group :IOSETUP

Details:

- *port_type* specifies the code for the type of port whose comment is being returned. Codes are defined in FR:KLIOTYPS.KL.
- *port_no* specifies the port number whose comment is being set.
- *value* is returned with the current value (status) of the specified port. For BOOLEAN port types, (i.e. DIN), this will be 0 = OFF, or 1 = ON.
- *status* is returned with zero if the parameters are valid and the comment is returned for the specified port.

See Also: GET_PORT_CMT, GET_PORT_MOD, SET_PORT_CMT, SET_PORT_VAL, SET_PORT_MOD Built-in Procedures.

A.8.11 GET_POS_FRM Built-In Procedure

Purpose: Gets the uframe number and utool number of the specified position in the specified teach pendant program.

Syntax : GET_POS_FRM(open_id, position_no, gnum, ufram_no, utool_no, status)

Input/Output Parameters :

[in] open_id :INTEGER

[in] position_no :INTEGER

[in] gnum :INTEGER

[out] ufram_no :INTEGER

[out] utool_no :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :pbcore

Details:

- *open_id* specifies the opened teach pendant program. A program must be opened before calling this built-in.
- *position_no* specifies the position in the teach pendant program.

- *gnum* specifies the group number of position.
- *ufram_no* is returned with the frame number of position_no.
- *utool_no* is returned with the tool number of position_no.
- If the specified position, *position_no* , is uninitialized, the *status* is set to 17038, "Uninitialized TPE position."
- *status* indicates the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: GET_POS_TYP, CHECK_EPOS.

A.8.12 GET_POS_REG Built-In Function

Purpose: Gets an XYZWPR value from the specified register

Syntax : GET_POS_REG(register_no, status <,group_no>)

Function Return Type :XYZWPREXT

Input/Output Parameters:

[in] register_no :INTEGER

[out] status :INTEGER

[in] group_no :INTEGER

%ENVIRONMENT Group :REGOPE

Details:

- *register_no* specifies the position register to get.
- If *group_no* is omitted, the default group for the program is assumed.
- If *group_no* is specified, it must be in the range of 1 to the total number of groups defined on the controller.
- GET_POS_REG returns the position in XYZWPREXT format. Use POS_REG_TYPE to determine the position representation.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: GET_JPOS_REG, SET_JPOS_REG, SET_POS_REG, GET_REG Built-in Procedures.

Example: Refer to Section B.5 ,"Using Register Built-ins" (REG_EX.KL), for a detailed program example.

A.8.13 GET_POS_TPE Built-In Function

Purpose: Gets an XYZWPREXT value from the specified position in the specified teach pendant program

Syntax : GET_POS_TPE(open_id, position_no, status <, group_no>)

Function Return Type :XYZWPREXT

Input/Output Parameters:

[in] open_id : INTEGER

[in] position_no : INTEGER

[out] status : INTEGER

[in] group_no : INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *open_id* specifies the opened teach pendant program. A program must be opened before calling this built-in.
- *position_no* specifies the position in the program to get.
- No conversion is done for the position representation. The positional data must be in XYZWPR or XYZWPREXT, otherwise, an error status is returned. Use GET_POS_TYP to get the position representation.
- If the specified position in the program is uninitialized, the returned XYZWPR value is uninitialized and status is set to 17038, "Uninitialized TPE Position."
- If *group_no* is omitted, the default group for the program is assumed.
- If *group_no* is specified, it must be in the range of 1 to the total number of groups defined on the controller.
- *status* explains the status of the attempted operation. If not equal to 0, then an error has occurred.

See Also: GET_JPOS_TPE, SET_JPOS_TPE, SET_POS_TPE, GET_POS_TYP Built-in Procedures.

Example: Refer to Section B.14 , "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL), for a detailed program example.

A.8.14 GET_POS_TYP Built-In Procedure

Purpose: Gets the position representation of the specified position in the specified teach pendant program

Syntax : GET_POS_TYP(open_id, position_no, group_no, posn_typ, num_axs, status)

Input/Output Parameters:

[in] open_id :INTEGER

[in] position_no :INTEGER

[in] group_no :INTEGER

[out] posn_typ :INTEGER

[out] num_axs :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *open_id* specifies the opened teach pendant program. A program must be opened before calling this built-in.
- *position_no* specifies the position in the program.
- *group_no* specifies the group number.
- Position type is returned by *posn_typ*. *posn_typ* is defined as follows:2 :XYZWPR6 :XYZWPREXT9 :JOINTPOS
- If it is in joint position, the number of the axis in the representation is returned by *num_axs* .
- If the specified position in the program is uninitialized, then a status is set to 17038, "Unintialized TPE Position."
- *status* explains the status of the attempted operation. If not equal to 0, then an error has occurred.

Example: Refer to Section B.14 , "Applying Offsets to a Copied Teach Pendant Program" (CPY_T.KL), for a detailed program example.

A.8.15 GET_PREG_CMT Built-In-Procedure

Purpose: To retrieve the comment information of a KAREL position register based on a given register number.

Syntax: GET_PREG_CMT (register_no, comment_string, status)

Input/Output Parameters:

[in] register_no: INTEGER

[out] comment_string: STRING

[out] status: INTEGER

%ENVIORNMENT group: REGOPE

Details:

- Register_no specifies which position register to retrieve the comments from. The comment of the given position register is returned in the comment_string.

A.8.16 GET_QUEUE Built-In Procedure

Purpose: Retrieves the specified oldest entry from a queue

Syntax : GET_QUEUE(queue, queue_data, value, status, sequence_no)

Input/Output Parameters:

[in,out] queue_t :QUEUE_TYPE

[in,out] queue_data :ARRAY OF INTEGER

[out] value :INTEGER

[out] sequence_no :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBQMGR

Details:

- *queue_t* specifies the queue variable for the queue from which the value is to be obtained.
- *queue_data* specifies the array variable with the queue data.
- *value* is returned with the oldest entry obtained from the queue.
- *sequence_no* is returned with the sequence number of the returned entry.
- *status* is returned with the zero if an entry is successfully obtained from the queue. Otherwise, a value of 61002, ‘‘Queue is empty,’’ is returned.

See Also: MODIFY_QUEUE Built-In Procedure, Section 14.8 , "Using Queues for Task Communication

Example: In the following example the routine **get_nxt_err** returns the oldest entry from the error queue, or zero if the queue is empty.

GET_QUEUE Built-In Procedure

```
PROGRAM get_queue_x
  %environment PBQMGR
  VAR
    error_queue FROM global_vars: QUEUE_TYPE
    error_data FROM global_vars: ARRAY[100] OF INTEGER

  ROUTINE get_nxt_err: INTEGER
  VAR
    status: INTEGER
    value: INTEGER
    sequence_no: INTEGER

  BEGIN
  GET_QUEUE(error_queue, error_data, value, sequence_no, status)
  IF (status = 0) THEN
    RETURN (value)
  ELSE
    RETURN (0)
  ENDIF
  END get_nxt_err
  BEGIN
  END get_queue_x
```

A.8.17 GET_REG Built-In Procedure

Purpose: Gets an INTEGER or REAL value from the specified register

Syntax : GET_REG(register_no, real_flag, int_value, real_value, status)

Input/Output Parameters:

[in] register_no :INTEGER

[out] real_flag :BOOLEAN

[out] int_value :INTEGER

[out] real_value :REAL

[out] status :INTEGER

%ENVIRONMENT Group :REGOPE

Details:

- *register_no* specifies the register to get.
- *real_flag* is set to TRUE and *real_value* to the register content if the specified register has a real value. Otherwise, *real_flag* is set to FALSE and *int_value* is set to the contents of the register.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

Example: Refer to Section B.5 ,"Using Register Built-ins" (REG_EX.KL), for a detailed program example.

A.8.18 GET_REG_CMT

Purpose: To retrieve the comment information of a KAREL register based on a given register number.

Syntax: GET_REG_CMT (register_no, comment_string, status)

Input/Output Parameters:

[in] register_no: INTEGER

[out] comment_string: STRING

[out] status: INTEGER

%ENVIRONMENT group: REGOPE

Details:

- Register_no specifies which register to retrieve the comments from. The comment of the given register is returned in comment_string.

A.8.19 GET_TIME Built-In Procedure

Purpose: Retrieves the current time (in integer representation) from within the KAREL system

Syntax : GET_TIME(i)

Input/Output Parameters:

[out] i :INTEGER

%ENVIRONMENT Group :TIM

Details:

- *i* holds the INTEGER representation of the current time stored in the KAREL system. This value is represented in 32-bit INTEGER format as follows:

Table A–11. INTEGER Representation of Current Time

31–25	24–21	20–16
year	month	day
15–11	10–5	4–0
hour	minute	second

- The contents of the individual fields are as follows:
  - — DATE:

    Bits 31-25 — Year since 1980

    Bits 24-21 — Month (1-12)

    Bits 20-16 — Day of the month
  - — TIME:

    Bits 15-11 — Number of hours (0-23)

    Bits 10-5 — Number of minutes (0-59)

    Bits 4-0 — Number of 2-second increments (0-29)
- INTEGER values can be compared to determine if one time is more recent than another.
- Use the CNV_TIME_STR built-in procedure to convert the INTEGER into the ‘‘DD-MMM-YYY HH:MM:SS’’ STRING format.

See Also: CNV_TIME_STR Built-In Procedure

Example: Refer to Section B.9 , "Using the File and Device Built-ins" (FILE_EX.KL), for a detailed program example.

A.8.20 GET_TPE_CMT Built-in Procedure

Purpose: This built-in provides the ability for a KAREL program to read the comment associated with a specified position in a teach pendant program.

Syntax : GET_TPE_CMT(open_id, pos_no, comment, status)

Input/Output Parameters:

[in] open_id :INTEGER

[in] pos_no :INTEGER

[out] comment :STRING

[out] status :INTEGER

%ENVIRONMENT Group :TPE

Details:

- *open_id* specifies the open_id returned from a previous call to OPEN_TPE.
- *pos_no* specifies the number of the position in the TPP program to get a comment from.
- *comment* is associated with specified positions and is returned with a zero length string if the position has no comment. If the string variable is too short for the comment, an error is returned and the string is not changed.
- *status* indicates zero if the operation was successful, otherwise an error code will be displayed.

See Also: SET_TPE_CMT and OPEN_TPE for more Built-in Procedures.

A.8.21 GET_TPE_PRM Built-in Procedure

Purpose: Gets the values of the parameters when parameters are passed in a TPE CALL or MACRO instruction.

Syntax : GET_TPE_PRM(param_no, data_type, int_value, real_value, str_value, status)

Input/Output Parameters:

[in] param_no :INTEGER

[out] data_type :INTEGER

[out] int_value :INTEGER

[out] real_value :REAL

[out] str_value :STRING

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *param_no* indicates the number of the parameter. There can be at most ten parameters.
- *data_type* indicates the data type for the parameter, as follows:
  - 1 : INTEGER
  - 2 : REAL
  - 3 : STRING
- *int_value* is the value of the parameter if the data_type is INTEGER.
- *real_value* is the value of the parameter if the data_type is REAL.
- *str_value* is the value of the parameter if the data_type is STRING.
- *status* explains the status of the attempted operation. If not equal to 0, then an error has occurred.
- If the parameter designated by param_no does not exist, a status of 17042 is returned, which is the error message: "ROUT-042 WARN TPE parameters do not exist." If this error is returned, confirm the param_no and the parameter in the CALL or MACRO command in the main TPE program.

See Also: *FANUC Robotics SYSTEM R-J3iC Controller Application-Specific Setup and Operations Manual* , for information on using parameters in teach pendant CALL or MACRO instructions.

Example: The following example shows the implementation of a macro (Send Event) with CALL parameters that are retrieved by a KAREL program that uses the GET_TPE_PRM built-in.

GET_TPE_PRM Built-In Procedure

```
Macro table entry for the Send Event macro:
109 [Send Event             ] [SENDEVNT]--[  0]
Teach pendant program, TEST1.TP, which uses the Send Event
macro:
1:  ! Send Event 7
   2:  ! Wait for PC answer
   3:  ! Answer in REG 5
   4:  Send Event(7,1,5)
   5:  IF R[5]<9999,JMP LBL[10]
   6:  ! Error in macro
   7:  !
   8:  LBL[10]
Teach pendant program SENDEVNT.TP, which implements the
Send Event macro by calling the GESNDEVT KAREL
program and passing the CALL parameters from Send Event:
   1:  !Send Event Macro
   2:  CALL GESNDEVT(AR[1],AR[2],AR[3])
Snippet of the KAREL program GESNDEVT.KL, which gets the
```

```
parameter information using the GET_TPE_PRM
built-in:
 PROGRAM GESNDEVT
  . . .
 BEGIN
  --  Send Event(event_no [,wait_sw [,status_reg]] )
  -- get parameter 1 (mandatory parameter)
  Get_tpe_prm(1, data_type, event_no,real_value,string_value,status)
  IF status<>0 THEN  -- 17042 "ROUT-042 TPE parameters do not exist"
    POST_ERR(status, '', 0, er_abort)
  ELSE
    IF data_type <> PARM_INTEGER THEN  -- make sure parm is an integer
      POST_ERR(er_pceventer, '1', 0, er_abort)
    ELSE
      IF (event_no < MIN_EVENT) OR (event_no > MAX_EVENT) THEN
        POST_ERR(er_illevent, '', 0, er_abort)
     ENDIF
    ENDIF
  ENDIF

  -- get second parameter (optional)
  Get_tpe_prm(2, data_type, wait_sw,real_value,string_value,status)
  IF status<>0 THEN
    IF status = ER17042 THEN   -- "ROUT-142 Parameter doesn't exist"
       wait_sw = 0  -- DEFAULT no wait
    ELSE
      POST_ERR(status, '', 0, er_warn) -- other error
    ENDIF
  . . .
```

A.8.22 GET_TSK_INFO Built-In Procedure

Purpose: Get the value of the specified task attribute

Syntax : GET_TSK_INFO(task_name, task_no, attribute, value_int, value_str, status)

Input/Output Parameters:

[in,out] task_name :STRING

[in,out] task_no :INTEGER

[in] attribute :INTEGER

[out] value_int :INTEGER

[out] value_str :STRING

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *task_name* is the name of the task of interest. *task_name* is used as input only if *task_no* is uninitialized or set to 0, otherwise, *task_name* is considered an output parameter.
- *task_no* is the task number of interest. If *task_no* is uninitialized or set to 0, it is returned as an output parameter.
- *attribute* is the task attribute whose value is to be returned. It will be returned in *value_int* unless otherwise specified. The following attributes are valid:

  TSK_HOLDCOND : Task hold conditions

  TSK_LINENUM : Current executing line number

  TSK_LOCKGRP : Locked group

  TSK_MCTL : Motion controlled groups

  TSK_NOABORT : Ignore abort request

  TSK_NOBUSY : Busy lamp off

  TSK_NOPAUSE : Ignore pause request

  TSK_NUMCLDS : Number of child tasks

  TSK_PARENT : Parent task number

  TSK_PAUSESFT : Pause on shift release

  TSK_PRIORITY : Task priority

  TSK_PROGNAME : Current program name returned in value_str

  TSK_PROGTYPE : Program type - refer to description below

  TSK_ROUTNAME : Current routine name returned in value_str

  TSK_STACK : Stack size

  TSK_STATUS : Task status — refer to description below

  TSK_STEP : Single step task

TSK_TIMESLIC : Time slice duration in ms

TSK_TPMOTION : TP motion enable

TSK_TRACE : Trace enable

TSK_TRACELEN : Length of trace array

- TSK_STATUS is the task status: The return values are:

  PG_RUNACCEPT : Run request has been accepted

  PG_ABORTING : Abort has been accepted

  PG_RUNNING : Task is running

  PG_PAUSED : Task is paused

  PG_ABORTED : Task is aborted

- TSK_PROGTYPE is the program type. The return values are:

  PG_NOT_EXEC : Program has not been executed yet

  PG_MNEMONIC : Teach pendant program is or was executing

  PG_AR_KAREL : KAREL program is or was executing

- *status* explains the status of the attempted operation. If it is not equal to 0, then an error occurred.

See Also: Chapter 14 *MULTI-TASKING*

Example: See examples in Chapter 14 *MULTI-TASKING*

A.8.23 GET_USEC_SUB Built-In Procedure

Purpose: Returns an INTEGER value indicating the elapsed time in microseconds (1/1,000,000).

Syntax: us_delta = GET_USEC_SUB(us2, us1)

Function Return Type :INTEGER

Input/Output Parameters :

[in] us2: INTEGER

[in] us1: INTEGER

%ENVIRONMENT Group: TIM

Details:

- us2 is the second time returned from GET_USEC_TIM.
- us1 is the first time returned from GET_USEC_TIM.
- The returned value is the INTEGER representation of the elapsed time us2 - us1 in microseconds.
- This is intended to measure fast operations. The result will wrap after 2 minutes and will no longer be valid.

Example: The following example measures the amount of time in microseconds to increment a number.

Figure A–2. GET_USEC_SUB Built-In Function

```
i = 0
us1 = GET_USEC_TIM
i = i + 1
us_delta = GET_USEC_SUB(GET_USEC_TIM, us1)
WRITE ('Time to increment a number: ', us_delta, ' us', CR)
```

A.8.24 GET_USEC_TIM Built-In Function

Purpose: Returns an INTEGER value indicating the current time in microseconds (1/1,000,000) from within the KAREL system.

Syntax: us = GET_USEC_TIM

Function Return Type: INTEGER

Input/Output Parameters:

None

%ENVIRONMENT Group: TIM

Details:

- The returned value is the INTEGER representation of the current time in microseconds stored in the KAREL system.
- This function is used with the GET_USEC_SUB built-in function to determine the elapsed time of an operation.

A.8.25 GET_VAR Built-In Procedure

Purpose: Allows a KAREL program to retrieve the value of a specified variable

Syntax : GET_VAR(entry, prog_name, var_name, value, status)

Input/Output Parameters:

[in,out] entry :INTEGER

[in] prog_name :STRING

[in] var_name :STRING

[out] value :Any valid KAREL data type except PATH, VIS_PROCESS, and MODEL

[out] status :INTEGER

%ENVIRONMENT Group :SYSTEM

Details:

- *entry* returns the entry number in the variable data table of *var_name* in the device directory where *var_name* is located. This variable should not be modified.
- *prog_name* specifies the name of the program that contains the specified variable. If *prog_name* is blank, it will default to the current task name being executed. Set the *prog_name* to '*SYSTEM*' to get a system variable.
- *var_name* must refer to a static, program variable.
- *var_name* can contain node numbers, field names, and/or subscripts.
- If both *var_name* and *value* are ARRAYs, the number of elements copied will equal the size of the smaller of the two arrays.
- If both *var_name* and *value* are STRINGs, the number of characters copied will equal the size of the smaller of the two strings.
- If both *var_name* and *value* are STRUCTUREs of the same type, *value* will be an exact copy of *var_name* .
- *value* is the value of *var_name* .
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.
- If the value of *var_name* is uninitialized, then *value* will be set to uninitialized and *status* will be set to 12311.

See Also: SET_VAR Built-In Procedure



Caution

Using GET_VAR to modify system variables could cause unexpected results.

Example: The following example displays two programs, **util_prog** and **task** . The program **util_prog** uses a FOR loop to increment the value of the INTEGER variable **num_of_parts** . **util_prog** also assigns values to the ARRAY **part_array** . The program **task** uses two GET_VAR statements to retrieve the values of **num_of_parts** and **part_array[3]** . The value of **num_of_parts** is assigned to the INTEGER variable **count** and **part_array[3]** is assigned to the STRING variable **part_name** . The last GET_VAR statement places the value of **count** into another INTEGER variable **newcount** .

GET_VAR Built-In Procedure

```
PROGRAM util_prog
    VAR
      j, num_of_parts : INTEGER
      part_array      : ARRAY[5] OF STRING[10]
    BEGIN
      num_of_parts = 0

      FOR j = 1 to 20 DO
        num_of_parts = num_of_parts + 1
      ENDFOR
      part_array[1] = 10
      part_array[2] = 20
      part_array[3] = 30
      part_array[4] = 40
      part_array[5] = 50
    END util_prog
  PROGRAM task
    VAR
      entry, status    : INTEGER
      count, new_count : INTEGER
      part_name        : STRING[20]
    BEGIN
      GET_VAR(entry, 'util_prog', 'part_array[3]', part_name, status)
      WRITE('Part Name is Now....>', part_name, cr)

      GET_VAR(entry, 'util_prog', 'num_of_parts', count, status)
      WRITE('COUNT Now Equals....>', count, cr)

      GET_VAR(entry, 'task', 'count', new_count, status)

    END task
```

A.8.26 GO TO Statement

Purpose: Transfers control to a specified statement

Syntax : || GO TO | GOTO || stmnt_label

where:

stmnt_label : A valid KAREL identifier

Details:

- *stmnt_label* must be defined in the same routine or program body as the GO TO statement.
- Label identifiers are followed by double colons (::). Executable statements may or may not follow on the same line.
- GOTO should only be used in special circumstances where normal control structures such as WHILE, REPEAT, and FOR loops would be awkward or difficult to implement.

See Also: Section 2.1.5, "Labels," for more information on rules for labels, Appendix E, "Syntax Diagrams," for additional syntax information

Example: The following example moves the TCP from one position to another depending on the status of DIN[1].

GO TO Statement

```
BEGIN
     IF NOT DIN[1] THEN MOVE TO p1
     ELSE GO TO end_it
     ENDIF
     IF NOT DIN[1] THEN MOVE TO p2
     ELSE GO TO end_it
     ENDIF
  END_IT::
```

A.8.27 GROUP_ASSOC Data Type

Purpose: Declares a variable or structure field as a GROUP_ASSOC data type

Syntax : GROUP_ASSOC <IN GROUP[n]>

Details:

- GROUP_ASSOC consists of a record containing the standard associated data for a motion group.

It contains the following predefined fields, all INTEGERs except for SEGBREAK, which is a BOOLEAN:

— SEGRELSPEED : percentage of nominal speed

— SEGMOTYPE : motion type

— SEGORIENTYPE: orientation control mode

— SEGBREAK : not implemented

- Variables and fields of structures can be declared GROUP_ASSOC.
- Subfields of this structure can be accessed and set using the usual structure field notation.
- Variables and fields declared GROUP_ASSOC can be:
  — Passed as parameters.
  — Written to and read from unformatted files.
  — Assigned to one another.
- Each subfield of a GROUP_ASSOC variable or structure field can be passed as a parameter to a routine, but is always passed by value.
- The keyword GROUP_ASSOC can be followed by a clause IN GROUP[n] to specify the group to which the data applies. If it is not present, it is assumed that the data is to apply to the default group specified by the %DEFGROUP directive.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: Section 8.5.7 , "Path Motion," for default values

Example: Refer to Section B.2 , "Copying Path Variables" (CPY_PTH.KL), for a detailed program example.

A.9 - H - KAREL LANGUAGE DESCRIPTION

A.9.1 HOLD Action

Purpose: Causes the current motion to be held and prevents subsequent motions from starting

Syntax : HOLD <GROUP[n,{,n}]>

Details:

- Any motion in progress is held. Robot and auxiliary or extended axes decelerate to a stop.
- An attempted motion after a HOLD is executed is also held. HOLD cannot be overridden by a condition handler which issues a motion.
- HOLD is released using the UNHOLD statement or action.
- If the group clause is not present, all groups for which the task has control (when the condition is defined) will be canceled.
- If a motion that is held is part of a SIMULTANEOUS or COORDINATED motion with other groups, the motions for all groups are held.
- Motion cannot be held for a different task.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: Chapter 8 *MOTION* , for more information on starting and stopping motions

Example: The following example uses a local condition handler to move along the path pathvar but stops the motion before node 3 using the HOLD action.

HOLD Action

```
MOVE ALONG pathvar,
  WHEN TIME 200 BEFORE NODE[3] DO
    HOLD
ENDMOVE
```

A.9.2 HOLD Statement

Purpose: Causes the current motion to be held and prevents subsequent motions from starting

Syntax : HOLD <GROUP[n{,n}]>

Details:

- Any motion in progress is held. Robot and auxiliary or extended axes decelerate to a stop.

- An attempted motion after a HOLD is executed is also held. HOLD cannot be overridden by a condition handler which issues a motion.
- HOLD is released using the UNHOLD statement or action.
- All held motions are canceled if a RELEASE statement is executed while motion is held.
- If the group clause is not present, all groups for which the task has control will be canceled.
- If a motion that is stopped, resumed, canceled, or held is part of a SIMULTANEOUS or COORDINATED motion with other groups, the motions for all groups are stopped, resumed, canceled, or held.
- Motion cannot be held for a different task.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: Chapter 8 *MOTION* , for more information on starting and stopping motions, Appendix E, "Syntax Diagrams," for additional syntax information

Example: The following example initiates a move along the path *pathvar* but stops the motion until the F1 key TPIN[1] on the teach pendant is pressed.

HOLD Statement

```
MOVE ALONG path_var NOWAIT
  HOLD
  WRITE ('Press F1 on teach pendant to resume motion')
  WAIT FOR TPIN[129]+
  UNHOLD
```

A.10 - I - KAREL LANGUAGE DESCRIPTION

A.10.1 IF ... ENDIF Statement

Purpose: Executes a sequence of statements if a BOOLEAN expression is TRUE; an alternate sequence can be executed if the condition is FALSE.

Syntax : IF bool_exp THEN

{ true_stmnt } < ELSE

{ false_stmnt } >ENDIF

where:

bool_exp : BOOLEAN

true_stmnt : An executable KAREL statement

false_stmnt : An executable KAREL statement

Details:

- If *bool_exp* evaluates to TRUE, the statements contained in the *true_stmnt* are executed. Execution then continues with the first statement after the ENDIF.
- If *bool_exp* evaluates to FALSE and no ELSE clause is specified, execution skips directly to the first statement after the ENDIF.
- If bool_exp evaluates to FALSE and an ELSE clause is specified, the statements contained in the *false_stmnt* are executed. Execution then continues with the first statement after the ENDIF.
- IF statements can be nested in either *true_stmnt* or *false_stmnt* .

See Also: Appendix E , ‘‘Syntax Diagrams,’’ for additional syntax information

Example: Refer to the following sections for detailed program examples:

Section B.3, "Saving Data to the Default Device" (SAVE_VR.KL)

Section B.5, "Using Register Built-ins" (REG_EX.KL)

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.7, "Listing Files and Programs and Manipulating Strings" (LIST_EX.KL)

Section B.9, "Using the File and Device Built-ins" (FILE_EX.KL)

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL)

Section B.13, "Using the DISCTRL_ALPHA Built-in" (DCALP_EX.KL)

Section B.14, "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.10.2 IN Clause

Purpose: Specifies where a variable will be created

Syntax : IN (CMOS | DRAM | SHADOW)

Details:

- The IN clause can be part of a variable declaration. It should be specified before the FROM clause.
- IN *CMOS* specifies that the variable will be created in permanent memory.
- IN *DRAM* specifies that the variable will be created in temporary memory.
- IN *SHADOW* specifies that any changes made to the variable will be maintained in CMOS. Writes to this type of variable are slower but reads are much faster. This a good memory type to use for configuration parameters that are currently in CMOS.
- IN *UNINIT_DRAM* specifies that a DRAM variable is UNINITIALIZED at startup.
- If the IN clause is not specified all variables are created in temporary memory; unless the %CMOSVARS or %SHADOW directive is specified, in which case all variables will be created in permanent memory.
- The IN clause cannot be used when declaring variables in the declaration section of a routine.

See Also: Section 1.4.1 , %CMOSVARS Translator Directive, %SHADOW Translator Directive, %SHADOWCMOS Translator Directive

Example: Refer to the following sections for detailed program examples:

In DRAM, Section B.2 , "Copying Path Variables" (CPY_PTH.KL)

In CMOS, Section B.10 , "Using Dynamic Display Built-ins" (DYN_DISP.KL) or Section B.11 , "Manipulating Values of Dynamically Displayed Variables" (CHG_DATA.KL)

A.10.3 %INCLUDE Translator Directive

Purpose: Inserts other files in a program at translation time.

Syntax : %INCLUDE file_spec

Details:

- *file_spec* is the name of the file to include. It has the following details:
  - — The file name specified must be no longer than 12 characters.

— The file type defaults to .KL, and so it does not appear in the directive.

- The %INCLUDE directive must appear on a line by itself.
- The specified files usually contain declarations, such as CONST or VAR declarations. However, they can contain any portion of a program including executable statements and even other %INCLUDE directives.
- Included files can themselves include other files up to a maximum depth of three nested included files. There is no limit on the total number of included files.
- When the KAREL language translator encounters a %INCLUDE directive during translation of a file, it begins translating the included file just as though it were part of the original file. When the entire file has been included, the translator resumes with the original file.
- Some examples in Appendix A reference the following include files:

  %INCLUDE FR:\klevkmsk

  %INCLUDE FR:\klevkeys

  %INCLUDE FR:\klevccdf

  %INCLUDE FR:\kliotyps

  These files contain constants that can be used in your KAREL programs. If you are translating on the controller, you can include them directly from the FROM disk.

  The include files are also available on the OLPC disks, and are copied to the hard disk as part of the installation process.

  Example: Refer to the following sections for detailed program examples:

Section B.2, "Copying Path Variables" (CPY_PTH.KL)

Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL)

Section B.13, "Using the DISCTRL_ALPHA Built-in" (DCALP_EX.KL)

Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.10.4 INDEX Built-In Function

Purpose: Returns the index for the first character of the first occurrence of a specified STRING argument in another specified STRING argument. If the argument is not found, a 0 value is returned.

Syntax : INDEX(main, find)

Function Return Type :INTEGER

Input/Output Parameters:

[in] main :STRING

[in] find :STRING

%ENVIRONMENT Group :SYSTEM

Details:

- The returned value is the index position in *main* corresponding to the first character of the first occurrence of *find* or 0 if *find* does not occur in *main* .

Example: The following example uses the INDEX built-in function to look for the first occurrence of the string "Old" in **part_desc** .

INDEX Built-In Function

```
class_key = 'Old'
   part_desc = 'Refurbished Old Part'
   IF INDEX(part_desc, class_key) > 0 THEN
      in_class = TRUE
   ENDIF
```

A.10.5 INI_DYN_DISB Built-In Procedure

Purpose: Initiates the dynamic display of a BOOLEAN variable. This procedure displays elements of a STRING ARRAY depending of the current value of the BOOLEAN variable.

Syntax : INI_DYN_DISB (b_var, window_name, field_width, attr_mask, char_size, row, col, interval, strings, status)

Input/Output Parameters :

[in] b_var :BOOLEAN

[in] window_name :STRING

[in] field_width :INTEGER

[in] attr_mask :INTEGER

[in] char_size :INTEGER

[in] row :INTEGER

[in] col :INTEGER

[in] interval :INTEGER

[in] strings :ARRAY OF STRING

[out] status :INTEGER

%ENVIRONMENT Group :UIF

Details:

- The dynamic display is initiated based on the value of *b_var* . If *b_var* is FALSE, *strings[1]* is displayed; if *b_var* is TRUE, *strings[2]* is displayed. If *b_var* is uninitialized, a string of *'s is displayed. Both *b_var* and *strings* must be static (not local) variables.
- *window_name* must be a previously defined window name. See Section 7.10.1 . and Section 7.10.2 for predefined window names.
- If *field_width* is non-zero, the display is extended with blanks if the element of *strings[n]* is shorter than this specified width. The area is cleared when the dynamic display is canceled.
- *attr_mask* is a bit-wise mask that indicates character display attributes. This should be one of the following constants:

  0 :Normal

  1 :Bold (Supported only on the CRT)

  2 :Blink (Supported only on the CRT)

  4 :Underline

  8 :Reverse video
- To have multiple display attributes, use the OR operator to combine the constant attribute values together. For example, to have the text displayed as bold and underlined use 1 OR 4.
- *char_size* specifies whether data is to be displayed in normal, double-wide, or double-high, double-wide sizes. This should be one of the following constants:

  0 :Normal

  1 :Double-wide (Supported only on the CRT)

2 :Double-high, double-wide

- *row* and *col* specify the location in the window in which the data is to be displayed.
- *interval* indicates the minimum time interval, in milliseconds, between updates of the display. This must be greater then zero. The actual time might be greater since the task that formats the display runs at a low priority.
- *strings[n]* contains the text that will be displayed.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: CNC_DYN_DISB built-in procedure

Example: Refer to Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL), for a detailed program example.

A.10.6 INI_DYN_DISE Built-In Procedure

Purpose: Initiates the dynamic display of an INTEGER variable. This procedure displays elements of a STRING ARRAY depending of the current value of the INTEGER variable.

Syntax : INI_DYN_DISE (e_var, window_name, field_width, attr_mask, char_size, row, col, interval, strings, status)

Input/Output Parameters :

[in] e_var :INTEGER

[in] window_name :STRING

[in] field_width :INTEGER

[in] attr_mask :INTEGER

[in] char_size :INTEGER

[in] row :INTEGER

[in] col :INTEGER

[in] interval :INTEGER

[in] strings :ARRAY OF STRING

[out] status :INTEGER

%ENVIRONMENT Group :UIF

Details:

- The dynamic display is initiated based on the value of *e_var* . If *e_var* has a value of n, *strings[n+1]* is displayed; if *e_var* has a negative value, or a value greater than or equal to the length of the array of *strings* , a string of '?'s is displayed. Both *e_var* and *string s* must be static (not local) variables.
- Refer to the INI_DYN_DISB built-in procedure for a description of the other parameters listed above.

See Also: CNC_DYN_DISE built-in procedure

Example: Refer to Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL), for a detailed program example.

A.10.7 INI_DYN_DISI Built-In Procedure

Purpose: Initiate the dynamic display of an INTEGER variable in a specified window.

Syntax : INI_DYN_DISI(i_var, window_name, field_width, attr_mask, char_size, row, col, interval, buffer_size, format, status)

Input/Output Parameters:

[in] i_var :INTEGER

[in] window_name :STRING

[in] field_width :INTEGER

[in] attr_mask :INTEGER

[in] char_size :INTEGER

[in] row :INTEGER

[in] col :INTEGER

[in] interval :INTEGER

[in] buffer_size :INTEGER

[in] format :STRING

[out] status :INTEGER

%ENVIRONMENT Group :UIF

Details:

- *i_var* is the integer whose dynamic display is to be initiated.
- If *field_width* is non-zero, the display is extended with blanks if *i_var* is shorter than this specified width. The area is cleared when the dynamic display is canceled.
- *buffer_size* is not implemented.
- *format* is used to print out the variable. This can be passed as a literal enclosed in single quotes. The format string begins with a % and ends with a conversion character. Between the % and the conversion character there can be, in order:
  - — Flags (in any order), which modify the specification:

    - : specifies left adjustment of this field.

    + : specifies that the number will always be printed with a sign.

    0 specifies padding a numeric field width with leading zeroes.
  - — A number that specifies the minimum field width. The converted argument will be printed in a field at least this wide. If necessary it will be padded on the left (or right, if left adjustment is called for) to make up the field width.
  - — A period, which separates the field width from the precision.
  - — A number, the precision, that specifies the maximum number of characters to be printed from a string, or the number of digits after the decimal point of a floating-point value, or the minimum number of digits for an integer.

The format specifier must contain one of the conversion characters in Table A–12 .

Table A–12. Conversion Characters

Character	Argument Type; Printed As
d	INTEGER; decimal number
o	INTEGER; unsigned octal notation (without a leading zero).
x,X	INTEGER; unsigned hexadecimal notation (without a leading 0x or 0X), using abcdef or ABCDEF for 10, ..., 15.
u	INTEGER; unsigned decimal notation.

Table A–12. Conversion Characters (Cont'd)

Character	Argument Type; Printed As
s	STRING; print characters from the string until end of string or the number of characters given by the precision.
f	REAL; decimal notation of the form [-]mmm.dddddd, where the number of d's is given by the precision. The default precision is 6; a precision of 0 suppresses the decimal point.
e,E	REAL; decimal notation of the form [-]m.dddddde+-xx or [-]m.ddddddE+-xx, where the number of d's is given by the precision. The default precision is 6; a precision of 0 suppresses the decimal point.
g,G	REAL; %e or %E is used if the exponent is less than -4 or greater than or equal to the precision; otherwise %f is used. Trailing zeros and a trailing decimal pointer are not printed.
%	no argument is converted; print a %.

- Refer to the INI_DYN_DISB built-in procedure for a description of the other parameters listed above.

See Also: CNC_DYN_DISI, DEF_WINDOW Built-In Procedure

Example: Refer to Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL), for a detailed program example.

A.10.8 INI_DYN_DISP Built-In Procedure

Purpose: Initiates the dynamic display of a value of a port in a specified window, based on the port type and port number.

Syntax : INI_DYN_DISP (port_type, port_no, window_name, field_width, attr_mask, char_size, row, col, interval, strings, status)

Input/Output Parameters :

[in] port_type :INTEGER

[in] port_no :INTEGER

[in] window_name :STRING

[in] field_width :INTEGER

[in] attr_mask :INTEGER

[in] char_size :INTEGER

[in] row :INTEGER

[in] col :INTEGER

[in] interval :INTEGER

[in] strings :ARRAY OF STRING

[out] status :INTEGER

Details:

- *port_type* specifies the type of port to be displayed. Codes are defined in FROM: KLIOTYPS.KL.
  - — If the *port_type* is a BOOLEAN port (e.g., DIN), If the is FALSE, strings[1] is displayed; If variable is TRUE, strings[2] is displayed.
  - — If the *port_type* is an INTEGER port (e.g., GIN), if the value of the port is n, *strings[n+1*] will be displayed. If the value of the port is greater than or equal to the length of the array of strings, a string of '?'s is displayed.
- *port_no* specifies the port number to be displayed.
- Refer to the INI_DYN_DISB built-in procedure for a description of other parameters listed above.

See Also: CNC_DYN_DISP Built-In procedure

Example: Refer to Section B.10 , "Using Dynamic Display Built-ins" (DYN_DISP.KL), for a detailed program example.

A.10.9 INI_DYN_DISR Built-In Procedure

Purpose: Initiates the dynamic display of a REAL variable in a specified window.

Syntax : INI_DYN_DISR(r_var, window_name, field_width, attr_mask, char_size, row, col, interval, buffer_size, format, status)

Input/Output Parameters:

[in] r_var :REAL

[in] window_name :STRING

[in] field_width :INTEGER

[in] attr_ mask :INTEGER

[in] char_size :INTEGER

[in] row :INTEGER

[in] col :INTEGER

[in] interval :INTEGER

[in] buffer_size :INTEGER

[in] format :STRING

[out] status :INTEGER

%ENVIRONMENT Group :UIF

Details:

- *r_var* is the REAL variable whose dynamic display is to be initiated.
- If *field_width* is non-zero, the display is extended with blanks if *r_var* is shorter than this specified width. The area is cleared when the dynamic display is canceled.
- Refer to the INI_DYN_DISI built-in procedure for a description of other parameters listed above.

See Also: CNC_DYN_DISR Built-In Procedure

Example: Refer to Section B.10 , "Using Dynamic Display Built-ins" (DYN_DISP.KL), for a detailed program example.

A.10.10 INI_DYN_DISS Built-In Procedure

Purpose: Initiates the dynamic display of a STRING variable in a specified window.

Syntax : INI_DYN_DISS(s_var, window_name, field_width, attr_mask, char_size, row, col, interval, buffer_size, format, status)

Input/Output Parameters:

[in] s_var :STRING

[in] window_name :STRING

[in] field_width :INTEGER

[in] attr_ mask :INTEGER

[in] char_size :INTEGER

[in] row :INTEGER

[in] col :INTEGER

[in] interval :INTEGER

[in] buffer_size :INTEGER

[in] format :STRING

[out] status :INTEGER

%ENVIRONMENT Group :UIF

Details:

- *s_var* is the STRING variable whose dynamic display is to be initiated.
- If *field_width* is non-zero, the display is extended with blanks if *s_var* is shorter than this specified width. The area is cleared when the dynamic display is canceled.
- Refer to the INI_DYN_DISI built-in procedure for a description of other parameters listed above.

See Also: CNC_DYN_DISS, INI_DYN_DISI Built-In Procedures

Example: Refer to Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL), for a detailed program example.

A.10.11 INIT_QUEUE Built-In Procedure

Purpose: Sets a queue variable entry to have no entries in the queue

Syntax : INIT_QUEUE(queue)

Input/Output Parameters:

[out] queue_t :QUEUE_TYPE

%ENVIRONMENT Group : PBQMGR

Details:

- queue_t is the queue to be initialized

See Also: GET_QUEUE, MODIFY_QUEUE Built-In Procedures, QUEUE_TYPE Data Type, Section 14.8,"Using Queues for Task Communication"

Example: The following example initializes a queue called **job_queue.**

INIT_QUEUE Built-In Procedure

```
PROGRAM init_queue_x
%environment PBQMGR
VAR
  job_queue FROM globals: QUEUE_TYPE
BEGIN
  INIT_QUEUE(job_queue)
END init_queue_x
```

A.10.12 INIT_TBL Built-In Procedure

Purpose: Initializes a table on the teach pendant

Syntax : INIT_TBL(dict_name, ele_number, num_rows, num_columns, col_data, inact_array, change_array, value_array, vptr_array, table_data, status)

Input/Output Parameters:

[in] dict_name :STRING

[in] ele_number :INTEGER

[in] num_rows :INTEGER

[in] num_columns :INTEGER

[in] col_data :ARRAY OF COL_DESC_T

[in] inact_array :ARRAY OF BOOLEAN

[in] change_array :ARRAY OF ARRAY OF BOOLEAN

[in] value_array :ARRAY OF STRING

[out] vptr_array :ARRAY OF ARRAY OF INTEGER

[in,out] table_data :XWORK_T

[out] status :INTEGER

%ENVIRONMENT Group :UIF

Details:

- INIT_TBL must be called before using the ACT_TBL built-in.INIT_TBL does not need to be called if using the DISCTRL_TBL built-in.

- The INIT_TBL and ACT_TBL built-in routines should only be used instead of DISCTRL_TBL is special processing needs to be done with each keystroke or if function key processing needs to be done without exiting the table menu.
- *dict_name* is the four-character name of the dictionary containing the table header.
- *ele_number* is the element number of the table header.
- *num_rows* is the number of rows in the table.
- *num_columns* is the number of columns in the table.
- *col_data* is an array of column descriptor structures, one for each column in the table. It contains the following fields:
  - *item_type* : Data type of values in this column. The following data type constants are defined:

    TPX_INT_ITEM — Integer type

    TPX_REL_ITEM — Real type

    TPX_FKY_ITEM — Function key enumeration type

    TPX_SUB_ITEM — Subwindow enumeration type

    TPX_KST_ITEM — KAREL string type

    TPX_KSL_ITEM — KAREL string label type (can select, not edit)

    TPX_KBL_ITEM — KAREL boolean type

    TPX_BYT_ITEM — Byte type

    TPX_SHT_ITEM — Short type

    TPX_PBL_ITEM — Port boolean type

    TPX_PIN_ITEM — Port integer type
  - *start_col* : Starting character column (1..40) of the display field for this data column.
  - *field_width* : Width of the display field for this data column.
  - *num_ele* : Dictionary element used to display values for certain data types. The format of the dictionary elements for these data types are as follows:
    - TPX_FKY_ITEM: The enumerated values are placed on function key labels. There can be up to 2 pages of function key labels, for a maximum of 10 labels. Each label is a string of up to 8 characters. However, the last character of a label which is followed by another label should be left blank or the two labels will run together.
    - A single dictionary element defines all of the label values. Each value must be put on a separate line using &new_line. The values are assigned to the function keys F1..F5, F6..F10 and the numeric values 1..10 in sequence. Unlabeled function keys should be left

blank. If there are any labels on the second function key page, F6..F10, the labels for keys 5 and 10 must have the character ‘‘>’’ in column 8. If there are no labels on keys F6..F10, lines do not have to be specified for any key label after the last non-blank label.

Example:

```
$ example_fkey_label_c
   "" &new_line
   "F2" &new_line
   "F3" &new_line
   "F4" &new_line
   "F5 >" &new_line
   "F6" &new_line
   "F7" &new_line
   "" &new_line
   "" &new_line
   " >"
```

– -- TPX_SUB_ITEM: The enumerated values are selected from a subwindow on the display device. There can be up to 5 subwindow pages, for a maximum of 35 values. Each value is a string of up to 16 characters.

– A sequence of consecutive dictionary elements, starting with enum_dict, define the values. Each value must be put in a separate element, and must not end with &new_line. The character are assigned the numeric values 1..35 in sequence. The last dictionary element must be "\a".

Example:

```
$ example_sub_win_enum_c
   "Red"
   $
   "Blue"
   $
   "Green"
   $
   "Yellow"
   $
   "\a"
```

– TPX_KBL_ITEM, TPX_PBL_ITEM: The ‘‘true’’ and ‘‘false’’ values are placed on function key labels F4 and F5, in that order. Each label is a string of up to 8 characters. However, the last character of the ‘‘true’’ label should be left blank or the two labels will run together.

– A single dictionary element the label values. Each value must be put on a separate line using &new_line, with the ‘‘false’’ value first.

Example:

```
$ example_boolean_c
   "OFF" &new_line
   "ON"
```

— *enum_dict* : Dictionary name used to display data types TPX_FKY_ITEM, TPX_SUB_ITEM, TPX_KBL_ITEM, or TPX_PBL_ITEM

— *format_spec* : Format string is used to print out the data value. The format string contains a format specifier. The format string can also contain any desired characters before or after the format specifier. The format specifier itself begins with a % and ends with a conversion character. Between the % and the conversion character there may be, in order:

– Flags (in any order), which modify the specification:

- : specifies left adjustment of this field.

+ : specifies that the number will always be printed with a sign.

space : if the first character is not a sign, a space will be prefixed.

0 : specifies padding a numeric field width with leading zeroes.

– A number that specifies the minimum field width. The converted argument will be printed in a field at least this wide. If necessary it will be padded on the left (or right, if left adjustment is called for) to make up the field width.

– A period, which separates the field width from the precision.

– A number, the precision, that specifies the maximum number of characters to be printed from a string, or the number of digits after the decimal point of a floating-point value, or the minimum number of digits for an integer.

• The format specifier must contain one of the conversion characters in the following table:

Table A–13. Conversion Characters

Character	Argument Type; Printed As
d	INTEGER; decimal number.
o	INTEGER; unsigned octal notation (without a leading zero).
x,X	INTEGER; unsigned hexadecimal notation (without a leading 0x or 0X), using abcdef or ABCDEF for 10, ..., 15.
u	INTEGER; unsigned decimal notation.
s	STRING; print characters from the string until end of string or the number of characters given by the precision.
f	REAL; decimal notation of the form [-]mmm.dddddd, where the number of d's is given by the precision. The default precision is 6; a precision of 0 suppresses the decimal point.

Table A–13. Conversion Characters (Cont'd)

Character	Argument Type; Printed As
e,E	REAL; decimal notation of the form [-]m.dddddde+-xx or [-]m.ddddddE+-xx, where the number of d's is given by the precision. The default precision is 6; a precision of 0
g,G	REAL; %e or %E is used if the exponent is less than -4 or greater than or equal to the precision; otherwise %f is used. Trailing zeros and a trailing decimal pointer are not printed.
%	no argument is converted; print a %.

Example: "%d" or "%-10s"

The format specifiers which can be used with the data types specified in the item_type field in *col_data* are as follows:

TPX_INT_ITEM %d, %o, %x, %X, %u

TPX_REL_ITEM %f, %e, %E, %g, %G

TPX_FKY_ITEM %s

TPX_SUB_ITEM %s

TPX_KST_ITEM %s

TPX_KSL_ITEM %s

TPX_KBL_ITEM %s

TPX_BYT_ITEM %d, %o, %x, %X, %u, %c

TPX_SHT_ITEM %d, %o, %x, %X, %u

TPX_PBL_ITEM %s

TPX_PIN_ITEM %d, %o, %x, %X, %u

— *max_integer* : Maximum value if data type is TPX_INT_ITEM, TPX_BYT_ITEM, or TPX_SHT_ITEM.

— *min_integer* : Minimum value if data type is TPX_INT_ITEM, TPX_BYT_ITEM, or TPX_SHT_ITEM.

— *max_real* : Maximum value for reals.

— *min_real* : Minimum value for reals.

— *clear_flag* : If data type is TPX_KST_ITEM, 1 causes the field to be cleared before entering characters and 0 causes it not to be cleared.

— *lower_case* : If data type is TPX_KST_ITEM, 1 allows the characters to be input to the string in upper or lower case and 0 restricts them to upper case.

- *inact_array* is an array of booleans that corresponds to each column in the table.
  - — You can set each boolean to TRUE which will make that column inactive. This means the column cannot be cursored to.
  - — The array size can be less than or greater than the number of items in the table.
  - — If *inact_array* is not used, then an array size of 1 can be used, and the array does not need to be initialized.
- *change_array* is a two dimensional array of booleans that corresponds to formatted data item in the table.
  - — If the corresponding value is set, then the boolean will be set to TRUE, otherwise it is set to FALSE. You do not need to initialize the array.
  - — The array size can be less than or greater than the number of data items in the table.
  - — If *change_array* is not used, then an array size of 1 can be used.
- *value_array* is an array of variable names that correspond to the columns of data in the table. Each variable name can be specified as '[prog_name]var_name'.
  - — *[prog_name]* specifies the name of the program that contains the specified variable. If [prog_name] is not specified, then the current program being executed is used.
  - — *var_name* must refer to a static, global program variable.
  - — *var_name* can contain node numbers, field names, and/or subscripts.
  - — Each of these named variables must be a KAREL array of length *num_rows* . Its data type and values should be consistent with the value of the item_type field in *col_data* for the corresponding column, as follows:
    - – TPX_INT_ITEM: ARRAY OF INTEGER containing the desired values.
    - – TPX_REL_ITEM: ARRAY OF REAL containing the desired values.
    - – TPX_FKY_ITEM: ARRAY OF INTEGER with values referring to items in the dictionary element specified in the enum_ele field in *col_data* . There can be at most 2 function key pages, or 10 possible function key enumeration values.
    - – TPX_SUB_ITEM: ARRAY OF INTEGER with values referring to items in the dictionary element specified in the enum_ele field in *col_data* . There can be at most 28 subwindow enumeration values.
    - – TPX_KST_ITEM: ARRAY OF STRING containing the desired values.
    - – TPX_KST_ITEM: ARRAY OF STRING containing the desired values.
    - – TPX_KSL_ITEM: ARRAY OF STRING containing the desired values. These values cannot be edited by the user. If one is selected, ACT_TBL will return.

  - TPX_KBL_ITEM: ARRAY OF BOOLEAN containing the desired values. The dictionary element specified by the enum_ele field in *col_data* should have exactly two elements, with the false item first and the true item second. TPX_BYT_ITEM: ARRAY OF BYTE containing the desired values. "--" TPX_SHT_ITEM: ARRAY OF SHORT containing the desired values. "--" TPX_PBL_ITEM: ARRAY OF STRING containing the names of the ports, for example ‘‘DIN[5]’’. "--" TPX_PIN_ITEM: ARRAY OF STRING containing the names of the ports, for example ‘‘GOUT[3]’’.
  - TPX_BYT_ITEM: ARRAY OF BYTE containing the desired values.
  - TPX_SHT_ITEM: ARRAY OF SHORT containing the desired values.
  - TPX_PBL_ITEM: ARRAY OF STRING containing the names of the ports, for example ‘‘DIN[5]’’.
  - TPX_PIN_ITEM: ARRAY OF STRING containing the names of the ports, for example ‘‘GOUT[3]’’.

- *vptr_array* is an array of integers that corresponds to each variable name in *value_array.* **Do not change this data; it is used internally.**
- *table_data* is used to display and control the table. **Do not change this data; it is used internally.**
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

Example: In this example, TPXTABEG.TX is loaded as ‘XTAB’ on the controller. TPEXTBL calls INIT_TBL to initialize a table with five columns and four rows. It calls ACT_TBL in a loop to read and process each key pressed.

INIT_TBL Built-In Procedure

```
-----------------------------------------------
TPXTABEG.TX
-----------------------------------------------
$title
&reverse "DATA Test Schedule" &standard &new_line
"E1: " &new_line
"      W(mm) TEST  C(%%) G(123456) COLOR"
^1
?2
$function_keys
"f1"       &new_line
"f2"       &new_line
"f3"       &new_line
"f4"       &new_line
"  HELP >" &new_line
"f6"       &new_line
"f7"       &new_line
"f8"       &new_line
"f9"       &new_line
"f10    >"
$help_text "Help text goes here...
```

```
"$enum1
"" &new_line
"" &new_line
"TRUE" &new_line
"FALSE" &new_line
""
$enum2
"Red"
$
"Blue"
$
"Green"
$
"Yellow"
$
"Brown"
$
"Pink"
$
"Mauve"
$
"Black"
$
"......"
-----------------------------------------------
TPEXTBL.KL
-----------------------------------------------
PROGRAM tpextbl
%ENVIRONMENT uif
%INCLUDE FROM:\klevccdf
%INCLUDE FROM:\klevkeysVAR
  dict_name: STRING[6]
  ele_number: INTEGER
  num_rows: INTEGER
  num_columns: INTEGER
  col_data: ARRAY[5] OF COL_DESC_T
  inact_array: ARRAY[5] OF BOOLEAN
  change_array: ARRAY[4,5] OF BOOLEAN
  value_array: ARRAY[5] OF STRING[26]
  vptr_array: ARRAY[4,5] OF INTEGER
  table_data: XWORK_T
  status: INTEGER
  action: INTEGER
  def_item: INTEGER
  term_char: INTEGER
  attach_sw: BOOLEAN
  save_action:  INTEGER
```

```
  done: BOOLEAN
  value1: ARRAY[4] OF INTEGER
  value2: ARRAY[4] OF INTEGER
  value3: ARRAY[4] OF REAL
  value4: ARRAY[4] OF STRING[10]
  value5: ARRAY[4] OF INTEGER
BEGIN
  def_item = 1
  value_array[1] = 'value1'
  value_array[2] = 'value2'
  value_array[3] = 'value3'
  value_array[4] = 'value4'
  value_array[5] = 'value5'
  value1[1] = 21
  value1[2] = 16
  value1[3] = 1
  value1[4] = 4
  value2[1] = 3
  value2[2] = 2
  value2[3] = 3
  value2[4] = 2
  value3[1] = -13
  value3[2] = 4.1
  value3[3] = 23.9
  value3[4] = -41
  value4[1] = 'XXX---'
  value4[2] = '--X-X-'
  value4[3] = 'XXX-XX'
  value4[4] = '-X-X--'
  value5[1] = 1
  value5[2] = 1
  value5[3] = 2
  value5[4] = 3
  inact_array[1] = FALSE
  inact_array[2] = FALSE
  inact_array[3] = FALSE
  inact_array[4] = FALSE
  inact_array[5] = FALSE
  col_data[1].item_type = TPX_INT_ITEM
  col_data[1].start_col = 6
  col_data[1].field_width = 4
  col_data[1].format_spec = '%3d'
  col_data[1].max_integer = 99
  col_data[1].min_integer = -99
  col_data[2].item_type = TPX_FKY_ITEM
  col_data[2].start_col = 12
  col_data[2].field_width = 5
```

```
col_data[2].format_spec = '%s'
col_data[2].enum_ele = 3  -- enum1 element number
col_data[2].enum_dict = 'XTAB'
col_data[3].item_type = TPX_REL_ITEM
col_data[3].start_col = 18
col_data[3].field_width = 5
col_data[3].format_spec = '%3.1f'
col_data[4].item_type = TPX_KST_ITEM
col_data[4].start_col = 26
col_data[4].field_width = 6
col_data[4].format_spec = '%s'
col_data[5].item_type = TPX_SUB_ITEM
col_data[5].start_col = 34
col_data[5].field_width = 6
col_data[5].format_spec = '%s'
col_data[5].enum_ele = 4  -- enum2 element number
col_data[5].enum_dict = 'XTAB'
dict_name = 'XTAB'
ele_number = 0  -- title element number
num_rows = 4
num_columns = 5
def_item = 1
attach_sw = TRUE
INIT_TBL(dict_name, ele_number, num_rows, num_columns, col_data,
         inact_array, change_array, value_array, vptr_array,
         table_data, status)
IF status <> 0 THEN
  WRITE('INIT_TBL status = ', status, CR);
  ELSE
    def_item = 1
    -- Initial display of table
    ACT_TBL(ky_disp_updt, def_item, table_data, term_char,
            attach_sw, status)
    IF status <> 0 THEN
      WRITE(CR, 'ACT_TBL status = ', status)
    ENDIF
  ENDIF
  IF status = 0 THEN
    -- Loop until a termination key is selected.
    done = FALSE
    action = ky_reissue -- read new key
    WHILE NOT done DO
      -- Read new key, act on it, and return it
      ACT_TBL(action, def_item, table_data, term_char,
              attach_sw, status)save_action = action
      action = ky_reissue -- read new key
      -- Debug only
```

```
            WRITE TPERROR (CHR(cc_home) + CHR(cc_clear_win))
            -- Process termination keys.
            SELECT (term_char) OF
              CASE (ky_select, ky_new_menu):
                done = TRUE;
              CASE (ky_f1):
                -- Perform F1
                SET_CURSOR(TPERROR, 1, 1, status)
                WRITE TPERROR ('F1 pressed')
              CASE (ky_f2):
                -- Perform F2
                SET_CURSOR(TPERROR, 1, 1, status)
                WRITE TPERROR ('F2 pressed')
              CASE (ky_f3):
                -- Perform F3
                SET_CURSOR(TPERROR, 1, 1, status)
                WRITE TPERROR ('F3 pressed')
              CASE (ky_f4):
                -- Perform F4
                SET_CURSOR(TPERROR, 1, 1, status)
                WRITE TPERROR ('F4 pressed')
              CASE (ky_f5):
                -- Perform F5 Help
                action = ky_help
              CASE (ky_f6):
                -- Perform F6
                SET_CURSOR(TPERROR, 1, 1, status)
                WRITE TPERROR ('F6 pressed')
              CASE (ky_f7):
                -- Perform F7
                SET_CURSOR(TPERROR, 1, 1, status)
                WRITE TPERROR ('F7 pressed')
              CASE (ky_f8):
                -- Perform F8
                SET_CURSOR(TPERROR, 1, 1, status)
                WRITE TPERROR ('F8 pressed')
CASE (ky_f9):
                -- Perform F9
                SET_CURSOR(TPERROR, 1, 1, status)
                WRITE TPERROR ('F9 pressed')
              CASE (ky_f10):
                -- Perform F10
                SET_CURSOR(TPERROR, 1, 1, status)
                WRITE TPERROR ('F10 pressed')
              CASE (ky_undef):
                -- Process special keys.
                SELECT (save_action) OF
```

```
                CASE (ky_f1_s):
                  -- Perform Shift F1
                  SET_CURSOR(TPERROR, 1, 1, status)
                  WRITE TPERROR ('F1 shifted pressed')
                ELSE:
              ENDSELECT
            ELSE:
              action = term_char  -- act on this key
            ENDSELECT
        ENDWHILE
          IF term_char <> ky_new_menu THEN
          -- Cancel the dynamic display
          ACT_TBL(ky_cancel, def_item, table_data, term_char,
                  attach_sw, status)
        ENDIF
      ENDIF
END tpextbl
```

A.10.13 IN_RANGE Built-In Function

Purpose: Returns a BOOLEAN value indicating whether or not the specified position argument can be reached by a group of axes

Syntax : IN_RANGE(posn)

Function Return Type :BOOLEAN

Input/Output Parameters:

[in] posn : XYZWPREXT

%ENVIRONMENT Group :SYSTEM

Details:

- The returned value is TRUE if *posn* is within the work envelope of the group of axes; otherwise, FALSE is returned.
- The current $UFRAME and $UTOOL are applied to *posn* .

See Also: CHECK_EPROS Built-in procedure, Chapter 8 *MOTION* , Section 4.2.2, "Group Motion"

Example: The following example checks to see if the new position is in the work envelope before moving the TCP to it.

IN_RANGE Built-In Function

```
IF IN_RANGE(pallet :  part_slot) THEN
      WITH $UFRAME = pallet MOVE TO part_slot
   ELSE WRITE('I can't get there!',CR)
   ENDIF
```

A.10.14 INSERT_NODE Built-In Procedure

Purpose: Inserts an uninitialized node in the specified PATH argument preceding the specified path node number

Syntax : INSERT_NODE(path_var, node_num, status)

Input/Output Parameters:

[in] path_var :PATH

[in] node_num :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PATHOP

Details:

- *node_num* specifies the index number of the path node before which the new uninitialized node is to be inserted.
- The new node can be assigned values by directly referencing its NODEDATA structure.
- All nodes following the inserted node are renumbered.
- Valid *node_num* values are in the range *node_num* => 1 and *node_num* <= PATH_LEN(*path_va r*).
- If *node_num* is not a valid node number, status is returned with an error.
- If the program does not have enough RAM for an INSERT_NODE request, an error will occur.
- If the program is paused, the INSERT_NODE request is **NOT** retried.

See Also: DELETE_NODE, APPEND_NODE Built-in Procedures

Example: In the following example, the PATH_LEN built-in is used to set the variable length equal to the number of nodes in **path_var.** INSERT_NODE inserts a new path node after the last node in path_var.

INSERT_NODE Built-In Procedure

```
length = PATH_LEN(path_var)
INSERT_NODE(path_var, length, status)
```

A.10.15 INSERT_QUEUE Built-In Procedure

Purpose: Inserts an entry into a queue if the queue is not full

Syntax : INSERT_QUEUE(value, sequence_no, queue, queue_data, status)

Input/Output Parameters:

[in] value :INTEGER

[in] sequence_no :INTEGER

[in,out] queue_t :QUEUE_TYPE

[in,out] queue_data :ARRAY OF INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBQMGR

Details:

- *value* specifies the value to be inserted into the queue, queue_t.
- *sequence_no* specifies the sequence number of the entry before which the new entry is to be inserted.
- *queue_t* specifies the queue variable for the queue.
- *queue_data* specifies the array used to hold the data in the queue. The length of this array determines the maximum number of entries in the queue.
- *status* is returned with 61002, ‘‘Queue is full,’’ if there is no room for the entry in the queue, with 61003, ‘‘Bad sequence no,’’ if the specified sequence number is not in the queue.

See Also: MODIFY_QUEUE, APPEND_QUEUE, DELETE_QUEUE Built-In Procedures, Section 14.8 , "Using Queues for Task Communication"

Example: In the following example, the routine **ins_in_queue** adds an entry **value**) to a queue (**queue_t** and **queue_data**) following the specified entry **sequence_no**); it returns TRUE if this was successful; otherwise it returns FALSE.

INSERT_QUEUE Built-In Procedure

```
PROGRAM ins_queue_x
%environment PBQMGR
ROUTINE ins_in_queue(value: INTEGER;
                     sequence_no: INTEGER;
                     queue_t: QUEUE_TYPE;
                     queue_data: ARRAY OF INTEGER): BOOLEAN
VAR
  status: INTEGER
BEGIN
INSERT_QUEUE(value, sequence_no, queue_t, queue_data, status)
return (status = 0)
END ins_in_queue
BEGIN
END ins_queue_x
```

A.10.16 INTEGER Data Type

Purpose: Defines a variable, function return type, or routine parameter as INTEGER data type

Syntax : INTEGER

Details:

- An INTEGER variable or parameter can assume whole number values in the range -2147483648 through +2147483646.
- INTEGER literals consist of a series of digits, optionally preceded by a plus or minus sign. They cannot contain decimal points, commas, spaces, dollar signs ($), or other punctuation characters. (See Table A–14)

Table A–14. Valid and Invalid INTEGER Literals

Valid	Invalid	Reason
1	1.5	Decimal point not allowed (must be a whole number)
–2500450	–2,500,450	Commas not allowed
+65	+6 5	Spaces not allowed

- If an INTEGER argument is passed to a routine where a REAL parameter is expected, it is treated as a REAL and passed by value.
- Only INTEGER expressions can be assigned to INTEGER variables, returned from INTEGER function routines, or passed as arguments to INTEGER parameters.
- Valid INTEGER operators are:

— Arithmetic operators (+, -, *, /, DIV, MOD)

— Relational operators (>, >=, =, <>, <, <=)

— Bitwise operations (AND, OR, NOT)

See Also: Chapter 5 *ROUTINES* , for more information on passing by value, Chapter 7 *FILE INPUT/OUTPUT OPERATIONS* , for more information on format specifiers

Example: Refer to Appendix B for detailed program examples.

A.10.17 INV Built-In Function

Purpose: Used in coordinate frame transformations with the relative position operator (:) to determine the coordinate values of a POSITION in a frame that differs from the frame in which that POSITION was recorded

Syntax : INV(pos) Function Return Type :POSITION

Input/Output Parameters:

[in] pos :POSITION

%ENVIRONMENT Group :SYSTEM

Details:

- The returned value is the inverse of the *pos* argument.
- The configuration of the returned POSITION will be that of the *pos* argument.

Example: The following example uses the INV built-in to determine the POSITION of **part_pos** with reference to the coordinate frame that has **rack_pos** as its origin. Both **part_pos** and **rack_pos** were originally taught and recorded in User Frame. The robot is then instructed to move to that position.

INV Built-In Function

```
PROGRAM p_inv
VAR
  rack_pos, part_pos, p1 : POSITION
BEGIN
  p1 = INV(rack_pos):part_pos
  MOVE TO p1
END p_inv
```

A.10.18 IO_MOD_TYPE Built-In Procedure

Purpose: Allows a KAREL program to determine the type of module in a specified rack/slot

Syntax : IO_MOD_TYPE(rack_no, slot_no, mod_type, status)

Input/Output Parameters:

[in] rack_no :INTEGER

[in] slot_no :INTEGER

[out] mod_type :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :IOSETUP

Details:

- *rack_no* is the rack containing the port module. For process I/O boards, this is zero; for Allen-Bradley and Genius ports, this is 16.
- *slot_no* is the slot containing the port module. For process I/O boards, this is the position of the board in the SLC-2 chain.
- *mod_type* is the module type.

  6 A16B-2202-470

  7 A16B-2202-472

  8 A16B-2202-480
- *status* is returned with zero if the parameters are valid and there is a module or board with the specified rack/slot number as follows:

Example: The following example returns to the caller the module in the specified rack and slot number.

IO_MOD_TYPE Built-In Procedure

```
PROGRAM iomodtype
%ENVIRONMENT IOSETUP
   ROUTINE get_mod_type(rack_no: INTEGER;
                        slot_no: INTEGER;
                        mod_type: INTEGER): INTEGER
     VAR
       status: INTEGER
     BEGIN
```

```
        IO_MOD_TYPE(rack_no, slot_no, mod_type, status)
        RETURN (status)
      END get_mod_type
BEGIN
END iomodtype
```

A.10.19 IO_STATUS Built-In Function

Purpose: Returns an INTEGER value indicating the success or type of failure of the last operation on the file argument

Syntax : IO_STATUS(file_id)

Function Return Type :INTEGER

Input/Output Parameters:

[in] file_id :FILE

%ENVIRONMENT Group :PBCORE

Details:

- IO_STATUS can be used after an OPEN FILE, READ, WRITE, CANCEL FILE, or CLOSE FILE statement. Depending on the results of the operation, it will return 0 if successful or one of the errors listed in the *FANUC Robotics SYSTEM R-J3iC Controller HandlingTool Setup and Operations Manual* . Some of the common errors are shown in Table A–15 .

Table A–15. IO_STATUS Errors

0	Last operation on specified file was successful
2021	End of file for RAM disk device
10006	End of file for floppy device
12311	Uninitialized variable
12324	Illegal open mode string
12325	Illegal file string
12326	File var is already used
12327	Open file failed
12328	File is not opened
12329	Cannot write the variable

Table A–15. IO_STATUS Errors (Cont'd)

12330	Write file failed
12331	Cannot read the variable
12332	Read data is too short
12333	Illegal ASCII string for read
12334	Read file failed
12335	Cannot open pre_defined file
12336	Cannot close pre_defined file
12338	Close file failed
12347	Read I/O value failed
12348	Write I/O value failed
12358	Timeout at read request
12359	Read request is nested
12367	Bad base in format

- Use READ file_id(cr) to clear any IO_STATUS error.
- If *file_id* does not correspond to an opened file or one of the pre-defined ‘‘files’’ opened to the respective CRT/KB, teach pendant, and vision windows, the program is aborted with an error.

Example: Refer to Section B.12 , "Displaying a List From a Dictionary File" (DCLIST_EX.KL), for a detailed program example.

A.11 - J - KAREL LANGUAGE DESCRIPTION

A.11.1 J_IN_RANGE Built-In Function

Purpose: Returns a BOOLEAN value indicating whether or not the specified joint position argument can be reached by a group of axes

Syntax : J_IN_RANGE(posn)

Function Return Type :BOOLEAN

Input/Output Parameters:

[in] posn :JOINTPOS

%ENVIRONMENT Group :SYSTEM

Details:

- The returned value is TRUE if *posn* is within the work envelope; otherwise, FALSE is returned.

See Also: IN_RANGE Built-in Function, CHECK_EPROS Built-in procedure

A.11.2 JOINTPOS Data Type

Purpose: Defines a variable, function return type, or routine parameter as JOINTPOS data type.

Syntax : JOINTPOS<n> <IN GROUP[m]>

Details:

- A JOINTPOS consists of a REAL representation of the position of each axis of the group, expressed in degrees or millimeters (mm).
- *n* specifies the number of axes, with 9 as the default. The size in bytes is 4 + 4 * n.
- A JOINTPOS may be followed by IN GROUP[m], where m indicates the motion group with which the data is to be used. The default is the group specified by the %DEFGROUP directive or 1.
- CNV_REL_JPOS and CNV_JPOS_REL Built-ins can be used to access the real values.
- A JOINTPOS can be assigned to other positional types. Note that some motion groups, for example single axis positioners, have no XYZWPR representation. If you attempt to assign a JOINTPOS to a XYZWPR or POSITION type for such a group, a run-time error will result.

Example: Refer to the following sections for detailed program examples:

Section B.5,"Using Register Built-ins" (REG_EX.KL)

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.8, "Generating and Moving Along a Hexagon Path" (GEN_HEX.KL)

Section B.14, "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

A.11.3 JOINT2POS Built-In Function

Purpose: This routine is used to convert joint angles (in_jnt) to a Cartesian position (out_pos) by calling the forward kinematics routine.

Syntax : JOINT2POS (in_jnt - Joint angles can be converted to Cartesian, uframe, utool, config_ref, out_pos, wjnt_cfg, ext_ang, and status).

Input/Output Parameters:

[in] in_jnt :Jointpos

[in] uframe :POSITION

[in] utool :POSITION

[in] config_ref :INTEGER

[out] out_pos :POSITION

[out] wjnt_cfg :CONFIG

[out] ext_ang :ARRAY OF REAL

[out] status :INTEGER

%ENVIRONMENT Group :MOTN

Details:

- The input *in_jnt* is defined as the joint angles to be converted to the Cartesian position.
- The input *uframe* is the user frame for the Cartesian position.
- The input *utool* is defined as the corresponding tool frame.
- The input *config_ref* is an integer representing the type of solution desired. The values listed below are valid. Also, the pre-defined constants in the parentheses can be used and the values can be added as required. One example includes: config_ref = HALF_SOLN + CONFIG_TCP.
  - 0 :(FULL_SOLN) = Default
  - 1 : (HALF_SOLN) = Wrist joint (xyz456). This value does not calculate/use wpr.
  - 2 :(CONFIG_TCP) = The Wrist Joint Config (up/down) is based on the fixed wrist.
  - 4 :(APPROX_SOLN) = Approximate solution. This value reduce calculation time for some robots.
  - 8 :(NO_TURNS) = Ignore wrist turn numbers. Use the closest path for joints 4, 5 and 6 (uses ref_jnt).
  - 16 :(NO_M_TURNS) = Ignore major axis (J1 only) turn number. Use the closest path.
- The output *out_pos* is the Cartesian position corresponding to the input joint angles.
- The output *wjnt_cfg* is the wrist joint configuration. The value will be output when *config_ref* corresponds to HALF_SOLN.
- The output *ext_ang* contains the values of the joint angles for the extended axes if they exist.
- The output *status* explains the status of the attempted operation. If it is not equal to 0, then an error has occurred.

A.12 - K - KAREL LANGUAGE DESCRIPTION

A.12.1 KCL Built-In Procedure

Purpose: Sends the KCL command specified by the STRING argument to KCL for execution.

Syntax : KCL (command, status)

Input/Output Parameters :

[in] command :STRING

[out] status :INTEGER

%ENVIRONMENT Group :kclop

Details:

- *command* must contain a valid KCL command.
- *command* cannot exceed 126 characters.
- Program execution waits until execution of the KCL command is completed or until an error is detected.
- All KCL commands are performed as if they were entered at the command level, with the exception of destructive commands, such as CLEAR ALL, for which no confirmation is required.
- *status* indicates whether the command was executed successfully.
- If a KCL command file is being executed and $STOP_ON_ERR is FALSE, the KCL built-in will continue to run to completion. The first error detected will be returned or a 0 if no errors occurred.

See Also: KCL_NO_WAIT, KCL_STATUS Built-In Procedures

Example: The following example will show programs and wait until finished. Status will be the outcome of this operation.

KCL Built-In Procedure

```
PROGRAM kcl_test
VAR
 command :STRING[20]
 status :INTEGER
BEGIN
 command = 'SHOW PROGRAMS'
 KCL (command, status)
END kcl_test
```

Example: Refer to Example Program for Display Only Data Items for another example.

A.12.2 KCL_NO_WAIT Built-In Procedure

Purpose: Sends the KCL command specified by the STRING argument to KCL for execution, but does not wait for completion of the command before continuing program execution.

Syntax : KCL_NO_WAIT (command, status)

Input/Output Parameters :

[in] command :STRING

[out] status :INTEGER

%ENVIRONMENT Group :kclop

Details:

- *command* must contain a valid KCL command.
- *status* indicates whether KCL accepted the command.
- Program execution waits until KCL accepts the command or an error is detected.

See Also: KCL, KCL_STATUS Built-In Procedures

Example: The following example will load a program, but will not wait for the program to be loaded before returning. Status will indicate if the command was accepted or not.

KCL_NO_WAIT Built-In Procedure

```
PROGRAM kcl_test
VAR
 command :STRING[20]
 status :INTEGER
BEGIN
 command = 'Load prog test_1'
 KCL_NO_WAIT (command, status)
 delay 5000
 status = KCL_STATUS
END kcl_test
```

A.12.3 KCL_STATUS Built-In Procedure

Purpose: Returns the status of the last executed command from either KCL or KCL_NO_WAIT built-in procedures.

Syntax : KCL_STATUS

Function Return Type :INTEGER

%ENVIRONMENT Group :kclop

Details:

- Returns the *status* of the last executed command from the KCL or KCL_NO_WAIT built-ins.
- Program execution waits until KCL can return the status.

See Also: KCL_NO_WAIT, KCL Built-In Procedures

A.13 - L - KAREL LANGUAGE DESCRIPTION

A.13.1 LN Built-In Function

Purpose: Returns the natural logarithm of a specified REAL argument

Syntax : LN(x)

Function Return Type :REAL

Input/Output Parameters:

[in] x : REAL

%ENVIRONMENT Group :SYSTEM

Details:

- The returned value is the natural logarithm of *x* .
- *x* must be greater than zero. Otherwise, the program will be aborted with an error.

Example: The following example returns the natural logarithm of the input variable **a** and assigns it to the variable **b** .

LN Built-In Function

```
WRITE(CR, CR, 'enter a number =')
  READ(a,CR)
```

```
b = LN(a)
```

A.13.2 LOAD Built-In Procedure

Purpose: Loads the specified file

Syntax : LOAD (file_spec, option_sw, status)

Input/Output Parameters:

[in] file_spec :STRING

[in] option_sw :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *file_spec* specifies the device, name, and type of the file to load. The following types are valid:

  .TP Teach pendant program

  .PC KAREL program

  .VR KAREL variables

  .SV KAREL system variables

  .IO I/O configuration data

  no ext KAREL program and variables

- *option_sw* specifies the type of options to be done during loading.

  The following value is valid for .TP files:

  — 1 If the program already exists, then it overwrites the program. If option_sw is not 1 and the program exists, an error will be returned.

  The following value is valid for .SV files:

  — 1 Converts system variables.

- *option_sw* is ignored for all other types.

- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

Example: Refer to the following sections for detailed program examples:

Section B.2, "Copying Path Variables" (CPY_PTH.KL)

Section B.7, "Listing Files and Programs and Manipulating Strings" (LIST_EX.KL)

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

A.13.3 LOAD_STATUS Built-In Procedure

Purpose: Determines whether the specified KAREL program and its variables are loaded into memory

Syntax : LOAD_STATUS(prog_name, loaded, initialized)

Input/Output Parameters:

[in] prog_name :STRING

[out] loaded :BOOLEAN

[out] initialized :BOOLEAN

%ENVIRONMENT Group :PBCORE

Details:

- *prog_name* must be a program and cannot be a routine.
- *loaded* returns a value of TRUE if *prog_name* is currently loaded into memory. FALSE is returned if *prog_name* is not loaded.
- *initialized* returns a value of TRUE if any variable within *prog_name* has been initialized. FALSE is returned if all variables within *prog_name* are uninitialized.
- If either *loaded* or *initialized* is FALSE, use the LOAD built-in procedure to load *prog_name* and its variables.

Example: Refer to the following sections for detailed program examples:

Section B.7, "Listing Files and Programs and Manipulating Strings" (LIST_EX.KL)

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

A.13.4 LOCK_GROUP Built-In Procedure

Purpose: Locks motion control for the specified group of axes

Syntax : LOCK_GROUP(group_mask, status)

Input/Output Parameters:

[in] group_mask : INTEGER

[out] status : INTEGER

%ENVIRONMENT Group :MULTI

Details:

- *group_mask* specifies the group of axes to lock for the running task. The group numbers must be in the range of 1 to the total number of groups defined on the controller.
- The *group_mask* is specified by setting the bit(s) for the desired group(s).

Table A–16. Group_mask Setting

GROUP	DECIMAL	BIT
Group 1	1	1
Group 2	2	2
Group 3	4	3

To specify multiple groups select the decimal values, shown in Table A–16, which correspond to the desired groups. Then connect them together using the OR operator. For example to specify groups 1, 3, enter "1 OR 4".

- Motion control is gained for the specified motion groups.
- If one or more of the groups cannot be locked, then an error is returned, and any available groups will be locked.
- Moving a group automatically locks the group if it has not been previously locked by another task.
- If a task tries to move a group that is already locked by another task, it will be paused.
- *status* explains the status of the attempted operation. If not equal to 0, an error occurred.

Note Do not use more than one motion group in a KAREL program. If you need to use more than one motion group, you must use a teach pendant program.

> **Warning**
>
> **Do not run a KAREL program that includes more than one motion group. Otherwise, the robot could move unexpectedly and inure personnel or damage equipment.**

Example: The following example unlocks group 1, 2, and 3, and then locks group 3. Refer to Chapter 14 *MULTI-TASKING* , for more examples.

LOCK_GROUP Built-In Procedure

```
%ENVIRONMENT MOTN
%ENVIRONMENT MULTI
  VAR
    status: INTEGER
  BEGIN
    REPEAT
      -- Unlock groups 1, 2, and 3
      UNLOCK_GROUP(1 OR 2 OR 4, status)
      IF status = 17040 THEN
        CNCL_STP_MTN       -- or RESUME
      ENDIF
      DELAY 500
    UNTIL status = 0
    -- Lock only group 3
    LOCK_GROUP(4, status)
END lock_grp_ex
```

A.13.5 %LOCKGROUP Translator Directive

Purpose: Specifies the motion group(s) to be locked when calling this program or a routine from this program.

Syntax : %LOCKGROUP = n, n ,...

Details:

- *n* is the number of the motion group to be locked.
- The range of *n* is 1 to the number of groups on the controller.
- When the program or routine is called, the task will attempt to get motion control for all the specified groups if it does not have them locked already. The task will pause if it cannot get motion control.
- If %LOCKGROUP is not specified, all groups will be locked.
- The %NOLOCKGROUP directive can be specified if no groups should be locked.

Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: %NOLOCKGROUP Directive, LOCK_GROUP, UNLOCK_GROUP Built-In Procedures

A.14 - M - KAREL LANGUAGE DESCRIPTION

A.14.1 MIRROR Built-In Function

Purpose: Determines the mirror image of a specified position variable.

Syntax : MIRROR (old_pos, mirror_frame, orientation_flag)

Function Return Type: XYZWPREXT

Input/Output Parameters :

[in] old_pos :POSITION

[in] mirror_frame :POSITION

[in] orient_flag :BOOLEAN

%ENVIRONMENT Group :MIR

Details:

- *old_pos* and *mirror_frame* must both be defined relative to the same user frame.
- *old_pos* specifies the value whose mirror image is to be generated.
- *mirror_frame* specifies the value across whose xz_plane the image is to be generated.
- If *orient_flag* is TRUE, both the orientation and location component of *old_pos* will be mirrored. If FALSE, only the location is mirrored and the orientation of the new mirror-image position is the same as that of *old_pos*.
- The returned mirrored position is not guaranteed to be a reachable position, since the mirrored position can be outside of the robot's work envelope.

See Also: The appropriate application-specific *FANUC Robotics SYSTEM R-J3iC Controller Setup and Operations Manual* , chapter on "Advanced Functions"

Example: The following example gets the current position of the robot, creates a mirror frame, and generates a mirrored position which is mirrored about the y axis.

MIRROR Built-In Function

```
PROGRAM mir_exam
VAR
 cur_pos:   XYZWPREXT
 org_pos:   POSITION
 mir_pos:   XYZWPREXT
 mir_posa:  POSITION
 pos_frame:  XYZWPREXT
 frame:   POSITION
 orient_flag: BOOLEAN
BEGIN
 cur_pos = curpos(0,0) -- Get the current position of the robot
 cur_pos.x = 1000.00  -- Create a new position which (1000,0,300,w,p,r)
 cur_pos.y = 0.0
 cur_pos.z = 300.00
 move to cur_pos   -- The robot is now at a know position:
--(1000,0,300,w,p,r) where (w,p,r) have not
--changed from the original position.
 pos_frame = curpos(0,0) -- Create a frame used to mirror about.
 pos_frame.w = 0   -- By setting (w,p,r) to 0, the x-z plane of
 pos_frame.p = 0   -- pos_frame will be parallel to the world's x-z
 pos_frame.r = 0    -- plane. pos_frame now set to (1000,0,300,0,0,0)
 frame = pos_frame   -- Convert the mirror frame to a POSITION type.
 cur_pos.y = 200   -- Move 200mm in the y direction.
 move to cur_pos   -- Current position is (1000,200,300,w,p,r)
 org_pos = cur_pos   -- Convert org_pos to a POSITION type.
 orient_flag = FALSE  -- Send Mirror current position: (1000, 200, 300,
                      -- w,p,r), and mirror frame: (1000,0,300,0,0,0).
                      -- Mirrors about the y axis without mirroring the
                      -- orientation (w,p,r).
 mir_pos = mirror(org_pos, frame, orient_flag)
         -- mir_pos is the mirrored position: (1000, -200,
         -- 300, w, p, r).
         -- The orientation is the same as org_pos.
 orient_flag = TRUE  -- The mirrored position includes mirroring of
                     -- the tool orientation.
 mir_posa = mirror(org_pos,frame,orient_flag)
         -- mir_posa is the mirrored position where Normal
         -- Orient, & Approach vectors have been mirrored.
end mir_exam
```

A.14.2 MODIFY_QUEUE Built-In Procedure

Purpose: Replaces the value of an entry of a queue.

