DENSO ROBOT

Vertical articulated
V* SERIES

Horizontal articulated
H* SERIES

Cartesian coordinate
XYC SERIES

Integrated compact type
XR SERIES

STARTUP HANDBOOK

Preface

Thank you for purchasing this high-speed, high-accuracy assembly robot.

Before operating your robot, read this manual carefully to safely get the maximum benefit from your robot in your assembling operations.

Important

To ensure operator safety, be sure to read the precautions and instructions in "SAFETY PRECAUTIONS."

How this book is organized

This book is just one part of the documentation set. This book consists of SAFETY PRECAUTIONS and chapters one through five.

Comprehensive Guidance Flow for STARTUP MANUAL

Part 1 Preparation for Installation (Chapters 1 through 5)

This part provides information on preparation for installation--robot system, RC7M controller, interfacing, cabling, and wiring of dedicated signals.

Part 2 Robot Running (Chapters 6 through 8)

This part describes the coordinate systems, handling of the teach pendant, and teaching.

Part 3 Simple Programming (Chapters 9 through 11)

This part describes programming basics and provides instructions for creating programs with the teach pendant or WINCAPSIII, using practice exercises.

Part 4 Program Verification (Chapters 12 through 15)

This part describes program verification procedures--simulation with WINCAPSIII and operational check with the teach pendant and from external equipment. It also provides instructions for monitoring I/O signals and variables.

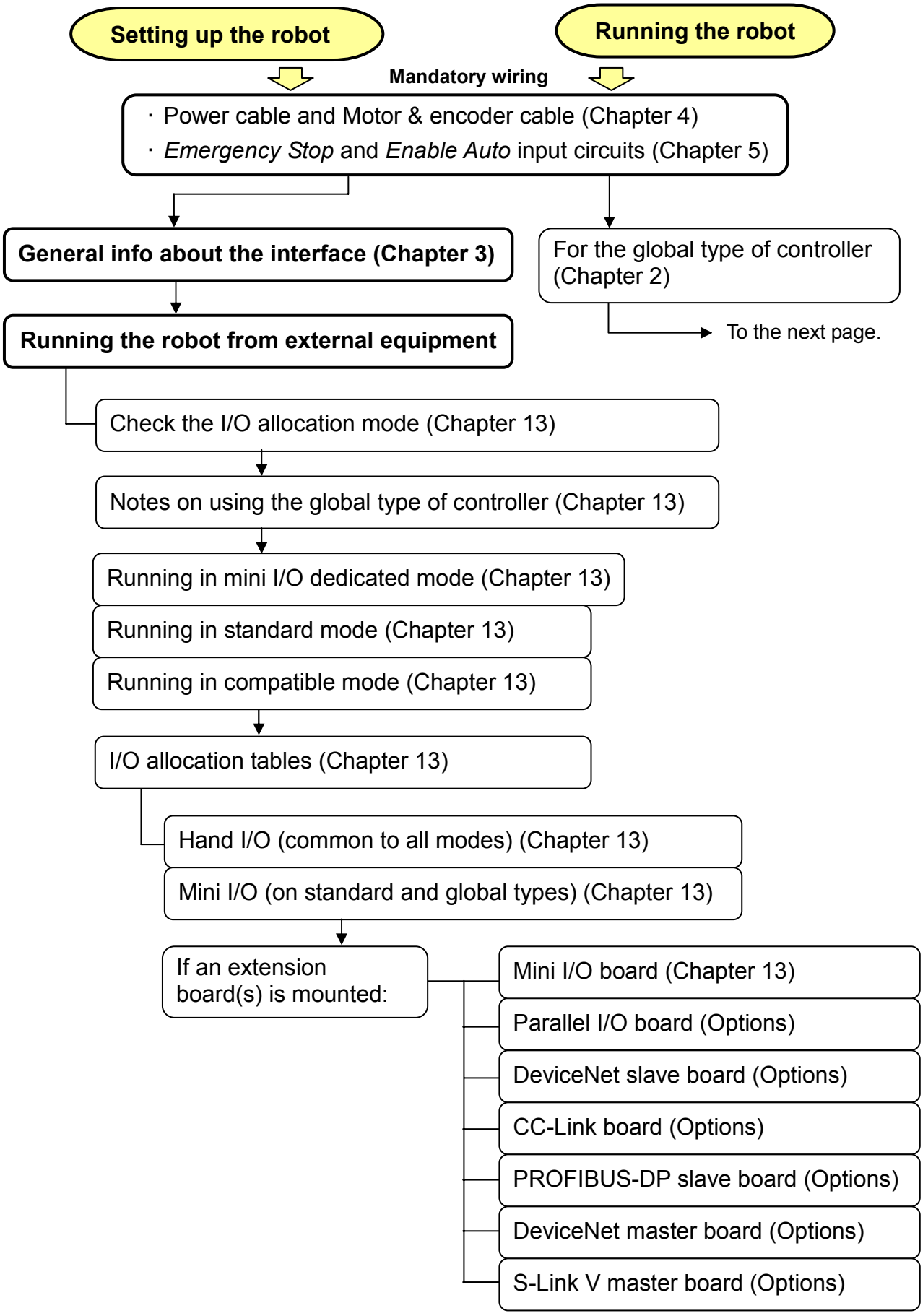
Part 5 Advanced Usage (Chapters 16 through 20)

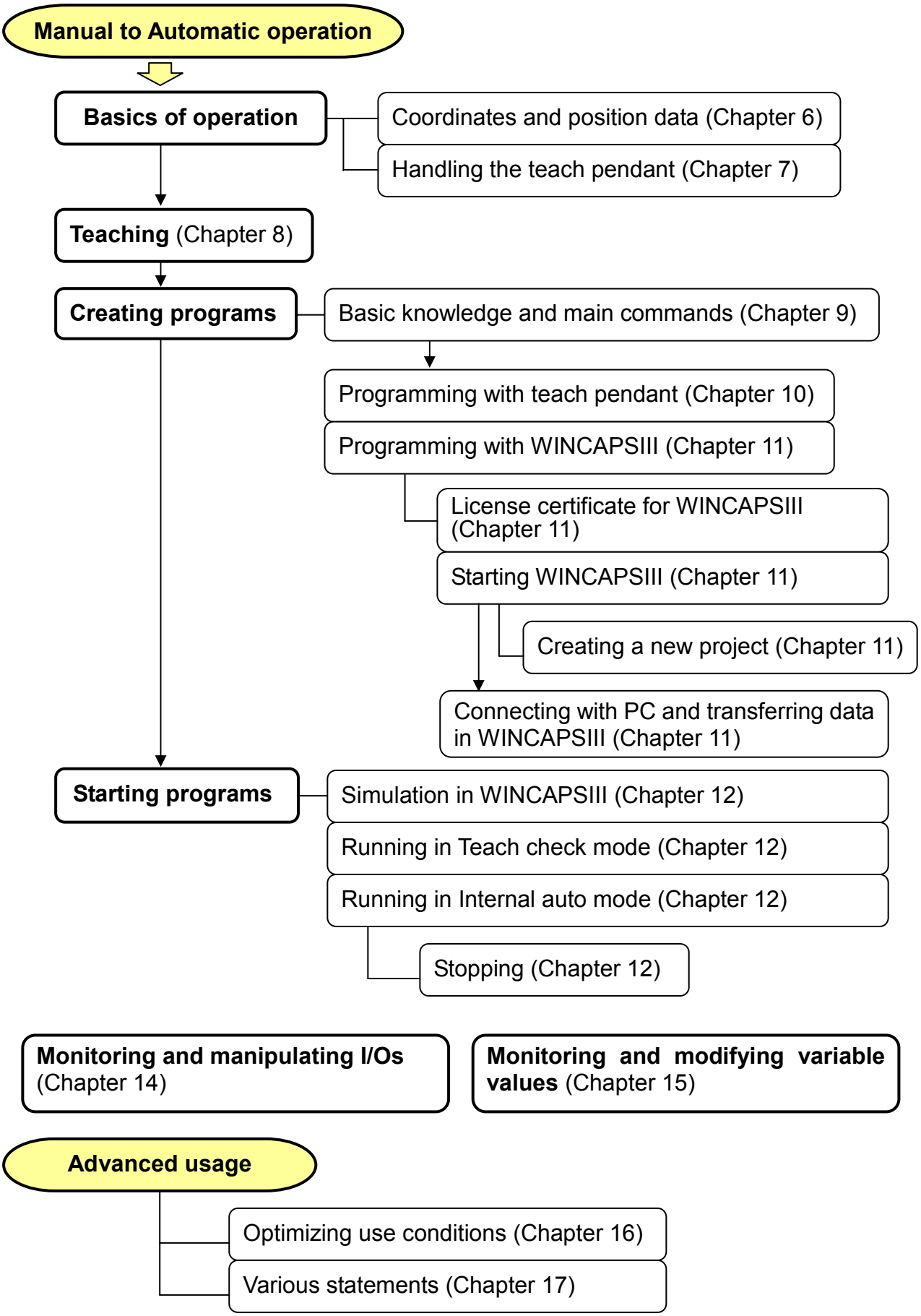
This part provides optimization of use conditions, frequently used program commands, and other information for advanced usage.

Appendices

Appendix 1 Sample Answers to Practice Exercises
Appendix 2 Commands Listed According to Functions
Appendix 3 Menu Tree of Commands on Teach Pendant
Appendix 4 Program Samples
Appendix 5 Glossary

Comprehensive Guidance Flow for STARTUP MANUAL




Manual to Automatic operation
Basics of operation
Coordinates and position data (Chapter 6)
Handling the teach pendant (Chapter 7)
Teaching (Chapter 8)
Creating programs
Basic knowledge and main commands (Chapter 9)
Programming with teach pendant (Chapter 10)
Programming with WINCAPSIII (Chapter 11)
License certificate for WINCAPSIII (Chapter 11)
Starting WINCAPSIII (Chapter 11)
Creating a new project (Chapter 11)
Connecting with PC and transferring data in WINCAPSIII (Chapter 11)
Starting programs
Simulation in WINCAPSIII (Chapter 12)
Running in Teach check mode (Chapter 12)
Running in Internal auto mode (Chapter 12)
Stopping (Chapter 12)
Monitoring and manipulating I/Os (Chapter 14)
Monitoring and modifying variable values (Chapter 15)
Advanced usage
Optimizing use conditions (Chapter 16)
Various statements (Chapter 17)