Syntax : MODIFY_QUEUE(value, sequence_no, queue_t, queue_data, status)

Input/Output Parameters:

[in] value :INTEGER

[in] sequence_no :INTEGER

[in,out] queue_t :QUEUE_TYPE

[in,out] queue_data :ARRAY OF INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBQMGR

Details:

- *value* specifies the value to be inserted into the queue.
- *sequence_no* specifies the sequence number of the entry whose value is to be modified
- *queue_t* specifies the queue variable for the queue
- *queue_data* specifies the array used to hold the data in the queue. The length of this array determines the maximum number of entries in the queue.
- *status* is returned with 61003, ‘‘Bad sequence no,’’ if the specified sequence number is not in the queue.

See Also: COPY_QUEUE, GET_QUEUE, DELETE_QUEUE Built-In Procedures Section 14.8, "Using Queues for Task Communication"

Example: In the following example, the routine update_queue replaces the value of the specified entry (**sequence_no**); of a queue (**queue** and **queue_data** with a new value (**value**).

MODIFY_QUEUE Built-In Procedure

```
PROGRAM mod_queue_x
%ENVIRONMENT PBQMGR
ROUTINE update_queue(value: INTEGER;
                     sequence_no: INTEGER;
                     queue_t: QUEUE_TYPE;
                     queue_data: ARRAY OF INTEGER)
VAR
  status: INTEGER
BEGIN
```

```
MODIFY_QUEUE(value, sequence_no, queue_t, queue_data, status)
return
END update_queue
BEGIN
END mod_queue_x
```

A.14.3 MOTION_CTL Built-In Function

Purpose: Determines whether the KAREL program has motion control for the specified group of axes

Syntax : MOTION_CTL<(group_mask)>

Function Return Type :BOOLEAN

Input/Output Parameters:

[in] group_mask :INTEGER

%ENVIRONMENT Group :MOTN

Details:

- If *group_mask* is omitted, the default group mask for the program is assumed.
- The default *group_mask* is determined by the %LOCKGROUP and %NOLOCKGROUP directives.
- The *group_mask* is specified by setting the bit(s) for the desired group(s).

Table A–17. Group_mask Setting

GROUP	DECIMAL	BIT
Group 1	1	1
Group 2	2	2
Group 3	4	3

To specify multiple groups select the decimal values, shown in Table A–17, which correspond to the desired groups. Then connect them together using the OR operator. For example to specify groups 1, 3, enter "1 OR 4".

> **Warning**
>
> **Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.**

- Returns TRUE if the KAREL program has motion control for the specified group of axes.

A.14.4 MOUNT_DEV Built-In Procedure

Purpose: Mounts the specified device

Syntax : MOUNT_DEV (device, status)

Input/Output Parameters:

[in] device : STRING

[out] status :INTEGER

%ENVIRONMENT Group :FDEV

Details:

- *device* specifies the device to be mounted.
- *status* explains the status of the attempted operation. If it is not equal to 0, then an error occurred.

See Also: DISMOUNT_DEV and FORMAT_DEV

Example: Refer to Section B.9, "Using the File and Device Built-ins" (FILE_EX.KL), for a detailed program example.

A.14.5 MOVE ABOUT Statement

Purpose: Moves the TCP to a destination an angular distance about a specified vector from the current TCP position

Syntax : < WITH clause >

MOVE ABOUT vect BY angle

< NOWAIT > <,

cond_handler

{cond_handler}

ENDMOVE >

where:

WITH_clause : Described under ‘‘WITH clause’’

vect : VECTOR expression

angle :a REAL expression

NOWAIT : Described under ‘‘NOWAIT clause’’

cond_handler : a local condition handler

Details:

- *angle* is measured in degrees.
- The location of the destination will be the same as that of the current position when the move is completed.
- If $MOTYPE is linear, the location of the TCP remains fixed during the move.
- The shortest distance for the move is always used. For example, if the angle is > 180 degrees (or < -180), the actual motion will be in the opposite direction from what you might expect.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: Local condition handlers, composed of WHEN and UNTIL clauses, Chapter 6 *CONDITION HANDLERS* , Appendix E, ‘‘Syntax Diagrams,’’ for additional syntax information, NOWAIT, WHEN, WITH, UNTIL Clauses

Example: Initially, the following example moves the TCP to a desired position, defines a vector in the positive x direction (**direction**), and defines **angle** to be 30°. The TCP is then rotated about the **direction** vector by **angle** .

MOVE ABOUT Statement

```
$MOTYPE = JOINT
  MOVE TO tool_pos
```

```
direction.x = 1
direction.y = 0
direction.z = 0

angle = 30

WITH $SPEED = 200 MOVE ABOUT direction BY angle
```

A.14.6 MOVE ALONG Statement

Purpose: Moves the TCP (and, optionally, auxiliary axes) continuously along the nodes of a PATH.

Syntax : < WITH clause >

MOVE ALONG path_var <[start_node<..end_node>]>

<NOWAIT> < ,

cond_handler

{cond_handler}

ENDMOVE >

where:

WITH clause : Described under ‘‘WITH Clause’’

path_var : a PATH variable

start_node : an INTEGER expression

end_node : an INTEGER expression

NOWAIT : Described under ‘‘NOWAIT Clause’’

cond_handler : a local condition handler

Details:

- If *start_node* is not present, the TCP (and, optionally, auxiliary axes) moves to the first node of the PATH, then to each successive node until the end of the PATH is reached.
- If only *start_node* is present, the TCP (and, optionally, auxiliary axes) moves to the specified *start_node* , then to each successive node until the end of the PATH is reached.

- If a range of nodes is specified with *start_node...end _node* , the TCP (and, optionally, auxiliary axes) moves to the specified *start_node* , then to each successive node until the specified *end_node* is reached.
- *start_node* and *end_node* must be in the range from 1 to the length of the PATH. If, during program execution, one of these values is less than 1, the program will be aborted. If one of these values is greater than the actual length of the PATH, the program will be paused.
- The standard associated data values for each node are applied to the motion segment whose destination is the corresponding node.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: Local condition handlers, composed of WHEN and UNTIL clauses, Chapter 6 *CONDITION HANDLERS* , Appendix E, ‘‘Syntax Diagrams,’’ for additional syntax information, NOWAIT, WHEN, WITH, UNTIL Clauses

Example: Refer to the following sections for detailed program examples:

Section B.2, "Copying Path Variables" (CPY_PTH.KL)

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.14.7 MOVE AWAY Statement

Purpose: Moves the TCP away from its current position using a REAL value offset, measured in millimeters along the negative z-axis of the tool coordinate system.

Syntax : < WITH_clause >

MOVE AWAY distance

< NOWAIT >< ,

cond_handler

{ cond_handler }

ENDMOVE >

where:

WITH_clause : Described under ‘‘WITH Clause’’

distance : a REAL expression

NOWAIT : Described under ‘‘NOWAIT Clause’’

cond_handler : a local condition handler

Details:

- *distance* designates the offset distance, in millimeters, that the TCP is to move from the current TCP position.
- The direction of displacement is determined by the sign of the specified *distance* and the tool orientation at the starting point.
- If the distance is positive, displacement will be in the negative z direction in the coordinate frame of the tool. Otherwise it is in the positive z direction.
- The tool orientation at the end of the move will be the same as at the start. It will be constant during the move only if $MOTYPE is specified as linear.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: Local condition handlers, composed of WHEN and UNTIL clauses, Chapter 6 *CONDITION HANDLERS* , Appendix E, ‘‘Syntax Diagrams,’’ for additional syntax information, NOWAIT, WHEN, WITH, UNTIL Clauses

Example: The following example sets $MOTYPE to JOINT and moves the TCP to the position **start_pos.** Next the TCP moves away -100 millimeters which brings the tool closer to the surface. Moving the TCP away 100 millimeters brings the tool farther away from the surface.

MOVE AWAY Statement

```
$MOTYPE = JOINT        -- start_pos is located
  MOVE TO start_pos      -- 100 mm away from a
                         -- surface.  Tool is
                         -- perpendicular to
                         -- surface at start_pos.
  distance = 100.0
```

```
MOVE AWAY -distance
MOVE AWAY distance
```

A.14.8 MOVE AXIS Statement

Purpose: Moves a specified robot or auxiliary axis a distance specified in degrees or millimeters

Syntax : < WITH_clause >

MOVE AXIS axis_no BY distance

< NOWAIT > < ,

cond_handler

{ cond_handler }

ENDMOVE >

where:

WITH_clause : Described under ‘‘WITH Clause’’

axis_no : an INTEGER expression

distance : a REAL expression

NOWAIT : Described under ‘‘NOWAIT Clause’’

cond_handler : a local condition handler

Details:

- *axis_no* indicates the robot or auxiliary axis to move.
- Robot axes are numbered from one to the number of axes on the robot; auxiliary axes are numbered from one more than the last robot axis to the last auxiliary axis.
- *distance* designates the distance to move. The units of distance are degrees for rotational axes and millimeters for linear (prismatic) axes.
- If an emergency stop occurs during a MOVE AXIS motion, a new destination is computed using the current position at the time the motion is resumed. The original distance is used in the computation, meaning the axis will not end up at the position it was originally moving to before the emergency stop occurred.

Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: Appendix E, ‘‘Syntax Diagrams,’’ for additional syntax information, NOWAIT, WHEN, WITH, UNTIL Clauses

See Also: NOWAIT Clause, Appendix A, ‘‘KAREL Language Alphabetical Description,’’ WHEN Clause and UNTIL Clause, Appendix A, ‘‘KAREL Language Alphabetical Description,’’ WITH Clause, Appendix A, ‘‘KAREL Language Alphabetical Description,’’ Appendix E, ‘‘Syntax Diagrams,’’ for additional syntax information

Example: The following example moves each axis individually 45°.

MOVE AXIS Statement

```
degrees = 45

  FOR i = 1 TO 5 DO
    MOVE AXIS i BY degrees
  ENDFOR
```

A.14.9 MOVE_FILE Built-In Procedure

Purpose: Moves the specified file from one memory file device to another

Syntax : MOVE_FILE (file_spec, status)

Input/Output Parameters :

[in] file_spec : string

[out] status : integer

%ENVIRONMENT Group :FDEV

Details:

- *file_spec* specifies the device, name, and type of the file to be moved. The file should exist on the FROM or RAM disks.
- If *file_spec* is a file on the FROM disk, the file is moved to the RAM disk, and vice versa.

- The wildcard character (*) can be used to replace the entire file name, the first part of the file name, the last part of the file name, or both the first and last parts of the file name. The file type can also use the wildcard in the same manner. If file_spec specifies multiple files, then they are all moved to the other disk.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

Example: In the following example, all .KL files are moved from the RAM disk to the FROM disk.

MOVE_FILE Built-In Procedure

```
PROGRAM move_files
%NOLOCKGROUP
%ENVIRONMENT FDEV
VAR
  status: INTEGER
BEGIN
  MOVE_FILE('RD:\*.KL', status)
  IF status <> 0 THEN
    POST_ERR(status, '', 0, 0)
  ENDIF
END move_files
```

A.14.10 MOVE NEAR Statement

Purpose: Moves the TCP to a destination near the specified POSITION by the distance offset, which is measured along the negative z-axis of the POSITION

Syntax : < WITH_clause >

MOVE NEAR posn BY distance

< NOWAIT > < ,

cond_handler

{ cond_handler }

ENDMOVE >

where:

WITH_clause : Described under ‘‘WITH Clause’’

posn : a POSITION variable

distance : a REAL expression

NOWAIT : Described under ‘‘NOWAIT Clause’’

cond_handler : a local condition handler

Details:

- *distance* designates the offset from the POSITION *posn* to move to in millimeters.
- The direction of the offset is determined by the sign of *distance* and the orientation of the tool at *posn* .
- If *distance* is positive, the displacement will be along the negative z-axis of *posn* . Otherwise, the displacement will be along the positive z-axis.
- The orientation of the final POSITION will be the same as that specified in *posn* .



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: Local condition handlers, composed of WHEN and UNTIL clauses, Chapter 6 *CONDITION HANDLERS* , Appendix E , ‘‘Syntax Diagrams,’’ for additional syntax information, NOWAIT, WHEN, WITH, UNTIL Clauses

Example: Refer to Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.14.11 MOVE RELATIVE Statement

Purpose: Moves the TCP from its present location by a distance specified as a VECTOR or POSITION, in $UFRAME coordinates

Syntax : < WITH_clause >

MOVE RELATIVE distance

< NOWAIT ><,

cond_handler

{ cond_handler }

ENDMOVE >

where:

WITH_clause : Described under ‘‘WITH Clause’’

distance : a VECTOR or POSITION expression

NOWAIT : Described under ‘‘NOWAIT Clause’’

cond_handler : a local condition handler

Details:

- The *TCP* is moved the specified distance in x, y, and z directions of the default or specified $UFRAME.
- If a VECTOR is used, the orientation of the *TCP* at the destination will be the same as that of the *TCP* at the current position, when the move is complete.
- If a POSITION is used, the orientation of the TCP at the destination will be computed by premultiplying the orientation from the distance position to the current orientation of the current position.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: Local condition handlers, composed of WHEN and UNTIL clauses, Chapter 6 *CONDITION HANDLERS* , Appendix E, ‘‘Syntax Diagrams,’’ for additional syntax information, NOWAIT Clause

Example: The following example sets $MOTYPE to JOINT and uses the MOVE TO statement to move the TCP to position **start_pos** . The VECTOR variable **direction** is set to the x, y, and z values of 300, 0, 0. The MOVE RELATIVE statement moves the TCP from **start_pos** by the value of **direction** .

MOVE RELATIVE Statement

```
$MOTYPE = JOINT
  MOVE TO start_pos
  direction.x = 300
  direction.y = 0
  direction.z = 0
  MOVE RELATIVE direction
```

A.14.12 MOVE TO Statement

Purpose: Initiates motion of the robot TCP to a specified POSITION or PATH node

Syntax : < WITH_clause >

MOVE TO || posn | p_var[n] || < VIA_clause >

< NOWAIT ><,

cond_handler

{cond_handler}

ENDMOVE >

where:

WITH_clause : Described under ‘‘WITH clause’’

posn : a positional expression

p_var : a PATH

n : an INTEGER

VIA_clause : Described under ‘‘VIA Clause’’

NOWAIT : Described under ‘‘NOWAIT Clause’’

cond_handler : a local condition handler

Details:

- If the destination is a PATH variable, *n* specifies the node within *p_var* that is the destination of the motion.

Any other fields, including the standard associated data fields, do not affect the motion.

- A *positional expression* can be a POSITION, XYZWPR, XYZWPREXT or JOINTPOS.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: Local condition handlers, composed of WHEN and UNTIL Clauses, Chapter 6 *CONDITION HANDLERS* , Appendix E, ‘‘Syntax Diagrams,’’ for additional syntax information

Example: Refer to the following sections for detailed program examples:

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.8, "Generating and Moving Along a Hexagon Path" (GEN_HEX.KL)

A.14.13 MSG_CONNECT Built-In Procedure

Purpose: Connect a client or server port to another computer for use in Socket Messaging.

Syntax : MSG_CONNECT (tag, status)

Input/Output Parameters :

[in] tag :STRING

[out] status :INTEGER

%ENVIRONMENT Group :FLBT

Details:

- Tag is the name of a client port (C1:-C8) or server port (S1:S8).
- Status explains the status of the attempted operation. If it is not equal to 0, then an error occurred.

See Also: Socket Messaging in the *FANUC Robotics SYSTEM R-J3iC Controller Internet Options Setup and Operations Manual.*

Example: The following example connects to S8: and reads messages. The messages are displayed on the teach pendant screen.

MSG_CONNECT Built-In Procedure

```
PROGRAM tcpserv8
VAR
  file_var :  FILE
  tmp_int  :  INTEGER
  tmp_int1 :  INTEGER
  tmp_str  :  string [128]
  tmp_str1 :  string [128]
  status   :  integer
  entry    :  integer
BEGIN
```

```
   SET_FILE_ATR (file_var, ATR_IA)
  -- Set up S8 server tag
  DISMOUNT_DEV('S8:',status)
  MOUNT_DEV('S8:',status)
  write  (' Mount Status = ',status,cr)
  status = 0
  IF status = 0 THEN
    -- Connect the tag
    write ('Connecting ..',cr)
    MSG_CONNECT ('S8:',status)
    write  ('Connect Status = ',status,cr)
    IF status < > 0 THEN
      MSG_DISCO('S8:',status)
      write  (' Connecting..',cr)
      MSG_CONNECT('S8:',status)
      write  (' Connect Status = ',status,cr)
      ENDIF
    IF status = 0 THEN
      -- OPEN S8:
      write ('Opening',cr)
      OPEN FILE file_var ('rw','S8:')
      status = io_status(file_var)
      FOR tmp_int  1 TO 1000 DO
        write  ('Reading',cr)
        BYTES_AHEAD(file_var, entry, status)
        -- Read 10 bytes
        READ file_var (tmp_str::10)
        status = i/o_status(file_var)
       --Write 10 bytes
       write (tmp_str::10,cr)
       status = io_status(file_var)
       ENDFOR
     CLOSE FILE file_var
     write  ('Disconnecting..',cr)
     MSG_DISCO('S8:',status)
     write  ('Done.',cr)
   ENDIF
 ENDIF
END tcpserv8
```

A.14.14 MSG_DISCO Built-In Procedure

Purpose: Disconnect a client or server port from another computer.

Syntax : MSG_DISCO (tag, status)

Input/Output Parameters :

[in] tag :STRING

[out] status :INTEGER

%ENVIRONMENT Group :FLBT

Details:

- Tag is the name of a client port (C1:-C8) or server port (S1:S8).
- Status explains the status of the attempted operation. If it is not equal to 0, then an error occurred.

See Also: Socket Messaging in the *FANUC Robotics SYSTEM R-J3iC Controller Internet Options Setup and Operations Manual* .

Example: Refer to MSG_CONNECT Built-In Procedure for more examples.

A.14.15 MSG_PING

Syntax : MSG_PING (host name, status)

Input/Output Parameters :

[in] host name :STRING

[out] status :INTEGER

%ENVIRONMENT Group :FLBT

Details:

- Host name is the name of the host to perform the check on. An entry for the host has to be present in the host entry tables (or the DNS option loaded and configured on the robot).
- Status explains the status of the attempted operation. If it is not equal to 0, then an error occurred.

See Also: Ping in the *FANUC Robotics SYSTEM R-J3iC Controller Internet Options Setup and Operations Manual.*

Example: The following example performs a PING check on the hostname "fido". It writes the results on the teach pendant.

MSG_PING Built-In Procedure

```
PROGRAM pingtest
VAR
 Tmp_int  : INTEGER
 Status   : integer
BEGIN
  WRITE('pinging..',cr)
  MSG_PING('fido',status)
  WRITE('ping Status = ',status,cr)
END pingtest
```

A.15 - N - KAREL LANGUAGE DESCRIPTION

A.15.1 NOABORT Action

Purpose: Prevents program execution from aborting when an external error occurs

Details:

- The NOABORT action usually corresponds to an ERROR[n].
- If the program is aborted by itself (i.e., executing an ABORT statement, run time error), the NOABORT action will be ignored and program execution will be aborted.

Example: The following example uses a global condition handler to test for error number 11038, "Pulse Mismatch." If this error occurs, the NOABORT action will prevent program execution from being aborted.

NOABORT Action

```
PROGRAM noabort_ex
%NOLOCKGROUP
BEGIN
  --Pulse Mismatch condition handler
  CONDITION[801]:
    WHEN ERROR[11038] DO
    NOABORT
  ENDCONDITION
  ENABLE CONDITION[801]
END noabort_ex
```

A.15.2 %NOABORT Translator Directive

Purpose: Specifies a mask for aborting

Syntax : %NOABORT = ERROR + COMMAND

Details:

- ERROR and COMMAND are defined as follows:

```
ERROR : ignore abort error severity
   COMMAND : ignore abort command
```

- Any combination of ERROR and COMMAND can be specified.
- If the program is aborted by itself (for example, executing an ABORT statement, run-time error), the %NOABORT directive will be ignored and program execution will be aborted.
- This directive is only effective for programs with %NOLOCKGROUP. If the program has motion control, the %NOABORT directive will be ignored and program execution will be aborted.

A.15.3 %NOBUSYLAMP Translator Directive

Purpose: Specifies that the busy lamp will be OFF during execution.

Syntax: %NOBUSYLAMP

Details:

- The busy lamp can be set during task execution by the SET_TSK_ATTR built-in.

A.15.4 NODE_SIZE Built-In Function

Purpose: Returns the size (in bytes) of a PATH node

Syntax : NODE_SIZE(path_var)

Function Return Type :INTEGER

Input/Output Parameters:

[in] path_var : PATH

%ENVIRONMENT Group :PATHOP

Details:

- The returned value is the size of an individual PATH node, including the positional data type size and any associated data.
- The returned value can be used to calculate file positions for random access to nodes in files.

Example: The following example program reads a path, while overlapping reads with preceding moves. The routine **read_header** reads the path header and prepares for reading of nodes. The routine **read_node** reads a path node.

NODE_SIZE Built-In Function

```
PROGRAM read_and_mov
VAR my_path: PATH
    path_base: INTEGER
    node_size: INTEGER
    max_node_no: INTEGER
    i: INTEGER
    file_var:  FILE
ROUTINE read_header
BEGIN
  READ file_var(my_path[0])
  IF IO_STATUS(file_var) <> 0 THEN
    WRITE('HEADER READ ERROR:',IO_STATUS(file_var),cr)
    ABORT
  ENDIF
  max_node_no = PATH_LEN(my_path)
  node_size = NODE_SIZE(my_path)
  path_base = GET_FILE_POS(file_var)
END read_header
ROUTINE read_node(node_no: INTEGER)
--
VAR status: INTEGER
BEGIN
  SET_FILE_POS(file_var, path_base+(node_no-1)*node_size, status)
  READ file_var(my_path[node_no])
END read_node
BEGIN
  SET_FILE_ATR(file_var, atr_uf)
  OPEN FILE F1('RO','PATHFILE.DT')
  read_header
  FOR i = 1 TO max_node_no DO
    read_node(i)
    MOVE TO my_path[i] NOWAIT
  ENDFOR
  CLOSE FILE file_var
END read_and_mov
```

A.15.5 %NOLOCKGROUP Translator Directive

Purpose: Specifies that motion groups do not need to be locked when calling this program, or a routine defined in this program.

Syntax : %NOLOCKGROUP

Details:

- When the program or routine is called, the task will not attempt to get motion control.
- If %NOLOCKGROUP is not specified, all groups will be locked when the program or routine is called, and the task will attempt to get motion control. The task will pause if it cannot get motion control.
- The task will keep motion control while it is executing the program or routine. When it exits the program or routine, the task automatically unlocks all the motion groups.
- If the task contains executing or stopped motion, then task execution is held until the motion is completed. Stopped motion must be resumed and completed or cancelled.
- If a program that has motion control calls a program with the %NOLOCKGROUP Directive or a routine defined in such a program, the program will keep motion control even though it is not needed.
- The UNLOCK_GROUP built-in routine can be used to release control.
- If a motion statement is encountered in a program that has the %NOLOCKGROUP Directive, the task will attempt to get motion control for all the required groups if it does not already have it. The task will pause if it cannot get motion control.



Caution

Many of the fields in the $GROUP system variable are initialized to a set of default values when a KAREL task is started, see KAREL Motion Initialization . When %NOLOCKGROUP is specified, this initialization does not occur. Therefore, when a motion is issued the current values of these fields are used. This could cause unexpected motion.

KAREL Motion Initialization

```
$GROUP[n].$MOTYPE       = JOINT
   $GROUP[n].$TERMTYPE     = FINE
   $GROUP[n].$SEGTERMTYPE  = FINE
   $GROUP[n].$DECELTOL     = 0
   $GROUP[n].$USE_CONFIG   = TRUE
   $GROUP[n].$ORIENT_TYPE  = RSWORLD
   $GROUP[n].$SPEED        = 300.0
   $GROUP[n].$ROTSPEED     = 500.0   ($MRR_GRP[n].$ROTSPEEDLIM x 57.29577951)
   $GROUP[n].$CONTAXISVEL  = 0.0
```

```
$GROUP[n].$SEG_TIME     = 0
```



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: %LOCKGROUP Translator Directive, LOCK_GROUP, UNLOCK_GROUP Built-In Procedures

Example: Refer to the following sections for detailed program examples:

Section B.3,"Saving Data to the Default Device" (SAVE_VR.KL)

Section B.5,"Using Register Built-ins" (REG_EX.KL)

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.11, "Manipulating Values of Dynamically Displayed Variables" (CHG_DATA.KL)

Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL)

Section B.13, "Using the DISCTRL_ALPHA Built-in" (DCALP_EX.KL)

A.15.6 NOMESSAGE Action

Purpose: Suppresses the display and logging of error messages

Syntax : NOMESSAGE

Details:

- Display and logging of the error messages are suppressed only for the error number specified in the corresponding condition.
- Use a wildcard (*) to suppress all messages.
- Abort error messages still will be displayed and logged even if NOMESSAGE is used.

Example: Refer to Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.15.7 NOPAUSE Action

Purpose: Resumes program execution if the program was paused, or prevents program execution from pausing

Syntax : NOPAUSE

Details:

- The NOPAUSE action usually corresponds to an ERROR[n] or PAUSE condition.
- The program will be resumed, even if it was paused before the error.
- If the program is paused by itself, the NOPAUSE action will be ignored and program execution will be paused.

Example: The following example uses a global condition handler to test for error number 12311. If this error occurs, the NOPAUSE action will prevent program execution from being paused and the NOMESSAGE action will suppress the error message normally displayed for error number 12311. This will allow the routine **uninit_error** to be executed without interruption.

NOPAUSE Action

```
ROUTINE uninit_error
  BEGIN
    WRITE ('Uninitialized operand',CR)
    WRITE ('Use KCL> SET VAR to initialize operand',CR)
    WRITE ('Press Resume at Test/Run screen to ',cr)
    WRITE ('continue program',cr)
    PAUSE  --pauses program (undoes NOPAUSE action)
  END uninit_error
CONDITION[1]:
  WHEN ERROR[12311] DO
    NOPAUSE, NOMESSAGE, uninit_error
ENDCONDITION
```

A.15.8 %NOPAUSE Translator Directive

Purpose: Specifies a mask for pausing

Syntax : %NOPAUSE = ERROR + COMMAND + TPENABLE

Details:

- The bits for the mask are as follows:

```
ERROR : ignore pause error severity
   COMMAND : ignore pause command
```

```
TPENABLE : ignore paused request when TP enabled
```

- Any combination of ERROR, COMMAND, and TPENABLE can be specified.
- If the program is paused by itself, the %NOPAUSE directive will be ignored and program execution will be paused.
- This directive is only effective for programs with %NOLOCKGROUP. If the program has motion control, the %NOPAUSE Directive will be ignored and program execution will be paused.

A.15.9 %NOPAUSESHFT Translator Directive

Purpose: Specifies that the task is not paused if shift key is released.

Syntax : %NOPAUSESHFT

Details:

- This attribute can be set during task execution by the SET_TSK_ATTR built-in routine.

A.15.10 NOWAIT Clause

Purpose: Allows program execution to overlap with motion or a pulse

Syntax : NOWAIT

Details:

- If NOWAIT is included in a motion statement, the next statement will be executed at the same time motion begins.
- NOWAIT follows the motion specification of a MOVE statement and the VIA clause but precedes any condition handler clauses.
- If NOWAIT is not included, the next statement will be executed when the motion is completed or canceled.
- A NOWAIT motion will be canceled at the time the CANCEL action or statement is executed.

See Also: PULSE Statement, MOVE Statements Syntax Diagrams, Appendix E "Syntax Diagrams"

Example: In the following example, the NOWAIT clause is used so that all statements will be executed at the same time.

NOWAIT Clause

```
PULSE DOUT[2] FOR 50 NOWAIT
```

```
MOVE TO p1 NOWAIT
DOUT[1] = ON
```

A.16 - O - KAREL LANGUAGE DESCRIPTION

A.16.1 OPEN FILE Statement

Purpose: Associates a data file or communication port with a file variable

Syntax : OPEN FILE file_var (usage_string, file_string)

where:

file_var : FILE

usage_string : a STRING

file_string : a STRING

Details:

- *file_var* must be a static variable not already in use by another OPEN FILE statement.
- The *usage_string* is composed of the following:

  'RO' :Read only

  'RW' :Read write

  'AP' :Append

  'UD' :Update
- The *file_string* identifies a data file name and type, a window or keyboard, or a communication port.
- The SET_FILE_ATR built-in routine can be used to set a file's attributes.
- When a program is aborted or exits normally, any opened files are closed. Files are not closed when a program is paused.
- Use the IO_STATUS built-in function to verify if the open file operation was successful.

See Also: IO_STATUS Built-In Function, SET_FILE_ATR Built-In Procedure, Chapter 7 *FILE INPUT/OUTPUT OPERATIONS* , Chapter 9 *FILE SYSTEM* , Appendix E, ''Syntax Diagrams'' for more syntax information

Example: Refer to the following sections for detailed program examples:

Section B.2, "Copying Path Variables" (CPY_PTH.KL)

Section B.12 , "Displaying a List From a Dictionary File" (DCLST_EX.KL)

A.16.2 OPEN HAND Statement

Purpose: Opens a hand on the robot

Syntax : OPEN HAND hand_num

where:

hand_num : an INTEGER expression

Details:

- The actual effect of the statement depends on how the HAND signals are set up. Refer to Chapter 13, ‘‘Input/Output System.’’
- *hand_num* must be a value in the range 1-2. Otherwise, the program is aborted with an error.
- The statement has no effect if the value of *hand_num* is in range but the hand is not connected.
- If the value of **hand_num** is in range but the HAND signal represented by that value has not been assigned, the program is aborted with an error.

See Also: Appendix D, ‘‘Syntax Diagrams’’ for more syntax information

Example: The following example moves the TCP to the position **p2** and opens the hand of the robot specified by the INTEGER variable **hand_num** .

OPEN HAND Statement

```
MOVE TO p2
OPEN HAND hand_num
```

A.16.3 OPEN_TPE Built-In Procedure

Purpose: Opens the specified teach pendant program

Syntax : OPEN_TPE(prog_name, open_mode, reject_mode, open_id, status)

Input/Output Parameters:

[in] prog_name :STRING

[in] open_mode :INTEGER

[in] reject_mode :INTEGER

[out] open_id :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *prog_name* specifies the name of the teach pendant program to be opened. *prog_name* must be in all capital letters.
- *prog_name* must be closed, using CLOSE_TPE, before *prog_name* can be executed.
- *open_mode* determines the access code to the program. The access codes are defined as follows:

  0 : none

  TPE_RDACC : Read Access

  TPE_RWACC : Read/Write Access
- *reject_mode* determines the reject code to the program. The program that has been with a reject code cannot be opened by another program. The reject codes are defined as follows:

  TPE_NOREJ : none

  TPE_RDREJ : Read Reject

  TPE_WRTREJ : Write Reject

  TPE_RWREJ : Read/Write Reject

  TPE_ALLREJ : All Reject
- *open_id* indicates the id number of the opened program.
- *status* explains the status of the attempted operation. If not equal to 0, then an error has occurred.
- All open teach pendant programs are closed automatically when the KAREL program is aborted or exits normally.

See Also: CREATE_TPE Built-In Procedure, COPY_TPE Built-In Procedure, AVL_POS_NUM Built-In Procedure

Example: Refer to Section B.14, "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL), for a detailed program example.

A.16.4 ORD Built-In Function

Purpose: Returns the numeric ASCII code corresponding to the character in the STRING argument that is referenced by the index argument

Syntax : ORD(str, str_index)

Function Return Type :INTEGER

Input/Output Parameters:

[in] str :STRING

[in] str_index :INTEGER

%ENVIRONMENT Group :SYSTEM

Details:

- The returned value represents the ASCII numeric code of the specified character.
- *str_index* specifies the indexed position of a character in the argument *str* . A value of 1 indicates the first character.
- If *str_index* is less than one or greater than the current length of *str* , the program is paused with an error.

See Also: Appendix D, ‘‘Character Codes’’

Example: Refer to Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL), for a detailed program example.

A.16.5 ORIENT Built-In Function

Purpose: Returns a unit VECTOR representing the y-axis (orient vector) of the specified POSITION argument

Syntax : ORIENT(posn)

Function Return Type :VECTOR

Input/Output Parameters:

[in] posn : POSITION

%ENVIRONMENT Group :VECTR

Details:

- Instead of using this built-in, **you can directly access the Orient Vector of a POSITION.**
- The returned value is the orient vector of *posn* .
- The orient vector is the positive y-direction in the tool coordinate frame.

Example: The following example initially moves the TCP to the POSITION **start_pos** . The VECTOR **pos_vector** is then set to the value of the orient vector for **start_pos** . The MOVE ABOUT statement moves the TCP about **pos_vector** by 45°.

ORIENT Built-In Function

```
MOVE TO start_pos
  pos_vector = ORIENT (start_pos)
  MOVE ABOUT pos_vector BY 45
```

A.17 - P - KAREL LANGUAGE DESCRIPTION

A.17.1 PATH Data Type

Purpose: Defines a variable or routine parameter as PATH data type

Syntax : PATH

Details:

- A PATH is a varying length list of elements called path nodes, numbered from 1 to the number of nodes in the PATH.
- No valid operators are defined for use with PATH variables.
- A PATH variable is indexed (or subscripted) as if it were an ARRAY variable. For example, *tool_track[1]* refers to the first node of a PATH called *tool_track* .
- An uninitialized PATH has a length of zero.
- PATH variables cannot be declared local to routines and cannot be returned from functions.
- Only PATH expressions can be assigned to PATH variables or passed as arguments to PATH parameters.
- A PATH variable can specify a data structure constituting the data for each path node.
- A PATH variable can specify a data structure constituting the path header. This can be used to specify the UFRAME and/or UTOOL to be used with recording or moving along the path. It can also specify an axis group whose current position defines a table-top coordinate frame with respect to which the robot data is recorded and moved.

- A PATH can be declared with either, neither, or both of the following clauses following the word PATH:
  - NODEDATA = node_struct_name, specifying the data structure constituting a path node.
  - PATHHEADER = header_struct_name, specifying the structure constituting the path header.

If both fields are present, they can appear in either order and are separated by a comma and optionally a new line.

- If NODEDATA is not specified, it defaults to the STD_PTH_NODE structure described in Appendix A.
- If PATHHEADER is not specified, there is no (user-accessible) path header.
- An element of the PATHHEADER structure can be referenced with the syntax path_var_name.header_field_name.
- An element of a NODEDATA structure can be referenced with the syntax path_var_name[node_no].node_field_name.
- The path header structure can be copied from one path to another with the path_var1 = path_var2 statement.
- The path node structure can be copied from one node to another with the path_var[2] = path_var[1] statement.
- A path can be passed as an argument to a routine as long as the PATHHEADER and NODEDATA types match. A path that is passed as an argument to a built-in routine can be of any type.
- A path node can be passed as an argument to a routine as long as the routine parameter is the same type as the NODEDATA structure.
- If the data structure specified for NODEDATA in a path includes more than one position data type for the same group, only the first for that group will be used in move statements specifying the path.
- PATHs provide the ability to specify motion groups to be used for local condition handlers.
- A path can be declared with a NODEDATA structure having no position type elements. This can be a useful way of maintaining a list structure. Such a path can not be used in a MOVE statement.

See Also: APPEND_NODE, DELETE_NODE, INSERT_NODE Built-In Procedures, PATH_LEN, NODE_SIZE Built-In Functions

Example: The following example shows different declarations of PATH variables.

PATH Data Type

```
TYPE
      node_struct = STRUCTURE
        node_posn: XYZWPR IN GROUP[1]
        node_data: GROUP_ASSOC IN GROUP[1]
        aux_posn: JOINTPOS IN GROUP[2]
        common_data: COMMON_ASSOC
```

```
    weld_time: INTEGER
    weld_current: INTEGER
  ENDSTRUCTURE
std_pth_node = STRUCTURE  -- This type is predefined
    node_pos: POSITION IN GROUP[1]
    group_data: GROUP_ASSOC IN GROUP[1]
    common_data: COMMON_ASSOC
  ENDSTRUCTURE
hdr_struct = STRUCTURE
    uframe1: POSITION
    utool: POSITION
    speed: REAL
  ENDSTRUCTURE
VAR
  path_1a: PATH PATHHEADER = hdr_struct, NODEDATA = node_struct
  path_1b: PATH NODEDATA = node_struct, PATHHEADER = hdr_struct
  path_2:  PATH NODEDATA = node_struct -- no header
  path_3:  PATH -- equivalent to PATH NODEDATA = std_pth_node
  path_4:  PATH PATHHEADER = hdr_struct -- std_pth_node
```

The following example shows how an element of a NODEDATA structure can be referenced.

PATH Data Type

```
-- Using declaration for path_1a:
-- Using NODEDATA fields:
 path_1a[1].node_posn = CURPOS(0, 0)
 cnt_dn_time = path_1a[node_no].weld_time
 path_1a[1].node_data.SEGRELSPEED = new_value
 path_1a[1].common_data.SEGTERMTYPE = new_value
-- Using PATHHEADER fields:
 path_1a.utool = tool_1
 WITH $UFRAME = path_1a.uframe, $SPEED = path_1a.speed
  MOVE ALONG path_1a
```

Example: Refer to the following sections for detailed program examples:

Section B.2, "Copying Path Variables" (CPY_PTH.KL)

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

A.17.2 PATH_LEN Built-In Function

Purpose: Returns the number of nodes in the PATH argument

Syntax : PATH_LEN(path_nam)

Function Return Type : INTEGER

Input/Output Parameters :

[in] path_nam : PATH

%ENVIRONMENT Group :PBCORE

Details:

- The returned value corresponds to the number of nodes in the PATH variable argument.
- Calling PATH_LEN with an uninitialized PATH returns a value of zero.

See Also: COPY_PATH Built-in

Example: Refer to the following sections for detailed program examples:

Section B.2, "Copying Path Variables" (CPY_PTH.KL)

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.17.3 PAUSE Action

Purpose: Suspends execution of a running task

Syntax : PAUSE <PROGRAM[n]>

Details:

- The PAUSE action pauses task execution in the following manner:
  - — Any motion already initiated continues until completed.
  - — Files are left open.
  - — All connected timers continue being incremented.
  - — All PULSE statements in execution continue execution.
  - — Sensing of conditions specified in condition handlers continues.
  - — Any Actions, except routine call actions, are completed. Routine call actions are performed when the program is resumed.
- The PAUSE action can be followed by the clause PROGRAM[n], where n is the task number to be paused.

- Use GET_TSK_INFO to find a task number.

See Also: UNPAUSE Action

A.17.4 PAUSE Condition

Purpose: Monitors the pausing of program execution

Syntax : PAUSE < PROGRAM [n] >

Details:

- The PAUSE condition is satisfied when a program is paused, for example, by an error, a PAUSE Statement, or the PAUSE Action.
- If one of the actions corresponding to a PAUSE condition is a routine call, it is necessary to specify a NOPAUSE action to allow execution of the routine.

  Also, the routine being called needs to include a PAUSE statement so the system can handle completely the cause of the original pause.
- The PAUSE condition can be followed by the clause PROGRAM[n], where n is the task number to be paused.
- Use GET_TSK_INFO to find a task number.

Example: The following example scans for the PAUSE condition in a global condition handler. If this condition is satisfied, DOUT[1] will be turned on. The CONTINUE action continues program execution; ENABLE reenables the condition handler.

PAUSE Condition

```
CONDITION[1]:
  WHEN PAUSE DO
    DOUT[1] = TRUE
    CONTINUE
    ENABLE CONDITION[1]
ENDCONDITION
```

A.17.5 PAUSE Statement

Purpose: Suspends execution of a KAREL program

Syntax : PAUSE < PROGRAM [n] >

Details:

- The PAUSE statement pauses program execution in the following manner:
  - — Any motion already initiated continues until completed.
  - — Files are left open.
  - — All connected timers continue being incremented.
  - — All PULSE statements in execution continue execution.
  - — Sensing of conditions specified in condition handlers continues.
  - — Any actions, except routine call actions, are completed. Routine call actions are performed when the program is resumed.
- The PAUSE statement can be followed by the clause PROGRAM[n], where n is the task number to be paused.
- Use GET_TSK_INFO to find a task number.

See Also: Appendix E, "Syntax Diagrams," for more syntax information

Example: If DIN[1] is TRUE, the following example pauses the KAREL program using the PAUSE statement. The message, "Program is paused. Press RESUME function key to continue" will be displayed on the CRT/KB screen.

PAUSE Statement

```
PROGRAM p_pause
BEGIN
   IF DIN[1] THEN
      WRITE ('Program is Paused. ')
      WRITE ('Press RESUME function key to continue', CR)
      PAUSE
   ENDIF
END p_pause
```

A.17.6 PAUSE_TASK Built-In Procedure

Purpose: Pauses the specified executing task

Syntax : PAUSE_TASK(task_name, force_sw, stop_mtn_sw, status)

Input/Output Parameters:

[in] task_name :STRING

[in] force_sw :BOOLEAN

[in] stop_mtn_sw :BOOLEAN

[out] status :INTEGER

%ENVIRONMENT Group :MULTI

Details:

- *task_name* is the name of the task to be paused. If task name is '*ALL*', all executing tasks are paused except the tasks that have the ''ignore pause request'' attribute set.
- *force_sw* specifies whether a task should be paused even if the task has the ''ignore pause request'' attribute set. This parameter is ignored if task_name is '*ALL*'.
- *stop_mtn_sw* specifies whether all motion groups belonging to the specified task are stopped.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: RUN_TASK, CONT_TASK, ABORT_TASK Built-In Procedures, Chapter 14 *MULTI-TASKING*

Example: The following example pauses the user-specified task and stops any motion. Refer to Chapter 14 *MULTI-TASKING* , for more examples.

PAUSE_TASK Built-In Procedure

```
PROGRAM pause_ex
%ENVIRONMENT MULTI
VAR
  task_str: STRING[12]
  status  : INTEGER
BEGIN
  WRITE('Enter task name to pause:')
  READ(task_str)
  PAUSE_TASK(task_str, TRUE, TRUE, status)
END pause_ex
```

A.17.7 PEND_SEMA Built-In Procedure

Purpose: Suspends execution of the task until either the value of the semaphore is greater than zero or max_time expires

Syntax : PEND_SEMA(semaphore_no, max_time, time_out)

Input/Output Parameters:

[in] semaphore_no :INTEGER

[in] max_time :INTEGER

[out] time_out :BOOLEAN

%ENVIRONMENT Group :MULTI

Details:

- PEND_SEMA decrements the value of the semaphore.
- *semaphore_no* specifies the semaphore number to use.
- *semaphore_no* must be in the range of 1 to the number of semaphores defined on the controller.
- *max_time* specifies the expiration time, in milliseconds. A max_time value of -1 indicates to wait forever, if necessary.
- On continuation, *time_out* is set TRUE if max_time expired without the semaphore becoming nonzero, otherwise it is set FALSE.

See Also: POST_SEMA, CLEAR_SEMA Built-In Procedures, SEMA_COUNT Built-In Function, Chapter 14 *MULTI-TASKING*

Example: See examples in Chapter 14 *MULTI-TASKING*

A.17.8 PIPE_CONFIG Built-In Procedure

Purpose: Configure a pipe for special use.

Syntax : pipe_config(pipe_name, cmos_flag, n_sectors, record_size, form_dict, form_ele, status)

Input/Output Parameters :

[in] pipe_name :STRING

[in] cmos_flag :BOOLEAN

[in] n_sectors :INTEGER

[in] record_size :INTEGER

[in] form_dict :STRING

[in] form_ele :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :FLBT

Details:

- pipe_name is the name of the pipe file. If the file does not exist it will be created with this operation.
- CMOS_flag if set to TRUE will put the pipe data in CMOS. By default pipe data is in DRAM.
- n_sectors number of 1024 byte sectors to allocate to the pipe. The default is 8.
- record_size the size of a binary record in a pipe. If set to 0 the pipe is treated as ASCII. If a pipe is binary and will be printed as a formatted data then this must be set to the record length.
- form_dict is the name of the dictionary containing formatting information.
- form_ele is the element number in form_dict containing the formatting information.
- status explains the status of the attempted operation. If it is not equal to 0, then an error occurred.

See Also: For further information see "PIP: Device" in Section 9.3.4 .

A.17.9 POP_KEY_RD Built-In Procedure

Purpose: Resumes key input from a keyboard device

Syntax : POP_KEY_RD(key_dev_name, pop_index, status)

Input/Output Parameters:

[in] key_dev_name :STRING

[in] pop_index :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- Resumes all suspended read requests on the specified keyboard device.
- If there were no read requests active when suspended, this operation will not resume any inputs. This is not an error.
- *key_dev_name* must be one of the keyboard devices already defined:

  'TPKB' :Teach Pendant Keyboard Device

  'CRKB' :CRT Keyboard Device
- *pop_id* is returned from PUSH_KEY_RD and should be used to re-activate the read requests.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: PUSH_KEY_RD, READ_KB Built-in Procedures

Example: Refer to the example for the READ_KB Built-In Routine.

A.17.10 Port_Id Action

Purpose: Sets the value of a port array element to the result of an expression

Syntax : port_id[n] = expression

where:

port_id :an output port array

n :an INTEGER

expression :a variable, constant, or EVAL clause

Details:

- The value of *expression* is assigned to the port array element referenced by *n* .
- The port array must be an output port array that can be written to by a KAREL program. Refer to Chapter 2, ‘‘Language Elements.’’
- *expression* can be a user-defined, static variable, a system variable that can be read by a KAREL program, any constant, or an EVAL clause.
- If *expression* is a variable, the value used is the current value of the variable at the time the action is taken, not when the condition handler is defined.
- If *expression* is an EVAL clause, it is evaluated when the condition handler is defined and that value is assigned when the action is taken.
- The expression must be of the same type as *port_id* .
- You cannot assign a port array element to a port array element directly.
- If the expression is a variable that is uninitialized when the condition handler is enabled, the program will be aborted with an error.

See Also: Chapter 6 *CONDITION HANDLERS* , Chapter 7 *FILE INPUT/OUTPUT OPERATIONS* , Relational Conditions, Appendix A, ‘‘KAREL Language Alphabetical Description’’

Example: Refer to Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.17.11 Port_Id Condition

Purpose: Monitors a digital port signal

Syntax : <NOT> port_id[n] < + | - >

where:

port_id :a port array

n :an INTEGER

Details:

- *n* specifies the port array signal to be monitored.
- *port_id* must be one of the predefined BOOLEAN port array identifiers with read access. Refer to Chapter 2, ‘‘Language Elements.’’
- For event conditions, only the + or - alternatives are used.
- For state conditions, only the NOT alternative is used.

See Also: Chapter 6 *CONDITION HANDLERS* , Chapter 7 *FILE INPUT/OUTPUT OPERATIONS* , Relational Conditions, Appendix A, ‘‘KAREL Language Alphabetical Description’’

Example: Refer to Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.17.12 POS Built-In Function

Purpose: Returns an XYZWPR composed of the specified location arguments (x,y,z), orientation arguments (w,p,r), and configuration argument (c)

Syntax : POS(x, y, z, w, p, r, c)

Function Return Type : XYZWPR

Input/Output Parameters:

[in] x, y, z, w, p, and r :REAL

[in] c :CONFIG

%ENVIRONMENT Group :SYStem

Details:

- *c* must be a valid configuration for the robot attached to the controller. CNV_STR_CONF can be used to convert a string to a CONFIG variable.
- *x* , *y* , and *z* are the Cartesian values of the location (in millimeters). Each argument must be in the range±10000000 mm (±10 km). Otherwise, the program is paused with an error.

- *w* , *p* , and *r* are the yaw, pitch, and roll values of the orientation (in degrees). Each argument must be in the range ±180 degrees. Otherwise, the program is paused with an error.

See Also: Chapter 8 *MOTION*

Example: The following example uses the POS Built-In to designate numerically the POSITION **next_pos** and then moves the TCP to that position.

POS Built-In Function

```
CNV_STR_CONF('n', config_var, status)
next_pos = POS(100,-400.25,0.5,10,-45,30,config_var)
MOVE TO next_pos
```

A.17.13 POS2JOINT Built-In Function

Purpose: This routine is used to convert Cartesian positions (in_pos) to joint angles (out_jnt) by calling the inverse kinematics routine.

Syntax : POS2JOINT (in_pos, uframe, utool, config_ref, wjnt_cfg, ext_ang, out_jnt, and status).

Input/Output Parameters:

[in] ref_jnt :Jointpos

[in] in_pos :POSITION

[in] uframe :POSITION

[in] utool :POSITION

[in] config_ref :INTEGER

[in] wjnt_cfg :CONFIG

[in] ext_ang :ARRAY OF REAL

[out] out_jnt :JOINTPOS

[out] status :INTEGER

%ENVIRONMENT Group :MOTN

Details:

- The input *ref_jnt* are the reference joint angles that represent the robot's position just before moving to the current position.

- The input *in_pos* is the robot Cartesian position to be converted to joint angles.
- The input *uframe* is the user frame for the Cartesian position.
- The input *utool* is the corresponding tool frame.
- The input *config_ref* is an integer representing the type of solution desired. The values listed below are valid. Also, the pre-defined constants in the parentheses can be used and the values can be added as required. One example includes: config_ref = HALF_SOLN + CONFIG_TCP.
  - 0 :(FULL_SOLN) = Default
  - 1 : (HALF_SOLN) = Wrist joint (XYZ456). This does not calculate/use WPR.
  - 2 :(CONFIG_TCP) = The Wrist Joint Config (up/down) is based on the fixed wrist.
  - 4 :(APPROX_SOLN) = Approximate solution. Reduce calculation time for some robots.
  - 8 :(NO_TURNS) = Ignore wrist turn numbers. Use the closest path for joints 4, 5 and 6 (uses ref_jnt).
  - 16 :(NO_M_TURNS) = Ignore major axis (J1 only) turn number. Use the closest path.
- The input *wjnt_cfg* is the wrist joint configuration. This value must be input when *config_ref* corresponds to HALF_SOLN.
- The input *ext_ang* contains the values of the joint angles for the extended axes if they exist.
- The output *out_jnt* are the joint angles that correspond to the Cartesian position
- The output *status* explains the status of the attempted operation. If it is not equal to 0, then an error has occurred.

A.17.14 POS_REG_TYPE Built-In Procedure

Purpose: Returns the position representation of the specified position register

Syntax : POS_REG_TYPE (register_no, group_no, posn_type, num_axes, status)

Input/Output Parameters :

[in] register : INTEGER

[in] group_no : INTEGER

[out] posn_type : INTEGER

[out] num_axes : INTEGER

[out] status : INTEGER

%ENVIRONMENT Group :REGOPE

Details:

- *register_no* specifies the position register.
- If *group_no* is omitted, the default group for the program is assumed.
- If *group_no* is specified, it must be in the range of 1 to the total number of groups defined on the controller.
- *posn_type* returns the position type. posn_type is defined as follows:
  - 1 :POSITION
  - 2 :XYZWPR
  - 6 :XYZWPREXT
  - 9 :JOINTPOS
- *num_axes* returns number of axes in the representation if the position type is a JOINTPOS. If the position type is an XYZWPREXT, only the number of extended axes is returned by num_axes.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: GET_POS_REG, GET_JPOS_REG, SET_POS_REG, SET_JPOS_REG Built-in Procedures

Example: The following example determines the position type in the register and uses the appropriate built-in to get data.

POS_REG_TYPE Built-In Procedure

```
PROGRAM get_reg_data
%NOLOCKGROUP
%ENVIRONMENT REGOPE
VAR
  entry: INTEGER
  group_no: INTEGER
  jpos: JOINTPOS
  maxpregnum: integer
  num_axes: INTEGER
  posn_type: INTEGER
  register_no: INTEGER
  status: INTEGER
  xyz: XYZWPR
  xyzext: XYZWPREXTBEGIN
  group_no = 1
  GET_VAR(entry, '*POSREG*' ,'$MAXPREGNUM', maxpregnum, status)
  -- Loop for each register
  FOR register_no = 1 to 10 DO
    -- Get the position register type
    POS_REG_TYPE(register_no, group_no, posn_type, num_axes, status)
    -- Get the position register
```

```
    WRITE('PR[', register_no, '] of type ', posn_type, CR)
    SELECT posn_type OF
      CASE (2):
        xyz = GET_POS_REG(register_no, status)
      CASE (6):
        xyzext = GET_POS_REG(register_no, status)
      CASE (9):
        jpos = GET_JPOS_REG(register_no, status)
      ELSE:
    ENDSELECT
  ENDFOR
END get_reg_data
```

A.17.15 POSITION Data Type

Purpose: Defines a variable, function return type, or routine parameter as POSITION data type

Syntax : POSITION <IN GROUP[n]>

Details:

- A POSITION consists of a matrix defining the normal, orient, approach, and location vectors and a component specifying a configuration string, for a total of 56 bytes.
- The configuration string indicates the joint placements and multiple turns that describe the configuration of the robot when it is at a particular position.
- A POSITION is always referenced with respect to a specific coordinate frame.
- The POSITION data type can be used to represent a frame of reference in which case the configuration component is ignored.
- Coordinate frame transformations can be done using the relative position operator (:).
- A POSITION can be assigned to other positional types.
- Valid POSITION operators are the
  - — Relative position (:) operator
  - — Approximately equal (>=<) operator
- A POSITION can be followed by IN GROUP[n], where n indicates the motion group with which the data is to be used. The default is the group specified by the %DEFGROUP directive, or 1.
- Components of POSITION variables can be accessed or set as if they were defined as follows:

POSITION Data Type

```
POSITION = STRUCTURE
     NORMAL:  VECTOR           -- read-only
```

```
  ORIENT:  VECTOR          -- read-only
  APPROACH:  VECTOR        -- read-only
  LOCATION:  VECTOR        -- read-write
  CONFIG_DATA:  CONFIG     -- read-write
ENDSTRUCTURE
```

See Also: Chapter 8 *MOTION* , POS, UNPOS Built-In Functions

Example: Refer to Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.17.16 POST_ERR Built-In Procedure

Purpose: Posts the error code and reason code to the error reporting system to display and keep history of the errors

Syntax: POST_ERR(error_code, parameter, cause_code, severity)

Input/Output Parameters:

[in] error_code :INTEGER

[in] parameter :STRING

[in] cause_code :INTEGER

[in] severity :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *error_code* is the error to be posted.
- *parameter* will be included in *error_code's* message if %s is specified in the dictionary text. If not necessary, then enter the null string.
- *cause_code* is the reason for the error. 0 can be used if no cause is applicable.
- *error_code* and *cause_code* are in the following format:

```
ffccc (decimal)
```

where

ff represents the facility code of the error. specified facility.

ccc represents the error code within the

- *severity* is defined as follows:

  0 : WARNING, no change in task execution

  1 : PAUSE, all tasks and stop all motion all motion

  2 : ABORT, all tasks and cancel

See Also: ERR_DATA Built-In Procedure, the appropriate application-specific *FANUC Robotics SYSTEM R-J3iC Controller Setup and Operations Manual,* "Error Codes"

Example: Refer to Section B.13 , "Using the DISCTRL_ALPHA Built-in" (DCALP_EX.KL), for a detailed program example.

A.17.17 POST_SEMA Built-In Procedure

Purpose: Add one to the value of the indicated semaphore

Syntax : POST_SEMA(semaphore_no)

Input/Output Parameters:

[in] semaphore_ no : INTEGER

%ENVIRONMENT Group : MULTI

Details:

- The semaphore indicated by *semaphore_no* is incremented by one.
- *semaphore_no* must be in the range of 1 to the number of semaphores defined on the controller.

See Also: PEND_SEMA, CLEAR_SEMA Built-In Procedures, SEMA_COUNT Built-In Function, Chapter 14 *MULTI-TASKING* ,

Example: See examples in Chapter 14 *MULTI-TASKING*

A.17.18 PRINT_FILE Built-In Procedure

Purpose: Prints the contents of an ASCII file to the default device

Syntax : PRINT_FILE(file_spec, nowait_sw, status)

Input/Output Parameters:

[in] file_spec :STRING

[in] nowait_sw :BOOLEAN

[out] status :INTEGER

%ENVIRONMENT Group : FDEV

Details:

- *file_spec* specifies the device, name, and type of the file to print.
- If *nowait_sw* is TRUE, execution of the program continues while the command is executing. If it is FALSE, the program stops, including condition handlers, until the operation has completed. If you have time critical condition handlers in your program, put them in another program that executes as a separate task.

  Note *nowait_sw* is not available in this release and should be set to FALSE.

- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

A.17.19 %PRIORITY Translator Directive

Purpose: Specifies task priority

Syntax : %PRIORITY = n

Details:

- *n* is the priority and is defined as follows:

```
1 to 89 : lower than motion, higher than user interface
90 to 99 : lower than user interface
```

- The lower the value, the higher the task priority.
- The default priority is 50. Refer to Section 14.4, "Task Scheduling" for more information on how the specified priority is converted into the system priority.
- The priority can be set during task execution by the SET_TSK_ATTR Built-In routine.

Example: Usually an error handling task pends on an error and when an error occurs, it processes the error recovery as soon as possible. In this case, the error handling task might need to have a higher priority than other tasks, so ‘‘n’’ should be less than 50.

%PRIORITY Translator Directive

```
%PRIORITY = 49
```

A.17.20 PROG_BACKUP Built-In Procedure

Purpose: Saves the specified program and all called programs from execution memory to a storage device. If the called programs call other programs they will be saved recursively. You can specify that any associated program variables be saved.

Syntax: PROG_BACKUP (file_spec, prog_type, max_size, write_prot, status)

Input/Output Parameters

[in] file_spec :STRING

[in] prog_type :INTEGER

[in] max_size: INTEGER

[in] write_prot: BOOLEAN

[out] status :INTEGER

%ENVIRONMENT Group: CORE

Details:

- *file_spec* specifies the device and program to save. If a file type is specified, it is ignored.
- *prog_type* specifies the type of programs to be saved. The valid types are:

  PBR_VRTYPE :VR - programs which contain variables

  PBR_MNTYPE :JB, PR, MR, TP

  PBR_JBTYPE :JB - job programs only

  PBR_PRTYPE :PR - process programs only

  PBR_MRTYPE :MR - macro programs only

  PBR_PCTYPE : VR - saves VR files not PC files

  PBR_ALLTYPE :all programs VR, JB, PR, MR, TP

  PBR_NVRTYPE :all programs except VR

  PBR_NMRTYPE :JB, PR, TP (all TPs except Macros)
- *max_size* specifies the maximum size of disk space in kilobytes required to backup the programs. If not enough memory is available on the storage device, no programs will be backed up and status will equal 2002, “FILE-002 Device is Full”.

- If the required disk space to backup the programs exceeds max_size the backup will continue. The backup might still fail if there is not enough space to save all the programs. The return status will equal 2002, " FILE-002 Device is Full". In this case a partial backup will exist. To prevent this case be sure that max_size is large enough to prevent this error.
- *write_prot* , if true, specifies that write protected programs should be saved. If false, specifies that write protected programs should not be saved.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.
- The system will stay in the loop and handle as many programs as it can even when it gets an error. For example, if there is one missing program out of eight, the remaining seven programs are saved. In this case the error "Program does not exist" is returned to the user in status. An error is posted in this case with the program name in the error for each program. The cause code is whatever is returned from the save routine.
- If a subdirectory is specified on the storage device, it will be created if it does not already exist. All programs will be saved into the subdirectory.
- If a file already exists but the no changes have occurred, the file is not overwritten.
- If a file already exists but the program has been changed, it will be overwritten and no error is returned.
- A KAREL or teach pendant program of the same name with variables must exist in memory as a called program or else the system will not save the VR.

Example: The following example saves ANS00003 with the appropriate extension to GMX_211 subdirectory on FR: device. It will save all programs that are called recursively by ANS00003 regardless of program type. It will not save KAREL variables. It will fail if there is less than 200k of free space on the FR: device.

```
VAR
    status: INTEGER

BEGIN
    PROG_BACKUP('FR:\GMX_211\ANS00003', PBR_NVRTYPE, 200, TRUE, status)
```

Example : The following example saves ANS00003 with the appropriate file extension to GMX_211 subdirectory on FR: device. It will save JB, PR, MR, or TP programs that are called recursively by ANS00003. It will not save write-protected programs. It will fail if there is less than 100k of free space on the FR: device.

```
VAR
    status: INTEGER

BEGIN
    PROG_BACKUP('FR:\GMX_211\ANS00003', PBR_MNTYPE, 100, FALSE, status)
```

Example : The following example saves MAIN to MC: device with the appropriate file extension. It will save all programs and variables that are called recursively by MAIN. It will fail if there is less than 300k of free space on the MC: device.

```
VAR
    status: INTEGER

BEGIN
    PROG_BACKUP('MC:\MAIN', PBR_ALLTYPE, 300, TRUE, status)
```

A.17.21 PROG_CLEAR Built-In Procedure

Purpose: Clear the specified program and all called programs from execution memory. If the called programs call other programs they will be cleared recursively. You can specify that any associated program variables also be cleared. Variables which are referenced from other programs will not be cleared.

Syntax: PROG_CLEAR (prog_name, prog_type, status)

Input/Output Parameters:

[in] prog_name :STRING

[in] prog_type :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group: CORE

Details:

- *prog_name* specifies the root program which is to be cleared.
- *prog_type* specifies the type of programs to be cleared. The valid types are:

  PBR_VRTYPE :VR - programs which contain variables

  PBR_MNTYPE :JB, PR, MR, TP

  PBR_JBTYPE :JB - job programs only

  PBR_PRTYPE :PR - process programs only

  PBR_MRTYPE :MR - macro programs only

  PBR_PCTYPE : VR - saves VR files not PC files

  PBR_ALLTYPE :all programs VR, JB, PR, MR, TP

  PBR_NVRTYPE :all programs except VR

  PBR_NMRTYPE :JB, PR, TP (all TPs except Macros)
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.
- The system will stay in the loop and clear as many programs as it can. If one of the called programs is missing, this is not an error. However, if that missing program calls other programs those other programs will not be found and will not be cleared. Errors are posted with the program name in the error for each program which is not cleared. The cause code is whatever is returned from the clear routine.

- Clearing of any VR data is subject to being referenced by another program. This error will be ignored for any variable clear operation.
- If a programs which is identified for clearing is the selected program it will not be cleared. The error “Program is in use” is returned in this case. As a countermeasure the use must use SELECT_TPE() built-in to select a program which is not in the clear set.

Example: The following example clears ANS00003.TP from memory. It will clear all programs that are called recursively by ANS00003 regardless of program type and clear them from memory. It will not clear write-protected programs. It will not clear any KAREL variables.

```
VAR
    status: INTEGER

BEGIN
    PROG_CLEAR('ANS00003.TP', PBR_NVRTYPE, status)
```

Example: The following example clears ANS00003.TP program from memory. It will clear only JB, PR, MR, and TP programs that are called recursively by ANS00003. It will not clear write-protected programs.

```
VAR
    status: INTEGER

BEGIN
        PROG_CLEAR('ANS00003.TP', PBR_MNTYPE, status)
```

A.17.22 PROG_RESTORE Built-In Procedure

Purpose: Restores (loads) the specified program and all called programs into execution memory. If the called programs call other programs they will be loaded recursively. Any associated program variables will also be loaded if the VR files exist.

Syntax: PROG_RESTORE (file_spec, status)

Input/Output Parameters:

[in] file_spec :STRING

[out] status :INTEGER

%ENVIRONMENT Group: CORE

Details:

- *file_spec* specifies the storage device and program to restore. If a file type is specified, it is ignored.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.
- The system will stay in the loop and handles as many programs as it can even when it gets an error. For example, if there is one missing program out of eight, the remaining seven programs are loaded. In this case the error "File does not exist" is returned to the user in status. An error is posted in this case with the program name in the error for each program. The cause code is whatever is returned from the load routine.
- If a subdirectory is specified, the called programs are loaded from that subdirectory. Any extra files in that subdirectory will not automatically be loaded.
- If the program already exists, it will not be restored and no error is returned.
- A KAREL or TP program of the same name must already exist in memory as a called program or else the system will not load the VR.
- VR types will be restored even if the variables already exist. That is the system will overwrite any existing variable values with the values saved in the VR file.
- ASCII programs (.LS) cannot be restored.
- If not enough memory is available, then an error is returned and the restore is incomplete.

Example: The following example restores ANS00003.TP from GMX_211 subdirectory on FR: device. It will restore all programs that are called recursively by ANS00003 regardless of program type. It will restore VR files if they are in the restore directory.

```
VAR
    status: INTEGER

BEGIN
    PROG_RESTORE('FR:\GMX_211\ANS00003.TP', status)
```

Example: The following example restores ANS00003.TP from GMX_211 subdirectory on FR: device. It will restore only TP programs that are called recursively by ANS00003.

```
VAR
    status: INTEGER

BEGIN
    PROG_RESTORE('FR:\GMX_211\ANS00003', status)
```

Example: The following example restores MAIN from MC: device by finding its file type. It will restore all programs and variables that are called recursively by MAIN.

```
  VAR
    status: INTEGER

BEGIN
    PROG_RESTORE('MC:\MAIN', status)
```

A.17.23 PROG_LIST Built-In Procedure

Purpose: Returns a list of program names.

Syntax : prog_list(prog_name, prog_type, n_skip, format, ary_name, n_progs <,f_index>)

Input/Output Parameters :

[in] prog_name :STRING

[in] prog_type :INTEGER

[in] n_skip :INTEGER

[in] format :INTEGER

[out] ary_name :ARRAY of string

[out] n_progs :INTEGER

[out] status :INTEGER

[in,out] f_index :INTEGER

%ENVIRONMENT Group :BYNAM

Details:

- *prog_name* specifies the name of the program(s) to be returned in *ary_name* . *prog_name* may use the wildcard (*) character, to indicate that all programs matching the *prog_type* should be returned in *ary_name* .
- *prog_type* specifies the type of programs to be retrieved. The valid types are:

  1 :VR - programs which contain only variables

  2 :JB, PR, MR, TP3 :JB - job programs only

  4 :PR - process programs only

  5 :MR - macro programs only

  6 :PC - KAREL programs only

  7 :all programs VR, JB, PR, MR, TP, PC

  8 :all programs except VR

- *n_skip* is used when more programs exist than the declared length of *ary_name*. Set *n_skip* to 0 the first time you use PROG_LIST. If *ary_name* is completely filled with program names, copy the array to another ARRAY of STRINGS and execute PROG_LIST again with *n_skip* equal to *n_skip* + *n_progs* . The call to PROG_LIST will then skip the programs found in the previous passes and locate only the remaining programs.
- *format* specifies the format of the program name. The following values are valid for *format* :

  1 :program name only, no blanks

  2 :'program name program type'

  total length = 15 characters
- *prog_name* = 12 characters followed by a space
- *prog_type* = 2 characters
- *ary_name* is an ARRAY of STRING used to store the program names.
- *n_progs* is the number of variables stored in the *ary_name* .
- *status* will return zero if successful.
- *f_index* is an optional parameter for fast indexing. If you specify prog_name as a complex wildcard (anything other than the straight *), then you should use this parameter. The first call to PROG_LIST set *f_index* and *n_skip* both to zero. *f_index* will then be used internally to quickly find the next prog_name. DO NOT change *f_index* once a listing for a particular *prog_name* has begun.

See Also: VAR_LIST Built-In Procedure

Example: Refer to the following sections for detailed program examples:

Section B.2, "Copying Path Variables" (CPY_PTH.KL)

Section B.7, "Listing Files and Programs and Manipulating Strings" (LIST_EX.KL)

Section B.14, "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

A.17.24 PROGRAM Statement

Purpose: Identifies the program name in a KAREL source program

Syntax : PROGRAM prog_name

where:

prog_name : a valid KAREL identifier

Details:

- It must be the first statement (other than comments) in a program.
- The identifier used to name a program cannot be used in the program for any other purpose, such as to identify a variable or constant.
- *prog_name* must also appear in the END statement that marks the end of the executable section of the program.
- The program name can be used to call the program as a procedure routine from within a program in the same way routine names are used to call procedure routines.

Example: Refer to Appendix B, "KAREL Example Programs," for more detailed examples of how to use the PROGRAM Statement.

A.17.25 PULSE Action

Purpose: Pulses a digital output port for a specified number of milliseconds

Syntax : PULSE DOUT[port_no] FOR time_in_ms

where:

port_no : an INTEGER variable or literal

time_in_ms : an INTEGER

Details:

- *port_no* must be a valid digital output port number.
- *time_in_ms* specifies the duration of the pulse in milliseconds.
- If *time_in_ms* duration is zero, no pulse will occur. Otherwise, the period is rounded up to the next multiple of 8 milliseconds.
- A pulse always turns on the port at the start of the pulse and turns off the port at the end of the pulse.
- If the port is ‘‘normally on,’’ negative pulses can be accomplished by setting the port to reversed polarity, or by executing the following sequence:

```
DOUT[n] = FALSE
DELAY x
DOUT[n] = TRUE
```

- NOWAIT is not allowed in a PULSE action.
- If the program is paused while a pulse is in progress, the pulse will end at the correct time.

- If the program is aborted while a pulse is in progress, the port stays in whatever state it was in when the abort occurred.
- If *time_in_ms* is negative or greater than 86,400,000 (24 hours), the program is aborted with an error.

See Also: Chapter 6 *CONDITION HANDLERS* , Chapter 7 *FILE INPUT/OUTPUT OPERATIONS*

Example: Refer to Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.17.26 PULSE Statement

Purpose: Pulses a digital output port for a specified number of milliseconds.

Syntax : PULSE DOUT[port_no] FOR time_in_ms < NOWAIT >

where:

port_no : an INTEGER variable or literal

time_in_ms : an INTEGER

Details:

- *port_no* must be a valid digital output port number.
- *time_in_ms* specifies the duration of the pulse in milliseconds.
- If *time_in_ms* duration is zero, no pulse will occur. Otherwise, the period is rounded up to the next multiple of 8 milliseconds.

  The actual duration of the pulse will be from zero to 8 milliseconds less than the rounded value.

  For example, if 100 is specified, it is rounded up to 104 (the next multiple of 8) milliseconds. The actual duration will be from 96 to 104 milliseconds.
- A pulse always turns on the port at the start of the pulse and turns off the port at the end of the pulse.
- If the port is ‘‘normally on,’’ negative pulses can be accomplished by setting the port to reversed polarity, or by executing the following sequence:

```
DOUT[n] = FALSE
DELAY x
DOUT[n] = TRUE
```

- If NOWAIT is specified in a PULSE statement, the next KAREL statement will be executed concurrently with the pulse.
- If NOWAIT is not specified in a PULSE statement, the next KAREL statement will not be executed until the pulse is completed.

See Also: Appendix E, ‘‘Syntax Diagrams’’ for more syntax information

Example: In the following example a digital output is pulsed, followed by the pulsing of a second digital output. Because NOWAIT is specified, **DOUT[start_air]** will be executed before **DOUT[5]** is completed.

PULSE Statement

```
PULSE DOUT[5] FOR (seconds * 1000) NOWAIT
PULSE DOUT[start_air] FOR 50 NOWAIT
```

A.17.27 PURGE CONDITION Statement

Purpose: Deletes the definition of a condition handler from the system

Syntax : PURGE CONDITION[cond_hand_no]

where:

cond_hand_no : an INTEGER expression

Details:

- The statement has no effect if there is no condition handler defined with the specified number.
- The PURGE CONDITION Statement is used only to purge global condition handlers.
- The PURGE CONDITION Statement will purge enabled conditions.
- If a condition handler with the specified number was previously defined, it must be purged before it is replaced with a new one.

See Also: ENABLE CONDITION Statement Chapter 6 *CONDITION HANDLERS* , Appendix E, ‘‘Syntax Diagrams’’ for more syntax information

Example: In the following example, if the BOOLEAN variable **ignore_cond** is TRUE, the global condition handler, CONDITION[1], will be purged using the PURGE statement; otherwise CONDITION[1] is enabled.

PURGE CONDITION Statement

```
IF ignore_cond THEN
  PURGE CONDITION[1]
```

```
ELSE
  ENABLE CONDITION[1]
ENDIF
```

A.17.28 PURGE_DEV Built-In Procedure

Purpose: Purges the specified memory file device by freeing any used blocks that are no longer needed

Syntax : PURGE_DEV (device, status)

Input/Output Parameters :

[in] device : STRING

[out] status : INTEGER

%ENVIRONMENT Group :FDEV

Details:

- *device* specifies the memory file device to purge. *device* should be set to 'FR:' for FROM disk, 'RD:' for RAM disk, or 'MF:' for both disks.
- The purge operation is only necessary when the device does not have enough memory to perform an operation. The 'FR:' device will return 85001 if the FROM disk is full. The 'RD:' device will return 85020 if the RAM disk is full.
- The purge operation will erase file blocks that were previously used, but no longer needed. These are called garbage blocks. The FROM disk may contain many garbage blocks if files are deleted or overwritten. The RAM disk does not normally contain garbage blocks, but they can occur when power is removed during a file copy.
- The VOL_SPACE built-in can be used to determine the number of garbage blocks on the FROM disk. Hardware limitations may reduce the number of blocks actually freed.
- The device must be mounted and no files can be open on the device or an error will be returned.
- *status* explains the status of the attempted operation. If not equal to 0 then an error occurred. 85023 is returned if no errors occurred, but no blocks were purged.

Example: Return to Section B.9, "Using the File and Device Built-Ins" (FILE_EX.KL), for a more detailed program example.

A.17.29 PUSH_KEY_RD Built-In Procedure

Purpose: Suspend key input from a keyboard device

Syntax : PUSH_KEY_RD(key_dev_name, key_mask, pop_index, status)

Input/Output Parameters:

[in] key_dev_name :STRING

[in] key_mask :INTEGER

[out] pop_index :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- Suspends all read requests on the specified keyboard device that uses (either as accept_mask or term_mask) any of the specified key classes.
- If there are no read requests active, a null set of inputs is recorded as suspended. This is not an error.
- *key_dev_name* must be one of the keyboard devices already defined:

  'TPKB' :Teach Pendant Keyboard Device

  'CRKB' :CRT Keyboard Device
- *key_mask* is a bit-wise mask indicating the classes of characters that will be suspended. This should be an OR of the constants defined in the include file klevkmsk.kl.

  kc_display :Displayable keys

  kc_func_key :Function keys

  kc_keypad :Keypad and Edit keys

  kc_enter_key :Enter and Return keys

  kc_delete :Delete and Backspace keys

  kc_lr_arw :Left and Right Arrow keys

  kc_ud_arw :Up and Down Arrow keys

  kc_other :Other keys (such as Prev)

- *pop_id* is returned and should be used in a call to POP_KEY_RD to re-activate the read requests.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: POP_KEY_RD Built-In Procedure

Example: Refer to the READ_KB Built-In Procedure for an example.

A.18 - Q - KAREL LANGUAGE DESCRIPTION

A.18.1 QUEUE_TYPE Data Type

Purpose: Defines the data type for use in QUEUE built-in routines

Syntax : queue_type = STRUCTURE

n_entries : INTEGER

sequence_no : INTEGER

head : INTEGER

tail : INTEGER

ENDSTRUCTURE

Details:

- *queue_type* is used to initialize and maintain queue data for the QUEUE built-in routines. **Do not change this data; it is used internally.**

See Also: APPEND_QUEUE, DELETE_QUEUE, INSERT_QUEUE, COPY_QUEUE, GET_QUEUE, INIT_QUEUE, MODIFY_QUEUE Built-In Procedures

A.19 - R - KAREL LANGUAGE DESCRIPTION

A.19.1 READ Statement

Purpose: Reads data from a serial I/O device or file

Syntax : READ < file_var > (data_item {,data_item})

where:

file_var : a FILE variable

data_item : a variable identifier and its optional format specifiers or the reserved word CR

Details:

- If *file_var* is not specified in a READ statement the default TPDISPLAY is used. %CRTDEVICE directive will change the default to INPUT.
- If *file_var* is specified, it must be one of the input devices (INPUT, CRTPROMPT, TPDISPLAY, TPPROMPT) or a variable that was set in the OPEN FILE statement.
- If *file_var* attribute was set with the UF option, data is transmitted into the specified variables in binary form. Otherwise, data is transmitted as ASCII text.
- *data_item* can be a system variable that has RW access or a user-defined variable.
- When the READ statement is executed, data is read beginning with the next nonblank input character and ending with the last character before the next blank, end of line, or end of file for all input types except STRING.
- If *data_item* is of type ARRAY, a subscript must be provided.
- If *data_item* is of type PATH, you can specify that the entire path be read, a specific node be read ([n]), or a range of nodes be read ([n .. m]).
- Optional format specifiers can be used to control the amount of data read for each *data_item* . The effect of format specifiers depends on the data type of the item being read and on whether the data is in text (ASCII) or binary (unformatted) form.
- The reserved word CR, which can be used as a data item, specifies that any remaining data in the current input line is to be ignored. The next data item will be read from the start of the next input line.
- If reading from a file and any errors occur during input, the variable being read and all subsequent variables up to CR in the data list are set uninitialized.
- If *file_var* is a window device and any errors occur during input, an error message is displayed indicating the bad data item and you are prompted to enter a replacement for the invalid data item and to reenter all subsequent items.
- Use IO_STATUS (file_var) to determine if the read operation was successful.

Note Read CR should never be used in unformatted mode.

See Also: Chapter 7 *FILE INPUT/OUTPUT OPERATIONS* , for more information on the READ format specifiers, IO_STATUS Built-In Function, Appendix E, ‘‘Syntax Diagrams,’’ for more syntax information

Example: Refer to the following sections for detailed program examples:

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL)

Section B.13, "Using the DISCTRL_ALPHA Built-in" (DCALP_EX.KL)

Section B.14, "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

A.19.2 READ_DICT Built-In Procedure

Purpose: Reads information from a dictionary

Syntax : READ_DICT(dict_name, element_no, ksta, first_line, last_line, status)

Input/Output Parameters:

[in] dict_name : STRING

[in] element_no : INTEGER

[out] ksta : ARRAY OF STRING

[in] first_line : INTEGER

[out] last_line : INTEGER

[out] status : INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *dict_name* specifies the name of the dictionary from which to read.
- *element_no* specifies the element number to read. This element number is designated with a $ in the dictionary file.
- *ksta* is a KAREL STRING ARRAY used to store the information being read from the dictionary text file.
- If *ksta* is too small to store all the data, then the data is truncated and status is set to 33008, "Dictionary Element Truncated."
- *first_line* indicates the array element of *ksta* , at which to begin storing the information.
- *last_line* returns a value indicating the last element used in the *ksta* array.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred reading the element from the dictionary file.
- &new_line is the only reserved attribute code that can be read from dictionary text files using READ_DICT. The READ_DICT Built-In ignores all other reserved attribute codes.

See Also: ADD_DICT, WRITE_DICT, REMOVE_DICT Built-In Procedures. Refer to the program example for the DISCTRL_LIST Built-In Procedure. Chapter 10 *DICTIONARIES AND FORMS*

Example: Refer to Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL), for a detailed program example.

A.19.3 READ_DICT_V Built-In-Procedure

Purpose: Reads information from a dictionary with formatted variables

Syntax : READ_DICT_V(dict_name, element_no, value_array, ksta, status)

Input/Output Parameters:

[in] dict_name : STRING

[in] element_no : INTEGER

[in] value_array : ARRAY OF STRING

[out] ksta : ARRAY OF STRING

[out] status : INTEGER

%ENVIRONMENT Group :UIF

Details:

- *dict_name* specifies the name of the dictionary from which to read.
- *element_no* specifies the element number to read. This number is designated with a $ in the dictionary file.
- *value_array* is an array of variable names that corresponds to each formatted data item in the dictionary text. Each variable name can be specified as '[prog_name]var_name'.
  - *[prog_name]* specifies the name of the program that contains the specified variable. If not specified, then the current program being executed is used.
  - *var_name* must refer to a static variable.
  - *var_name* may contain node numbers, field names, and/or subscripts.
- *ksta* is a KAREL STRING ARRAY used to store the information that is being read from the dictionary text file.
- If *ksta* is too small to store all the data, then the data is truncated and status is set to 33008, "Dictionary Element Truncated."
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred reading the element from the dictionary file.
- &new_line is the only reserved attribute code that can be read from dictionary text files using READ_DICT_V. The READ_DICT_V Built-In ignores all other reserved attribute codes.

See Also: WRITE_DICT_V Built-In Procedure, Chapter 10 *DICTIONARIES AND FORMS*

Example: In the following example, **TPTASKEG.TX** contains dictionary text information which will display a system variable. This information is the first element in the dictionary. Element numbers start at 0. **util_prog** uses READ_DICT_V to read in the text and display it on the teach pendant.

READ_DICT_V Built-In Procedure

```
-------------------------------------------
TPTASKEG.TX
-------------------------------------------
$ "Maximum number of tasks = %d"
-------------------------------------------
UTILITY PROGRAM:
-------------------------------------------
PROGRAM util_prog
  %ENVIRONMENT uif
  VAR
    ksta: ARRAY[1] OF STRING[40]
    status: INTEGER
    value_array: ARRAY[1] OF STRING[30]
  BEGIN
    value_array[1] = '[*system*].$scr.$maxnumtask'
    ADD_DICT('TPTASKEG', 'TASK', dp_default, dp_open, status)
    READ_DICT_V('TASK', 0, value_array, ksta, status)
    WRITE(ksta[i], cr)
END util_prog
```

A.19.4 READ_KB Built-In Procedure

Purpose: Read from a keyboard device and wait for completion

Syntax : READ_KB(file_var, buffer, buffer_size, accept_mask, term_mask, time_out, init_data, n_chars_got, term_char, status)

Input/Output Parameters:

[in] file_var : FILE

[out] buffer : STRING

[in] buffer_size : INTEGER

[in] accept_mask : INTEGER

[in] time_out : INTEGER

[in] term_mask : INTEGER

[in] init_data : STRING

[out] n_chars_got : INTEGER

[out] term _char : INTEGER

[out] stat us : INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- Causes data from specified classes of characters to be stored in a user-supplied buffer until a termination condition is met or the buffer is full. Returns to the caller when the read is terminated.
- If you use READ_KB for the CRT/KB, you will get "raw" CRT characters returned. To get teach pendant equivalent key codes, you must perform the following function:
  `tp_key = $CRT_KEY_TBL[crt_key + 1]`

  This mapping allows you to use common software between the CRT/KB and teach pendant devices.
- READ_KB and some other utilities use a variable in your KAREL program called device_stat to establish the association between the KAREL program and user interface display. For example, if you have a task [MAINUIF] which calls READ_KB, the variable which is used to make the association is [MAINUIF]device_stat. If you do not set device_stat, then you can only read characters in single screen mode, or in the left pane.
- device_stat must be set to the paneID in which your application is running. For the standard single mode/monochrome pendant, device_stat =1. To interact in the right pane, set device_stat=2. To interact in the lower right pane, set device_stat=3. External Internet Explorer connections use panes 4-9. For the CRT/KB, set device_stat=255.
- [MAINUIF]device_stat must be set to the correct pane ID before you open the keyboard file that is assoicated with READ_KB. The pane ID for the iPendant can be either 1, 2 or 3.
- The application running in Pane ID 1 is stored in $TP_CURSCRN. Pane ID 2 is stored in $UI_CURSCRN[1], or in general $UI_CURSCRN[device_stat-1]. The CRT applicaton uses $CT_CURSCRN.
- *file_var* must be open to a keyboard-device. If *file_var* is also associated with a window, the characters are echoed to the window.
- The characters are stored in *buffer* , up to a maximum of *buffer_size* or the size of the string, whichever is smaller.
- *accept_mask* is a bit-wise mask indicating the classes of characters that will be accepted as input. This should be an OR of the constants defined in the include file klevkmsk.kl.

kc_display :Displayable keys

kc_func_key :Function keys

kc_keypad :Key-pad and Edit keys

kc_enter_key :Enter and Return keys

kc_delete :Delete and Backspace keys

kc_lr_arw :Left and Right Arrow keys

kc_ud_arw :Up and Down Arrow keys

kc_other :Other keys (such as Prev)

- It is reasonable for *accept_mask* to be zero; this means that no characters are accepted as input. This is used when waiting for a single key that will be returned as the term_char. In this case, *buffer_size* would be zero.
- If *accept_mask* includes displayable characters, the following characters, if accepted, have the following meanings:
  - — Delete characters - If the cursor is not in the first position of the field, the character to the left of the cursor is deleted.
  - — Left and right arrows - Position the cursor one character to the left or right from its present position, assuming it is not already in the first or last position already.
  - — Up and down arrows - Fetch input previously entered in reads to the same file.
- *term_mask* is a bit-wise mask indicating conditions which will terminate the request. This should be an OR of the constants defined in the include file klevkmsk.kl.

  kc_display :Displayable keys

  kc_func_key :Function keys

  kc_keypad :Key-pad and Edit keys

  kc_enter_key :Enter and Return keys

  kc_delete :Delete and Backspace keys

  kc_lr_arw :Left and Right Arrow keys

  kc_ud_arw :Up and Down Arrow keys

  kc_other :Other keys (such as Prev)

- *time_out* specifies the time, in milliseconds, after which the input operation will be automatically canceled. A value of -1 implies no timeout.