Contents

Part 1 Preparation for Installation

Part 2 Robot Running

Part 3 Simple Programming

Part 4 Program Verification

Part 5 Advanced Usage

Appendices

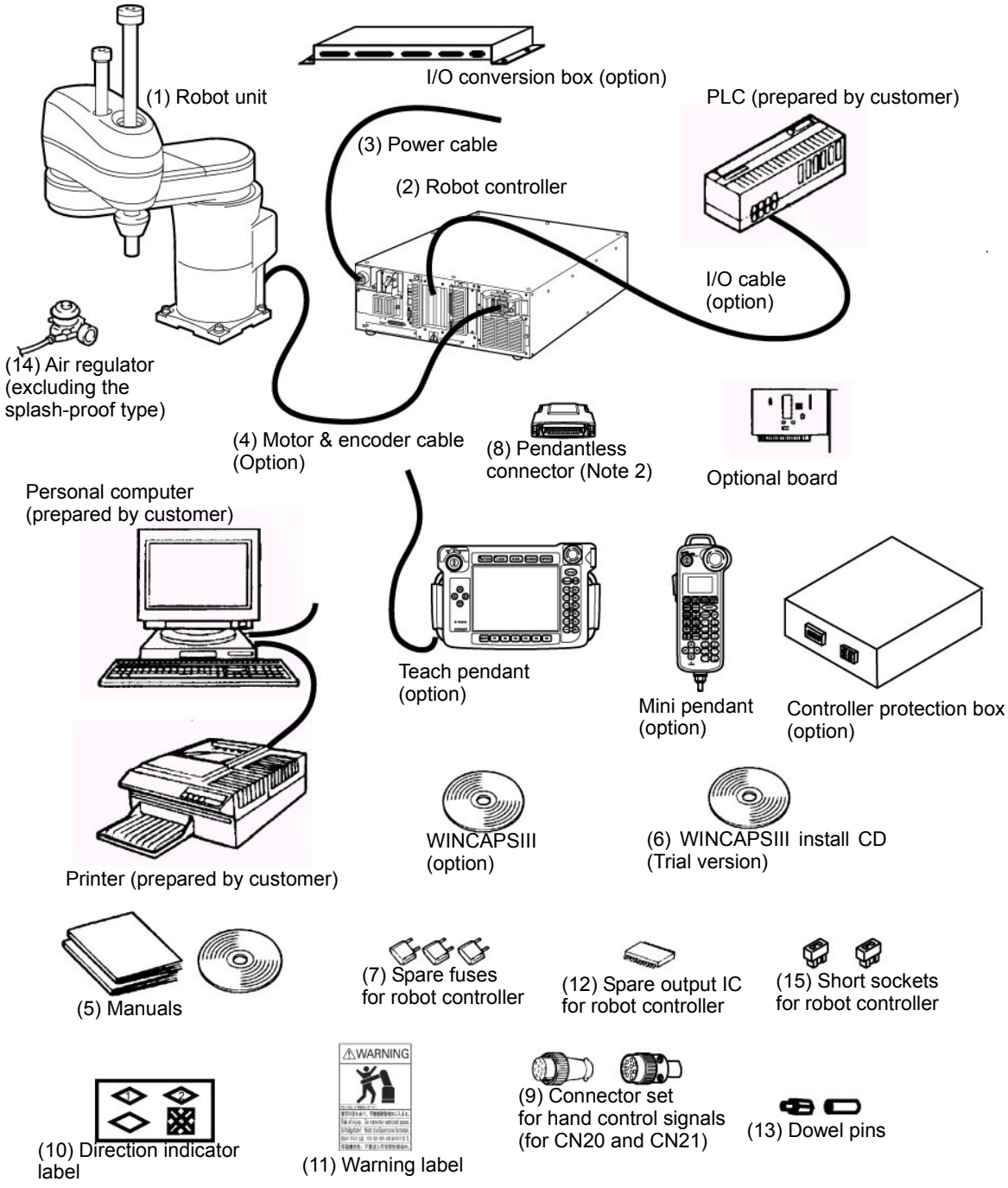
Part 1

Preparation for Installation

Chapter 1 Configuration of the Robot System

1.1 Configurators

The figure below shows configurators of the typical robot system.



Note 1: Items (1) to (16) are the standard components listed in Section 1.2.
Note 2: The pendantless connector should be attached to the robot controller connector when no teach pendant or mini-pendant is connected.
Note 3: The components illustrated above are typical models or parts.

Configurators of the Robot System

1.2 Standard Components

The components listed below are contained in the product package.

Standard Components

No.	Item	Q'ty	Applicable to:							
			HS series	HM series	XYC series	VP series	VS series	VH series	XR series	VS-*** series
(1)	Robot unit	1	√	√	√	√	√	√	√	√
(2)	Robot controller	1	√	√	√	√	√	√	√	√
(3)	Power cable (5 m)	1	√	√	√	√	√	√	√	√
(4)	Motor & encoder cable **(Note 1)** (Option)	1	√	√	√	√	√	√	√	√
(5)	Manuals ("Manual Pack CD" and "Safety Precautions")	1 set	√	√	√	√	√	√	√	√
(6)	WINCAPSIII INSTALL CD (TRIAL VERSION)	1	√	√	√	√	√	√	√	√
(7)	Spare fuses for robot controller (1.3A x 2 pcs, 3.2A x 1 pc)	3	√	√	√	√	√	√	√	√
(8)	Pendantless connector (Dummy connector) (not contained in UL-Listed robot systems)	1	√	√	√	√	√	√	√	√
(9)	Connector set for hand control signals (for CN20 and CN21)	1 set	√	√	√	√	√	√	√	option
(10)	Direction indicator label **(Note 2)**	1	√	√	√	√	√	√	√	√
(11)	Warning label **(Note 3)**	1	√	√	√	√	√	√	√	√
(12)	Spare output IC for robot controller	1	√	√	√	√	√	√	√	√
(13)	Dowel pins (internally threaded positioning pin and diamond-shaped pin)	1 set	√	√	--	√	√	--	--	√
(14)	Air regulator **(Note 4)**	1	--	√	√	--	--	--	--	--
(15)	Short sockets for robot controller	2	√	√	√	√	√	√	√	√

Note 1: Choose and order a motor & encoder cable from the table below. The 20-m motor & encoder cable (standard/splash-proof) is not available for controllers equipped with extended-joint options or UL-Listed robot units. The internal cable bending radius shall at least be 200 mm. Excessively bending will result in broken lead wires.

Robot series except XYC series and VS-* series**

Item		Part No.	Remarks
Standard cable	2 m	410141-4400	For standard type
Standard cable	4 m	410141-3611	
Standard cable	6 m	410141-3621	
Standard cable	12 m	410141-3631	
Standard cable	20 m	410141-4440	
Splash-proof cable	2 m	410141-4420	For dust- & splash-proof type and cleanroom type
Splash-proof cable	4 m	410141-3681	
Splash-proof cable	6 m	410141-3691	
Splash-proof cable	12 m	410141-3701	
Splash-proof cable	20 m	410141-4460	

XYC series

Item		Part No.
Standard cable	4 m	410149-0960
Standard cable	6 m	410149-0970

VS-* series (Note 5)**

Item	Part No.
Intrabody cable RC7-B 2m	410141-4560
Intrabody cable RC7-B 4m	410141-4570
Intrabody cable RC7-B 6m	410141-4580
Intrabody cable RC7-B 12m	410141-4590
Intrabody cable RC7-B 20m	410141-4600

Note 2: After installation, attach the direction indicator label in a position on the robot unit that can be easily seen.

Note 3: Attach the warning label on the robot safety fence or other location where workers will easily notice it. If necessary, prepare a plate for attaching the label.

Note 4: The dust- & splash-proof type has no Z-axis balance cylinder, so no air regulator comes with the robot.

Note 5: The internal cable bending radius of cables used to connect to the main unit of VS-*** series shall be at least 33.8 mm when the cables are fixed, and at least 225 mm when the cables are movable. Excessive bending will result in broken lead wires. In addition, the cable RC7-B 20 m to be connected to the main unit cannot be used for the controller with extended-joint option.

When placing an order for UL-Listed robot systems, be sure to order the optional teach pendant or mini-pendant also which is essential to UL-Listed ones.

1.3 Optional Components

The table below lists the optional components.

Optional Components (1)

Classification	No.	Item		Remarks		Part No.
I/O cables	1	Standard I/O cable set		(8 m) Incl. Nos. 1-1 and 1-2.		410149-0940
				(15 m) Incl. Nos. 1-1 and 1-2.		410149-0950
	1-1	I/O cable for "Mini I/O" (68 pins)		(8 m)		410141-2700
				(15 m)		410141-2710
	1-2	I/O cable for "HAND I/O"		(8 m)		410141-1740
				(15 m)		410141-1750
	2	I/O cable for "Parallel I/O board" (96 pins)		(8 m)		410141-3050
				(15 m)		410141-3060
	3	I/O cable for "SAFETY I/O" (36 pins) (Only for global type)		(8 m)		410141-3580
				(15 m)		410141-3590
Operation devices	4	Teach pendant		(4 m) With cable		410100-1572
				(8 m) With cable		410100-1582
				(12 m) With cable		410100-1592
	5	Mini-pendant kit (incl. cable and WINCAPSIII Light)		(4 m)	Japanese indication	410109-0392
					English indication	410109-0402
				(8 m)	Japanese indication	410109-0412
					English indication	410109-0422
				(12 m)	Japanese indication	410109-0432
					English indication	410109-0442
	6	Pendant extension cable		(4 m)	For TP, MP	410141-3711
				(8 m)	For TP, MP	410141-3721
Programming support tool	7	WINCAPSIII		CD-ROM (common to the languages-- Japanese, English, German, Korean, and Chinese)		410090-0980
Optional boards for RC7M controller	8	Parallel I/O board	Shipped as installed on the controller	NPN		410010-3320
				PNP		410010-3330
			Shipped as individual boards (supply part)	NPN		410010-3340
				PNP		410010-3350
	9	DeviceNet board	Shipped as installed on the controller	For Slave station		410010-3370
				For Master station		410010-3380
				For Master & slave station		410010-3390
			Shipped as individual boards (supply part)	For Slave station		410010-3400
				For Master station		410010-3410
				For Master & slave station		410010-3480
	10	CC-Link board		Shipped as installed on the controller		410010-3430
				Shipped as individual boards (supply part)		410010-3440
	11	Conveyor tracking board		Shipped as installed on the controller		410010-3460
				Shipped as individual boards (supply part)		410010-3470

Optional Components (2)

Classification	No.	Item	Remarks	Part No.
Optional functions (For customer-procured extended boards etc.)	12	Optional function for RS-232C board Board manufacturer: CONTEC CO., LTD. Model: COM-2P(PCI)H	Shipped after integrated in the controller	410006-0260
			Added when the board is purchased as a spare part	410006-0270
	13	Optional function for S-LINK V board Board manufacturer: SUNX CO., LTD. Model: SL-VPCI	Shipped after integrated in the controller	410006-0280
			Added when the board is purchased as a spare part	410006-0290
	14	Optional function for PROFIBUS-DP slave board Board manufacturer: Hilscher GmbH Model: CIF50-DPS\DENSO	Shipped after integrated in the controller	410006-0300
			Added when the board is purchased as a spare part	410006-0310
	15	EtherNet/IP function Board manufacturer: Hilscher GmbH Model: CIFX 50-RE\DENSO	Shipped after integrated in the controller	410006-0800
			Added when the board is purchased as a spare part	410006-0810
	16	Optional function for memory extension	Extension only upon controller shipment (Only program area expandable from 3.25 MB to 5.5 MB)	410006-0320
Optional box	17	Controller protection box		410181-0091
	18	I/O conversion box	For interchangeability with RC5 controller	410181-0100
CD Manuals	19	Manual Pack CD	Contained in the robot package.	410002-2661
Printed manuals (option)	20-a	Full set of instruction manuals for HS-G	Incl. Nos. C-a and D-a.	410009-0360
	20-b	Full set of instruction manuals for HM-G	Incl. Nos. C-b and D-b.	410009-0304
	20-c	Full set of instruction manuals for VP-G	Incl. Nos. C-c and D-c.	410009-0320
	20-d	Full set of instruction manuals for VS-G	Incl. Nos. C-d and D-d.	410009-0300
	20-e	Full set of instruction manuals for VM-G	Incl. Nos. C-e and D-e.	410009-0280
	20-f	Full set of instruction manuals for XYC-4G	Incl. Nos. C-f and D-f.	410009-0430
	20-g	Full set of instruction manuals for XR-G	Incl. Nos. C-g and D-g.	410009-0870
	C-a	Basic set of instruction manuals for HS-G	Incl. Nos. C-a-1, C-2 and C-3.	410009-0260
	C-b	Basic set of instruction manuals for HM-G	Incl. Nos. C-b-1, C-2 and C-3.	410009-0240
	C-c	Basic set of instruction manuals for VP-G	Incl. Nos. C-c-1, C-2 and C-3.	410009-0220
	C-d	Basic set of instruction manuals for VS-G	Incl. Nos. C-d-1, C-2 and C-3.	410009-0200
	C-e	Basic set of instruction manuals for VM-G	Incl. Nos. C-e-1, C-2 and C-3.	410009-0180
	C-f	Basic set of instruction manuals for XYC-4G	Incl. Nos. C-f-1, C-2 and C-3.	410009-0410
	C-g	Basic set of instruction manuals for XR-G	Incl. Nos. C-f-1, C-2 and C-3.	410009-0850
	C-a-1	GENERAL INFORMATION ABOUT ROBOT	For HS-G	410002-2610
	C-b-1	GENERAL INFORMATION ABOUT ROBOT	For HM-G	410002-2570
	C-c-1	GENERAL INFORMATION ABOUT ROBOT	For VP-G	410002-2530
	C-d-1	GENERAL INFORMATION ABOUT ROBOT	For VS-G	410002-2490
	C-e-1	GENERAL INFORMATION ABOUT ROBOT	For VM-G	410002-2450
	C-f-1	GENERAL INFORMATION ABOUT ROBOT	For XYC-4G	410002-2770
	C-g-1	GENERAL INFORMATION ABOUT ROBOT	For XR-G	410002-3210
	C-2	RC7M CONTROLLER MANUAL	For RC7M controller	410002-2430
	C-3	ERROR CODE TABLES		410002-3370
	D-a	Extension set of instruction manuals for HS-G	Incl. Nos. D-a-1, and D-2 to D-7.	410009-0140
	D-b	Extension set of instruction manuals for HM-G	Incl. Nos. D-b-1, and D-2 to D-7.	410009-0120
	D-c	Extension set of instruction manuals for VP-G	Incl. Nos. D-c-1, and D-2 to D-7.	410009-0100
	D-d	Extension set of instruction manuals for VS-G	Incl. Nos. D-d-1, and D-2 to D-7.	410009-0080
	D-e	Extension set of instruction manuals for VM-G	Incl. Nos. D-e-1, and D-2 to D-7.	410009-0060
	D-f	Extension set of instruction manuals for XYC-4G	Incl. Nos. D-f-1, and D-2 to D-7.	410009-0390
	D-g	Extension set of instruction manuals for XR-G	Incl. Nos. D-g-1, and D-2 to D-7.	410009-0830

Optional Components (3)

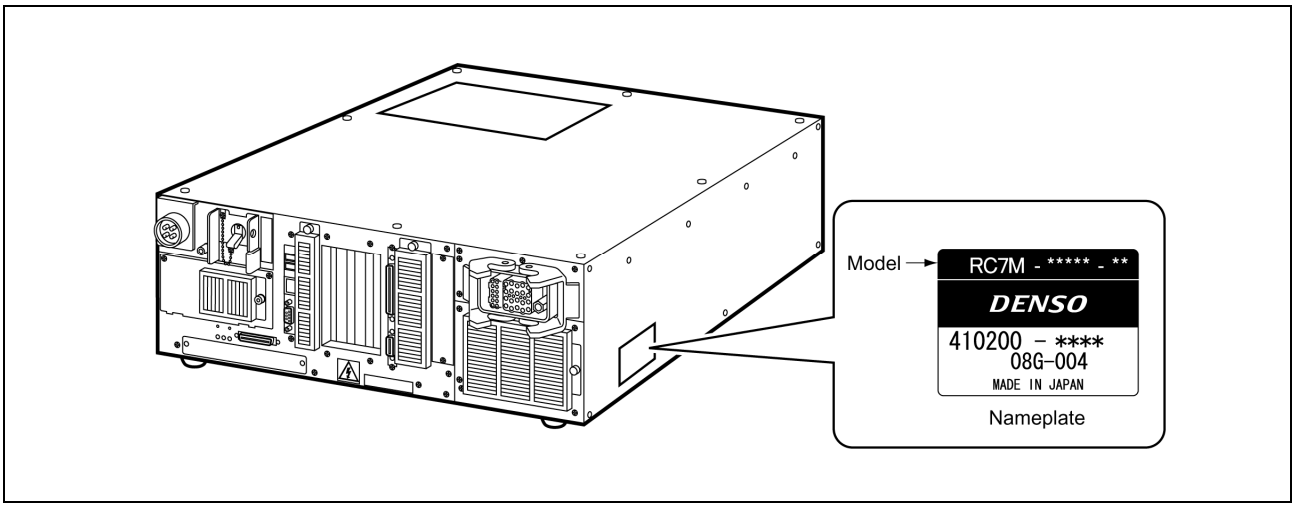
Classification	No.	Item	Remarks	Part No.
Printed manuals (option)	D-a-1	INSTALLATION & MAINTENANCE GUIDE	For HS-G	410002-2630
	D-b-1	INSTALLATION & MAINTENANCE GUIDE	For HM-G	410002-2590
	D-c-1	INSTALLATION & MAINTENANCE GUIDE	For VP-G	410002-2550
	D-d-1	INSTALLATION & MAINTENANCE GUIDE	For VS-G	410002-2510
	D-e-1	INSTALLATION & MAINTENANCE GUIDE	For VM-G	410002-2470
	D-f-1	INSTALLATION & MAINTENANCE GUIDE	For XYC-4G	410002-2790
	D-g-1	INSTALLATION & MAINTENANCE GUIDE	For XR-G	410002-3230
	D-2	STARTUP MANUAL		410002-2750
	D-3	SETTING-UP MANUAL		410002-3310
	D-4	PROGRAMMER'S MANUAL I		410002-3330
	D-5	PROGRAMMER'S MANUAL II		410002-3350
	D-6	Panel Designer USER'S MANUAL		410002-6480
	D-7	OPTIONS MANUAL	For RC7M controller	410002-2650
For robot unit	21-a	Flange kit (For HS)	For HS-G series	410329-0060
	21-b	Flange kit (For HM)	For 10 kg payload	410329-0070
			For 20 kg payload	410329-0080
Piping and wiring set for robot hand	21-g	Valve assembly (For XR-G)	Single shipment (supply part) 4-station manifold valve	410640-0230
	22-g	Valve assembly (For XR-G)	Robot mounting shipping 4-station manifold valve	410640-0330
	23-g	Cable kit for robot hand control (For XR-G)		410879-0470
	24-g	Cable kit for robot hand control (For XR-G)	2m	410870-3350
Optional stand	25	Full-range stand(For XR-G)		411759-0010
	26	Half-range stand(For XR-G)		411759-0020

Chapter 2
General Information about RC7M Controller

The RC7M controller is available in several models which differ in detailed specifications to match robot models.

2.1 Controller Model Name on Nameplate

The model name of the controller is printed on the nameplate attached to the rear side of the controller as shown below. The model name is coded as listed below.



Coding of RC7M Controller Model Name (G Type Robot)

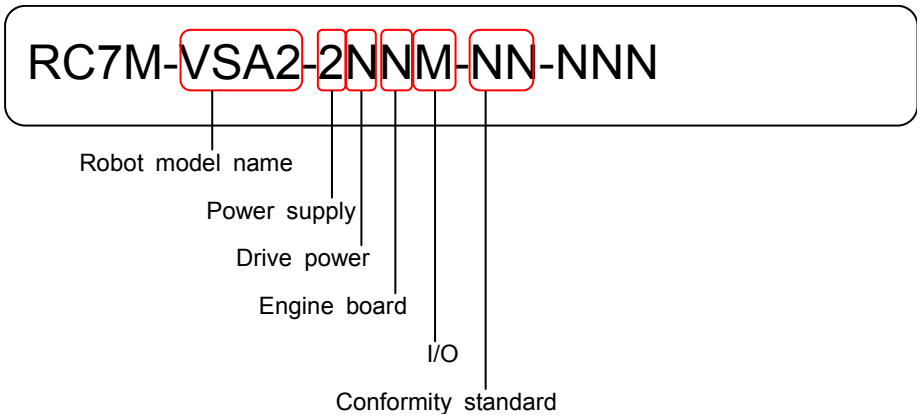
RC7M - VSG 6 B A _ - B P
(a) (b) (c) (d) (e) (f) (g)

Position	Code sample	Denotes:	Coding
(a)	VSG	Robot model name	VMG: VM-G series, VSG: VS-G series, VPG: VP-G series, HMG: HM-G series, HSG: HS-G series, XYCG: XYC-4G series , XRG: XR-G series
(b)	6	No. of controllable axes	4: 4 axes, 5/6: 5 or 6 axes, 6: 6 axes
(c)	B	Engineering symbol 1	A: Encoder A B: Encoder B C: Encoder C
(d)	A	Engineering symbol 2	A: 24V brake
(e)		Engineering symbol 3	Blank: 200 VAC power A: 100 VAC power
(f)	B	Controller type (Note)	Blank: Standard type B: Global type (with safety board) C: Global type (with safety box) D: Global type in UL-Listed robot system (with safety board) E: Global type in UL-Listed robot system (with safety box)
(g)	P	I/O type	Blank or N: NPN I/O P: PNP I/O

(Note) Regarding global type controllers, see "2.2 Differences between Global and Standard Types of Robot Controllers".

2.1.1 RC7M Robot Controller Model for VS-*** Series

Robot controller models are as follows.