- *init_data_p* points to a string which is displayed as the initial value of the input field. This must not be longer than buffer_size.
- *n_chars_got* is set to the number of characters in the input buffer when the read is terminated.
- *term_char* receives a code indicating the character or other condition that terminated the form. The codes for key terminating conditions are defined in the include file klevkeys.kl. Keys normally returned are pre-defined constants as follows:

  ky_up_arw

  ky_dn_arw

  ky_rt_arw

  ky_lf_arw

  ky_enter

  ky_prev

  ky_f1

  ky_f2

  ky_f3

  ky_f4

  ky_f5

  ky_next
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

Example: Refer to Section B.2, "Copying Path Variables" (CPY_PTH.KL), for a detailed program example.

The following example suspends any teach pendant reads, uses READ_KB to read a single key, and then resumes any suspended reads.

READ_KB Built-In Procedure

```
PROGRAM readkb
%NOLOCKGROUP
%ENVIRONMENT flbt
%ENVIRONMENT uif
%INCLUDE FR:eklevkmsk
VAR
  file_var: FILE
  key: INTEGER
```

```
  n_chars_got: INTEGER
  pop_index: INTEGER
  status: INTEGER
  str: STRING[1]

BEGIN
  -- Suspend any outstanding TP Keyboard reads
  PUSH_KEY_RD('TPKB', 255, pop_index, status)
  IF (status = 0) THEN
    WRITE (CR, 'pop_index is ', pop_index)
  ELSE
    WRITE (CR, 'PUSH_KEY_RD status is ', status)
  ENDIF
  -- Open a file to TP Keyboard with PASALL and FIELD attributes
  -- and NOECHO
  SET_FILE_ATR(file_var, ATR_PASSALL)
  SET_FILE_ATR(file_var, ATR_FIELD)
  OPEN FILE file_var ('RW', 'KB:TPKB')
  -- Read a single key from the TP Keyboard
  READ_KB(file_var, str, 1, 0, kc_display+kc_func_key+kc_keypad+
          kc_enter_key+kc_lr_arw+kc_ud_arw+kc_other, 0, '',
          n_chars_got, key, status)
  IF (status = 0) THEN
    WRITE (CR, 'key is ', key, ', n_chars_got = ', n_chars_got)
  ELSE
    WRITE (CR, 'READ_KB status is ', status)
  ENDIF
  CLOSE FILE file_var
  -- Resume any outstanding TP Keyboard reads
  POP_KEY_RD('TPKB', pop_index, status)
  IF (status <> 0) THEN
    WRITE (CR, 'POP_KEY_RD status is ', status)
  ENDIF
END readkb
```

A.19.5 REAL Data Type

Purpose: Defines a variable, function return type, or routine parameter as a REAL data type with a numeric value that includes a decimal point and a fractional part, or numbers expressed in scientific notation

Syntax : REAL

Details:

- REAL variables and expressions can have values in the range of -3.4028236E+38 through -1.175494E-38, 0.0, and from +1.175494E-38 through +3.4028236E+38, with approximately seven decimal digits of significance. Otherwise, the program will be aborted with the ‘‘Real overflow’’ error.
- The decimal point is mandatory when defining a REAL constant or literal (except when using scientific notation). The decimal point is not mandatory when defining a REAL variable as long as it was declared as REAL.
- Scientific notation is allowed and governed by the following rules:
  - — The decimal point is shifted to the left so that only one digit remains in the INTEGER part.
  - — The fractional part is followed by the letter E (upper or lower case) and ±an INTEGER. This part specifies the magnitude of the REAL number. For example, 123.5 is expressed as 1.235E2.
  - — The fractional part and the decimal point can be omitted. For example, 100.0 can be expressed as 1.000E2, as 1.E2, or 1E2.
- All REAL variables with magnitudes between -1.175494E- 38 and +1.175494E-38 are treated as 0.0.
- Only REAL or INTEGER expressions can be assigned to REAL variables, returned from REAL function routines, or passed as arguments to REAL parameters.
- If an INTEGER expression is used in any of these instances, it is treated as a REAL value. If an INTEGER variable is used as an argument to a REAL parameter, it is always passed by value, not by reference.
- Valid REAL operators are (refer to Table A–18):
  - — Arithmetic operators (+, +, *, /)
  - — Relational operators (>, >=, =, < >, <, <=)

Table A–18. Valid and Invalid REAL operators

VALID	INVALID	REASON
1.5	15	Decimal point is required (15 is an INTEGER not a REAL)
1.	.	Must include an INTEGER or a fractional part
+2500.450	+2,500.450	Commas not allowed
1.25E-4	1.25E -4	Spaces not allowed

Example: Refer to the following sections for detailed program examples:

Section B.5,"Using Register Built-ins" (REG_EX.KL)

Section B.8, "Generating and Moving Along a Hexagon Path" (GEN_HEX.KL)

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.11, "Manipulating Values of Dynamically Displayed Variables" (CHG_DATA.KL)

Section B.14, "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

A.19.6 Relational Condition

Purpose: Used to test the relationship between two operands

Syntax : variable <[subscript]> rel_op expression

where:

variable : a static INTEGER or REAL variable or a BOOLEAN port array element

subscript : an INTEGER expression (only used with port arrays)

rel_op : a relational operator

expression : a static variable, constant, or EVAL clause

Details:

- Relational conditions are state conditions, meaning the relationship is tested during every scan.
- The following relational operators can be used:

  = :equal

  <> :not equal

  < :less than

  =< :less than or equal

  > :greater than

  >= :greater than or equal
- Both operands must be of the same data type and can only be of type INTEGER, REAL, or BOOLEAN. INTEGER values can be used where REAL values are required, and will be treated as REAL values.
- *variable* can be any of the port array signals, a user-defined static variable, or a system variable that can be read by a KAREL program.
- *expression* can be a user-defined static variable, a system variable that can be read by a KAREL program, any constant, or an EVAL clause.
- Variables used in relational conditions must be initialized before the condition handler is enabled.

Example: Refer to Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.19.7 RELAX HAND Statement

Purpose: Turns off open signal for a tool controlled by one signal or turns off both open and close signals for a tool controlled by a pair of signals.

Syntax : RELAX HAND hand_num

where:

hand_num : an INTEGER expression

Details:

- The actual effect of the statement depends on how the HAND signals are set up. Refer to Chapter 13, ‘‘Input/Output System.’’
- *hand_num* must be a value in the range 1-2. Otherwise, the program is aborted with an error.
- The statement has no effect if the value of *hand_num* is in range but the hand is not connected.
- If the value of *hand_num* is in range but the HAND signal represented by that value has not been assigned, the program is aborted with an error.

See Also: Chapter 13, ‘‘Input/Output System,’’ Appendix D, ‘‘Syntax Diagrams,’’ for more syntax information

Example: In the following example, the robot hand, specified by **gripper** , is relaxed using the RELAX HAND statement. The robot then moves to the POSITION **pstart** before closing the hand.

RELAX HAND Statement

```
PROGRAM p_release
%NOPAUSE=TPENABLE
%ENVIRONMENT uif
BEGIN
 RELAX HAND gripper
 MOVE TO pstart
 CLOSE HAND gripper
END p_release
```

A.19.8 RELEASE Statement

Purpose: Releases all motion control of the robot arm and auxiliary or extended axes from the KAREL program so that they can be controlled by the teach pendant while a KAREL program is running

Syntax : RELEASE

Details:

- Motion stopped prior to execution of the RELEASE statement can only be resumed after the execution of the next ATTACH statement.
- If motion is initiated from the program while in a released state, the program is aborted with the following error, ‘‘MCTRL Denied because Released.’’
- If RELEASE is executed while motion is in progress or in a HOLD condition, the program is aborted with the following error, "Detach request failed."
- All motion control from all KAREL tasks will be released.

See Also: Appendix E, ‘‘Syntax Diagrams,’’ for more syntax information

Example: Refer to Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.19.9 REMOVE_DICT Built-In Procedure

Purpose: Removes the specified dictionary from the specified language or from all existing languages

Syntax : REMOVE_DICT(dict_name, lang_name, status)

Input/Output Parameters:

[in] dict_name : STRING

[in] lang_name : STRING

[out] status : INTEGER

%ENVIRONMENT Group :UIF

Details:

- *dict_name* specifies the name of the dictionary to remove.
- *lang_name* specifies which language the dictionary should be removed from. One of the following pre-defined constants should be used:

dp_default

dp_english

dp_japanese

dp_french

dp_german

dp_spanish

If *lang_name* is '', it will be removed from all languages in which it exists.

- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred removing the dictionary file.

See Also: ADD_DICT Built-In Procedure, Chapter 10 *DICTIONARIES AND FORMS*

Example: Refer to Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL), for a detailed program example.

A.19.10 RENAME_FILE Built-In Procedure

Purpose: Renames the specified file name

Syntax : RENAME_FILE(old_file, new_file, nowait_sw, status)

Input/Output Parameters:

[in] old_file : STRING

[in] new_file : STRING

[in] nowait_sw : BOOLEAN

[out] status : INTEGER

%ENVIRONMENT Group :FDEV

Details:

- *old_file* specifies the device, name, and type of the file to rename.
- *new_file* specifies the name and type of the file to rename to.
- If *nowait_sw* is TRUE, execution of the program continues while the command is executing. If it is FALSE, the program stops, including condition handlers, until the operation has completed.

If you have time critical condition handlers in your program, put them in another program that executes as a separate task.

Note *nowait_sw* is not available in this release and should be set to FALSE.

- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: COPY_FILE, DELETE_FILE Built-In Procedures

A.19.11 RENAME_VAR Built-In Procedure

Purpose: Renames a specified variable in a specified program to a new variable name

Syntax : RENAME_VAR(prog_nam, old_nam, new_nam, status)

Input/Output Parameters:

[in] prog_nam : STRING

[in] old_nam : STRING

[in] new_nam : STRING

[out] status : INTEGER

%ENVIRONMENT Group :MEMO

Details:

- *prog_nam* is the name of the program that contains the variable to be renamed.
- *old_nam* is the current name of the variable.
- *new_nam* is the new name of the variable.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: CREATE_VAR, SET_VAR Built-In Procedures

A.19.12 RENAME_VARS Built-In Procedure

Purpose: Renames all of the variables in a specified program to a new program name

Syntax : RENAME_VARS(old_nam, new_nam, status)

Input/Output Parameters:

[in] old_nam : STRING

[in] new_nam : STRING

[out] status : INTEGER

%ENVIRONMENT Group :MEMO

Details:

- *old_nam* is the current name of the program.
- *new_nam* is the new name of the program.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: CREATE_VAR, RENAME_VARS Built-in Procedures

A.19.13 REPEAT ... UNTIL Statement

Purpose: Repeats statement(s) until a BOOLEAN expression evaluates to TRUE

Syntax : REPEAT

{ statement }

UNTIL boolean_exp

where:

statement : a valid KAREL executable statement

boolean_exp : a BOOLEAN expression

Details:

- *boolean_exp* is evaluated after execution of the statements in the body of the REPEAT loop to determine if the statements should be executed again.
- *statement* continues to be executed and the *boolean_exp* is evaluated until it equals TRUE.
- *statement* will always be executed at least once.



Caution

Make sure your REPEAT statement contains a boolean flag that is modified by some condition, and an UNTIL statement that terminates the loop. If it does not, your program could loop infinitely.

See Also: Appendix E , ‘‘Syntax Diagrams,’’ for more syntax information

Example: Refer to the following sections for detailed program examples:

Section B.2, "Copying Path Variables" (CPY_PTH.KL)

Section B.7, "Listing Files and Programs and Manipulating Strings" (LIST_EX.KL)

Section B.9, "Using the File and Device Built-ins" (FILE_EX.KL)

Section B.11, "Manipulating Values of Dynamically Displayed Variables" (CHG_DATA.KL)

Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL)

Section B.14, "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

A.19.14 RESET Built-In Procedure

Purpose: Resets the controller

Syntax : RESET(successful)

Input/Output Parameters:

[out] successful : BOOLEAN

%ENVIRONMENT Group :MOTN

Details:

- *successful* will be TRUE even if conditions exist which prevent resetting the controller.
- To determine whether the reset operation was successful, delay 1 second and check OPOUT[3] (FAULT LED). If this is FALSE, the reset operation was successful.
- The statement following the RESET Built-In is not executed until the reset fails or has completed. The status display on the CRT or teach pendant will indicate PAUSED during the reset.
- The controller appears to be in a PAUSED state while a reset is in progress but, during this time, PAUSE condition handlers will not be triggered.

Example: Refer to Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.19.15 RESUME Action

Purpose: Restarts the last stopped motion issued by the task

Syntax : RESUME <GROUP[n{,n}]>

Details:

- A motion set is a group of motions issued but not yet terminated when a STOP statement or action is issued.
- If there are no stopped motion sets, no motion will result from the RESUME.
- If more than one motion set has been stopped, RESUME restarts the most recently stopped, unresumed motion set. Subsequent RESUMEs will start the others in last-in-first-out sequence.
- The motions contained in a stopped motion set are resumed in the same order in which they were originally issued.
- If a motion is in progress when the RESUME action is issued, any resumed motion(s) occur after the current motion is completed.
- If the group clause is not present, all groups for which the task has control (when the condition is defined) will be resumed.
- If the motion that is stopped, resumed, canceled, or held is part of a SIMULTANEOUS or COORDINATED motion with other groups, the motions for all groups are stopped, resumed, canceled, or held.
- Motion cannot be resumed for a different task.

Example: Refer to Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.19.16 RESUME Statement

Purpose: Restarts the last stopped motion issued by the task

Syntax : RESUME <GROUP[n{,n}]>

- A motion set is a group of motions issued but not yet terminated when a STOP statement or action is issued.
- If there are no stopped motion sets, no motion will result from the RESUME.
- If more than one motion set has been stopped, RESUME restarts the most recently stopped, unresumed motion set. Subsequent RESUMEs will start the others in last-in-first-out sequence.
- Those motions in a stopped motion set are resumed in the same order in which they were originally issued.

- If a motion is in progress when the RESUME statement is issued, any resumed motion(s) occur after the current motion is completed.
- If the group clause is not present, all groups for which the task has control will be resumed.
- If the motion that is stopped, resumed, canceled, or held is part of a SIMULTANEOUS or COORDINATED motion with other groups, the motions for all groups are stopped, resumed, canceled, or held.
- Motion cannot be resumed for a different task.

See Also: Appendix E, "Syntax Diagrams" for more syntax information

Example: In the following example, motion is stopped if **DIN[1]** is ON. It is resumed after F1 is pressed.

RESUME Statement

```
MOVE ALONG some_path NOWAIT
IF DIN[1] THEN
  WRITE(' Motion stopped')
  STOP
  WRITE(CR, 'Motion and the program will resume')
  WRITE(CR, '    when F1 of teach pendant is pressed')
  WAIT FOR TPIN[129]
  RESUME
ENDIF
```

A.19.17 RETURN Statement

Purpose: Returns control from a routine/program to the calling routine/program, optionally returning a result

Syntax : RETURN < (value) >

Details:

- *value* is required when returning from functions, but is not permitted when returning from procedures. The data type of *value* must be the same as the type used in the function declaration.
- If a main program executes a RETURN statement, execution is terminated and cannot be resumed. All motions in progress will be completed normally.
- If no RETURN is specified, the END statement serves as the return.
- If a function routine returns with the END statement instead of a RETURN statement, the program is aborted with the 12321 error, "END STMT of a func rtn."

See Also: Appendix E , "Syntax Diagrams," for more syntax information

Example: Refer to the following sections for detailed program examples:

Section B.7, "Listing Files and Programs and Manipulating Strings" (LIST_EX.KL)

Section B.14, "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

A.19.18 ROUND Built-In Function

Purpose: Returns the INTEGER value closest to the specified REAL argument

Syntax : ROUND(x)

Function Return Type :INTEGER

Input/Output Parameters:

[in] x :REAL

%ENVIRONMENT Group :SYStem

Details:

- The returned value is the INTEGER value closest to the REAL value x, as demonstrated by the following rules:
  - If x >= 0, let n be a positive INTEGER such that n <= x <= n + 1
  - If x >= n + 0.5, then n + 1 is returned; otherwise, n is returned.
  - If x <= 0, let n be a negative INTEGER such that n >= x >= n - 1
  - If x <= n - 0.5, then n - 1 is returned; otherwise, n is returned.
- *x* must be in the range of -2147483648 to +2147483646. Otherwise, the program will be aborted with an error.

See Also: TRUNC Built-In Function

Example: Refer to Section B.7, "Listing Files and Programs and Manipulating Strings" (LIST_.EX.KL), for a detailed program example.

A.19.19 ROUTINE Statement

Purpose: Specifies a routine name, with parameters and types, and a returned value data type for function routines

Syntax : ROUTINE name < param_list > <: return_type >

where:

name : a valid KAREL identifier

param_list : described below

return_type : any data type that can be returned by a function, that is, any type except FILE, PATH, and vision types

Details:

- *name* specifies the routine name.
- *param_list* is of the form (*name_group { ; name_group }*)
  - *name_group* is of the form *param_name : param_type*
  - *param_name* is a parameter which can be used within the routine body as a variable of data type *param_type.*
  - If a *param_type* or *return_type* is an ARRAY, the size is excluded. If the *param_type* is a STRING, the string length is excluded.
- When the routine body follows the ROUTINE statement, the names in *param_list* are used to associate arguments passed in with references to parameters within the routine body.
- When a routine is from another program, the names in the parameter list are of no significance but must be present in order to specify the number and data types of parameters.
- If the ROUTINE statement contains a *return_type,* the routine is a function routine and returns a value. Otherwise, it is a procedure routine.
- The ROUTINE statement must be followed by a routine body or a FROM clause.

Example: Refer to the following sections for detailed program examples:

Section B.2, "Copying Path Variables" (CPY_PTH.KL)

Section B.4,"Standard Routines" (ROUT_EX.KL)

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.7 , "Listing Files and Programs and Manipulating Strings" (LIST_EX.KL)

Section B.8, "Generating and Moving Along a Hexagon Path" (GEN_HEX.KL)

Section B.9, "Using the File and Device Built-ins" (FILE_EX.KL)

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL)

Section B.14, "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.19.20 RUN_TASK Built-In Procedure

Purpose: Runs the specified program as a child task

Syntax : RUN_TASK (task_name, line_number, pause_on_sft, tp_motion, lock_mask, status)

Input/Output Parameters:

[in] task_name : STRING

[in] line_number : INTEGER

[in] pause_on_sft : BOOLEAN

[in] tp_motion : BOOLEAN

[in] lock_mask : INTEGER

[out] status : INTEGER

%ENVIRONMENT Group :MULTI

Details:

- *task_name* is the name of the task to be run. This creates a child task. The task that executes this built-in is called the parent task.
- If the task already exists and is paused, it will be continued. A new task is not created.
- *line_number* specifies the line from which execution starts. Use 0 to start from the beginning of the program. This is only valid for teach pendant programs.
- If *pause_on_sft* is TRUE, the task is paused when the teach pendant shift key is released.
- If *tp_motion* is TRUE, the task can execute motion while the teach pendant is enabled. The TP must be enabled if *tp_motion* is TRUE.
- The control of the motion groups specified in *lock_mask* will be transferred from parent task to child task, if *tp_motion* is TRUE and the teach pendant is enabled. The group numbers must be in the range of 1 to the total number of groups defined on the controller. Bit 1 specifies group 1, bit 2 specifies group 2, and so forth.

Table A–19. Group_mask setting

GROUP	DECIMAL	BIT
Group 1	1	1
Group 2	2	2
Group 3	4	3

To specify multiple groups select the decimal values, shown in Table A–19, which correspond to the desired groups. Then connect them together using the OR operator. For example to specify groups 1 and 3, enter "1 OR 4".

Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: CONT_TASK, PAUSE_TASK, ABORT_TASK Built-In Procedures, Chapter 14 *MULTI-TASKING*

Example: Refer to Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL), for a detailed program example.

A.20 - S - KAREL LANGUAGE DESCRIPTION

A.20.1 SAVE Built-In Procedure

Purpose: Saves the program or variables into the specified file

Syntax : SAVE (prog_nam, file_spec, status)

Input/Output Parameters :

[in] prog_nam :STRING

[in] file_spec :STRING

[out] status :INTEGER

%ENVIRONMENT Group :MEMO

Details:

- *prog_nam* specifies the program name. If program name is '*', all programs or variables of the specified type are saved. prog_name must be set to "*SYSTEM*" in order to save all system variables.
- *file_spec* specifies the device, name, and type of the file being saved to. The type also implies whether programs or variables are being saved.

The following types are valid:

.TP : Teach pendant program

.VR : KAREL variables

.SV : KAREL system variables

.IO : I/O configuration data

- If *file_spec* already exists on the specified device, then an error is returned the save does not occur.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: CLEAR, LOAD Built-In Procedures

Example: Refer to Section B.3 ,"Saving Data to the Default Device" (SAVE_VRS.KL), for a detailed program example.

A.20.2 SAVE_DRAM Built-In Procedure

Purpose: Saves the RAM variable content to FlashROM.

Syntax: SAVE_DRAM (prog_nam, status)

Input/Output Parameters:

[in] prog_nam: STRING

[out] status: INTEGER

%ENVIRONMENT Group: MEMO

Details:

- prog_nam specifies the program name. This operation will save the current values of any variables in DRAM to FlashROM for the specified program. At power up these saved values will automatically be loaded into DRAM.
- status explains the status of the attempted operation. If not equal to 0, then an error occurred.

A.20.3 SELECT ... ENDSELECT Statement

Purpose: Permits execution of one out of a series of statement sequences, depending on the value of an INTEGER expression.

Syntax: SELECT case_val OF

CASE(value{,value}):

{statement}

{ CASE(value{, value}):

{statement} }

<ELSE:

{ statement }>

ENDSELECT

where:

case_val : an INTEGER expression

value : an INTEGER constant or literal

statement : a valid KAREL executable statement

Details:

- *case_val* is compared with each of the values following the CASE in each clause. If it is equal to any of these, the statements between the CASE and the next clause are executed.
- Up to 1000 CASE clauses can be used in a SELECT statement.
- If the same INTEGER value is listed in more than one CASE, only the statement sequence following the first matching CASE will be executed.
- If the ELSE clause is used and the expression *case_val* does not match any of the values in the CASE clauses, the statements between the keywords ELSE and ENDSELECT are executed.

- If no ELSE clause is used and the expression *case_val* does not match any of the values in the CASE clauses, the program is aborted with the ‘‘No match in CASE’’ error.

See Also: Appendix E , ‘‘Syntax Diagrams,’’ for more syntax information

Example: Refer to the following sections for detailed program examples:

Section B.3 , "Saving Data to the Default Device" (SAVE_VR.KL)

Section B.12 , "Displaying a List From a Dictionary File" (DCLST_EX.KL)

Section B.14 , "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

A.20.4 SELECT_TPE Built-In Procedure

Purpose: Selects the program of the specified name

Syntax : SELECT_TPE(prog_name, status)

Input/Output Parameters :

[in] prog_name :STRING

[out] status : :INTEGER

%ENVIRONMENT Group :TPE

Details:

- *prog_name* specifies the name of the program to be selected as the teach pendant default. This is the program that is "in use" by the teach pendant. It is also the program that will be executed if the CYCLE START button is pressed or the teach pendant FWD key is pressed.
- *status* explains the status of the attempted operation. If it is not equal to 0, then an error has occurred.

See Also: OPEN_TPE Built-in Procedure

Example: Refer to Section B.14 , "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL), for a detailed program example.

A.20.5 SEMA_COUNT Built-In Function

Purpose: Returns the current value of the specified semaphore

Syntax : SEMA_COUNT (semaphore_no)

Function Return Type :INTEGER

Input/Output Parameters :

[in] semaphore_no : INTEGER

%ENVIRONMENT Group :MULTI

Details:

- The value of the semaphore indicated by *semaphore_no* is returned.
- This value is incremented by every POST_SEMA call and SIGNAL SEMAPHORE Action specifying the same *semaphore_no* . It is decremented by every PEND_SEMA call.
- If SEMA_COUNT is greater than zero, a PEND_SEMA call will "fall through" immediately. If it is *-n* (minus n), then there are *n* tasks pending on this semaphore.

See Also: POST_SEMA, PEND_SEMA, CLEAR_SEMA Built-In Procedures, Chapter 14 *MULTI-TASKING*

Example: See examples in Chapter 14 *MULTI-TASKING*

A.20.6 SEMAPHORE Condition

Purpose: Monitors the value of the specified semaphore

Syntax : SEMAPHORE[semaphore_no]

Details:

- *semaphore_no* specifies the semaphore number to use.
- *semaphore_no* must be in the range of 1 to the number of semaphores defined on the controller.
- When the value of the indicated semaphore is greater than zero, the condition is satisfied (TRUE).

A.20.7 SEND_DATAPC Built-In Procedure

Purpose: To send an event message and other data to the PC.

Syntax : SEND_DATAPC(event_no, dat_buffer, status)

Input/Output Parameters :

[in] event_no :INTEGER

[in] dat_buffer :ARRAY OF BYTE

[out] status :INTEGER

%ENVIRONMENT Group :PC

Details:

- *event_no* - a GEMM event number. Valid values are 0 to 255.
- *dat_buffer* - an array of up to 244 bytes. The KAREL built-ins ADD_BYNAMEPC, ADD_INTPC, ADD_REALPC, and ADD_STRINGPC can be used to format a KAREL byte buffer. The actual data buffer format depends on the needs of the PC. There is no error checking of the dat_buffer format on the controller.
- *status* - the status of the attempted operation. If not 0, then an error occurred and the event request was not sent to the PC.

See Also: ADD_BYNAMEPC, ADD_INTPC, ADD_REALPC, ADD_STRINGPC

Example: The following example sends event 12 to the PC with a data buffer.

SEND_DATAPC Built-In Procedure

```
PROGRAM TESTDATA
%ENVIRONMENT PC
CONST
  er_abort = 2
VAR
  dat_buffer:   ARRAY[100] OF BYTE
  index:        INTEGER
  status:       INTEGER
BEGIN
  index = 1
  ADD_INTPC(dat_buffer,index,55,status)
  ADD_REALPC(dat_buffer,index,123.5,status)
  ADD_STRINGPC(dat_buffer,index,'YES',status)

  -- send event 12 and data buffer to PC
  SEND_DATAPC(12,dat_buffer,status)
  IF status<>0 THEN
    POST_ERR(status,'',0,er_abort)
  ENDIF
END testdata
```

A.20.8 SEND_EVENTPC Built-In Procedure

Purpose: To send an event message to the PC.

Syntax : SEND_EVENTPC(event_no, status)

Input/Output Parameters :

[in] event_no :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PC

Details:

- *event_no* - a GEMM event number. Valid values are 0 through 255.
- *status* - the status of the attempted operation. If not 0, then an error occurred and the event request was not sent to the PC.

Example: The following example sends event 12 to the PC.

SEND_EVENTPC Built-In Procedure

```
PROGRAM TESTEVT
%ENVIRONMENT PC
CONST
  er_abort = 2
VAR
  status:  INTEGER
BEGIN
  -- send event 12 to PC
  SEND_EVENTPC(12,status)    -- call built-in here
  IF status<>0 THEN
    POST_ERR(status,'',0,er_abort)
  ENDIF
END testevt
```

A.20.9 SET_ATTR_PRG Built-In Procedure

Purpose: Sets attribute data of the specified teach pendant or KAREL program

Syntax : SET_ATTR_PRG(program_name, attr_number, int_value, string_value, status)

Input/Output Parameters :

[in] program_name : STRING

[in] attr_number : INTEGER

[in] int_value : INTEGER

[in] string_value : STRING

[out] status : INTEGER

%ENVIRONMENT Group :TPE

Details:

- *program_name* specifies the program to which attribute data is set.
- *attr_number* is the attribute whose value is to be set. The following attributes are valid:

  AT_PROG_TYPE : (#) Program type

  AT_PROG_NAME : Program name (String[12])

  AT_OWNER : Owner (String[8])

  AT_COMMENT : Comment (String[16])

  AT_PROG_SIZE : (#) Size of program

  AT_ALLC_SIZE : (#) Size of allocated memory

  AT_NUM_LINE : (#) Number of lines

  AT_CRE_TIME : (#) Created (loaded) time

  AT_MDFY_TIME : (#) Modified time

  AT_SRC_NAME : Source file (or original file) name (String[128])

  AT_SRC_VRSN : Source file version

  AT_DEF_GROUP : Default motion groups (for task attribute)

  AT_PROTECT : Protection code; 1 :protection OFF; 2 : protection ON

  AT_STK_SIZE : Stack size (for task attribute)

  AT_TASK_PRI : Task priority (for task attribute)

AT_DURATION : Time slice duration (for task attribute)

AT_BUSY_OFF : Busy lamp off (for task attribute)

AT_IGNR_ABRT : Ignore abort request (for task attribute)

AT_IGNR_PAUS : Ignore pause request (for task attribute)

AT_CONTROL : Control code (for task attribute)

(#) --- Cannot be set.

- If the attribute data is a number, it is set to *int_value* and *string_value* is ignored.
- If the attribute data is a string, it is set to *string_value* and *int_value* is ignored.
- *status* explains the status of the attempted operation. If it is not equal to 0, then an error has occurred. Some of the errors which could occur are:

  7073 The program specified in *program_name* does not exist

  7093 The attribute of a program cannot be set while it is running

  17033 *attr_number* has an illegal value or cannot be set

A.20.10 SET_CURSOR Built-In Procedure

Purpose: Set the cursor position in the window

Syntax : SET_CURSOR(file_var, row, col, status)

Input/Output Parameters :

[in] file_var : FILE

[in] row : INTEGER

[in] col : INTEGER

[out] status : INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- Sets the current cursor of the specified file that is open to a window so subsequent writes will start in the specified position.
- *file_var* must be open to a window.

- A *row* value of 1 indicates the top row of the window. A *col* value of 1 indicates the left-most column of the window.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: DEF_WINDOW Built-In Procedure

Example: Refer to the following sections for detailed program examples:

Section B.2 , "Copying Path Variables" (CPY_PTH.KL)

Section B.6 , "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.13 , "Using the DISCTRL_ALPHA Built-in" (DCALP_EX.KL)

A.20.11 SET_EPOS_REG Built-In Procedure

Purpose: Stores an XYZWPREXT value in the specified register

Syntax : SET_EPOS_REG(register_no, posn, status <, group_no>)

Input/Output Parameters :

[in] register_no : INTEGER

[in] posn : XYZWPREXT

[out] status : INTEGER

[in] group_no :INTEGER

%ENVIRONMENT Group :REGOPE

Details:

- *register_no* specifies the position register in which to store the value.
- The *position* data is set in XYZWPREXT representation.
- *status* explains the status of the attempted operation. If it is not equal to 0, then an error occurred.
- If *group_no* is omitted, the default group for the program is assumed. Data for other groups is not changed.
- If *group_no* is specified, it must be in the range of 1 to the total number of groups defined on the controller.

See Also: SET_POS_REG, SET_JPOS_REG Built-In Procedures, GET_POS_REG, GET_JPOS_REG Built-In Functions

Example: The following example sets the extended position for the specified register.

SET_EPOS_REG Built-In Procedure

```
PROGRAM spe
%environment REGOPE
VAR
  cur_pos: XYZWPREXT
  posget: XYZWPREXT
  status: INTEGER
  v_mask, g_mask: INTEGER
  reg_no: INTEGER
BEGIN
  reg_no = 1
  cur_pos = CURPOS(v_mask,g_mask)
  SET_EPOS_REG(reg_no,cur_pos,status)
  posget = GET_POS_REG(reg_no,status)
END spe
```

A.20.12 SET_EPOS_TPE Built-In Procedure

Purpose: Stores an XYZWPREXT value in the specified position in the specified teach pendant program

Syntax: SET_EPOS_TPE (open_id, position_no, posn, status <,group_no>)

Input/Output Parameters :

[in] open_id : INTEGER

[in] position_no : INTEGER

[in] posn : XYZWPREXT

[out] status : INTEGER

[in] group_no : INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *open_id* specifies the opened teach pendant program. A program must be opened before calling this built-in.
- *position_no* specifies the position in the program in which to store the value.

- A motion instruction must already exist that uses the *position_no* or the position will not be used by the teach pendant program.
- The position data is set in XYZWPREXT representation with no conversion.
- *status* explains the status of the attempted operation. If not equal to 0, then an error has occurred.
- If *group_no* is omitted, the default group for the program is assumed. Data for other groups is not changed.
- If *group_no* is specified, it must be in the range of 1 to the total number of groups defined on the controller.

A.20.13 SET_FILE_ATR Built-In Procedure

Purpose: Sets the attributes of a file before it is opened

Syntax : SET_FILE_ATR(xml_file, ATR_XML)

Input/Output Parameters :

[in] xml_file: FILE

[in] ATR_XML: INTEGER expression

%ENVIRONMENT Group :PBCORE

Details:

- *xml_file* is the file variable that will be used in the OPEN FILE, WRITE, READ, and/or CLOSE FILE statements.
- *ATR_XML* specifies the attribute type to set. The predefined constants as specified in Table 7-2 should be used.
- The file must then be opened as a RO file. You cannot do any other XMl operations until the file has been opened.

See Also:

Example: Refer to the following sections for detailed program examples:

A.20.14 SET_FILE_POS Built-In Procedure

Purpose: Sets the file position for the next READ or WRITE operation to take place in the specified file to the value of the new specified file position

Syntax : SET_FILE_POS(file_id, new_file_pos, status)

Input/Output Parameters :

[in] file_id : FILE

[in] new_file_pos : INTEGER expression

[out] status : INTEGER variable

%ENVIRONMENT Group :FLBT

Details:

- The file associated with *file_id* must be opened and uncompressed on either the FROM or RAM disks. Otherwise, the program is aborted with an error.
- *new_file_pos* must be in the range of -1 to the number of bytes in the file.at_eof : specifies that the file position is to be set at the end of the file. at_sof : specifies that the file position is to be set at the start of the file.
  - — Any other value causes the file to be set the specified number of bytes from the beginning of the file.
- *status* is set to 0 if the *new_file_pos* is between -1 and the number of bytes in the file, indicating the file position was successfully set. If not equal to 0, then an error occurred.

See Also: Chapter 7 *FILE INPUT/OUTPUT OPERATIONS*

Example: The following example opens the **filepos.dt** data file, sets the file position from a directory, reads the positions from the file, and stores the positions in the PATH, **my_path** .

SET_FILE_POS Built-In Procedure

```
OPEN FILE file_id ('RW','filepos.dt')
FOR i = 1 TO PATH_LEN(my_path) DO
  SET_FILE_POS(file_id, pos_dir[i], status)
  IF status = 0 THEN
    READ file_id (temp_pos)
    my_path[i].node_pos = temp_pos
  ENDIF
ENDFOR
```

A.20.15 SET_INT_REG Built-In Procedure

Purpose: Stores an integer value in the specified register

Syntax : SET_INT_REG(register_no, int_value, status)

Input/Output Parameters :

[in] register_no : INTEGER

[in] int_value : INTEGER

[out] status : INTEGER

%ENVIRONMENT Group :REGOPE

Details:

- *register_no* specifies the register into which *int_value* will be stored.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: GET_INT_REG, GET_REAL_REG, SET_REAL_REG Built-in Procedures

Example: Refer to Section B.5 , "Using Register Built-ins" (REG_EX.KL), for a detailed program example.

A.20.16 SET_JPOS_REG Built-In Procedure

Purpose: Stores a JOINTPOS value in the specified register

Syntax : SET_JPOS_REG(register_no, jpos, status<, group_no>)

Input/Output Parameters :

[in] register_no : INTEGER

[in] jpos : JOINTPOS

[out] status :INTEGER

[in] group_no :INTEGER

%ENVIRONMENT Group :REGOPE

Details:

- *register_no* specifies the position register in which to store the position, *jpos* .
- The position data is set in JOINTPOS representation with no conversion.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.
- If *group_no* is omitted, the default group for the program is assumed. Data for other groups is not changed.

- If *group_no* is specified, it must be in the range of 1 to the total number of groups defined on the controller.

See Also: GET_JPOS_REG, GET_POS_REG, SET_POS_REG, POS_REG_TYPE Built-in Procedures

Example: Refer to Section B.5 ,"Using Register Built-ins" (REG_EX.KL), for a detailed program example.

A.20.17 SET_JPOS_TPE Built-In Procedure

Purpose: Stores a JOINTPOS value in the specified position in the specified teach pendant program

Syntax : SET_JPOS_TPE(open_id, position_no, posn, status<, group_no>)

Input/Output Parameters :

[in] open_id : INTEGER

[in] position_no : INTEGER

[in] posn : JOINTPOS

[out] status : INTEGER

[in] group_no :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *open_id* specifies the opened teach pendant program. Before calling this built-in, a program must be opened using the OPEN_TPE Built-In, and have read/write access.
- *position_no* specifies the position in the program in which to store the value.
- The position data is set in JOINTPOS representation with no conversion.
- *status* explains the status of the attempted operation. If not equal to 0, then an error has occurred.
- If *group_no* is omitted, the default group for the program is assumed. Data for other groups is not changed.
- If *group_no* is specified, it must be in the range of 1 to the total number of groups defined on the controller.

See Also: GET_JPOS_TPE, GET_POS_TPE, SET_POS_TPE, GET_POS_TYP Built-in Procedures

Example: Refer to Section B.14 , "Applying Offsets to a Copied Teach Pendant Program" (CPY.TP.KL), for a detailed program example.

A.20.18 SET_LANG Built-In Procedure

Purpose: Changes the current language

Syntax : SET_LANG(lang_name, status)

Input/Output Parameters :

[in] lang_name :STRING

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *lang_name* specifies which language from which the dictionaries should be read/written. Use one of the following pre-defined constants:

  dp_default

  dp_english

  dp_japanese

  dp_french

  dp_german

  dp_spanish
- The read-only system variable $LANGUAGE indicates which language is currently in use.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred setting the language.
- The error, 33003, "No dict found for language," will be returned if no dictionaries are loaded into the specified language. The KCL command "SHOW LANGS" can be used to view which languages are created in the system.

See Also: Chapter 10 *DICTIONARIES AND FORMS*

Example: Refer to Section B.13 , "Using the DISCTRL_ALPHA Built-in" (DCALP_EX.KL), for a detailed program example.

A.20.19 SET_PERCH Built-In Procedure

Purpose: Sets the perch position and tolerance for a group of axes

Syntax : SET_PERCH(jpos, tolerance, indx)

Input/Output Parameters :

[in] jpos : JOINTPOS

[in] tolerance : ARRAY[6] of REAL

[in] indx : INTEGER

%ENVIRONMENT Group :SYSTEM

Details:

- The values of *jpos* are converted to radians and stored in the system variable $REFPOS1[*indx*].$perch_pos.
- The *tolerance* array is converted to degrees and stored in the system variable $REFPOS1[*indx*].$perchtol. If the tolerance array is uninitialized, an error is generated.
- *indx* specifies the element number to be set in the $REFPOS1 array.
- The group of axes is implied from the specified position, *jpos* . If JOINTPOS is not in group 1, then the system variable $REFPOSn is used where n corresponds to the group number of *jpos* and *indx* must beset to 1.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: The appropriate application-specific *FANUC Robotics SYSTEM R-J3iC Controller Setup and Operations Manual* to setup Reference Positions

Example: In the following example, $REFPOS1[2].$perchpos and $REFPOS1[2].$perchtol are set according to **perch_pos** and **tolerance[i].**

SET_PERCH Built-In Procedure

```
VAR
  perch_pos: JOINTPOS IN GROUP[1]
```

```
BEGIN
  FOR i = 1 to 6 DO
    tolerance[i] = 0.01
  ENDFOR
  SET_PERCH (perch_pos, tolerance, 2)
END
```

A.20.20 SET_PORT_ASG Built-In Procedure

Purpose: Allows a KAREL program to assign one or more logical ports to specified physical port(s)

Syntax : SET_PORT_ASG(log_port_type, log_port_no, rack_no, slot_no, phy_port_type, phy_port_no, n_ports, status)

Input/Output Parameters :

[in] log_port_type : INTEGER

[in] log_port_no : INTEGER

[in] rack_no : INTEGER

[in] slot_no : INTEGER

[in] phy_port_type : INTEGER

[in] phy_port_no : INTEGER

[in] n_ports : INTEGER

[out] status : INTEGER

%ENVIRONMENT Group :IOSETUP

Details:

- *log_port_type* specifies the code for the type of port to be assigned. Codes are defined in KLIOTYPS.KL.
- *log_port_no* specifies the number of the port to be assigned.
- *rack_no* is the rack containing the port module. For process I/O boards, memory-image, and dummy ports, this is zero; for Allen-Bradley and Genius ports, this is 16.
- *slot_no* is the slot containing the port module. For process I/O boards, this is the sequence in the SLC-2 chain. For memory-image and dummy ports, this is zero; for Allen-Bradley and Genius ports, this is 1.

- *phy_port_type* is the type of port to be assigned to. Often this will be the same as *log_port_type* . Exceptions are if *log_port_type* is a group type (*io_gpin* or *io_gpout*) or a port is assigned to memory-image or dummy ports.
- *phy_port_no* is the number of the port to be assigned to. If *log_port_type* is a group, this is the port number for the least-significant bit of the group.
- *n_ports* is the number of physical ports to be assigned to the logical port. If *log_port_type* is a group type, *n_ports* indicates the number of bits in the group. When setting digital I/O, *n_ports* is the number of points you are configuring. In most cases this will be 8, but may be 1 through 8.
- *status* is returned with zero if the parameters are valid. Otherwise, it is returned with an error code. The assignment is invalid if the specified port(s) do not exist or if the assignment of *log_port_type* to *phy_port_type* is not permitted.

For example, GINs cannot be assigned to DOUTs. Neither *log_port_type* nor *phy_port_type* can be a system port type (SOPIN, for example).

Note The assignment does not take effect until the next power-up.

Example: Refer to Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.20.21 SET_PORT_ATR Built-In Function

Purpose: Sets the attributes of a port

Syntax : SET_PORT_ATR(port_id, atr_type, atr_value)

Function Return Type :INTEGER

Input/Output Parameters :

[in] port_id : INTEGER

[in] atr_type : INTEGER

[in] atr_value : INTEGER

%ENVIRONMENT Group :FLBT

Details:

- *port_id* is one of the predefined constants as follows:

  port_1

  port_2

port_3

port_4

- *atr_type* specifies the attribute type to set. One of the following predefined constants should be used:

  atr_readahd :Read ahead buffer

  atr_baud :Baud rate

  atr_parity :Parity

  atr_sbits :Stop bits

  atr_dbits :Data length

  atr_xonoff :XON/XOFF

  atr_eol :End of line

  atr_modem :Modem line

- *atr_value* specifies the value for the attribute type. See Table A–20 on the following page which contains acceptable pre-defined attribute types with corresponding values.

Table A–20. Attribute Values

ATR_TYPE	ATR_VALUE
atr_readahd	any integer, represents multiples of 128 bytes (for example: atr_value=1 means the buffer length is 128 bytes.
atr_baud	baud_9600 baud_4800 baud_2400 baud_1200
atr_parity	parity_none parity_even parity_odd
atr_sbits	sbits_1 sbits_15 sbits_2
atr_dbits	dbits_5 dbits_6 dbits_7 dbits_8

Table A–20. Attribute Values (Cont'd)

ATR_TYPE	ATR_VALUE
atr_xonoff	xf_not_used xf_used
atr_eol	an ASCII code value, Refer to Appendix D , "Character Codes"
atr_modem	md_not_used md_use_dsr md_nouse_dsr md_use_dtr md_nouse_dtr md_use_rts md_nouse_rts

- A returned integer is the status of this action to port.

See Also: SET_FILE_ATR Built-In Procedure, Section 7.3.1 , ''Setting File and Port Attributes,'' for more information

Example: Refer to the example for the GET_PORT_ATR Built_In Function.

A.20.22 SET_PORT_CMT Built-In Procedure

Purpose: Allows a KAREL program to set the comment displayed on the teach pendant, for a specified logical port

Syntax : SET_PORT_CMT(port_type, port_no, comment_str, status)

Input/Output Parameters :

[in] port_type : INTEGER

[in] port_no : INTEGER

[in] comment_str : STRING

[out] status : INTEGER

%ENVIRONMENT Group :IOSETUP

Details:

- *port_type* specifies the code for the type of port whose mode is being set. Codes are defined in KLIOTYPS.KL.

- *port_no* specifies the port number whose mode is being set.
- *comment_str* is a string whose value is the comment for the specified port. This must not be over 16 characters long.
- *status* is returned with zero if the parameters are valid and the specified mode can be set for the specified port.

See Also: SET_PORT_VALUE, SET_PORT_MOD, GET_PORT_CMT, GET_PORT_VALUE, GET_PORT_MOD Built-in Procedures

Example: Refer to Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.20.23 SET_PORT_MOD Built-In Procedure

Purpose: Allows a KAREL program to set (or reset) special port modes for a specified logical port

Syntax : SET_PORT_MOD(port_type, port_no, mode_mask, status)

Input/Output Parameters :

[in] port_type : INTEGER

[in] port_no : INTEGER

[in] mode_mask : INTEGER

[out] status : INTEGER

%ENVIRONMENT Group :IOSETUP

Details:

- *port_type* specifies the code for the type of port whose mode is being set. Codes are defined in KLIOTYPS.KL.
- *port_no* specifies the port number whose mode is being set.
- *mode_mask* is a mask specifying which modes are turned on. The following modes are defined:

  1 :reverse mode - sense of the port is reversed; if the port is set to TRUE, the physical output is set toFALSE. If the port is set to FALSE, the physical output is set to TRUE. If a physical input is TRUE when the port is read, FALSE is returned. If a physical input is FALSE when the port is read, TRUE is returned.ports.

  2 :complementary mode - the logical port is assigned to two physical ports whose values are complementary. In this case, port_no must be an odd number. If port n is set to TRUE, port n is

set to TRUE, and port n + 1 is set to FALSE. If port n is set to FALSE, port n is set to FALSE and port n + 1 is set to TRUE. This is effective only for output

Note The mode setting does not take effect until the next power-up.

- *status* is returned with zero if the parameters are valid and the specified mode can be set for the specified port.

Example: Refer to Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.20.24 SET_PORT_SIM Built-In Procedure

Purpose: Sets port simulated

Syntax : SET_PORT_SIM(port_type, port_no, value, status)

Input/Output Parameters :

[in] port_type : INTEGER

[in] port_no : INTEGER

[in] value : INTEGER

[out] status : INTEGER

%ENVIRONMENT Group :IOSETUP

Details:

- *port_type* specifies the code for the type of port to simulate. Codes are defined in KLIOTYPS.KL.
- *port_no* specifies the number of the port to simulate.
- *value* specifies the initial value to set.
- *status* is returned with zero if the port is simulated.

See Also: SET_PORT_ASG, GET_PORT_ASG, GET_PORT_SIM Built-in Procedures

Example: Refer to Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.20.25 SET_PORT_VAL Built-In Procedure

Purpose: Allows a KAREL program to set a specified output (or simulated input) for a specified logical port

Syntax : SET_PORT_VAL(port_type, port_no, value, status)

Input/Output Parameters :

[in] port_type : INTEGER

[in] port_no : INTEGER

[in] value : INTEGER

[out] status : INTEGER

%ENVIRONMENT Group :IOSETUP

Details:

- *port_type* specifies the code for the type of port whose mode is being set. Codes are defined in KLIOTYPS.KL.
- *port_no* specifies the port number whose mode is being set.
- *value* indicates the value to be assigned to a specified port. If the *port_type* is BOOLEAN (i.e. DOUT), this should be 0 = OFF, or 1 = ON. This field can be used to set input ports if the port is simulated.
- *status* is returned with zero if the parameters are valid and the specified mode can be set for the specified port.

See Also: SET_PORT_VALUE, SET_PORT_MOD, GET_PORT_CMT, GET_PORT_VALUE, GET_PORT_MOD Built-in Procedures

Example: The following example sets the value for a specified port.

SET_PORT_VAL Built-In Procedure

```
PROGRAM setvalprog
%ENVIRONMENT IOSETUP
%INCLUDE FR:\kliotyps
 ROUTINE set_value(port_type: INTEGER;
       port_no:  INTEGER;
       g_value:  BOOLEAN): INTEGER
  VAR
   value: INTEGER
   status: INTEGER
```

```
 BEGIN
  IF g_value THEN
   value = 1
  ELSE
   value = 0;
  ENDIF
  SET_PORT_VAL (port_type, port_no, value, status)
  RETURN (status)
 END set_value
BEGIN
END setvalprog
```

A.20.26 SET_POS_REG Built-In Procedure

Purpose: Stores an XYZWPR value in the specified position register

Syntax : SET_POS_REG(register_no, posn, status<, group_no>)

Input/Output Parameters :

[in] register_no : INTEGER

[in] posn : XYZWPR

[out] status : INTEGER

[in] group_no : INTEGER

%ENVIRONMENT Group :REGOPE

Details:

- *register_no* specifies the position register in which to store the value.
- The position data is set in XYZWPR representation with no conversion.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.
- If *group_no* is omitted, the default group for the program is assumed. Data for other groups is not changed.
- If *group_no* is specified, it must be in the range of 1 to the total number of groups defined on the controller.

Example: Refer to Section B.5 ,"Using Register Built-ins" (REG_EX.KL), for a detailed program example.

A.20.27 SET_POS_TPE Built-In Procedure

Purpose: Stores an XYZWPR value in the specified position in the specified teach pendant program

Syntax : SET_POS_TPE(open_id, position_no, posn, status<, group_no>)

Input/Output Parameters :

[in] open_id : INTEGER

[in] position_no : INTEGER

[in] posn : XYZWPR

[out] status : INTEGER

[in] group_no : INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *open_id* specifies the opened teach pendant program. Before calling this built-in, a program must be opened using the OPEN_TPE Built-In, and have read/write access.
- *position_no* specifies the position in the program in which to store the value.
- A motion instruction must already exist that uses the *position_no* or the position will not be used by the teach pendant program.
- The position data is set in XYZWPR representation with no conversion.
- *status* explains the status of the attempted operation. If not equal to 0, then an error has occurred.
- If *group_no* is omitted, the default group for the program is assumed. Data for other groups is not changed.
- If *group_no* is specified, it must be in the range of 1 to the total number of groups defined on the controller.

Example: Refer to Section B.14 , "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL), for a detailed program example.

A.20.28 SET_PREG_CMT Built-In-Procedure

Purpose: To set the comment information of a KAREL position register based on a given register number and a given comment.

Syntax: SET_PREG_CMT (register_no, comment_string, status)

Input/Output Parameters:

[in] register_no: INTEGER

[in] comment_string: STRING

[out] status: INTEGER

%ENVIRONMENT group: REGOPE

A.20.29 SET_REAL_REG Built-In Procedure

Purpose: Stores a REAL value in the specified register

Syntax : SET_REAL_REG(register_no, real_value, status)

Input/Output Parameters :

[in] register_no : INTEGER

[in] real_value : REAL

[out] status : INTEGER

%ENVIRONMENT Group :REGOPE

Details:

- *register_no* specifies the register into which *real_value* will be stored.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: SET_INT_REG, GET_REAL_REG, GET_INT_REG Built-in Procedures

A.20.30 SET_REG_CMT Built-In-Procedure

Purpose: To set the comment information of a KAREL register based on a given register number and a given comment.

Syntax: SET_REG_CMT (register_no, comment_string, status

Input/Output Parameters:

[in] register_no: INTEGER

[in] comment_string: STRING

[out] status: INTEGER

%ENVIRONMENT group REGOPE

Details:

- Register_no specifies which register to retrieve the comments from. The comment_string represents the data which is to be used to set the comment of the given register. If the comment_string exceeds more than 16 characters, the built-in will truncate the string.

A.20.31 SET_TIME Built-In Procedure

Purpose: Set the current time within the KAREL system

Syntax : SET_TIME(i)

Input/Output Parameters :

[in] i : INTEGER

%ENVIRONMENT Group :TIM

Details:

- *i* holds the INTEGER representation of time within the KAREL system. This value is represented in 32-bit INTEGER format as follows:

Table A–21. 32–Bit INTEGER Format of Time

31–25	24–21	20–16
year	month	day
15–11	10–5	4–0
hour	minute	second

- The contents of the individual fields are as follows:
  — DATE:

    Bits 15-9 — Year since 1980

    Bits 8-5 — Month (1-12)

    Bits 4-0 — Day of the month

— TIME:

Bits 31-25 — Number of hours (0-23)

Bits 24-21 — Number of minutes (0-59)

Bits 20-16 — Number of 2-second increments (0-29)

- This value can be determined using the GET_TIME and CNV_STR_TIME Built-In procedures.
- If *i* is 0, the time on the system will not be changed.
- INTEGER values can be compared to determine if one time is more recent than another.

See Also: CNV_STR_TIME, GET_TIME Built-In Procedures

Example: The following example converts the STRING variable *str_time* , input by the user in "DD-MMM-YYY HH:MM:SS" format, to the INTEGER representation of time **int_time** using the CNV_STR_TIME Built-In procedure. SET_TIME is then used to set the time within the KAREL system to the time specified by **int_time** .

SET_TIME Built-In Procedure

```
WRITE('Enter the new time : ')
READ(str_time)
CNV_STR_TIME(str_time,int_time)
SET_TIME(int_time)
```

A.20.32 SET_TPE_CMT Built-In Procedure

Purpose: Provides the ability for a KAREL program to set the comment associated with a specified position in a teach pendant program.

Syntax : SET_TPE_CMT(open_id, pos_no, comment, status)

Input/Output Parameters :

[in] open_id :INTEGER

[in] pos_no :INTEGER

[in] comment :STRING

[out] status :INTEGER

%ENVIRONMENT Group :TPE

Details:

- *open_id* specifies the open_id returned from a previous call to OPEN_TPE. An open mode of TPE_RWACC must be used in the OPEN_TPE call.
- *pos_id* specifies the number of the position in the teach pendant program to get a comment from. The specified position must have been recorded.
- *comment* is the comment to be associated with the specified position. A zero length string can be used to ensure that a position has no comment. If the string is over 16 characters, it is truncated and used and a warning error is returned.
- *status* indicates zero if the operation was successful, otherwise an error code will be displayed.

See Also: GET_TPE_CMT and OPEN_TPE for more Built-in Procedures.

A.20.33 SET_TRNS_TPE Built-In Procedure

Purpose: Stores a POSITION value within the specified position in the specified teach pendant program

Syntax : SET_TRNS_TPE(open_id, position_no, posn, status)

Input/Output Parameters :

[in] open_id : INTEGER

[in] position_no : INTEGER

[in] posn : POSITION

[out] status : INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *open_id* specifies the opened teach pendant program. A program must be opened before calling this built-in.
- *position_no* specifies the position in the program in which to store the value specified by *posn* . Data for other groups is not changed.
- The position data is set in POSITION representation with no conversion.
- *posn* is the group number of *position_no* .
- *status* explains the status of the attempted operation. If not equal to 0, then an error has occurred.

A.20.34 SET_TSK_ATTR Built-In Procedure

Purpose: Set the value of the specified running task attribute

Syntax : SET_TSK_ATTR(task_name, attribute, value, status)

Input/Output Parameters :

[in] task_name : STRING

[in] attribute : INTEGER

[in] value : INTEGER

[out] status : INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *task_name* is the name of the specified running task. A blank *task_name* will indicate the calling task.
- *attribute* is the task attribute whose value is to be set. The following attributes are valid:

  TSK_PRIORITY :Priority, see %PRIORITY for value information

  TSK_TIMESLIC :Time slice duration, see %TIMESLICE for value information

  TSK_NOBUSY :Busy lamp off, see %NOBUSYLAMP

  TSK_NOABORT :Ignore abort request

  Pg_np_error :no abort on error

  Pg_np_cmd :no abort on command

  TSK_NOPAUSE :Ignore pause request

  pg_np_error :no pause on error

  pg_np_end :no pause on command when TP is enabled

  pg_np_tpenb :no pause

  TSK_TRACE :Trace enable

TSK_TRACELEN :Maximum number of lines to store when tracing

TSK_TPMOTION :TP motion enable, see %TPMOTION for value information

TSK_PAUSESFT :Pause on shift, reverse of %NOPAUSESHFT

- *value* depends on the task attribute being set.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: GET_TSK_INFO Built-in Procedure

Example: See examples in Chapter 14 *MULTI-TASKING*

A.20.35 SET_TSK_NAME Built-In Procedure

Purpose: Set the name of the specified task

Syntax : SET_TSK_NAME(old_name, new_name, status)

Input/Output Parameters :

[in] old_name : STRING

[in] new_name : STRING

[out] status : INTEGER

%ENVIRONMENT Group :MULTI

Details:

- *task_name* is the name of the task of interest. A blank *task_name* will indicate the calling task.
- *new_name* will become the new task name.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: GET_ATTR_PRG Built-in Procedure

Example: See examples in Chapter 14 *MULTI-TASKING*

A.20.36 SET_VAR Built-In Procedure

Purpose: Allows a KAREL program to set the value of a specified variable

Syntax : SET_VAR(entry, prog_name, var_name, value, status)

Input/Output Parameters :

[in,out] entry : INTEGER

[in] prog_name : STRING

[in] var_name : STRING

[in] value : Any valid KAREL data type except PATH, VIS_PROCESS, and MODEL

[out] status : INTEGER

%ENVIRONMENT Group :SYSTEM

Details:

- *entry* returns the entry number in the variable data table of *var_name* in the device directory where *var_name* is located. **This variable should not be modified.**
- prog_name specifies the name of the program that contains the specified variable. If *prog_name* is ’’, then it defaults to the current task name being executed.
- Use *prog_name* of ’*SYSTEM*’ to set a system variable.
- *var_name* must refer to a static variable.
- *var_name* can contain node numbers, field names, and/or subscripts.
- If both *var_name* and *value* are ARRAYs, the number of elements copied will equal the size of the smaller of the two arrays.
- If both *var_name* and *value* are STRINGs, the number of characters copied will equal the size of the smaller of the two strings.
- If both *var_name* and *value* are STRUCTUREs of the same type, *value* will be an exact copy of *var_name* .
- *var_name* will be set to *value* .
- If *value* is uninitialized, the value of *var_name* will be set to uninitialized and *status* will be set to 12311. *value* must be a static variable within the calling program.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.



Caution

Using SET_VAR to modify system variables could cause unexpected results.

See Also: CREATE_VAR, RENAME_VAR Built-In Procedures

Example: Refer to Section B.2 , "Copying Path Variables" (CPY_PTH.KL), for a detailed program example.

A.20.37 %SHADOWVARS Translator Directive

Purpose: This directive specifies that all variables by default are created in SHADOW.

Syntax : %SHADOWVARS

A.20.38 SHORT Data Type

Purpose: Defines a variable as a SHORT data type

Syntax : SHORT

Details:

- SHORT, is defined as 2 bytes with the range of (-32768 <= n >= 32766). A SHORT variable assigned to (32767) is considered uninitialized.
- SHORTs are allowed only within an array or within a structure.
- SHORTs can be assigned to BYTEs and INTEGERs, and BYTEs and INTEGERs can be assigned to SHORTs. An assigned value outside the SHORT range is detected during execution and causes the program to be aborted.

A.20.39 SIGNAL EVENT Action

Purpose: Signals an event that might satisfy a condition handler or release a waiting program

Syntax : SIGNAL EVENT[event_no]

where:

event_no : an INTEGER expression

Details:

- You can use the SIGNAL EVENT action to indicate a user-defined event has occurred.
- *event_no* occurs when signaled and is not remembered. Thus, if a WHEN clause has the event as its only condition, the associated actions will occur.

- If other conditions are specified that are not met at the time the event is signaled, the actions are not taken, even if the other conditions are met at another time.
- *event_no* must be in the range of -32768 to 32767. Otherwise, the program is aborted with an error.

See Also: EVENT Condition

Example: Refer to Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.20.40 SIGNAL EVENT Statement

Purpose: Signals an event that might satisfy a condition handler or release a waiting program

Syntax : SIGNAL EVENT [event_no]

where:

event_no : an INTEGER

Details:

- You can use the SIGNAL EVENT statement to indicate a user-defined event has occurred.
- *event_no* occurs when signaled and is not remembered. Thus, if a WHEN clause has the event as its only condition, the associated actions will occur.
- If other conditions are specified that are not met at the time the event is signaled, the actions are not taken, even if the other conditions are met at another time.
- *event_no* must be in the range of -32768 to 32767. Otherwise, the program is aborted with an error.

See Also: Appendix E , ‘‘Syntax Diagrams’’ for more syntax information, EVENT Condition

Example: Refer to the DISABLE CONDITION Statement example program.

A.20.41 SIGNAL SEMAPHORE Action

Purpose: Adds one to the value of the indicated semaphore

Syntax : SIGNAL SEMAPHORE[semaphore_no]

where:

semaphore_no : an INTEGER expression

Details:

- The semaphore indicated by *semaphore_no* is incremented by one.
- *semaphore_no* must be in the range of 1 to the number of semaphores defined on the controller.

See Also: Section 14.8 , "Task Communication" for more information and examples.

A.20.42 SIN Built-In Function

Purpose: Returns a REAL value that is the sine of the specified angle argument

Syntax : SIN(angle)

Function Return Type :REAL

Input/Output Parameters :

[in] angle : REAL

%ENVIRONMENT Group :SYSTEM

Details:

- *angle* specifies an angle in degrees.
- *angle* must be in the range of ± 18000 degrees. Otherwise, the program will be aborted with an error.

Example: Refer to Section B.8 , "Generating and Moving Along a Hexagon Path" (GEN_HEX.KL), for a detailed program example.

A.20.43 SQRT Built-In Function

Purpose: Returns a REAL value that is the positive square root of the specified REAL argument

Syntax : SQRT(x)

Function Return Type :REAL

Input/Output Parameters :

[in] x : REAL

%ENVIRONMENT Group :SYSTEM

Details:

- *x* must not be negative. Otherwise, the program will be aborted with an error.

Example: The following example calculates the square root of the expression (a*a+b*b) and indicates that this is the hypotenuse of a triangle.

SQRT Built-In Function

```
c = SQRT(a*a+b*b)
WRITE ('The hypotenuse of the triangle is ',c::6::2)
```

A.20.44 %STACKSIZE Translator Directive

Purpose: Specifies stack size in long words.

Syntax : %STACKSIZE = n

Details:

- *n* is the stack size.
- The default value of *n* is 300 (1200 bytes).

See Also: Section 5.1.6 , ‘‘Stack Usage,’’ for information on computing stack size

A.20.45 STD_PTH_NODE Data Type

Purpose: Defines a data type for use in PATHs.

Syntax : STD_PTH_NODE = STRUCTURE

node_pos : POSITION in GROUP[1]

group_data : GROUP_ASSOC in GROUP[1]

common_data : COMMON_ASSOC

ENDSTRUCTURE

Details:

- If the NODEDATA clause is omitted from the PATH declaration, then STD_PTH_NODE will be the default.
- Each node in the PATH will be of this type.

A.20.46 STOP Action

Purpose: Stops any motion in progress, leaving it in a resumable state

Syntax : STOP <GROUP[n{,n}]>

Details:

- Any motion in progress is decelerated to a stop. The unfinished motion as well as any pending motions are grouped together in a motion set and placed on a stack.
- More than one motion might be stacked by a single STOP action.
- If the KAREL program was waiting for the completion of the motion in progress, it will continue to wait.
- The stacked motion set can be removed from the stack and restarted with either a RESUME statement or action or by issuing RESUME from the operator interface (CRT/KB).
- If the group clause is not present, all groups for which the task has control (when the condition is defined) will be stopped.
- If the motion that is stopped, resumed, canceled, or held is part of a SIMULTANEOUS or COORDINATED motion with other groups, the motions for all groups are stopped, resumed, canceled, or held.
- Motion cannot be stopped for a different task.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: Chapter 8 *MOTION* , RESUME Statement

Example: Refer to Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.20.47 STOP Statement

Purpose: Stops any motion in progress, leaving it in a resumable state

Syntax : STOP <GROUP[n{,n}]>

Details:

- Any motion in progress is decelerated to a stop. The unfinished motion as well as any pending motions are grouped together in a motion set and placed on a stack.
- More than one motion might be stacked by a single STOP statement.
- If the KAREL program was waiting for the completion of the motion in progress, it will continue to wait.
- The stacked motion set can be removed from the stack and restarted with either a RESUME statement or action, or by issuing RESUME from the CRT/KB.
- If the group clause is not present, all groups for which the task has control will be stopped.
- If the motion that is stopped, resumed, canceled, or held is part of a SIMULTANEOUS or COORDINATED motion with other groups, the motions for all groups are stopped, resumed, canceled, or held.
- Motion cannot be stopped for a different task.



Warning

Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.

See Also: Chapter 8 *MOTION* , RESUME Action, RESUME Statement, Appendix E , "Syntax Diagrams," for more syntax information

Example: The following example stops motion if the digital input is ON.

STOP Statement

```
IF DIN[2] THEN
  STOP
ENDIF
```

A.20.48 STRING Data Type

Purpose: Defines a variable or routine parameter as STRING data type

Syntax : STRING[length]

where:

length : an INTEGER constant or literal

Details:

- *length* , the physical length of the string, indicates the maximum number of characters for which space is allocated for a STRING variable.
- *length* must be in the range 1 through 128 and must be specified in a STRING variable declaration.
- A *length* value is not used when declaring STRING routine parameters; a STRING of any length can be passed to a STRING parameter.
- Attempting to assign a STRING to a STRING variable that is longer than the physical length of the variable results in the STRING value being truncated on the right to the physical length of the STRING variable.
- Only STRING expressions can be assigned to STRING variables or passed as arguments to STRING parameters.
- STRING values cannot be returned by functions.
- Valid STRING operators are:
  - — Relational operators (>, >=, =, <>, <, and <=)
  - — Concatenation operator (+)
- STRING literals consist of a series of ASCII characters enclosed in single quotes (apostrophes). Examples are given in the following table.

Table A–22. Example STRING Literals

VALID	INVALID	REASON
‘123456’	123456	Without quotes 123456 is an INTEGER literal

Example: Refer to the following sections for detailed program examples:

Section B.2 , "Copying Path Variables" (CPY_PTH.KL)

Section B.3 , "Saving Data to the Default Device" (SAVE_VR.KL)

Section B.7 , "Listing Files and Programs and Manipulating Strings" (LIST_EX.KL)

Section B.9 , "Using the File and Device Built-ins" (FILE_EX.KL)

Section B.10 , "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.12 , "Displaying a List From a Dictionary File" (DCLST_EX.KL)

Section B.13 , "Using the DISCTRL_ALPHA Built-in" (DCALP_EX.KL)

Section B.14 , "Applying Offsets to a Copied Teach Pendant Program" (CPY_TP.KL)

Section B.1 , "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.20.49 STR_LEN Built-In Function

Purpose: Returns the current length of the specified STRING argument

Syntax : STR_LEN(str)

Function Return Type :INTEGER

Input/Output Parameters :

[in] str : STRING

%ENVIRONMENT Group :SYSTEM

Details:

- The returned value is the length of the STRING currently stored in the *str* argument, not the maximum length of the STRING specified in its declaration.

Example: Refer to Section B.12 , "Displaying a List from a Dictionary File" (DCLST_EX.KL) for a detailed program example.

A.20.50 STRUCTURE Data Type

Purpose: Defines a data type as a user-defined structure

Syntax : new_type_name = STRUCTURE

field_name_1: type_name_1

field_name_2: type_name_2

...

ENDSTRUCTURE

Details:

- A user-defined structure is a data type consisting of a list of component fields, each of which can be a standard data type or another, previously defined, user data type.
- When a program containing variables of user-defined types is loaded, the definitions of these types is checked against a previously created definition. If this does not exist, it is created.
- The following data types are not permitted as part of a data structure:
  - STRUCTURE definitions (types that are declared structures are permitted)
  - PATH types
  - FILE types
  - Vision types
  - Variable length arrays
  - The data structure itself, or any type that includes it, either directly or indirectly
- A variable may not be defined as a structure, but as a data type previously defined as a structure

See Also: Section 2.4.2 , ‘‘User-Defined Data Structures’’

Example: Refer to Section B.2 , "Copying Path Variables" (CPY_PTH.KL), for a detailed program example.

A.20.51 SUB_STR Built-In Function

Purpose: Returns a copy of part of a specified STRING argument

Syntax : SUB_STR(src, strt, len)

Function Return Type :STRING

Input/Output Parameters :

[in] src : STRING

[in] strt : INTEGER

[in] len : INTEGER

%ENVIRONMENT Group :SYSTEM

Details:

- A substring of *src* is returned by the function.
- The length of substring is the number of characters, specified by *len* , that starts at the indexed position specified by *strt* .
- *strt* must be positive. Otherwise, the program is aborted with an error. If *strt* is greater than the length of *src* , then an empty string is returned.
- *len* must be positive. Otherwise, the program is aborted with an error. If *len* is greater than the declared length of the return STRING, then the returned STRING is truncated to fit.

Example: Refer to the following sections for detailed program examples:

Section B.2 , "Copying Path Variables" (CPY_PTH.KL)

Section B.7 , "Listing Files and Programs and Manipulating Strings" (LIST_EX.KL)

Section B.9 , "Using the File and Device Built-ins" (FILE_EX.KL)

A.21 - T - KAREL LANGUAGE DESCRIPTION

A.21.1 TAN Built-In Function

Purpose: Returns a REAL value that is the tangent of the specified REAL argument

Syntax : TAN(angle)

Function Return Type :REAL

Input/Output Parameters:

[in] angle : REAL

%ENVIRONMENT Group :SYSTEM

Details:

- The value of *angle* must be in the range of ± 18000 degrees. Otherwise, the program will be aborted with an error.

Example: The following example uses the TAN Built-In function to specify the tangent of the variable *angle* . The tangent should be equal to the SIN(*angle*) divided by COS(*angle*).

TAN Built-In Function

```
WRITE ('enter an angle:')
READ (angle,CR)

ratio = SIN(angle)/COS(angle)
IF ratio = TAN(angle) THEN
  WRITE ('ratio is correct',CR)
ENDIF
```

A.21.2 TIME Condition

Purpose: Monitors the progress of a move to a POSITION or along a PATH

Syntax : TIME t ||BEFORE | AFTER|| NODE[n]

where:

t : INTEGER expression

n : INTEGER expression

Details:

- The TIME conditions can be used only in local condition handlers.
- *t* indicates the time interval in milliseconds BEFORE or AFTER NODE[*n*].
- The maximum value for *t* is 500.
- NODE[*n*] indicates the node BEFORE which or AFTER which the condition is satisfied.
- If *n* is a wildcard (*), any node will satisfy the BEFORE or AFTER condition.
- Node 0 indicates the start of the move.
- If the move is along a PATH or to a path node, *n* specifies a path node.
- If the move is to a POSITION, node 1 can be used to indicate the destination.
- If *n* is greater than the length of the path (or greater than 1 if the move is to a POSITION), the condition is never satisfied.
- If *n* is less than zero or greater than 1000, the program is aborted with an error.

See Also: Chapter 6 *CONDITION HANDLERS* , Appendix E, ‘‘Syntax Diagrams,’’ for more syntax information

Example: Refer to Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.21.3 %TIMESLICE Translator Directive

Purpose: Supports round-robin type time slicing for tasks with the same priority

Syntax : %TIMESLICE = n

Details:

- *n* specifies task execution time in msec for one slice. The default value is 256 msec.
- The timeslice value must be greater than 0.
- This value is the maximum duration for executing the task continuously if there are other tasks with the same priority that are ready to run.
- This function is effective only when more than one KAREL task with the same priority is executing at the same time.
- The timeslice duration can be set during task execution by the SET_TSK_ATTR Built-In routine.

A.21.4 %TPMOTION Translator Directive

Purpose: Specifies that task motion is enabled when the teach pendant is on

Syntax : %TPMOTION

Details:

- This attribute can be set during task execution by the SET_TSK_ATTR Built-In routine.

A.21.5 TRANSLATE Built-In Procedure

Purpose: Translates a KAREL source file (.KL file type) into p-code (.PC file type), which can be loaded into memory and executed.

Syntax : TRANSLATE(file_spec, listing_sw, status)

Input/Output Parameters:

[in] file_spec : STRING

[in] listing_sw : BOOLEAN

[out] status : INTEGER

%ENVIRONMENT Group :trans

Details:

- *file_spec* specifies the device, name and type of the file to translate. If no device is specified, the default device will be used. The type, if specified, is ignored and .KL is used instead.
- The p-code file will be created on the default device. The default device should be set to the ram disk.
- *listing_sw* specifies whether a .LS file should be created. The .LS file contains a listing of the source lines and any errors which may have occurred. The .LS file will be created on the default device.
- The KAREL program will wait while the TRANSLATE Built-In executes. If the KAREL program is paused, translation will continue until completed. If the KAREL program is aborted, translation will also be aborted and the .PC file will not be created.
- If the KAREL program must continue to execute during translation, use the KCL_NO_WAIT Built-In instead.
- *status* explains the status of the attempted operation. If the number 0 is returned, the translation was successful. If not, an error occurred. Some of the status codes are shown below:

  0 Translation was successful

  268 Translator option is not installed

  35084 File cannot be opened or created.KL file cannot be found or default device is not the RAM disk

-1 Translation was not successful (Please see .LS file for details)

Example: The following example program will create, translate, load, and run another program called hello.

TRANSLATE Built-In Procedure

```
OPEN FILE util_file ('RW', 'hello.kl')
  WRITE util_file ('PROGRAM hello', CR)
  WRITE util_file ('%NOLOCKGROUP', CR)
  WRITE util_file ('BEGIN', CR)
  WRITE util_file (' WRITE (''hello world'', CR)', CR)
  WRITE util_file ('END hello', CR)
  CLOSE FILE util_file
  TRANSLATE('hello', TRUE, status)
  IF status = 0 THEN
    LOAD('hello.pc', 0, status)
  ENDIF
  IF status = 0 THEN
    CALL_PROG('hello', prog_index)
  ENDIF
```

A.21.6 TRUNC Built-In Function

Purpose: Converts the specified REAL argument to an INTEGER value by removing the fractional part of the REAL argument

Syntax : TRUNC(x)

Function Return Type :INTEGER

Input/Output Parameters:

[in] x : REAL

%ENVIRONMENT Group :SYStem

Details:

- The returned value is the value of *x* after any fractional part has been removed. For example, if x = 2.3, the .3 is removed and a value of 2 is returned.
- *x* must be in the range of -2147483648 to +2147483583. Otherwise, the program is aborted with an error.
- ROUND and TRUNC can both be used to convert a REAL expression to an INTEGER expression.

See Also: ROUND Built-In Function

Example: The following example uses the TRUNC Built-In to determine the actual INTEGER value of **miles** divided by **hours** to get **mph.**

TRUNC Built-In Function

```
WRITE ('enter miles driven, hours used: ')
  READ (miles,hours,CR)
  mph = TRUNC(miles/hours)
  WRITE ('miles per hour=',mph::5)
```

A.22 - U - KAREL LANGUAGE DESCRIPTION

A.22.1 UNHOLD Action

Purpose: Releases a HOLD of motion

Syntax : UNHOLD <GROUP [n{,n}]>

Details:

- Any motion that was in progress when the last HOLD was executed is resumed.

- If motions are not held, the action has no effect.
- Held motions are canceled if a RELEASE statement is executed.
- If the group clause is not present, all groups or which the task has control (when the condition is defined) will be resumed.
- Motion cannot be stopped for a different task.

Example: The following example moves the robot along the PATH **pathvar** and holds the robot motion 200 milliseconds before node[3]. The global condition handler is triggered when TPIN[1] is pressed. This condition handler then issues a UNHOLD statement to resume robot motion.

UNHOLD Action

```
CONDITION[1]:
  WHEN TPIN[1]+ DO
    UNHOLD
ENDCONDITION
ENABLE CONDITION[1]
MOVE ALONG pathvar,
  WHEN TIME 200 BEFORE NODE[3] DO
    HOLD
ENDMOVE
```

A.22.2 UNHOLD Statement

Purpose: Releases a HOLD of motion

Syntax : UNHOLD <GROUP [n{,n}]>

Details:

- Any motion that was in progress when the last HOLD was executed is resumed.
- If motions are not held, the statement has no effect.
- Held motions are canceled if a RELEASE statement is executed.

- If the group clause is not present, all groups or which the task has control (when the condition is defined) will be resumed.
- Motion cannot be stopped for a different task.

See Also: Appendix E , ‘‘Syntax Diagrams,’’ for more syntax information

Example: The following example initiates a move to **p1** and HOLDs the motion. If **DIN[1]** is ON, UNHOLD allows the program to resume motion.

UNHOLD Statement

```
MOVE TO p1 NOWAIT
HOLD
IF DIN[1] THEN
  UNHOLD
ENDIF
```

A.22.3 UNINIT Built-In Function

Purpose: Returns a BOOLEAN value indicating whether or not the specified argument is uninitialized

Syntax : UNINIT(variable)

Function Return Type :BOOLEAN

Input/Output Parameters :

[in] variable :any KAREL variable

%ENVIRONMENT Group :SYSTEM

Details:

- A value of TRUE is returned if *variable* is uninitialized. Otherwise, FALSE is returned.

- *variable* can be of any data type except an unsubscripted ARRAY, PATH, or structure.

Example: Refer to Section B.12 , "Displaying a List from a Dictionary File" (DCLST_EX.KL) for a detailed program example.

A.22.4 %UNINITVARS Translator Directive

Purpose: This directive specifies that all variables are by default uninitialized.

Syntax : %UNINITVARS

A.22.5 UNLOCK_GROUP Built-In Procedure

Purpose: Unlocks motion control for the specified group of axes

Syntax : UNLOCK_GROUP(group_mask, status)

Input/Output Parameters:

[in] group_mask :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :MULTI

Details:

- *group_mask* specifies the group of axes to unlock for the running task. The group numbers must be in the range of 1 to the total number of groups defined on the controller.

Table A–23. Group_mask Settings

GROUP	DECIMAL	BIT
Group 1	1	1

Table A–23. Group_mask Settings (Cont'd)

GROUP	DECIMAL	BIT
Group 2	2	2
Group 3	4	3

To specify multiple groups select the decimal values, shown in Table A–23, which correspond to the desired groups. Then connect them together using the OR operator. For example to specify groups 1, 3, enter "1 OR 4".

- Unlocking a group indicates that the task is done with the motion group.
- When a task completes execution (or is aborted), all motion groups that are locked by the program will be unlocked automatically.
- If motion is executing or pending when the UNLOCK_GROUP Built-In is called, then status is set to 17039, "Executing motion exists."
- If motion is stopped when the UNLOCK_GROUP Built-In is called, then status is set to 17040, "Stopped motion exists."
- If a motion statement is encountered in a program that has the %NOLOCKGROUP Directive, the task will attempt to get motion control for all the required groups if it does not already have it. The task will pause if it cannot get motion control.



Caution

Many of the fields in the $GROUP system variable are initialized to a set of default values when the UNLOCK_GROUP built-in is executed, see KAREL Motion Initialization . This could cause unexpected motion.

KAREL Motion Initialization

```
$GROUP[n].$MOTYPE       = JOINT
   $GROUP[n].$TERMTYPE    = FINE
   $GROUP[n].$SEGTERMTYPE = FINE
   $GROUP[n].$DECELTOL    = 0
   $GROUP[n].$USE_CONFIG  = TRUE
   $GROUP[n].$ORIENT_TYPE = RSWORLD
   $GROUP[n].$SPEED       = 300.0
   $GROUP[n].$ROTSPEED    = 500.0   ($MRR_GRP[n].$ROTSPEEDLIM x 57.29577951)
   $GROUP[n].$CONTAXISVEL = 0.0
   $GROUP[n].$SEG_TIME    = 0
```

- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

See Also: LOCK_GROUP Built-In Procedure, Chapter 14 *MULTI-TASKING* , for more information and examples.

Example: The following example unlocks groups 1, 2, and 3, and then locks group 3.

UNLOCK_GROUP Built-In Procedure

```
PROGRAM lock_grp_ex
%ENVIRONMENT MOTN
%ENVIRONMENT MULTI
  VAR
    status: INTEGER
  BEGIN
    REPEAT
      -- Unlock groups 1, 2, and 3
      UNLOCK_GROUP(1 OR 2 OR 4, status)
      IF status = 17040 THEN
        CNCL_STP_MTN       -- or RESUME
      ENDIF
      DELAY 500
    UNTIL status = 0
    -- Lock only group 3
    LOCK_GROUP(4, status)
END lock_grp_ex
```

A.22.6 UNPAUSE Action

Purpose: Resumes program execution long enough for a routine action to be executed

Syntax : UNPAUSE

Details:

- If a routine is called as an action, but program execution is paused, execution is resumed only for the duration of the routine and then is paused again.
- If more than one routine is called, all of the routines will be executed before execution is paused again.
- The resume and pause caused by UNPAUSE do not satisfy any RESUME and PAUSE conditions.

See Also: RESUME, PAUSE Actions

Example: Refer to Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.22.7 UNPOS Built-In Procedure

Purpose: Sets the specified REAL variables to the location (x,y,z) and orientation (w,p,r) components of the specified XYZWPR variable and sets the specified CONFIG variable to the configuration component of the XYZWPR

Syntax : UNPOS(posn, x, y, z, w, p, r, c)

Input/Output Parameters:

[in] posn :XYZWPR

[out] x, y, z :REAL

[out] w, p, r :REAL

[out] c :CONFIG

%ENVIRONMENT Group :SYSTEM

Details:

- *x, y, z, w, p* , and *r* arguments are set to the x, y, and z location coordinates and yaw, pitch, and roll orientation angles of *posn* .
- *c* returns the configuration of *posn* .

See Also: Chapter 8 *MOTION*

Example: The following example uses the UNPOS Built-In to add 100 to the **x** location argument.