Robot model name

VSA2	VS-068 / VS-087
VSA1	VS-050 / VS-060

Power supply

2	200V

Drive power

N	Standard

Engine board

N	Standard

I/O

M	Negative common (NPN)
P	Positive common (PNP)

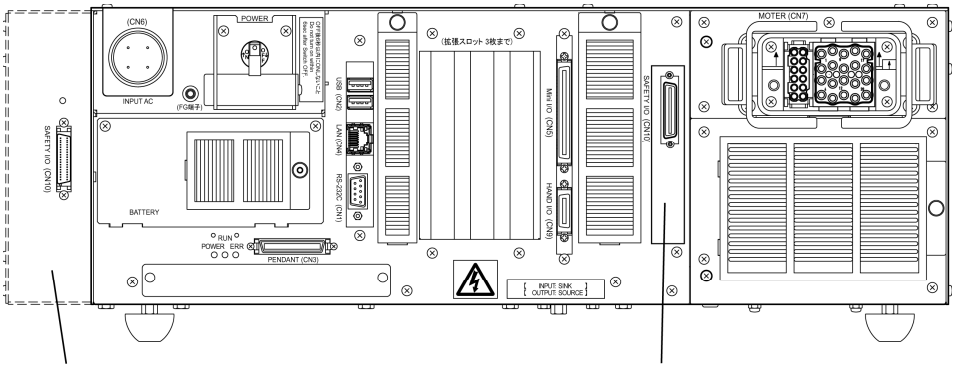
Conformity standards

NN	-
NB	CE (Safety category: 3, safety board attached) Note 1
NC	CE (Safety category: 4, safety box attached) Note 1
UB	CE, UL (Safety category: 3, safety board attached) Note 1
UC	CE, UL (Safety category: 4, safety box attached) Note 1

Note1: Global type controller

2.2 Differences between Global and Standard Types of Robot Controllers

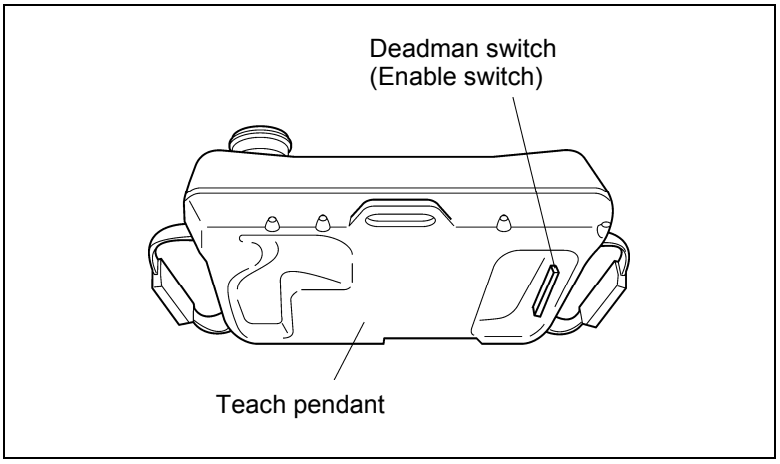
The global type of the robot controller has either a safety board or safety box which the standard type has not. Described below are the functional differences between the global and standard types.

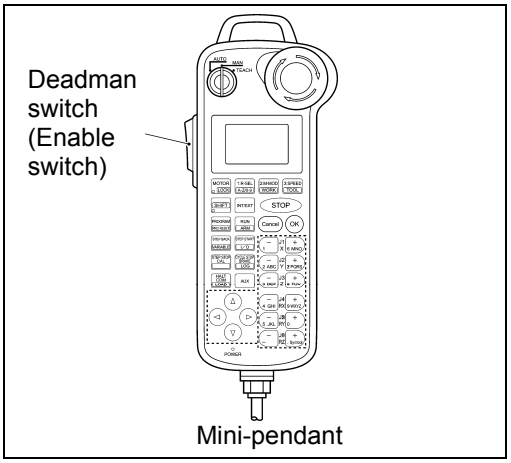


2.2.1 Deadman Switch Function (Enable Switch Function)

The global type controls the deadman switch provided on the teach pendant or mini-pendant in a partially different way than the standard type does. When reading the instruction manuals that are prepared for the standard type, be careful with the following differences.

(1) Location of deadman switches (enable switches) on the teach pendant and mini-pendant





(2) Difference in deadman switch operation

The table below lists the functional differences of the teach pendant and mini-pendant between the global and standard types in Manual mode and Teach check mode.

Global type	Standard type (described in the instruction manuals)
(1) Unless the deadman switch is held down, you can neither operate the robot nor turn the motor power ON.	(1) Unless the deadman switch is held down, you cannot operate the robot, but you can turn the motor power ON.
(2) When the robot is in operation, releasing the deadman switch will stop not only the robot but also turn the motor power OFF.	(2) When the robot is in operation, releasing the deadman switch will stop the robot but not turn the motor power OFF (servo lock).

2.2.2 "Single Point of Control" Function

The global type of the robot controller supports the "single point of control" function, while other types do not.

This function limits the robot-start that other equipments except specified one device (for example: Teach pendant) cannot enable to start the robot.

The "single point of control" function, which is one of the robot safety functions, limits the robot control sources (command sources) to only one. This function is specified by the parameter "Single point of control" that limits the control to either "Internal Auto" or "External Auto" limited mode.

■ Internal Auto limited mode

The "Auto mode" is limited to the "Internal Auto" limited mode in which a program start can be triggered from the teach pendant, but cannot from external equipment.

■ External Auto limited mode

The "Auto mode" is limited to the "External Auto" limited mode in which a program start can be triggered from external equipment, but cannot from the teach pendant.

Note: In this mode, the teach pendant operation panel editor "Panel Designer" cannot be used in External Auto.

Setting the Internal/External Auto Limited Mode Parameters

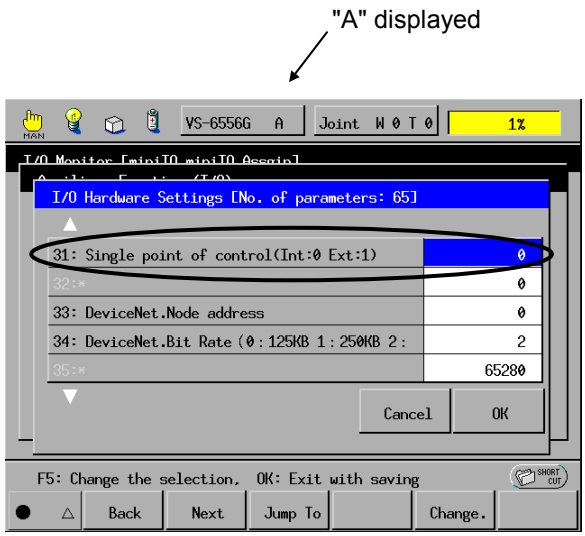
Using the teach pendant, set the parameters with the following access.

Note 1: The "External Auto Limited Mode" is the factory default.

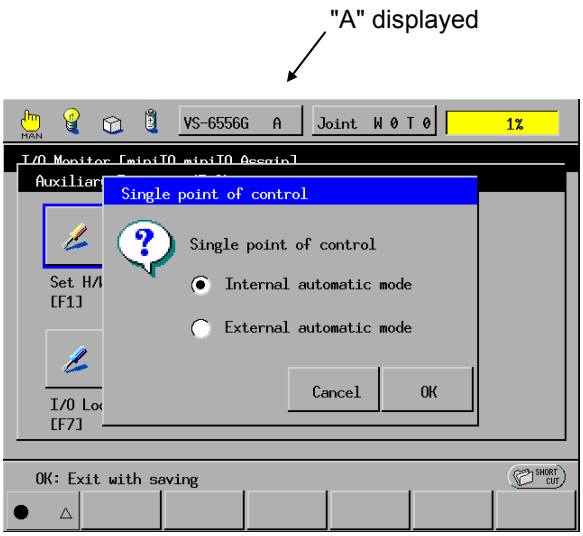
Note 2: The global type displays letter "A" following the robot type on the teach pendant screen.

Access: [Top screen]—[F4 I/O]—[F6 Aux.]—[F1 Set H/W]—[F3 Jump To]—"31"

In Ver. 2.3 or later:
Access: [Top screen]—[F4 I/O]—[F6 Aux.]—[F4 Int/Ext]



Setting on the "I/O Hardware Settings" window



Setting on the "Single point of control" window (Ver. 2.3 or later)

Chapter 3
General Information about the Interface

3.1 Types and General Information about Mini I/O Signals

This section describes the I/O signals on the robot controller.

The I/O signals are grouped into two--user I/O signals and system I/O ones.

If no optional I/O extension board is mounted, the controller handles I/O signals in the mini I/O dedicated mode via the mini I/O connector (CN5) and the HAND I/O connector (CN9).

3.1.1 Types of Mini I/O Signals on the Standard Type of Controller

Seven input points for command execution are used to direct program start and other instructions as I/O commands.

The table below lists the types of system I/O signals.

Types of I/O Signals (Standard type of controller)

Fixed by system		
Type	**No. of points**	**Function**
System input	4	*External Emergency Stop 1*, *External Emergency Stop 2*, *Enable Auto*, *Step Stop (All tasks)*
System output	13 (Note)	*Auto Mode*, *Robot Initialized*, *Robot Running*, *CPU Normal,* *Robot Error*, *Operation Preparation Completed*, *Battery Warning*, *Emergency Stop 1*, *Emergency Stop 2*, *Deadman SW 1* [*Enable SW 1*], *Deadman SW 2* [*Enable SW 2*], *Pendant Emergency Stop 1*, *Pendant Emergency Stop 2*, *Continue Start Permission* (selectable by I/O hardware setting) (See Note below.)
Input for command execution	7	Command (3 bits), data area (3 bits), and *Strobe Signal*
Output for command execution	1	*Command Processing Completed*
Controlled by user program		
Type	**No. of points**	**Function**
User input	8	Inputs to read the external I/O status with an IN command or IO [ ] variable. Used for analysis condition identification, condition satisfaction wait, data input from the external equipment, etc.
User output	8 (Note)	Outputs to issue a signal to the external equipment during program execution with SET and RESET commands, etc.
HAND input	8	Inputs to read the external I/O status with an IN command or IO [ ] variable. Used for checking the hand status.
HAND output	8	Outputs to issue signals to the external equipment with SET and RESET commands, etc. Used for controlling the hand to open or close.

Note: Terminal #53 on CN5 (port 24) is assigned a user output by factory default. It can be assigned the *Continue Start Permission* output signal with the I/O hardware setting.

3.1.2 Types of Mini I/O Signals on the Global Type of Controller

The global type of the controller concentrates emergency stop related system I/Os on the safety I/O (CN10), so it does not use the Mini I/O (CN5). (Refer to the RC7M CONTROLLER MANUAL, Sections 4.1.3, 4.1.4, 5.1.3, and 5.1.4.)

It issues PROGRAM START commands as I/O commands by using seven command execution inputs.