UNPOS Built-In Procedure

```
UNPOS (CURPOS,x,y,z,w,p,r,config)
  next_pos = POS (x+100,y,z,w,p,r,config)
  MOVE TO next_pos
```

A.22.8 UNTIL Clause

Purpose: Used in a MOVE statement to specify a local condition handler

Syntax : UNTIL cond_list < THEN action_list >

where:

cond_list : one or more conditions

action_list : one or more actions

Details:

- Multiple conditions in *cond_list* must be separated by the AND operator or the OR operator. Mixing of AND and OR is not allowed.
- For the AND operator, all of the conditions in a single UNTIL clause must be satisfied simultaneously for the condition handler to be triggered.
- If the condition handler is triggered, the motion is canceled.
- The optional *action_list* represents a list of additional actions to be taken when the condition handler is triggered.
- Multiple actions must be separated by a comma or a new line.
- Calls to function routines are not allowed in an UNTIL clause.
- Local condition handlers can include multiple WHEN and UNTIL clauses.
- The condition handler is enabled when the motion physically begins.
- The condition handler is purged when the motion completes.
- The motion is treated as complete if the condition handler is triggered.

See Also: Chapter 6 *CONDITION HANDLERS* , Appendix E, ‘‘Syntax Diagrams,’’ for more syntax information

A.22.9 USING ... ENDUSING Statement

Purpose: Defines a range of executable statements in which fields of a variable of a STRUCTURE type can be accessed without repeating the name of the variable.

Syntax : USING struct_var{,struct_var} DO

{statement} ENDUSING

where:

struct_var : a variable of STRUCTURE type

statement : an executable KAREL statement

Details:

- In the executable statement, if the same name is both a field name and a variable name, the field name is used.

- If the same field name appears in more than one variable, the right-most variable in the USING statement is used.
- When the translator sees any field, it searches the structure type variables listed in the USING statement from right to left.

Example: Refer to Section B.2, "Copying Path Variables" (CPY_PTH.KL), for a detailed program example.

A.23 - V - KAREL LANGUAGE DESCRIPTION

A.23.1 VAR_INFO Built-In Procedure

Purpose: Allows a KAREL program to determine data type and numerical information regarding internal or external program variables

Syntax: VAR_INFO(prog_name, var_name, uninit, type_nam, type_value, dims, slen, status)

Input/Output Parameters:

[in] prog_name :STRING

[in] var_name :STRING

[out] uninit_b :BOOLEAN

[out] type_nam :STRING

[out] dims:ARRAY[3] OF INTEGER

[out] type_value :INTEGER

[out] status :INTEGER

[out] slen :INTEGER

%ENVIRONMENT Group :BYNAM

Details:

- *prog_name* specifies the name of the program that contains the specified variable. If *prog_name* is blank, then it defaults to the current program being executed.
- *var_name* must refer to a static program variable.
- *var_name* can contain node numbers, field names, and/or subscripts.

- *uninit_b* will return a value of TRUE if the variable specified by *var_name* is uninitialized and FALSE if the variable specified by *var_name* is initialized.
- *type_nam* returns a STRING specifying the type name of *var_name*
- *type_value* returns an INTEGER corresponding to the data type of *var_name.* The following table lists valid data types and their representative INTEGER values.

Table A–24. Valid Data Types

Data Type	Value
POSITION	1
XYZWPR	2
XYZWPREXT	6
INTEGER	16
REAL	17
BOOLEAN	18
VECTOR	19
COMMON_ASSOC	20
VIS_PROCESS	21
MODEL	22
SHORT	23
BYTE	24
JOINTPOS1	25
CONFIG	28
FILE	29
GROUP_ASSOC	30
PATH	31
CAM_SETUP	32
JOINTPOS2	41
JOINTPOS3	57
JOINTPOS4	73
JOINTPOS5	89
JOINTPOS6	105
JOINTPOS7	121
JOINTPOS8	137
JOINTPOS9	153

Table A–24. Valid Data Types (Cont'd)

Data Type	Value
JOINTPOS	153
STRING	209
user-defined type	210

- *dims* returns the dimensions of the array, if any. The size of the *dims* array should be 3.
  - — dims[1] = 0 if not an array
  - — dims[2] = 0 if not a two-dimensional array
  - — dims[3] = 0 if not a three-dimensional array
- *slen* returns the declared length of the variable specified by *var_name* if it is a STRING variable.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred.

Example: The following example retrieves information regarding the variable **counter** , located in **util_prog** , from within the program **task.**

VAR_INFO Built-In Procedure

```
PROGRAM util_prog
  VAR
    counter, i : INTEGER
  BEGIN
    counter = 0
    FOR i = 1 TO 10 DO
      counter = counter + 1
    ENDFOR
  END util_prog
PROGRAM task
  VAR
    uninit_b           : BOOLEAN
    type_name          : STRING[12]
    type_code          : INTEGER
    slen, status       : INTEGER
    alen               : ARRAY[3] OF INTEGER
  BEGIN
    VAR_INFO('util_prog', 'counter', uninit_b, type_name, type_code,
             alen, slen, status)
    WRITE('counter : ', CR)
    WRITE('UNINIT : ', uninit_b, '    TYPE : ', type_name, cr)
  END task
```

A.23.2 VAR_LIST Built-In Procedure

Purpose: Locates variables in the specified KAREL program with the specified name and data type

Syntax : VAR_LIST(prog_name, var_name, var_type, n_skip, format, ary_nam, n_vars, status)

Input/Output Parameters:

[in] prog_name : STRING

[in] var_name : STRING

[in] var_type : INTEGER

[in] n_skip : INTEGER

[in] format : INTEGER

[out] ary_nam : ARRAY of STRING

[out] n_vars : INTEGER

[out] status : INTEGER

%ENVIRONMENT Group :BYNAM

Details:

- *prog_name* specifies the name of the program that contains the specified variables. *prog_name* can be specified using the wildcard (*) character, which specifies all loaded programs.
- *var_name* is the name of the variable to be found. *var_name* can be specified using the wildcard (*) character, which specifies that all variables for *prog_name* be found.
- *var_type* represents the data type of the variables to be found. The following is a list of valid data types:

Table A–25. Valid Data Types

Data Type	Value
All variable types	0
POSITION	1
XYZWPR	2
INTEGER	16
REAL	17

Table A–25. Valid Data Types (Cont'd)

Data Type	Value
BOOLEAN	18
VECTOR	19
COMMON_ASSOC	20
VIS_PROCESS	21
MODEL	22
SHORT	23
BYTE	24
JOINTPOS1	25
CONFIG	28
FILE	29
GROUP_ASSOC	30
PATH	31
CAM_SETUP	32
JOINTPOS2	41
JOINTPOS3	57
JOINTPOS4	73
JOINTPOS5	89
JOINTPOS6	105
JOINTPOS7	121
JOINTPOS8	137
JOINTPOS9	153
JOINTPOS	153
STRING	209
user-defined type	210

- *n_skip* is used when more variables exist than the declared length of *ary_nam* . Set *n_skip* to 0 the first time you use VAR_LIST. If *ary_nam* is completely filled with variable names, copy the array to another ARRAY of STRINGs and execute the VAR_LIST again with *n_skip* equal to *n_vars* . The call to VAR_LIST will skip the variables found in the first pass and locate only the remaining variables.
- *format* specifies the format of the program name and variable name. The following values are valid for *format* :

```
1=prog_name only, no blanks
```

```
2 =var_name only, no blanks
3 =[prog_name]var_name, no blanks
4 ='prog_name var_name   ',
Total length = 27 characters, prog_name
starts with character 1 and var_name starts with character 16.
```

- *ary_nam* is an ARRAY of STRINGs to store the variable names. If the declared length of the STRING in *ary_nam* is not long enough to store the formatted data, then status is returned with an error.
- *n_vars* is the number of variables stored in *ary_name.*
- *status* will return zero if successful.

See Also: FILE_LIST, PROG_LIST Built-In Procedures

Example: Refer to Section B.2 , "Copying Path Variables" (CPY_PTH.KL), for a detailed program example.

A.23.3 VECTOR Data Type

Purpose: Defines a variable, function return type, or routine parameter as VECTOR data type

Syntax : VECTOR

Details:

- A VECTOR consists of three REAL values representing a location or direction in three dimensional Cartesian coordinates.
- Only VECTOR expressions can be assigned to VECTOR variables, returned from VECTOR function routines, or passed as arguments to VECTOR parameters.
- Valid VECTOR operators are:
  - Addition (+) and subtraction (-) mathematical operators
  - Equal (=) and the not equal (<>) relational operators
  - Cross product (#) and the inner product (@) operators.
  - Multiplication (*) and division (÷) operators
  - Relative position (:) operator
- Component fields of VECTOR variables can be accessed or set as if they were defined as follows:

VECTOR Data Type

```
VECTOR = STRUCTURE
 X:  REAL
 Y:  REAL
```

```
 Z:  REAL
ENDSTRUCTURE
Note:  All fields are read-write
```

Example: The following example shows VECTOR as variable declarations, as parameters in a routine, and as a function routine return type.

VECTOR Data Type

```
VAR
  direction, offset : VECTOR
ROUTINE calc_offset(offset_vec:VECTOR):VECTOR FROM util_prog
```

A.23.4 VIA Clause

Purpose: Specifies an intermediate POSITION in a move statement using circular interpolation

Syntax : VIA posn

where:

posn : a POSITION variable

Details:

- VIA clauses are required and permitted only in moves using circular interpolation ($MOTYPE=CIRCULAR).
- VIA clauses are permitted only in MOVE TO statements (not in MOVE ALONG, MOVE NEAR, and so on).
- The circle is computed using the current POSITION, the POSITION given in the VIA clause, and the destination POSITION specified in the MOVE statement.

Example: Refer to Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL) for a detailed program example.

A.23.5 VOL_SPACE Built-In Procedure

Purpose: Returns the total bytes, free bytes, and volume name for the specified device

Syntax : VOL_SPACE(device, total, free, volume)

Input/Output Parameters:

[in] device :STRING

[out] total :INTEGER

[out] free :INTEGER

[out] volume :STRING

%ENVIRONMENT Group :FLBT

Details:

- *devices* can be:

  RD: The RAM disk returns all three parameters, but the volume name is ” since it is not supported. The RAM disk must be mounted in order to query it.

  FR: The FROM disk returns all three parameters, but the volume name is ” since it is not supported. The FROM disk must be mounted in order to query it.

  FR: Size of the Flash ROM. This only sets the *total* parameter.

  DRAM: Size of the DRAM. This only sets the *total* parameter.

  CMOS: Size of the CMOS ROM. This only sets the *total* parameter.

  TPP : The area of system memory where teach pendant programs are stored.

  PERM: The area of permanent CMOS RAM memory where system variables and selected KAREL variables are stored.

  TEMP: The area of temporary DRAM memory used for loaded KAREL programs, KAREL variables, program execution information, and system operations.

  SYSTEM: The area of temporary DRAM memory where the system software and options are stored. This memory is saved to FROM and restored on power up.

  Note All device names must end with a *colon* (:).

- *total* is the original size of the memory, in bytes.
- *free* is the amount of available memory, in bytes.
- *volume* is the name of the storage device used.

See Also: Section 1.4.1 , Status Memory in the "Status Displays and Indicators," chapter of the appropriate application-specific *FANUC Robotics SYSTEM R-J3iC Controller Setup and Operations Manual* .

Example: The following example gets information about the different devices.

VOL_SPACE Built-In Procedure

```
PROGRAM space
%NOLOCKGROUP
%ENVIRONMENT FLBT
VAR
  total:  INTEGER
  free:   INTEGER
  volume: STRING [30]
BEGIN
  VOL_SPACE('rd:', total, free, volume)
  VOL_SPACE('fr:', total, free, volume)
  VOL_SPACE('frp:', total, free, volume)
  VOL_SPACE('fr:', total, free, volume)
  VOL_SPACE('dram:', total, free, volume)
  VOL_SPACE('cmos:', total, free, volume)
  VOL_SPACE('tpp:', total, free, volume)
  VOL_SPACE('perm:', total, free, volume)
  VOL_SPACE('temp:', total, free, volume)
END space
```

A.24 - W - KAREL LANGUAGE DESCRIPTION

A.24.1 WAIT FOR Statement

Purpose: Delays continuation of program execution until some condition(s) are met

Syntax : WAIT FOR cond_list

where:

cond_list: one or more conditions

Details:

- All of the conditions in a single WAIT FOR statement must be satisfied simultaneously for execution to continue.

See Also: Chapter 6 *CONDITION HANDLERS* , Appendix E, "Syntax Diagrams," for more syntax information

Example: Refer to the following sections for detailed program examples:

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.24.2 WHEN Clause

Purpose: Used to specify a conditions/actions pair in a local or global condition handler

Syntax : WHEN cond_list DO action_list

where:

cond_list : one or more conditions

action_list : one or more conditions

Details:

- All of the conditions in the *cond_list* of a single WHEN clause must be satisfied simultaneously for the condition handler to be triggered.
- The *action_list* represents a list of actions to be taken when the corresponding conditions of a WHEN clause are satisfied simultaneously.
- Calls to function routines are not allowed in a CONDITION or MOVE statement and, therefore, cannot be used in a WHEN clause.
- CONDITION and MOVE statements can include multiple WHEN clauses.

See Also: Chapter 6 *CONDITION HANDLERS* , Appendix E, ‘‘Syntax Diagrams,’’ for more syntax information

Example: Refer to the following sections for detailed program examples:

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.10, "Using Dynamic Display Built-ins" (DYN_DISP.KL)

Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.24.3 WHILE...ENDWHILE Statement

Purpose: Used when an action is to be executed as long as a BOOLEAN expression remains TRUE

Syntax : WHILE boolean_exp DO{ statement }ENDWHILE

where:

boolean_exp : a BOOLEAN expression

statement : a valid KAREL executable statement

Details:

- *boolean_exp* is evaluated before each iteration.
- As long as *boolean_exp* is TRUE, the statements in the loop are executed.
- If *boolean_exp* is FALSE, control is transferred to the statement following ENDWHILE, and the statement or statements in the body of the loop are not executed.

See Also: Appendix E, "Syntax Diagrams," for more syntax information

Example: Refer to Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL) for a detailed program example.

A.24.4 WITH Clause

Purpose: Used in a MOVE statement to specify temporary values for system variables. Also used in condition handlers to specify condition handler qualifiers

Syntax : WITH param_spec {, param_spec}

where:

param_spec is of the form : move_sys_var = value or move_sys_var[n] = value

move_sys_var : one of the system variables available for use in the WITH clause

n : specifies the group number

value : an expression of the type corresponding to the type of the system variable

Details:

- The actual system variables specified are not changed. The temporary value is used only by the motion environment while executing the move in which the WITH clause is used.
- The temporary value remains in effect until the next time the system variable is used by the motion environment. At that time, the assigned system variable value is used and the temporary value ceases to exist.
- INTEGER values can be used where REAL values are expected.

- Predefined constants are used to specify values for some system variables that can be used in the WITH clause. For example, $MOTYPE is specified as LINEAR, CIRCULAR, or JOINT.
- $PRIORITY and $SCAN_TIME are condition handler qualifiers that can be used in a WITH clause only when the WITH clause is part of a condition handler statement.

> **Warning**
>
> **Do not run a KAREL program that performs motion if more than one motion group is defined on your controller. If your controller is set up for more than one motion group, all motion must be initiated from a teach pendant program. Otherwise, the robot could move unexpectedly and injure personnel or damage equipment.**

See Also: Chapter 6 *CONDITION HANDLERS* , Chapter 11 *SYSTEM VARIABLES* , for a list of the system variables that can be used in the WITH clause

Example: Refer to the following sections for detailed program examples:

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.8, "Generating and Moving Along a Hexagon Path" (GEN_HEX.KL)

Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.24.5 WRITE Statement

Purpose: Writes data to a serial device or file

Syntax : WRITE <file_var> (data_item { ,data_item })

where:

file_var : a FILE variable

data_item : an expression and its optional format specifiers or the reserved word CR

Details:

- If *file_var* is not specified in a WRITE statement the default TPDISPLAY is used. %CRTDEVICE directive will change the default to OUTPUT.
- If *file_var* is specified, it must be one of the output devices or a variable that has been equated to one of them.
- If *file_var* attribute was set with the UF option, data is transmitted to the specified file or device in binary form. Otherwise, data is transmitted as ASCII text.

- *data_item* can be any valid KAREL expression.
- If *data_item* is of type ARRAY, a subscript must be provided.
- If *data_item* is of type PATH, you can specify that the entire path be read, a specific node be read [n], or a range of nodes be read [n .. m].
- Optional format specifiers can be used to control the amount of data that is written for each *data_item* .
- The reserved word CR, which can be used as a data item, specifies that the next data item to be written to the file_var will start on the next line.
- Use the IO_STATUS Built-In to determine if the write operation was successful.

See Also: PATH Data Type, for more information on writing PATH variables, Chapter 7 *FILE INPUT/OUTPUT OPERATIONS* , for more information on format specifiers and file_vars. Appendix E, "Syntax Diagrams," for more syntax information

Example: Refer to Appendix B, "KAREL Example Programs" for more detailed program examples.

A.24.6 WRITE_DICT Built-In Procedure

Purpose: Writes information from a dictionary

Syntax : WRITE_DICT(file_var, dict_name, element_no, status)

Input/Output Parameters:

[in] file_var :FILE

[in] dict_name :STRING

[in] element_no :INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *file_var* must be opened to the window where the dictionary text is to appear.
- *dict_name* specifies the name of the dictionary from which to write.
- *element_no* specifies the element number to write. This number is designated with a "$" in the dictionary file.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred writing the element from the dictionary file.

See Also: READ_DICT, REMOVE_DICT Built-In Procedures, Chapter 10 *DICTIONARIES AND FORMS*

Example: Refer to Section B.12, "Displaying a List From a Dictionary File" (DCLST_EX.KL), for a detailed program example.

A.24.7 WRITE_DICT_V Built-In Procedure

Purpose: Writes information from a dictionary with formatted variables

Syntax : WRITE_DICT_V(file_var, dict_name, element_no, value_array, status)

Input/Output Parameters:

[in] file_var :FILE

[in] dict_name :STRING

[in] element_no :INTEGER

[in] value_array :ARRAY OF STRING

[out] status :INTEGER

%ENVIRONMENT Group :UIF

Details:

- *file_var* must be opened to the window where the dictionary text is to appear.
- *dict_name* specifies the name of the dictionary from which to write.
- *element_no* specifies the element number to write. This number is designated with a $ in the dictionary file.
- *value_array* is an array of variable names that corresponds to each formatted data item in the dictionary text. Each variable name may be specified as '[prog_name]var_name'.
  - — *[prog_name]* specifies the name of the program that contains the specified variable. If not specified, then the current program being executed is used.
  - — *var_name* must refer to a static, global program variable.
  - — *var_name* may contain node numbers, field names, and/or subscripts.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred writing the element from the dictionary file.

See Also: READ_DICT_V Built-In Procedure, Chapter 10 *DICTIONARIES AND FORMS*

Example: In the following example, TPTASKEG.TX contains dictionary text information which will display a system variable. This information is the first element in the dictionary and element numbers start at 0. **util_prog** uses WRITE_DICT_V to display the text on the teach pendant.

WRITE_DICT_V Built-In Procedure

```
-------------------------------------------
TPTASKEG.TX
-------------------------------------------
$ "Maximum number of tasks = %d"
-------------------------------------------
UTILITY PROGRAM:
-------------------------------------------
PROGRAM util_prog
  %ENVIRONMENT uif
  VAR
    status: INTEGER
    value_array: ARRAY[1] OF STRING[30]
  BEGIN
    value_array[1] = '[*system*].$scr.$maxnumtask'
    ADD_DICT('TPTASKEG', 'TASK', dp_default, dp_open, status)
    WRITE_DICT_V(TPDISPLAY, 'TASK', 0, value_array, status)
END util_prog
```

A.25 - X - KAREL LANGUAGE DESCRIPTION

A.25.1 XML_ADDTAG Built-In Procedure

Purpose: Associates the tag “tag_name” with the “xml_file”.

Syntax : XML_ADDTAG(xml_file, tag_name, numchar, caseflag, tag_ident, status)

Input/Output Parameters:

[in] xml_file :FILE

[in] tag_name:STRING

[in] numchar:INTEGER

[in] caseflag:boolean

[in] tag_ident:INTEGER

[out] status :INTEGER

%ENVIRONMENT Group :PBCORE

Details:

- *xml_file* specifies an open KAREL file with AR_XML attribute set
- *tag_name* Name of the tag you want to know about
- *numchar* specifies the number of characters to use when looking for the tag
- *caseflag* If TRUE, specifies whether the tag_name is case sensitive
- *tag_ident* Application identifier that user associates with tag There are some system tag idents that the user cannot use. This is used to allow you to switch on his tags and the user return codes. When the scanning encounters the registered tag it will return with the tag_ident. The file MUST be open before you can register a tag. tag_ident should be a unique number within the application. This allows the application to do a select based on the return identifier. NOTE: The system reserves some identifiers for error and scan limit status returns. This allows the application to easily include these constants in the select statement.
- *status* explains the status of the attempted operation. If not equal to 0, then an error occurred writing the element from the dictionary file. The return status will be bad if the user has not opened the file and set the XML attribute.

See Also:

Example: Refer to

A.25.2 XML_GETDATA Built-In Procedure

Purpose: Returns the attribute names and values associated with the tag causing the return.

Syntax : xml_getdata(xml_file, numattr, attrnames, attrvalues, text, textdone)

Input/Output Parameters:

[in] xml_file :FILE

[out] numattr: INTEGER

[out] attrnames: ARRAY OF STRING

[out] attrvalues: ARRAY OF STRING

[out] textdata: STRING

[out] textdone: BOOLEAN

[out] status: INTEGER

Details:

- *xml_file* An open KAREL file with AR_XML attribute set
- *numattr* indicates the number of attributes
- *attrnames* indicates attribute names
- *attrvalues* indicates attribute values
- *textdata* indicates the text that follows the tag
- *textdone* If this is FALSE, more text is to be read
- *status* indicates the result of the operation

A.25.3 XML_REMTAG Built-In Procedure

Purpose: Removes the tag name from the list.

Syntax: xml_remtag(xml_file, tag_name, tag_ident, status)

Input/Output Parameters:

[in] xml_file :FILE

[in] tag_name: STRING

[OUT] status: INTEGER

Details:

- *xml_file* Open KAREL file with AR_XML attribute set
- *tag_name* Indicates the name of the tag to remove
- *status* Indicates the result of the operation

A.25.4 XML_SCAN Built-In Procedure

Purpose: Scan through a previously opened XML file

Syntax : XML_SCAN(xml_file, tag_name, func_code, status)

Input/Output Parameters:

[in] xml_file :FILE

[out] tag_name:STRING

[out] tag_ident:INTEGER

[out] func_code::INTEGER

[out] status :INTEGER

Details:

- *xml_file* Open KAREL file with AR_XML attribute set
- *tag_name* Name of the tag system found
- *tag_ident* Tag user associated in addtag call
- *func_code* Function code, start etc
- *status* Result of operation

- When a registered tag is found
  - Func_code = XML_START or XML_END or XML_STEND
  - Tag_ident = The value associated with the tag when it was registered
- When a text buffer is full
  - Func_code = XML_TXCONT
  - Tag_ident = The value associated with the tag when it was registered
- After 50 lines are scanned
  - Status = XML_SCANLIM, just recall the built-in when the is encountered
  - Tag_ident = XML_SCANLIM
  - This is not an error and indicates that there is more to come
- If it encounters a parsing error
  - Status = Some error
  - Tag_ident = XML_ERROR
- At the end of file, Status = SUCCESS
- Valid Parse Errors are:
  - XML_TAG_SIZE Too many characters in tag
  - XML_ATTR_SIZE Too many characters in attribute
  - XML_NOSLASH Invalid use of / character
  - XML_INVTAG Invalid character in tag
  - XML_UNMATCHATTR No value for attribute

— XML_UNMATCHTAG End tag with no matching start

— XML_INVATTR Invalid character in attribute

— XML_NOFILE Cannot find file

— XML_TAGNEST Tag nesting level too deep

— XML_COMMENT Error in comment

- The system will provide a separate return for the start of the tag and the end of the tag if the tag does not contain both starting and ending information. The attribute data is NOT valid when the call is made for the END tag.
- The *tag_ident* will be the tag_ident that the user registered for the registered tag return. If the system returns for other reasons then the tag_ident may contain system tag data.

A.25.5 XML_SETVAR Built-In Procedure

Purpose: Sets the variable [prog_name]var_name according to the attributes that were associated with the tag causing the return.

Syntax : xml_setvar(xml_file, prog_name, var_name, status)

Input/Output Parameters:

[in] xml_file :FILE

[in] prog_name:STRING

[in] var_name:STRING

[out] status:INTEGER

Details:

- In this case the text for the attribute will be matched with the text field name of the KAREL variable. So a variable of this type:

```
xmlstrct_t = STRUCTURE
  first: integer
  second: real
  third: BOOLEAN
  fourth: string[20]
ENDSTRUCTURE
```

Can be set via the XML:

<xmlstrct_t first="123456" second="7.8910" third="1" fourth="A string"\>

- The XML tag name does not need to match the TYPE name. The association of the field names and attribute names is based on the [program]variable in the call to xml_setvar.

A.25.6 XYZWPR Data Type

Purpose: Defines a variable, function return type, or routine parameter as XYZWPR data type

Syntax : XYZWPR <IN GROUP [n]>

Details:

- An XYZWPR consists of three REAL components specifying a Cartesian location (x,y,z), three REAL components specifying an orientation (w,p,r), and a component specifying a CONFIG Data Type, 32 bytes total.
- The configuration string indicates the joint placements and multiple turns that describe the configuration of the robot when it is at a particular position.
- A position is always referenced with respect to a specific coordinate frame.
- Components of XYZWPR variables can be accessed or set as if they were defined as follows:

XYZWPR Data Type

```
XYZWPR = STRUCTURE
 X: REAL
 Y: REAL
 Z: REAL
 W: REAL
 P: REAL
 R: REAL
 CONFIG_DATA:  CONFIG
ENDSTRUCTURE
Note:  All fields are read-write access.
```

Example: Refer to the following sections for detailed program examples:

Section B.2, "Copying Path Variables" (CPY_PTH.KL)

Section B.5,"Using Register Built-ins" (REG_EX.KL)

Section B.6, "Path Variables and Condition Handlers Program" (PTH_MOVE.KL)

Section B.8, "Generating and Moving Along a Hexagon Path" (GEN_HEX.KL)

Section B.1, "Setting Up Digital Output Ports for Monitoring" (DOUT_EX.KL)

A.25.7 XYZWPREXT Data Type

Purpose: Defines a variable, function return type, or routine parameter as an XYZWPREXT

Syntax : XYZWPREXT <IN GROUP [n]>

Details:

- An XYZWPREXT consists of three REAL components specifying a Cartesian location (x,y,z), three REAL components specifying an orientation (w,p,r), and a component specifying a configuration string. It also includes three extended axes, 44 bytes total.
- The configuration string indicates the joint placements and multiple turns that describe the configuration of the robot when it is at a particular position.
- A position is always referenced with respect to a specific coordinate frame.
- Components of XYZWPREXT variables can be accessed or set as if they were defined as follows:

XYZWPREXT Data Type

```
XYZWPRext = STRUCTURE
 X: REAL
 Y: REAL
 Z: REAL
 W: REAL
 P: REAL
 R: REAL
 CONFIG_DATA:  CONFIG
 EXT1: REAL
 EXT2: REAL
 EXT3: REAL
ENDSTRUCTURE
--Note:  All fields are read-write access.
```

A.26 - Y - KAREL LANGUAGE DESCRIPTION

There are no KAREL descriptions beginning with "Y".

A.27 - Z - KAREL LANGUAGE DESCRIPTION

There are no KAREL descriptions beginning with "Z".

Appendix B

KAREL EXAMPLE PROGRAMS

Contents

Appendix B	KAREL EXAMPLE PROGRAMS	B–1
B.1	SETTING UP DIGITAL OUTPUT PORTS FOR PROCESS MONITORING	B–7
B.2	COPYING PATH VARIABLES	B–18
B.3	SAVING DATA TO THE DEFAULT DEVICE	B–28
B.4	STANDARD ROUTINES	B–31
B.5	USING REGISTER BUILT-INS	B–33
B.6	PATH VARIABLES AND CONDITION HANDLERS PROGRAM	B–38
B.7	LISTING FILES AND PROGRAMS AND MANIPULATING STRINGS	B–44
B.8	GENERATING AND MOVING ALONG A HEXAGON PATH	B–49
B.9	USING THE FILE AND DEVICE BUILT-INS	B–53
B.10	USING DYNAMIC DISPLAY BUILT-INS	B–57
B.11	MANIPULATING VALUES OF DYNAMICALLY DISPLAYED VARIABLES	B–67
B.12	DISPLAYING A LIST FROM A DICTIONARY FILE	B–70
B.12.1	Dictionary Files	B–79
B.13	USING THE DISCTRL_ALPHA BUILT-IN	B–80
B.13.1	Dictionary Files	B–84
B.14	APPLYING OFFSETS TO A COPIED TEACH PENDANT PROGRAM	B–85

This appendix contains some KAREL program examples. These programs are meant to show you how to use the KAREL built-ins and commands described in Appendix A , "KAREL Language Alphabetical Description."

This section includes examples of how to use the KAREL built-ins and commands in a program. Refer to Appendix A , for more detailed information on each of the KAREL built-ins and commands.

Table B–1 lists the programs in this section, their main function, the built-ins used in each program, and the section to refer to for the program listing.

Conventions

Each program in this appendix is divided into five sections.

Section 0 - Lists each element of the KAREL language that is used in the example program.

Section 1 - Contains the program and environment declarations.

Section 2 - Contains the constant, variable, and type declarations.

Section 3 - Contains the routine declarations.

Section 4 - Contains the main body of the program.

Table B–1. KAREL Example Programs

Program Name	Program Function	Built-ins Used	Section to Refer
CPY_PTH.KL	Copies path variables.	APPEND_NODE BY_NAME CALL_PROG CNV_INT_STR COPY_PATH CREATE_VAR CURPOS DELETE_NODE LOAD PATH_LEN PROG_LIST READ_KB SET_CURSOR SET_FILE_ATR SET_VAR SUB_STR VAR_LIST	Section B.2
SAVE_VRS.KL	Saves data to the default device.	DELETE_FILE SAVE	Section B.3
ROUT_EX.KL	Contains standard routines that are used throughout the program examples.	CHR FORCE_SPMENU	Section B.4
REG_EX.KL	Uses Register built-ins.	CALL_PROGLIN CHR CURPOS GET_JPOS_REG GET_POS_REG GET_REG POS_REG_TYP SET_INT_REG SET_JPOS_REG SET_POS_REG FORCE_SPMENU	Section B.5
PTH_MOVE.KL	Teaches and moves along a path. Also uses condition handlers.	CHR CNV_REL_JPOS PATH_LEN SET_CURSOR	Section B.6

Table B–1. KAREL Example Programs (Cont'd)

Program Name	Program Function	Built-ins Used	Section to Refer
LIST_EX.KL	Lists files and programs, and manipulate strings.	ABS ARRAY_LEN CNV_INT_STR FILE_LIST LOAD LOAD_STATUS PROG_LIST ROUND SUB_STR	Section B.7
GEN_HEX.KL	Generates a hexagon, and moves along the path.	CNV_REL_JPOS COS CURPOS SIN	Section B.8
FILE_EX.KL	Uses the File and Device built-ins.	CNV_TIME_STR COPY_FILE DISMOUNT_DEV FORMAT_DEV GET_TIME MOUNT_DEV SUB_STR	Section B.9
DYN_DISP.KL	Uses Dynamic Display built-ins.	ABORT_TASK CNC_DYN_DISB CNC_DYN_DISE CNC_DYN_DISP CNC_DYN_DISS CNC_DYN_DISI CNC_DYN_DISR INI_DYN_DISB INI_DYN_DISE INI_DYN_DISP INI_DYN_DISS INI_DYN_DISI INI_DYN_DISR LOAD LOAD_STATUS RUN_TASK	Section B.10

Table B–1. KAREL Example Programs (Cont'd)

Program Name	Program Function	Built-ins Used	Section to Refer
CHG_DATA.KL	Processes and changes values of dynamically displayed variables.		Section B.11
DCLST_EX.KL	Displays a list from a dictionary file.	ADD_DICT ACT_SCREEN ATT_WINDOW_S CHECK_DICT CLR_IO_STAT CNV_STR_INT DEF_SCREEN DISCTRL_LIST FORCE_SPENU IO_STATUS ORD READ_DICT REMOVE_DICT SET_FILE_ATR SET_WINDOW STR_LEN UNINIT WRITE_DICT	Section B.12.1
DCLISTEG.UTX	Dictionary file.	N/A	Section B.12
DCALP_EX.KL	Uses the DISCTRL_ALPHA Built-in.	ADD_DICT CHR DISCTRL_ALPH FORCE_SPEMU POST_ERR SET_CURSOR SET_LANG	Section B.13
DCALPHEG.UTX	Dictionary file.	N/A	Section B.13.1

Table B–1. KAREL Example Programs (Cont'd)

Program Name	Program Function	Built-ins Used	Section to Refer
CPY_TP.KL	Applies offsets to copied teach pendant pro grams.	AVL_POS_NUM CHR CLOSE_TPE CNV_JPOS_REL CNV_REL_JPOS COPY_TPE GET_JPOS_TYP GET_POS_TPE GET_POS_TYP OPEN TPE PROG_LIST SELECT_TPE SET_JPOS_TPE SET_POS_TPE	Section B.14
DOUT_EX.KL	Sets up digital output ports for process monitoring. The DOUTs are used to monitor the status of the external equipment and to show the current status of the process. The equipment status DOUTs are simulated, but in practice they are looked up to the actual external equipment as a feedback response. The robot is moved along a path until the external equipment needs servicing, which is triggered by the DOUT values.	CHRPATH_LEN CURPOS DELAY FORCE_SPMENU RESET SET_PORT_ASG SET_PORT_CMT SET_PORT_MOD SET_PORT_SIM	Section B.1

B.1 SETTING UP DIGITAL OUTPUT PORTS FOR PROCESS MONITORING

This program sets up digital output ports for process monitoring. The DOUT are to monitor the external equipment status and show the current status of the process. The equipment status DOUT's are simulated, but in practice are hooked up to the actual external equipments as a feedback response. The robot is moved along a path until external equipment needs to be serviced, which is triggered by the DOUT values.

Setting Up Digital Output Ports for Process Monitoring - Overview

```
------------------------------------------------------------------------
----    DOUT_EX.Kl
------------------------------------------------------------------------
------------------------------------------------------------------------
----    Section 0:  Detail about DOUT_EX.kl
------------------------------------------------------------------------
---- Elements of KAREL Language Covered:
----    Action:
----            CONTINUE                            Sec 4-A
----            PORT_ID                             Sec 4-D,E
----            ENABLE CONDITION                    Sec 3-B; 4-D
----            NOMESSAGE                           Sec 4-A
----            PULSE                               Sec 4-E
----            RESUME                              Sec 4-D
----            ROUTINE CALL                        Sec 4-A,D
----            SIGNAL EVENT                        Sec 4-D
----            STOP                                Sec 4-D
----            UNPAUSE                             Sec 4-A
----    Clauses:
----            FROM                                Sec 3-A
----            WHEN                                Sec 4-A,D,E
----            WITH                                Sec 3-E
----    Conditions:
----            AT NODE                             Sec 4-E
----            PORT_ID                             Sec 4-D
----            ERROR[xxx]                          Sec 4-A
----            EVENT                               Sec 4-D
----            RELATIONAL condition                Sec 4-A
----            TIME xxx BEFORE                     Sec 4-E
----    Data types:
----            BOOLEAN                             Sec 2
----            INTEGER                             Sec 2
----            PATH                                Sec 2
----            POSITION                            Sec 2
----            STRING                              Sec 2
```

```
----            XYZWPR                                  Sec 2
```

Setting Up Digital Output Ports for Monitoring Teach Pendant Program - Overview Continued

```
----    Directives:
----            ALPHABETIZE                             Sec 1
----            COMMENT                                 Sec 1
----            CMOSVARS                                Sec 1
----            INCLUDE                                 Sec 1
----    Built-in Functions & Procedures:
----            CHR                                     Sec 3-E; 4-E
----            CURPOS                                  Sec 3-E
----            DELAY                                   Sec 3-B,E
----            FORCE_SPMENU                            Sec 3-E; 4-E
----            PATH_LEN                                Sec 4-C; 4-E
----            RESET                                   Sec 3-B
----            SET_PORT_ASG                            Sec 3-D
----            SET_PORT_CMT                            Sec 3-D
----            SET_PORT_MOD                            Sec 3-C
----            SET_PORT_SIM                            Sec 4-E
----    Statements:
----            ABORT                                   Sec 3-D; 4-C,E
----            ATTACH                                  Sec 4-C
----            CONNECT TIMER                           Sec 4-A
----            CONDITION...ENDCONDITON                 Sec 4-A,D,E
----            ENABLE CONDITION                        Sec 3-E; 4-A,D
----            FOR...ENDFOR                            Sec 3-D
----            IF...THEN...ENDIF                       Sec 3-B,C,D; 4-C,D,E
----            MOVE ALONG                              Sec 4-E
----            MOVE NEAR                               Sec 3-E
----            RELEASE                                 Sec 4-C
----            ROUTINE                                 Sec 3-A,B,C,D,E
----            WAIT FOR                                Sec 3-E
----            WHILE...ENDWHILE                        Sec 4-C
----            WRITE                                   Sec 3-B,D,E; 4-C,E
----    Reserve Words:
----            BEGIN                                   Sec 3-B,C,D,E; 4
----            CONST                                   Sec 2
----            CR                                      Sec 3-B,D,E; 4-C,E
----            END                                     Sec 3-B,C,D,E, 4-E
----            NOT                                     Sec 3-B; 4-D
----            PROGRAM                                 Sec 1
----            VAR                                     Sec 2
----    Predefined FILE names:
----            TPFUNC                                  Sec 4-E
```

Setting Up Digital Output Ports for Process Monitoring - Declaration Section

```
--------------------------------------------------------------------------------
----    Section 1:  Program and Environment Declaration
--------------------------------------------------------------------------------
PROGRAM DOUT_EX                 -- Define the program name
%ALPHABETIZE                    -- CReate the variables in alphabetical order
%NOPAUSE  = TPENABLE            -- Do not pause the program if TP is ENABLED.
                                -- during execution.
%COMMENT  = 'PORT/CH DOUT_EX'
%CMOSVARS                       -- Make sure variables are stored in CMOS
%INCLUDE KLIOTYPS
--------------------------------------------------------------------------------
----    Section 2:  Constant and Variable Declarations
--------------------------------------------------------------------------------
CONST
-- Condition Handler Numbers
   CONT_CH    = 2                           -- Continue execution condition
   EQIP_FAIL  = 3                           -- Equipment Failure Condition
   RESTART    = 6                           -- Restart condition Handler
   SERV_DONE  = 4                           -- Servicing Done condition
   UNINIT_CH  = 10                          -- Monitor for uninit error
   WARMED_UP  = 5                           -- Event to notify eqip is ready
-- Process DOUT numbers ( 1 thru 6 are complementary DOUT )
--                      ( 3 and 4 are simulated DOUT )
   EQIP_READY = 1                           -- Equipment Ready
   EQIP_NOT_RD= 2                           -- Equipment Not Ready
   EQIP_ERROR = 3                           -- Equipment Failed during process
   EQIP_FIXED = 4                           -- Equipment Fixed after failure
   EQIP_ON    = 5                           -- Turn Eqip-1 ON DOUT
   EQIP_OFF   = 6                           -- Turn Eqip-1 OFF DOUT
   NODE_PULSE = 7                           -- Node Pulsing DOUT
   FINISH    = 8                            -- Path Finishing signal DOUT
-- Process Constants
   SUCCESS    = 0                           -- Successful Operation Status
   UNASIGNED  = 13007                       -- Unassigned Port Deletion Error
VAR
   cont_timer,
   last_node,
   status              :INTEGER             -- Status from builtin calls
   prg_abrt            :BOOLEAN             -- Set when the program is aborted
   pth1                :PATH                -- Process Path
   stop_pos            :POSITION            -- Process Stop Position
   perch_pos           :XYZWPR              -- Perch Position
   indx                :INTEGER             -- Used a FOR loop counter
   ports_ready         :BOOLEAN             -- Check if ports assigned
   cmt_str             :STRING[10]          -- Comment String
```

Setting Up Digital Output Ports for Process Monitoring - Declare Routines

```
--------------------------------------------------------------------------
----    Section 3:  Routine Declaration
--------------------------------------------------------------------------
--------------------------------------------------------------------------
----    Section 3-A:  TP_CLS  Declaration
----                  This routine is from ROUT_EX.kl and will
----                  clear the TP USER menu screen and force
----                  it to be visible.
--------------------------------------------------------------------------
ROUTINE tp_cls FROM rout_ex             -- ROUT_EX must also be loaded.
--------------------------------------------------------------------------
----    Section 3-B:  port_init  Declaration
----                  This routine assigns a value to, ports_ready, which
----                  allows the ports to be initialized.  It resets the
----                  controller so that program execution may be continued
----                  automatically thought the CONT_CH condition handler.
--------------------------------------------------------------------------
ROUTINE init_port
VAR
        reset_ok: BOOLEAN
BEGIN
  ports_ready = FALSE              -- Set false so ports will be initialized
  DELAY 500;
  RESET(reset_ok)                  -- Reset the controller
  IF (NOT reset_ok) THEN
     WRITE('Reset Failed', CR)
   ENDIF
  cont_timer = 0                   -- Set a timer to continue the processprocess
  ENABLE CONDITION[CONT_CH]        -- Enabled the CONT_CH which continues
                                   -- program execution
END init_port
```

Setting Up Digital Output Ports for Process Monitoring - Declaration Section

```
--------------------------------------------------------------------------
----    Section 3-C:  SET_MODE Declaration
----                  Sets up the mode of IO's.  Depending on the passed
----                  parameter the IO ports will be set to REVERSE
----                  and/or COMPLEMENTARY mode.  When the ports are set
----                  to REVERSE mode, the TRUE condition is represented by
----                  a FALSE signal.  When COMPLEMENTARY mode is selected
----                  for a port (odd number port), the  port n and n+1 are
```

```
----                   complementary signal of each other.
-------------------------------------------------------------------------------
ROUTINE set_mode(port_type:     INTEGER;
                 port_no:       INTEGER;
                 reverse:       BOOLEAN;
                 complmnt:      BOOLEAN)
VAR
    mode:           INTEGER
BEGIN  -- set_mode
 IF reverse THEN
    mode = 1                              -- Set the reverse mode
 ELSE
    mode = 0
 ENDIF
 IF complmnt THEN
    mode = mode OR 2                      -- Set complementary mode
 ENDIF
 SET_PORT_MOD(port_type, port_no, mode, status)
END set_mode
```

Setting Up Digital Output Ports for Process Monitoring - Declaration Section

```
-------------------------------------------------------------------------------
----    Section 3-D:  SETUP_PORTS Declaration
----          This section assumes that you do not have an AB or GENIUS I/O
----          or any other external I/O board.  Therefore, any previous port
----          assignments are no longer needed for this application, and
----          can be deleted.
-------------------------------------------------------------------------------
ROUTINE setup_ports
VAR
    port_n  : INTEGER
BEGIN
-- Delete DIGITAL OUTPUT PORTS 1 thru 48
  FOR port_n = 0 to 5 DO
    -- Indexing of 0 to 5 may not be obvious, But look into the DIGITAL
    -- OUT Configuration screen in TP, you will see the 8 DIGITAL OUTPUT
    -- ports are grouped together in configuration.
    SET_PORT_ASG(IO_DOUT, port_n*8+1, 0, 0, 0, 0, 0, status)
    IF (status <> SUCCESS) AND (status <> UNASIGNED) THEN
      -- Verify that deletion by SET_PORT_ASG was successful
      WRITE ('SET_PORT_ASG built-in  for DOUT (deletion) failed',CR)
      WRITE ('Status = ',status,CR)
    ENDIF
  ENDFOR
    --  Assign the DIGITAL PORTS 1 THRU 48 as memory images.
```

```
FOR port_n = 0 TO 5 DO
  SET_PORT_ASG(IO_DOUT, port_n*8+1, 0, 0, io_mem_boo, port_n*8+1, 8, status)
  IF (status <> 0 ) THEN     -- Verify that SET_PORT_ASG was successful
    WRITE ('SET_PORT_ASG built-in  for DOUT (assignment) failed',CR)
    WRITE ('Status = ',status,CR)
  ENDIF
ENDFOR
-- Suppose equipment-1 is turned ON by the DOUT[1] = TRUE signal and
-- turned OFF by the DOUT[2] = TRUE signal. To avoid both signals being
-- TRUE or FALSE at the same time, set DOUT[1] to be a complement.
-- Once the DOUT[1] is set in complementary mode, the DOUT[1] and
-- DOUT[2] will always show the opposite signal of each other.
-- Thus avoiding the confusion of turning the equipment OFF and ON
-- at the same time.
-- Set port-1, port-3 and port-5 to COMPLEMENTARY mode.
FOR port_n = 1 to 6 DO
  SET_MODE(io_dout, port_n, TRUE, TRUE)
  IF (status <> SUCCESS) THEN
    WRITE ('SET_PORT_MODE Failed on port ',1,CR)
    WRITE ('With Status = ',status,CR)
  ENDIF
ENDFOR
```

Setting Up Digital Output Ports for Process Monitoring - Main

```
-- Set appropriate comments for the ports.
  SET_PORT_CMT(IO_DOUT, EQIP_READY, 'Equip-READY ',status)
  IF (status <> 0 ) THEN             -- Verify SET_PORT_CMT was successful
    WRITE ('SET_PORT_CMT built-in failed',CR)
    WRITE ('Status = ',status,CR)
  ENDIF
  SET_PORT_CMT(IO_DOUT, EQIP_NOT_RD, 'E - NOT READY',status)
  IF (status <> 0 ) THEN             -- Verify SET_PORT_CMT was successful
    WRITE ('SET_PORT_CMT built-in failed',CR)
    WRITE ('Status = ',status,CR)
  ENDIF
  SET_PORT_CMT(IO_DOUT, EQIP_ERROR, 'Equip- ERROR',status)
  IF (status <> 0 ) THEN            -- Verify SET_PORT_CMT was successful
    WRITE ('SET_PORT_CMT built-in failed',CR)
    WRITE ('Status = ',status,CR)
  ENDIF
  SET_PORT_CMT(IO_DOUT, EQIP_FIXED, 'Equip- FIXED',status)
  IF (status <> 0 ) THEN             -- Verify SET_PORT_CMT was successful
    WRITE ('SET_PORT_CMT built-in failed',CR)
    WRITE ('Status = ',status,CR)
  ENDIF
```

```
  SET_PORT_CMT(IO_DOUT, EQIP_ON, 'Equip- ON',status)
  IF (status <> 0 ) THEN            -- Verify SET_PORT_CMT was successful
    WRITE ('SET_PORT_CMT built-in failed',CR)
    WRITE ('Status = ',status,CR)
  ENDIF
  SET_PORT_CMT(IO_DOUT, EQIP_OFF, 'Equip- OFF',status)
  IF (status <> 0 ) THEN            -- Verify SET_PORT_CMT was successful
    WRITE ('SET_PORT_CMT built-in failed',CR)
    WRITE ('Status = ',status,CR)
  ENDIF
  SET_PORT_CMT(IO_DOUT, NODE_PULSE, 'Pulse @ node',status)
  IF (status <> 0 ) THEN            -- Verify SET_PORT_CMT was successful
    WRITE ('SET_PORT_CMT built-in failed',CR)
    WRITE ('Status = ',status,CR)
  ENDIF
  SET_PORT_CMT(IO_DOUT, FINISH, 'Finish PATH',status)
  IF (status <> 0 ) THEN            -- Verify SET_PORT_CMT was successful
    WRITE ('SET_PORT_CMT built-in failed',CR)
    WRITE ('Status = ',status,CR)
  ENDIF
```

Setting Up Digital Output Ports for Process Monitoring - Main

```
TP_CLS   -- clear the teach pendant USER sCReen

  WRITE ('PORT SETUP IS COMPLETE',CR)
  WRITE ('AT THIS POINT YOU NEED TO COLD START',CR)
  WRITE ('Configuration changes of PORTs will not',CR)
  WRITE ('take effect until after a COLD START.',CR,CR)
  WRITE ('Once the controller is ready after',CR)
  WRITE ('COLD START, re-load this program',CR)
  WRITE ('rerun.',CR)

  ports_ready = TRUE      -- Set the ports_ready variable so re-execution of
                          -- this routine, setup_ports, is not performed.
  -- Aborting program to allow for the cold start.
  ABORT
END setup_ports
-----------------------------------------------------------------------------
----    Section 3-E:  SERVICE_RTN interrupt routine Declaration
----                  This routine waits until the equipment has been
----                  serviced and then moves the robot back to where
----                  it was before servicing.  It then sets the DOUT
----                  to notify that the equipment is ready.
-----------------------------------------------------------------------------
ROUTINE service_rtn
```

```
BEGIN
  TP_CLS
-- store the current position, where the process is stopped due to failure
-- so after resuming the process can be started from this point.
  stop_pos = CURPOS(0,0)
-- move the robot to the perch position so the equipment
-- can be worked on safely.
  WITH $SPEED = 1000  MOVE TO perch_pos
  WRITE (chr(139),' PLEASE READ ',chr(143),CR)     --Display in reverse video
  WRITE ('Equipment - 1 failed during',CR)
  WRITE ('processing. Motions have been stopped.',CR)
  WRITE ('Please Fix the equipment then',CR)
  WRITE ('SET DOUT[',EQIP_FIXED,'] = TRUE ',CR)
        --Display the following message in reverse video
  WRITE (chr(139), 'IMPORTANT: Once the DOUT is set, current',CR)
  WRITE ('STOPPED motion will be RESUMED',chr(143),CR)
  WAIT FOR DOUT[EQIP_FIXED]  -- wait until equipment has been fixed
```

Setting Up Digital Output Ports for Process Monitoring - Main

```
-- Move close to the point where the process was stopped
  -- Depending on orientation and path , the "by offset" value should be
   -- selected properly.
  WITH $SPEED = 1000 MOVE NEAR stop_pos by +100
  -- Move slowly to the point where the process was stopped
  WITH $SPEED = 500 MOVE NEAR stop_pos by 0

  -- Enable the SERVICE-DONE condition handler to resume the process.
  ENABLE CONDITION[SERV_DONE]
  -- Wait a sufficient time to allow equipment to warm up and get ready for
  -- processing after the fix is completed.
  WRITE ('Continuing the process.....',CR)
  DELAY 2000

  --Signal that the equipment is now ready.
  DOUT[EQIP_READY] = TRUE

  -- Force the teach pendant back to the IO sCReen
  FORCE_SPMENU(tp_panel, SPI_TPDIGIO, 1)
END service_rtn
--------------------------------------------------------------------------------
----    Section 4:  Main Program
--------------------------------------------------------------------------------
BEGIN   -- DOUT_EX
--------------------------------------------------------------------------------
----    Section 4-A: Global Condition Handler Declaration
```

```
--------------------------------------------------------------------------------
CONDITION[UNINIT_CH]:
 WHEN ERROR[12311] DO                  -- Trap UNINITIALIZATION error
   NOMESSAGE                           -- Supress the error message
   UNPAUSE                             -- UNPAUSE
   init_port                           -- Allow ports to be initialized.
ENDCONDITION
ENABLE CONDITION[UNINIT_CH]
CONNECT TIMER to cont_timer
CONDITION [CONT_CH]:
   WHEN cont_timer > 1000 DO
    CONTINUE
ENDCONDITION
```

Setting Up Digital Output Ports for Process Monitoring - Main

```
--------------------------------------------------------------------------------
----    Section 4-C: Verify PATH variable, pth1, has been taught.
--------------------------------------------------------------------------------
TP_CLS                          -- Routine Call; Clears the TP USER menu and
                                -- forces the TP USER menu to be visible.
-- Check the number of nodes in the path
IF PATH_LEN(pth1) = 0 THEN                  -- Path is empty (no nodes)
   WRITE ('You need to teach the path.',CR) -- Display instructions
   WRITE ('before executing this program.',CR)
   WRITE ('Teach the PATH variable pth1', CR, 'and restart the program',CR)
   WRITE ('PROGRAM ABORTED',CR)
   ABORT                            -- ABORT the task. do not continue
                                    -- There are no nodes to move to
ENDIF
-- Set Perch Position
-- This position is used in the service_rtn routine
IF UNINIT(perch_pos) THEN

   WRITE ('PERCH POSITION is not recorded.',cr)
   WRITE ('RELEASing Motion Control to TP.',cr)
   WRITE ('Please Move robot to desired Perch Pos',cr)
   -- Wait until the DEADMAN switch is HELD and
   -- TP is TURNED ON to move robot from TP.
   WHILE ((TPIN[248] = ON) AND (TPIN[247] = ON)) DO
     WRITE TPPROMPT(CHR(128),CHR(137),'Hold Down the DEAD-MAN switch')
     DELAY 500
   ENDWHILE
   -- Release motion control from the KAREL program to the
   -- TP control.  Robot can be moved to desired Perch
   -- position with out disturbing the flow of this KAREL task.
```

```
   RELEASE
   WHILE (TPIN[249] = OFF ) DO
     WRITE TPPROMPT(CHR(128),CHR(137),'Turn the TP ON')
     DELAY 1000
   ENDWHILE
   WRITE ('ROBOT is ready to move from TP',cr)
   WRITE ('After moving ROBOT to PERCH position ',cr)
   WRITE ('Turn OFF the TP then RELEASE DEADMAN ',cr)
   WHILE (TPIN[249] = ON ) DO
     WRITE TPPROMPT(CHR(128),CHR(137),'Turn OFF TP, after MOVE is done
     DELAY 10000
   ENDWHILE
```

Setting Up Digital Output Ports for Process Monitoring - Main

```
-- KAREL program execution will not continue passed ATTACH
   -- statement until the TP is turned OFF.
   -- Wait until the TP is TURNED OFF after move from TP is completed.
   WHILE (TPIN[249] = ON ) DO
     DELAY 2000
   ENDWHILE
  -- At this point the robot is positioned to the desired
   -- Perch position. Get the motion
   -- control back from TP and record the perch position.
   ATTACH
   perch_pos = CURPOS(0,0,1)
ENDIF
--------------------------------------------------------------------------------
----Section 4-D: Set up Ports and Declare Process dependant condition
handler
--------------------------------------------------------------------------------
-- Port assignments need to be assigned only once and take effect
-- after the controller is COLD STARTED.
-- The ports_ready variable is used to determine if the ports have
-- already been assigned by this program.
-- Therefore only the first execution of this program will assign the ports
IF  NOT(ports_ready) THEN
   setup_ports
ENDIF
-- Define a condition handler to trap equipment failure.
-- If equipment fails during the process, then the DOUT[EQIP_ERROR] is
-- set to TRUE. Which will stop the motion and require the equipment to be
-- fixed before motion can be resumed.
CONDITION[EQIP_FAIL]:
  WHEN DOUT[EQIP_ERROR]  DO
    STOP
```

```
    DOUT[EQIP_FIXED] = FALSE
    DOUT[EQIP_READY] = FALSE
    ENABLE CONDITION[RESTART]
    service_rtn
ENDCONDITION
ENABLE CONDITION[EQIP_FAIL]
-- Define a condition handler to monitor the servicing process.
-- Once Servicing/Fixing of equipment is complete, wait for the equipment
-- to be in READY mode.  When the equipment is READY, signal an event
-- which will restart the process where it left off.  The SERV_DONE
-- condition handler is ENABLED from the SERVICE_RTN interrupt routine.
CONDITION[SERV_DONE]:
   WHEN DOUT[EQIP_READY] DO
    SIGNAL EVENT[WARMED_UP]
    DOUT[EQIP_ERROR] = FALSE
ENDCONDITION
```

Setting Up Digital Output Ports for Process Monitoring - Main

```
-- Define a condition handler to monitor when the warm up is complete, then
-- resume the stopped motion and continue the process.  Also re-enable
-- the EQIP_FAIL condition handler to continue monitoring for equipment
-- failure.
CONDITION[RESTART]:
  WHEN EVENT[WARMED_UP] DO
    RESUME
    ENABLE CONDITION[EQIP_FAIL]
ENDCONDITION
-------------------------------------------------------------------------------
----    Section 4-E: Do process manipulation
-------------------------------------------------------------------------------
-- Using the PATH_LEN built-in find out the last node of the path
last_node = PATH_LEN(pth1)
-- Setting EQIP_ERROR/EQIP_FIXED number ports to be simulated.
-- This setup does not require cold start, can change the port to be
-- simulated on the fly.
SET_PORT_SIM(io_dout, NODE_PULSE, 1, status)
IF (status <> SUCCESS) THEN
  WRITE ('SET_PORT_SIM Failed on port ',indx,CR)
  WRITE ('With Status = ',status,CR)
ENDIF
SET_PORT_SIM(io_dout, FINISH, 1, status)
IF (status <> SUCCESS) THEN
  WRITE ('SET_PORT_SIM Failed on port ',indx,CR)
  WRITE ('With Status = ',status,CR)
ENDIF
```

Setting Up Digital Output Ports for Process Monitoring - Main

```
WRITE (' NOW YOU WILL SEE THE DOUT[',NODE_PULSE,'] PULSE',CR)
WRITE (' as the robot moves through every node.',CR,CR)
WRITE (' To simulate EQUIPMENT failure, change ',CR)
WRITE (' DOUT[',EQIP_ERROR,'] = TRUE. ',CR)
WRITE (' Press ''ENTER'' to Continue',CR)
READ(CR)
-- Change the TP display to the DI/O sCReen
FORCE_SPMENU(tp_panel, SPI_TPDIGIO, 1)
-- Moving along path when equipment is ready.
-- Need to turn on equipment-1 for 1/2 second when robot position
-- is at 1st node.  Pulse the DOUT[NODE_PULSE] for every node
-- Turn on the DOUT[FINISH] about 200 ms before the last node.
IF DOUT[EQIP_READY] THEN
  MOVE ALONG pth1,
    WHEN AT NODE[*] DO
         PULSE DOUT[NODE_PULSE] for 1000
    WHEN AT NODE[1] DO
         PULSE DOUT[EQIP_ON] for 500
    WHEN TIME 200 BEFORE NODE[last_node] DO
         DOUT[FINISH] = TRUE
  ENDMOVE
ELSE
  FORCE_SPMENU(TP_PANEL,SPI_TPUSER,1)
  WRITE (' Equipment is not READY',CR)
  WRITE (' Set equipment to READY MODE',CR)
  WRITE (' before executing this program.',CR)
  WRITE (' SET DOUT[',EQIP_READY,'] = TRUE ',CR)
  ABORT
ENDIF
WRITE TPFUNC    (CHR(128),CHR(137))  -- Home Cursor and Clear to End-of-line
                                     -- This will remove the ABORT displayed
                                     -- above F1.
END DOUT_EX
```

B.2 COPYING PATH VARIABLES

This example shows the different ways of copying and appending PATH variables. The PATH Data Type can be copied from one to another only with hard coded path variable names. However, user defined paths can be copied from one to another. The path variable names can be determined during execution of the program.

Copy Path Variables Program - Overview

```
--------------------------------------------------------------------------------
----    Detail about CPY_PTH.Kl
--------------------------------------------------------------------------------
---- Elements of KAREL Language Covered:    In Section:
----    Action:
----    Clauses:
----            FROM                        Sec 3-A
----            IN DRAM                     Sec 2
----            WHEN                        Sec 4-A
----    Conditions:
----    Data types:
----            ARRAY OF STRING             Sec 2
----            BOOLEAN                     Sec 2; 3-C
----            COMMON_ASSOC                Sec 2
----            FILE                        Sec 2
----            GROUP_ASSOC                 Sec 2
----            INTEGER                     Sec 2; 3-B,C
----            PATH                        Sec 2
----            STRING                      Sec 2; 3-B
----            STRUCTURE...ENDSTRUCTURE    Sec 2
----            USER DEFINED PATH           Sec 2
----            XYZWPR                      Sec 2
----    Directives:
----            ALPHABETIZE                 Sec 1
----            COMMENT                     Sec 1
----            CMOSVARS                    Sec 1
----            CRTDEVICE                   Sec 1
----            INCLUDE                     Sec 2
```

Copy Path Variables Program - Overview and Declaration Section

```
----    Built-in Functions & Procedures:
----            APPEND_NODE                 Sec 4-D
----            BYNAME                      Sec 4-E
----            CALL_PROG                   Sec 4-B
----            COPY_PATH                   Sec 3-C; 4-D
----            CNV_INT_STR                 Sec 4-E
----            CREATE_VAR                  Sec 4-E
----            CURPOS                      Sec 4-B
----            DELETE_NODE                 Sec 4-C
----            LOAD                        Sec 4-B
----            PATH_LEN                    Sec 4-C,E
----            PROG_LIST                   Sec 4-B
----            READ_KB                     Sec 3-B
```

```
----            SET_CURSOR                  Sec 4-E
----            SET_FILE_ATR                Sec 4-A
----            SET_VAR                     Sec 4-B
----            SUB_STR                     Sec 4-E
----            VAR_LIST                    Sec 4-E
----    Statements:
----            ABORT                       Sec 4-C,E
----            CLOSE FILE                  Sec 4-E
----            FOR .... ENDFOR             Sec 3-C; 4-C,D,E
----            IF...THEN...ENDIF           Sec 3-B,C; 4-B,C,D,E
----            MOVE ALONG                  Sec 4-D
----            OPEN FILE                   Sec 4-A
----            REPEAT...UNTIL              Sec 3-B; 4-E
----            ROUTINE                     Sec 3
----            WRITE                       Sec 3-B,C; 4-A,B,C,E
----            USING...ENDUSING            Sec 4-D
----    Reserve Word:
----            BEGIN                       Sec 3-B,C; 4
----            END                         Sec 3-B,C; 4-E
----            PROGRAM                     Sec 1
----            TYPE                        Sec 2
----            VAR                         Sec 2
----     Predefined File Names:
----           CRTFUNC                      Sec 3-B
----           CRTPROMPT                    Sec 3-B,C
-------------------------------------------------------------------------------
----    Section 1:  Program and Environment Declaration
-------------------------------------------------------------------------------
PROGRAM CPY_PTH
%ALPHABETIZE
%COMMENT = 'COPY PATH'         -- Display information by default to
CRT/KB
%CRTDEVICE                    -- Use CMOS RAM to store all static
variables,
%CMOSVARS                     -- except those specified with IN DRAM
```

Copy Path Variables Program - Declaration Section

```
-------------------------------------------------------------------------------
----    Section 2:  Constant, Variable and Type Declarations
-------------------------------------------------------------------------------
CONST
   SUCCESS       = 0 -- The value returned from all built-ins when successful
TYPE
    node_struc    = STRUCTURE      -- Create a user defined node structure
      posn_dat      :XYZWPR
```

```
      grup_dat      :GROUP_ASSOC
      comn_dat      :COMMON_ASSOC
    ENDSTRUCTURE
    user_path     = PATH nodedata = node_struc  --Create a user defined path
VAR
    pth1,
    pth2,
    pth3
    pth4            :PATH         -- These are system defined PATHs
    upth1,
    upth2,
    upth3,
    upth4           :user_path    -- These are user defined PATHs

    p1_len,
    p2_len,
    status,
    total_node      :INTEGER
    F1_press,
    F2_press        :BOOLEAN
    src_num,
    des_num         :INTEGER
    dummy_str,
    src_var,
    des_var         :STRING[20]
    cur_name        :STRING[12]
    entry           :INTEGER
    var_type        :INTEGER
    mem_loc         :INTEGER
```

Copy Path Variables Program - Storing Variables in Memory

```
-- Store the following variables in DRAM, which is temporary memory
    indx      IN DRAM  :INTEGER
    prog_name IN DRAM  :STRING[10]
    prog_type IN DRAM  :INTEGER
    n_match   IN DRAM  :INTEGER
    n_skip    IN DRAM  :INTEGER
    format    IN DRAM  :INTEGER
    ary_nam   IN DRAM  :ARRAY[5] OF STRING[20]
    prog_indx IN DRAM  :INTEGER
    do_copy   IN DRAM  :BOOLEAN
    crt_kb    IN DRAM  :FILE
%INCLUDE KLEVKMSK     -- system supplied file: definition of KC_FUNC_KEY
%INCLUDE KLEVKEYS     -- system supplied file: definition of KY_F1 & KY_F2
```

Copy Path Variables Program - Monitor User Response

```
-------------------------------------------------------------------------------
----    Section 3:  Routine Declaration
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
----    Section 3-A:  CRT_CLS Declaration
-------------------------------------------------------------------------------
ROUTINE CRT_CLS FROM rout_ex -- include this routine from the file rout_ex.kl
-------------------------------------------------------------------------------
----  Section 3-B:  YES_NO Declaration
----                LABEL the F1 key as YES and F2 key as NO, ask for user
----                 confirmation.  These two keys are monitored by global
----                 condition handler,so User response can be trapped.
-------------------------------------------------------------------------------
ROUTINE YES_NO
VAR
 key_press : INTEGER
 str : STRING[1]
 n_chars: INTEGER
 l_status: INTEGER
 BEGIN  ---- YES_NO
  WRITE CRTFUNC   (CHR(128),CHR(137))  --- Clear  Window, Home Cursor
  -- Display YES above F1 & NO above F2 & clear rest of Function window
  WRITE CRTFUNC   ('   YES     NO ',chr(129))
  F1_press = FALSE
  F2_press = FALSE
  REPEAT -- until user presses either the F1 or F2 key
    -- Read just the function keys of the CRT/KB.
    -- The read will be satisfied only when a function key is pressed.
    READ_KB (crt_kb, str , 0, 0, kc_func_key, -1,
             '', n_chars, key_press, l_status)
    -- key_press must be converted from a "raw" CRT character to the teach
    -- pendant equivalent character.g
    key_press = $CRT_KEY_TBL[key_press+1]
    IF (key_press = ky_f1) THEN -- The user pressed F1
      F1_press = true
    ENDIF
    IF (key_press = ky_f2) THEN -- The user pressed F2
      F2_press = true
    ENDIF
  UNTIL ((f1_press = TRUE) OR (F2_press = TRUE))
  WRITE CRTFUNC    (CHR(128),CHR(137))  --- Clear Window, Home Cursor
  WRITE CRTPROMPT  (CHR(128),CHR(137))  --- Clear Window, Home Cursor
END YES_NO
```

Copy Path Variables Program - Copying Path Variables

```
--------------------------------------------------------------------------------
---- Section 3-C: PTH_CPY Declaration
----       Copy one user defined path variable to another user defined path
----       variable. The first parameter is the source path.  The second
----       parameter is the destination path. The path parameters can only
----       be passed using BYNAME and the path's must be user defined
--------------------------------------------------------------------------------
ROUTINE PTH_CPY(src_path: USER_PATH; des_path: USER_PATH)
VAR
    node_indx  :INTEGER
    do_it       :BOOLEAN
    1_stat      :INTEGER
BEGIN --- pth_cpy
CRT_CLS     -- Clear the CRT/KB USER Menu screen
do_it = true
--  WRITE ('Peform copy',CR)
    yes_no
    do_it = F1_press -- F1_press will be true only if the user selected
YES
    IF (do_it) THEN
     --  Copy the entire path of src_path to des_path
       COPY_PATH (src_path, 0,0, des_path, l_stat)
        IF (l_stat <> 0) THEN
          WRITE ('Error in COPY_PATH', l_stat, CR)
        ELSE
          WRITE ('Path Copy function Completed ',cr)
        ENDIF
    ELSE
      WRITE ('Path Copy function canceled by choice',cr,cr)
    ENDIF
END PTH_CPY
```

Copy Path Variables Program - Opens CRT/KB & Sends Data to Default Device

```
--------------------------------------------------------------------------------
----    Section 4:  Main Program
--------------------------------------------------------------------------------
BEGIN --- CPY_PATH
--------------------------------------------------------------------------------
----    Section 4-A: Open CRT KB for reading YES/NO inputs from user
--------------------------------------------------------------------------------
CRT_CLS --  will force the CRT USER menu to be visible & clear the screen
 SET_FILE_ATR(crt_kb, ATR_FIELD) -- Needed so the read is satisfied with one
                                 -- character.
```

```
 OPEN FILE crt_kb ('RO', 'KB:crkb') -- Open a file to the CRT/KB
                                    -- Used within the YES_NO routine.
--------------------------------------------------------------------------------
----    Section 4-B: Check if SAVE_VRS.PC is loaded. If loaded then execute
--------------------------------------------------------------------------------
---- First check if the "SAVE_VRS" program is loaded or not.
prog_name = 'SAVE_VRS' -- Only interested in SAVE_VRS program
prog_type = 6          -- Interested only in PC type files
n_skip = 0             -- First time do not skip any files
format = 1             -- Return just the filename
do_copy = TRUE
WRITE ('Checking Program List',cr)
PROG_LIST(prog_name, prog_type, n_skip, format, ary_nam, n_match, status)
  IF (status <>SUCCESS ) THEN
    IF (status = 7073 ) THEN  ---- Program does not exist error
        --- Program SAVE_VRS is not loaded on the controller.
      WRITE ( 'LOADING ',prog_name, CR)
      LOAD (prog_name+'.PC', 0, status)
      IF (status <> SUCCESS) THEN
        WRITE ('Error loading ', prog_name,cr)
        WRITE CRTPROMPT('Copy path''s WITHOUT saving program variables?',CR)
        YES_NO
        do_copy = F1_press -- F1_press is true only if user selected
YES
                           -- Copy without saving variables.
      ENDIF
    ELSE
     -- The program listing failed.
      WRITE ('PROG_LIST built-in failed',cr,' with Status = ',status,cr)
      WRITE CRTPROMPT('Copy path''s WITHOUT saving program variables?',CR)
      YES_NO
      do_copy = F1_press -- F1_press is true only if user selected
YES
    ENDIF              -- Copy without saving variables.
  ENDIF
```

Copy Path Variables Program - Checks Path Initialization

```
IF (status = SUCCESS)  THEN
  -- This is one way to set variables within another program without
  -- using the FROM clause in the variable section.
  -- It is very useful if you want to have run-time independent code,
  -- where the program or variable name you are setting is not
  -- known until run-time.
  cur_name = CURR_PROG
   SET_VAR (entry, prog_name, 'del_vr', TRUE, status)
```

```
   SET_VAR (entry, prog_name, 'prog_name',cur_name , status)
   SET_VAR (entry, prog_name, 'sav_type', 1, status)
   SET_VAR (entry, prog_name, 'dev', 'FLPY:', status)
   WRITE ('Saving program variables before copy', CR)
   CALL_PROG(prog_name,prog_indx) -- call SAVE_VRS
ENDIF
-------------------------------------------------------------------------
----    Section 4-C: Check for initialization of PATHs pth1 and pth2.
-------------------------------------------------------------------------
IF (NOT do_copy) THEN
  WRITE ('Program exiting, unable to save variables,',cr)
  WRITE ('before copying path''s',cr)
  -- NOTICE:
  --  Two single quotes will display as one single quote
  --  so this write statement will appear as :
  --  "before copying path's"
  ABORT
ENDIF
WRITE ('Checking Variable initialization',cr)
-- Check if the pth variables are initialized.
p1_len = PATH_LEN(pth1)  ; p2_len = PATH_LEN(pth2)
IF ( (p1_len = 0) OR (p2_len = 0) )THEN
  WRITE  ('PTH1 or PTH2 is empty path',cr)
  WRITE  ('Please make sure both paths are taught then restart',cr)
  ABORT  -- Cannot copy uninitialized variables.
ENDIF
-- Check if the pth3 variable is initialized.
IF  (PATH_LEN(pth3) <> 0) THEN
  WRITE ('Deleting nodes from pth3',cr) -- Delete the old path of pth3
  FOR indx = PATH_LEN(pth3) DOWNTO 1 DO
    -- its easy to delete nodes from the end instead of deleting node from
    -- the front end. Since after every deletion the nodes are renumbered.
    DELETE_NODE(pth3, indx, status) -- Delete last node of pth3
    IF status <> SUCCESS THEN
       WRITE ('While Deleting ',indx, ' node',cr)
       WRITE ('DELETE_NODE unsuccessful: Status = ',status,cr)
    ENDIF
  ENDFOR
ENDIF
```

Copy Path Variables Program - Path Initialization

```
-------------------------------------------------------------------------
----    Section 4-D: Add pth1 and pth2 together to create pth3.
----                 Move along pth1 and pth2.
----                 Move backwards through pth3.
```

```
--------------------------------------------------------------------------------
total_node = p1_len + p2_len     -- Total number of nodes needed for pth3
-- Copy the node data from pth1 to pth3
WRITE ('copying pth1 to pth3',cr)
COPY_PATH (pth1, 0,0, pth3, status)
     IF (status <> 0) THEN
     WRITE ('ERROR in COPY_PATH', status, CR)
   ENDIF
-- Create the required number of nodes for pth3.
-- We know that pth3 now has PATH_LEN(pth3) nodes.
WRITE ('Appending nodes to pth3',cr)
FOR indx = p1_len+1 TO total_node DO -- Append the correct number of nodes.
   APPEND_NODE(pth3, status)
   IF (status <> 0) THEN
     WRITE ('While Appending ',indx, ' node',cr)
     WRITE ('APPEND_NODE unsuccessful: Status = ',status,cr)
   ENDIF
ENDFOR
-- Append the node data of pth2 to pth3.
WRITE ('Appending pth2 to pth3',cr)
FOR indx = p1_len+1 TO total_node DO
  USING pth2[indx - p1_len] DO
    pth3[indx].node_pos    = node_pos
    pth3[indx].group_data  = group_data
    pth3[indx].common_data = common_data
  ENDUSING
ENDFOR
-- Move Along the path pth1 and pth2
WRITE ('Moving Along Path pth1',cr)
MOVE ALONG pth1
WRITE ('Moving Along Path pth2',cr)
MOVE ALONG pth2
--Copy pth3 in reverse order to pth4
COPY_PATH (pth3, PATH_LEN(pth3), 1, pth4, status)
IF (status <> 0) THEN
  WRITE ('ERROR in COPY_PATH', status, CR)
ENDIF--- Move along pth4 which is a reverse order of pth3.
WRITE ('Moving Along Path pth4',cr)
MOVE ALONG pth4
```

Copy Path Variables Program - Copy User Defined Paths

```
--------------------------------------------------------------------------------
----    Section 4-E: Copy User Defined Paths.
----                 Copy one user defined path to another user defined path,
----                 where the user specifies which paths to be copied.
```

```
--------------------------------------------------------------------------------
CRT_CLS
SET_CURSOR(OUTPUT,2,10, status)     -- Position cursor nicely on CRT
IF (status <> 0 ) THEN
   WRITE ('SET_CURSOR built-in failed with status = ',status,cr)
ENDIF
-- write message in reverse video and then set back to normal video
WRITE (chr(139),' COPY PATH FUNCTION',chr(143),CR,cr)
WRITE ('Currently you have the following ',cr)
WRITE ('User Defined Paths',cr,cr)
n_skip = 0
var_type = 31                      -- Get listing of only PATH type variables
REPEAT
VAR_LIST ('CPY_PTH', '*',var_type, n_skip, 2, ary_nam, n_match, status)
  FOR indx = 1 TO n_match DO
   IF (SUB_STR (ary_nam[indx], 1, 4) = 'UPTH') THEN -- Verify it's one of
                                                    -- the user defined path's
    WRITE (ary_nam[indx], CR)
   ENDIF
  ENDFOR
  n_skip = n_skip + n_match
UNTIL (n_match < ARRAY_LEN(ary_nam))
Write ('Enter the source path number:')
  READ(src_num);
Write ('Enter the destination path number:')
  READ(des_num);
CNV_INT_STR(src_num,2,0,dummy_str)       -- Convert source number to string
src_var = 'UPTH'+ SUB_STR(dummy_str,2,1) -- SUB_STR will remove the leading
                                         -- blank from dummy_str before
                                         -- concatenating to create the
var_type = 0                             -- source variable name
VAR_LIST ('CPY_PTH', src_var, var_type, 0, 2, ary_nam, n_match, status)
IF (status <> SUCCESS) THEN
  WRITE ('Var_list for src_var: status ', status, cr)
ENDIF
```

Copy Path Variables Program - Copy User Defined Paths Continued

```
-- If the variable does not exist create it.
IF (n_match = 0) THEN
  CREATE_VAR ('', src_var, '', 'USER_PATH', 1, 0, 0, 0, status, mem_loc)
  IF (status <> SUCCESS) THEN
    WRITE ('Error creating ', src_var, ':', status, cr)
  ENDIF
ENDIF
--Create the destination variable name
```

```
CNV_INT_STR(des_num,2,0,dummy_str)      -- Convert des_num to a string
des_var = 'UPTH'+ SUB_STR(dummy_str,2,1)-- The SUB_STR will remove the leading
                                        -- blank from dummy_str before
                                        -- concatenating to create the
                                        -- source variable name
-- Verify that the des_var variable exists.
VAR_LIST ('CPY_PTH', des_var, var_type, 0, 2, ary_nam, n_match, status)
IF (status <> SUCCESS) THEN
  WRITE ('Var_list for des_vr: status', status, cr)
ENDIF
-- If the variable does not exist create it.
IF (n_match = 0) THEN
  CREATE_VAR ('', des_var, '', 'USER_PATH', 1, 0, 0, 0, status, mem_loc)
  IF (status <> SUCCESS) THEN
    WRITE ('Error creating ', des_var, ':', status, cr)
  ENDIF
ENDIF
-- Copy the specified source path to the specified destination path
pth_cpy(BYNAME('', src_var, indx), BYNAME('', des_var, indx) )
-- Close file before quitting
CLOSE FILE crt_kb
WRITE ('CPY_PTH example completed',cr)
END CPY_PTH
```

B.3 SAVING DATA TO THE DEFAULT DEVICE

This program will save variables or teach pendant programs to the default device. If the user specified to overwrite the file then the file will be deleted before performing the save.

Note This program is called by the CPY_PTH.KL program. Refer to Section B.2 , for information on CPY_PTH.KL.

Saving Data Program - Overview

```
------------------------------------------------------------------------------
----    SAVE_VRS.KL
------------------------------------------------------------------------------
----    Section 0:  Detail about SAVE_VRS.KL
------------------------------------------------------------------------------
---- Elements of KAREL Language Covered:    In Section:
----    Actions:
----    Clauses:
----    Conditions:
----    Data types:
----            BOOLEAN                    Sec 2
```

```
----            INTEGER                     Sec 2
----            STRING                      Sec 2
----    Directives:
----            COMMENT                     Sec 1
----            ENVIRONMENT                 Sec 1
----            NOLOCKGROUP                 Sec 1
----    Built-in Functions & Procedures:
----            DELETE_FILE                 Sec 4-B
----            SAVE                        Sec 4-B
----    Statements:
----            IF, THEN, ENDIF             Sec 4-B
----           SELECT, CASE, ENDSELECT      Sec 4-A
----            WRITE                       Sec 4-B
----    Reserve Words:
----            BEGIN                       Sec 4
----            CONST                       Sec 2
----            CR                          Sec 4-B
----            END                         Sec 4-B
----            PROGRAM                     Sec 1
----            VAR                         Sec 2
```

Saving Data Program - Declarations Section

```
--------------------------------------------------------------------------------
----    Section 1:  Program and Environment Declaration
--------------------------------------------------------------------------------
PROGRAM SAVE_VRS
%NOLOCKGROUP
%COMMENT = 'Save .vr, .tp, .sv'
%ENVIRONMENT MEMO
%ENVIRONMENT FDEV
--------------------------------------------------------------------------------
----    Section 2:  Constant, Variable and Type Declarations
--------------------------------------------------------------------------------
CONST
  DO_VR  = 1       -- Save variable file(s)
  DO_TP  = 2       -- Save TP program(s)
  DO_SYS = 3       -- Save system variables
  SUCCESS = 0      -- The value expected from all built-in calls.
VAR
  sav_type  : INTEGER     -- Specifies the type of save to perform
  prog_name : STRING[12]  -- The program name to save
  status    : INTEGER    -- The status returned from the built-in calls
  file_spec : STRING[30]  -- The created file specification for SAVE
  dev       : STRING[5]   -- The device to save to specify whether to
  del_vr    : BOOLEAN   -- delete file_spec before performing the SAVE.
```

```
-----------------------------------------------------------------------
----    Section 3:  Routine Declaration
-----------------------------------------------------------------------
```

Saving Data Program - Create File Spec

```
-----------------------------------------------------------------------
----    Section 4:  Main Program
-----------------------------------------------------------------------
BEGIN -- SAVE_VRS
-----------------------------------------------------------------------
----    Section 4-A: Create the file_spec, which contains the device, file
----                 name and type to be saved.
-----------------------------------------------------------------------
  SELECT (sav_type) OF
    CASE (DO_VR):
     -- If prog_name is '*' then all PC variables will be saved with the
     -- correct program name, irregardless of the file name part of
     -- file_spec.
     file_spec = dev+prog_name+'.VR'   -- Create the variable file name
    CASE (DO_TP):
     -- If prog_name is '*' then all TP programs will be saved with the
     -- correct TP program name, irregardless of the prog_name part of
     -- file_spec.
     file_spec = dev+prog_name+'.TP'   -- Create the TP program name
    CASE (DO_SYS):
     prog_name = '*SYSTEM*'
     file_spec = dev+'ALLSYS.SV'       -- All system variables will be
                                       -- saved into this one file.
  ENDSELECT
```

Saving Data Program - Delete/Overwrite

```
-----------------------------------------------------------------------
----    Section 4-B: Decide whether to delete the file before saving
----                 and then perform the SAVE.
-----------------------------------------------------------------------
   -- If the user specified to delete the file before saving, then
   -- delete the file and verify that the delete was successful.
   -- It is possible that the delete will return a status of:
   --  10003 : "file does not exist", for the FLPY: device
   --    OR
   --  85014 : "file not found", for all RD: and FR: devices
   -- We will disregard these errors since we do not care if the
   -- file did not previously exist.
```

```
    IF (del_vr = TRUE)  THEN
      DELETE_FILE (file_spec, FALSE, status) -- Delete the file.
      IF (status <> SUCCESS) AND (status <> 10003) AND
         (status <> 85014) THEN
        WRITE ('Error ', status,' in attempt to delete ',cr, file_spec,cr)
      ENDIF
    ENDIF
    -- If prog_name is specified as an '*' for either .tp or .vr files then
    -- the SAVE builtin will save the appropriate files/programs with the
    -- correct names.
    SAVE (prog_name, file_spec, status) -- Save the variable/program
    IF (status <> SUCCESS) THEN       -- Verify SAVE was successful
      WRITE ('error saving ', file_spec, 'variables', status, cr)
    ENDIF
END  SAVE_VRS
```

B.4 STANDARD ROUTINES

This program is made up of several routines which are used through out the examples. The following is a list of the routines within this file:

- CRT_CLS Clears the CRT/KB USER Menu screen
- TP_CLS Clears the teach pendant USER Menu screen

Standard Routines - Overview

```
    ------------------------------------------------------------------------
    ----    ROUT_EX.KL
    ------------------------------------------------------------------------
    ----    Section 0:  Detail about ROUT_EX.kl
    ------------------------------------------------------------------------
    ---- Elements of KAREL Language Covered:    In Section:
    ----    Actions:
    ----    Clauses:
    ----    Conditions:
    ----    Data types:
    ----    Built-in Functions & Procedures:
    ----            CHR                         Sec 3-A,B
    ----            FORCE_SPMENU                Sec 3-A,B
    ----    Statements:
    ----            ROUTINE                     Sec 3-A,B
    ----            WRITE                       Sec 3-A,B
    ----
    ----    Reserve Words:
    ----            BEGIN                        Sec 3-A,B; 4
```

```
   ----            CR                          Sec 3-B
   ----            END                         Sec 3-A,B; 4
   ----            PROGRAM                     Sec 1
   ----    Predefined File Names:
   ----            CRTERROR                   Sec 3-A
   ----            CRTFUNC                    Sec 3-A
   ----            CRTPROMPT                  Sec 3-A
   ----            CRTSTATUS                  Sec 3-A
   ----            OUTPUT                     Sec 3-A
   ----            TPERROR                    Sec 3-B
   ----            TPFUNC                     Sec 3-B
   ----            TPSTATUS                   Sec 3-B
   ----            TPPROMPT                   Sec 3-B
```

Standard Routines - Declaration Section

```
------------------------------------------------------------------------
----    Section 1:  Program and Environment Declaration
------------------------------------------------------------------------
PROGRAM ROUT_EX
%NOLOCKGROUP   ---- Don't lock any motion groups
%COMMENT = 'MISC_ROUTINES'
------------------------------------------------------------------------
----    Section 2:  Constant and Variable Declarations
------------------------------------------------------------------------
------------------------------------------------------------------------
----    Section 3:  Routine Declarations
------------------------------------------------------------------------
------------------------------------------------------------------------
----    Section 3-A:  CRT_CLS Declaration
----                  Clear the predefined windows:
----                  CRTPROMPT, CRTSTATUS, CRTFUNC, CRTERROR, OUTPUT
----                  Force Display of the CRT/KB USER SCREEN.
------------------------------------------------------------------------
ROUTINE CRT_CLS
BEGIN  ---- CRT_CLS
--See Chapter 7.9.2 for more information on the PREDEFINED window names
  WRITE CRTERROR   (CHR(128),CHR(137))  -- Clear Window, Home Cursor
  WRITE CRTSTATUS  (CHR(128),CHR(137))  -- Clear Window, Home Cursor
  WRITE CRTPROMPT  (CHR(128),CHR(137))  -- Clear Window, Home Cursor
  WRITE CRTFUNC    (CHR(128),CHR(137))  -- Clear Window, Home Cursor
  WRITE OUTPUT     (CHR(128),CHR(137))  -- Clear Window, Home Cursor
  FORCE_SPMENU(CRT_PANEL,SPI_TPUSER,1) -- Force the CRT USER Menu
                                       -- to be visible last.  This will
```

```
                                        -- avoid the screen from flashing
                                        -- since the screen will be clean
                                        -- when you see it.
END CRT_CLS
```

Standard Routines - Clears Screen and Displays Menu

```
--------------------------------------------------------------------------
----    Section 3-B:   TP_CLS Declaration
                       Clear the predefined windows:
----                   TPERROR, TPSTATUS, TPPROMPT, TPFUNC TPDISPLAY
----                   Force Display of the TP USER Menu SCREEN.
--------------------------------------------------------------------------
ROUTINE TP_CLS
BEGIN
  WRITE (CHR(128),CHR(137)) -- By default this will clear TPDISPLAY
  WRITE TPERROR (CR,'                                          ',CR)
  WRITE TPSTATUS(CR,'                                          ',CR)
  WRITE TPPROMPT(CR,'                                          ',CR)
  WRITE TPFUNC  (CR,'                                          ',CR)
  FORCE_SPMENU(TP_PANEL,SPI_TPUSER,1) -- Force the USER menu screen
     -- to be visible last.
     -- This will avoid the screen from
     -- flashing since the screen will
     -- be clean when you see it.
END TP_CLS
--------------------------------------------------------------------------
----    Section 4:  Main Program
--------------------------------------------------------------------------
BEGIN -- ROUT_EX
END  ROUT_EX
```

B.5 USING REGISTER BUILT-INS

This program demonstrates the use of the REGISTER builtins. REG_EX.KL retrieves the current position and stores it in PR[1]. Then it executes the program PROG_VAL.TP. PROG_VAL will modify the value within the Position Register PR[1].

After PROG_VAL is completed, REG_EX.KL retrieves the PR[1] position. The position is then manipulated and restored in PR[2], and an INTEGER number is stored in R[1]. A different teach pendant program, PROG_1.TP, is executed which loops through some positions and stores a value to R[2]. The number of loops depends on the value of the R[1] (which was initially set by the KAREL program.)

After PROG_1.TP has completed, the KAREL program gets the value from R[2] and verifies it was the expected value.

The PROG_VAL.TP teach pendant program should look similar to the following.

```
PROG_VAL                                JOINT 10%
1:  !POSITION REG VALUE ;
2:J P[1:ABOVE JOINT] 100% FINE ;
3:  PR[1,2]=600 ;
4:L PR[1] 100.0 Inch/mm FINE ;
5:J P[1:ABOVE JOINT]100% FINE ;
```

The PROG_VAL.TP teach pendant program does the following:

- Moves to position 1 in joint mode.
- Changes the 'y' location of the position in Position Register 1, PR[1] (which was set by the KAREL program).
- Moves to the new PR[1] position.
- Finally moves back to position 1.

The PROG_1.TP teach pendant program should look similar to the following.

```
PROG_1                                  JOINT 10%
1:  LBL[1:START] ;
2:  IF R[1]=0, JMP LBL[2] ;
3:J P[1] 100% FINE ;
4:J P[2] 100% FINE ;
5:  R[1]=R[1]-1 ;
6:  JMP LBL[1] ;
7:  LBL[2:DONE] ;
8:  R[2]=1 ;
```

The PROG_1.TP teach pendant program does the following:

- Checks the value of the R[1].
- If the value of R[1] is not 0, then moves to J P[1] and J P[2] and decrements the value of R[1]. PROG_1.TP continues in this loop until the Register R[1] is zero.

- After the looping is complete, PROG_1.TP stores value 1 in R[2], which will be checked by the KAREL program.

Using Register Built-ins Program - Overview

```
------------------------------------------------------------------------------
----    REG_EX.Kl
------------------------------------------------------------------------------
---- Elements of KAREL Language Covered:         In Section:
----    Actions:
----    Clauses:
----    Conditions:
----    Data types:
----                BOOLEAN                       Sec 2
----                JOINTPOS                      Sec 2
----                REAL                          Sec 2
----                XYZWPR                        Sec 2
----    Directives:
----                ALPHABETIZE                   Sec 1
----                COMMENT                       Sec 1
----                NOLOCKGROUP                   Sec 1
----    Built-in Functions & Procedures:
----                CALL_PROGLIN                   Sec 4-A, 4-C
----                CHR                            Sec 4
----                CURPOS                         Sec 4-A
----                FORCE_SPMENU                   Sec 4
----                GET_POS_REG                    Sec 4-B
----                GET_JPOS_REG                   Sec 4-B
----                GET_REG                        Sec 4-C
----                POS_REG_TYP                    Sec 4-B
----                SET_JPOS_REG                   Sec 4-B
----                SET_INT_REG                    Sec 4-B
----                SET_POS_REG                    Sec 4-A
----    Statements:
----                WRITE                          Sec 4, 4-A,B,C
----                IF..THEN..ELSE..ENDIF          Sec 4-A,B,C
----                SELECT...CASE...ENDSELECT      Sec 4-B
----    Reserve Words:
----                BEGIN                          Sec 4
----                CONST                          Sec 2
----                CR                             Sec 4-A,B,C
----                END                            Sec 4-C
----                PROGRAM                        Sec 4
----                VAR                            Sec 2
```

Using Register Built-ins Program - Declaration Section

```
--------------------------------------------------------------------------
----    Section 1:  Program and Environment Declaration
--------------------------------------------------------------------------
PROGRAM reg_ex
%nolockgroup
%comment = 'Reg-Ops'
%alphabetize
--------------------------------------------------------------------------
----    Section 2:  Variable Declaration
--------------------------------------------------------------------------
CONST
    cc_success     = 0         -- Success status
    cc_xyzwpr      = 2     -- Position Register has an XYZWPR
    cc_jntpos      = 9      -- Position Register has a JOINTPOS
VAR
    xyz                :XYZWPR
    jpos               :JOINTPOS
    r_val              :REAL
    prg_indx,
    i_val,
    pos_type,
    num_axes,
    status             :INTEGER
    r_flg              :BOOLEAN
--------------------------------------------------------------------------
----    Section 3: Routine Declaration
--------------------------------------------------------------------------
--------------------------------------------------------------------------
----    Section 4: Main program
--------------------------------------------------------------------------
BEGIN -- REG_EX
 write(chr(137),chr(128));           -- Clear the TP USER menu screen
 FORCE_SPMENU(TP_PANEL,SPI_TPUSER,1) -- Force the TP USER menu to be
                                     -- visible
```

Using Register Built-ins - Storing and Manipulating Positions

```
--------------------------------------------------------------------------
---- Section 4-A: Store current position in PR[1] and  execute PROG_VAL.TP
--------------------------------------------------------------------------
 WRITE('Getting Current Position',cr)
 xyz = CURPOS(0,0)                    -- Get the current position
 WRITE('Storing Current position to PR[1]',cr)
 SET_POS_REG(1,xyz, status)           -- Store the position in PR[1]
```

```
 IF (status = cc_success) THEN        -- verify SET_POS_REG is successful
   WRITE('Executing "PROG_VAL.TP"',cr)
   CALL_PROGLIN('PROG_VAL',2,prg_indx, FALSE)
                                        --Execute 'PROG_VAL.TP' starting
                                       -- at line 2.  Do not pause on
                                       -- entry of PROG_VAL.
-------------------------------------------------------------------------
---- Section 4-B: Get new position from PR[1]. Manipulate and store in PR[2]
-------------------------------------------------------------------------
  WRITE('Getting Position back from PR[1]',cr)
    -- Decide what type of position is stored in Position Register 1, PR[1]
   POS_REG_TYPE(1, 1, pos_type, num_axes, status)
   IF (status = cc_success) THEN
   -- Get the position back from PR[1], using the correct builtin.
   -- This position was modified in PROG_VAL.TP
     SELECT pos_type OF
       CASE (cc_xyzwpr):
         xyz= GET_POS_REG(1, status)
       CASE (cc_jntpos):
         jpos = GET_JPOS_REG(1, status)
         xyz = jpos
       ELSE:
         write ('The position register set to invalid type', pos_type,CR)
         status = -1                    -- set status so do not continue.
     ENDSELECT
     IF (status = cc_success) THEN     -- Verify GET_POS_REG/GET_JPOS_REG is
                                       -- successful
       xyz.x = xyz.x+10                -- Manipulate the position.
       xyz.z = xyz.z-10
       jpos  = xyz                     -- Convert to a JOINTPOS
       WRITE('Setting New Position to PR[2]',cr)
       SET_JPOS_REG(2,jpos,status)     -- Set the JOINTPOS into PR[2]
       IF (status = cc_success) THEN   -- Verify SET_JPOS_REG is successful
          WRITE('Setting Integer Value to R[1]',cr)
          SET_INT_REG(1, 10, status)   -- Set the value 10 into R[1]
```

Using Register Built-ins - Executing Program and Checking Register

```
-------------------------------------------------------------------------
----    Section 4-C: Execute PROG_1.TP and check the R[2]
-------------------------------------------------------------------------
        IF (status=cc_success) THEN --Verify SET_INT_REG is successful
            WRITE('Executing "PROG_1.TP"',cr)
            CALL_PROGLIN('PROG_1',1, prg_indx, FALSE)
   --Execute PROG_1.TPstarting on first line.
   --Do not pause on entry of PROG_1.
```

```
            WRITE('Getting Value from R[2]',cr)
            GET_REG(2,r_flg, i_val, r_val, status) --Get R[2] value
            IF (status = cc_success) THEN      --Verify GET_REG success
              IF (r_flg) THEN                   --REAL value in register
              WRITE('Got REAL value from R[2]',cr)
                IF (r_val <> 1.0) THEN                  --Verify value set
                 WRITE ('PROG_1 failed to set R[2]',cr)-- by PROG_1_TP
                  WRITE ('PROG_1 failed to set R[2]',cr)
                ENDIF
              ELSE                  --Register contained an INTEGER
                WRITE('Got INTEGER value from R[2]',cr)
                IF (i_val <> 1) THEN     --Verify value set by
  WRITE ('PROG_1 failed to set R[2]',cr) --PROG_1.TP
                ENDIF
             ENDIF
           ELSE                      --GET_REG was NOT successful
             WRITE('GET_REG Failed',cr,' Status = ',status,cr)
           ENDIF
         ELSE                      --SET_INT_REG was NOT successful
           WRITE('SET_INT_REG Failed, Status = ',status,cr)
         ENDIF
       ELSE                        --SET_JPOS_REG was NOT successful
         WRITE('SET_JPOS_REG Failed, Status = ',status,cr)
       ENDIF
     ELSE                          -- GET_POS_REG was NOT Successful
       WRITE('GET_POS_REG Failed, Status = ',status,cr)
     ENDIF
   ELSE
     WRITE ('POS_REG_TYPE Failed, Status =', status, cr)
   ENDIF
 ELSE                              -- SET_POS_REG was NOT successful
   WRITE('SET_POS_REG Failed, Status = ',status,cr)
 ENDIF
 IF (status = cc_success) THEN; WRITE ('Program Completed
Successfully',cr)
 ELSE ;                    WRITE ('Program Aborted due to error',cr)
 ENDIF
END reg_ex
```

B.6 PATH VARIABLES AND CONDITION HANDLERS PROGRAM

This program checks to determine if PATH variables are taught or not. If the paths are taught, the robot moves to a joint position and then loops along a path 5 times.

This example also sets up two global condition handlers.

- The first condition handler detects if the user has pushed a teach pendant key, and if so aborts the program.
- The second condition handler sets a variable when the program is aborted.

Path Variables and Condition Handlers Program - Overview

```
------------------------------------------------------------------------
----    PTH_MOVE.Kl
------------------------------------------------------------------------
------------------------------------------------------------------------
----    Section 0:  Detail about PTH_MOVE.kl
------------------------------------------------------------------------
---- Elements of KAREL Language Covered:       In Section:
----    Actions:
----            ABORT                                 Sec 4-A
----    Clauses:
----            WHEN                                  Sec 4-A
----            WITH                                  Sec 4-D
----            FROM                                  Sec 3-A
----            VIA                                   Sec 4-D
----    Conditions:
----            ABORT                                 Sec 4-A
----    Data types:
----            ARRAY OF REAL                         Sec 2
----            BOOLEAN                               Sec 2
----            INTEGER                               Sec 2
----            JOINTPOS6                             Sec 2
----            PATH                                  Sec 2
----            XYZWPR                                Sec 2
----    Directives:
----            ALPHABETIZE                           Sec 1
----            COMMENT                               Sec 1
----            ENVIRONMENT                           Sec 1
----    Built-in Functions & Procedures:
----            PATH_LEN                              Sec 4-C
----            CHR                                   Sec 3-B; 4-B,D
----            CNV_REL_JPOS                          Sec 4-D
----            SET_CURSOR                            Sec 4-B
```

Path Variables and Condition Handlers Program - Overview Continued

```
----    Statements:
----             Abort                              Sec 4-C
----           CONDITION...ENDCONDITION             Sec 4-A
```

```
----            FOR...ENDFOR                        Sec 4-D
----            ROUTINE                             Sec 3-A, B
----            WAIT FOR                            Sec 3-B
----            WRITE                               Sec 3-B; 4-B,C,D
----    Reserve Words:
----            BEGIN                               Sec 3-A,B, 4
----            CONST                               Sec 2
----            END                                 Sec 3-A,B: 4-D
----            VAR                                 Sec 2
----            PROGRAM                             Sec 1
----    Predefined File Names:
----            TPFUNC                              Sec 3-B; 4-D
----            TPDISPLAY                           Sec 4-B
```

Path Variables and Condition Handlers Program - Declaration Section

```
--------------------------------------------------------------------------------
----    Section 1:  Program and Environment Declaration
--------------------------------------------------------------------------------
PROGRAM PTH_MOVE         -- Define the program name
%ALPHABETIZE             -- Create the variables in alphabetical order
%COMMENT     = 'PATH MOVES'
%ENVIRONMENT PATHOP      -- Necessary for PATH_LEN
%ENVIRONMENT SYSDEF      -- Necessary for using the $MOTYPE in the
MOVEs
%ENVIRONMENT UIF         -- Necessary for SET_CURSOR
--------------------------------------------------------------------------------
----    Section 2:  Constant and Variable Declarations
--------------------------------------------------------------------------------
CONST
    CH_ABORT   = 1                          -- Number associated with the
                                            -- abort Condition handler
    CH_F1      = 2                          -- Number associated with the
                                            -- F1 key Condition handler
VAR
    status              :INTEGER            -- Status from built-in calls
    loop_pth            :INTEGER            -- Used in a FOR loop counter
    prg_abrt            :BOOLEAN            -- Set when program is aborted
    pth1                :PATH
    strt_jnt            :JOINTPOS6          -- starting position of a move
    via_pos             :XYZWPR             -- via point for a circular move
    des_pos             :XYZWPR             -- destination point
    real_ary            :ARRAY[6] OF REAL   -- This is used for creating
                                            -- a joint position with 6 axes
    index               :INTEGER            -- FOR loop counter
```

Path Variables and Condition Handlers Program - Declare Routines

```
--------------------------------------------------------------------------------
----    Section 3:  Routine Declaration
--------------------------------------------------------------------------------
----    Section 3-A:  RANDOM Declaration
----     ROUTINE TP_CLS FROM ROUT_EX        -- ROUT_EX must also be loaded.
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
----    Section 3-B:  YES_NO Declaration
----                 Display maximum elements of ary_nam.
---                  Display choices on the function line of the TP.
----                  Asks for user response.
---                  F1 key is monitored by the Global condition handler
----                 [CH_F1] and the F2 is monitored here.
----                 If F1 is pressed the program will abort.
---                  But, if the F2 is pressed the program will continue.
--------------------------------------------------------------------------------
ROUTINE YES_NO
BEGIN
  WRITE TPFUNC (CHR(137))                  -- Home Cursor in Function window
  WRITE TPFUNC ('  ABORT  CONT')           -- Display Function key options
  WAIT FOR TPIN[131]                       -- Wait for user to respond to
                                           -- continue.  If the user presses
                                           -- F1 (abort) condition handler
                                           -- CH_ABORT will abort program.
  WRITE TPFUNC (CHR(137))                  -- Home Cursor in Function window
  WRITE TPFUNC ('  ABORT',chr(129))        -- Redisplay just Abort option and
                                           -- clear rest of Function window
END YES_NO
```

Path Variables and Condition Handlers Program - Declare Condition Handlers

```
--------------------------------------------------------------------------------
----    Section 4:  Main Program
--------------------------------------------------------------------------------
BEGIN   -- PTH_MOVE
--------------------------------------------------------------------------------
----    Section 4-A: Global Condition Handler Declaration
--------------------------------------------------------------------------------
CONDITION[CH_ABORT]:
  WHEN ABORT DO       -- When the program is aborting set prg_abrt flag.
                      -- This will be triggered if this program aborts itself
                      --  or if an external mechanism aborts this program.
    prg_abrt = TRUE   -- You may then have another task which detects
                      -- prg_abrt being set, and does shutdown operations
```

```
                      -- (ie: set DOUT/GOUT's, send signals to a PLC)
ENDCONDITION
CONDITION[CH_F1]:
  WHEN TPIN[129] DO   -- Monitor TP 'F1' Key. If 'F1' key is pressed,
    ABORT             -- abort the program.
ENDCONDITION
prg_abrt = false               -- Initialize variable which is set
only if
                               -- the program is aborted and CH_ABORT is
                               -- enabled.
ENABLE CONDITION[CH_ABORT]     -- Start scanning abort condition as defined.
ENABLE CONDITION[CH_F1]        -- Start scanning F1 key condition as defined.
-------------------------------------------------------------------------------
----    Section 4-B: Display banner message and wait for users response
-------------------------------------------------------------------------------
TP_CLS                                -- Routine Call; Clears the TP USER
                                      -- menu, and forces the TP USER menu
                                      -- to be visible.
SET_CURSOR(TPDISPLAY,2,13, status)    -- Set cursor position in TP
USER menu
IF (status <> 0 ) THEN                -- Verify that SET_CURSOR was successful
   WRITE ('SET_CURSOR built-in failed with status = ',status,cr)
   YES_NO                             -- Ask whether to quit, due to error.
ENDIF
--- Write heading in REVERSE video, then turn reverse video off
WRITE (chr(139),' PLEASE READ ',chr(143),CR)
WRITE (cr,' *** F1 Key is labelled as ABORT key *** ')
WRITE (cr,' Any time the F1 key is pressed the program')
WRITE (cr,' will abort. However, the F2 key is active ')
WRITE (cr,' only when the function key is labeled.',cr,cr)
YES_NO  -- Wait for user response
```

Path Variables and Condition Handlers Program - Teach and Move Along Path

```
-------------------------------------------------------------------------------
----    Section 4-C: Verify PATH variable, pth1, has been taught
-------------------------------------------------------------------------------
-- Check the number of nodes in the path
IF PATH_LEN(pth1) = 0 THEN                    -- Path is empty (has no nodes)
   WRITE ('You need to teach the path.',cr)   -- Display instructions to user
   WRITE ('before executing this program.',cr)
   WRITE ('Teach the PATH variable pth1', CR, ' and restart the program',cr)
   ABORT                                      -- Simply ABORT the task
                                              -- do not continue since there
ENDIF                                         -- are no nodes to move to
-------------------------------------------------------------------------------
```

```
----    Section 4-D: Creating a joint position and moving along path's
--------------------------------------------------------------------------------
FOR indx = 1 to 6 DO                        -- Set all joint angles to zero
    real_ary[indx] = 0.0
ENDFOR
real_ary[5] = 90.0                          -- Make sure that the position
                                            -- is not at a singularity point.
CNV_REL_JPOS(real_ary, strt_jnt, status)  -- Convert real_ary values into
                                            -- a joint position, strt_jnt
IF (status <> 0 ) THEN                      -- Converting joint position
                                            -- was NOT successful
   WRITE ('CNV_REL_JPOS built-in failed with status = ',status,cr)
   YES_NO                                   -- Ask user if want to continue.
ELSE                                        -- Converting joint position was
                                            -- successful.
   -- The start position, strt_jnt, has been created and is located at
   -- axes 1-4 = 0.0, axes 5 = 90.0, axes 6 = 0.0.
   via_pos = strt_jnt                       -- Copy the strt_jnt to via_pos
   via_pos.x = via_pos.x +200               -- Add offset to the x location
   via_pos.y = via_pos.y +200               -- Add offset to the y location
   -- The via position, via_pos, has been created to be the same position
   -- as strt_jnt except it has been offset in the x and y locations by
   -- 200 mm.
   des_pos = strt_jnt                       -- Copy the strt_jnt to des_pos
   des_pos.x = des_pos.x + 400              -- Add offset to the x location
  -- The destination position, des_pos, has been created to be the same
  -- position as strt_jnt except it has been offset in the x location by
  -- 200 mm.
```

Path Variables and Condition Handlers Program - Move Along Path

```
MOVE TO strt_jnt                        -- Move to the start position

   WRITE (cr,'Moving to Destination Position',cr)
   WITH $MOTYPE = CIRCULAR MOVE TO des_pos VIA via_pos
                                        -- Move robot to destination
                                        -- position using circular motion
                                        -- via the via_pos
ENDIF
--- Execute the same path for 5 times.
FOR loop_pth = 1 TO 5 DO
  WRITE ('Moving Along pth1 ',loop_pth::2, ' times',cr)
      -- Display the loop iteration
      -- NOTICE: that "loop_pth::2" will cause 2 blanks to be
      -- displayed after "pth1 '" and before loop_pth.
```

```
  MOVE ALONG pth1
ENDFOR
WRITE TPFUNC    (CHR(128),CHR(137))  -- Home Cursor and Clear to
                                     -- End-of-line.  This will remove
                                     -- the ABORT displayed above F1.
WRITE ('pth_move Successfully Completed',cr)
END PTH_MOVE
```

B.7 LISTING FILES AND PROGRAMS AND MANIPULATING STRINGS

This program displays the list of files on the FLPY: device, and lists the programs loaded on the controller. It also shows basic STRING manipulating capabilities, using semi-colons(;) as a statement separator, and nesting IF statements.

Listing Files and Programs and Manipulating Strings - Overview

```
------------------------------------------------------------------------------
----    LIST_EX.Kl
------------------------------------------------------------------------------
----    Section 0:  Detail about LIST_EX.kl
------------------------------------------------------------------------------
---- Elements of KAREL Language Covered:    In Section:
----    Actions:
----    Clauses:
----            FROM                       Sec 3-B
----
----    Conditions:
----    Data types:
----            ARRAY OF STRING            Sec 2
----            BOOLEAN                    Sec 2, 3
----            INTEGER                    Sec 2, 3
----            STRING                     Sec 2
----    Directives:
----            %COMMENT                   Sec 1
----            %NOLOCKGROUP               Sec 1
----    Built-in Functions & Procedures:
----            ABS                        Sec 4-A
----            ARRAY_LEN                  Sec 4-C&D
----            CNV_INT_STR                Sec 4-A
----            FILE_LIST                  Sec 4-C
----            LOAD                       Sec 4-B
----            LOAD_STATUS                Sec 4-B
----            PROG_LIST                  Sec 4-D
----            ROUND                      Sec 4-A
```

```
----            SUB_STR                     Sec 4-A
```

Listing Files and Programs and Manipulating Strings - Overview Continued

```
----    Statements:
----            FOR .... ENDFOR             Sec 3-B
----            IF...THEN...ENDIF           Sec 4-A,B,C,D
----            ROUTINE                     Sec 3-A,B,C
----            REPEAT...UNTIL              Sec 4-C,D
----            RETURN                      Sec 3-A
----            WRITE                       Sec 3-B; 4-A,B
----    Reserve Words:
----             BEGIN                      Sec 3-A,B; 4
----             CONST                      Sec 2
----             CR                         Sec 3-B; 4-A,B
----             END                        Sec 3-A,B, 4-B
----             PROGRAM                    Sec 1
----             VAR                        Sec 2
----
----    Operators:
----             MOD                        Sec 3-A
----             /                          Sec 3-A
----             *                          Sec 3-A
----    Devices Used:
----             FLPY:                      Sec 4-C
----    Basic Concepts:
----         Semi-colon(;) as statement separator
----         Nested IF..THEN..ELSE..IF..THEN..ELSE..ENDIF..ENDIF structure
----         Concatenation of STRINGS using '+'
----
```

Listing Files and Programs and Manipulating Strings - Declarations Section

```
--------------------------------------------------------------------------------
----    Section 1:  Program and Environment Declaration
--------------------------------------------------------------------------------
PROGRAM LIST_EX
%NOLOCKGROUP   ---- Don't lock any motion groups
%COMMENT = 'FILE_LIST'
--------------------------------------------------------------------------------
----    Section 2:  Constant and Variable Declarations
--------------------------------------------------------------------------------
CONST
      INCREMENT   = 13849
      MODULUS     = 65536
```

```
      MULTIPLIER  = 25173
VAR
      pr_cases      :STRING[6]  -- psuedo random number converted to string
      prg_nm        :STRING[50] -- Concatenated program name
      loaded        :BOOLEAN    -- Used to see if program is loaded
      initi         :BOOLEAN    -- Used to see if variables initialized
      indx1    :INTEGER   -- FOR loop index
      cases,                    -- Random number returned
      max_number,               -- Maximum random number
      seed     :INTEGER   -- Seed for generating a random number
      file_spec     :STRING[20] -- File specification for FILE_LIST
      n_files       :INTEGER    -- Number of files returned from FILE_LIST
      n_skip        :INTEGER    -- Number to skip for FILE_LIST & PROG_LIST
      format        :INTEGER    -- Format of returned names
                                -- For FILE_LIST & PROG_LIST
      ary_nam       :ARRAY[9] OF STRING[20] -- Returned names
                                            -- from FILE_LIST & PROG_LIST
      prog_name     :STRING[10] -- Program names to list from PROG_LIST
      prog_type     :INTEGER    -- Program types to list form PROG_LIST
      n_progs       :INTEGER    -- Number of programs returned from PROG_LIST
      status    :INTEGER   -- Status of built-in procedure call
```

Listing Files and Programs and Manipulating Strings - Declare Routines

```
--------------------------------------------------------------------------------
----    Section 3:  Routine Declaration
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
----    Section 3-A:  RANDOM Declaration
---                  Creates a pseudo-random number and returns the number.
--------------------------------------------------------------------------------
ROUTINE random(seed : INTEGER) : REAL
BEGIN
  seed = (seed * MULTIPLIER + INCREMENT) MOD MODULUS
  RETURN(seed/65535.0)
END random
--------------------------------------------------------------------------------
----    Section 3-B:  DISPL_LIST  Declaration
----                   Display maxnum elements of ary_nam.
--------------------------------------------------------------------------------
ROUTINE displ_list(maxnum :INTEGER)
BEGIN
  FOR indx1 = 1 TO maxnum DO ;  WRITE (ary_nam[indx1],cr);   ENDFOR
  -- Notice the use of the semi-colon, which allows multiple statements
  -- on a line.
END displ_list
```

```
--------------------------------------------------------------------------------
----    Section 3-C:  TP_CLS  Declaration
----                  This routine is from ROUT_EX.KL and will
----                  clear the TP USER menu screen and force it to be visible.
--------------------------------------------------------------------------------
ROUTINE tp_cls FROM rout_ex
```

Listing Files and Programs and Manipulating Strings - Main Program

```
--------------------------------------------------------------------------------
----    Section 4:  Main Program
--------------------------------------------------------------------------------
BEGIN -- LIST_EX
tp_cls                -- Use routine from the rout_ex.kl file
--------------------------------------------------------------------------------
----  Section 4-A: Generate a pseudo random number, convert INTEGER to STRING
--------------------------------------------------------------------------------
max_number = 255 ;                          -- So the random number is 0..255
seed = 259 ;
  WRITE ('Manupulating String',cr)
  cases = ROUND(ABS((random(seed)*max_number)))-- Call random then take the
                                              -- absolute value of the number
                                              -- returned and round off the
                                              -- number.
  CNV_INT_STR(cases, 1, 0, pr_cases)          -- Convert cases to its
                                              -- ascii representation
  pr_cases =  SUB_STR(pr_cases, 2,3)          -- get at most 3 characters,
                                              -- starting at the second
                                              -- character, since first
                                              -- character is a blank.
```

Listing Files and Programs and Manipulating Strings - Create and Load Program

```
--------------------------------------------------------------------------------
----    Section 4-B: Build a program name from the number and try to load it
--------------------------------------------------------------------------------
  --- Build a random program name to show the manipulation of
  --- STRINGS and INTEGERs.
  prg_nm = 'MYPROG' + pr_cases + '.PC'     -- Concatenate the STRINGs together
                                           -- which create a program name
  --- Verify that the program is not already loaded
  WRITE ('Checking load status of ',prg_nm,cr)
  LOAD_STATUS(prg_nm, loaded, initi)
  IF (NOT loaded) THEN                      -- The program is not loaded
     WRITE ('Loading ',prg_nm,cr)
```

```
    LOAD(prg_nm, 0 , status)              -- Load in the program
    IF (status =  0 ) THEN                -- Verify load is successful
       WRITE ('Loading ','MYPROG' + pr_cases + '.VR',cr)
       LOAD('MYPROG' + pr_cases + '.VR', 0, status) -- Load the .vr file
       IF (status <> 0 ) THEN             -- Loading variables failed
          WRITE ('Loading of ', 'MYPROG' + pr_cases + '.VR', ' failed',cr)
          WRITE ('Status = ',status);
       ENDIF
    ELSE                                  -- Load of program failed
       IF (status = 10003) THEN           -- File does not exist
          WRITE (prg_nm, ' file does not exist',cr)
       ELSE
          WRITE ('Loading of ',prg_nm, ' failed',cr,'Status = ',status);
       ENDIF
    ENDIF

ELSE                                      -- The program is already loaded
    IF (NOT initi) THEN                   -- Variables not initialized
       WRITE ('Loading ','MYPROG' + pr_cases + '.VR',cr)
       LOAD('MYPROG' + pr_cases + '.VR', 0, status) -- Load in variables
       IF (status <> 0 ) THEN             -- Load of variables failed
          WRITE ('Loading of ', 'MYPROG' + pr_cases + '.VR', ' failed',cr)
          WRITE ('Status = ',status);
       ENDIF
    ENDIF
ENDIF
```

Listing Files and Programs and Manipulating Strings - List Programs

```
--------------------------------------------------------------------------------
---- Section 4-C: Check the file listing of the drive FLPY: and display them
--------------------------------------------------------------------------------
  --- Display a directory listing of files on the Flpy:
  file_spec = 'FLPY:*.*'      -- All files in FLPY: drive
  n_skip = 0                  -- First time do not skip any files
  format = 3                  -- Return list in filename.filetype format
  WRITE ('Doing File list',cr)
  REPEAT                      -- UNTIL all files have been listed
    FILE_LIST(file_spec, n_skip, format, ary_nam, n_files, status)
    IF (status <>0 ) THEN     -- Error occurred
       WRITE ('FILE_LIST builtin failed with Status = ',status,cr)
    ELSE
       displ_list(n_files)    -- Write the names to the TP USER menu
       n_skip = n_skip + n_files  -- Skip the files we already got.
    ENDIF
  UNTIL (ARRAY_LEN(ary_nam) <> n_files) -- When n_files does not equal
```

```
                                        -- declared size of ary_name then
                                        --  all files have been listed.
-------------------------------------------------------------------------------
----    Section 4-D: Show the programs loaded in controller
-------------------------------------------------------------------------------
  --- Display the list of programs loaded on the controller
  prog_name = '*'            -- All program names should be listed
  prog_type = 6              -- Only PC type files should be listed
  n_skip = 0                 -- First time do not skip any file
  format = 2                 -- Return list in  filename.filetype format
  WRITE ('Doing Program list',cr)
  REPEAT                    -- UNTIL all programs have been listed
    PROG_LIST(prog_name, prog_type, n_skip, format, ary_nam, n_progs, status)
    -- The program names are stored in ary_nam
    -- n_progs is the number of program names stored in ary_nam
    IF (status <>0 ) THEN
       WRITE ('PROG_LIST builtin failed with Status = ',status,cr)
    ELSE
       displ_list(n_progs)              -- Display the current list
       n_skip = n_skip + n_progs        -- Skip the programs already listed
    ENDIF
  UNTIL (ARRAY_LEN(ary_nam) <> n_progs)  -- When n_files does not equal the
                                        -- declared size of ary_name then all
                                        --  programs have been listed.
END LIST_EX
```

B.8 GENERATING AND MOVING ALONG A HEXAGON PATH

This program generates a hexagon path and moves along each side of the hexagon.

Generate and Move Along Hexagon Path - Overview

```
-------------------------------------------------------------------------------
----    GEN_HEX.KL
-------------------------------------------------------------------------------
----    Section 0:  Detail about GEN_HEX.KL
-------------------------------------------------------------------------------
---- Elements of KAREL Language Covered: In Section:---- Action:---- Clauses:
----            WITH                        Sec 3-B; 4-B
----    Conditions:----    Data types:
----            ARRAY OF REAL               Sec 3-B
----            ARRAY OF XYZWPR             Sec 2
----            INTEGER                     Sec 2; 3-A,B
----            JOINTPOS6                   Sec 2
----            REAL                        Sec 3-A
```

```
----    Directives:
              %COMMENT                    Sec 1----    Built-in Functions &
                                                       Procedures:
----           CHECK_EPOS                  Sec 4-B
----           CNV_REL_JPOS                Sec 3-B
----           COS                         Sec 3-A
----           CURPOS                      Sec 4-A
----           SIN                         Sec 3-A----    Statements:
----           CONNECT TIMER               Sec 4-A
----           FOR ... ENDFOR              Sec 3-A,B; 4-B
----           MOVE TO                     Sec 3-B; 4-B
----           ROUTINE                     Sec 3-A,B
----           WRITE                       Sec 4-A,B----    Reserve Word:
----           BEGIN                       Sec 3-A,B; 4
----           CONST                       Sec 2
----           CR                          Sec 4-A
----           END                         Sec 3-A,B; 4-B
----           PROGRAM                     Sec 1
----           VAR                         Sec 2
```

Generate and Move Along Hexagon Path - Declaration Section

```
--------------------------------------------------------------------------------
----    Section 1:  Program and Environment Declaration
--------------------------------------------------------------------------------
PROGRAM gen_hex
%COMMENT = 'HEXAGON'
--------------------------------------------------------------------------------
----    Section 2:  Constant and Variable Declaration
--------------------------------------------------------------------------------
CONST
  L_HEX_SIDE = 300            -- Length of one side of the hexagon
  NUM_AXES      = 6               -- Number of robot axesVAR
  p_cntr         : JOINTPOS6   -- Center of the hexagon
  p_xyzwpr        : ARRAY[NUM_AXES] OF XYZWPR
                 -- Six vertices of the hexagon  clock,
  t_start,
  t_end,
  t_total        : INTEGER  status,
  p_indx            : INTEGER
```

Generate and Move Along Hexagon Path - Declare Routines

```
--------------------------------------------------------------------------------
----    Section 3:  Routine Declaration
```

```
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
----    Section 3-A:  R_CALC_HEX Declaration
----                  Calculates the hexagon points based on distance
----                  between point 1 and 4 of the hexagon.
--------------------------------------------------------------------------------
ROUTINE r_calc_hex
VAR
  p1_to_pcntr : REAL -- Distance from the center of the hex to point 1
  vertice     : INTEGER   -- the index used specify each vertice of hexagon
BEGIN
  p1_to_pcntr = (L_HEX_SIDE / 2) + (L_HEX_SIDE * COS(60))
  p_xyzwpr[1] = p_cntr      -- p_cntr was calculated in r_hex_center
  p_xyzwpr[1].y = p_xyzwpr[1].y - p1_to_pcntr --set the first vertice of hex
  FOR vertice = 2 TO NUM_AXES DO   -- start at 2 since 1 is already set
    p_xyzwpr[vertice] = p_xyzwpr[1]   -- Intialize all vertices
  ENDFOR
  -- Calculating individual components for each vertice of the hexagon
  p_xyzwpr[2].x = p_xyzwpr[1].x + (L_HEX_SIDE * SIN(60))
  p_xyzwpr[2].y = p_xyzwpr[1].y + (L_HEX_SIDE * COS(60))
  p_xyzwpr[3].x = p_xyzwpr[1].x + (L_HEX_SIDE * SIN(60))
  p_xyzwpr[3].y = p_xyzwpr[1].y + (L_HEX_SIDE + (L_HEX_SIDE * COS(60)))

  p_xyzwpr[4].y = p_xyzwpr[1].y + (L_HEX_SIDE + (2 * (L_HEX_SIDE * COS(60)))
  p_xyzwpr[5].x = p_xyzwpr[1].x - (L_HEX_SIDE * SIN(60))
  p_xyzwpr[5].y = p_xyzwpr[3].y
  p_xyzwpr[6].x = p_xyzwpr[1].x - (L_HEX_SIDE * SIN(60))
  p_xyzwpr[6].y = p_xyzwpr[2].y
END r_calc_hex
```

Generate and Move Along Hexagon Path - Declare Routines

```
--------------------------------------------------------------------------------
----    Section 3-B:  R_CALC_HEX Declaration
----                  Positions the face plate perpendicular
----                  to the xy world coordinate plane.
--------------------------------------------------------------------------------
ROUTINE r_hex_center
VAR
  status, indx   : INTEGER
  p_cntr_arry    : ARRAY[NUM_AXES] OF REAL
BEGIN
-- Initalize the center position array to zero
  FOR indx = 1 TO NUM_AXES DO
     p_cntr_arry[indx] = 0
  ENDFOR
```

```
-- Set JOINT 3 and 5 to -45 and 45 degrees
  p_cntr_arry[3] = -45
  p_cntr_arry[5] =  45-- Convert the REAL array to a joint position,
p_cntr
  CNV_REL_JPOS(p_cntr_arry,p_cntr,status)
  $motype  = JOINT
  WITH $GROUP[1].$SPEED = 1000
       MOVE TO p_cntr

END r_hex_center
```

Generate and Move Along Hexagon Path - Main Program

```
-------------------------------------------------------------------------------
----    Section 4:  Main Program
-------------------------------------------------------------------------------
BEGIN  --- GEN_HEX
-------------------------------------------------------------------------------
----    Section 4-A: Connect timer, set uframe, call routines
-------------------------------------------------------------------------------
  clock = 0                  -- Initialize clock value to zero
  CONNECT TIMER TO clock                   -- Connect the timer
  WRITE ('Moving to the center of the HEXAGON',CR) -- update user of process
  r_hex_center                       -- position the face plate of robot.
  $UFRAME = CURPOS(0,0)              -- Set uframe to CURPOS of the robot.
  WRITE ('Calculating the sides of HEXAGON',CR)  -- update user
  r_calc_hex                         -- Calculate the hexagon points
-------------------------------------------------------------------------------
----    Section 4-B: Move on sides of hexagon
-------------------------------------------------------------------------------
  WRITE ('Moving along the sides of the Hexagon',CR) -- Update user
  $MOTYPE   = JOINT           -- Set the system variable $GROUP[1].$MOTYPE
  $SPEED    = 2000            -- Set the system variable $GROUP[1].$SPEED
  $TERMTYPE = FINE            -- Set the system variable $GROUP[1].$TERMTYPE
  t_start = clock        -- Record the time before motion begins

  FOR p_indx = 1 TO 6 DO
   -- Verify that the position is reachable
   CHECK_EPOS ((p_xyzwpr[p_indx]), $UFRAME, $UTOOL, status)
   IF (status <> 0) THEN
    WRITE ('unable to move to p_xyzwpr[', p_indx,']',CR);
   ELSE
    MOVE TO p_xyzwpr[1]         -- Move to first vertice of hexagon
   ENDIF
  ENDFOR
  MOVE TO p_xyzwpr[1]         -- Move back to first vertice of hexagon
```

```
  WITH $GROUP[1].$MOTYPE = LINEAR MOVE TO p_cntr -- Move TCP in a straight
                                                 -- line to the center position
  t_end = clock                        -- Record ending time
  WRITE('Total motion time = ',t_end-t_start,CR) --Display the total time for
                                                 -- motion.
                                                 -- NOTE that the total was
                                                 -- computed in the
WRITE
                                                 -- statement.
END GEN_HEX£
```

B.9 USING THE FILE AND DEVICE BUILT-INS

This program demonstrates how to use the File and Device built-ins. This program FORMATS and MOUNTS the RAM disk. Then copies files from the FLPY: device to RD:. If the RAM disk gets full the RAM disk size is increased and reformatted. This program continues until either all the files are copied successfully, or the built-in operations fail.

File and Device Built-ins Program - Overview

```
--------------------------------------------------------------------------------
----    FILE_EX.Kl
--------------------------------------------------------------------------------
----    Section 0:  Detail about FILE_EX.kl
--------------------------------------------------------------------------------
---- Elements of KAREL Language Covered:            In Section:
----    Action:
----    Clauses:
----            FROM                            Sec 3
----    Conditions:
----    Data types:
----              BOOLEAN                         Sec 2
----             INTEGER                          Sec 2
----              STRING                          Sec 2
----    Directives:
----              COMMENT                         Sec 1
----             NOLOCKGROUP                      Sec 1
----    Built-in Functions & Procedures:
----              CNV_TIME_STR                    Sec 4-A
----              COPY_FILE                       Sec 4-B
----              DISMOUNT_DEV                    Sec 4-B
----              FORMAT_DEV                      Sec 4-B
----              GET_TIME                        Sec 4-A
----              MOUNT_DEV                       Sec 4-B
----              PURGE_DEV                       Sec 4-B
```

```
----              SUB_STR                          Sec 4-A
----    Statements:
----  IF...THEN...ELSE...ENDIF          Sec 4-B
----  REPEAT...UNTIL                    Sec 4-A
----  ROUTINE                           Sec 3
----  SELECT...ENDSELECT                Sec 4-B
----  WRITE                             Sec 4-A,B
```

File and Device Built-ins Program - Overview Continued

```
----    Reserve Words:
----              BEGIN                          Sec 4
----              CONST                          Sec 2
----              CR                             Sec 4-A,B
----              END                            Sec 4-B
----              PROGRAM                        Sec 4
----              VAR                            Sec 2
----    Devices Used:
----              FLPY                           Sec 4-B
----              MF3                            Sec 4-B
----              RD                             Sec 4-B
----              FR                             Sec 4-B
```

File and Device Built-ins Program - Declaration Section, Declare Routines

```
-------------------------------------------------------------------------------
----    Section 1:  Program and Environment Declaration
-------------------------------------------------------------------------------
PROGRAM FILE_EX
%nolockgroup
%comment = 'COPY FILES'
-------------------------------------------------------------------------------
----    Section 2:  Variable Declaration
-------------------------------------------------------------------------------
CONST
    SUCCESS     = 0          -- Success status from builtins
    FINISHED    = TRUE        -- Finished Copy
    TRY_AGAIN   = FALSE       -- Try to copy again
    RD_FULL     = 85020       -- RAM disk full
    NOT_MOUNT   = 85005       -- Device not mounted
    FR_FULL     = 85001       -- FROM disk is full
    MNT_RD      = 85004       -- RAM disk must be mounted
  --Refer to
```

FANUC Robotics SYSTEM R-J3iC Controller KAREL

```
Setup and Operations Manual for an Error Code listing
VAR
    time_int    : INTEGER
    time_str    : STRING[30]
    status      : INTEGER
    cpy_stat    : BOOLEAN
    to_dev      : STRING[5]
--------------------------------------------------------------------------------
----    Section 3: Routine Declaration
--------------------------------------------------------------------------------
ROUTINE tp_cls FROM ROUT_EX
--------------------------------------------------------------------------------
----    Section 4: Main program
--------------------------------------------------------------------------------
BEGIN  -- FILE_EX
  tp_cls     -- from rout_ex.kl
--------------------------------------------------------------------------------
----    Section 4-A: Get Time and FORMAT ramdisk with date as volume name
--------------------------------------------------------------------------------
 GET_TIME(time_int)                                -- Get the system time
 CNV_TIME_STR(time_int, time_str)                  -- Convert the INTEGER time
                                                   -- to readable format
 WRITE ('Today is ', SUB_STR(time_str, 2,8),CR)    -- Display the date part
 WRITE ('Time is ', SUB_STR(time_str, 11,5),CR)    -- Display the time part
```

File and Device Built-ins Program - Mount and Copy to RAM Disk

```
--------------------------------------------------------------------------------
----    Section 4-B: Mount RAMDISK and start copying from FLPY to
MF3:
--------------------------------------------------------------------------------
to_dev = 'MF3:'
REPEAT                            -- Until all files have been copied
  cpy_stat = FINISHED
  WRITE('COPYing......',cr)
  -- Copy the files from FLPY: to to_dev and overwrite the file if it
  -- already exists.
  COPY_FILE('FLPY:*.kl', to_dev, TRUE, FALSE, status)
  SELECT (status) OF
    CASE (RD_FULL):               -- RAM disk is full
                                  -- Dismount and re-size the RAM-DISK
      WRITE ('DISMOUNTing RD: ....',cr)
      DISMOUNT_DEV('RD:', status)
                                  -- Verify DISMOUNT was successful or that
```

```
                              -- the device was not already mounted
        IF (status = SUCCESS) OR (status = NOT_MOUNT) THEN
             -- Increase the size of RD:
          WRITE('Increasing RD: size...',cr)
          $FILE_MAXSEC = ROUND($FILE_MAXSEC * 1.2)
                              -- Increase the RAM disk size
                              -- Format the RAM-DISK
          WRITE('FORMATTING RD:......',cr)
          FORMAT_DEV('RD:','' ,FALSE, status) -- Format the RAM disk
          IF (status <> SUCCESS) THEN
            WRITE ('FORMAT of RD: failed, status:', status,CR)
            WRITE ('Copy incomplete',cr)
          ELSE
            cpy_stat = TRY_AGAIN
          ENDIF
          WRITE('MOUNTing RD:......',cr)
          MOUNT_DEV ('RD:', status)
          IF (status <> SUCCESS) THEN
            WRITE ('MOUNTing of RD: failed, status:', status,CR)
            WRITE ('Copy incomplete',cr)
          ELSE
            cpy_stat = TRY_AGAIN
          ENDIF
        ELSE
          WRITE ('DISMOUNT of RD: failed, status:', status,cr)
          WRITE ('Copy incomplete',cr)
        ENDIF
```

File and Device Built-ins Program - Mount and Copy to RAM Disk Continued

```
    CASE (FR_FULL):     -- FROM disk is full
          WRITE ('FROM disk is full',CR, 'PURGING FROM.....', CR)
          PURGE_DEV ('FR:', status)   -- Purge the FROM
          IF (status <> SUCCESS) THEN
            WRITE ('PURGE of FROM failed, status:', status, CR)
            WRITE ('Copy incomplete', CR)
          ELSE
            cpy_stat = TRY_AGAIN
          ENDIF
    CASE (NOT_MOUNT, MNT_RD):    -- Device is not mounted
          WRITE ('MOUNTing ',to_dev,'.....',CR)
          MOUNT_DEV(to_dev, status)
          IF (status <> SUCCESS) THEN
            WRITE ('MOUNTing of ',to_dev,': failed, status:', status, CR)
            WRITE ('Copy incomplete', CR)
          ELSE
```

```
        cpy_stat = TRY_AGAIN
      ENDIF
CASE (SUCCESS):
      WRITE ('Copy completed successfully!',CR)
ELSE:
      WRITE ('Copy failed, status:', status,CR)
ENDSELECT
UNTIL (cpy_stat = FINISHED)
END file_ex
```

B.10 USING DYNAMIC DISPLAY BUILT-INS

This program demonstrates how to use the dynamic display built-ins. This program initiates the dynamic display of various data types. It then executes another task, CHG_DATA, which changes the values of these variables.

Before exiting this program the dynamic displays are cancelled and the other task is aborted. If DYN_DISP is aborted, it will set a variable which CHG_DATA detects. This ensures that CHG_DATA cannot continue executing once DYN_DISP is aborted.

Using Dynamic Display Built-ins - Overview

```
------------------------------------------------------------------------------
----    DYN_DISP.Kl
------------------------------------------------------------------------------
----    Section 0:  Detail about DYN_DISP.KL
------------------------------------------------------------------------------
---- Elements of KAREL Language Covered:         In Section:
----    Actions:
----    Clauses:
----                FROM                            Sec 3-C
----                IN CMOS                         Sec 2
----                WHEN                            Sec 4
----    Conditions:
----                ABORT                           Sec 4
----    Data types:
----                BOOLEAN                         Sec 2
----                INTEGER                         Sec 2
----                REAL                            Sec 2
----                STRING                          Sec 2
----    Directives:
----                ALPHABETIZE                     Sec 1
----                COMMENT                         Sec 1
----                NOLOCKGROUP                     Sec 1
```

Using Dynamic Display Built-ins - Overview Continued

```
----    Built-in Functions & Procedures:
----                ABORT_TASK                      Sec 4-C
----                CNC_DYN_DISI                    Sec 4-C
----                CNC_DYN_DISR                    Sec 4-C
----                CNC_DYN_DISB                    Sec 4-C
----                CNC_DYN_DISE                    Sec 4-C
----                CNC_DYN_DISP                    Sec 4-C
----                CNC_DYN_DISS                    Sec 4-C
----                INI_DYN_DISI                    Sec 3-A, 4-A
----                INI_DYN_DISR                    Sec 3-B, 4-A
----                INI_DYN_DISB                    Sec 3-C, 4-A
----                INI_DYN_DISE                    Sec 3-D, 4-A
----                INI_DYN_DISP                    Sec 3-E, 4-A
----                INI_DYN_DISS                    Sec 3-F, 4-A
----                LOAD_STATUS                     Sec 4-B
----                LOAD                            Sec 4-B
----                RUN_TASK                        Sec 4-B
----
----    Statements:
----                CONDITION...ENDCONDITION        Sec 4
----                IF...THEN...ENDIF               Sec 4-A,B,C
----                READ                            Sec 4-C
----                ROUTINE                         Sec 3-A,B,C
----                WRITE                           Sec 4-A,B,C
----
----    Reserve Words:
----                BEGIN                           Sec 3-A,B; 4
----                CR                              Sec 4-A
----                CONST                           Sec 2
----                END                             Sec 3-A,B; 4-C
----                PROGRAM                         Sec 4
----                VAR                             Sec 2
----    Predefined File Variables:
----               TPPROMPT                         Sec 4-B,C
----    Predefined Windows:
----               T_FU                             Sec 3-A,B
```

Using Dynamic Display Built-ins - Declaration Section

```
--------------------------------------------------------------------------------
----    Section 1:  Program and Environment Declaration
--------------------------------------------------------------------------------
PROGRAM DYN_DISP
%nolockgroup
```

```
%comment = 'Dynamic Disp'
%alphabetize
%INCLUDE KLIOTYPS
-------------------------------------------------------------------------------
----    Section 2:  Variable Declaration
-------------------------------------------------------------------------------
CONST
  cc_success     = 0      -- Success status
  cc_clear_win   = 128    -- Clear window
  cc_clear_eol   = 129    -- Clear to end of line
  cc_clear_eow   = 130    -- Clear to end of window
  CH_ABORT       = 1      -- Condition Handler to detect when program aborts
VAR
  Int_wind          :STRING[10]
  Rel_wind          :STRING[10]
  Field_Width       :INTEGER
  Attr_Mask         :INTEGER
  Char_Size         :INTEGER
  Row               :INTEGER
  Col               :INTEGER
  Interval          :INTEGER
  Buffer_Size       :INTEGER
  Format            :STRING[7]
  bool_names        :ARRAY[2] OF STRING[10]
  enum_names        :ARRAY[4] OF STRING[10]
  pval_names        :ARRAY[2] OF STRING[10]
  bool1 IN CMOS     :BOOLEAN
  enum1 IN CMOS     :INTEGER
  port_type         :INTEGER
  port_no           :INTEGER
  Str1  IN CMOS     :STRING[10]
  Int1  IN CMOS     :INTEGER    -- Using IN CMOS will create the variables
  Real1 IN CMOS     :REAL       -- in CMOS RAM, which is permanent memory.
  status            :INTEGER
  loaded,
  initialized       :BOOLEAN
  dynd_abrt         :BOOLEAN  -- Set to true when program aborts.
```

Using Dynamic Display Built-ins - Declare Routines

```
-------------------------------------------------------------------------------
----    Section 3: Routine Declaration
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
----    Section 3-A: SET_INT Declaration
----                  Set all the input parameters for the INI_DYN_DISI call.
```

```
--------------------------------------------------------------------------------
ROUTINE Set_Int
Begin
  -- Valid predefined windows are described in
  -- Chapter 7.9.1, "USER MENU on the Teach Pendant
  --    Error  Line     --> 'ERR'   1  line
  --    Status Line     --> 'T_ST'  3  lines
  --    Display Window  --> 'T_FU'  10 lines
  --    Prompt Line     --> 'T_PR'  1  line
  --    Function Key    --> 'T_FK'  1  line
  Int_Wind          = 'T_FU'            -- Use the predefined display window
  Field_Width       = 0                 -- Use the minimum width necessary
  Attr_Mask         = 1 OR 4            -- BOLD and UNDERLINED
  Char_Size         = 0                 -- Normal
  Row               = 1                 -- Specify the location within 'T_FU'
  Col               = 16                --    to dynamically displayed
  Interval          = 250                -- 250ms between updates
  Buffer_Size       = 10                -- Minimum value required.
  Format            = '%-8d'            -- 8 character minimum field width
--- With this specification the INTEGER will be displayed as follows:
---               --------
---              |xxxxxxxx|
---               --------
---      Where the integer value  will be left justified.
---      The x's will be the integer value unless the integer value is
---      less then 8 characters, then the right side will be blanks up to
---      a total 8 characters.  If the integer value is greater than the 8
---      characters the width is dynamically increased to display the whole
---      integer value.  The INTEGER value will also be bold and underlined.
End Set_Int
```

Using Dynamic Display Built-ins - Declare Routines Continued

```
--------------------------------------------------------------------------------
----    Section 3-B: SET_REAL Declaration
----                 Set all the input parameters for the INI_DYN_DISR call.
--------------------------------------------------------------------------------
ROUTINE Set_Real
Begin
  Rel_Wind          = 'T_FU'            -- Use the predefined display window
  Field_Width       = 10                -- Maximum width of display.
  Attr_Mask         = 2 OR 8            -- blinking and reverse video
  Char_Size         = 0                 -- Normal
  Row               = 2                 -- Specify the location within 'TFU'
  Col               = 16                --    to dynamically display
  Interval          = 200               -- 200ms between update
```

```
  Buffer_Size       = 10                -- Minimum value required.
  Format            = '%2.2f'
--- With the format and field_width specification the REAL will be
--- displayed as follows:
---               ----------
---              |xxxx.xx   |
---               ----------
---      Where the real value  will be left justified.
---      There will always be two digits after the decimal point.
---      A maximum width of 10 will be used.
---      If the real value is less then 10 characters the right side will be
---      padded with blanks up to 10 character width.
---      If the real value exceeds 10 characters, the display width will not
---      expand but will display a ">" as the last character, indicating the
---      entire value is not displayed.
---      The value will also be blinking and in reverse video.
End Set_Real
```

Using Dynamic Display Built-ins - Declare Routines Continued

```
--------------------------------------------------------------------------------
----    Section 3-C: SET_BOOL Declaration
----                  Set all the input parameters for the INI_DYN_DISB call
--------------------------------------------------------------------------------
ROUTINE Set_Bool
Begin
  -- Valid predefined windows are described in
  -- Chapter 7.9.1, "USER MENU on the Teach Pendant
  --    Error  Line     --> 'ERR'   1  line
  --    Status Line     --> 'T_ST'  3  lines
  --    Display Window  --> 'T_FU'  10 lines
  --    Prompt Line     --> 'T_PR'  1  line
  --    Function Key    --> 'T_FK'  1  line
  Int_Wind            = 'T_FU'          -- Use the predefined display window
  Field_Width       = 10                -- Display 10 chars
  Attr_Mask         = 2                 -- Blinking
  Char_Size         = 0                 -- Normal
  Row               = 3                 -- Specify the location within 'T_FU'
  Col               = 16                --    to dynamically displayed
  Interval          = 250               -- 250ms between updates
  Buffer_Size       = 10                -- Minimum value required
  bool_names[1]     = 'YES'             -- string display in bool_var is FALSE
  bool_names[2]     = 'NO'              -- string display in bool_var is TRUE
--- With this specification the BOOLEAN will be displayed as follows:
---               --------
---              |xxxxxxxx|
```

```
---               --------
---      Where the boolean value will be left justified.
---      The x's will be one of the strings 'YES' or 'NO', depending on
---      the value of bool1.  The string will be blinking.
End Set_Bool
```

Using Dynamic Display Built-ins - Declare Routines Continued

```
--------------------------------------------------------------------------------
----    Section 3-D: SET_ENUM Declaration
----                  Set all the input parameters for the INI_DYN_DISE call.
--------------------------------------------------------------------------------
ROUTINE Set_Enum
Begin
  -- Valid predefined windows are described in
  -- Chapter 7.9.1, "USER MENU on the Teach Pendant
  --    Error  Line     --> 'ERR'   1  line
  --    Status Line     --> 'T_ST'  3  lines
  --    Display Window  --> 'T_FU'  10 lines
  --    Prompt Line     --> 'T_PR'  1  line
  --    Function Key    --> 'T_FK'  1  line
  Int_Wind          = 'T_FU'          -- Use thE predefined display window
  Attr_Mask         = 8                 -- REVERSED
  Field_Width       = 10                -- Display to characters
  Char_Size         = 0                 -- Normal
  Row               = 4                 -- Specify the location within 'T_FU'
  Col               = 16                --    to dynamically displayed
  Interval          = 250               -- 250ms between updates
  Buffer_Size       = 10                -- Minimum value required
  enum_names[1]     = 'Enum-0'          -- value displayed if enum_var = 0
  enum_names[2]     = 'Enum-1'          -- value displayed if enum_var = 1
  enum_names[3]     = 'Enum-2'          -- value displayed if enum_var = 2
  enum_names[4]     = 'Enum-3'          -- value displayed if enum_var = 3
--- With this specification enum_var will be displayed as follows:
---               --------
---              |xxxxxxxx|
---               --------
---      Where one of the strings enum_names will be displayed,
---      depending on the integer value enum1.  If enum1 is outside
---      the range 0-3, a string of 10 '?'s will be displayed.
---      The string will be displayed in reversed video.
End Set_Enum
```

Using Dynamic Display Built-ins - Declare Routines Continued

```
--------------------------------------------------------------------------------
----    Section 3-E: SET_PORT Declaration
----                 Set all the input parameters for the INI_DYN_DISP call.
--------------------------------------------------------------------------------
ROUTINE Set_Port
Begin
  -- Valid predefined windows are described in
  -- Chapter 7.9.1, "USER MENU on the Teach Pendant
  --    Error  Line     --> 'ERR'   1  line
  --    Status Line     --> 'T_ST'  3  lines
  --    Display Window  --> 'T_FU'  10 lines
  --    Prompt Line     --> 'T_PR'  1  line
  --    Function Key    --> 'T_FK'  1  line
  Int_Wind          = 'T_FU'          -- Use the predefined display window
  Field_Width       = 10              -- Display to characters
  Attr_Mask         = 1               -- BOLD
  Char_Size         = 0               -- Normal
  Row               = 5               -- Specify the location within 'T_FU'
  Col               = 16              --    to dynamically displayed
  Interval          = 250             -- 250ms between updates
  Buffer_Size       = 10              -- Minimum value required.
  pval_names[1]     = 'RELEASED'      -- text displayed if key is not pressed
  pval_names[2]     = 'PRESSED'       -- text displayed if key is pressed
  port_type         = io_tpin         -- port type = TP key
  port_no           = 175             -- user-key 3
--- With this specification PRESSED or RELEASED will be displayed as follows:
---               --------
---              |xxxxxxxx|
---               --------
---      Where the string will be left justified.
---      The x's will be either 'RELEASED' or 'PRESSED'.
---      The string will also be normal video.
---      (Bold is not supported on the teach pendant.)
End Set_Port
```

Using Dynamic Display Built-ins - Declare Routines Continued

```
--------------------------------------------------------------------------------
----    Section 3-F: SET_STR Declaration
----                 Set all the input parameters for the INI_DYN_DISS call.
--------------------------------------------------------------------------------
ROUTINE Set_Str
Begin
  -- Valid predefined windows are described in
  -- Chapter 7.9.1, "USER MENU on the Teach Pendant
  --    Error  Line     --> 'ERR'   1  line
```

```
  --    Status Line     --> 'T_ST'  3  lines
  --    Display Window  --> 'T_FU'  10 lines
  --    Prompt Line     --> 'T_PR'  1  line
  --    Function Key    --> 'T_FK'  1  line
  Int_Wind            = 'T_FU'          -- Use th predefined display window
  Field_Width       = 10                -- Use the minimum width neccessary
  Attr_Mask         = 1 OR 4            -- BOLD and UNDERLINED
  Char_Size         = 0                 -- Normal
  Row               = 6                 -- Specify the location within 'T_FU'
  Col               = 16                --    to dynamically displayed
  Interval          = 250               -- 250ms between updates
  Buffer_Size       = 10                -- Minimum value required.
  Format            = '%10s'            -- 10 character minimum field width
--- With this specification the STRING will be displayed as follows:
---               --------
---              |xxxxxxxx|
---               --------
---      Where the string value will be left justified.
---      The x's will be the string value.
---      The STRING will also be underlined.
End Set_Str
--------------------------------------------------------------------------------
----    Section 3-G: TP_CLS Declaration
----              Clear the TP USER menus screen and force it to be visible.
--------------------------------------------------------------------------------
ROUTINE tp_cls FROM rout_ex
```

Using Dynamic Display Built-ins - Initiate Dynamic Displays

```
--------------------------------------------------------------------------------
----    Section 4: Main program
--------------------------------------------------------------------------------
BEGIN --- DYN_DISP
dynd_abrt = FALSE
CONDITION[CH_ABORT]:
  WHEN ABORT DO      -- When the program is aborting set dynd_abrt flag.
                     -- This will be triggered if this program aborts itself
                     --  or if an external mechanism aborts this program.
    dynd_abrt = TRUE -- CHG_DATA will detect this and complete execution.
ENDCONDITION
ENABLE CONDITION [CH_ABORT]
--------------------------------------------------------------------------------
----    Section 4-A: Setup variables, initiate dynamic display
--------------------------------------------------------------------------------
  TP_CLS                                -- Clear the TP USER screen
                                        -- Force display of the TP USER screen
```

```
  STATUS = cc_success                  -- Initialize the status variable
  -- Initialize the dynamically displayed variables
  Int1       = 1
  Real1      = 1.0
  Bool1      = FALSE
  Enum1      = 0
  Strl       = ''
  -- Display messages to the TP USER screen
  WRITE ('Current INT1 =',CR)
  WRITE ('Current REAL1=',CR)
  WRITE ('Current BOOL1=',CR)
  WRITE ('Current ENUM1=',CR)
  WRITE ('Current PORT =',CR)
  WRITE ('Current STR1 =',CR)
  Set_Int                -- Set parameter values for INTEGER DYNAMIC DISPLAY
  INI_DYN_DISI(Int1,Int_Wind,Field_Width,Attr_Mask,Char_Size,
               Row,Col, Interval, Buffer_Size, Format ,Status)
  IF Status <> cc_success THEN -- Check the status
     WRITE(' INI_DYN_DISI failed, Status=',status,CR)
  ENDIF
 Set_Bool               -- Set parameter values for BOOLEAN DYNAMIC
DISPLAY
  INI_DYN_DISB(Bool1,Int_Wind,Field_Width,Attr_Mask,Char_Size,
               Row,Col, Interval, bool_names,Status)
  IF Status <> cc_success THEN -- Check the status
     WRITE(' INI_DYN_DISB failed, Status=',status,CR)
  ENDIF
```

Using Dynamic Display Built-ins - Initiate Dynamic Displays

```
Set_Enum                  -- Set parameter values for Enumerated Integer
                          --    DYNAMIC DISPLAY
  INI_DYN_DISE(Enum1,Int_Wind,Field_Width,Attr_Mask,Char_Size,
               Row,Col, Interval, enum_names,Status)
  IF Status <> cc_success THEN -- Check the status
     WRITE(' INI_DYN_DISE failed, Status=',status,CR)
  ENDIF
  Set_Port               -- Set parameter values for Port DYNAMIC DISPLAY
  INI_DYN_DISP(port_type, port_no ,Int_Wind,Field_Width,Attr_Mask,Char_Size,
               Row,Col, Interval, pval_names, Status)
  IF Status <> cc_success THEN -- Check the status
     WRITE(' INI_DYN_DISP failed, Status=',status,CR)
  ENDIF
  Set_Real                  -- Set parameter values for REAL DYNAMIC DISPLAY
  INI_DYN_DISR(Real1,Rel_Wind,Field_Width,Attr_Mask,Char_Size,
               Row,Col, Interval, Buffer_Size, Format ,Status)
```

```
  IF Status <> cc_success THEN -- Check the status
     WRITE(' INI_DYN_DISR failed, Status=',status,CR)
  ENDIF
 Set_Str                -- Set parameter values for STRING DYNAMIC
DISPLAY
  INI_DYN_DISS(Str1,Int_Wind,Field_Width,Attr_Mask,Char_Size,
               Row,Col, Interval, Buffer_Size, Format ,Status)
  IF Status <> cc_success THEN -- Check the status
     WRITE(' INI_DYN_DISS failed, Status=',status,CR)
  ENDIF
```

Using Dynamic Display Built-ins - Execute Subordinate Task

```
--------------------------------------------------------------------------------
----    Section 4-B: Check on subordinate program and execute it.
--------------------------------------------------------------------------------
  -- Check the status of the other program which will change the value
  -- of the variables.
  LOAD_STATUS('chg_data', loaded, initialized)
  IF (loaded = FALSE ) THEN
    WRITE TPPROMPT(CHR(cc_clear_win))            -- Clear the prompt line
    WRITE TPPROMPT('CHG_DATA is not loaded. Loading now...')
    LOAD('chg_data.pc',0,status)
    IF (status =  cc_success) THEN              -- Check the status
      RUN_TASK('CHG_DATA',1,false,false,1,status)
      IF (Status <> cc_success) THEN              -- Check the status
        WRITE ('Changing the value of the variables',CR)
        WRITE ('by another program failed',CR)
        WRITE ('BUT you can try changing the values',CR)
        WRITE ('from KCL',CR)
      ENDIF
    ELSE
      WRITE ('LOAD Failed, status = ',status,CR)
    ENDIF
  ELSE
    RUN_TASK('CHG_DATA',1,false,false,1,status)
    IF (Status <> cc_success) THEN                -- Check the status
      WRITE ('Changing the value of the variables',CR)
      WRITE ('by another program failed',CR)
      WRITE ('BUT you can try changing the values',CR)
      WRITE ('from KCL',CR)
    ENDIF
  ENDIF
```

Using Dynamic Display Built-ins - User Response Cancels Dynamic Displays

```
-------------------------------------------------------------------------------
----    Section 4-C: Wait for user response, and cancel dynamic displays
-------------------------------------------------------------------------------
  WRITE TPPROMPT(CHR(cc_clear_win))        -- Clear the prompt line
  WRITE TPPROMPT('Enter a number to cancel DYNAMIC display: ')
  READ (CR)                                -- Read only one character
                                           -- See Chapter 7.7.1,
                                           -- "Formatting INTEGER Data Items"
  ABORT_TASK('CHG_DATA',TRUE, TRUE,status)   -- Abort CHG_DATA
  IF (status <> cc_success) THEN             -- Check the status
     WRITE(' ABORT_TASK failed, Status=',status,CR)
  ENDIF
  CNC_DYN_DISI(Int1, Int_Wind,Status)       -- Cancel display of Intl
  IF Status <> 0 THEN                       -- Check the status
     WRITE(' CND_DYN_DISI failed, Status=',status,CR)
  ENDIF
  CNC_DYN_DISR(Real1,Rel_Wind,Status)       -- Cancel display of Real1
  IF Status <> 0 THEN                       -- Check the status
     WRITE(' CND_DYN_DISR failed, Status=',status,CR)
  ENDIF
  CNC_DYN_DISB(Bool1, Int_Wind,Status)      -- Cancel display of Bool1
  IF Status <> 0 THEN                       -- Check the status
     WRITE(' CND_DYN_DISB failed, Status=',status,CR)
  ENDIF
  CNC_DYN_DISE(Enum1, Int_Wind,Status)     -- Cancel display of Enum1
  IF Status <> 0 THEN                      -- Check the status
     WRITE(' CND_DYN_DISE failed, Status=',status,CR)
  ENDIF
  CNC_DYN_DISP(port_type, Port_no, Int_Wind,Status) -- Cancel display of Port
  IF Status <> 0 THEN                        -- Check the status
     WRITE(' CND_DYN_DISP failed, Status=',status,CR)
  ENDIF
  CNC_DYN_DISS(Str1, Int_Wind,Status)        -- Cancel display of String
  IF Status <> 0 THEN                        -- Check the status
     WRITE(' CND_DYN_DISS failed, Status=',status,CR)
  ENDIF
END DYN_DISP
```

B.11 MANIPULATING VALUES OF DYNAMICALLY DISPLAYED VARIABLES

The CHG_DATA.KL program is called by DYN_DISP, where the actual variables are displayed dynamically. This program does some processing and changes the value of those variables.

Manipulate Dynamically Displayed Variables - Overview

```
------------------------------------------------------------------------------
----    CHG_DATA.KL
------------------------------------------------------------------------------
------------------------------------------------------------------------------
----    Section 0:  Detail about CHG_DATA.KL
------------------------------------------------------------------------------
---- Elements of KAREL Language Covered:          In Section:
----    Actions:
----    Clauses:
----                FROM                           Sec 2
----    Conditions:
----    Data types:
----                INTEGER                        Sec 2
----                REAL                           Sec 2
----
----    Directives:
----    Built-in Functions & Procedures:
----    Statements:
----                DELAY                          Sec 4
----                FOR....ENDFOR                  Sec 4
----                REPEAT...UNTIL                 Sec 4
----
----    Reserve Words:
----                BEGIN                          Sec 4
----                END                            Sec 4
----                PROGRAM                        Sec 1
----                VAR                            Sec 2
------------------------------------------------------------------------------
----    Section 1:  Program and Environment Declaration
------------------------------------------------------------------------------
PROGRAM CHG_DATA
%nolockgroup
%comment = 'Dynamic Disp2'
```

Manipulate Dynamically Displayed Variables - Declaration Section

```
------------------------------------------------------------------------------
----    Section 2:  Variable Declaration
------------------------------------------------------------------------------
VAR
 -- IF the following variables did NOT have IN CMOS, the following errors
 -- would be posted when loading this program:
 --   VARS-012 Create var -INT1 failed  VARS-038 Cannot change CMOS/DRAM type
 --   VARS-012 Create var -REAL1 failed VARS-038 Cannot change CMOS/DRAM type
```

```
 -- This indicates that there is a discrepancy between DYN_DISP and CHG_DATA.
 -- One program has specified to create the variables in DRAM the
 -- other specified CMOS.
  Int1 IN CMOS FROM dyn_disp   :INTEGER    -- dynamically displayed variable
  Real1 IN CMOS FROM dyn_disp  :REAL       -- dynamically displayed variable
  Bool1 IN CMOS FROM dyn_disp  :BOOLEAN    -- dynamically displayed variable
  Enum1 IN CMOS FROM dyn_disp  :INTEGER    -- dynamically displayed variable
  Str1 IN CMOS FROM dyn_disp   :STRING[10] -- dynamically displayed variable
  indx                          :INTEGER
  dynd_abrt FROM dyn_disp       :BOOLEAN   -- Set in dyn_disp when dyn_disp
                                           -- is aborting
--------------------------------------------------------------------------------
----    Section 3: Routine Declaration
--------------------------------------------------------------------------------
```

Manipulate Dynamically Displayed Variables - Main Program

```
--------------------------------------------------------------------------------
----    Section 4: Main program
--------------------------------------------------------------------------------
BEGIN  -- CHG_DATA

 -- This demonstrates that the variables are changed from this task, CHG_DATA.
 -- The dynamic display initiated in task DYN_DISP, will continue
 -- to correctly display the updated values of these variables.
 -- Do real application processing.
 -- Simulated here in a FOR loop.
REPEAT
  FOR indx  = -9999 to 9999 DO
    int1  = (indx DIV 2) * 7
    real1 = (indx DIV 3)* 3.13
    bool1 = ((indx AND 4) = 0)
    enum1 = (ABS(indx) DIV 5) MOD 5
    Str1 = SUB_STR('123456789A', 1, (ABS(indx) DIV 6) MOD 7 + 1)
    delay 200   -- Delay for 1/5 of a second as if processing is going on.
  ENDFOR
UNTIL (DYND_ABRT)   -- This task is aborted from DYN_DISP.  However, if
                    -- DYN_DISP aborts abnormally (ie from a KCL> ABORT), it
                    -- will set DYND_ABRT, which will allow CHG_DATA to
                    -- complete execution.
END CHG_DATA
```

B.12 DISPLAYING A LIST FROM A DICTIONARY FILE

This program controls the display of a list which is read in from the dictionary file DCLISTEG.UTX. For more information on DCLISTEG.UTX refer to Section B.12.1 . DCLST_EX.KL controls the placement of the cursor along with the action taken for each command.

Note The use of DISCTRL_FORM is the preferred method of displaying information. DISCTRL_FORM will automatically take care of all the key inputs and is much easier to use. For more information, refer to Chapter 10 *DICTIONARIES AND FORMS* .