The table below lists the types of system I/O signals.

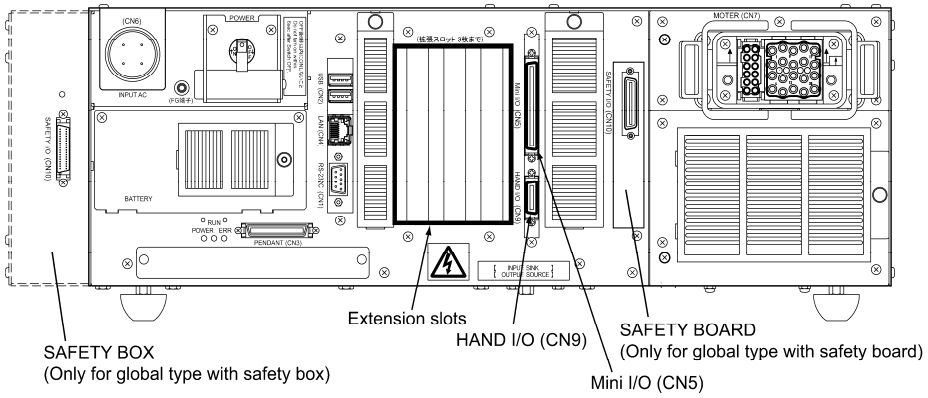
Types of I/O Signals (Global type of controller)

Fixed by system		
Type	**No. of points**	**Function**
System input	7	*External Emergency Stop 1*, *External Emergency Stop 2*, *Enable Auto 1*, *Enable Auto 2*, *Step Stop (All tasks)*, *Protective Stop 1*, *Protective Stop 2*
System output	12 (Note)	*Auto Mode*, *Robot Initialized*, *Robot Running*, *CPU Normal*, *Robot Error*, *Operation Preparation Completed*, *Battery Warning*, *Pendant Emergency Stop 1*, *Pendant Emergency Stop 2*, *Deadman SW 1* [*Enable SW 1*], *Deadman SW 2* [*Enable SW 2*], *Contactor Contact Monitor*, *Continue Start Permission* (selectable by I/O hardware setting) (Note)
Input for command execution	7	Command (3 bits), data area (3 bits), and *Strobe Signal*
Output for command execution	1	*Command Processing Completed*
Controlled by user program		
Type	**No. of points**	**Function**
User input	8	Inputs to read the external I/O status with an IN command or IO [ ] variable. Used for analysis condition identification, condition satisfaction wait, data input from the external equipment, etc.
User output	7 (Note)	Outputs to issue a signal to the external equipment during program execution with SET and RESET commands, etc.
HAND input	8	Inputs to read the external I/O status with an IN command or IO [ ] variable. Used for checking the hand status.
HAND output	8	Outputs to issue signals to the external equipment with SET and RESET commands, etc. Used for controlling the hand to open or close.

Note: Terminal #53 on CN5 (port 24) is assigned a user output by factory default. It can be assigned the *Continue Start Permission* output signal with the I/O hardware setting.

3.2 Overview of I/O Extension Boards

If you need I/O signal lines more than the ones provided on the Mini I/O port (CN5) and HAND I/O port (CN9) or if you want to control the robot in any of the various field networks, add up to two I/O extension boards to the extension slots (there are three slots) in the controller as shown below.



3.2.1 I/O Extension Boards Available

The robot controller is available with I/O extension boards optionally provided by Denso Wave and recommended commercial ones as listed below.

Note: For the repeat system in the RC5 controller, an optional "I/O conversion box" is convenient to use. Refer to the OPTIONS MANUAL, Section 4.7 "I/O Conversion Box."

(1) Denso Wave I/O Extension Boards (option)

	Board name	Part number	
		Board built in the controller	Board as a spare part
Place an order with Denso Wave.	Parallel I/O board (NPN type)	410010-3320	410010-3340
	Parallel I/O board (PNP type)	410010-3330	410010-3350
	DeviceNet slave board	410010-3370	410010-3400
	DeviceNet master board	410010-3380	410010-3410
	DeviceNet master/slave board	410010-3390	410010-3480
	CC-Link board	410010-3430	410010-3440

(2) Commercial I/O Extension Boards (recommended)

	Board name	Manufacturer (Model)	Part number of license certificate for permitting the configuration software to run	
			Permitted at the factory	To be permitted by the user
Prepare on the user's responsibility.	PROFIBUS-DP slave board	Hilscher GmbH (CIF50-DPS\DENSO)	410006-0300	410006-0310
	S-LINK V board	SUNX (SL-VPCI)	410006-0280	410006-0290
	RS-232C extension board	CONTEC (COM-2P(PCI)H)	410006-0260	410006-0270
	Ethernet/IP adapter board	Hilscher GmbH (CIF50-DPS\DENSO)	410006-0800	410006-0810

3.3 Combination of I/O Extension Boards and Allocation Mode

Up to two I/O extension boards can be mounted on the controller. There are no restrictions on the choice of extension slots or the mounting order.

The table below lists the permitted combination of I/O extension boards and selectable allocation mode.

Combination of I/O Extension Boards

No.	I/O extension boards (Max. 2 boards per controller)			Allocation modes			
	Extension 1	Extension 2	Extension 3	Mini I/O dedicated	Allocated to Extension 1		All user I/O
					Compatible	Standard	
0	-	-	-	√			
1	-	S-Link V board	-	√			√
2	-	DeviceNet master board	-				√
3	-	DeviceNet master board	Parallel I/O board				√
4	-	DeviceNet master board	S-Link V board				√
5	Parallel I/O board	-	-	√	√	√	
6	Parallel I/O board	Parallel I/O board	-	√	√	√	
7	Parallel I/O board	S-Link V board	-	√	√	√	√
8	DeviceNet slave board	-	-		√	√	
9	DeviceNet slave board	Parallel I/O board	-		√	√	
10	DeviceNet slave board	S-Link V board	-		√	√	√
11	DeviceNet master/slave board	-	-		√	√	√
12	DeviceNet master/slave board	Parallel I/O board	-		√	√	√
13	DeviceNet master/slave board	S-Link V board	-		√	√	√
14	CC-Link board	-	-		√	√	
15	CC-Link board	Parallel I/O board	-		√	√	
16	CC-Link board	DeviceNet master board	-		√	√	√
17	CC-Link board	S-Link V board	-		√	√	√
18	PROFIBUS-DP slave board	-	-		√	√	
19	PROFIBUS-DP slave board	Parallel I/O board	-		√	√	
20	PROFIBUS-DP slave board	DeviceNet master board	-		√	√	√
21	PROFIBUS-DP slave board	S-Link V board	-		√	√	√
22	Ethernet/IP adapter board	-	-		√	√	
23	Ethernet/IP adapter board	Parallel I/O board	-		√	√	
24	Ethernet/IP adapter board	DeviceNet master board	-		√	√	√
25	Ethernet/IP adapter board	S-Link V board	-		√	√	√

Note 1: Only one mode can be selected from among check-marked modes in the "Application modes" column.

Note 2: Up to two I/O extension boards can be mounted on the controller. There are no restrictions on the choice of extension slots or the mounting order.

Note 3: When two parallel I/O boards are mounted, the controller recognizes the board inserted in the left-hand extension slot as Extension 1. The allocation I/O port numbers on Extension 1 and 2 boards differ with each other.

3.3.1 I/O Allocation in Individual Allocation Modes

The table below lists the I/O allocation for extension boards in individual allocation modes. For details, refer to Section 13.6 "I/O Allocation Tables."

Note: For the I/O allocation for the DeviceNet master/slave board, see the allocation tables for the DeviceNet master and slave boards.

I/O Allocation of Extension Boards in Individual Allocation Modes

Allocation modes	Allocation for CN5 and extension boards	
	I/O	Allocation tables to apply
Mini I/O dedicated mode	CN5	Tables for mini I/O board in mini I/O dedicated mode
	Extensions 1, 2, 3	Tables for extension boards in all user I/O mode
Compatible mode	CN5	Tables for mini I/O board in compatible, standard and all user I/O modes
	Extension 1	Tables for extension boards in compatible mode
	Extensions 2, 3	Tables for extension boards in all user I/O mode
Standard mode	CN5	Tables for mini I/O boards in compatible, standard and all user I/O modes
	Extension 1	Tables for extension boards in standard mode
	Extensions 2, 3	Tables for extension boards in all user I/O mode
All user I/O mode	CN5	Tables for mini I/O board in compatible, standard and all user I/O modes
	Extensions 1, 2, 3	Tables for extension boards in all user I/O mode
Note: Extensions 1, 2, and 3 correspond to the ones listed in the "Combination of I/O Extension Boards" table on the previous page.		

3.3.2 Functions in Individual Allocation Modes

Functions of I/O signals differ depending on the allocation modes, as shown in the table below.

Functions in Individual Allocation Modes

Allocation mode	General description
Mini I/O dedicated	Combination of bits commands operations. Some functions are deleted from the ones provided in Standard allocation. Mini I/O system allocation is allocated to the Mini I/O area. When an I/O option board is attached, only the user signal is allocated to the I/O option board area.
Compatible	Functions, such as program activation, are specified by each bit. Operations are directed by the bit being set. "Compatible" system allocation is allocated to the I/O extension board area. Only the user signal (excluding CPU Normal) is allocated to all ports of the Mini I/O area.
Standard	Directs program activation, etc. with a combination of bits (I/O command.) This allocation has the greatest number of functions. "Standard" system allocation is allocated to the I/O extension board area. Only the user signal (excluding CPU Normal) is allocated to all ports of the Mini I/O area.
All user I/O	Only the user signal is allocated to the I/O extension board area. Only the user signal (excluding CPU Normal) is allocated to all ports of the Mini I/O area.

3.4 Mini I/O Functions in Compatible, Standard, or All User I/O Mode

When any of the I/O allocation modes (compatible, standard, or all user I/O) except the mini I/O dedicated mode is selected, all of the ports (except *CPU Normal*) occupied by the system I/O signals in the mini I/O dedicated mode will be released and used as user I/O ports as shown below.

- System input ports #0 to #7 (Terminals #11 to #18 on CN5) will be used as user input ports.
- System output ports #17 to #23 (Terminals #46 to #52 on CN5) will be used as user output ports.

Note: The system output signal *CPU Normal* remains assigned to port #16 (Terminal #45 on CN5) even in the compatible, standard, or all user I/O mode.

3.5 Requirements for Interface Setting

3.5.1 Configuring the I/O Allocation Mode Parameter

To switch between the mini I/O dedicated, compatible, standard, and all user I/O modes, you need to change the I/O allocation mode parameter using the teach pendant or WINCAPSIII.

For the changing procedure, refer to the, Section 3.6 "Configuring the I/O Allocation Mode Parameter."

Note: If the controller has an I/O extension board that can be used in the compatible or standard mode as a factory option, the default is the standard mode.

3.5.2 Setting up the I/O Power Source (+24 VDC)

The mini I/O board (CN5) and parallel I/O board (option) can select the power source (+24 VDC) from internal and external power supplies by changing the jumper switch setting.

For the jumper switch changing procedure, see Section 3.7 "Setting up Mini I/O Power Source" and Section 3.8 "Setting up Parallel I/O Board Power Source."

Note: The factory default is an external power supply.

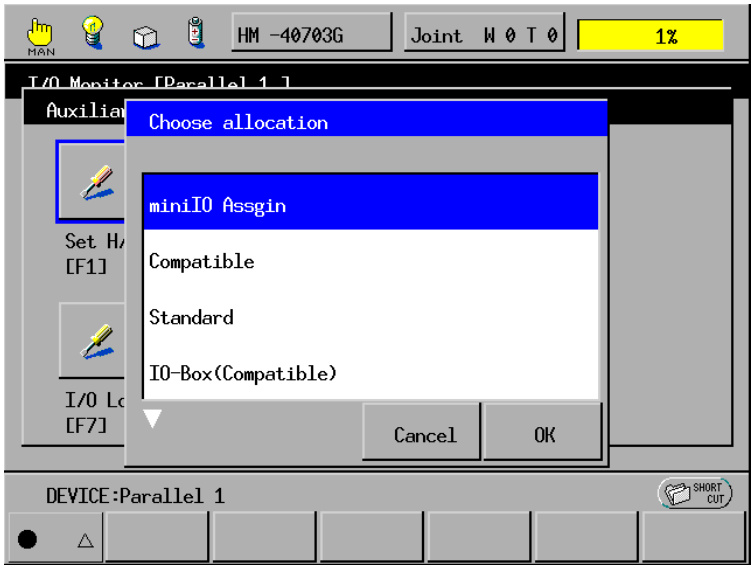
3.6 Configuring the I/O Allocation Mode Parameter

3.6.1 With Teaching Pendant

Access: [F4 I/O]—[F6 Aux.]—[F2 AlocMode]

Mount the floppy disk drive into the robot controller according to the following procedure:

After completing the above operations, use the cursor keys or jog dial to select one of the allocations and then press OK. Restart the robot controller to make the new settings take effect.

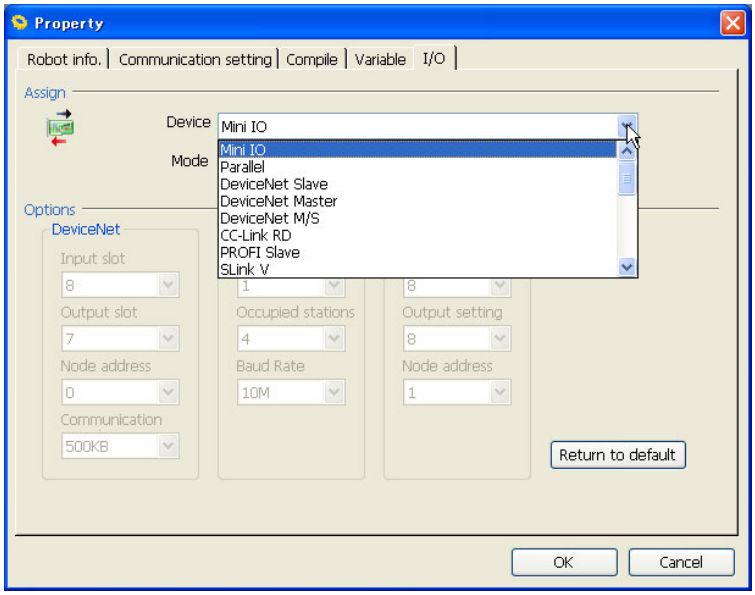


3.6.2 Method for setting from WINCAPSIII

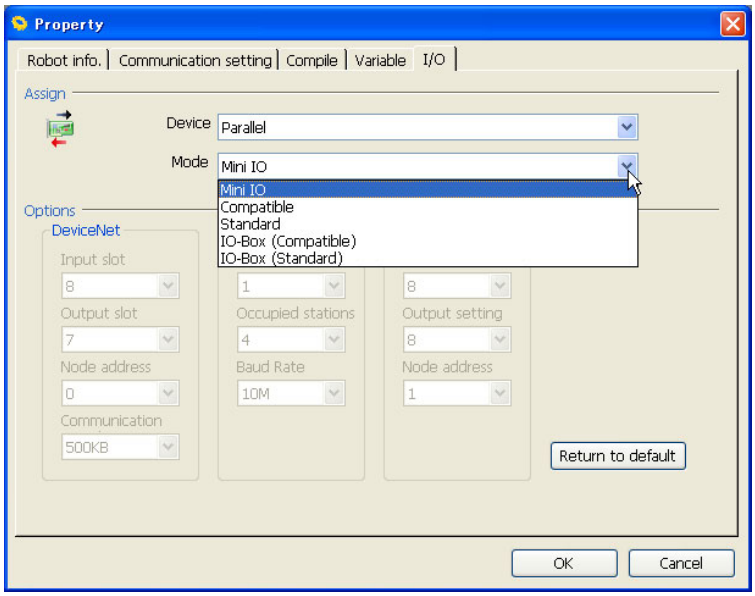
(1) Choose Project | Property to display the Property window.Choose the I/O tab.

(2) In the Assign area, pull down the Device menu and select the desired I/O extension board.

Note: Do not select an I/O extension board not mounted. Doing so and transferring assignment data to the controller results in an error when the controller is restarted after reception of the data.

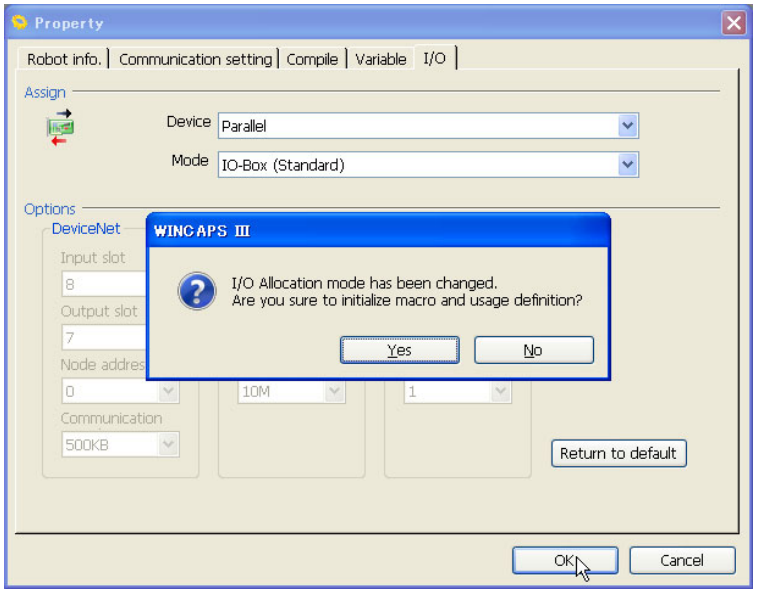


(3) Pull down the Mode menu and select the desired assignment.

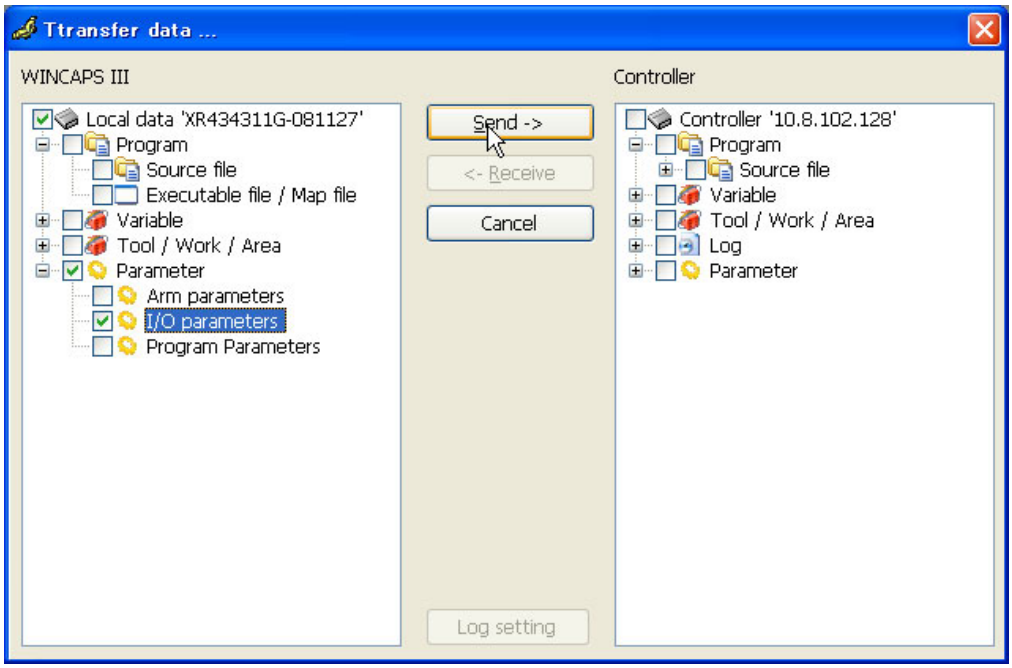


(4) In the window above, press OK, and the following message appears.

In the dialog box below, press Yes if there is no problem with initialization of macro and usage definition; press No if there is a problem. Pressing either one changes the allocation.

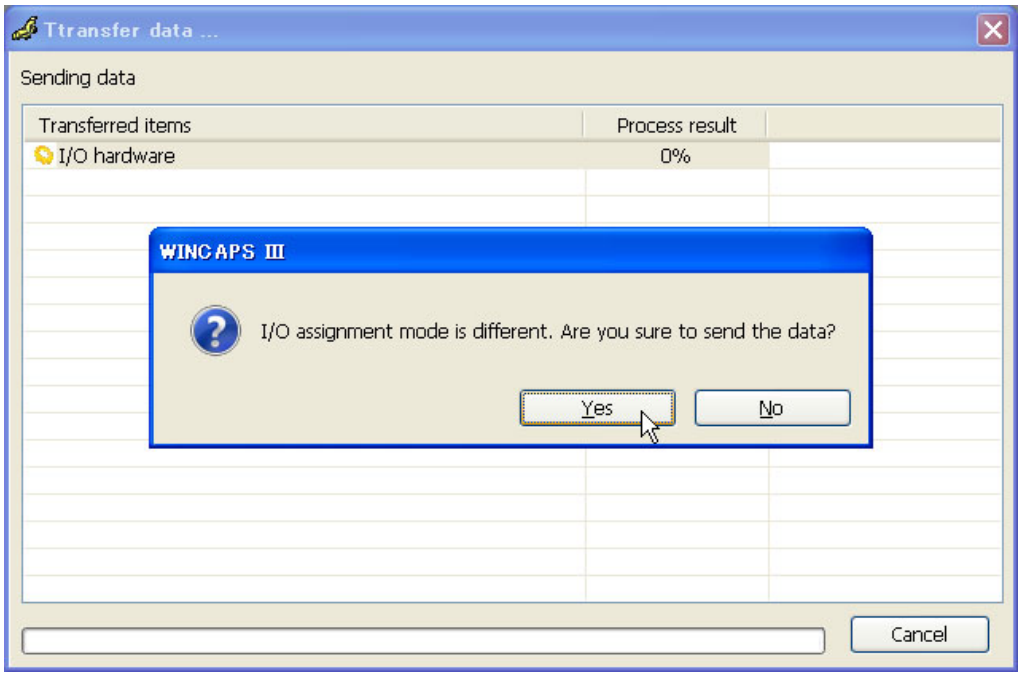


(5) Choose Connect | Transfer data to display the bidirectional transfer dialog box. Select I/O parameters in WINCAPSIII and press Send to transfer I/O assignment from WINCAPSIII to the robot controller.