Display List from Dictionary File - Overview

```
--------------------------------------------------------------------------------
----   DCLST_EX.KL
--------------------------------------------------------------------------------
----    Section 0:  Detail about DCLST_EX.KL
--------------------------------------------------------------------------------
---- Elements of KAREL Language Covered:      In Section:
----    Actions:
----    Clauses:
----            FROM                              Sec 3-E
----    Conditions:
----    Data types:
----            ARRAY OF STRING                    Sec 2
----            BOOLEAN                            Sec 2
----            DISP_DAT_T                         Sec 2
----            FILE                               Sec 2
----            INTEGER                            Sec 2
----            STRING                             Sec 2
----    Directives:
----            ALPHABETIZE                        Sec 1
----            COMMENT                            Sec 1
----            INCLUDE                            Sec 1
----            NOLOCKGROUP                        Sec 1
----    Built-in Functions & Procedures:
----            ADD_DICT                           Sec 3-B
----            ACT_SCREEN                         Sec 4-I
----            ATT_WINDOW_S                       Sec 4-C
----            CHECK_DICT                         Sec 3-B
----            CLR_IO_STAT                        Sec 3-A,C
----            CNV_STR_INT                        Sec 4-E
----            DEF_SCREEN                         Sec 4-B
----            DET_WINDOW                         Sec 4-I
----            DISCTRL_LIST                       Sec 4-G,H
----            FORCE_SPMENU                       Sec 4-A,B,C
----            IO_STATUS                          Sec 3-A,
----            ORD                                Sec 4-H
```

```
----            READ_DICT                           Sec 4-E,F
```

Display List from Dictionary File - Overview Continued

```
----            REMOVE_DICT                         Sec 4-I
----            SET_FILE_ATR                        Sec 4-G
----            STR_LEN                             Sec 4-F
----            UNINIT                              Sec 3-C
----            WRITE_DICT                          Sec 4-D,H,I
----    Statements:
----            ABORT                               Sec 3-B
----            CLOSE FILE                          Sec 4-I
----            FOR...ENDFOR                        Sec 4-F
----            IF...THEN...ENDIF                   Sec 3-A,B,C,D; 4-F,H,I
----            OPEN FILE                           Sec 3-A; 4-H
----            READ                                Sec 4-A,B,H
----            REPEAT...UNTIL                      Sec 4-H
----            ROUTINE                             Sec 3-A,B,C,D,E
----            SELECT...ENDSELECT                  Sec 4-H
----            WRITE                               Sec 3-A,B,C,D;4-A,I
----    Reserve Words:
----            BEGIN                               Sec 3-A,B,C,D;4
----            CR                                  Sec 4-A,B,C
----            END                                 Sec 3-A,B,C,D; 4-I
----            PROGRAM                             Sec 1
----            VAR                                 Sec 2
----    Predefined File Names:
----            TPDISPLAY                           Sec 4-D,G,H,I
----            TPFUNC                              Sec 4-D,H
----            TPPROMPT                            Sec 4-D,H,I
----            TPSTATUS                            Sec 4-D,I
----    Devices Used:
----            RD2U                                Sec 3-B
----    Predefined Windows:
----            ERR                                 Sec 4-C
----            T_ST                                Sec 4-C
----            T_FU                                Sec 4-C
----            T_PR                                Sec 4-C
----            T_FR                                Sec 4-C
```

Display List from Dictionary File - Declaration Section

```
-------------------------------------------------------------------------------
----    Section 1:  Program and Environment Declaration
-------------------------------------------------------------------------------
```

```
PROGRAM DCLST_EX
%COMMENT='DISCTRL_LIST '
%ALPHABETIZE
%NOLOCKGROUP
%INCLUDE DCLIST -- the include file from the dictionary DCLISTEG.UTX
--------------------------------------------------------------------------------
----    Section 2:   Variable  Declarations
--------------------------------------------------------------------------------
VAR
  exit_Cmnd      : INTEGER
  act_pending    : INTEGER              -- decide if any action is pending
  display_data   : DISP_DAT_T           -- information needed for DICTRL_LIST
  done           : BOOLEAN              -- decides when to complete execution
  Kb_file        : FILE                 -- file opened to the TPKB
  i              : INTEGER              -- just a counter
  key            : INTEGER              -- which key was pressed
  last_line      : INTEGER              -- number of last line of information
  list_data      : ARRAY[20] OF STRING[40] -- exact string information
  num_options    : INTEGER              -- number of items in list
  old_screen     : STRING[4]            -- previously attached screen
  status         : INTEGER              -- status returned from built-in call
  str            : STRING[1]            -- string read in from teach pendant
  Err_file       : FILE                 -- err log file
  Opened         : BOOLEAN              -- err log file open or not
```

Display List from Dictionary File - Declare Routines

```
--------------------------------------------------------------------------------
----    Section 3:  Routine Declaration
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
----    Section 3-A: Op_Err_File Declaration
----                  Open the error log file.
--------------------------------------------------------------------------------
Routine Op_Err_File
Begin
  Opened = false
  Write TPPROMPT(CR,'Creating Auto Error File ..............')
  OPEN FILE Err_File ('RW','RD2U:\D_LIST.ERR')  -- open for output
  IF (IO_STATUS(Err_File) <> 0 ) THEN
     CLR_IO_STAT(Err_File)
     Write TPPROMPT('*** USE USER WINDOW FOR ERROR OUTPUT ***',CR)
  ELSE
     Opened = TRUE
  ENDIF
End Op_Err_File
```

```
--------------------------------------------------------------------------
----    Section 3-B: Chk_Add_Dct  Declaration
----                  Check whether a dictionary is loaded.
----                  If not loaded then load in the dictionary.
--------------------------------------------------------------------------
Routine Chk_Add_Dct
Begin -- Chk_Add_Dct
  -- Make sure 'DLST' dictionary is added.
    CHECK_DICT('DLST',TPTSSP_TITLE,STATUS)
    IF STATUS <> 0 THEN
       Write TPPROMPT(CR,'Loading Required Dictionary.............')
       ADD_DICT('RD2U:\DCLISTEG','DLST',DP_DEFAULT,DP_DRAM,STATUS)
       IF status <> 0 THEN
           WRITE TPPROMPT('ADD_DICT failed, STATUS=',STATUS,CR)
           ABORT  -- Without the dictionary this program can not continue.
       ENDIF
    ELSE
       WRITE TPPROMPT ('Dictionary already loaded in system.    ')
    ENDIF
End Chk_Add_Dct
```

Display List from Dictionary File - Declare Error Routines

```
--------------------------------------------------------------------------
----    Section 3-C:  Log_Errors Declaration
----                   Log detected errors to a file to be reviewed later.
--------------------------------------------------------------------------
ROUTINE Log_Errors(Out: FILE; Err_Str:STRING;Err_No:INTEGER)
BEGIN
  IF NOT Opened THEN  -- If error log file not opened then write errors to
                      -- screen
    WRITE (Err_Str,Err_No,CR)
  ELSE
    IF NOT UNINIT(Out)  THEN
      CLR_IO_STAT(Out)
      WRITE Out(Err_Str,Err_No,CR,CR)
    ELSE
      WRITE (Err_Str,Err_No, CR)
    ENDIF
  ENDIF
END Log_Errors
--------------------------------------------------------------------------
----    Section 3-D:  Chk_Stat Declaration
----                   Check the global variable, status.
----                   If not zero then log input parameter, err_str,
----                   to error file.
```

```
--------------------------------------------------------------------------------
ROUTINE Chk_Stat ( err_str: STRING)
BEGIN -- Chk_Stat
  IF( status <> 0) then
    Log_Errors(Err_File, err_str,Status)
  ENDIF
END Chk_Stat
--------------------------------------------------------------------------------
----    Section 3-E:  TP_CLS Declaration
--------------------------------------------------------------------------------
ROUTINE TP_CLS FROM ROUT_EX
```

Display List from Dictionary File - Setup and Define Screen

```
--------------------------------------------------------------------------------
----    Section 4:  Main Program
--------------------------------------------------------------------------------
BEGIN -- DCLST_EX
--------------------------------------------------------------------------------
----    Section 4-A:  Perform Setup operations
--------------------------------------------------------------------------------
  TP_CLS   -- Call routine to clear and force the TP USER menu to be visible
  Write ('   ***** Starting DISCTRL_LIST Example *****', CR, CR)
  Chk_Add_Dct     -- Call routine to check and add dictionary
  Op_Err_File     -- Call routine open error log file
--------------------------------------------------------------------------------
----    Section 4-B:  Define and Active a screen
--------------------------------------------------------------------------------
  DEF_SCREEN('LIST', 'TP', status)   -- Create/Define a screen called LIST
   Chk_Stat ('DEF_SCREEN LIST')      -- Verify DEF_SCREEN was successful
  ACT_SCREEN('LIST', old_screen, status) -- activate the LIST screen that
                                         -- that was just defined.
   Chk_Stat ('ACT_SCREEN LIST')          -- Verify ACT_SCREEN was successful
--------------------------------------------------------------------------------
----    Section 4-C:  Attach windows to the screen
--------------------------------------------------------------------------------
  -- Attach the required windows to the LIST screen.
  -- SEE:
  --  Chapter 7.9.1 "USER Menu on the Teach Pendant,
  --  for more details on predefined window names.
  ATT_WINDOW_S('ERR', 'LIST', 1, 1, status)  -- attach the error window
    Chk_Stat('Attaching ERR')
  ATT_WINDOW_S('T_ST', 'LIST', 2, 1, status) -- attach the status window
    Chk_Stat('T_ST not attached')
  ATT_WINDOW_S('T_FU', 'LIST', 5, 1, status) -- attach the full window
    Chk_Stat('T_FU not attached')
```

```
  ATT_WINDOW_S('T_PR', 'LIST', 15, 1, status)-- attach the prompt window
    Chk_Stat('T_PR not attached')
  ATT_WINDOW_S('T_FK', 'LIST', 16, 1, status)-- attach the function window
    Chk_Stat('T_FK not attached')
```

Display List from Dictionary File - Write Elements to the Screen

```
--------------------------------------------------------------------------------
----    Section 4-D:  Write dictionary elements to windows
--------------------------------------------------------------------------------
    -- Write dictionary element,TPTSSP_TITLE, from DLST dictionary.
    -- Which will clear the status window, and display intro message in
    -- reverse video.
    WRITE_DICT(TPSTATUS, 'DLST', TPTSSP_TITLE, status)
       Chk_Stat( 'TPTSSP_TITLE not written')
    -- Write dictionary element,TPTSSP_FK1, from DLST dictionary.
    -- Which will display "[TYPE]" to the function line window.
    WRITE_DICT(TPFUNC, 'DLST', TPTSSP_FK1, status)
       Chk_Stat( 'TPTSSP_FK1 not written')
    -- Write dictionary element, TPTSSP_CLRSC, from DLST dictionary.
    -- Which will clear the teach pendant display window.
    WRITE_DICT(TPDISPLAY, 'DLST', TPTSSP_CLRSC, status)
       Chk_Stat( 'TPTSSP_CLRSC not written')
    -- Write dictionary element, TPTSSP_INSTR, from DLST dictionary.
    -- Which will display instructions to the prompt line window.
    WRITE_DICT(TPPROMPT, 'DLST', TPTSSP_INSTR, status)
       Chk_Stat( 'TPTSSP_INSTR not written')
--------------------------------------------------------------------------------
----    Section 4-E:   Determine the number of menu options
--------------------------------------------------------------------------------
    -- Read the dictionary element, TPTSSP_NUM, from DLST dictionary,
    -- Into the first element of list_data.
    -- list_data[1] will be an ASCII representation of the number of
    --  menu options.  last_line will be returned with the number of
    --  lines/elements used in list_data.
    READ_DICT('DLST', TPTSSP_NUM, list_data, 1, last_line, status)
       Chk_Stat( 'TPTSSP_NUM not read')
    -- convert the string into the INTEGER, num_options
    CNV_STR_INT(list_data[1], num_options)
```

Display List from Dictionary File - Initialize Display Data

```
--------------------------------------------------------------------------------
----    Section 4-F:   Initialize the data structure, display_data
----                   Which is used to display the list of menu options.
```

```
-------------------------------------------------------------------------------
    -- Initialize the display data structure
    -- In this example we only deal with window 1.
    display_data.win_start[1] = 1  -- Starting row for window 1.
    display_data.win_end[1]  = 10  -- Ending row for window 1.
    display_data.curr_win = 0      -- The current window to display, where
                                   --   zero (0) specifies first window.
    display_data.cursor_row = 1    -- Current row the cursor is on.
    display_data.lins_per_pg = 10  -- The number of lines scrolled when the
                                   -- user pushes SHIFT Up or Down. Usually
                                   -- it is the same as the window size.
    display_data.curs_st_col[1] = 0 -- starting column for field 1
    display_data.curs_en_col[1] = 0 -- ending column for field 1, will be
                                    -- updated a little later
    display_data.curr_field = 0     -- Current field, where
                                    --   zero (0) specifies the first field
    display_data.last_field = 0     -- Last field in the list (only using one
                                    --   field in this example).
    display_data.curr_it_num = 1    -- Current item number the cursor is on.
    display_data.sob_it_num = 1     -- Starting item number.
    display_data.eob_it_num = num_options  -- Ending item number, which is
                                           --  the number of options read in.
    display_data.last_it_num  = num_options-- Last item number, also the
                                           --   number of options read in
 -- Make sure the window end is not beyond total number of elements in list.
    IF display_data.win_end[1] > display_data.last_it_num THEN
      display_data.win_end[1] = display_data.last_it_num --reset to last item
    ENDIF
    -- Read dictionary element, TPTSSP_MENU, from dictionary DLST.
    -- list_data will be populated with the menu list information
    -- list_data[1] will contain the first line of information from
    -- the TPTSSP_MENU and list_data[last_line] will contain the last
    -- line of information read from the dictionary.
    READ_DICT('DLST', TPTSSP_MENU, list_data, 1, last_line, status)
     Chk_Stat('Reading menu list failed')
-- Determine longest list element & reset cursor end column for first field.
    FOR i = 1 TO last_line DO
      IF (STR_LEN(list_data[i]) > display_data.curs_en_col[1]) THEN
        display_data.curs_en_col[1] = STR_LEN(list_data[i])
      ENDIF
    ENDFOR
```

Display List from Dictionary File - Control Cursor Movement

```
-------------------------------------------------------------------------------
----    Section 4-G:   Display the list.
```

```
------------------------------------------------------------------------------
    -- Initial Display the menu list.
    DISCTRL_LIST(TPDISPLAY, display_data, list_data, DC_DISP, status)
      Chk_Stat('Error displaying list')
    -- Open a file to the TPDISPLAY window with PASSALL and FIELD attributes
    -- and NOECHO
    SET_FILE_ATR(kb_file, ATR_PASSALL)  -- Get row teach pendant input
    SET_FILE_ATR(kb_file, ATR_FIELD)    -- so that a single key will
                                        -- satisfy the reads.
    SET_FILE_ATR(kb_file, ATR_NOECHO)   -- don't echo the keys back to
                                        -- the screen
    OPEN FILE Kb_file ('RW', 'KB:TPKB') -- open a file to the Teach pendant
                                        -- keyboard (keys)
      status = IO_STATUS(Kb_file)
      Chk_Stat('Error opening TPKB')
    act_pending = 0
    done = FALSE
------------------------------------------------------------------------------
----    Section 4-H:  Control cursor movement within the list
------------------------------------------------------------------------------
    REPEAT      -- Wait for a key input
      READ Kb_file (str::1)
      key = ORD(str,1)
      key = key AND 255           -- Convert the key to correct value.
      SELECT key OF               -- Decide how to handle key inputs
       CASE (KY_UP_ARW) :         -- up arrow key pressed
        IF act_pending <> 0 THEN  -- If a menu item was selected...
                                  -- Clear confirmation prompt
          WRITE_DICT(TPPROMPT, 'DLST', TPTSSP_CLRSC, status)
             -- Clear confirmation function keys
          WRITE_DICT(TPFUNC, 'DLST', TPTSSP_CLRSC, status)
        ENDIF
        DISCTRL_LIST(TPDISPLAY, display_data, list_data, DC_UP, status)
          Chk_Stat ('Error displaying list')
       CASE (KY_DN_ARW) : -- down arrow key pressed
        IF act_pending <> 0 THEN -- If a menu item was selected...
          -- Clear confirmation prompt
          WRITE_DICT(TPPROMPT, 'DLST', TPTSSP_CLRSC, status)
          -- Clear confirmation function keys
          WRITE_DICT(TPFUNC, 'DLST', TPTSSP_CLRSC, status)
        ENDIF
        DISCTRL_LIST(TPDISPLAY, display_data, list_data,
DC_DN, status)
           Chk_Stat ('Error displaying list')
```

Display List from Dictionary File - Control Cursor Movement Continued

```
CASE (KY_ENTER) :
        -- Perform later
CASE (KY_F4) : -- "YES" function key pressed
       IF act_pending <> 0 THEN -- If a menu item was selected...
          -- Clear confirmation prompt
          WRITE_DICT(TPPROMPT, 'DLST', TPTSSP_CLRSC, status)
          -- Clear confirmation function keys
          WRITE_DICT(TPFUNC, 'DLST', TPTSSP_CLRSC, status)
          IF act_pending = num_options THEN
            -- Exit the routine
            done = TRUE
          ENDIF
          -- Clear action pending
          act_pending = 0
        ENDIF
CASE (KY_F5) : -- "NO" function key pressed
               -- Clear confirmation prompt
      WRITE_DICT(TPPROMPT, 'DLST', TPTSSP_INSTR, status)
               -- Clear confirmation function keys
      WRITE_DICT(TPFUNC, 'DLST', TPTSSP_CLRSC, status)
               -- Clear action pending
       act_pending = 0
ELSE :         -- User entered an actual item number.  Calculate which
               -- row the cursor should be on and redisplay the list.
       IF ((key > 48) AND (key <= (48 + num_options))) THEN
         -- Translate number to a row
         key = key - 48
         display_data.cursor_row = key
        DISCTRL_LIST(TPDISPLAY,display_data,list_data,DC_DISP,status)
          Chk_Stat ('Error displaying list')
         key = KY_ENTER
       ENDIF
ENDSELECT
IF key = KY_ENTER THEN -- User has specified an action
  -- Write confirmation prompt for selected item
  WRITE_DICT (TPPROMPT, 'DLST',
     (TPTSSP_CNF1 - 1 + display_data.cursor_row), status)
  -- Display confirmation function keys
  WRITE_DICT(TPFUNC, 'DLST', TPTSSP_FK2, status)
  -- Set action pending to selected item
  act_pending = display_data.cursor_row -- this is the item selected
ENDIF
UNTIL done   -- repeat until the user selects the exit option
```

Display List from Dictionary File - Cleanup and Exit Program

```
-------------------------------------------------------------------------------
----    Section 4-I:  Cleanup before exiting program
-------------------------------------------------------------------------------
  -- Clear the TP USER menu windows
  WRITE_DICT(TPDISPLAY, 'DLST', TPTSSP_CLRSC, status)
  WRITE_DICT(TPSTATUS, 'DLST', TPTSSP_CLRSC, status)
  -- Close the file connected to the TP keyboard.
  CLOSE FILE Kb_file
  -- Close the error log file if it is open.
  IF opened THEN
     close file Err_File
  ENDIF
  Write TPPROMPT (cr,'Example Finished ')
  REMOVE_DICT ( 'LIST', dp_default, status) -- remove the dictionary
    write ('remove dict', status,cr)
    Chk_Stat ('Removing dictionary')
  ACT_SCREEN(old_screen, old_screen, status) -- activate the previous screen
    Chk_stat ('Activating old screen')
  DET_WINDOW('ERR', 'LIST', status)  -- Detach all the windows that were
    Chk_stat ('Detaching ERR window')
  DET_WINDOW('T_ST', 'LIST', status) -- previously attached.
    Chk_stat ('Detaching T_ST window')
  DET_WINDOW('T_FU', 'LIST', status)
    Chk_stat ('Detaching T_FU window')
  DET_WINDOW('T_PR', 'LIST', status)
    Chk_stat ('Detaching T_PR window')
  DET_WINDOW('T_FK', 'LIST', status)
    Chk_stat ('Detaching T_FK window')
END DCLST_EX
```

B.12.1 Dictionary Files

This ASCII dictionary file is used to create a teach pendant screen which is used with DCLST_EX.KL. For more information on DCLST_EX.KL refer to Section B.7 .

Dictionary File

```
.kl dclist
*
$-,TPTSSP_TITLE &home &reverse "Karel DISCTRL_LIST Example
"
&standard
```

```
$-,TPTSSP_CLRSC &home &clear_2_eow
$-,TPTSSP_FK1 &home" [TYPE]                                    "
$-,TPTSSP_FK2 &home"                          YES      NO    "
$-,TPTSSP_INSTR &home "Press 'ENTER' or number key to select." &clear_2_eol
* Add menu options here, "Exit" must be last option
* TPTSSP_NUM specifies the number of menu options
$-,TPTSSP_NUM "14"
$-,TPTSSP_MENU
" 1  Test Cycle 1" &new_line
" 2  Test Cycle 2" &new_line
" 3  Test Cycle 3" &new_line
" 4  Test Cycle 4" &new_line
" 5  Test Cycle 5" &new_line
" 6  Test Cycle 6" &new_line
" 7  Test Cycle 7" &new_line
" 8  Test Cycle 8" &new_line
" 9  Test Cycle 9" &new_line
" 10  Test Cycle 10" &new_line
" 11  Test Cycle 11" &new_line
" 12  Test Cycle 12" &new_line
" 13  Test Cycle 13" &new_line
" 14  EXIT"
* Confirmations must be in order
$-,TPTSSP_CNF1 &home"Perform test cycle 1? [NO]" &clear_2_eol
$-,TPTSSP_CNF2 &home"Perform test cycle 2? [NO]" &clear_2_eol
$-,TPTSSP_CNF3 &home"Perform test cycle 3? [NO]" &clear_2_eol
$-,TPTSSP_CNF4 &home"Perform test cycle 4? [NO]" &clear_2_eol
$-,TPTSSP_CNF5 &home"Perform test cycle 5? [NO]" &clear_2_eol
$-,TPTSSP_CNF6 &home"Perform test cycle 6? [NO]" &clear_2_eol
$-,TPTSSP_CNF7 &home"Perform test cycle 7? [NO]" &clear_2_eol
$-,TPTSSP_CNF8 &home"Perform test cycle 8? [NO]" &clear_2_eol
$-,TPTSSP_CNF9 &home"Perform test cycle 9? [NO]" &clear_2_eol
$-,TPTSSP_CNF10 &home"Perform test cycle 10? [NO]" &clear_2_eol
$-,TPTSSP_CNF11 &home"Perform test cycle 11? [NO]" &clear_2_eol
$-,TPTSSP_CNF12 &home"Perform test cycle 12? [NO]" &clear_2_eol
$-,TPTSSP_CNF13 &home"Perform test cycle 13? [NO]" &clear_2_eol
$-,TPTSSP_CNF14 &home"Exit? [NO]" &clear_2_eol
```

B.13 USING THE DISCTRL_ALPHA BUILT-IN

This program shows three different ways to use the DISCTRL_ALPH built-in. The DISCTRL_ALPH built-in displays and controls alphanumeric string entry in a specified window. Refer to Appendix A , "KAREL Language Alphabetic Description" for more information.

Method 1 allows a program name to be entered using the default value for the dictionary name. See Section 4-A in Using the DISCTRL_ALPHA Built-in - Enter Data from Teach Pendant .

Method 2 allows a comment to be entered using the default value for the dictionary name. See Section 4-B in Using the DISCTRL_ALPHA Built-in - Enter Data from Teach Pendant .

Method 3 uses a user specified dictionary name and element to enter a program name. See Section 4-C in Using the DISCTRL_ALPHA Built-in - Enter Data from CRT/KB .

This program also posts all errors to the controller.

Using the DISCTRL_ALPHA Built-in - Overview

```
------------------------------------------------------------------------------
----    DCALP_EX.KL
------------------------------------------------------------------------------
---- Elements of KAREL Language Covered:          In Section:
----    Actions:
----    Clauses:
----    Conditions:
----    Data types:
----            INTEGER                            Sec 2
----            STRING                             Sec 2
----    Directives:
----            COMMENT                           Sec 1
----            INCLUDE                           Sec 1
----            NOLOCKGROUP                       Sec 1
----    Built-in Functions & Procedures:
----            ADD_DICT                           Sec 4-C
----            CHR                                Sec 4-A,B,C
----            DISCTRL_ALPH                       Sec 4-A,B,C
----            FORCE_SPMENU                       Sec 4-A,B,C
----            POST_ERR                           Sec 4-A,B,C
----            SET_CURSOR                         Sec 4-A,B,C
----            SET_LANG                           Sec 4-C
----    Statements:
----            READ                               Sec 4-A,B
----            WRITE                              Sec 4-A,B,C
----            IF...THEN...ENDIF                  Sec 4-A,B,C
----    Reserve Words:
----            BEGIN                              Sec 4
----            CONST                              Sec 2
----            CR                                 Sec 4-A,B,C
----            END                                Sec 4-C
----            PROGRAM                            Sec 1
----            VAR                                Sec 2
----    Predefined File Names:
```

```
----            OUTPUT                                  Sec 4-C
----            TPDISPLAY                               Sec 4-A,B
----     Predefined Windows:
----            T_FU                                    Sec 4-A,B
----            C_FU                                    Sec 4-C
```

Using the DISCTRL_ALPHA Built-in - Declaration Section

```
-------------------------------------------------------------------------------
----    Section 1:  Program and Environment Declaration
-------------------------------------------------------------------------------
PROGRAM DCALP_EX
%COMMENT   = 'Display Alpha'
%NOLOCKGROUP
%INCLUDE KLEVKEYS    -- Necessary for the KY_ENTER
%INCLUDE DCALPH      -- Necessary for the ALPH_PROG Element, see section 4-C
-------------------------------------------------------------------------------
----    Section 2:  Constant and Variable  Declarations
-------------------------------------------------------------------------------
CONST
  cc_home      = 137
  cc_clear_win = 128
  cc_warn      = 0     -- Value passed to POST_ERR to display warning only.
  cc_pause     = 1     -- value passed to POST_ERR to pause program.
VAR
  status       : INTEGER
  device_stat  : INTEGER
  term_char    : INTEGER
  window_name  : STRING[4]
  prog_name    : STRING[12]
  comment      : STRING[40]
-------------------------------------------------------------------------------
----    Section 3:  Routine Declaration
-------------------------------------------------------------------------------
```

Using the DISCTRL_ALPHA Built-in - Enter Data from Teach Pendant

```
-------------------------------------------------------------------------------
----    Section 4:  Main Program
-------------------------------------------------------------------------------
BEGIN   -- DCALP_EX
-------------------------------------------------------------------------------
---- Section 4-A: Enter a program name from the teach pendant USER menu
-------------------------------------------------------------------------------
  WRITE (CHR(cc_home), CHR(cc_clear_win))   -- Clear TP USER menu
```

```
  FORCE_SPMENU(tp_panel, SPI_TPUSER, 1)     -- Force TP USER menu to be
                                            -- visible
  SET_CURSOR(TPDISPLAY, 12, 1, status)      -- reposition cursor
  WRITE ('prog_name: ')
  prog_name = ''                           -- initialize program name
  DISCTRL_ALPH('t_fu', 12, 12, prog_name, 'PROG', 0, term_char, status)
  IF status <> 0 THEN
    POST_ERR(status, '', 0, cc_warn)
  ENDIF
  IF term_char = ky_enter THEN             -- User pressed the ENTER key
    WRITE (CR, 'prog_name was changed:', prog_name, CR)
  ELSE
    WRITE (CR, 'prog_name was not changed')
  ENDIF
  WRITE (CR, 'Press enter to continue')
  READ (CR)
-------------------------------------------------------------------------------
---- Section 4-B: Enter a comment from the teach pendant
-------------------------------------------------------------------------------
  WRITE (CHR(cc_home) + CHR(cc_clear_win))-- Clear TP USER menu
  SET_CURSOR(TPDISPLAY, 12, 1, status)   -- reposition cursor
  comment = ' '                          -- Initialize the comment
  WRITE ('comment: ')                    -- Display message
  DISCTRL_ALPH('t_fu', 12, 10, comment, 'COMM', 0, term_char, status)
  IF status <> 0 THEN                    -- Verify DISCTRL_ALPH was successful
    POST_ERR(status, '', 0, cc_warn)     -- Post the status as a warning
  ENDIF
  IF term_char = ky_enter THEN
    WRITE (CR, 'comment was changed:', comment, CR) -- Display new comment
  ELSE
    WRITE (CR, 'comment was not changed', CR)
  ENDIF
  WRITE (CR, 'Press enter to continue')
  READ (CR)
```

Using the DISCTRL_ALPHA Built-in - Enter Data from CRT/KB

```
-------------------------------------------------------------------------------
---- Section 4-C: This section will perform program name entry from the
----              CRT/KB.  The dictionary name and element values are
----              explicitly stated here, instead of using the available
----               default values.
-------------------------------------------------------------------------------
  -- Set the dictionary language to English
  -- This is useful if you want to use this same code for multiple
  -- languages.  Then any time you load in a dictionary you check
```

```
  -- to see what the current language, $language, is and load the
  -- correct dictionary.
  -- For instance you could have a DCALPHJP.TX file which
  -- would be the Japanese dictionary. If the current language, $language,
  -- was set to Japanese you would load this dictionary.
  SET_LANG ( dp_english, status)
  IF (status <> 0) THEN
    POST_ERR (status, '', 0,cc_warn)   -- Post the status as a warning
  ENDIF
  -- Load the dcalpheg.tx file, using ALPH as the dictionary name,
  --  to the English language, using DRAM as the memory storage device.
  ADD_DICT ('DCALPHEG', 'ALPH', dp_english,  dp_dram, status)
  IF (status <> 0 ) THEN
    POST_ERR (status, '', 0, cc_pause)     -- Post the status and pause the
                                           -- program, since the dictionary
  ENDIF                                    -- must be loaded to continue.
 device_stat = crt_panel                     -- Give control to the CRT/KB
  WRITE OUTPUT (CHR(cc_home) + CHR(cc_clear_win))--Clear CRT/KB USER menu
  FORCE_SPMENU (device_stat, SPI_TPUSER, 1) -- Force the CRT/KB USER menu
                                            --  to be visible
  SET_CURSOR(OUTPUT, 12, 1, status)         -- Reposition the cursor
  WRITE OUTPUT ('prog_name: ')
  prog_name = ' '                           -- Initialize program name
  DISCTRL_ALPH('c_fu',12,12,prog_name,'ALPH',alph_prog,term_char,status)
--DISCTRL_ALPHA uses the ALPH dictionary and ALPH_PROG dictionary element
  IF status <> 0 THEN                       -- Verify DISCTRL_ALPH was
                                            -- successful.
    POST_ERR(status, '', 0, cc_warn)        -- Post returned status to the
  ENDIF                                     -- error ('err') window.
  IF term_char = ky_enter THEN
    WRITE (CR, 'prog_name was changed:', prog_name, CR)
  ELSE
    WRITE (CR, 'prog_name was NOT changed.', CR)
  ENDIF
  device_stat = tp_panel                     -- Make sure to reset
 END DCALP_EX
```

B.13.1 Dictionary Files

This ASCII dictionary file is used to write text to the specified screen. DCALPH_EG.UTX is also used with DCAL_EX.KL. For more information on DCAL_EX.KL, refer to Section B.13 .

DCALPHEG.UTX Dictionary File

```
.KL DCALPH
$, alpha_prog
" PRG       MAIN     SUB       TEST    >"&new_line
" PROC      JOB      MACRO             >"&new_line
" TEST1     TEST2    TEST3     TEST4   >"
```

Note The greater than symbol (>) in DCALPHEG.UTX Dictionary File is a reminder to use the NEXT key to scroll through the multiple lines. Also notice that the &new_line appears only on the first two lines. This ensures that the lines will scroll correctly.

B.14 APPLYING OFFSETS TO A COPIED TEACH PENDANT PROGRAM

This program copies a teach pendant program and then applies an offset to the positions within the newly created program. This is useful when you create the teach pendant program offline and then realized that all the teach pendant positions are off by some determined amount. However, you should be aware that the utility PROGRAM ADJUST is far more adequate for this job.

Applying Offsets to Copied Teach Pendant Program - Overview

```
------------------------------------------------------------------------------
----    CPY_TP.KL
------------------------------------------------------------------------------
---- Elements of KAREL Language Covered:         In Section:
----    Actions:
----
----    Clauses:
----            FROM                              Sec 3-F
----
----    Conditions:
----
----    Data Types:
----            ARRAY OF REAL                      Sec 2
----            ARRAY OF STRING                    Sec 2
----            BOOLEAN                            Sec 2
----            INTEGER                            Sec 2; 3-B,C,D,E
----            JOINTPOS                           Sec 2
----            REAL                               Sec 2
----            STRING                             Sec 2
----            XYZWPR                             Sec 2
----    Directives:
----            ENVIRONMENT                       Sec 1
----    Built-in Functions & Procedures:
----            AVL_POS_NUM                        Sec 3-E
----            CHR                                Sec 3-B, 4
```

```
----            CLOSE_TPE                           Sec 3-E
----            CNV_REL_JPOS                        Sec 3-E
----            CNV_JPOS_REL                        Sec 3-E
----            COPY_TPE                            Sec 3-E
----            GET_JPOS_TPE                        Sec 3-E
----            GET_POS_TYP                         Sec 3-E
----            GET_POS_TPE                         Sec 3-E
----            OPEN_TPE                            Sec 3-E
----            PROG_LIST                           Sec 3-B
----            SELECT_TPE                          Sec 3-E
----            SET_JPOS_TPE                        Sec 3-E
----            SET_POS_TPE                         Sec 3-E
```

Applying Offsets to Copied Teach Pendant Program - Overview Continued

```
----    Statements:
----            FOR...ENDFOR                        Sec 3-B,D,E
----            IF ...THEN...ELSE...ENDIF           Sec 3-A,B,C,E
----            READ                                Sec 3-B,C,D
----            REPEAT...UNTIL                      Sec 3-B,C,D
----            RETURN                              Sec 3-E
----            ROUTINE                             Sec 3-A,B,C,D,E,F
----            SELECT...ENDSELECT                  Sec 3-E
----            WRITE                               Sec 3-B,C,D,E,4
----
----    Reserve Words:
----            BEGIN                               Sec 3-A,B,C,D,E;
4
----            CONST                               Sec 2
----            CR                                  Sec 3-B,C,D,E
----            END                                 Sec 3-A,B,C,D,E;
4
----            PROGRAM                             Sec 1
----            VAR                                 Sec 2
```

Applying Offsets to Copied Teach Pendant Program - Declaration Section

```
-------------------------------------------------------------------------------
----   Section 1:  Program and Environment Declaration
-------------------------------------------------------------------------------
PROGRAM CPY_TP
%ENVIRONMENT TPE            -- necessary for all xxx_TPE built-ins
%ENVIRONMENT BYNAM          -- necessary for PROG_LIST built-in
-------------------------------------------------------------------------------
----    Section 2:  Constant and Variable Declaration
```

```
--------------------------------------------------------------------------------
CONST
  ER_WARN = 0                    -- warning constant for use in POST_ERR
  SUCCESS = 0                    -- success constant
  JNT_POS = 9                    -- constant for GET_POS_TYP
  XYZ_POS = 2                    -- constant for GET_POS_TYP
  MAX_AXS = 9                    -- Maximum number of axes JOINTPOS has
VAR
 from_prog: STRING[13]           -- TP program name to be copied FROM
 to_prog  : STRING[13]           -- TP program name to be copied TO
 over_sw  : BOOLEAN              -- Decides whether to overwrite an existing
                                 --  program when performing COPY_TPE
 status   : INTEGER              -- Holds error status from the builtin calls
 off_xyz  : XYZWPR               -- Offset amount for the XYZWPR positions
 jp_off   : ARRAY [9] of REAL    -- Offset amount for the JOINT positions
 new_xyz  : XYZWPR               -- XYZWPR which has offset applied
 org_xyz  : XYZWPR               -- Original XYZWPR from to_prog
 new_jpos : JOINTPOS             -- JOINTPOS which as the offset applied
 org_jpos : JOINTPOS             -- Original JOINTPOS from to_prog
 open_id  : INTEGER              -- Identifier for the opened to_prog
 jp_org   : ARRAY [9] of REAL    -- REAL representation of org_jpos
 jp_new   : ARRAY [9] of REAL    -- REAL representation of jp_new
```

Applying Offsets to Copied Teach Pendant Program - Declare Routines

```
--------------------------------------------------------------------------------
----    Section 3:  Routine Declaration
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
----    Section 3-A: CHK_STAT Declaration
----                 Tests whether the status was successful or not.
----                 If the status was not successful the status is posted
--------------------------------------------------------------------------------
ROUTINE chk_stat (rec_stat: integer)
begin
 IF (rec_stat <> SUCCESS) THEN   -- if rec_stat is not SUCCESS
     -- then post the error
  POST_ERR (rec_stat, '', 0, ER_WARN)   -- Post the error to the system.
 ENDIF
END chk_stat
--------------------------------------------------------------------------------
----    Section 3-B: GetFromPrg Declaration
----                 Generate a list of loaded TPE programs.
----                 Lets the user select one of these programs
----                 to be the program to be copied, ie FROM_prog
--------------------------------------------------------------------------------
```

```
ROUTINE GetFromPrg
VAR
 tp_type   : INTEGER          -- Types of program to list
 n_skip    : INTEGER          -- Index into the list of programs
 format    : INTEGER          -- What type of format to store programs in
 n_progs   : INTEGER          -- Number of programs returned in prg_name
 prg_name  : ARRAY [8] of STRING[20] --Program names returned from PROG_LIST
 status    : INTEGER          -- Status of PROG_LIST call
 f_index   : INTEGER          -- Fast index for generating the program listing.
 arr_size  : INTEGER          -- Array size of prg_name
 prg_select: INTEGER          -- Users selection for which program to copy
 indx      : INTEGER          -- FOR loop counter which displays prg_name
```

Applying Offsets to Copied Teach Pendant Program - Generate Program List for User

```
BEGIN
  f_index = 0    -- Initialize the f_index
  n_skip  = 0    -- Initialize the n_skip
  tp_type = 2    -- find any TPE program
  format  = 1    -- return just the program name in prg_name
  n_progs = 0    -- Initialize the n_progs
  arr_size = 8   -- Set equal to the declared array size of prg_name
  prg_select = 0 -- Initialize the program selector
  REPEAT
     WRITE (chr(128),chr(137))  -- Clear the TP USER screen
     -- Get a listing of all TP program which begin with "TEST"
    PROG_LIST('TEST*',tp_type,n_skip,format,prg_name,n_progs,status,f_index)
     chk_stat (status)    --Check status from PROG_LIST
     FOR indx = 1 to n_progs DO
      WRITE (indx,':',prg_name[indx], CR) -- Write the list of programs out
     ENDFOR
     IF (n_skip > 0) OR ( n_prog >0) THEN
       WRITE ('select program to be copied:',CR)
       WRITE ('PRESS -1 to get next page of programs:')
       REPEAT
         READ (prg_select)  -- get program selection
       UNTIL ((prg_select >= -1) AND (prg_select <= n_progs)
                AND (prg_select <> 0))
     ELSE
       WRITE ('no TP programs to COPY', CR)
       WRITE ('Aborting program, since need',CR)
       WRITE ('at least one TP program to copy.',CR)
       ABORT
     ENDIF
     -- Check if listing is complete and user has not made a selection.
     IF ((prg_select = -1) AND (n_progs < arr_size)) THEN
```

```
      f_index = 0               --reset f_index to re-generate list.
      n_progs = arr_size       --set so the REPEAT/UNTIL will continue
    ENDIF
    -- Check if user user has made a selection
    IF (prg_select <> -1) then
      from_prog = prg_name[prg_select]-- Set from_prog to name selected
      n_progs = 0                -- Set n_prog to stop looping.
    ENDIF
  UNTIL (n_progs < arr_size)
END GetFromPrg
```

Applying Offsets to Copied Teach Pendant Program - Overwrite or Delete Program

```
--------------------------------------------------------------------------------
----    Section 3-C: GetOvrSw Declaration
----                 Ask user whether to overwrite the copied
----                 program, TO_prog, if it exists.
--------------------------------------------------------------------------------
ROUTINE GetOvrSw
VAR
  yesno  : INTEGER
BEGIN
  WRITE (CR, 'If Program already exists do you want',CR)
  WRITE ('to overwrite the file Yes:1, No:0 ? ')
  REPEAT
    READ (yesno)
  UNTIL ((yesno = 0) OR( yesno = 1))
  IF yesno = 1 then   --Set over_sw so program is overwriten if it exists
     over_sw = TRUE
  ELSE               --Set over_sw so program is NOT overwriten if it exists
     over_sw = FALSE
  ENDIF
END GetOvrSw
```

Applying Offsets to Copied Teach Pendant Program - Input Offset Positions

```
--------------------------------------------------------------------------------
----    Section 3-D: GetOffset Declaration
----                 Have the user input the offset for both
----                 XYZWPR and JOINTPOS positions.
--------------------------------------------------------------------------------
ROUTINE GetOffset
VAR
 yesno  : INTEGER
 index   : INTEGER
```

```
BEGIN
     --Get the XYZWPR offset, off_xyz
 REPEAT
   WRITE ( 'Enter offset for XYZWPR positions',CR)
   WRITE (' X = ')
   READ  (off_xyz.x)
   WRITE (' Y = ')
   READ  (off_xyz.y)
   WRITE (' Z = ')
   READ  (off_xyz.z)
   WRITE (' W = ')
   READ  (off_xyz.w)
   WRITE (' P = ')
   READ  (off_xyz.p)
   WRITE (' R = ')
   READ  (off_xyz.r)
   --Display the offset values the user input
   WRITE (' Offset XYZWPR position is',CR, off_xyz,CR)
   WRITE ('Is this offset correct? Yes:1, No:0 ? ')
   READ  (yesno)
 UNTIL (yesno = 1)    -- enter offset amounts until the user
    -- is satisfied.
 --Get the JOINTPOS offset, jp_off
 REPEAT
   WRITE ( 'Enter offset for JOINT positions',CR)
   FOR indx = 1 TO 6 DO     -- loop for number of robot axes
      WRITE (' J',indx,' = ')
      READ  (jp_off[indx])
   ENDFOR   WRITE ('JOINT position offset is', CR)
   FOR indx = 1 TO 6 DO
      write ( jp_off[indx],CR)    -- Display the values the user input
   ENDFOR
   WRITE ('Is this offset correct? Yes:1, No:0 ? ')
   READ  (yesno)
 UNTIL (yesno = 1)    -- Enter offset amounts until the user
END GetOffset   -- is satisfied
```

Applying Offsets to Copied Teach Pendant Program - Apply Offsets to Positions

```
-------------------------------------------------------------------------------
----    Section 3-E: ModifyPrg Declaration
----                 Apply the offsets to each position within the TP program
-------------------------------------------------------------------------------
ROUTINE ModifyPrg
VAR
  pos_typ : INTEGER  --The type of position returned from GET_POS_TYP
```

```
  num_axs : INTEGER  -- The number of axes if position is a JOINTPOS type
  indx_pos: INTEGER  -- FOR loop counter, that increments through TP position
  group_no: INTEGER  -- The group number of the current position setting.
  num_pos : INTEGER  -- The next available position number within TP program
  indx_axs: INTEGER  -- FOR loop counter, increments through REAL array
BEGIN
  SELECT_TPE (’’, status)  -- Make sure the to_prog is currently not selected
  to_prog = ’MDFY_TP’      -- Set the to_prog to desired name.
  ------ Copy the from_prog to to_prog -----
  COPY_TPE (from_prog, to_prog, over_sw, status)
  chk_stat(status)           -- check status of COPY_TPE
--- If the user specified not to overwrite the TPE program and
---  the status returned is 7015, "program already exist",
---  then quit the program.  This will mean not altering the already
---  existing to_prog.
  IF ((over_sw = FALSE) AND (status = 7015)) THEN
      WRITE (’ABORTING:: PROGAM ALREADY EXISTS!’,CR)
      RETURN
  ENDIF
--- Open the to_prog with the Read/Write access
 OPEN_TPE (to_prog, TPE_RWACC, TPE_RDREJ, open_id, status)
 chk_stat(status)              -- check status of OPEN_TPE
 group_no = 1
--- apply offset to each position within to_prog
--- The current number of position that the TPE program has is num_pos -1
 FOR indx_pos = 1 to num_pos-1 DO
   --Get the DATA TYPE of each position within the to_prog
   --If it is a JOINTPOS also get the number of axes.
   GET_POS_TYP (open_id, indx_pos, group_no, pos_typ, num_axs, status)
   chk_stat (status)
   WRITE(’get_pos_typ status’, status,cr)
```

Applying Offsets to Copied Teach Pendant Program - Apply Offsets to Positions Cont.

```
--Decide if the position, indx_pos, is a JOINTPOS or a XYZWPR
   SELECT pos_typ OF
     CASE (JNT_POS):       -- The position is a JOINTPOS
        FOR indx_axs = 1 TO MAX_AXS DO    -- initialize with default values
          jp_org[indx_axs] = 0.0          -- This avoids problems with the
          jp_new[indx_axs] = 0.0          -- CNV_REL_JPOS
        ENDFOR
        -- get the JOINTPOS P[indx_pos] from to_prog  -----
        org_jpos = GET_JPOS_TPE (open_id, indx_pos, status)
        chk_stat( status)
        -- Convert the JOINTPOS to a REAL array, in order to perform offset
        CNV_JPOS_REL (org_jpos,  jp_org, status)
```

```
        chk_stat (status)
        -- Apply the offset to the REAL array
        FOR indx_axs = 1 to num_axs DO
          jp_new[indx_axs] = jp_org[indx_axs] + jp_off[indx_axs]
        ENDFOR
        -- Converted back to a JOINTPOS.
        -- The input array, jp_new, must not have any uninitialized values
        -- or the error 12311 - "Data uninitialized" will be posted.
        -- This is why we previously set all the values to zero.
        CNV_REL_JPOS (jp_new, new_jpos, status)
        chk_stat(status)
        -- Set the new offset position, new_jpos, into the indx_pos
        SET_JPOS_TPE (open_id, indx_pos, new_jpos, status)
        chk_stat(status)
        write ('indx_pos', indx_pos, 'new_jpos',cr, new_jpos,cr)
      CASE (XYZ_POS): -- The position is a XYZWPR
         -- Get the XYZWPR position P[indx_pos] from to_prog
        org_xyz = GET_POS_TPE (open_id , indx_pos, status)
        chk_stat( status)               -- Check status from GET_POS_TPE
```

Applying Offsets to Copied Teach Pendant Program - Clears TP User Menu

```
-- Apply offset to the XYZWPR
        new_xyz.x = org_xyz.x + off_xyz.x
        new_xyz.y = org_xyz.y + off_xyz.y
        new_xyz.z = org_xyz.z + off_xyz.z
        new_xyz.w = org_xyz.w + off_xyz.w
        new_xyz.p = org_xyz.p + off_xyz.p
        new_xyz.r = org_xyz.r + off_xyz.r
         --Set the new offset position, new_xyz, into the indx_pos
        SET_POS_TPE (open_id, indx_pos, new_xyz, status)
        chk_stat (status)             -- Check status from SET_POS_TPE
   ENDSELECT
 ENDFOR
 ---Close TP program before quitting program
 CLOSE_TPE (open_id, status)
 chk_stat (status)                   --Check status from CLOSE_TPE
END ModifyPrg
-------------------------------------------------------------------------------
----    Section 3-F:  TP_CLS Declaration
----                  Clears the TP USER Menu screen and forces it to
----                  become visible.  The actual code resides in
ROUT_EX.KL
-------------------------------------------------------------------------------
ROUTINE TP_CLS FROM rout_ex
-------------------------------------------------------------------------------
```

```
----    Section 4:  Main Program
--------------------------------------------------------------------------------
BEGIN  -- CPY_TP
 tp_cls                              -- Clear the TP USER Menu screen
 GetFromPrg                          -- Get the TPE program to copy FROM
 GetOvrSw                            -- Get the TPE program name to copy TO
 GetOffset                           -- Get the offset for modifying
                                     -- the teach pendant program
 ModifyPrg                          -- Modify the copied program by the offset
END CPY_TP
```

Appendix C

KCL COMMAND ALPHABETICAL DESCRIPTION

Contents

Appendix C KCL COMMAND ALPHABETICAL DESCRIPTION C–1
C.1 ABORT command C–5
C.2 APPEND FILE command C–6
C.3 APPEND NODE command C–6
C.4 CHDIR command C–7
C.5 CLEAR ALL command C–7
C.6 CLEAR BREAK CONDITION command C–8
C.7 CLEAR BREAK PROGRAM command C–8
C.8 CLEAR DICT command C–8
C.9 CLEAR PROGRAM command C–9
C.10 CLEAR VARS command C–9
C.11 COMPRESS DICT command C–10
C.12 COMPRESS FORM command C–10
C.13 CONTINUE command C–10
C.14 COPY FILE command C–11
C.15 CREATE VARIABLE command C–12
C.16 DELETE FILE command C–12
C.17 DELETE NODE command C–13
C.18 DELETE VARIABLE command C–13
C.19 DIRECTORY command C–14
C.20 DISABLE BREAK PROGRAM command C–14

C.21 DISABLE CONDITION command C–15
C.22 DISMOUNT command C–15
C.23 EDIT command C–15
C.24 ENABLE BREAK PROGRAM C–16
C.25 ENABLE CONDITION command C–16
C.26 FORMAT command C–17
C.27 HELP command C–17
C.28 HOLD command C–17
C.29 INSERT NODE command C–18
C.30 LOAD ALL command C–18
C.31 LOAD DICT command C–19
C.32 LOAD FORM command C–19
C.33 LOAD MASTER command C–20
C.34 LOAD PROGRAM command C–20
C.35 LOAD SERVO command C–21
C.36 LOAD SYSTEM command C–21
C.37 LOAD TP command C–22
C.38 LOAD VARS command C–22
C.39 LOGOUT command C–23
C.40 MKDIR command C–24
C.41 MOUNT command C–24
C.42 MOVE FILE command C–24
C.43 PAUSE command C–25
C.44 PURGE command C–26
C.45 PRINT command C–26
C.46 RECORD command C–26
C.47 RENAME FILE command C–27
C.48 RENAME VARIABLE command C–27
C.49 RENAME VARS command C–28
C.50 RESET command C–29
C.51 RMDIR command C–29
C.52 RUN command C–29
C.53 RUNCF command C–30
C.54 SAVE MASTER command C–30
C.55 SAVE SERVO command C–31
C.56 SAVE SYSTEM command C–31
C.57 SAVE TP command C–32
C.58 SAVE VARS command C–32
C.59 SET BREAK CONDITION command C–33
C.60 SET BREAK PROGRAM command C–33
C.61 SET CLOCK command C–34

C.62 SET DEFAULT command C–35
C.63 SET GROUP command C–35
C.64 SET LANGUAGE command C–35
C.65 SET LOCAL VARIABLE command C–36
C.66 SET PORT command C–36
C.67 SET TASK command C–37
C.68 SET TRACE command C–37
C.69 SET VARIABLE command C–38
C.70 SET VERIFY command C–39
C.71 SHOW BREAK command C–39
C.72 SHOW BUILTINS command C–40
C.73 SHOW CONDITION command C–40
C.74 SHOW CLOCK command C–40
C.75 SHOW CURPOS command C–40
C.76 SHOW DEFAULT command C–41
C.77 SHOW DEVICE command C–41
C.78 SHOW DICTS command C–41
C.79 SHOW GROUP command C–41
C.80 SHOW HISTORY command C–41
C.81 SHOW LANG command C–42
C.82 SHOW LANGS command C–42
C.83 SHOW LOCAL VARIABLE command C–42
C.84 SHOW LOCAL VARS command C–43
C.85 SHOW MEMORY command C–44
C.86 SHOW PROGRAM command C–44
C.87 SHOW PROGRAMS command C–44
C.88 SHOW SYSTEM command C–45
C.89 SHOW TASK command C–45
C.90 SHOW TASKS command C–45
C.91 SHOW TRACE command C–46
C.92 SHOW TYPES command C–46
C.93 SHOW VARIABLE command C–46
C.94 SHOW VARS command C–47
C.95 SHOW data_type command C–47
C.96 SIMULATE command C–48
C.97 SKIP command C–49
C.98 STEP OFF command C–49
C.99 STEP ON command C–50
C.100 TRANSLATE command C–50
C.101 TYPE command C–50
C.102 UNSIMULATE command C–51

C.103 WAIT command C–51

This section describes each KCL command in alphabetical order. Each description includes the purpose of the command, its syntax, and details of how to use it. Examples of each command are also provided.

The following notation is used to describe KCL command syntax:

- < > indicates optional arguments to a command
- | indicates a choice which must be made
- { } indicates an item can be repeated
- file_spec: <device_name:><\\host_name\><path_name\>file_name.f ile_type |<device_name:><\\host_name\>‘host_specific_name’
- path_name: <file_device:\><dir\dir\. . .>
- file_name: maximum of 8 characters, no file type

device_name: is a two to five-character optional field, followed by a colon. The first character is a letter, the remaining characters must be alphanumeric. If this field is left blank, the default device from the system variable $DEVICE will be used.

host_name: file_name type - is a one to eight character optional field. The host_name selects the network node that receives this command. It must be preceded by two backslashes and separated from the remaining fields by a backslash.

path_name : file_name\<path_name> - is a recursively defined optional field consisting of a maximum of 64 characters. It is used to select the file subdirectory. The root or source directory is handled as a special case. It is designated by a file_name of zero length. For example, access to the subdirectory SYS linked off of the root would have path name ‘\SYS’. A fully qualified file_spec using this path_name would look like this, ‘C1:\HOST\SYS\FILE.KL’.

file_name: from one to eight characters

file_type: from zero to three characters

KCL commands can be abbreviated allowing you to type in fewer letters as long as the abbreviated version remains unique among all keywords. For example, ‘‘ABORT’’ can be ‘‘AB’’ but ‘‘CONTINUE’’ must be ‘‘CONT’’ to distinguish it from ‘‘CONDITION.’’

KCL commands that have <prog_name> as part of the command syntax will use the default program if none is specified. KCL commands that have <file_name> as part of the command syntax will use the default program as the file name if none is specified.

C.1 ABORT command

Syntax: ABORT < (**prog_name**) | ALL) > <FORCE>

where:

prog_name : the name of any KAREL or TP program which is a task

ALL : aborts all running or paused tasks

FORCE : aborts the task even if the NOABORT attribute is set. FORCE only works with ABORT prog_name; FORCE does not work with ABORT ALL

Purpose: Aborts the specified running or paused task. If **prog_ name** is not specified, the default program is used.

Execution of the current program statement is completed before the task aborts except for the current motion, DELAY, WAIT, or READ statements, which are canceled.

Examples: KCL> ABORT test_prog FORCE

KCL> ABORT ALL

C.2 APPEND FILE command

Syntax: APPEND FILE **input_file_spec** TO **output_ file_spec**

where:

input_file_spec : a valid file specification

output_file_spec : a valid file specification

Purpose: Appends the contents of the specified input file to the end of the specified output file. The **input_file_spec** and the **output_file_spec** must include both the file name and the file type.

Examples: KCL> APPEND FILE flpy:test.kl TO productn.kl

KCL> APPEND FILE test.kl TO productn.kl

C.3 APPEND NODE command

Syntax: APPEND NODE <[**prog_name**]> **var_name**

where:

prog_name : the name of any KAREL or TP program

var_name : the name of any variable of type PATH

Purpose: Appends one node to the end of the specified PATH variable previously loaded in RAM. The appended node value is uninitialized and the index number is one more than the last node index. Execute the KCL> SAVE VARS command to make the change permanent.

Examples: KCL> APPEND NODE [test_prog]weld_pth

KCL> APPEND NODE weld_pth

C.4 CHDIR command

Syntax: CHDIR < **device_name** >\< **path_name** >\ or CD < **device_name** >\< **path_nam e** >

where:

device_name : a specified device

path_name : a subdirectory previously created on the memory card device using the mkdir command. When the chdir command is used to change to a subdirectory, the entire path will be displayed on the teach pendant screen as mc:\new_dir\new_file.

The double dot (..) can be used to represent the directory one level above the current directory.

Purpose: Changes the default device. If a **device_name** is not specified, displays the default device.

Examples: KCL> CHDIR rd:\

KCL> CD

KCL> CD mc:\a

KCL> CD ..

C.5 CLEAR ALL command

Syntax: CLEAR ALL <YES>

where:

YES : confirmation is not prompted

Purpose: Clears all KAREL and teach pendant programs and variable data from memory. All cleared programs and variables (if they were saved with the KCL> SAVE VARS command) can be reloaded into memory using the KCL> LOAD command.

Examples: KCL> CLEAR ALL

Are you sure? YES

KCL> CLEAR ALL Y

C.6 CLEAR BREAK CONDITION command

Syntax: CLEAR BREAK CONDITION < **prog_name** > (**brk_pnt_no** | ALL)

where:

prog_name : the name of any KAREL program in memory

brk_pnt_no : a particular condition break point

ALL : clears all condition break points

Purpose: Clears specified condition break point(s) from the specified or default program.

A condition break point only affects the program in which it is set.

Examples: KCL> CLEAR BREAK CONDITION test_prog 3

KCL> CLEAR BREAK COND ALL

C.7 CLEAR BREAK PROGRAM command

Syntax: CLEAR BREAK PROGRAM < **prog_name** > (**brk_pnt_no** | ALL)

where:

prog_name : the name of any KAREL program in memory

brk_pnt_no : a particular program break point

ALL : clears all break points

Purpose: Clears specified break point(s) from the specified or default program.

A break point only affects the program in which it is set.

Examples: KCL> CLEAR BREAK PROGRAM test_prog 3

KCL> CLEAR BREAK PROG ALL

C.8 CLEAR DICT command

Syntax: CLEAR DICT **dict_name** <(**lang_name** | ALL)>

where:

dict_name : the name of any dictionary to be cleared

lang_name : the name of the language. The available choices are ENGLISH, JAPANESE, FRENCH, GERMAN, SPANISH or DEFAULT.

ALL : clears the dictionary from all languages

Purpose: Clears a dictionary from the specified language or from all languages. If no language is specified, it is cleared from the DEFAULT language only.

Examples: KCL> CLEAR DICT tpsy ENGLISH

KCL> CLEAR DICT tpsy

C.9 CLEAR PROGRAM command

Syntax: CLEAR PROGRAM < **prog_name** > <YES>

where:

prog_name : the name of any KAREL or teach pendant program in memory

YES : confirmation is not prompted

Purpose: Clears the program data from memory for the specified or default program.

Examples: KCL> CLEAR PROGRAM test_prog

Are you sure? YES

KCL> CLEAR PROG test_prog Y

C.10 CLEAR VARS command

Syntax: CLEAR VARS < **prog_name** > <YES>

where:

prog_name : the name of any KAREL or teach pendant program with variables

YES : confirmation is not prompted

Purpose: Clears the variable and type data associated with the specified or default program from memory.

Variables and types that are referenced by a loaded program are not cleared.

Examples: KCL> CLEAR VARS test_prog

Are you sure? YES

KCL> CLEAR VARS test_prog Y

C.11 COMPRESS DICT command

Syntax: COMPRESS DICT **file_name**

where:

file_name : the file name of the user dictionary you want to compress.

Purpose: Compresses a dictionary file from the default storage device, using the specified dictionary name. The file type of the user dictionary must be ".UTX". The compressed dictionary file will have the same file name as the user dictionary, and be of type ".TX".

See Also: Chapter 10 *DICTIONARIES AND FORMS*

Example: KCL> COMPRESS DICT tphcmneg

C.12 COMPRESS FORM command

Syntax: COMPRESS FORM < **file_name** >

where:

file_name : the file name of the form you want to compress.

Purpose: Compresses a form file from the default storage device using the specified form name. The file type of the form must be ".FTX". A compressed dictionary file and variable file will be created. The compressed dictionary file will have the same file name as the form file and be of type ".TX". The variable file will have a four character file name, that is extracted from the form file name, and be of type ".VR". If no form file name is specified, the name "FORM" is used.

See Also: Chapter 10 *DICTIONARIES AND FORMS*

Examples: KCL> COMPRESS FORM

KCL> COMPRESS FORM mnpalteg

C.13 CONTINUE command

Syntax: CONTINUE <(**prog_name**) | ALL)>

where:

prog_name : the name of any KAREL or teach pendant program which is a task

ALL : continues all paused tasks

Purpose: Continues program execution of the specified task that has been paused by a hold, pause, or test run operation. If the program is aborted, the program execution is started at the first executable line.

When a task is paused, the CYCLE START button on the operator panel has the same effect as the KCL> CONTINUE command.

CONTINUE is a motion command; therefore, the device from which it is issued must have motion control.

See Also: Refer to the $RMT_MASTER description in the *FANUC Robotics SYSTEM R-J3iC Controller Software Reference Manual* for more information about assigning motion control to a remote device.

Examples: KCL> CONTINUE test_prog

KCL> CONT ALL

C.14 COPY FILE command

Syntax: COPY <FILE> **from_file_spec** TO **to_file_spec** <OVERWRITE>

where:

from_file_spec : a valid file specification

to_file_spec : a valid file specification

OVERWRITE : specifies copy over (overwrite) an existing file

Purpose: Copies the contents of one file to another with overwrite option. Allows file transfers between different devices and between the controller and a host system.

The wildcard character (*) can be used to replace **from_file_spec** 's entire file name, the first part of the file name, the last part of the file name, or both the first and last parts of the file name. The file type can also use the wildcard in the same manner. The wildcard character in the **to_file_spec** can only replace the entire file name or the entire file type.

Examples: KCL> COPY flpy:\test.kl TO rdu:newtest.kl

KCL> COPY mc:\test_dir\test.kl TO mc:\test_dir\newtest.kl

KCL> COPY FILE flpy:*.kl TO rd:*.kl

KCL> COPY *.* TO fr:

KCL> COPY FILE *.kl TO rd:*.bak OVERWRITE

KCL> COPY FILE flpy:*main*.kl TO rd:* OV

KCL> COPY mdb:*.tp TO mc:

C.15 CREATE VARIABLE command

Syntax: CREATE VARIABLE <[**prog_name**]> **var_name <IN (CMOS | DRAM)> : data_type**

where:

prog_name : the name of any KAREL or TP program

var_name:data_type : a valid variable name and data type

Purpose: Allows you to declare a variable that will be associated with the specified or default program. You must specify a valid identifier for the **var_name** and a valid **data_type** .

Only one variable can be declared with the CREATE VAR command. You must enter the KCL> SAVE VARS command to save the declared variable with the program variable data. Use the KCL> SET VARIABLE command to assign a value to a variable.

The following data types are valid (user types are also supported): ARRAY OF BYTE, JOINTPOS, ARRAY OF SHORT, JOINTPOS1 to JOINTPOS9, BOOLEAN, POSITION, COMMON_ASSOC, REAL, CONFIG, VECTOR, FILE, XYZWPR, GROUP_ASSOC, XYZWPREXT, INTEGER

You can create multi-dimensional arrays of the above type. A maximum of 3 dimensions may be specified. Paths may only be created from a user defined type.

By default, the variable will be created in temporary memory (in DRAM), and must be recreated every power up. The value will always be reset to uninitialized.

If IN CMOS is specified the variable will be created in permanent memory. The variable's value will be recovered every time the controller is turned on.

See Also: SET VARIABLE command

Examples: KCL> CREATE VAR [test_prog]count IN CMOS: INTEGER

KCL> CREATE VAR vec:ARRAY[3,2,4] OF VECTOR

C.16 DELETE FILE command

Syntax: DELETE FILE **file_spec** <YES>

where:

file_spec : a valid file specification

YES : confirmation is not prompted

Purpose: Deletes the specified file from the specified storage device. The wildcard character (*) can be used to replace the entire file name, the first part of the file name, the last part of the file name, or both the first and last parts of the file name. The file type can also use the wildcard in the same manner.

Examples: KCL> DELETE FILE testprog.pc

Are you sure? YES

KCL> DELETE FILE rd:\testprog.pc YES

KCL> DELETE FILE rd:*.* Y

C.17 DELETE NODE command

Syntax: DELETE NODE <[**prog_name**]> **var_name node_index**]

where:

prog_name : the name of any KAREL or TP program

var_name : the name of any variable of type PATH

[**node_index**] : a node in the path

Purpose: Deletes the specified node from the specified PATH variable. The PATH variable must be loaded in memory. Enter the KCL> SAVE VARS command to make the change permanent.

Examples: KCL> DELETE NODE [test_prog]weld_pth[4]

KCL> DELETE NODE weld_pth[3]

C.18 DELETE VARIABLE command

Syntax: DELETE VARIABLE <[**prog_name**]> **var_name**

where:

prog_name : the name of any KAREL or TP program with variables

var_name : the name of any program variable

Purpose: Deletes the specified variable from memory. A variable that is linked with loaded p-code cannot be deleted. Enter the KCL> SAVE VARS command to make the change permanent.

Examples: KCL> DELETE VARIABLE [test_prog]weld_pth

KCL> DELETE VAR weld_pth

C.19 DIRECTORY command

Syntax: DIRECTORY < **file_spec** >

where:

file_spec : a valid file specification

Purpose: Displays a list of the files that are on a storage device. If **file_spec** is not specified, directory information is displayed for all of the files stored on a specified device. The directory information displayed includes the following:

The volume name of the device (if specified when the device was initialized)

The name of the subdirectory, if available

The names and types of files currently stored on the device and the sizes of the files in bytes

The number of files, the number of bytes left, and the number of bytes total, if available

The wildcard character (*) can be used to replace the entire file name, the first part of the file name, the last part of the file name, or both the first and last parts of the file name. The file type can also use the wildcard in the same manner.

Examples: KCL> DIRECTORY rd:

KCL> DIR *.kl

KCL> DIR *SPOT*.kl

KCL> CD MC: \test_dir

Use the CD command to change to the KCL> DIR subdirectory before you use the DIR commandor KCL> DIR \test_dir*.* display the subdirectory contents without using the CD command.

C.20 DISABLE BREAK PROGRAM command

Syntax: DISABLE BREAK PROGRAM < **prog_name** > **brk_pnt_no**

where:

prog_name : the name of any KAREL or TP program in memory

brk_pnt_no : a particular program break point

Purpose: Disables the specified break point in the specified or default program.

Examples: KCL> DISABLE BREAK PROGRAM test_prog 3

KCL> DISABLE BREAK PROG 3

C.21 DISABLE CONDITION command

Syntax: DISABLE CONDITION < **prog_name** > **condition_no**

where:

prog_name : the name of any KAREL program in memory

condition_no : a particular condition

Purpose: Disables the specified condition in the specified or default program.

Examples: KCL> DISABLE CONDITION test_prog

KCL> DISABLE COND 3

C.22 DISMOUNT command

Syntax: DISMOUNT **device_name:**

where:

device_name : device to be dismounted

Purpose: Dismounts a mounted storage device and indicates to the controller that a storage device is no longer available for reading or writing data.

Example: KCL> DISMOUNT rd:

C.23 EDIT command

Syntax: EDIT < **file_spec** >

where:

file_spec : a valid file specification

Purpose: Provides an ASCII text editor which can be used for editing dictionary files, command files and KAREL source files.

If **file_spec** is not specified, the default program name is used as the file name and the default file type is .KL (KAREL source code).

If a previous editing session exists, then **file_spec** is ignored and the editing session is resumed.

Examples: KCL> EDIT startup.cf

KCL> ED

C.24 ENABLE BREAK PROGRAM

Syntax: ENABLE BREAK PROGRAM < **prog_name** > **brk_pnt_no**

where:

prog_name : the name of any KAREL or TP program in memory

brk_pnt_no : a particular program break point

Purpose: Enables the specified break point in the specified or default program.

Examples: KCL> ENABLE BREAK PROGRAM test_prog 3

KCL> ENABLE BREAK PROG 3

C.25 ENABLE CONDITION command

Syntax: ENABLE CONDITION < **prog_name** > **condition_no**

where:

prog_name : the name of any KAREL program in memory

condition_no : a particular condition

Purpose: Enables the specified condition in the specified or default program.

Examples: KCL> ENABLE CONDITION test_prog

KCL> ENABLE COND 3

C.26 FORMAT command

Syntax: FORMAT **device_name:** < **volume_name** > <YES>

where:

device_name : the specified device to be initialized

volume_name : label for the device

YES : confirmation is not prompted

Purpose: Formats a specified device. A device must be formatted before storing files on it.

Examples: KCL> FORMAT rd:

Are you sure? YES

KCL> FORMAT rd: Y

C.27 HELP command

Syntax: HELP < **command_name** >

where:

command_name : a KCL command

Purpose: Displays on-line help for KCL commands. If you specify a **command_name** argument, the required syntax and a brief description of the specified command is displayed.

Examples: KCL> HELP LOAD PROG

KCL> HELP

C.28 HOLD command

Syntax: HOLD <(**prog_name** | ALL)>

where:

prog_name : the name of any KAREL or TP program

ALL : holds all executing programs

Purpose: Pauses the specified or default program that is being executed and holds motion at the current position (after a normal deceleration).

Use the KCL> CONTINUE command or the CYCLE START button on the operator panel to resume program execution.

Examples: KCL> HOLD test_prog

KCL> HO ALL

C.29 INSERT NODE command

Syntax: INSERT NODE <[**prog_name**]> **var_name node_index**]

where:

prog_name : the name of any KAREL or TP program

var_name : the name of any variable of type PATH

node_index: : a node in the path

Purpose: Inserts a node in front of the specified node in the PATH variable. The PATH variable must be loaded in memory.

The inserted node index number is the **node_index** you specify and the inserted node value is uninitialized. The index numbers for subsequent nodes are incremented by one. You must enter the KCL> SAVE VARS command to make the change permanent.

Examples: KCL> INSERT NODE [test_prog]weld_pth[2]

KCL> INSERT NODE weld_pth[3]

C.30 LOAD ALL command

Syntax: LOAD ALL < **file_name** > <CONVERT>

where:

file_name : a valid file name

CONVERT : converts variables to system definition

Purpose: Loads a p-code and variable file from the default storage device and default directory into memory using the specified or default file name. The file types for the p-code and variable files are assumed to be “.PC” and “.VR” respectively.

If **file_name** is not specified, the default program is used. If the default has not been set, then the message, ‘‘Default program name not set,’’ will be displayed.

Examples: KCL> LOAD ALL test_prog

KCL> LOAD ALL

C.31 LOAD DICT command

Syntax: LOAD DICT **file_name dict_name** < **lang_name** >

where:

file_name : the name of the file to be loaded

dict_name : the name of any dictionary to be loaded. The name will be truncated to 4 characters.

lang_name : a particular language. The available choices are ENGLISH, JAPANESE, FRENCH, GERMAN, SPANISH or DEFAULT.

Purpose: Loads a dictionary file from the default storage device and default directory into memory using the specified file name. The file type is assumed to be ‘‘.TX.’’

See Also: Chapter 10 *DICTIONARIES AND FORMS*

Examples: KCL> LOAD DICT tpaleg tpal FRENCH

KCL> LOAD DICT tpaleg tpal

C.32 LOAD FORM command

Syntax: LOAD FORM < **form_name** >

where:

form_name : the name of the form to be loaded

Purpose: Loads the specified form, from the default storage device, into memory. A form consists of a compressed dictionary file and a variable file. If no name is specified, ’FORM.TX’ and ’FORM.VR’ are loaded.

If the specified **form_name** is greater than four characters, the first two characters are not used for the dictionary name or the variable file name.

See Also: For more information on creating and using forms, refer to Chapter 10 *DICTIONARIES AND FORMS*

Example: KCL> LOAD FORM

Loading FORM.TX with dictionary name FORM

Loading FORM.VR

KCL> LOAD FORM tpexameg

Loading TPEXAMEG.TX with dictionary name EXAM

Loading EXAM.VR

C.33 LOAD MASTER command

Syntax: LOAD MASTER < **file_name** > <CONVERT>

where:

file_name : a valid file name

CONVERT : converts variables to system definition

Purpose: Loads a mastering data file from the default storage device and default directory into memory using the specified or default file name. The file type is assumed to be ".SV."

If **file_name** is not specified, the default file name, "SYSMAST.SV," is used.

Example: KCL> LOAD MASTER

C.34 LOAD PROGRAM command

Syntax: LOAD PROGRAM < **file_name** >

where:

file_name : a valid file name

Purpose: Loads a p-code file from the default storage device and default directory into memory using the specified or default file name. The file type is assumed to be ".PC."

If **file_spec** is not specified, the default program is used. If the default has not been set, then the message, "Default program name not set," will be displayed.

Examples: KCL> LOAD PROGRAM test_prog

KCL> LOAD PROG

C.35 LOAD SERVO command

Syntax: LOAD SERVO < **file_name** > <CONVERT>

where:

file_name : a valid file name

CONVERT : converts variables to system definition

Purpose: Loads a servo parameter file from the default storage device and default directory into memory using the specified or default file name. The file type is assumed to be ‘‘.SV.’’

If **file_name** is not specified, the default file name, ‘‘SYSSERVO.SV,’’ is used.

Example: KCL> LOAD SERVO

C.36 LOAD SYSTEM command

Syntax: LOAD SYSTEM < **file_name** > <CONVERT>

where:

file_name : a valid file name

CONVERT : converts variables to system definition

Purpose: Loads the specified system variable file into memory, assigning values to all of the saved system variables. The default storage device and default directory are used with the specified or default file name. The file type is assumed to be ‘‘.SV.’’

If **file_name** is not specified, the default file name, ‘‘SYSVARS.SV,’’ is used.

Examples: KCL> LOAD SYSTEM awdef

KCL> LOAD SYSTEM CONVERT

The following rules are applicable for system variables:

- If an array system variable that is not referenced by a program already exists when a .SV file is loaded, the size in the .SV file is used and the contents are loaded. No errors are posted.
- If an array system variable that is referenced by a program already exists when a .SV file with a LARGER size is loaded, the size in the .SV file is ignored, and NONE of the array values are loaded. The following errors are posted; " *var_name* memory not updated", "Array len creation mismatch".

- If an array system variable that is referenced by a program already exists when a .SV file with a SMALLER size is loaded, the size in the .SV file is ignored but ALL the array values are loaded. No errors are posted.
- If a .SV file with a different type definition is loaded, the .SV file will stop loading and detect the error. The following errors are posted; "Create type - *var_name* failed", "Duplicate creation mismatch".
- If a .SV. file with a different type definition is loaded, but the CONVERT option is specified, it tries to load as much as it can. For example, the controller has a SCR_T type which has the field $NEW but not the field $OLD. When an old .SV file is loaded that has $OLD but not $NEW, the load procedure creates the SCR_T type based on what is in the .SV file and posts a "Create type - var_name failed", "Duplicate creation mismatch" error. It then creates the type SCR_! which has the field $OLD but not the field $NEW. It then does a field by field copy of all of the old valid fields into the new type. Therefore, since there is not $NEW information in the old type that field is not updated and the $OLD information is discarded. Any fields whose types don't match are discarded from the loaded type. So if a field was changed from integer to real, the integer field in the loaded data would be discarded. Any fields that are arrays will follow the same rules as array system variables.

C.37 LOAD TP command

Syntax: LOAD TP < **file_name** > <OVERWRITE>

where:

file_name : a valid file name

OVERWRITE : If specified, may overwrite a previously loaded TP program with the same name

Purpose: Loads a TP program from the default storage device and default directory into memory using the specified or default file name. The file type is assumed to be ‘‘.TP.’’

If **file_name** is not specified, the default program is used. If the default has not been set, then the message, ‘‘Default program name not set,’’ will be displayed.

Examples: KCL> LOAD TP testprog

KCL> LOAD TP

C.38 LOAD VARS command

Syntax: LOAD VARS < **file_name** > <CONVERT>

where:

file_name : a valid file name

CONVERT : converts variables to system definition

Purpose: Loads the specified or default variable data file from the default storage device and directory into memory. The file type is assumed to be ‘‘.VR.’’

If **file_name** is not specified, the default program is used. If the default has not been set then the message, ‘‘Default program name not set,’’ will be displayed.

Examples: KCL> LOAD VARS test_prog

KCL> LOAD VARS

The following rules are applicable for array variables:

- If an array variable that is not referenced by a program already exists when a .VR file is loaded, the size in the .VR file is used and the contents are loaded. No errors are posted.
- If an array variable already exists when a program is loaded, the size in the .PC file is ignored and the program is loaded anyway. The following errors are posted: " *var_name* PC array length ignored", and "Array len creation mismatch".
- If an array variable that is referenced by a program already exists when a .VR file with a LARGER size is loaded, the size in the .VR file is ignored and NONE of the array values are loaded. The following errors are posted; " *var_name* memory not updated," "Array len creation mismatch."
- If an array variable that is referenced by a program already exists when a .VR file with a SMALLER size is loaded, the size in the .VR file is ignored but ALL the array values are loaded. The following errors are posted; " *var_name* array length updated," "Array len creation mismatch."

The following rules are applicable for user-defined types in KAREL programs:

- Once a type is created it can never be changed, regardless of whether a program references it or not. If all the variables referencing the type are deleted, the type will also be deleted. A new version can then be loaded.
- If a type already exists when a program with a different type definition is loaded, the .PC file will not be loaded. The following errors are posted; "Create type - *var_name* failed," "Duplicate creation mismatch."
- If a type already exists when a .VR file with a different type definition is loaded, the .VR file will stop loading when it detects the error. The following errors are posted; "Create type - *var_name* failed," "Duplicate creation mismatch".

C.39 LOGOUT command

Syntax: LOGOUT

Purpose: Logs the current user from the KCL device out of the system. The password level reverts to the OPERATOR level. If passwords are not enabled, an error message will be displayed by KCL such as, "No user currently logged in".

Example: KCL>LOGOUT

(The alarm message: "Logout (SAM) SETUP from KCL")

KCL Username>

C.40 MKDIR command

Syntax: MKDIR **<device_name>\path_name**

where:

device_name : a valid storage device

path_name : a subdirectory previously created on the memory card device using the mkdir command.

Purpose: MKDIR creates a subdirectory on the memory card (MC:) device. FANUC Robotics recommends you nest subdirectories only to 8 levels.

Example: KCL> MKDIR mc:\test_dir

KCL> MKDIR mc:\prog_dir\tpnx_dir

C.41 MOUNT command

Syntax: MOUNT **device_name**

where:

device_name : a valid storage device

Purpose: MOUNT indicates to the controller that a storage device is available for reading or writing data.

A device must be formatted with the KCL> FORMAT command before it can be mounted successfully.

Example: KCL> MOUNT rd:

C.42 MOVE FILE command

Syntax: MOVE <FILE> **file_spec**

where:

file_spec : a valid file specification.

Purpose: Moves the specified file from one memory file device to another. The file should exist on the FROM or RAM disks. If file_spec is a file on the FROM disk, the file is moved to the RAM disk, and vice versa.

The wildcard character (*) can be used to replace the entire file name, the first part of the file name, the last part of the file name, or both the first and last parts of the file name. The file type can also use the wildcard in the same manner. If file_spec specifies multiple files, then they are all moved to the other disk.

Examples: KCL> MOVE FILE fr:*.kl

KCL> MOVE rd:*.*

C.43 PAUSE command

Syntax: PAUSE <(**prog_name** | ALL)> <FORCE>

where:

prog_name : the name of any KAREL or TP program which is a task

ALL : pauses all running tasks

FORCE : pauses the task even if the NOPAUSE attribute is set

Purpose: Pauses the specified running task. If **prog_name** is not specified, the default program is used.

Execution of the current motion segment and the current program statement is completed before the task is paused.

Condition handlers remain active. If the condition handler action is NOPAUSE and the condition is satisfied, task execution resumes.

If the statement is a WAIT FOR and the wait condition is satisfied while the task is paused, the statement following the WAIT FOR is executed immediately when the task is resumed.

If the statement is a DELAY, timing will continue while the task is paused. If the delay time is finished while the task is paused, the statement following the DELAY is immediately executed when the task is resumed. If the statement is a READ, it will accept input even though the task is paused.

The KCL> CONTINUE command resumes execution of a paused task. When a task is paused, the CYCLE START button on the operator panel has the same effect as the KCL> CONTINUE command.

Examples: KCL> PAUSE test_prog FORCE

KCL> PAUSE ALL

C.44 PURGE command

Syntax: PURGE **device_name**

where:

device_name : the name of the memory file device to be purged

Purpose: Purges the specified memory file device by freeing any used blocks that are no longer needed. The device should be set to "FR:" for FROM disk, "RD:" for RAM disk, or "MF:" for both disks.

The purge operation is only necessary when the device does not have enough memory to perform an operation. The purge operation will erase file blocks that were previously used, but are no longer needed. These are called garbage blocks. The FROM disk can contain many garbage blocks if files are deleted or overwritten. The RAM disk will not normally contain garbage blocks, but they may occur when power is removed during a file copy.

The device must be mounted and no files can be open on the device or an error will be displayed.

Examples: KCL> PURGE fr:

KCL> PURGE mf:

C.45 PRINT command

Syntax: PRINT **file_spec**

where:

file_spec : a valid file specification

Purpose: Allows you to print the contents of an ASCII file to the default device.

Example: KCL> PRINT testprog.kl

C.46 RECORD command

Syntax: RECORD <[**prog_name**]> **var_name**

where:

prog_name : the name of any KAREL or TP program

var_name : the name of any POSITION, XYZWPR, or JOINTPOS variable

Purpose: Records the position of the TCP and/or auxiliary or extended axes. The robot must be calibrated before the RECORD command is issued. The variable can be a system variable or a program variable that exists in memory. The position is recorded relative to the user frame of reference.

You must enter the KCL> SAVE command to permanently assign the recorded position. The Record function key, F3, under the teach pendant TEACH menu also allows you to record positions.

Example: KCL> RECORD [paint_prog]start_pos

KCL> RECORD $GROUP[1].$uframe

C.47 RENAME FILE command

Syntax: RENAME FILE **old_file_spec** TO **new_file_ spec**

where:

old_file_spec : a valid file specification

new_file_spec : a valid file specification

Purpose: Changes the **old_file_spec** to the **new_file_spec** . The file will no longer exist under the **old_file_spec** . The **old_file_spec** and the **new_file_spec** must include both the file name and the file type. The same file type must be used in both file_specs but they cannot be the same file.

Use the KCL> COPY FILE command to change the device name of a file.

Examples: KCL> RENAME FILE test.kl TO productn.kl

KCL> RENAME FILE mycmd.cf TO yourcmd.cf

C.48 RENAME VARIABLE command

Syntax: RENAME VARIABLE <[**prog_name**]> **old_var_ name new_var_name**

where:

prog_name : the name of any KAREL or TP program

old_var_name : the name of any program variable

new_var_name : a valid program variable name

Purpose: Changes the **old_var_name** to the **new_var_name** in the program specified with the **old_var_name** . The variable will no longer exist under the **old_var_name** . The variable must exist in memory under the **old_var_name** in the specified program.

The **new_var_name** cannot already exist in memory. The variable still belongs to the same program. You cannot specify a **prog_name** with the **new_var_name.**

You must enter the KCL> SAVE VARS command to make the change permanent.

Examples: KCL> RENAME VARIABLE [test_prog]count part_count

KCL> RENAME VAR count part_count

C.49 RENAME VARS command

Syntax: RENAME VARS **old_prog_name new_prog_name**

where:

old_prog_name : the name of any KAREL or TP program

new_prog_name : the name of any KAREL or TP program

Purpose: Changes the name of the variable data associated with the **old_prog_name** to the **new_prog_name** . The variable data will no longer exist under the **old_prog_name** .

Before you use the RENAME VARS command, the variable data must exist in memory under the **old_prog_name** . Variable data cannot already exist in memory under the **new_prog_name** .

The command does not rename the program. To rename a KAREL program, use the KCL> RENAME FILE to rename the .KL file, edit the program name in the .KL file, translate the program, and load the new C file. To rename a TP program, use the SELECT menu.

You must enter the KCL> SAVE VARS command to make the change permanent.

Example: KCL> RENAME VARS test_1 test_2

Use this sequence of KCL commands to copy the variable data of one program (**prog_1**) into a variable file that is then used by another program (**prog_2**):

LOAD VARS **prog_1**

RENAME VARS **prog_1 prog_2**

SAVE VARS **prog_2**

LOAD ALL **prog_2**

The effect of this sequence of commands cannot be accomplished with the KCL> COPY FILE command.

The name of the program to which the variable data belongs is stored in the variable file. The KCL> COPY FILE command does not change that stored program name, so the data cannot be used with another program.

C.50 RESET command

Syntax: RESET

Purpose: Enables servo power after an error condition has shut off servo power, provided the cause of the error has been cleared. The command also clears the message line on the CRT/KB display. The error message remains displayed if the error condition still exists.

The RESET command has no effect on a program that is being executed. It has the same effect as the FAULT RESET button on the operator panel and the RESET function key on the teach pendant RESET screen.

Example: KCL> RESET

C.51 RMDIR command

Syntax: RMDIR **<device_name>\path_name**

where:

device_name : a valid storage device

path_name : a subdirectory previously created on the memory card device using the mkdir command.

Purpose: RMDIR deletes a subdirectory on the memory card (MC:) device. The directory must be empty before it can be deleted.

Example: KCL> RMDIR mc:\test_dir

KCL> RMDIR mc:\test_dir\prog_dir

C.52 RUN command

Syntax: RUN < **prog_name** >

where:

prog_name :the name of any KAREL or TP program

Purpose: Executes the specified program. The program must be loaded in memory. If no program is specified the default program is run. If uninitialized variables are encountered, program execution is paused.

Execution begins at the first executable line. RUN is a motion command; therefore, the device from which it is issued must have motion control. If a RUN command is issued in a command file, it is executed as a NOWAIT command. Therefore, the statement following the RUN command will be executed immediately after the RUN command is issued without waiting for the program, specified by the RUN command, to end.

See Also: Refer to the $RMT_MASTER description in the *FANUC Robotics SYSTEM R-J3iC Controller Software Reference Manual* for more information about assigning motion control to a remote device.

Example: KCL> RUN test_prog

C.53 RUNCF command

Syntax: RUNCF **input_file_spec** < **output_file_spec** >

where:

input_file_spec : a valid file specification

output_file_spec : a valid file specification

Purpose: Executes the KCL command procedure that is stored in the specified input file and displays the output to the specified output file. The input file type is assumed to be .CF. The output file type is assumed to be .LS if no file type is supplied.

If **output_file_spec** is not specified, the output will be displayed to the KCL output window.

The RUNCF command can be nested within command files up to four levels. Use **%INCLUDE input_file_spec** to include another .CF file into the command procedure. RUNCF command itself is not allowed inside a command procedure.

If the command file contains motion commands, the device from which the RUNCF command is issued must have motion control.

See Also: Refer to Section 12.4, "Command Procedures," for more information

Examples: KCL> RUNCF startup output

KCL> RUNCF startup

C.54 SAVE MASTER command

Syntax: SAVE MASTER < **file_name** >

where:

file_name : a valid file name

Purpose: Saves the mastering data file from the default storage device and default directory into memory using the specified or default file name. The file type will be ‘‘.SV.’’

If **file_name** is not specified, the default file name, ‘‘SYSMAST.SV,’’ is used.

Example: KCL> SAVE MASTER

C.55 SAVE SERVO command

Syntax: SAVE SERVO < **file_name** >

where:

file_name :a valid file name

Purpose: Saves the servo parameters into the default storage device using the specified or default file name. The file type will be ‘‘.SV.’’

If **file_name** is not specified, the default file name, ‘‘SYSSERVO.SV,’’ is used.

Example: KCL> SAVE SERVO

C.56 SAVE SYSTEM command

Syntax: SAVE SYSTEM < **file_name** >

where:

file_name :a valid file name

Purpose: Saves the system variable values into the default storage device and default directory using the specified system variable file (.SV). If you do not specify a **file_spec** the default name, ‘‘SYSVARS.SV,’’is used. For example:

SAVE SYSTEM **file_1**

In this case, the system variable data is saved in a variable file called **file_1.SV** .

SAVE SYSTEM

In this case, the system variable data is saved in a system variable file ‘‘SYSVARS.SV.’’

Examples: KCL> SAVE SYSTEM file_1

KCL> SAVE SYSTEM

C.57 SAVE TP command

Syntax: SAVE TP < **file_name** > <= **prog_name** >

where:

file_name : a valid file name

prog_name : the name of any TP program

Purpose: Saves the specified TP program to the specified file (.TP). If you do not specify a **file_name** or a **prog_name** , the default program name is used. If only a **file_name** is specified, that name will also be used for **prog_name** . For example:

SAVE TP **file_1**

In this case, the TP program **file_1** is saved in a file called **file_1.TP** .

SAVE TP = **prog_1**

In this case, the TP program **prog_1** is saved in a file whose name is the default program name.

If you specify a program name, it must be preceded by an equal sign (=).

Examples: KCL> SAVE TP file_1 = prog_1

KCL> SAVE TP file_1

KCL> SAVE TP = prog_1

KCL> SAVE TP

C.58 SAVE VARS command

Syntax: SAVE VARS < **file_name** > <= **prog_name** >

where:

file_name : a valid file name

prog_name : the name of any KAREL or TP program

Purpose: Saves variable data from the specified program, including the currently assigned values, to the specified variable file (.VR). If you do not specify a **file_name** or a **prog_name** , the default program name is used. If only a **file_name** is specified, that name will also be used for **prog_name** . For example:

SAVE VARS **file_1**

In this case, the variable data for the program **file_1** is saved in a variable file called **file_1.VR.**

SAVE VARS = **prog_** 1

In this case, the variable data for **prog_** 1 is saved in a variable file whose name is the default program name.

If you specify a program name, it must be preceded by an equal sign (=).

Any variable data that is not saved is lost when an initial start of the controller is performed.

Examples: KCL> SAVE VARS file_1 = prog_1

KCL> SAVE VARS file_1

KCL> SAVE VARS = prog_1

KCL> SAVE VARS

C.59 SET BREAK CONDITION command

Syntax: SET BREAK CONDITION < **prog_name** > **condition_no**

where:

prog_name : the name of any running or paused KAREL program

condition_no : a particular condition

Purpose: Allows you to set a break point on the specified condition in the specified program or default program. The specified condition must already exist so the program must be running or paused. When the break point is triggered, a message will be posted to the error log and the break point will be cleared.

Examples: KCL> SET BREAK CONDITION test_prog 1

KCL> SET BREAK COND 2

C.60 SET BREAK PROGRAM command

Syntax: SET BREAK PROGRAM < **prog_name** > **brk_pnt_no line_no** <(PAUSE | DISPLAY | TRACE ON | TRACE OFF)>

where:

prog_name : the name of any KAREL or TP program in memory

brk_pnt_no : a particular program break point

line_no : a line number

PAUSE : task is paused when break point is executed

DISPLAY : message is displayed on the teach pendant USER menu when break point is executed

TRACE ON : trace is enabled when break point is executed

TRACE OFF : trace is disabled when break point is executed

Purpose: Allows you to set a break point at a specified line in the specified or default program. The specified line must be an executable line of source code. Break points will be executed before the specified line in the program. By default the task will pause when the break point is executed. DISPLAY, TRACE ON, and TRACE OFF will not pause task execution.

Break points are local only to the program in which the break points were set. For example, break point #1 can exist among one or more loaded programs with each at a unique line number. If you specify an existing break point number, the existing break point is cleared and a new one is set in the specified program at the specified line.

Break points in a program are cleared if the program is cleared from memory. You also use the KCL> CLEAR BREAK PROGRAM command to clear break points from memory.