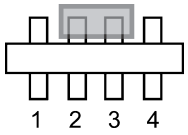
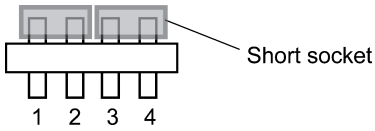
(6) As shown below, the two confirmation messages (for data updating and I/O assignment mode) appear. Press Yes in both dialog boxes to transfer data to the controller.

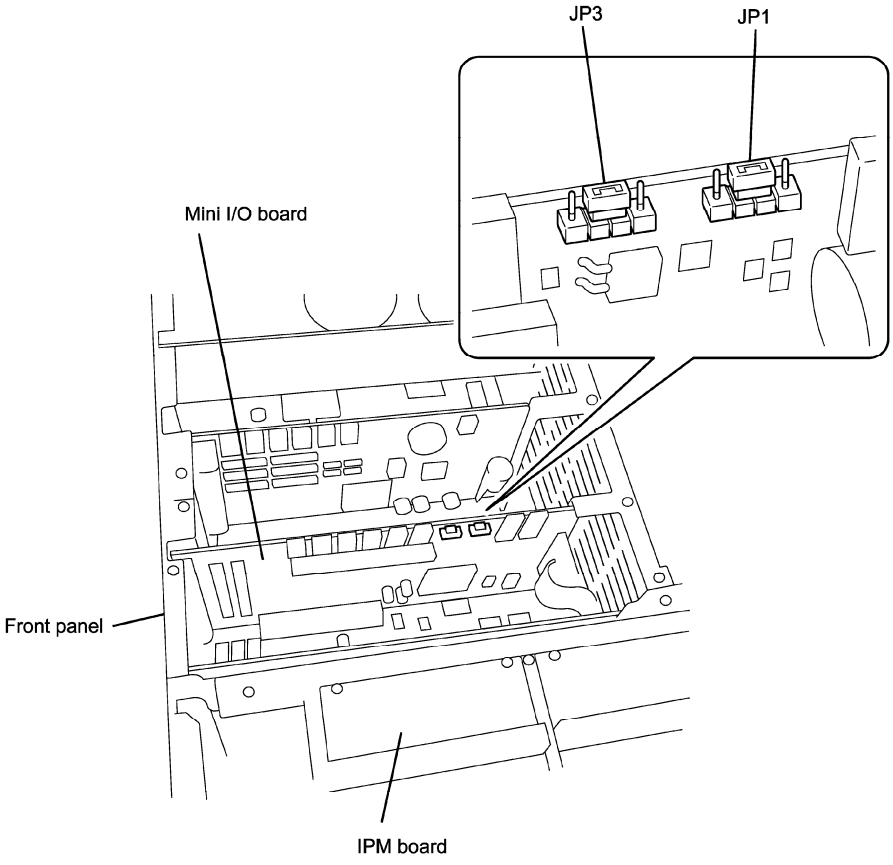
The data transferred takes effect when the controller is restarted.



3.7 Setting Up Mini I/O Power Source

The power source (+24 VDC) for the Mini I/O can be switched between internal and external power supplies by changing the jumper switch setting as listed below. The factory default is an external power supply.

Power supply for I/O	Jumper switches JP1 and JP3 on the controller printed circuit board		Description
External source	Short-circuit pins 2 and 3 (factory default)		Do not change the factory default setting.
Internal source	Short-circuit pins 1 and 2, and pins 3 and 4		Remove the controller top cover and change the JP1 and JP3 settings with short sockets that come with the robot.

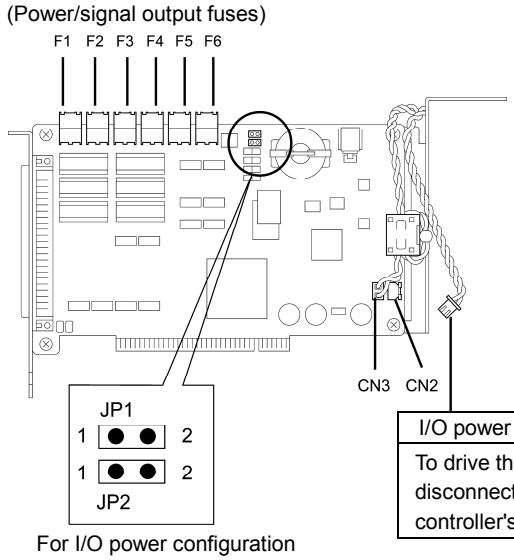


Note: Switching the power supply setting for I/O from external to internal changes the assignment to terminals #32 to #34 and #66 to #68 on CN5 from external DC power input to internal DC power output.

3.8 Setting up Parallel I/O Board Power Source

The power source (+24 VDC) for the parallel I/O board can be switched between internal and external power supplies. The factory default is an external power supply.

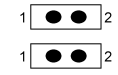
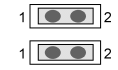
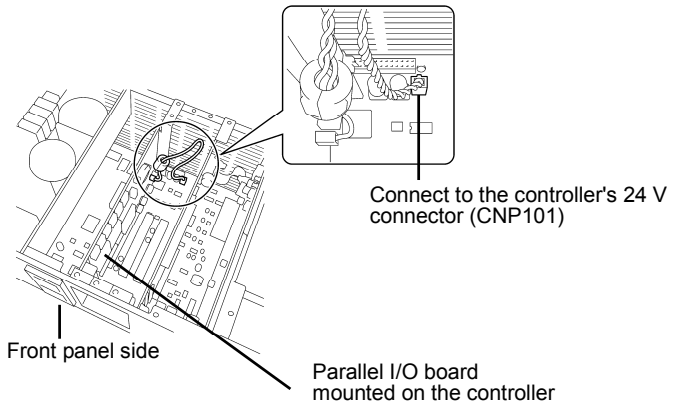
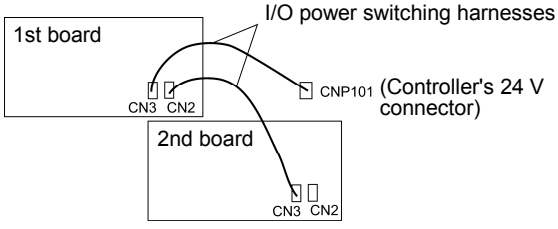
The names of components on the parallel I/O board are shown below.



For I/O power configuration

Note: Fuse F3 is not mounted on the NPN type.

I/O power switching harness
To drive this board with internal power supply, disconnect this harness from CN2 and connect it to the controller's 24 V connector.

I/O power supply settings	P1 and JP2 settings	Setting method
External power supply	 JP1, JP2 (Open)	Use the board under the factory default settings (both JP1 and JP2 are open).
Internal power supply	 JP1, JP2 (Short-circuit)	(1) Short-circuit pin 1 to 2 on each of JP1 and JP2 using a short socket. (2) Disconnect the I/O power switching harness from CN2 on the parallel I/O board and connect it to 24 V connector (CNP101) on the controller's printed circuit board.  (3) When mounting two parallel I/O boards and driving them with internal power supply, connect the I/O power switching harness of the 2nd board to CN2 on the 1st board. 

(Note) Check that the controller's power is turned OFF before setting.

3.9 I/O Port Map and Allocation

When an I/O extension board is not used, I/O port numbers (the number specified when I/O is processed with PAC program or I/O command) go up to 511. However, when an I/O extension board is used, I/O port numbers beyond 511 are added.

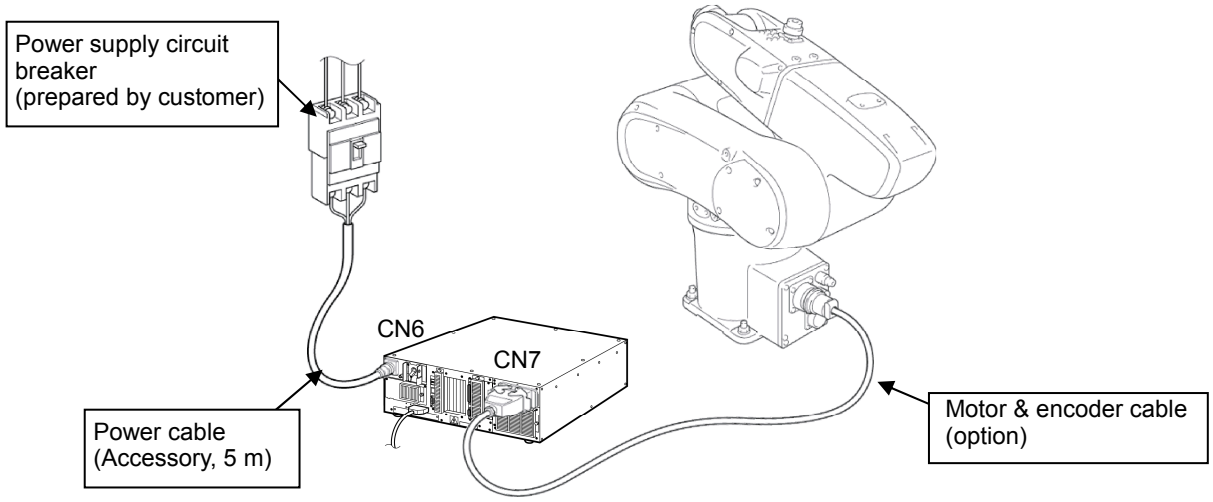
I/O Port Mapping and Allocation

I/O port number	Allocation	
0 to 15	Mini I/O input	Standard area
16 to 30	Mini I/O output	
32 to 47	Not used.	
48 to 55	Input by hand	
56 to 63	Not used.	
64 to 71	Output by hand	
72 to 127	Not used.	
128 to 511	Internal I/O	
512 to 767	DeviceNet slave board input CC-Link input PROFIBUS-DP slave input Ethernet/IP adapter input	I/O extension board area
768 to 1023	DeviceNet slave board output CC-Link output PROFIBUS-DP slave output Ethernet/IP adapter output	
1024 to 2047	DeviceNet master board input	
2048 to 3071	DeviceNet master board output	
3072 to 3327	S-Link V input	
3328 to 3583	S-Link V output	
3584 to 3623	(1st) Parallel I/O board input	
3624 to 3663	(2nd) Parallel I/O board input	
3664 to 3839	Not used.	
3840 to 3887	(1st) Parallel I/O board output	
3888 to 3935	(2nd) Parallel I/O board output	
3936 to 4095	Not used.	
4096 to 4351	CC-Link remote register RWw input	
4352 to 4607	Not used.	
4608 to 4863	CC-Link remote register RWr output	
4096 to 7871	Ethernet/IP adapter input	
7872 to 11647	Ethernet/IP adapter output	

Chapter 4
Connecting Cables

4.1 Connecting the Power Cable and Motor & Encoder Cable

Use the power cable (5 m) that comes with the robot system as standard for supplying power to the controller. Connect the robot unit to the controller using an optional motor & encoder cable (selectable from 2 m, 4 m, 6 m, 12 m or 20 m).