Use the KCL> CONTINUE command or the operator panel CYCLE START button to resume execution of a paused program.

Examples: KCL> SET BREAK PROGRAM test_prog 1 22 DISPLAY

KCL> SET BREAK PROG 3 30

C.61 SET CLOCK command

Syntax: SET CLOCK **'dd-mmm-yy hh:mm'**

where:

The date is specified using two numeric characters for the day, a three letter abbreviation for the month, and two numeric characters for the year; for example, 01-JAN- 00.

The time is specified using two numeric characters for the hour and two numeric characters for the minutes; for example, 12:45.

Purpose: Sets the date and time of the internal controller clock.

The date and time are included in directory and translator listings.

See Also: SHOW CLOCK command

Example: KCL> SET CLOCK ’02-JAN-xx 21:45’

C.62 SET DEFAULT command

Syntax: SET DEFAULT **prog_name**

where:

prog_name : the name of any KAREL or TP program

Purpose: Sets the default program name to be used as an argument default for program and file names. The default program name can also be set at the teach pendant.

See Also: Section 12.1.1, “Default Program”

Examples: KCL> SET DEFAULT test_prog

KCL> SET DEF test_prog

C.63 SET GROUP command

Syntax: SET GROUP **group_no**

where:

group_no : a valid group number

Purpose: Sets the default group number to use in other commands.

Example: KCL> SET GROUP 1

C.64 SET LANGUAGE command

Syntax: SET LANGUAGE **lang_name**

where:

lang_name : a particular language. The available choices are ENGLISH, JAPANESE, FRENCH, GERMAN, SPANISH or DEFAULT.

Purpose: Sets the $LANGUAGE system variable which determines the language to use.

Example: KCL> SET LANG ENGLISH

C.65 SET LOCAL VARIABLE command

Syntax: SET LOCAL VARIABLE **var_name** <IN **rout_name** > <FROM **prog_name** > < **task_name** > = **value** <{, **value** }>

where:

var_name :a local variable or parameter name

rout_name :the name of any KAREL routine

prog_name :the name of any KAREL program

task_name : the name of any KAREL task

value : new value for variable

Purpose: Assigns the specified value to the specified local variable or routine parameter. You can assign constant values or variable values, but the value must be of the data type that has been declared for the variable.

Please use the HELP SET VAR command for more information on assigning data types.

If the IN clause is omitted, the routine at the top of the stack is assumed. If the FROM clause is omitted, the default program is assumed. If the **task_name** is omitted, the stack of the KCL default task is searched.

Note The file RD: **prog_name.rs** is required to obtain local variable information.

Example: See SHOW LOCAL VARIABLE command.

See Also: SHOW LOCAL VARIABLE and TRANSLATE command.

C.66 SET PORT command

Syntax: SET PORT **port_name [index] = value**

where:

port_name[index] : a valid I/O port **value** : a new value for the port

Purpose: Assigns the specified value to a specified input or output port. SET PORT can be used with either physical or simulated output ports, but only with simulated input ports.

The valid ports are:

DIN, DOUT, RDO, OPOUT, TPOUT, WDI, WDO (BOOLEAN)-AIN, AOUT, GIN, GOUT (INTEGER)

See Also: SIMULATE, UNSIMULATE command, Chapter 13 *INPUT/OUTPUT SYSTEM* , *FANUC Robotics SYSTEM R-J3iC Controller HandlingTool Setup and Operations Manual.*

Example: KCL> SET PORT DOUT [1] = ON

KCL> SET PORT GOUT [2] = 255

KCL> SET PORT AIN [1] = 1000

C.67 SET TASK command

Syntax: SET TASK <[**prog_name**]> **attr_name** = **value**

where:

prog_name : the name of any KAREL or TP program which is a task

attr_name : PRIORITY or TRACELEN

value : new integer value for attribute

Purpose: Sets the specified task attribute. PRIORITY sets the task priority. The lower the number, the higher the priority. 1 to 89 is lower than motion, but higher than the user interface. 90 to 99 is lower than the user interface. The default is 50. TRACELEN sets the trace buffer length. The default is 10 lines.

C.68 SET TRACE command

Syntax: SET TRACE (OFF | ON) <[**prog_name**]>

where:

prog_name : the name of any KAREL or TP program loaded in memory

Purpose: Turns the trace function ON or OFF (default is OFF). The program statement currently being executed and its line number are stored in a buffer when TRACE is ON. TRACE should only be set to ON during debugging operations because it slows program execution. To see the trace data, SHOW TRACE command must be used.

See Also: SHOW TRACE command

C.69 SET VARIABLE command

Syntax: SET VARIABLE <[**prog_name**]> **var_name** = **value** <{, **value** }>

where:

prog_name : the name of any KAREL or TP program

var_name : a valid program variable

value : new value for variable or a program or system variable

Purpose: Assigns the specified value to the specified variable. You can assign constant values or variable values, but the value must be of the data type that has been declared for the variable.

You can assign values to system variables with KCL write access, to program variables, or to standard and user-defined variables and fields. You can assign only one ARRAY element. Use brackets ([]) after the variable name to specify an element.

Certain data types like positions and vectors might have more than one value specified.

KCL> SET VAR position_var = 0,0,0,0,0,0

The SET VARIABLE command displays the previous value of the specified variable followed by the value which you have just assigned, providing you with an opportunity to check the assignment. The DATA key on the teach pendant also allows you to assign values to variables.

When you use SET VARIABLE to define a position you can use one of the following formats:

KCL> SET VARIABLE var_name.X = value

KCL> SET VARIABLE var_name.Y = value

KCL> SET VARIABLE var_name.Z = value

KCL> SET VARIABLE var_name.W = value

KCL> SET VARIABLE var_name = value

where X,Y,Z,W,P, and R specify the location and orientation, c_str is a string value representing configuration in terms of joint placement and turn numbers. Refer to Section 8.1, ‘‘Positional Data.’’ For example, to set X=200.0, W=60.0 and the turn numbers for axes 4 and 6 to 1 and 0 you would type the following lines:

KCL> SET VARIABLE var_name.X = 200

KCL> SET VARIABLE var_name.W = 60

KCL> SET VARIABLE var_name.C = '1,0'

You must enter the KCL>SAVE VARS command to make the changes permanent.

See Also: Section 2.3, "Data Types"

Examples: KCL> SET VARIABLE [prog1] scale = $MCR.$GENOVERRIDE

KCL> SET VAR weld_pgm.angle = 45.0

KCL> SET VAR v[2,1,3].r = -0.897

KCL> SET VAR part_array[2] = part_array[1]

KCL> SET VAR weld_pos.x = 50.0

KCL> SET VAR pth_b[3].nodepos = pth_a[3].nodepos

C.70 SET VERIFY command

Syntax: SET VERIFY (ON | OFF)

Purpose: This turns the display of KCL commands ON or OFF during execution of a KCL command procedure (default is ON, meaning each command is displayed as it is executed). Only the RUNCF command is displayed when VERIFY is OFF.

C.71 SHOW BREAK command

Syntax: SHOW BREAK < **prog_name** >

where:

prog_name : the name of any KAREL or TP program in memory

Purpose: Displays a list of program break points for the specified or default program. The following information is displayed for each break point:

- Break point number
- Line number of the break point in the program

Examples: KCL> SHOW BREAK test_prog

KCL> SH BREAK

C.72 SHOW BUILTINS command

Syntax: SHOW BUILTINS

Purpose: Displays all the softpart built-ins that are loaded on the controller.

Example: KCL> SHOW BUILTINS

C.73 SHOW CONDITION command

Syntax: SHOW CONDITION < **prog_name** > < **condition_no** >

where:

prog_name : the name of any running or paused KAREL program

condition_no : a particular condition

Purpose: Displays the specified condition handler or a list of condition handlers for the specified or default program. Also displays enabled/disabled status and whether a break point is set. Condition handlers only exist when a program is running or paused.

Examples: KCL> SHOW CONDITION test_prog

KCL> SH COND

C.74 SHOW CLOCK command

Syntax: SHOW CLOCK

Purpose: Displays the current date and time of the controller clock.

See Also: SET CLOCK command

Example: KCL> SHOW CLOCK

C.75 SHOW CURPOS command

Syntax: SHOW CURPOS

Purpose: Displays the position of the TCP relative to the current user frame of reference with an x, y, and z location in millimeters; w, p, and r orientation in degrees; and the current configuration string. Be sure the robot is calibrated.

Example: KCL> SHOW CURPOS

C.76 SHOW DEFAULT command

Syntax: SHOW DEFAULT

Purpose: Shows the current default program name.

Example: KCL> SHOW DEFAULT

C.77 SHOW DEVICE command

Syntax: SHOW DEVICE **device_name:**

where:

device_name : device to be shown

Purpose: Shows the status of the device.

Example: KCL> SHOW DEVICE rd:

C.78 SHOW DICTS command

Syntax: SHOW DICTS

Purpose: Shows the dictionaries loaded in the system for the language specified in the system variable $LANGUAGE.

Example: KCL> SHOW DICTS

C.79 SHOW GROUP command

Syntax: SHOW GROUP

Purpose: Shows the default group number.

Example: KCL> SHOW GROUP

C.80 SHOW HISTORY command

Syntax: SHOW HISTORY

Purpose: Shows the nesting information of the routine calls. To display the source lines of KAREL programs, the .KL programs must exist on the RAM disk.

Example: KCL> SHOW HIST

C.81 SHOW LANG command

Syntax: SHOW LANG

Purpose: Shows the language specified in the system variable $LANGUAGE.

Example: KCL> SHOW LANG

C.82 SHOW LANGS command

Syntax: SHOW LANGS

Purpose: Shows all language currently available in the system.

Example: KCL> SHOW LANGS

C.83 SHOW LOCAL VARIABLE command

Syntax: SHOW LOCAL VARIABLE **var_name** <(HEXADECIMAL | BINARY)> <IN **rout_name** > <FROM **prog_name** > < **task_name** >

where:

var_name : a local variable or parameter name

rout_name : the name of any KAREL routine

prog_name : the name of any KAREL program

task_name : the name of any KAREL task

Purpose: Displays the name, type, and value of the specified local variable or routine parameter. Use brackets ([ ]) after the variable name to specify a specific ARRAY element. If you do not specify a specific element the entire variable is displayed.

If the IN clause is omitted, the routine at the top of the stack is assumed. If the FROM clause is omitted, the default program is assumed. If the **task_name** is omitted, the stack of the KCL default task is searched.

Note The file RD: **prog_name.rs** is required to obtain local variable information.

Example: Generate a .rs file from the KAREL translator.

KCL> TRANS testprog RS

Copy the .rs file to the RD device.

This is done automatically when you load the program from the KCL.

KCL> SET DEF testprog

KCL> LOAD PROG

Copied testprog.rs to RD:testprog.rs

To show local variables, the program must be running, paused, or aborted in the routine specified.

KCL> RUN

KCL> SHOW LOCAL VARS

KCL> SHOW LOCAL VARS IN testprog VALUES

KCL> SHOW LOCAL VAR var_1 IN rout_1 FROM testprog testtask

KCL> SHOW LOCAL VAR param_1

To set local variables, the program must be paused.

KCL> pause

KCL> set local var int_var = 12345

KCL> set local var strparam = "This is a string parameter"

See Also: TRANSLATE command.

C.84 SHOW LOCAL VARS command

Syntax: SHOW LOCAL VARS <VALUES> <IN **rout_name** > <FROM **prog_name** > < **task_name** >

where:

VALUES: :specifies values should be displayed

rout_name :the name of any KAREL routine

prog_name :the name of any KAREL program

task_name :the name of any KAREL task

Purpose: Displays a list including the name, type, and if specified, the current value of each local variable and each routine parameter.

If the IN clause is omitted, the routine at the top of the stack is assumed. If the FROM clause is omitted, the default program is assumed. If the **task_name** is omitted, the stack of the KCL default task is searched

Note The file RD: **prog_name.rs** is required to obtain local variable information.

Example: See SHOW LOCAL VARIABLE command.

See Also: TRANSLATE command and SHOW LOCAL VARIABLE.

C.85 SHOW MEMORY command

Syntax: SHOW MEMORY

Purpose: Displays current memory status. The command displays the following status information for memory and lists each memory pool separately:

Total number of bytes in the pool

Available number of bytes in the pool

Example: KCL> SHOW MEMORY

C.86 SHOW PROGRAM command

Syntax: SHOW PROGRAM < **prog_name** >

where:

prog_name : the name of any KAREL or TP program in memory

Purpose: Displays the status information of the specified or default program being executed.

Example: KCL> SHOW PROGRAM test_prog

KCL> SH PROG

C.87 SHOW PROGRAMS command

Syntax: SHOW PROGRAMS

Purpose: Shows a list of programs and variable data that are currently loaded in memory.

Examples: KCL> SHOW PROGRAMS

KCL> SH PROGS

C.88 SHOW SYSTEM command

Syntax: SHOW SYSTEM < **data_type** > <VALUES>

where:

data_type : any valid KAREL data type

Purpose: Displays a list including the name, type, and if specified, the current value of each system variable. If you specify a **data_type** , only the system variables of that type are listed.

See Also: SHOW VARIABLE command

Examples: KCL> SHOW SYSTEM REAL VALUES

KCL> SH SYS

C.89 SHOW TASK command

Syntax: SHOW TASK < **prog_name** >

where:

prog_name : the name of any KAREL or TP program which is a task

Purpose: Displays the task control data for the specified task. If **prog_name** is not specified, the default program is used.

Examples: KCL> SHOW TASK test_prog

KCL> SH TASK

C.90 SHOW TASKS command

Syntax: SHOW TASKS

Purpose: Displays the status of all known tasks running KAREL programs or TP programs.

You may see extra tasks running that are not yours. If the teach pendant is displaying a menu that was written using KAREL, such as Program Adjustment or Setup Passwords, you will see the status for this task also.

Examples: KCL> SHOW TASKS

C.91 SHOW TRACE command

Syntax: SHOW TRACE < **prog_name** >

where:

prog_name : the name of any KAREL or TP program which is a task

Purpose: Shows all the program statements and line numbers that have been executed since TRACE has been turned on.

The number of lines that are shown depends on the trace buffer length, which can be set with the SET_TASK command or the SET_TSK_ATTR built-in routine. To display the source lines of KAREL programs, the .KL files must exist on the RAM disk.

See Also: SET TRACE command

Example: KCL> SHOW TRACE

C.92 SHOW TYPES command

Syntax: SHOW TYPES < **prog_name** > < **FIELDS** >

where:

prog_name : the name of any KAREL or TP program

FIELDS : specifies fields should be displayed

Purpose: Displays a list including the name, type, and if specified, the fields of each user-defined type in the specified or default program. The actual array dimensions and string sizes are not shown.

See Also: SHOW VARS command, SHOW VARIABLE command

Examples: KCL> SHOW TYPES test_prog FIELDS

KCL> SH TYPES

C.93 SHOW VARIABLE command

Syntax: SHOW VARIABLE <[**prog_name**]> **var_name** <(HEXADECIMAL | BINARY)>

where:

prog_name : the name of any KAREL or TP program

var_name : a valid program variable

Purpose: Displays the name, type, and value of the specified variable.

You can display the values of system variables that allow KCL read access or the values of program variables. Use brackets ([]) after the variable name to specify a specific ARRAY element. If you do not specify a specific element the entire variable is displayed.

See Also: SHOW VARS command, SHOW SYSTEM command

Examples: KCL> SHOW VARIABLE $UTOOL

KCL> SH VAR [test_prog]group_mask HEX

KCL> SH VAR [test_prog]group_mask BINARY

KCL> SH VAR weld_pth[3]

C.94 SHOW VARS command

Syntax: SHOW VARS < **prog_name** > <VALUES>

where:

prog_name : the name of any KAREL or TP program

VALUES : specifies values should be displayed

Purpose: Displays a list including the name, type and, if specified, the current value of each variable in the specified or default program.

See Also: SHOW VARIABLE command, SHOW SYSTEM command, SHOW TYPES command

Example: KCL> SHOW VARS test_prog VALUES

KCL> SH VARS

C.95 SHOW data_type command

Syntax: SHOW **data_type** < **prog_name** > <VALUES>

where:

data_type : any valid KAREL data type

prog_name : the name of any KAREL or TP program

VALUES : specifies values should be displayed

Purpose: Displays a list of variables in the specified or default program (**prog_name**) of the specified data type (**data_type**). The list includes the name, type, and if specified, the current value of each variable.

See Also: SHOW VARS command, SHOW VARIABLE command

Examples: KCL> SHOW REAL test_prog VALUES

KCL> SH INTEGER

C.96 SIMULATE command

Syntax: SIMULATE **port_name[index]** < **= value** >

where:

port_name[index] : a valid I/O port

value : a new value for the port

Purpose: Simulating I/O allows you to test a program that uses I/O. Simulating I/O does not actually send output signals or receive input signals.



Warning

Depending on how signals are used, simulating signals might alter program execution. Do not simulate signals that are set up for safety checks. If you do, you could injure personnel or damage equipment.

When simulating a port value, you can specify its initial simulated value or allow the initial value to be the same as the physical port value. If no value is specified, the current physical port value is used.

The valid ports are:

DIN, DOUT, WDI, WDO (BOOLEAN)AIN, AOUT, GIN, GOUT (INTEGER)

See Also: UNSIMULATE command

Examples: KCL> SIMULATE DIN[17]

KCL> SIM DIN[1] = ON

KCL> SIM AIN[1] = 100

C.97 SKIP command

Syntax: SKIP < **prog_name** >

where:

prog_name : the name of any KAREL or TP program which is a task

Purpose: Skips execution of the current statement in the specified task. If **prog_name** is not specified, the default program is used. It has no effect when a task is running or when the system is in a READY state.

Entire motion statements are skipped with this command. You cannot skip single motion segments. The KCL> CONTINUE command resumes execution of the paused task with the statement following the last skipped statement. END statements cannot be skipped.

If you skip the last RETURN statement in a function routine, there is no way to return the value of the function to the calling program. Therefore, when executing the END statement of the routine, the task will abort.

If you skip into a FOR loop, you have skipped the statement that initializes the loop counter. When the ENDFOR statement is executed the program will try to remove the loop counter from the stack. If the FOR loop was nested in another FOR loop, the loop counter for the previous FOR loop will be removed from the stack, causing potentially invalid results. If the FOR loop was not nested, a stack underflow error will occur, causing the task to abort.

READ, MOVE, DELAY, WAIT FOR, and PULSE statements can be paused after they have begun execution. In these cases, when the task is resumed, execution of the paused statement must be finished before subsequent statements are executed. Subsequent skipped statements will not be executed. In particular, READ and WAIT FOR statements often require user intervention, such as entering data, before statement execution is completed.

Step mode operation and step mode type have no effect on the KCL> SKIP command.

Examples: KCL> SKIP test_prog

KCL> SKIP

C.98 STEP OFF command

Syntax: STEP OFF

Purpose: Disables single stepping for the program in which it was enabled.

Example: KCL> STEP OFF

C.99 STEP ON command

Syntax: STEP ON < **prog_name** >

where:

prog_name : the name of any KAREL or TP program which is a task

Purpose: Enables single stepping for the specified or default program.

Examples: KCL> STEP ON test_prog

KCL> STEP ON

C.100 TRANSLATE command

Syntax: TRANSLATE < **file_spec** > <DISPLAY> <LIST> <RS>

where:

file_spec : a valid file specification

DISPLAY : display source during translation

LIST : create listing file

RS : create routine stack (.rs) file for local var access

Purpose: Translates KAREL source code (.KL type files) into p-code (.PC type files), which can be loaded into memory and executed.

Translation of a program can be canceled using the CANCEL COMMAND key, CTRL-C, or CTRL-Y on the CRT/KB.

Examples: KCL> TRANSLATE testprog DISPLAY LIST

KCL> TRAN

C.101 TYPE command

Syntax: TYPE **file_spec**

where:

file_spec : a valid file specification

Purpose: This command allows you to display the contents of the specified ASCII file on the CRT/KB. You can specify any type of ASCII file.

Examples: KCL> TYPE rd:testprog.kl

KCL> TYPE testprog.kl

C.102 UNSIMULATE command

Syntax: UNSIMULATE (**port_name[index]** | **ALL**)

where:

port_name[index] : a valid I/O port

ALL : all simulated I/O ports

Purpose: Discontinues simulation of the specified input or output port. When a port is unsimulated, the physical value replaces the simulated value.



Warning

Depending on how signals are used, unsimulating signals might alter program execution or activate peripheral equipment. Do not unsimulate a signal unless you are sure of the result. If you do, you could injure personnel or damage equipment.

If you specify ALL instead of a particular port, simulation on all the simulated ports is discontinued.

The valid ports are:

DIN, DOUT, WDI, WDOAIN, AOUT, GIN, GOUT

See Also: SIMULATE command

Examples: KCL> UNSIMULATE DIN[17]

KCL> UNSIM ALL

C.103 WAIT command

Syntax: WAIT < **prog_name** > (DONE | PAUSE)

where:

prog_name : the name of any KAREL or TP program which is a task

DONE : specifies that the command procedure wait until execution of the current task is completed or aborted

PAUSE : specifies that the command procedure wait until execution of the current task is paused, completed, or aborted.

Purpose: Defers execution of the commands that follow the KCL> WAIT command in a command procedure until a task pauses or completes execution.

The command procedure waits until the condition specified with the DONE or PAUSE argument is met.

See Also: Section 12.4, ‘‘Command Procedures’’

Example: The following is an example of an executable command procedure:

```
> SET DEF testprog
> LOAD ALL
> RUN -- execute program
> WAIT PAUSE
> SHOW CURPOS -- display position of TCP when program pauses
> CONTINUE
> WAIT DONE
> CLEAR ALL YES -- clear after execution
```

Appendix D

CHARACTER CODES

Contents

Appendix D CHARACTER CODES D–1
D.1 CHARACTER CODES D–2

D.1 CHARACTER CODES

This appendix lists the ASCII numeric decimal codes and their corresponding ASCII, Multinational, graphic, and European characters as implemented on the KAREL system. The ASCII character set is the default character set for the KAREL system. Use the CHR Built-In Function, in Appendix A, to access the Multinational and Graphics character sets.

Table D–1. ASCII Character Codes

Decimal Code	Character Value	Decimal Code	Character Value	Decimal Code	Character Value	Decimal Code	Character Value
000	(NUL)	032	SP	064	@	096	‘
001	(SOH)	033	!	065	A	097	a
002	(STX)	034	"	066	B	098	b
003	(ETX)	035	#	067	C	099	c
004	(EOT)	036	$	068	D	100	d
005	(ENQ)	037	%	069	E	101	e
006	(ACK)	038	&	070	F	102	f
007	(BEL)	039	’	071	G	103	g
008	(BS)	040	(	072	H	104	h
009	(HT)	041	)	073	I	105	i
010	(LF)	042	*	074	J	106	j
011	(VT)	043	+	075	K	107	k
012	(FF)	044	’	076	L	108	l
013	(CR)	045	-	077	M	109	m
014	(SO)	046	.	078	N	110	n
015	(SI)	047	/	079	O	111	o
016	(DLE)	048	0	080	P	112	p
017	(DC1)	049	1	081	Q	113	q
018	(DC2)	050	2	082	R	114	r
019	(DC3)	051	3	083	S	115	s
020	(DC4)	052	4	084	T	116	t
021	(NAK)	053	5	085	U	117	u
022	(SYN)	054	6	086	V	118	v
023	(ETB)	055	7	087	W	119	w

Table D–1. ASCII Character Codes (Cont'd)

Decimal Code	Character Value	Decimal Code	Character Value	Decimal Code	Character Value	Decimal Code	Character Value
024	(CAN)	056	8	088	X	120	x
025	(EM)	057	9	089	Y	121	y
026	(SUB)	058	:	090	Z	122	z
027	(ESC)	059	;	091	[	123	{
028	(FS)	060	<	092	\	124	|
029	(GS)	061	=	093	]	125	}
030	(RS)	062	>	094	^	126	~
031	(US)	063	?	095	—	127	(DEL)

Table D–2. Special ASCII Character Codes

Decimal Code	Character Value	Decimal Code	Character Value
128	Clear window	154	Turn Multinational mode on
129	Clear to end of line	155 48	Foreground color black
130	Clear to end of window	155 49	Foreground color red
131	Set cursor position	155 50	Foreground color green
132	Carriage return	155 51	Foreground color yellow
133	Line feed	155 52	Foreground color blue
134	Reverse line feed	155 53	Foreground color magenta
135	Carriage return & line feed	155 54	Foreground color cyan
136	Back Space	155 55	Foreground color white

Table D–2. Special ASCII Character Codes (Cont'd)

Decimal Code	Character Value	Decimal Code	Character Value
137	Home cursor in window	155 127	Foreground color default
138	Blink video attribute	156 48	Background color black
139	Reverse video attribute	156 49	Background color red
140	Bold video attribute	156 50	Background color green
141	Underline video attribute	156 51	Background color yellow
142	Wide video size	156 52	Background color blue
143	Normal video attribute	156 53	Background color magenta
146	Turn Graphics mode on	156 54	Background color cyan
147	Turn ASCII mode on	156 55	Background color white
148	High/wide video size	156 127	Background color default
153	Normal video size		

Table D–3. Multinational Character Codes

Decimal Codes	Character Value	Decimal Codes	Character Value	Decimal Codes	Character Value	Decimal Codes	Character Value
000		032		064	À	096	à
001		033	¡	065	Á	097	á
002		034	©	066	Â	098	â
003		035	£	067	Ã	099	ã
004	(IND)	036		068	Ä	100	ä
005	(NEL)	037	¥	069	Å	101	å
006	(SSA)	038		070	Æ	102	æ
007	(ESA)	039	§	071	Ç	103	ç

Table D–3. Multinational Character Codes (Cont'd)

Decimal Codes	Character Value	Decimal Codes	Character Value	Decimal Codes	Character Value	Decimal Codes	Character Value
008	(HTS)	040	¤	072	È	104	è
009	(HTJ)	041	©	073	É	105	é
010	(VTS)	042	ª	074	Ê	106	ê
011	(PLD)	043	«	075	Ë	107	ë
012	(PLU)	044		076	Ì	108	ì
013	(RI)	045		077	Í	109	í
014	(SS2)	046		078	Î	110	î
015	(SS3)	047		079	Ï	111	ï
016	(DCS)	048	○	080		112	
017	(PU1)	049	±	081	Ñ	113	ñ
018	(PU2)	050	²	082	Ò	114	ò
019	(STS)	051	³	083	Ó	115	ó
020	(CCH)	052		084	Ô	116	ô
021	(MW)	053	µ	085	Õ	117	õ
022	(SPA)	054	¶	086	Ö	118	ö
023	(EPA)	055	•	087	Œ	119	œ
024		056		088	Ø	120	ø
025		057	¹	089	Ù	121	ù
026		058		090	Ú	122	ú
027	(CSI)	059	»	091	Û	123	û
028	(ST)	060	¼	092	Ü	124	ü
029	(OSC)	061	½	093	Y	125	ÿ
030	(PM)	062		094		126	
031	(APC)	063	¿	095	ß	127	

Table D–4. Graphics Character Codes

Decimal Codes	Character Value	Decimal Codes	Character Value	Decimal Codes	Character Value	Decimal Codes	Character Value
000	(NUL)	032	SP	064	@	096	♦
001	(SOH)	033	!	065	A	097	
002	(STX)	034	"	066	B	098	HT
003	(ETX)	035	#	067	C	099	FF
004	(EOT)	036	$	068	D	100	CR
005	(ENQ)	037	%	069	E	101	LF
006	(ACK)	038	&	070	F	102	○
007	(BEL)	039	’	071	G	103	±
008	(BS)	040	(	072	H	104	NL
009	(HT)	041	)	073	I	105	VT
010	(LF)	042	*	074	J	106	┘
011	(VT)	043	+	075	K	107	┐
012	(FF)	044	’	076	L	108	┌
013	(CR)	045	-	077	M	109	└
014	(SO)	046	.	078	N	110	+
015	(SI)	047	/	079	O	111	-
016	(DLE)	048	0	080	P	112	-
017	(DC1)	049	1	081	Q	113	-
018	(DC2)	050	2	082	R	114	-
019	(DC3)	051	3	083	S	115	_
020	(DC4)	052	4	084	T	116	├

Table D–4. Graphics Character Codes (Cont'd)

Decimal Codes	Character Value	Decimal Codes	Character Value	Decimal Codes	Character Value	Decimal Codes	Character Value
021	(NAK)	053	5	085	U	117	⊦
022	(SYN)	054	6	086	V	118	⊥
023	(ETB)	055	7	087	W	119	⊤
024	(CAN)	056	8	088	X	120	|
025	(EM)	057	9	089	Y	121	≤
026	(SUB)	058	:	090	Z	122	≥
027	(ESC)	059	;	091	[	123	Π
028	(FS)	060	<	092		124	≠
029	(GS)	061	=	093	]	125	£
030	(RS)	062	>	094	^	126	•
031	(US)	063	?	095	(blank)	127	(DEL)

Table D–5. Teach Pendant Input Codes

Code	Value	Code	Value
0	48	174	USER KEY 2
1	49	175	USER KEY 3
2	50	176	USER KEY 4
3	51	177	USER KEY 5
4	52	178	USER KEY 6
5	53	185	FWD
6	54	186	BWD
7	55	187	COORD

Table D–5. Teach Pendant Input Codes (Cont'd)

Code	Value	Code	Value
8	56	188	+X
9	57	189	+Y
128	PREV	190	+Z
129	F1	191	+X rotation
131	F2	192	+Y rotation
132	F3	193	+Z rotation
133	F4	194	-X
134	F5	195	-Y
135	NEXT	196	-Z
143	SELECT	197	-X rotation
144	MENUS	198	-Y rotation
145	EDIT	199	-Z rotation
146	DATA	210	USER KEY
147	FCTN	212	Up arrow
148	ITEM	213	Down arrow
149	+%	214	Right arrow
150	-%	215	Left arrow
151	HOLD	147	DEADMAN switch, left
152	STEP	248	DEADMAN switch, right
153	RESET	249	ON/OFF switch
173	USER KEY 1	250	EMERGENCY STOP

Table D–6. European Character Codes

Code	Value	Code	Value	Code	Value
192	A‘	213	O~	234	e^
193	A‘	214	O:	235	e:
194	A^	215	OE	236	i‘
195	A~	216	O/	237	i‘
196	A:	217	U‘	238	i^
197	Ao	218	U‘	239	i:

Table D–6. European Character Codes (Cont'd)

Code	Value	Code	Value	Code	Value
198	AE	219	U^	240	
199	CC	220	U:	241	n~
200	E‘	221	Y:	242	o‘
201	E‘	222		243	o‘
202	E^	223	Bb	244	o^
203	E:	224	a‘	245	o~
204	I‘	225	a‘	246	o:
205	I‘	226	a^	247	oe
206	I^	227	a~	248	
207	I:	228	a:	249	u‘
208		229	ao	250	u‘
209	N~	230	ae	251	u^
210	O‘	231		252	u:
211	O‘	232	e‘	253	y:
212	O^	233	e‘	254	

A^ = A with ^ on top

A‘ = A with ‘ on top

Ao = A with o on top

A~ = A with ~ on top

A: = A with .. on top

AE = A and E run together

OE = A and E run together

Bb = Beta

Table D–7. Graphics Characters

Decimal Value	ASCII Character	Graphic Character
97	a	solid box
102	f	diamond
103	g	plus/minus
106	j	lower-right box corner
107	k	upper-right box corner
108	l	upper-left box corner
109	m	lower-left box corner
110	n	intersection lines
111	o	pixel row 1 horizontal line
112	p	pixel row 2 horizontal line
113	q	pixel row 3 horizontal line
114	r	pixel row 4 horizontal line
115	s	pixel row 5 horizontal line
116	t	T from right
117	u	T from left
119	v	T from above
119	w	T from below
120	x	Vertical Line
121	y	Less than or equal
122	z	Greater than or equal
123	{	Pi
124	|	Not equal
125	}	British pound symbol

Appendix E

SYNTAX DIAGRAMS

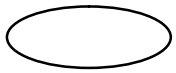
Contents

Appendix E SYNTAX DIAGRAMS E–1

KAREL syntax diagrams use the following symbols:

- Rectangle 

  A rectangle encloses elements that are defined in another syntax diagram or in accompanying text.

- Oval 

  An oval encloses KAREL reserved words that are entered exactly as shown.

- Circle 

  A circle encloses special characters that are entered exactly as shown.

- Dot 

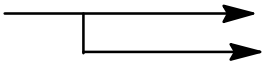
  A dot indicates a mandatory line–end (; or ENTER key) before the next syntax element.

- Caret ^

  A caret indicates an optional line–end.

- Arrows 

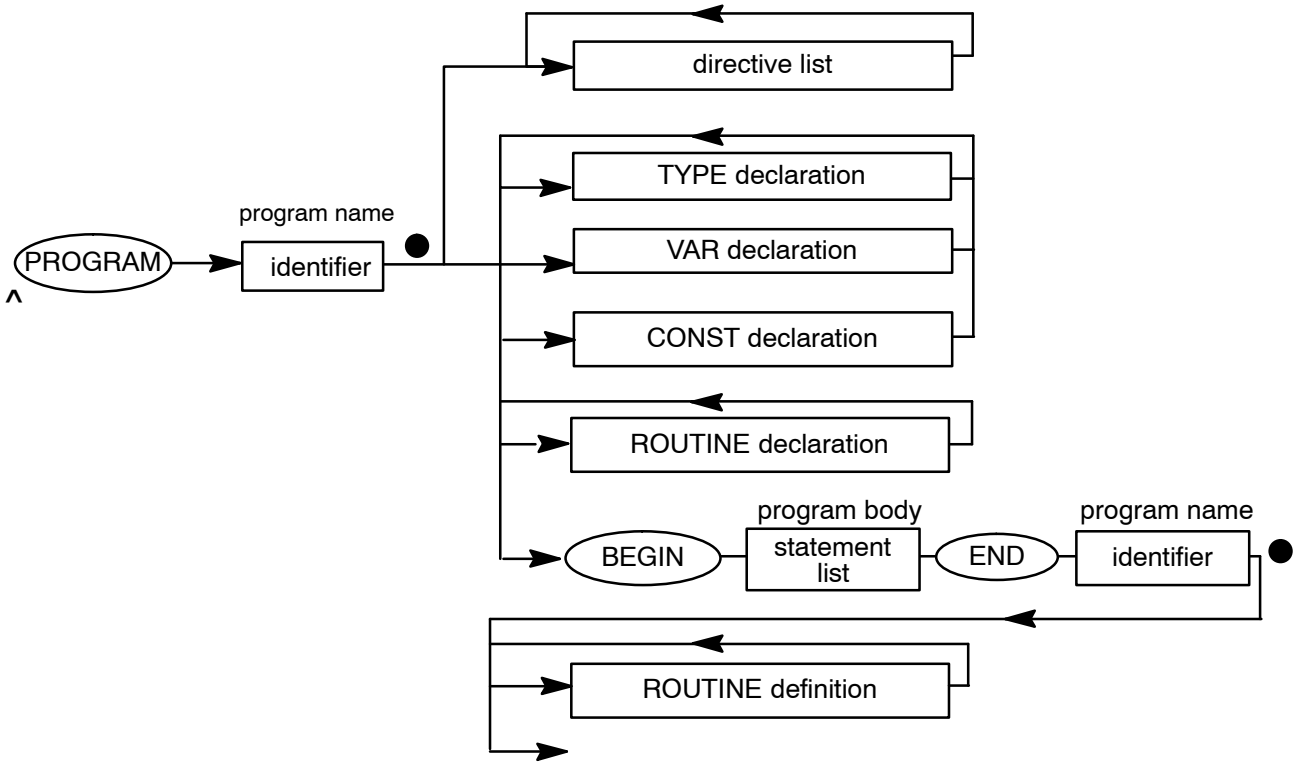
  Arrows indicate allowed paths and the correct sequence in a diagram.

- Branch 

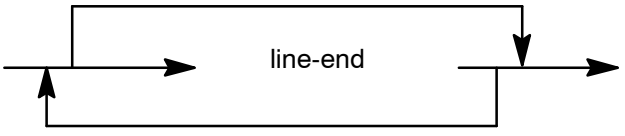
  Branches indicate optional paths or sequences.

Figure E–1.

PROGRAM– –module definition



^ -- 0 or more line-ends



● --newline

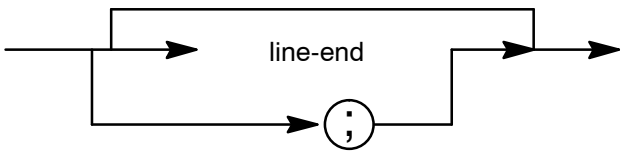


Figure E–2.

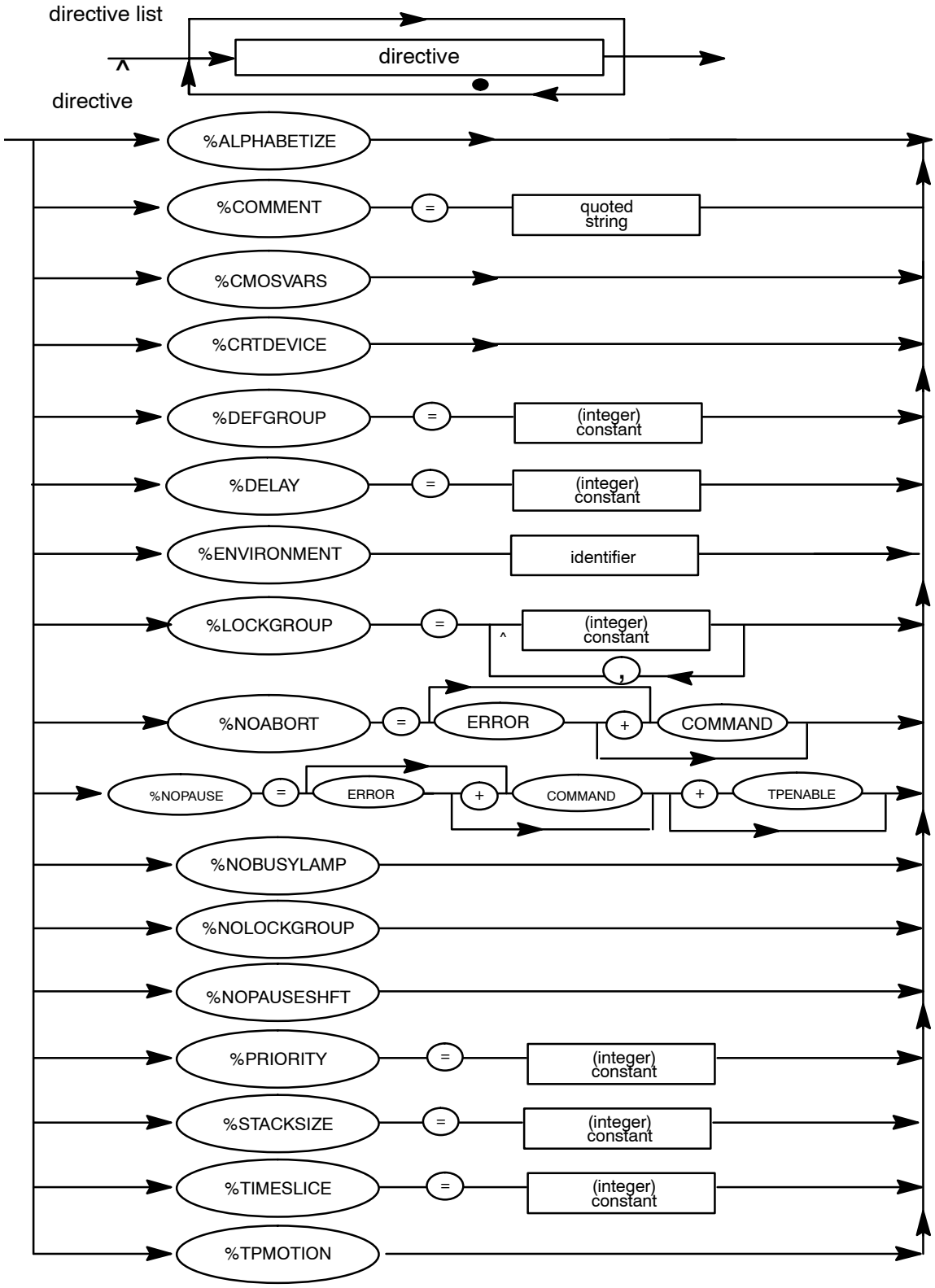
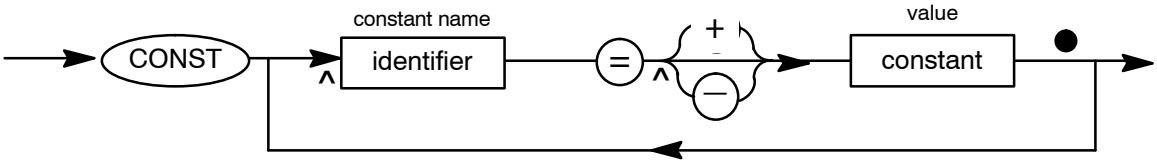
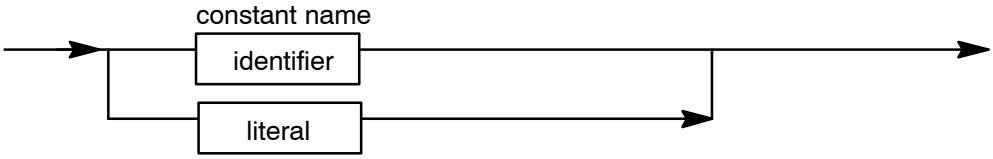

directive list
^
directive
directive
%ALPHABETIZE
%COMMENT
=
quoted string
%CMOSVARS
%CRTDEVICE
%DEFGROUP
=
(integer) constant
%DELAY
=
(integer) constant
%ENVIRONMENT
identifier
%LOCKGROUP
=
^
(integer) constant
,
%NOABORT
=
ERROR
+
COMMAND
%NOPAUSE
=
ERROR
+
COMMAND
+
TPENABLE
%NOBUSYLAMP
%NOLOCKGROUP
%NOPAUSESHFT
%PRIORITY
=
(integer) constant
%STACKSIZE
=
(integer) constant
%TIMESLICE
=
(integer) constant
%TPMOTION

Figure E–3.

CONST --constant declaration



constant



TYPE -- type declaration

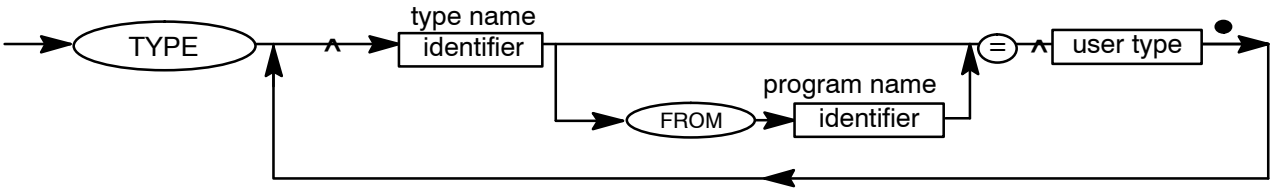
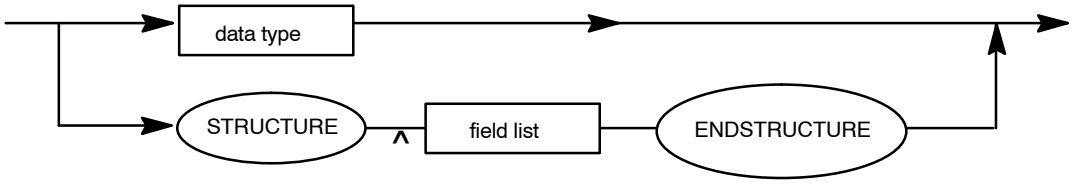
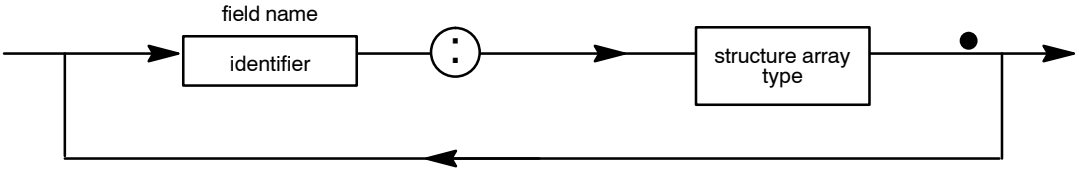


Figure E–4.

user type



field list



structure array type

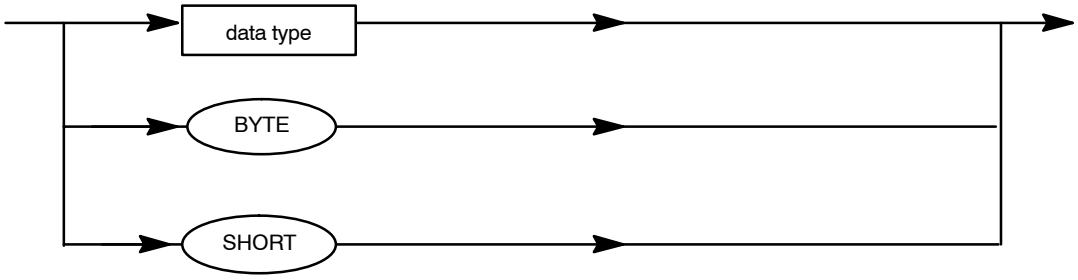


Figure E–5.

data type

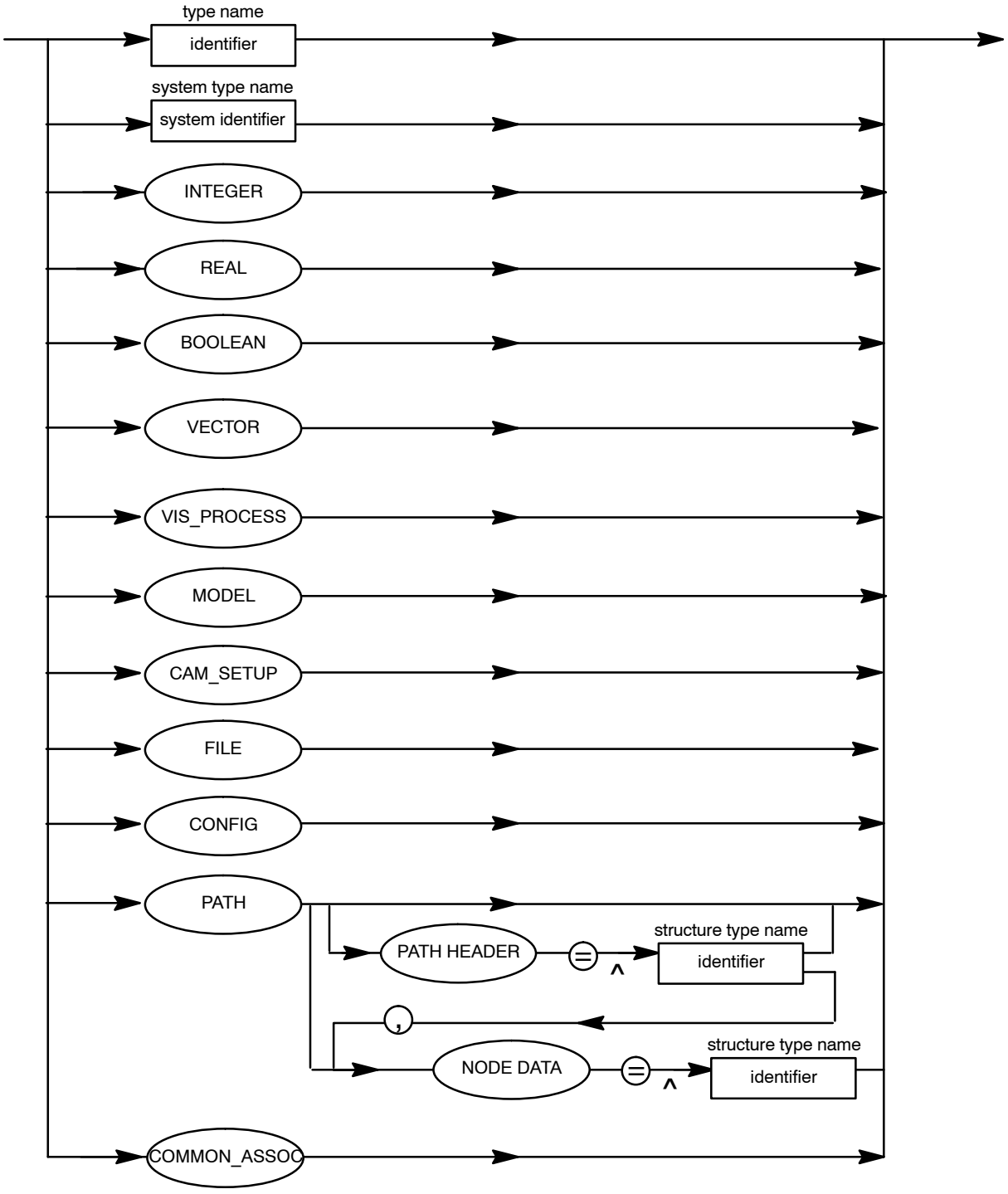


Figure E–6.

data type continued

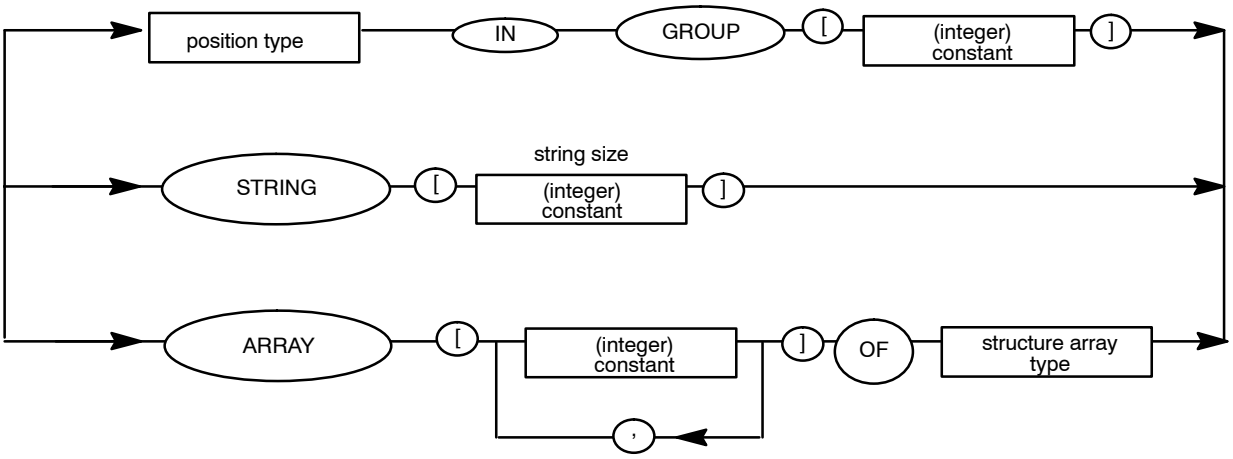


Figure E–7.

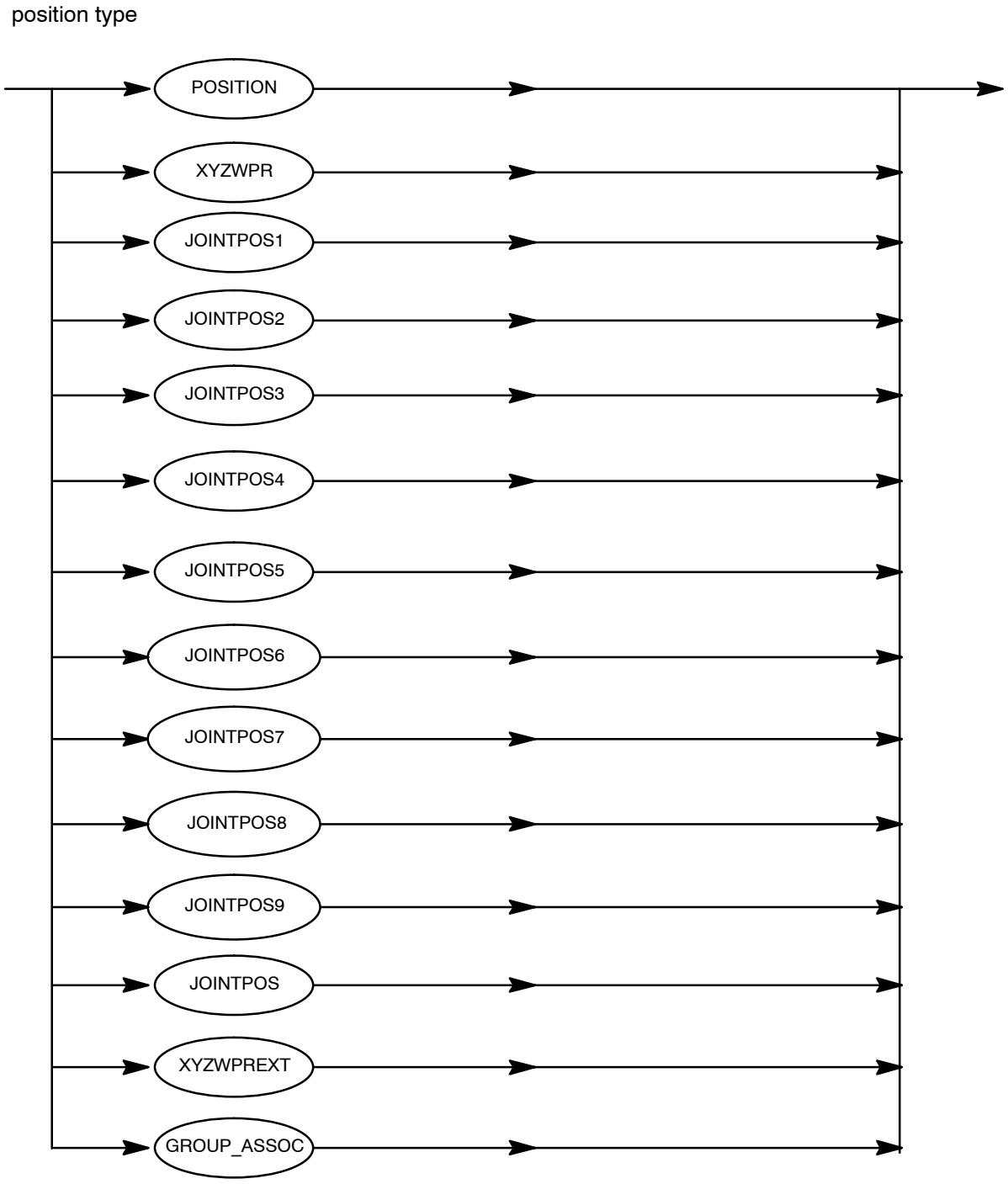
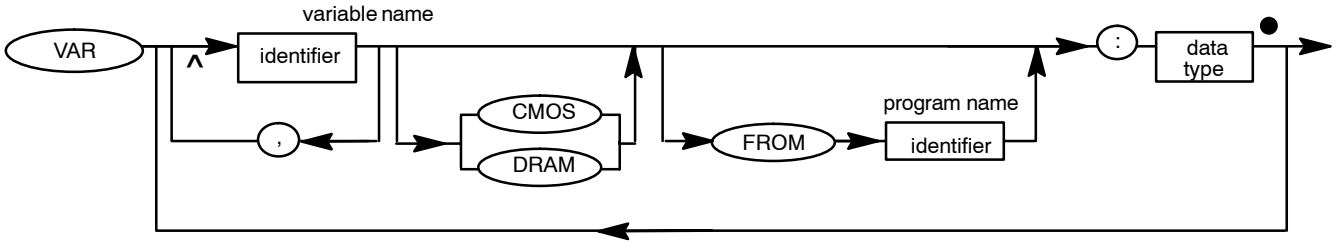

position type
POSITION
XYZWPR
JOINTPOS1
JOINTPOS2
JOINTPOS3
JOINTPOS4
JOINTPOS5
JOINTPOS6
JOINTPOS7
JOINTPOS8
JOINTPOS9
JOINTPOS
XYZWPREXT
GROUP_ASSOC

Figure E–8.

VAR -- variable declaration



ROUTINE -- routine declaration

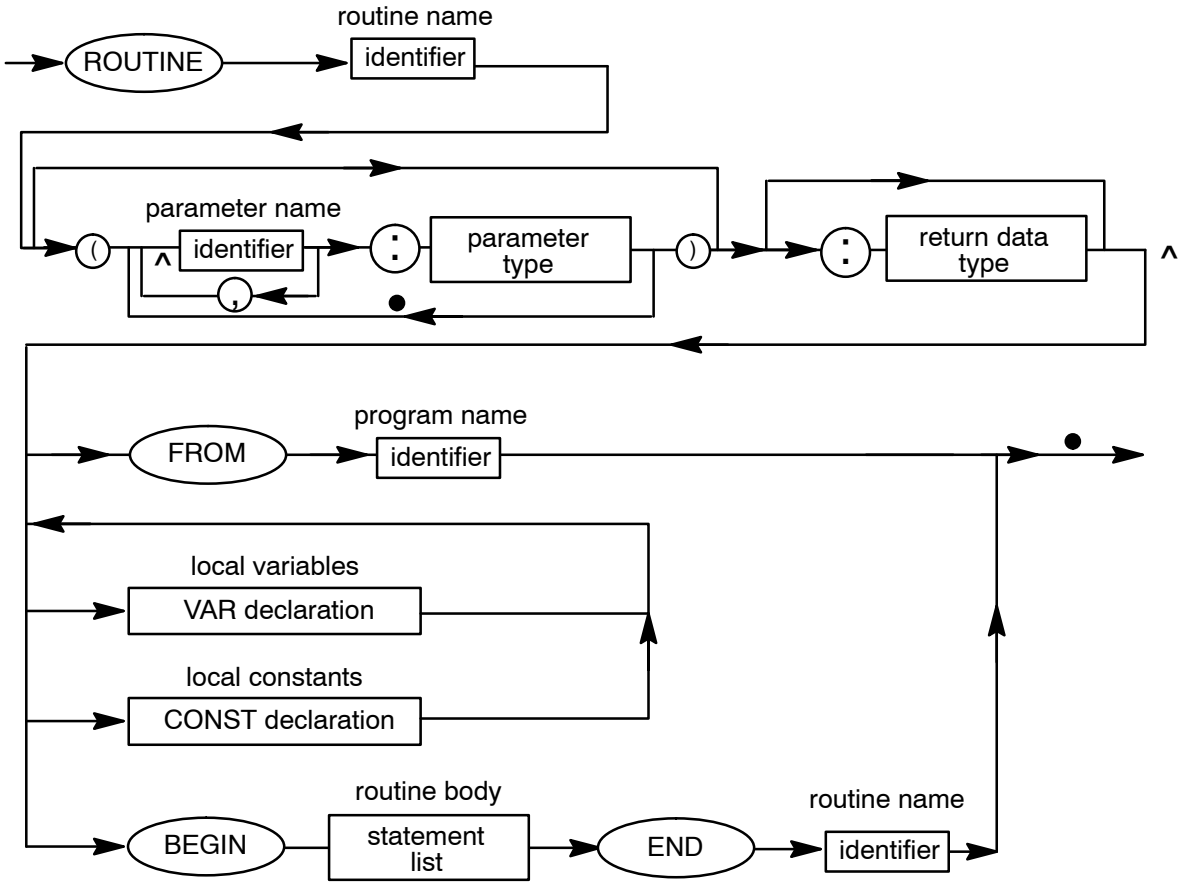


Figure E–9.

return data type

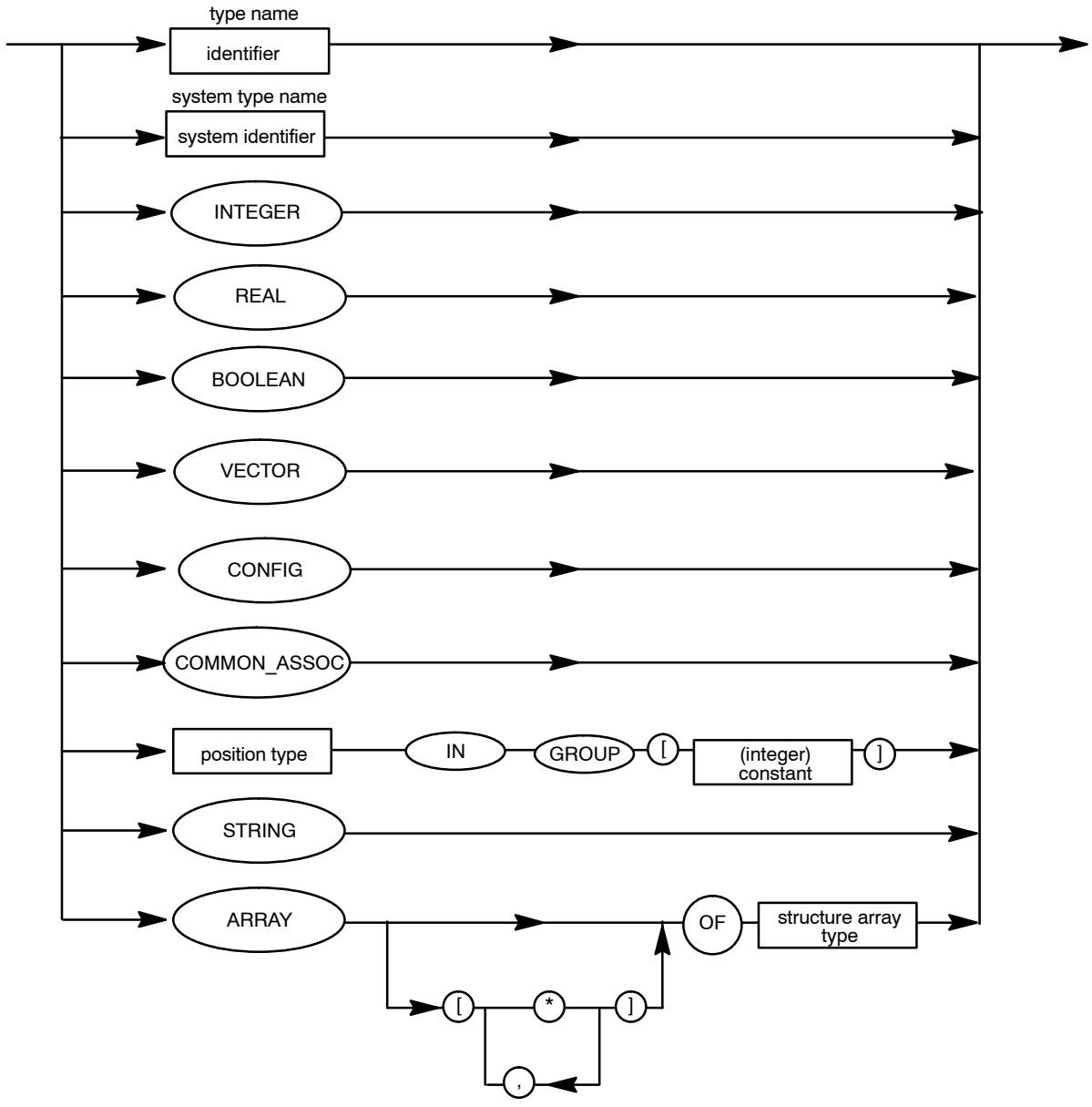


Figure E–10.

parameter type

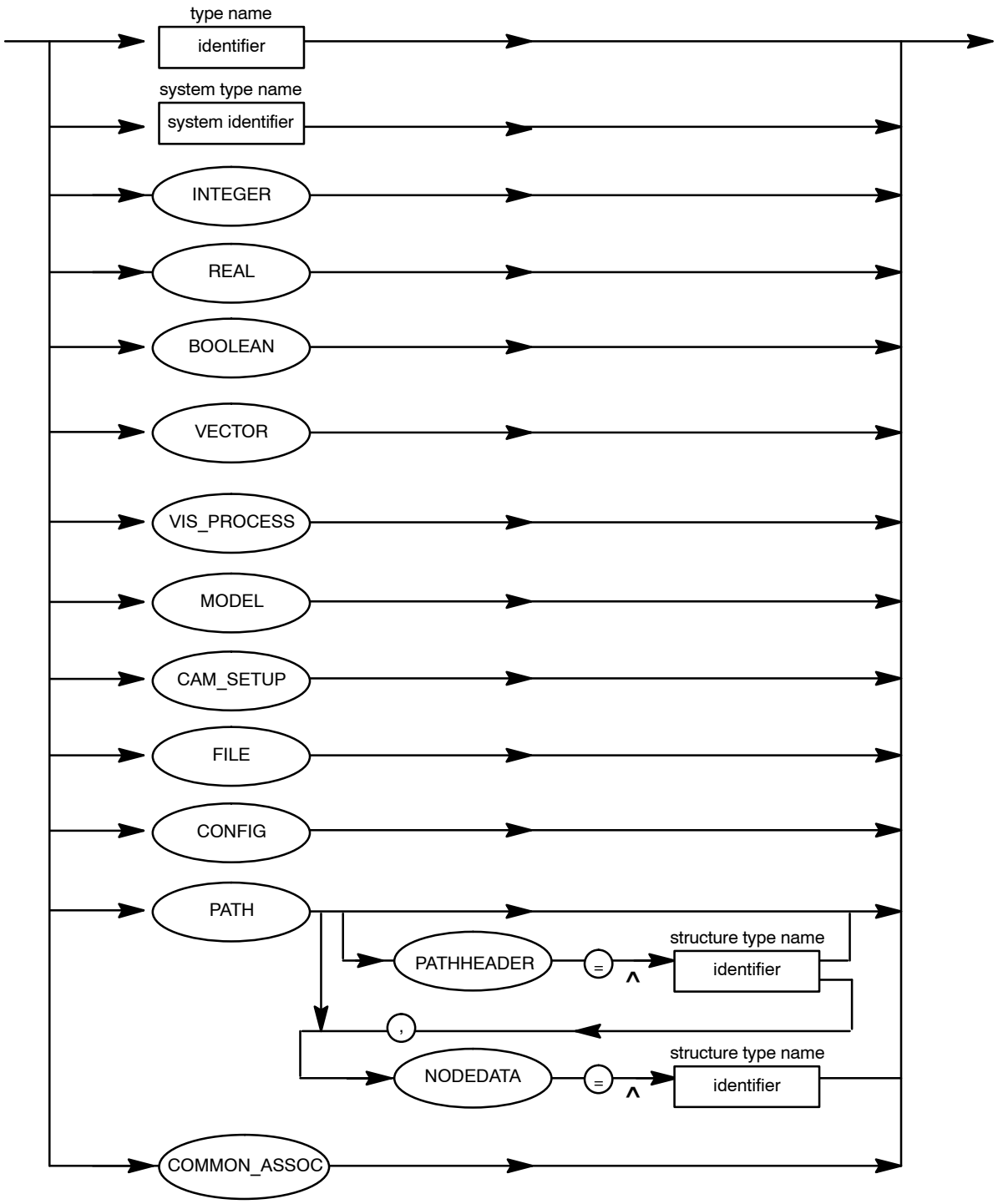


Figure E–11.

parameter type continued

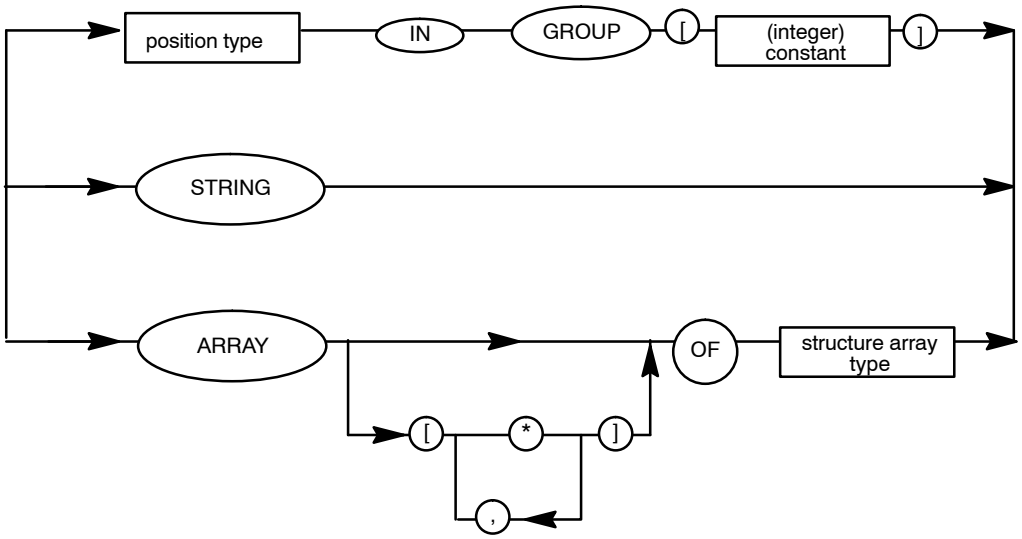


Figure E–12.

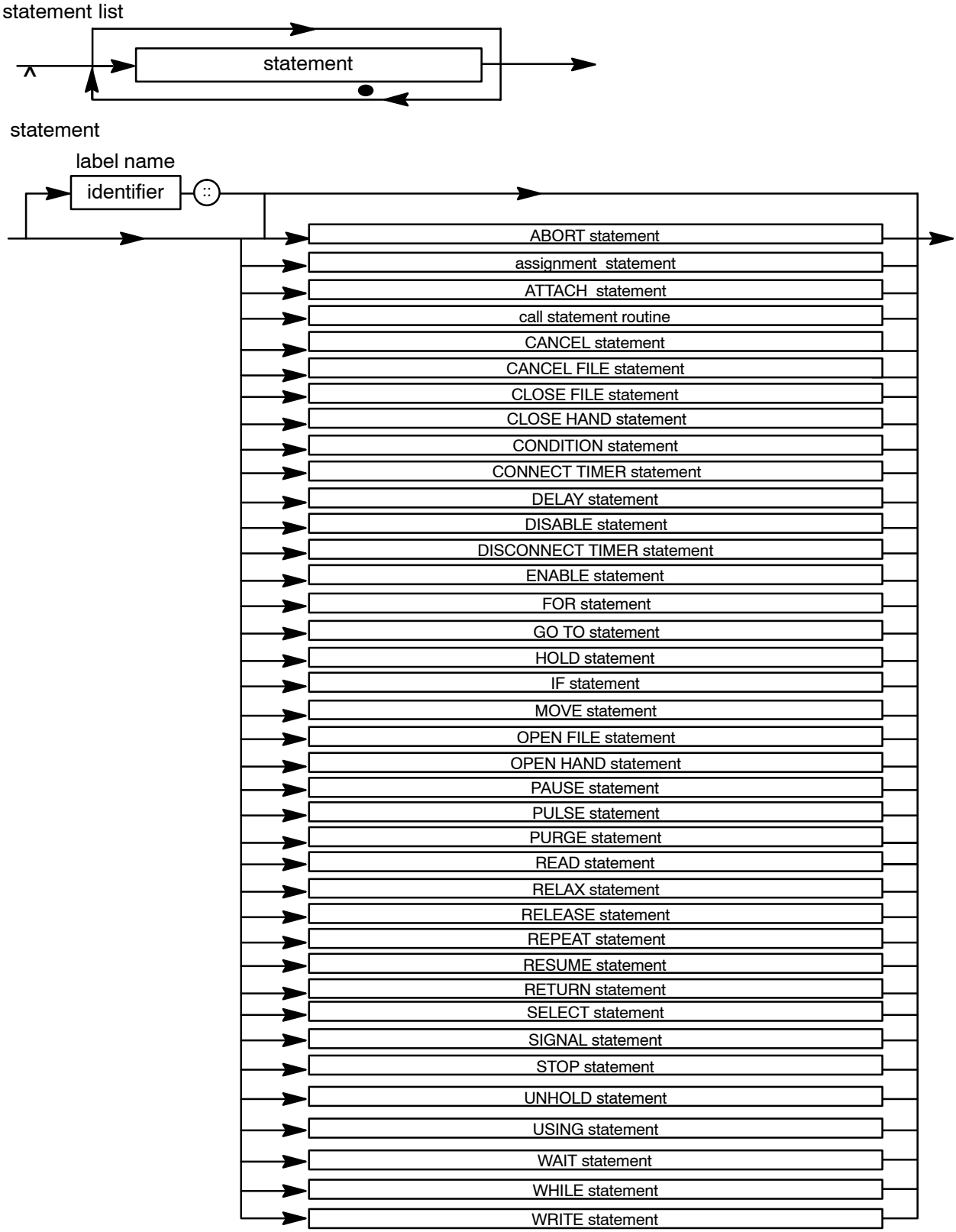

statement list
statement
statement
label name
identifier
::
ABORT statement
assignment statement
ATTACH statement
call statement routine
CANCEL statement
CANCEL FILE statement
CLOSE FILE statement
CLOSE HAND statement
CONDITION statement
CONNECT TIMER statement
DELAY statement
DISABLE statement
DISCONNECT TIMER statement
ENABLE statement
FOR statement
GO TO statement
HOLD statement
IF statement
MOVE statement
OPEN FILE statement
OPEN HAND statement
PAUSE statement
PULSE statement
PURGE statement
READ statement
RELAX statement
RELEASE statement
REPEAT statement
RESUME statement
RETURN statement
SELECT statement
SIGNAL statement
STOP statement
UNHOLD statement
USING statement
WAIT statement
WHILE statement
WRITE statement

Figure E–13.

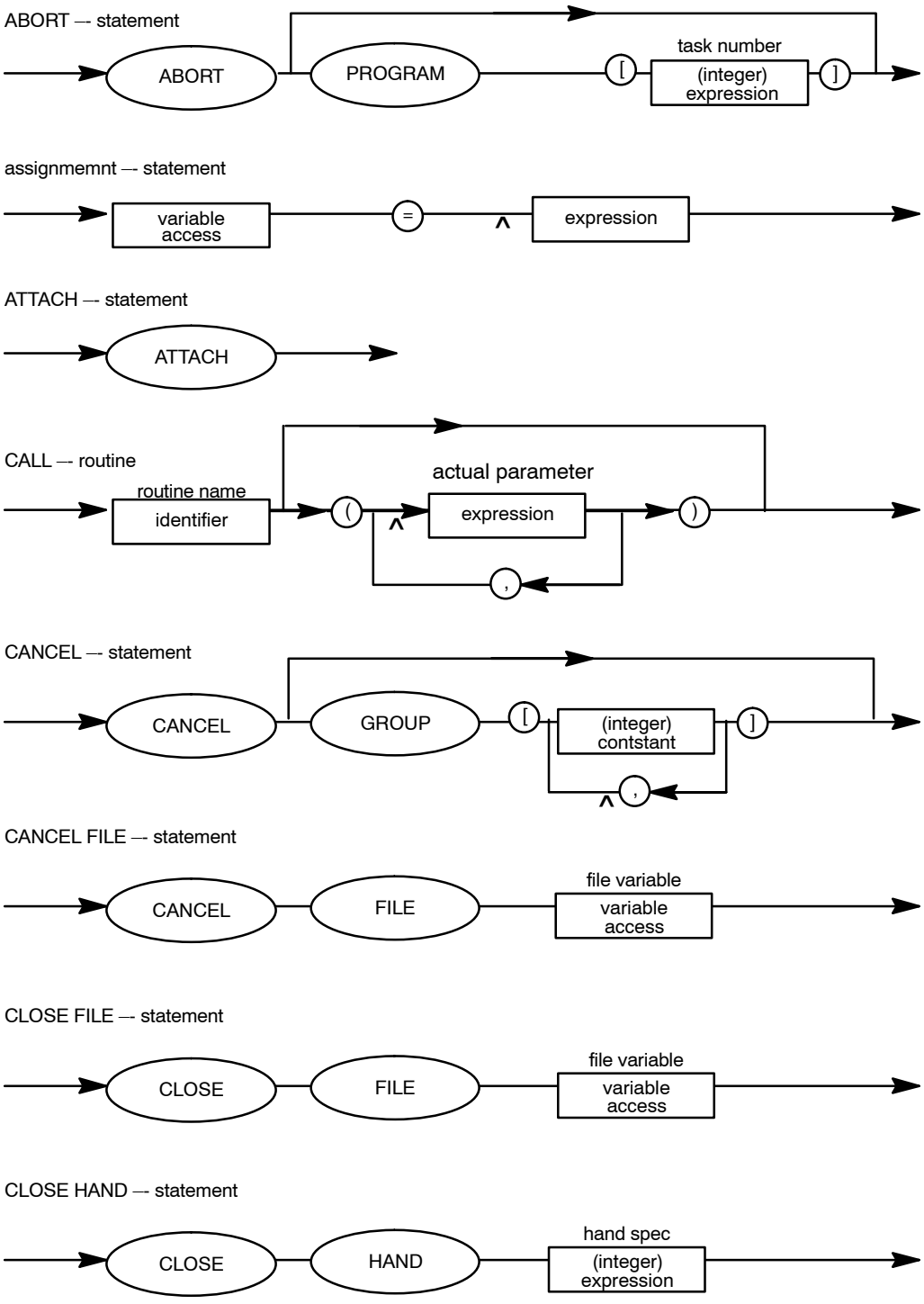
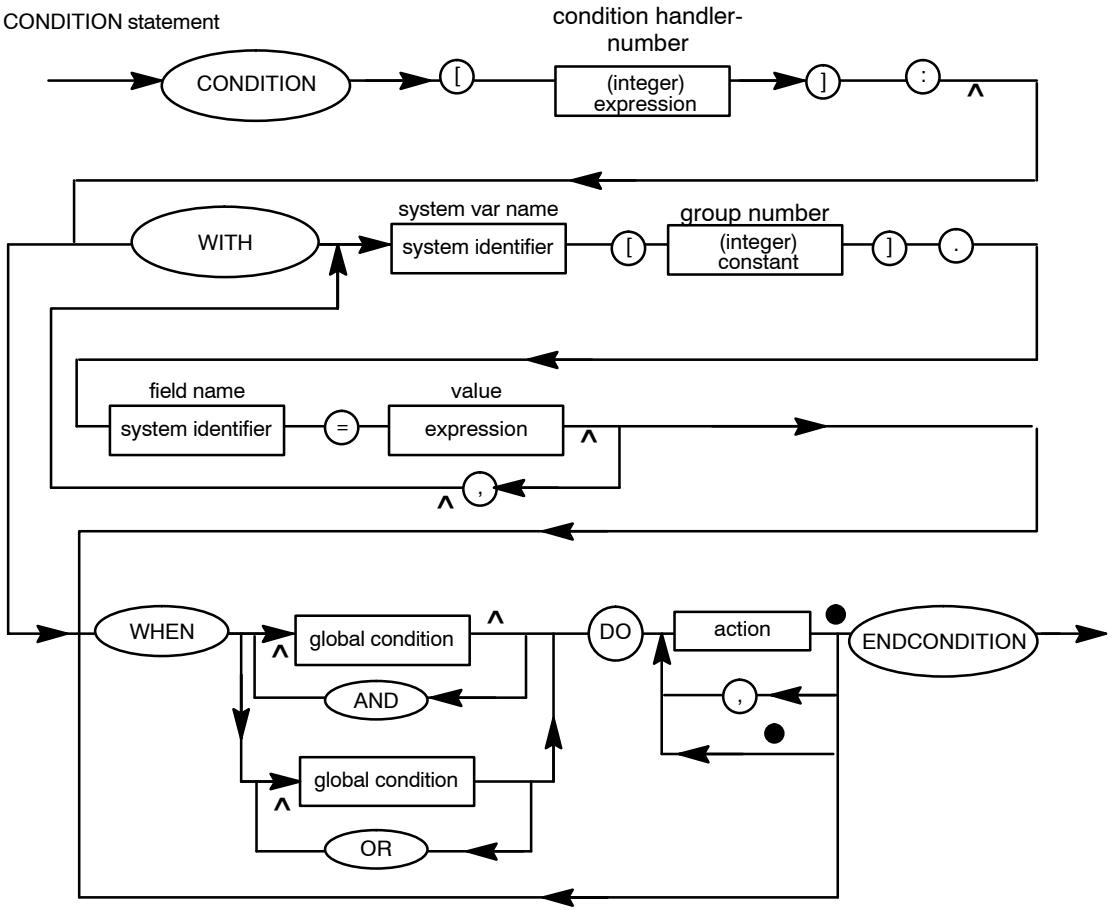

ABORT — statement
ABORT
PROGRAM
task number
[
(integer)
expression
]
assignmemnt — statement
variable
access
=
expression
ATTACH — statement
ATTACH
CALL — routine
routine name
identifier
(
actual parameter
expression
)
,
CANCEL — statement
CANCEL
GROUP
[
(integer)
contstant
]
,
CANCEL FILE — statement
CANCEL
FILE
file variable
variable
access
CLOSE FILE — statement
CLOSE
FILE
file variable
variable
access
CLOSE HAND — statement
CLOSE
HAND
hand spec
(integer)
expression

Figure E–14.

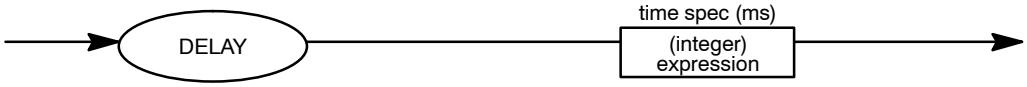
CONDITION statement



CONNECT TIMER —- statement



DELAY —- statement



DISABLE —- statement

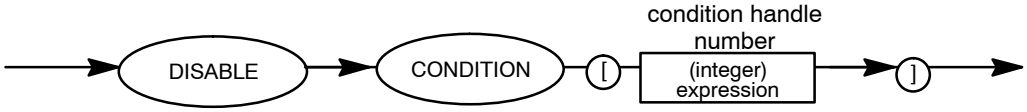
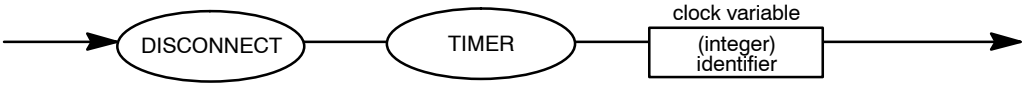
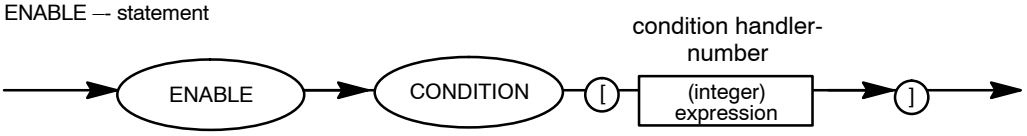


Figure E–15.

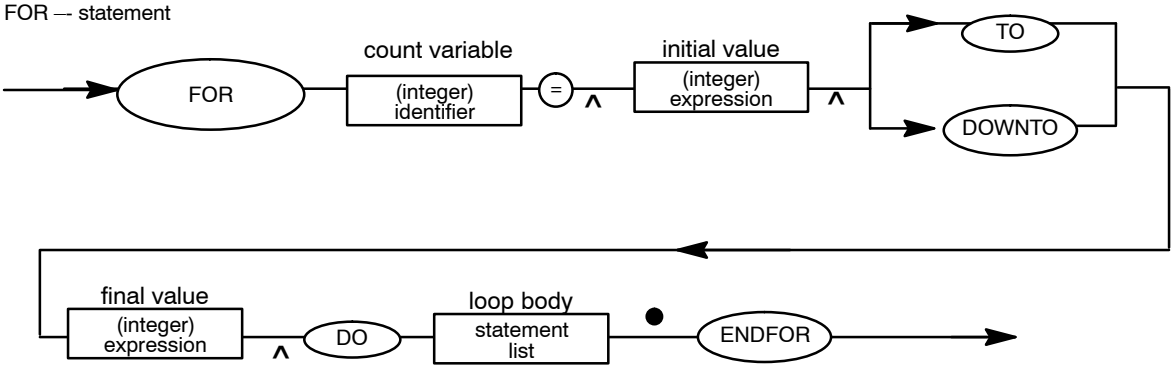
DISCONNECT TIMER —• statement



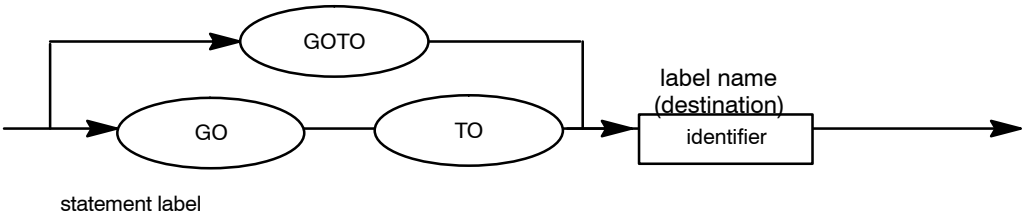
ENABLE —• statement



FOR —• statement

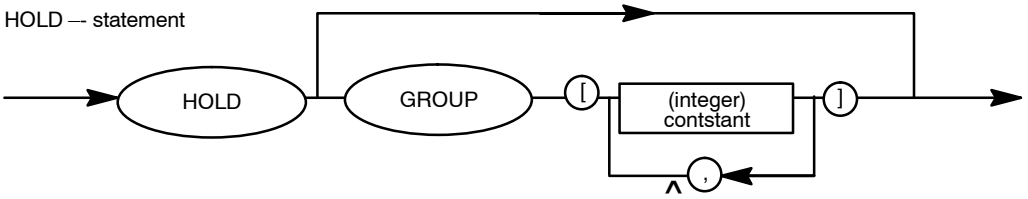


GO TO —• statement



statement label

HOLD —• statement



IF THEN —• statement

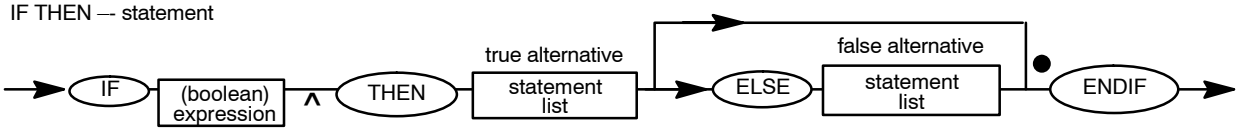


Figure E–16.

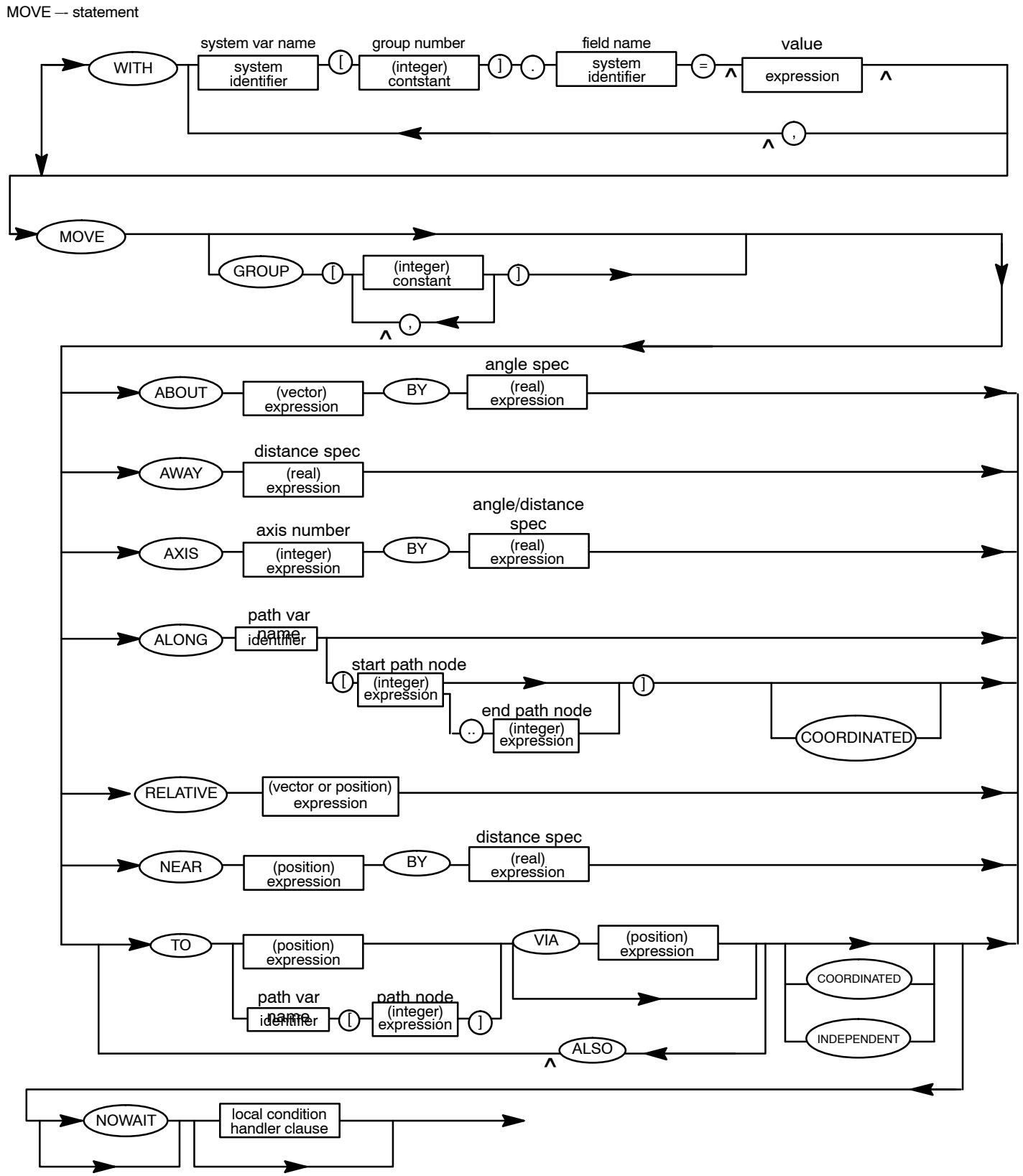

MOVE — statement
WITH
system var name
system identifier
[
group number
(integer) contstant
]
.
field name
system identifier
=
value
expression
,
MOVE
GROUP
[
(integer) constant
]
,
ABOUT
(vector) expression
BY
angle spec
(real) expression
AWAY
distance spec
(real) expression
AXIS
axis number
(integer) expression
BY
angle/distance spec
(real) expression
ALONG
path var name identifier
start path node
[
(integer) expression
]
..
end path node
(integer) expression
COORDINATED
RELATIVE
(vector or position) expression
NEAR
(position) expression
BY
distance spec
(real) expression
TO
(position) expression
path var name identifier
[
path node
(integer) expression
]
VIA
(position) expression
COORDINATED
INDEPENDENT
ALSO
NOWAIT
local condition handler clause

Figure E–17.

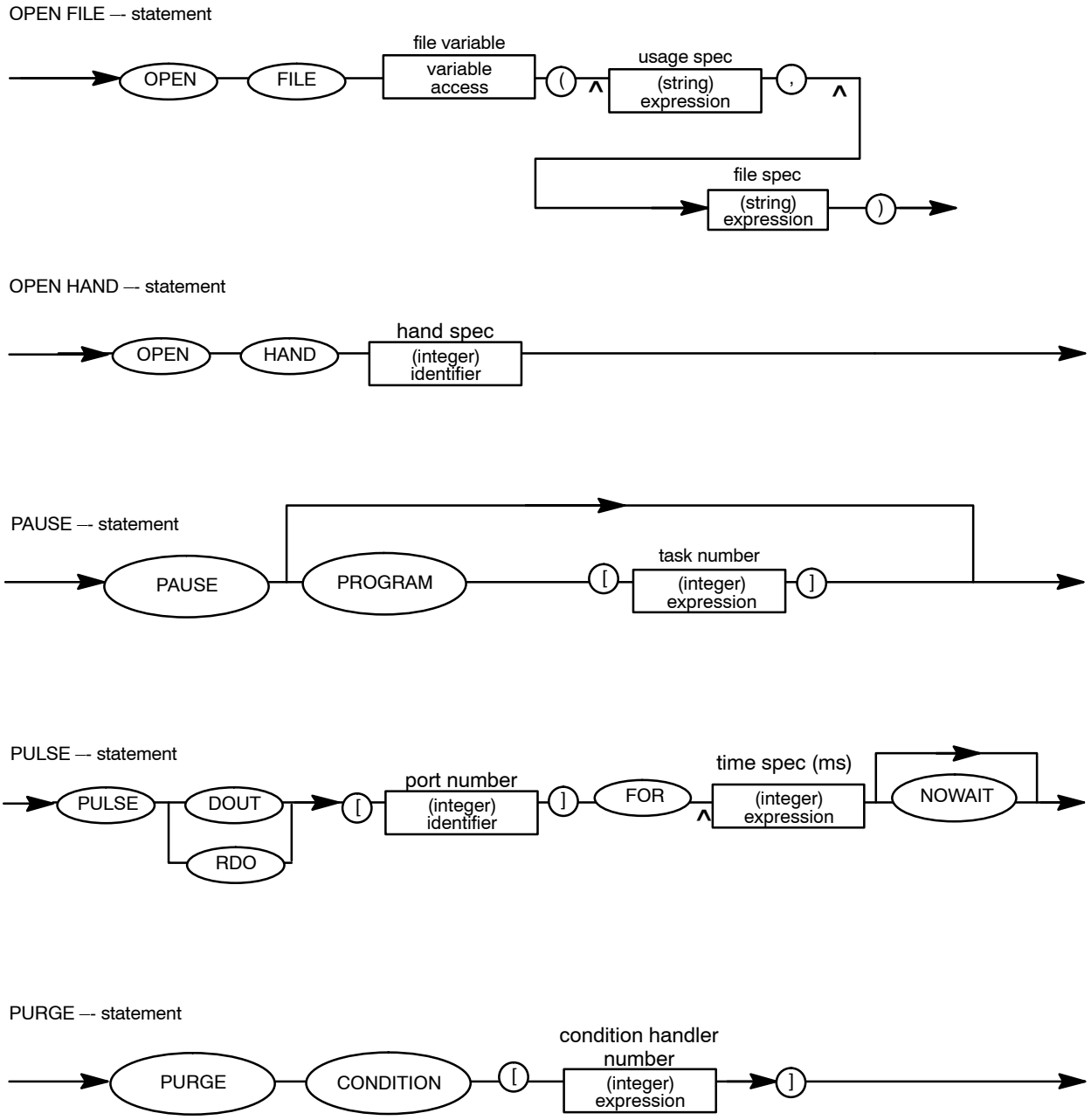
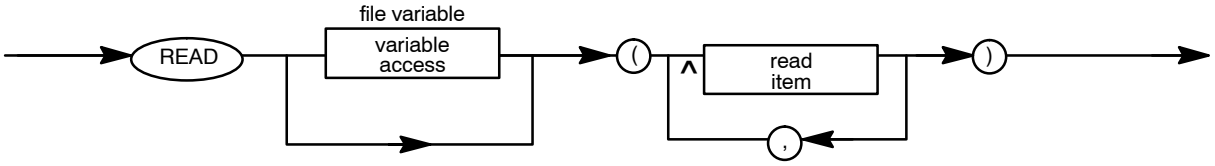
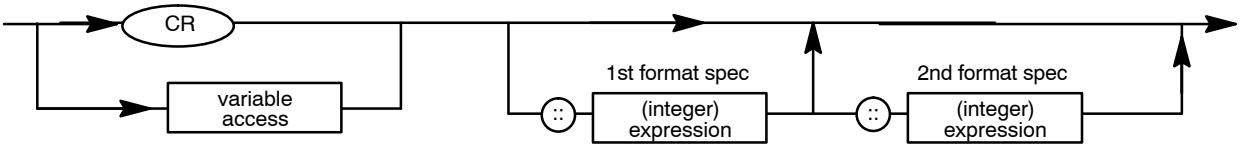

OPEN FILE —• statement
file variable
variable access
usage spec
(string) expression
OPEN
FILE
(
,
file spec
(string) expression
)
OPEN HAND —• statement
hand spec
(integer) identifier
OPEN
HAND
PAUSE —• statement
task number
(integer) expression
PAUSE
PROGRAM
[
]
PULSE —• statement
port number
(integer) identifier
time spec (ms)
(integer) expression
PULSE
DOUT
RDO
FOR
NOWAIT
PURGE —• statement
condition handler number
(integer) expression
PURGE
CONDITION

Figure E–18.

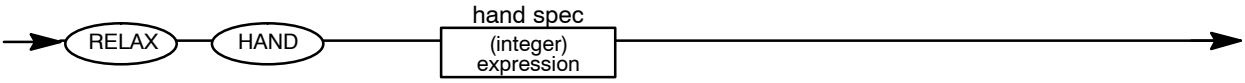
READ —• statement



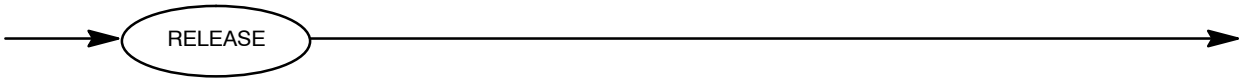
read item —• statement



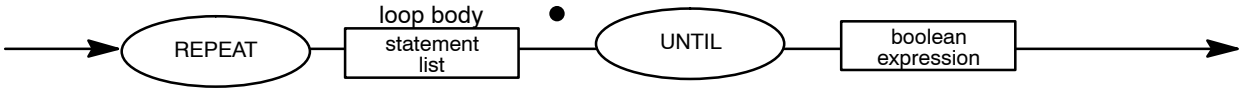
RELAX —• statement



RELEASE —• statement



REPEAT —• statement



RESUME —• statement

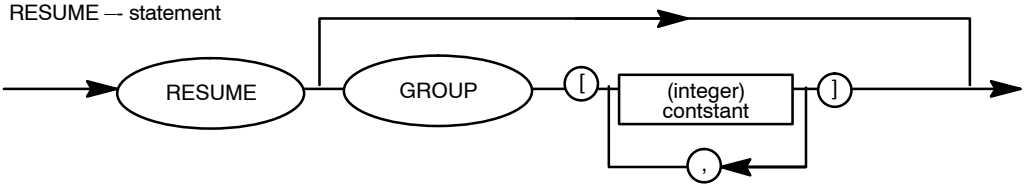


Figure E–19.

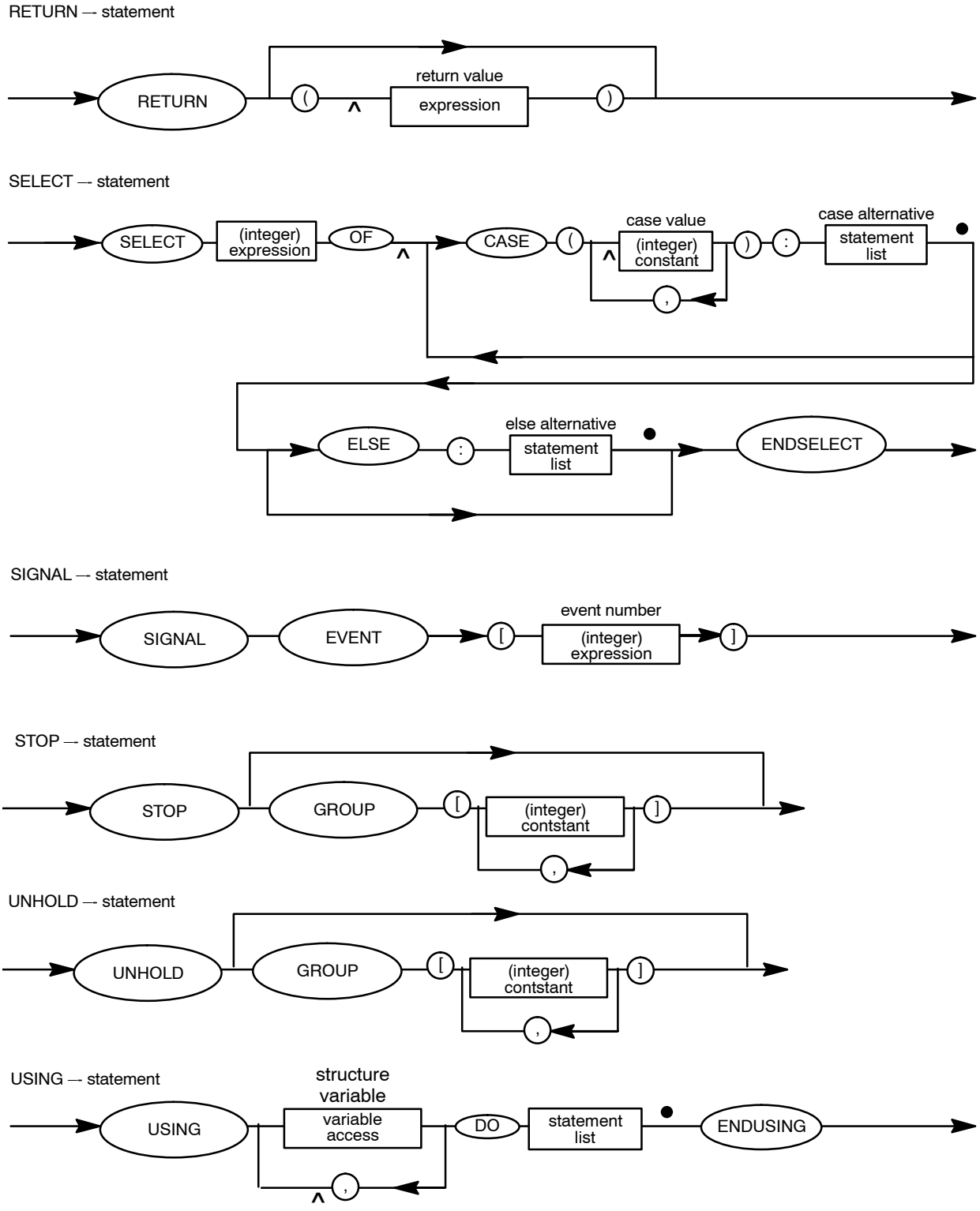
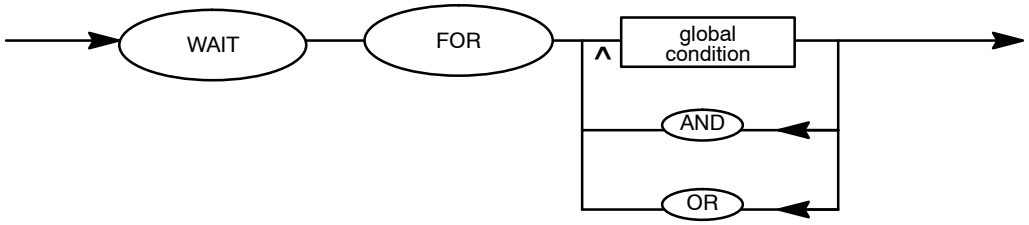
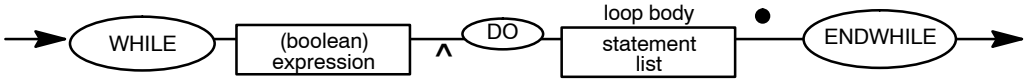

RETURN —- statement
RETURN
(
return value
expression
)
SELECT —- statement
SELECT
(integer) expression
OF
CASE
(
case value
(integer) constant
,
)
:
case alternative
statement list
ELSE
:
else alternative
statement list
ENDSELECT
SIGNAL —- statement
SIGNAL
EVENT
[
event number
(integer) expression
]
STOP —- statement
STOP
GROUP
[
(integer) contstant
,
]
UNHOLD —- statement
UNHOLD
GROUP
[
(integer) contstant
,
]
USING —- statement
USING
structure variable
variable access
,
DO
statement list
ENDUSING

Figure E–20.

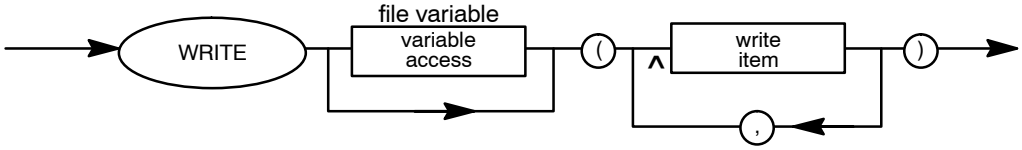
WAIT — statement



WHILE — statement



WRITE — statement



write item

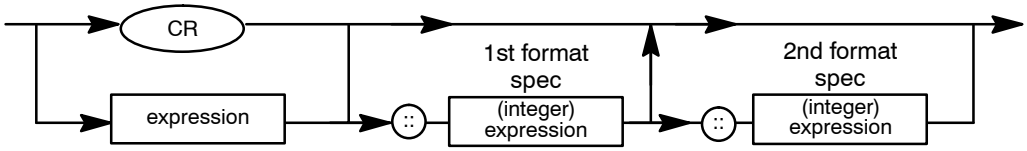


Figure E–21.

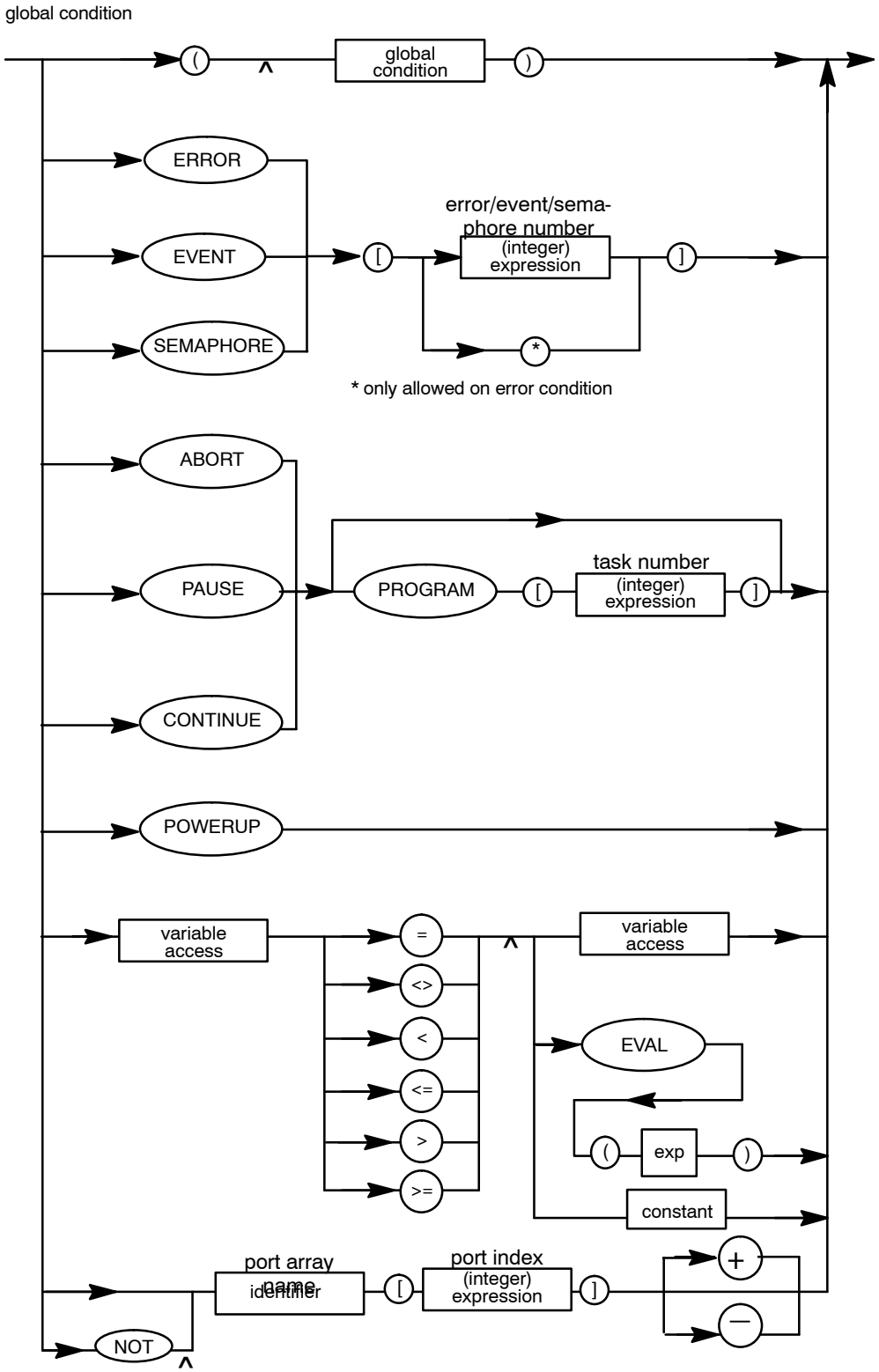

global condition
(
^
global condition
)
ERROR
EVENT
SEMAPHORE
error/event/sema-phore number
[
(integer) expression
]
*
* only allowed on error condition
ABORT
PAUSE
CONTINUE
PROGRAM
[
task number
(integer) expression
]
POWERUP
variable access
=
<>
<
<=
>
>=
^
variable access
EVAL
(
exp
)
constant
NOT
^
port array name
identifier
[
port index
(integer) expression
]
+
—

Figure E–22.

condition handler action

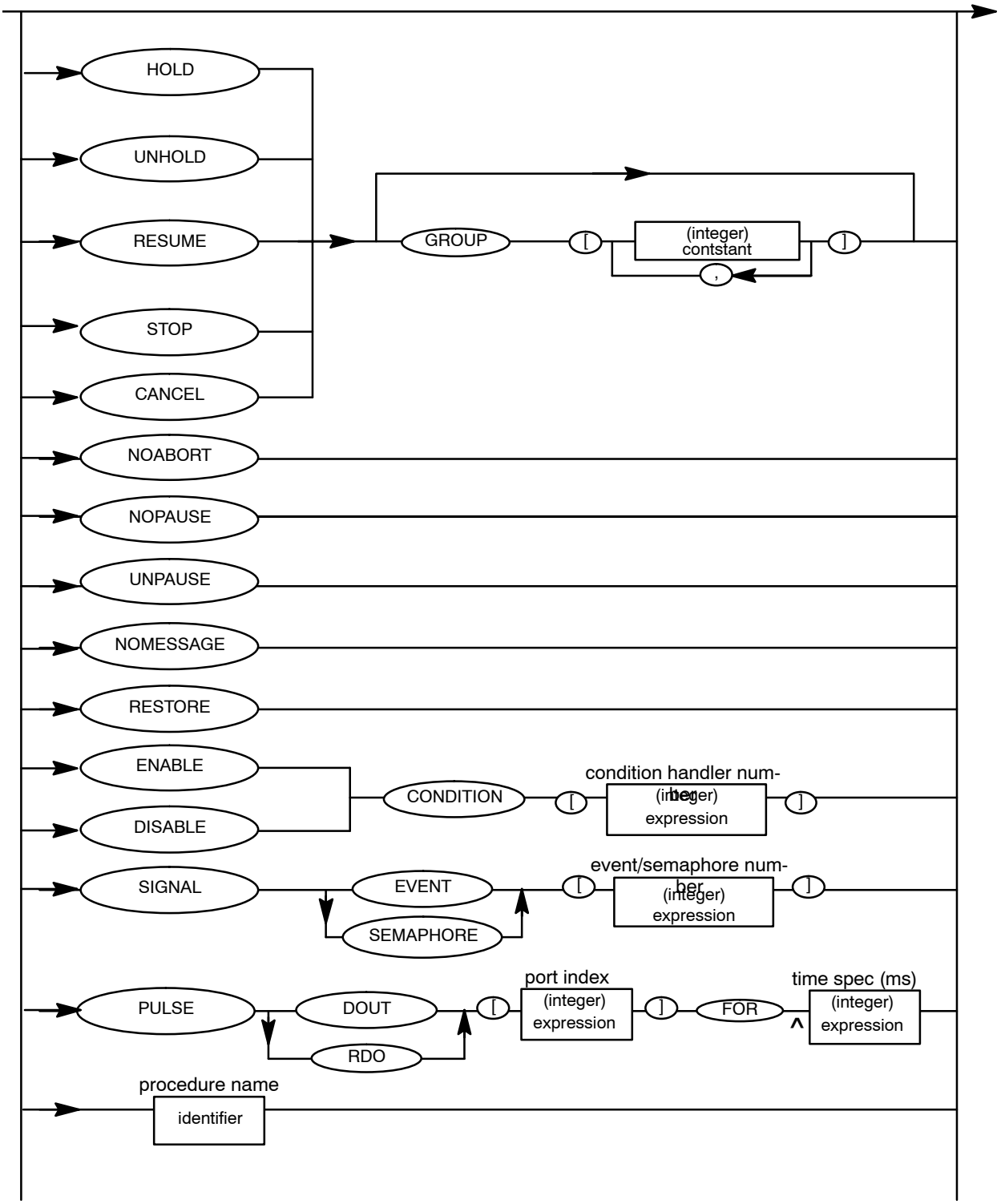


Figure E–23.

condition handler action continued

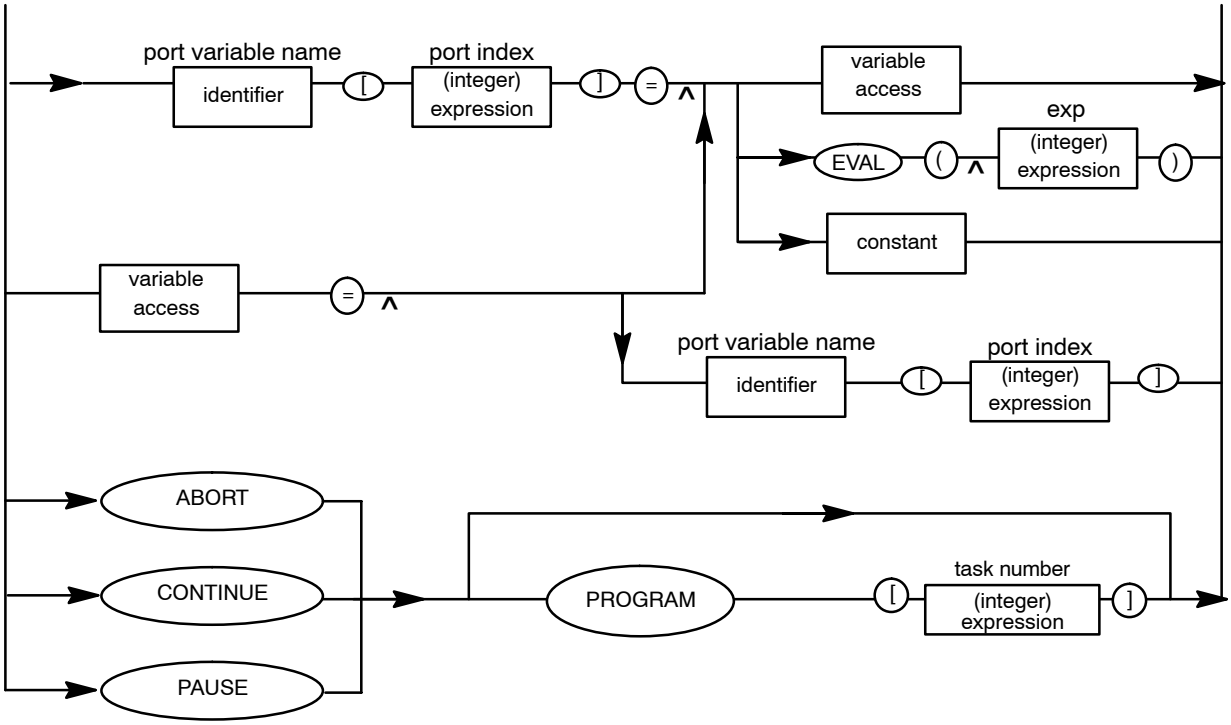
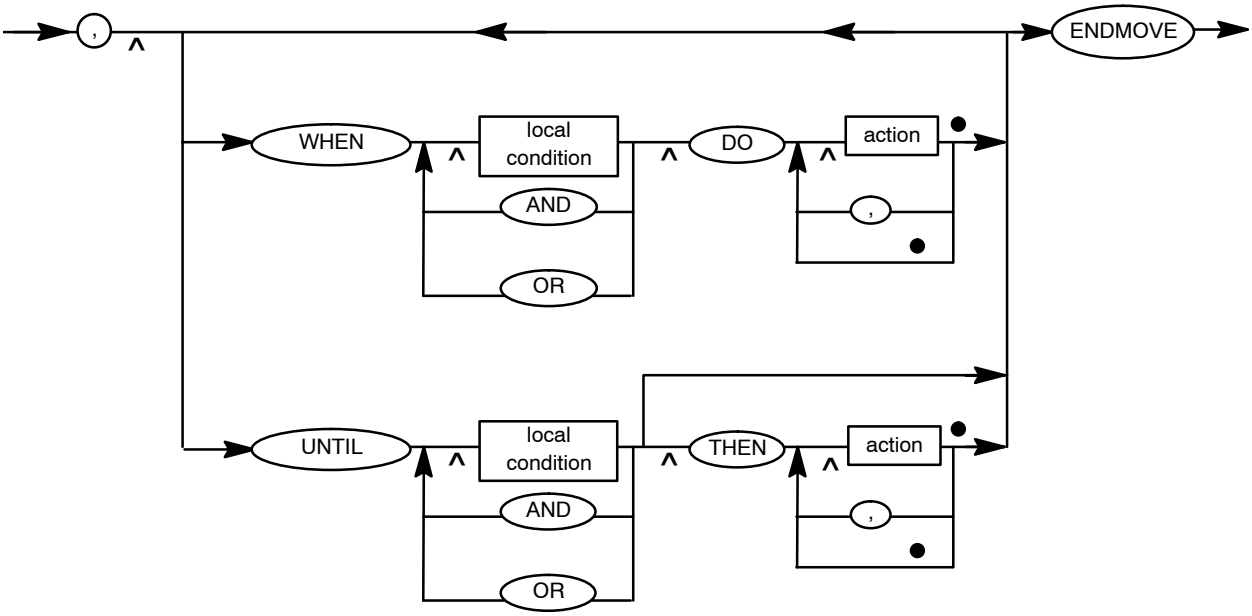


Figure E–24.

local condition handler clause



local condition

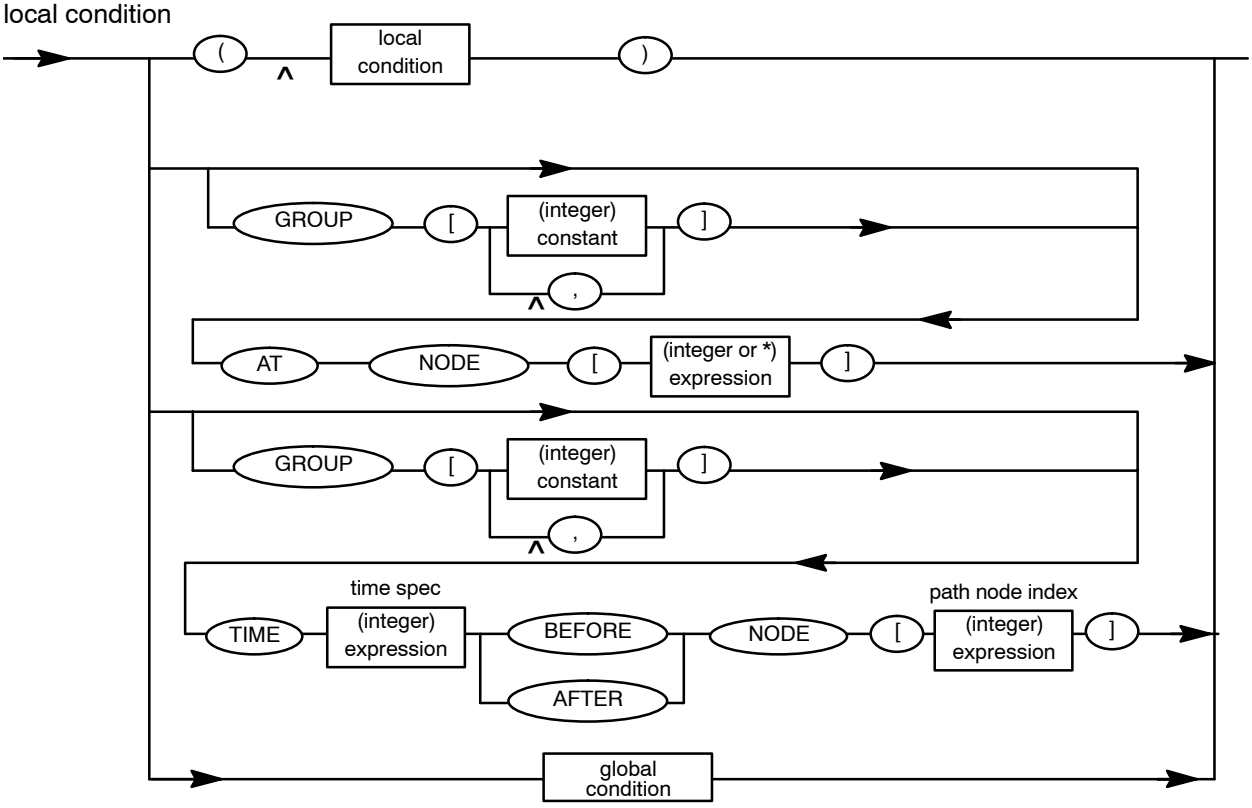
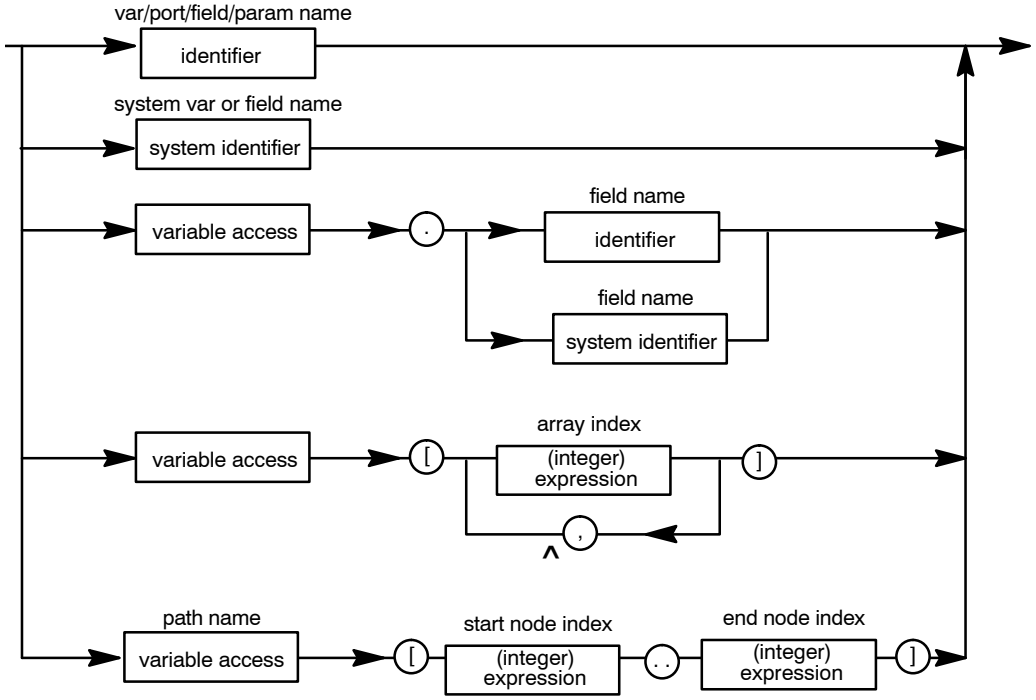


Figure E–25.

variable access



expression

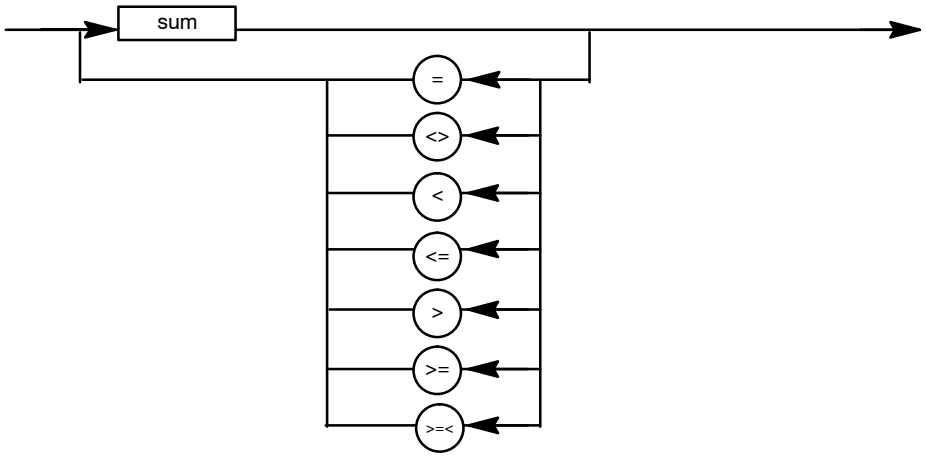
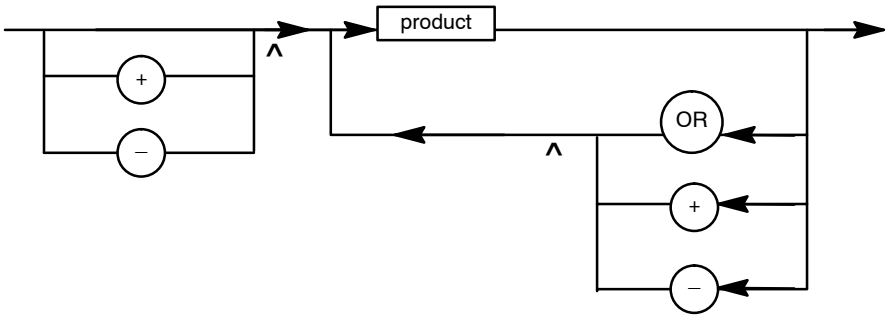
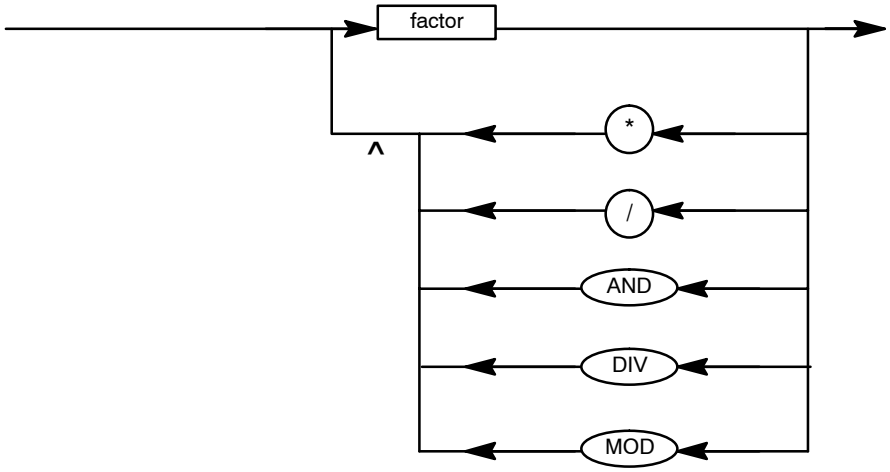


Figure E–26.

sum



product



factor

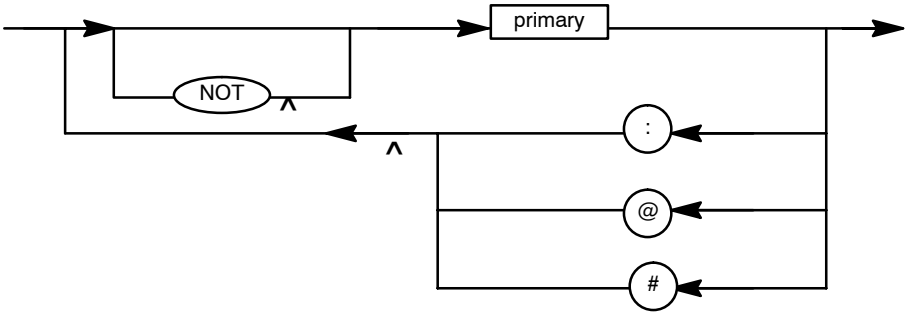
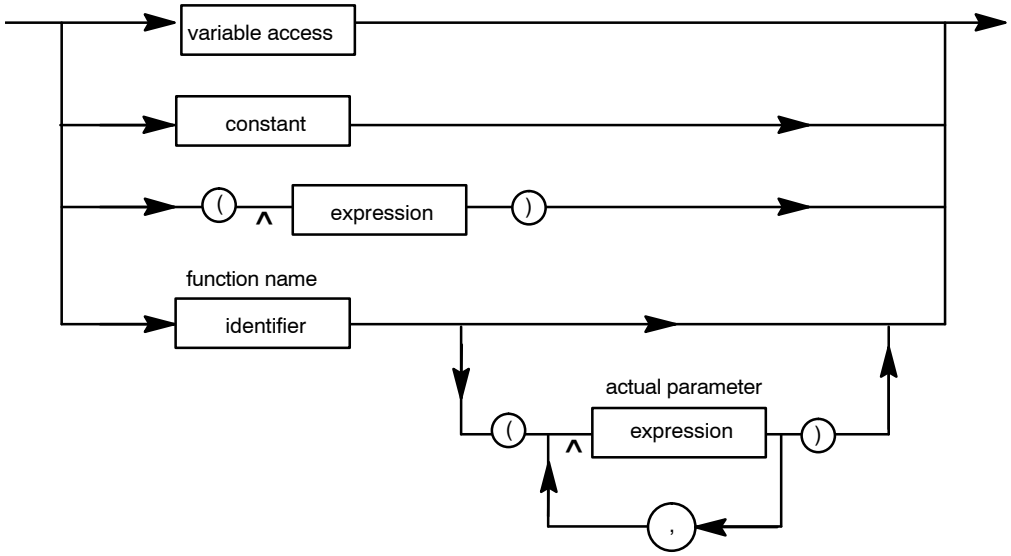
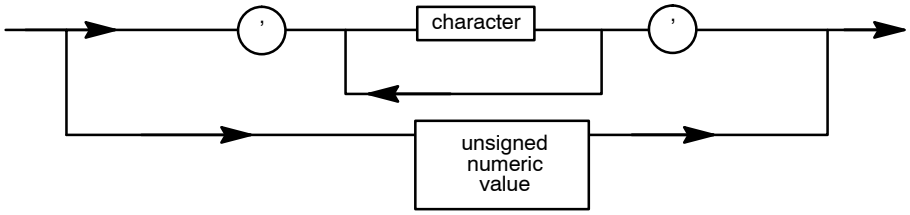


Figure E–27.

primary



literal



Glossary

A

abort

Abnormal termination of a computer program caused by hardware or software malfunction or operator cancellation.

absolute pulse code system

A positional information system for servomotors that relies on battery-backed RAM to store encoder pulse counts when the robot is turned off. This system is calibrated when it is turned on.

A/D value

An analog to digital-value. Converts a multilevel analog electrical system pattern into a digital bit.

AI

Analog input.

AO

Analog output.

alarm

The difference in value between actual response and desired response in the performance of a controlled machine, system or process. Alarm=Error.

algorithm

A fixed step-by-step procedure for accomplishing a given result.

alphanumeric

Data that are both alphabetical and numeric.

AMPS

Amperage amount.

analog

The representation of numerical quantities by measurable quantities such as length, voltage or resistance. Also refers to analog type I/O blocks and distinguishes them from discrete I/O blocks. Numerical data that can vary continuously, for example, voltage levels that can vary within the range of -10 to +10 volts.

AND

An operation that places two contacts or groups of contacts in series. All contacts in series control the resulting status and also mathematical operator.

ANSI

American National Standard Institute, the U.S. government organization with responsibility for the development and announcement of technical data standards.

APC

See absolute pulse code system.

APC motor

See servomotor.

application program

The set of instructions that defines the specific intended tasks of robots and robot systems to make them reprogrammable and multifunctional. You can initiate and change these programs.

arm

A robot component consisting of an interconnecting set of links and powered joints that move and support the wrist socket and end effector.

articulated arm

A robot arm constructed to simulate the human arm, consisting of a series of rotary motions and joints, each powered by a motor.

ASCII

Abbreviation for American Standard Code for Information Interchange. An 8-level code (7 bits plus 1 parity bit) commonly used for the exchange of data.

automatic mode

The robot state in which automatic operation can be initiated.

automatic operation

The time during which robots are performing programmed tasks through unattended program execution.

axis

1. A straight line about which a robot joint rotates or moves. 2. One of the reference lines or a coordinate system. 3. A single joint on the robot arm.

B

backplane

A group of connectors mounted at the back of a controller rack to which printed circuit boards are mated.

BAR

A unit of pressure equal to 100,000 pascals.

barrier

A means of physically separating persons from the restricted work envelope; any physical boundary to a hazard or electrical device/component.

battery low alarm

A programmable value (in engineering units) against which the analog input signal automatically is compared on Genius I/O blocks. A fault is indicated if the input value is equal to or less than the low alarm value.

baud

A unit of transmission speed equal to the number of code elements (bits) per second.

binary

A numbering system that uses only 0 and 1.

bit

Contraction of binary digit. 1. The smallest unit of information in the binary numbering system, represented by a 0 or 1. 2. The smallest division of a programmable controller word.

bps

Bits per second.

buffer

A storage area in the computer where data is held temporarily until the computer can process it.

bus

A channel along which data can be sent.

bus controller

A Genius bus interface board for a programmable controller.

bus scan

One complete communications cycle on the serial bus.

Bus Switching Module

A device that switches a block cluster to one bus or the other of a dual bus.

byte

A sequence of binary digits that can be used to store a value from 0 to 255 and usually operated upon as a unit. Consists of eight bits used to store two numeric or one alpha character.

C

calibration

The process whereby the joint angle of each axis is calculated from a known reference point.

Cartesian coordinate system

A coordinate system whose axes (x, y, and z) are three intersecting perpendicular straight lines. The origin is the intersection of the axes.

Cartesian coordinates

A set of three numbers that defines the location of a point within a rectilinear coordinate system and consisting of three perpendicular axes (x, y, z).

cathode ray tube

A device, like a television set, for displaying information.

central processing unit

The main computer component that is made up of a control section and an arithmetic-logic section. The other basic units of a computer system are input/output units and primary storage.

channel

The device along which data flow between the input/output units of a computer and primary storage.

character

One of a set of elements that can be arranged in ordered groups to express information. Each character has two forms: 1. a man-intelligible form, the graphic, including the decimal digits 0-9, the letters A-Z, punctuation marks, and other formatting and control symbols; 2. a computer intelligible form, the code, consisting of a group of binary digits (bits).

circular

A MOTYPE option in which the robot tool center point moves in an arc defined by three points. These points can be positions or path nodes.

clear

To replace information in a storage unit by zero (or blank, in some machines).

closed loop

A control system that uses feedback. An open loop control system does not use feedback.

C-MOS RAM

Complementary metal-oxide semiconductor random-access memory. A read/write memory in which the basic memory cell is a pair of MOS (metal-oxide semiconductor) transistors. It is an implementation of S-RAM that has very low power consumption, but might be less dense than other S-RAM implementations.

coaxial cable

A transmission line in which one conductor is centered inside and insulated from an outer metal tube that serves as the second conductor. Also known as coax, coaxial line, coaxial transmission line, concentric cable, concentric line, concentric transmission line.

component

An inclusive term used to identify a raw material, ingredient, part or subassembly that goes into a higher level of assembly, compound or other item.

computer

A device capable of accepting information, applying prescribed processes to the information, and supplying the results of these processes.

configuration

The joint positions of a robot and turn number of wrist that describe the robot at a specified position. Configuration is designated by a STRING value and is included in positional data.

continuous path

A trajectory control system that enables the robot arm to move at a constant tip velocity through a series of predefined locations. A rounding effect of the path is required as the tip tries to pass through these locations.

controller memory

A medium in which data are retained. Primary storage refers to the internal area where the data and program instructions are stored for active use, as opposed to auxiliary or external storage (magnetic tape, disk, diskette, and so forth.)

continuous process control

The use of transducers (sensors) to monitor a process and make automatic changes in operations through the design of appropriate feedback control loops. While such devices historically have been mechanical or electromechanical, microcomputers and centralized control is now used, as well.

continuous production

A production system in which the productive equipment is organized and sequenced according to the steps involved to produce the product. Denotes that material flow is continuous during the production process. The routing of the jobs is fixed and set-ups are seldom changed.

controlled stop

A controlled stop controls robot deceleration until it stops. When a safety stop input such as a safety fence signal is opened, the robot decelerates in a controlled manner and then stops. After the robot stops, the Motor Control Contactor opens and drive power is removed.

controller

A hardware unit that contains the power supply, operator controls, control circuitry, and memory that directs the operation and motion of the robot and communications with external devices. See control unit.

control, open-loop

An operation where the computer applies control directly to the process without manual intervention.

control unit

The portion of a computer that directs the automatic operation of the computer, interprets computer instructions, and initiates the proper signals to the other computer circuits to execute instructions.

coordinate system

See Cartesian coordinate system.

CPU

See central processing unit.

CRT

See cathode ray tube.

cps (viscosity)

Centipoises per second.

CRT/KB

Cathode ray tube/keyboard. An optional interface device for the robot system. The CRT/KB is used for some robot operations and for entering programs. It can be a remote device that attaches to the robot via a cable.

cycle

1. A sequence of operations that is repeated regularly. The time it takes for one such sequence to occur. 2. The interval of time during which a system or process, such as seasonal demand or a manufacturing operation, periodically returns to similar initial conditions. 3. The interval of time during which an event or set of events is completed. In production control, a cycle is the length of time between the release of a manufacturing order and shipment to the customer or inventory.

cycle time

1. In industrial engineering, the time between completion of two discrete units of production. 2. In materials management, the length of time from when material enters a production facility until it exits. See throughput.

cursor

An indicator on a teach pendant or CRT display screen at which command entry or editing occurs. The indicator can be a highlighted field or an arrow (> or ^).

cylindrical

Type of work envelope that has two linear major axes and one rotational major axis. Robotic device that has a predominantly cylindrical work envelope due to its design. Typically has fewer than 6 joints and typically has only 1 linear axis.

D

D/A converter

A digital-to-analog converter. A device that transforms digital data into analog data.

D/A value

A digital-to-analog value. Converts a digital bit pattern into a multilevel analog electrical system.

daisy chain

A means of connecting devices (readers, printers, etc.) to a central processor by party-line input/output buses that join these devices by male and female connectors. The last female connector is shorted by a suitable line termination.

daisy chain configuration

A communications link formed by daisy chain connection of twisted pair wire.

data

A collection of facts, numeric and alphabetical characters, or any representation of information that is suitable for communication and processing.

data base

A data file philosophy designed to establish the independence of computer program from data files. Redundancy is minimized and data elements can be added to, or deleted from, the file designs without changing the existing computer programs.

DC

Abbreviation for direct current.

DEADMAN switch

A control switch on the teach pendant that is used to enable servo power. Pressing the DEADMAN switch while the teach pendant is on activates servo power and releases the robot brakes; releasing the switch deactivates servo power and applies the robot brakes.

debugging

The process of detecting, locating and removing mistakes from a computer program, or manufacturing control system. See diagnostic routine.

deceleration tolerance

The specification of the percentage of deceleration that must be completed before a motion is considered finished and another motion can begin.

default

The value, display, function or program automatically selected if you have not specified a choice.

deviation

Usually, the absolute difference between a number and the mean of a set of numbers, or between a forecast value and the actual data.

device

Any type of control hardware, such as an emergency-stop button, selector switch, control pendant, relay, solenoid valve, or sensor.

diagnostic routine

A test program used to detect and identify hardware/software malfunctions in the controller and its associated I/O equipment. See debugging.

diagnostics

Information that permits the identification and evaluation of robot and peripheral device conditions.

digital

A description of any data that is expressed in numerical format. Also, having the states On and Off only.

digital control

The use of a digital computer to perform processing and control tasks in a manner that is more accurate and less expensive than an analog control system.

digital signal

A single point control signal sent to or from the controller. The signal represents one of two states: ON (TRUE, 1. or OFF (FALSE, 0).

directory

A listing of the files stored on a device.

discrete

Consisting of individual, distinct entities such as bits, characters, circuits, or circuit components. Also refers to ON/OFF type I/O blocks.

disk

A secondary memory device in which information is stored on a magnetically sensitive, rotating disk.

disk memory

A non-programmable, bulk-storage, random-access memory consisting of a magnetized coating on one or both sides of a rotating thin circular plate.

drive power

The energy source or sources for the robot servomotors that produce motion.

DRAM

Dynamic Random Access Memory. A read/write memory in which the basic memory cell is a capacitor. DRAM (or D-RAM) tends to have a higher density than SRAM (or S-RAM). Due to the support circuitry required, and power consumption needs, it is generally impractical to use. A battery can be used to retain the content upon loss of power.

E

edit

1. A software mode that allows creation or alteration of a program. 2. To modify the form or format of data, for example, to insert or delete characters.

emergency stop

The operation of a circuit using hardware-based components that overrides all other robot controls, removes drive power from the actuators, and causes all moving parts of to stop. The operator panel and teach pendant are each equipped with EMERGENCY STOP buttons.

enabling device

A manually operated device that, when continuously activated, permits motion. Releasing the device stops the motion of the robot and associated equipment that might present a hazard.

encoder

1. A device within the robot that sends the controller information about where the robot is. 2. A transducer used to convert position data into electrical signals. The robot system uses an incremental optical encoder to provide position feedback for each joint. Velocity data is computed from the encoder signals and used as an additional feedback signal to assure servo stability.

end effector

An accessory device or tool specifically designed for attachment to the robot wrist or tool mounting plate to enable the robot to perform its intended tasks. Examples include gripper, spot weld gun, arc weld gun, spray paint gun, etc.

end-of-arm tooling

Any of a number of tools, such as welding guns, torches, bells, paint spraying devices, attached to the faceplate of the robot wrist. Also called end effector or EOAT.

engineering units

Units of measure as applied to a process variable, for example, psi, Degrees F., etc.

envelope, maximum

The volume of space encompassing the maximum designed movements of all robot parts including the end effector, workpiece, and attachments.

EOAT

See end of arm tooling, tool.

EPROM

Erasable Programmable Read Only Memory. Semiconductor memory that can be erased and reprogrammed. A non-volatile storage memory.

error

The difference in value between actual response and desired response in the performance of a controlled machine, system or process. Alarm=Error.

error message

A numbered message, displayed on the CRT/KB and teach pendant, that indicates a system problem or warns of a potential problem.

Ethernet

A Local Area Network (LAN) bus-oriented, hardware technology that is used to connect computers, printers, terminal concentrators (servers), and many other devices together. It consists of a master cable and connection devices at each machine on the cable that allow the various devices to "talk" to each other. Software that can access the Ethernet and cooperate with machines connected to the cable is necessary. Ethernets come in varieties such as baseband and broadband and can run on different media, such as coax, twisted pair and fiber. Ethernet is a trademark of Xerox Corporation.

execute

To perform a specific operation, such as one that would be accomplished through processing one statement or command, a series of statements or commands, or a complete program or command procedure.

extended axis

An optional, servo-controlled axis that provides extended reach capability for a robot, including in-booth rail, single- or double-link arm, also used to control motion of positioning devices.

F

faceplate

The tool mounting plate of the robot.

feedback

1. The signal or data fed back to a commanding unit from a controlled machine or process to denote its response to the command signal. The signal representing the difference between actual response and desired response that is used by the commanding unit to improve performance of the controlled machine or process. 2. The flow of information back into the control system so that actual performance can be compared with planned performance, for instance in a servo system.

field

A specified area of a record used for a particular category of data. 2. A group of related items that occupy the same space on a CRT/KB screen or teach pendant LCD screen. Field name is the name of the field; field items are the members of the group.

field devices

User-supplied devices that provide information to the PLC (inputs: push buttons, limit switches, relay contacts, an so forth) or perform PLC tasks (outputs: motor starters, solenoids, indicator lights, and so forth.)

file

1. An organized collection of records that can be stored or retrieved by name. 2. The storage device on which these records are kept, such as bubble memory or disk.

filter

A device to suppress interference that would appear as noise.

Flash File Storage

A portion of FROM memory that functions as a separate storage device. Any file can be stored on the FROM disk.

Flash ROM

Flash Read Only Memory. Flash ROM is not battery-backed memory but it is non-volatile. All data in Flash ROM is saved even after you turn off and turn on the robot.

flow chart

A systems analysis tool to graphically show a procedure in which symbols are used to represent operations, data, flow, and equipment. See block diagram, process chart.

flow control

A specific production control system that is based primarily on setting production rates and feeding work into production to meet the planned rates, then following it through production to make sure that it is moving. This concept is most successful in repetitive production.

format

To set up or prepare a memory card or floppy disk (not supported on R-J3*i*C*i*C and later) so it can be used to store data in a specific system.

FR

See Flash ROM.

F-ROM

See Flash ROM.

FROM disk

See Flash ROM.

G

general override stat

A percentage value that governs the maximum robot jog speed and program run speed.

Genius I/O bus

The serial bus that provides communications between blocks, controllers, and other devices in the system especially with respect to GE FANUC Genius I/O.

gripper

The "hand" of a robot that picks up, holds and releases the part or object being handled. Sometimes referred to as a manipulator. See EOAT, tool.

group signal

An input/output signal that has a variable number of digital signals, recognized and taken as a group.

gun

See applicator.

H

Hand Model.

Used in Interference Checking, the Hand Model is the set of virtual model elements (spheres and cylinders) that are used to represent the location and shape of the end of arm tooling with respect to the robot's faceplate.

hardware

1. In data processing, the mechanical, magnetic, electrical and electronic devices of which a computer, controller, robot, or panel is built. 2. In manufacturing, relatively standard items such as nuts, bolts, washers, clips, and so forth.

hard-wire

To connect electric components with solid metallic wires.

hard-wired

1. Having a fixed wired program or control system built in by the manufacturer and not subject to change by programming. 2. Interconnection of electrical and electronic devices directly through physical wiring.

hazardous motion

Unintended or unexpected robot motion that can cause injury.

hexadecimal

A numbering system having 16 as the base and represented by the digits 0 through 9, and A through F.

hold

A smoothly decelerated stopping of all robot movement and a pause of program execution. Power is maintained on the robot and program execution generally can be resumed from a hold.

HTML.

Hypertext Markup Language. A markup language that is used to create hypertext and hypermedia documents incorporating text, graphics, sound, video, and hyperlinks.

http.

Hypertext transfer protocol. The protocol used to transfer HTML files between web servers.

I

impedance

A measure of the total opposition to current flow in an electrical circuit.

incremental encoder system

A positional information system for servomotors that requires calibrating the robot by moving it to a known reference position (indicated by limit switches) each time the robot is turned on or calibration is lost due to an error condition.

index

An integer used to specify the location of information within a table or program.

index register

A memory device containing an index.

industrial robot

A reprogrammable multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions in order to perform a variety of tasks.

industrial robot system

A system that includes industrial robots, end effectors, any equipment devices and sensors required for the robot to perform its tasks, as well as communication interfaces for interlocking, sequencing, or monitoring the robot.

information

The meaning derived from data that have been arranged and displayed in a way that they relate to that which is already known. See data.

initialize

1. Setting all variable areas of a computer program or routine to their desired initial status, generally done the first time the code is executed during each run. 2. A program or hardware circuit that returns a program a system, or hardware device to an original state. See startup, initial.

input

The data supplied from an external device to a computer for processing. The device used to accomplish this transfer of data.

input device

A device such as a terminal keyboard that, through mechanical or electrical action, converts data from the form in which it has been received into electronic signals that can be interpreted by the CPU or programmable controller. Examples are limit switches, push buttons, pressure switches, digital encoders, and analog devices.

input processing time

The time required for input data to reach the microprocessor.

input/output

Information or signals transferred between devices, discreet electrical signals for external control.

input/output control

A technique for controlling capacity where the actual output from a work center is compared with the planned output developed by CRP. The input is also monitored to see if it corresponds with plans so that work centers will not be expected to generate output when jobs are not available to work on.

integrated circuit

A solid-state micro-circuit contained entirely within a chip of semiconductor material, generally silicon. Also called chip.

interactive

Refers to applications where you communicate with a computer program via a terminal by entering data and receiving responses from the computer.

interface

1. A concept that involves the specifications of the inter-connection between two equipments having different functions. 2. To connects a PLC with the application device, communications channel, and peripherals through various modules and cables. 3. The method or equipment used to communicate between devices.

interference zone

An area that falls within the work envelope of a robot, in which there is the potential for the robot motion to coincide with the motion of another robot or machine, and for a collision to occur.

interlock

An arrangement whereby the operation of one control or mechanism brings about, or prevents, the operations of another.

interrupt

A break in the normal flow of a system or program that occurs in a way that the flow can be resumed from that point at a later time. Interrupts are initiated by two types of signals: 1. signals originating within the computer system to synchronize the operation of the computer system with the outside world; 2. signals originating exterior to the computer system to synchronize the operation of the computer system with the outside world.

I/O

Abbreviation for input/output or input/output control.

I/O block

A microprocessor-based, configurable, rugged solid state device to which field I/O devices are attached.

I/O electrical isolation

A method of separating field wiring from logic level circuitry. This is typically done through optical isolation devices.

I/O module

A printed circuit assembly that is the interface between user devices and the Series Six PLC.

I/O scan

A method by which the CPU monitors all inputs and controls all outputs within a prescribed time. A period during which each device on the bus is given a turn to send information and listen to all of the broadcast data on the bus.

ISO

The International Standards Organization that establishes the ISO interface standards.

isolation

1. The ability of a logic circuit having more than one inputs to ensure that each input signal is not affected by any of the others. 2. A method of separating field wiring circuitry from logic level circuitry, typically done optically.

item

1. A category displayed on the teach pendant on a menu. 2. A set of adjacent digits, bits, or characters that is treated as a unit and conveys a single unit of information. 3. Any unique manufactured or purchased part or assembly: end product, assembly, subassembly, component, or raw material.

J

jog coordinate systems

Coordinate systems that help you to move the robot more effectively for a specific application. These systems include JOINT, WORLD, TOOL, and USER.

JOG FRAME

A jog coordinate system you define to make the robot jog the best way possible for a specific application. This can be different from world coordinate frame.

jogging

Pressing special keys on the teach pendant to move the robot.

jog speed

Is a percentage of the maximum speed at which you can jog the robot.

joint

1. A single axis of rotation. There are up to six joints in a robot arm (P-155 swing arm has 8). 2. A jog coordinate system in which one axis is moved at a time.

JOINT

A motion type in which the robot moves the appropriate combination of axes independently to reach a point most efficiently. (Point to point, non-linear motion).

joint interpolated motion

A method of coordinating the movement of the joints so all joints arrive at the desired location at the same time. This method of servo control produces a predictable path regardless of speed and results in the fastest cycle time for a particular move. Also called joint motion.

K

K

Abbreviation for kilo, or exactly 1024 in computer jargon. Related to 1024 words of memory.

KAREL

The programming language developed for robots by the FANUC Robotics America, Inc.

L

label

An ordered set of characters used to symbolically identify an instruction, a program, a quantity, or a data area.

LCD

See liquid crystal display.

lead time

The span of time needed to perform an activity. In the production and inventory control context, this activity is normally the procurement of materials and/or products either from an outside supplier or from one's own manufacturing facility. Components of lead time can include order preparation time, queue time, move or transportation time, receiving and inspection time.

LED

See Light Emitting Diode.

LED display

An alphanumeric display that consists of an array of LEDs.

Light Emitting Diode

A solid-state device that lights to indicate a signal on electronic equipment.

limiting device

A device that restricts the work envelope by stopping or causing to stop all robot motion and that is independent of the control program and the application programs.

limit switch

A switch that is actuated by some part or motion of a machine or equipment to alter the electrical circuit associated with it. It can be used for position detection.

linear

A motion type in which the appropriate combination of axes move in order to move the robot TCP in a straight line while maintaining tool center point orientation.

liquid crystal display

A digital display on the teach pendant that consists of two sheets of glass separated by a sealed-in, normally transparent, liquid crystal material. Abbreviated LCD.

load

1. The weight (force) applied to the end of the robot arm. 2. A device intentionally placed in a circuit or connected to a machine or apparatus to absorb power and convert it into the desired useful form. 3. To copy programs or data into memory storage.

location

1. A storage position in memory uniquely specified by an address. 2. The coordinates of an object used in describing its x, y, and z position in a Cartesian coordinate system.

lockout/tagout

The placement of a lock and/or tag on the energy isolating device (power disconnecting device) in the off or open position. This indicates that the energy isolating device or the equipment being controlled will not be operated until the lock/tag is removed.

log

A record of values and/or action for a given function.

logic

A fixed set of responses (outputs) to various external conditions (inputs). Also referred to as the program.

loop

The repeated execution of a series of instructions for a fixed number of times, or until interrupted by the operator.

M

mA

See milliampere.

machine language

A language written in a series of bits that are understandable by, and therefore instruct, a computer. This is a "first level" computer language, as compared to a "second level" assembly language, or a "third level" compiler language.

machine lock

A test run option that allows the operator to run a program without having the robot move.

macro

A source language instruction from which many machine-language instructions can be generated.

magnetic disk

A metal or plastic floppy disk (not supported on R-J3*i*C*i*C and later) that looks like a phonograph record whose surface can store data in the form of magnetized spots.

magnetic disk storage

A storage device or system consisting of magnetically coated metal disks.

magnetic tape

Plastic tape, like that used in tape recorder, on which data is stored in the form of magnetized spots.

maintenance

Keeping the robots and system in their proper operating condition.

MC

See memory card.

mechanical unit

The robot arm, including auxiliary axis, and hood/deck and door openers.

medium

plural **media** . The physical substance upon which data is recorded, such as a memory card (or floppy disk which is not supported on R-J3*i*C*i*C and later).

memory

A device or media used to store information in a form that can be retrieved and is understood by the computer or controller hardware. Memory on the controller includes C-MOS RAM, Flash ROM and D-RAM.

memory card

A C-MOS RAM memory card or a flash disk-based PC card.

menu

A list of options displayed on the teach pendant screen.

message

A group of words, variable in length, transporting an item of information.

microprocessor

A single integrated circuit that contains the arithmetic, logic, register, control and memory elements of a computer.

microsecond
One millionth (0.000001) of a second

milliampere
One one-thousandth of an ampere. Abbreviated mA.

millisecond
One thousandth of a second. Abbreviated msec.

module
A distinct and identifiable unit of computer program for such purposes as compiling, loading, and linkage editing. It is eventually combined with other units to form a complete program.

motion type
A feature that allows you to select how you want the robot to move from one point to the next. MOTYPES include joint, linear, and circular.

mode
1. One of several alternative conditions or methods of operation of a device. 2. The most common or frequent value in a group of values.

N

network
1. The interconnection of a number of devices by data communication facilities. "Local networking" is the communications network internal to a robot. "Global networking" is the ability to provide communications connections outside of the robot's internal system. 2. Connection of geographically separated computers and/or terminals over communications lines. The control of transmission is managed by a standard protocol.

non-volatile memory
Memory capable of retaining its stored information when power is turned off.

O

Obstacle Model.
Used in Interference Checking, the Obstacle Model is the set of virtual model elements (spheres, cylinders, and planes) that are used to represent the shape and the location of a given obstacle in space.

off-line
Equipment or devices that are not directly connected to a communications line.

off-line operations
Data processing operations that are handled outside of the regular computer program. For example, the computer might generate a report off-line while the computer was doing another job.

off-line programming

The development of programs on a computer system that is independent of the "on-board" control of the robot. The resulting programs can be copied into the robot controller memory.

offset

The count value output from a A/D converter resulting from a zero input analog voltage. Used to correct subsequent non-zero measurements also incremental position or frame adjustment value.

on-line

A term to describe equipment or devices that are connected to the communications line.

on-line processing

A data processing approach where transactions are entered into the computer directly, as they occur.

operating system

Lowest level system monitor program.

operating work envelope

The portion of the restricted work envelope that is actually used by the robot while it is performing its programmed motion. This includes the maximum the end-effector, the workpiece, and the robot itself.

operator

A person designated to start, monitor, and stop the intended productive operation of a robot or robot system.

operator box

A control panel that is separate from the robot and is designed as part of the robot system. It consists of the buttons, switches, and indicator lights needed to operate the system.

operator panel

A control panel designed as part of the robot system and consisting of the buttons, switches, and indicator lights needed to operate the system.

optional features

Additional capabilities available at a cost above the base price.

OR

An operation that places two contacts or groups of contacts in parallel. Any of the contacts can control the resultant status, also a mathematical operation.

orientation

The attitude of an object in space. Commonly described by three angles: rotation about x (w), rotation about y (p), and rotation about z (r).

origin

The point in a Cartesian coordinate system where axes intersect; the reference point that defines the location of a frame.

OT

See overtravel.

output

Information that is transferred from the CPU for control of external devices or processes.

output device

A device, such as starter motors, solenoids, that receive data from the programmable controller.

output module

An I/O module that converts logic levels within the CPU to a usable output signal for controlling a machine or process .

outputs

Signals, typically on or off, that controls external devices based upon commands from the CPU.

override

See general override.

overtravel

A condition that occurs when the motion of a robot axis exceeds its prescribed limits.

overwrite

To replace the contents of one file with the contents of another file when copying.

P

parity

The anticipated state, odd or even, of a set of binary digits.

parity bit

A binary digit added to an array of bits to make the sum of all bits always odd or always even.

parity check

A check that tests whether the number of ones (or zeros) in an array of binary digits is odd or even.

parity error

A condition that occurs when a computed parity check does not agree with the parity bit.

part

A material item that is used as a component and is not an assembly or subassembly.

pascal

A unit of pressure in the meter-kilogram-second system equivalent to one newton per square meter.

path

1. A variable type available in the KAREL system that consists of a list of positions. Each node includes positional information and associated data. 2. The trajectory followed by the TCP in a move.

PCB

See printed circuit board.

PC Interface

The PC Interface software uses Ethernet connections to provide file transfer protocol (FTP) functions, PC send macros, telnet interface, TCP/IP interface web server functions, and host communications.

pendant

See teach pendant.

PLC

See programmable logic controller or cell controller.

PMC

The programmable machine controller (PMC) functions provide a ladder logic programming environment to create PMC functions. This provides the capability to use the robot I/O system to run PLC programs in the background of normal robot operations. This function can be used to control bulk supply systems, fixed automation that is part of the robot workcell, or other devices that would normally require basic PLC controls.

printed circuit board

A flat board whose front contains slots for integrated circuit chips and connections for a variety of electronic components, and whose back is printed with electrically conductive pathways between the components.

production mode

See automatic mode.

program

1. A plan for the solution of a problem. A complete program includes plans for the transcription of data, coding for the computer, and plans for the absorption of the results into the system. 2. A sequence of instructions to be executed by the computer or controller to control a robot/robot system. 3. To furnish a computer with a code of instructions. 4. To teach a robot system a specific set of movements and instructions to do a task.

programmable controller

See programmable logic controller or cell controller.

programmable logic controller

A solid-state industrial control device that receives inputs from user-supplied control devices, such as switches and sensors, implements them in a precise pattern determined by ladder diagram-based programs stored in the user memory, and provides outputs for control of processes or user-supplied devices such as relays and motor starters.

Program ToolBox

The Program ToolBox software provides programming utilities such as mirror image and flip wrist editing capabilities.

protocol

A set of hardware and software interfaces in a terminal or computer that allows it to transmit over a communications network, and that collectively forms a communications language.

psi

Pounds per square inch.

Q

queue.

1. Waiting lines resulting from temporary delays in providing service. 2. The amount of time a job waits at a work center before set-up or work is performed on the job. See also job queue.

R

RAM

See Random Access Memory.

random access

A term that describes files that do not have to be searched sequentially to find a particular record but can be addressed directly.

Random Access Memory

1. Volatile, solid-state memory used for storage of programs and locations; battery backup is required. 2. The working memory of the controller. Programs and variable data must be loaded into RAM before the program can execute or the data can be accessed by the program.

range

1. A characterization of a variable or function. All the values that a function can possess. 2. In statistics, the spread in a series of observations. 3. A programmable voltage or current spectrum of values to which input or output analog signals can be limited.

RI

Robot input.

RO

Robot output.

read

To copy, usually from one form of storage to another, particularly from external or secondary storage to internal storage. To sense the meaning of arrangements of hardware. To sense the presence of information on a recording medium.

Read Only Memory

A digital memory containing a fixed pattern of bits that you cannot alter.

record

To store the current set or sets of information on a storage device.

recovery

The restoration of normal processing after a hardware or software malfunction through detailed procedures for file backup, file restoration, and transaction logging.

register

1. A special section of primary storage in a computer where data is held while it is being worked on.
2. A memory device capable of containing one or more computer bits or words.

remote/local

A device connection to a given computer, with remote devices being attached over communications lines and local devices attached directly to a computer channel; in a network, the computer can be a remote device to the CPU controlling the network.

repair

To restore robots and robot systems to operating condition after damage, malfunction, or wear.

repeatability

The closeness of agreement among the number of consecutive movements made by the robot arm to a specific point.

reset

To return a register or storage location to zero or to a specified initial condition.

restricted work envelope

That portion of the work envelope to which a robot is restricted by limiting devices that establish limits that will not be exceeded in the event of any reasonably foreseeable failure of the robot or its controls. The maximum distance the robot can travel after the limited device is actuated defines the restricted work envelope of the robot.

RIA

Robotic Industries Association Subcommittee of the American National Standards Institute, Inc.

robot

A reprogrammable multifunctional manipulator designed to move material, parts, tools, or specialized devices, through variable programmed motions for the performance of a variety of tasks.

Robot Model.

Used in Interference Checking, the Robot Model is the set of virtual model elements (sphere and cylinders) that are used to represent the location and shape of the robot arm with respect to the robot's base. Generally, the structure of a six axes robot can be accurately modeled as a series of cylinders and spheres. Each model element represents a link or part of the robot arm.

ROM

See Read Only Memory.

routine

1. A list of coded instructions in a program. 2. A series of computer instructions that performs a specific task and can be executed as often as needed during program execution.

S

saving data.

Storing program data in Flash ROM, to a floppy disk (not supported on R-J3*i*C*i*C and later), or memory card.

scfm

Standard cubic feet per minute.

scratch start

Allows you to enable and disable the automatic recovery function.

sensor

A device that responds to physical stimuli, such as heat, light, sound pressure, magnetism, or motion, and transmits the resulting signal or data for providing a measurement, operating a control or both. Also a device that is used to measure or adjust differences in voltage in order to control sophisticated machinery dynamically.

serial communication

A method of data transfer within a PLC whereby the bits are handled sequentially rather than simultaneously as in parallel transmission.

serial interface

A method of data transmission that permits transmitting a single bit at a time through a single line. Used where high speed input is not necessary.

Server Side Include (SSI)

A method of calling or "including" code into a web page.

servomotor

An electric motor that is controlled to produce precision motion. Also called a "smart" motor.

SI

System input.

signal

The event, phenomenon, or electrical quantity that conveys information from one point to another.

significant bit

A bit that contributes to the precision of a number. These are counted starting with the bit that contributes the most value, of "most significant bit," and ending with the bit that contributes the least value, or "least significant bit."

slip sheet

A sheet of material placed between certain layers of a unit load. Also known as tier sheet.

SO

System output.

specific gravity

The ratio of a mass of solid or liquid to the mass of an equal volume of water at 45C. You must know the specific gravity of the dispensing material to perform volume signal calibration. The specific gravity of a dispensing material is listed on the MSDS for that material.

SRAM

A read/write memory in which the basic memory cell is a transistor. SRAM (or S-RAM) tends to have a lower density than DRAM. A battery can be used to retain the content upon loss of power.

slpm

Standard liters per minute.

Standard Operator Panel (SOP).

A panel that is made up of buttons, keyswitches, and connector ports.

state

The on or off condition of current to and from and input or output device.

statement

See instruction.

storage device

Any device that can accept, retain, and read back one or more times. The available storage devices are SRAM, Flash ROM (FROM or F-ROM), floppy disks (not available on R-J3*i*C*i*C), memory cards, or a USB memory stick.

system variable

An element that stores data used by the controller to indicate such things as robot specifications, application requirements, and the current status of the system.

T

Tare

The difference between the gross weight of an object and its contents, and the object itself. The weight of an object without its contents.

TCP

See tool center point.

teaching

Generating and storing a series of positional data points effected by moving the robot arm through a path of intended motions.

teach mode

1. The mode of operation in which a robot is instructed in its motions, usually by guiding it through these motions using a teach pendant. 2. The generation and storage of positional data. Positional data can be taught using the teach pendant to move the robot through a series of positions and recording those positions for use by an application program.

teach pendant

1. A hand-held device used to instruct a robot, specifying the character and types of motions it is to undertake. Also known as teach box, teach gun. 2. A portable device, consisting of an LCD display and a keypad, that serves as a user interface to the KAREL system and attaches to the operator box or operator panel via a cable. The teach pendant is used for robot operations such as jogging the robot, teaching and recording positions, and testing and debugging programs.

telemetry

The method of transmission of measurements made by an instrument or a sensor to a remote location.

termination type

Feature that controls the blending of robot motion between segments.

tool

A term used loosely to define something mounted on the end of the robot arm, for example, a hand, gripper, or an arc welding torch.

tool center point

1. The location on the end-effector or tool of a robot hand whose position and orientation define the coordinates of the controlled object. 2. Reference point for position control, that is, the point on the tool that is used to teach positions. Abbreviated TCP.

TOOL Frame

The Cartesian coordinate system that has the position of the TCP as its origin to stet. The z-axis of the tool frame indicates the approach vector for the tool.

TP.

See teach pendant.

transducer

A device for converting energy from one form to another.

U

UOP

See user operator panel.

URL

Universal Resource Locator. A standard addressing scheme used to locate or reference files on web servers.

USB memory stick

The R-J3*i*C*i*C Controller USB memory stick interface supports a USB 1.1 interface. The USB Organization specifies standards for USB 1.1 and 2.0. Most memory stick devices conform to the USB 2.0 specification for operation and electrical standards. USB 2.0 devices as defined by the USB Specification must be backward compatible with USB 1.1 devices. However, FANUC Robotics does not support any security or encryption features on USB memory sticks. The controller supports most widely-available USB Flash memory sticks from 32MB up to 1GB in size.

USER Frame

The Cartesian coordinate system that you can define for a specific application. The default value of the User Frame is the World Frame. All positional data is recorded relative to User Frame.

User Operator Panel

User-supplied control device used in place of or in parallel with the operator panel or operator box supplied with the controller. Abbreviated UOP .

V

variable

A quantity that can assume any of a given set of values.

variance

The difference between the expected (or planned) and the actual, also statistics definitions.

vision system

A device that collects data and forms an image that can be interpreted by a robot computer to determine the position or to "see" an object.

volatile memory

Memory that will lose the information stored in it if power is removed from the memory circuit device.

W

web server

An application that allows you to access files on the robot using a standard web browser.

warning device

An audible or visible device used to alert personnel to potential safety hazards.

work envelope

The volume of space that encloses the maximum designed reach of the robot manipulator including the end effector, the workpiece, and the robot itself. The work envelope can be reduced or restricted

by limiting devices. The maximum distance the robot can travel after the limit device is actuated is considered the basis for defining the restricted work envelope.

write

To deliver data to a medium such as storage.