Note: The internal cable bending radius of the motor & encoder cable shall at least be 200 mm. Excessively bending will result in broken lead wires.

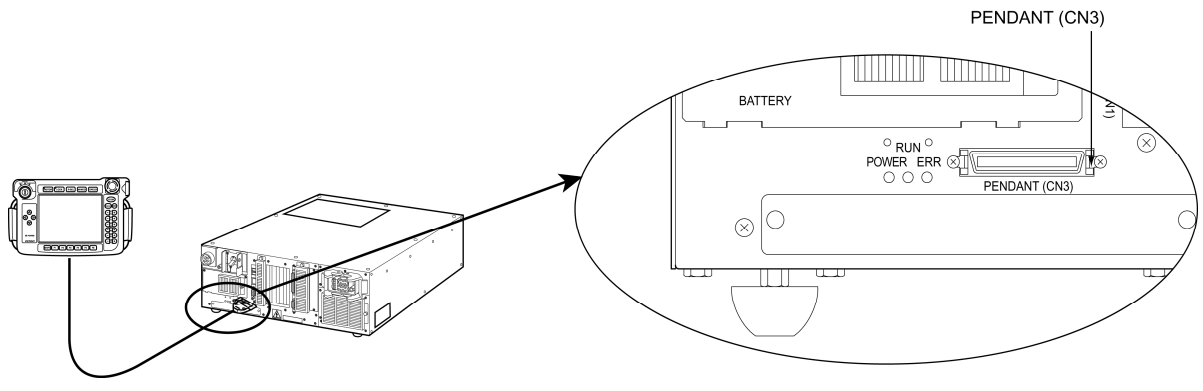
4.2 Connecting the Teach Pendant

Connect the teach pendant to the PENDANT connector (CN3) on the robot controller.

Cautions in connecting the pendant cable to the controller:

(1) After connecting the pendant cable, do not apply pressure on the connector in either direction. Such pressure may cause a communications error.

(2) When disconnecting the cable, unlock the connector and pull out the cable straight without twisting it.



Connecting the Teach Pendant

4.3 Power Supply Circuit Breaker (Recommendation)

Observe the following precautions when wiring the primary power source of the robot controller:

(1) Connect the robot power cable to a power source separate from the welder power source.

(2) Ground the protective grounding wire (green/yellow) of the robot power cable.

(3) Ground the functional grounding terminal of the robot controller using a wire of 1.25 mm^2 or more in size.

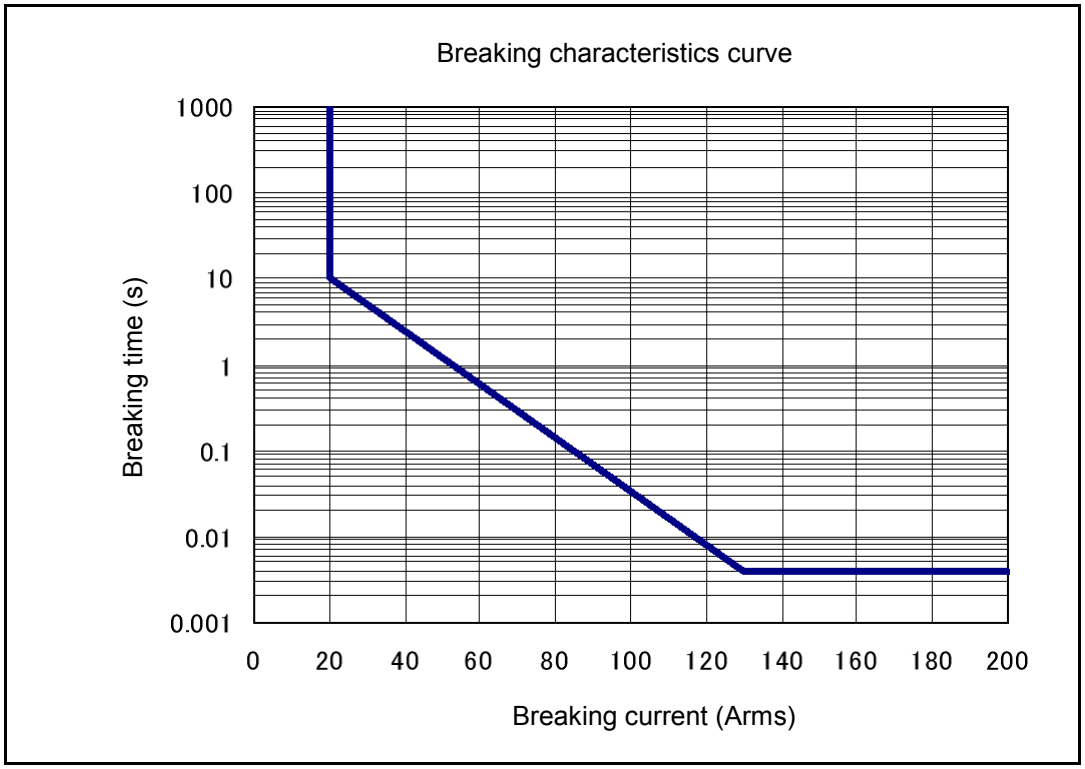
(4) For the robot power supply, use a protective grounding wire with grounding resistance of 100Ω or less.

(5) If the supply power source for the robot controller requires a leakage breaker, use a high frequency-proof leakage breaker for inverters.

(6) When inserting a circuit breaker between the robot and the AC input power supply, select the circuit breaker with breaking capacity higher than the following specification.

Recommended circuit breaker example: CP33V/20 (Fuji Electric FA Components & Systems Co., Ltd.)

Caution: Using a circuit breaker with breaking capacity lower than the following specification may cause the circuit breaker to be shut down due to robot operation.



Circuit Breaker Characteristics

4.4 Wiring of Primary Power Source

Observe the following precautions when wiring the primary power source of the robot controller:

(1) Connect the robot power cable to a power source separate from the welder power source.

(2) Ground the protective grounding wire (green/yellow) of the robot power cable.

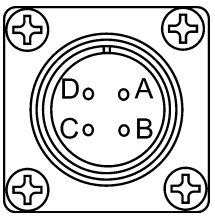
(3) Ground the functional grounding terminal of the robot controller using a wire of 1.25 mm^2 or more in size.

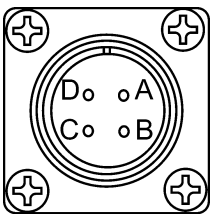
(4) For the robot power supply, use a protective grounding wire with grounding resistance of 100Ω or less.

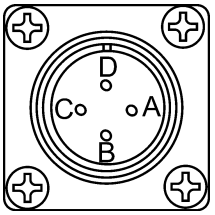
(5) If the supply power source for the robot controller requires a leakage breaker, use a high frequency-proof leakage breaker for inverters.

(6) Prepare power cables of proper capacity according to the tables given below.

Robot Controller Power Supply Specifications

<table>
<tr><th colspan="2">Item</th><th colspan="2">Specifications</th><th>Pin assignment on power connector (CN6) (View from the pin face of cable)</th></tr>
<tr><td rowspan="11">Power supply</td><td>Three-phase, 200 VAC</td><td colspan="2">Three-phase, 200 VAC -15% to 230 VAC +10%, 50/60 Hz</td><td rowspan="6"> 

A: 200 VAC, phase R
B: 200 VAC, phase S
C: 200 VAC, phase T
D: Protective ground</td></tr>
<tr><td rowspan="5">Power supply capacity</td><td>VMG6BA: 3.3 kVA</td><td>VSG6BA: 1.85 kVA</td></tr>
<tr><td>VPG5/6CA: 1 kVA</td><td>HMG4BA: 2.45 kVA</td></tr>
<tr><td>HSG4BA: 1.8 kVA</td><td>XYCG4AA: 1.15 kVA</td></tr>
<tr><td>XRG4BA : 1.8kVA</td><td>VS-050/060: 1.15 kVA</td></tr>
<tr><td></td><td>VS-068/087: 2.78 kVA</td></tr>
<tr><td>Single-phase, 200 VAC</td><td colspan="2">Single-phase, 230 VAC -10% to 230 VAC +10%, 50/60 Hz</td><td rowspan="5"> 

A: 200 VAC, phase R
B: 200 VAC, phase S
D: Protective ground</td></tr>
<tr><td rowspan="4">Power supply capacity</td><td></td><td>VSG6BA: 1.85 kVA</td></tr>
<tr><td>VPG5/6CA: 1 kVA</td><td>HMG4BA: 2.45 kVA</td></tr>
<tr><td>HSG4BA: 1.8 kVA</td><td>XYCG4AA: 1.15 kVA</td></tr>
<tr><td>XRG4BA: 1.8 kVA</td><td>VS-050/060: 1.15 kVA</td></tr>
<tr><td></td><td>VS-068/087: 2.78 kVA</td></tr>
<tr><td>Single-phase, 100 VAC</td><td colspan="2">Single-phase, 100 VAC -10% to 110 VAC +10%, 50/60 Hz</td><td rowspan="2"> 

A: 100 VAC, phase R
B: 100 VAC, phase S
D: Protective ground</td></tr>
<tr><td>Power supply capacity</td><td colspan="2">VPG5/6CAA: 1 kVA</td></tr>
<tr><td colspan="2">Max. rush current when the power is turned ON</td><td colspan="3">40 A (for 1/50 or 1/60 second)</td></tr>
</table>

Caution: If ERROR6102 (power voltage drop) occurs when the robot is in operation, then it may be due to an insufficient capacity of the primary power source.

(7) Do not bundle the teach pendant cable, I/O cables or motor & encoder cable together with high power lines such as power cables and peripheral device cables, or route the motor cables near high power devices (motor, welder, parts feeder, etc.).

(8) Do not route any additional cables or air tubes of end-effectors through the robot unit. Doing so will result in broken cables or tubes.

(9) Use the correct power source (200 VAC or 100 VAC) for the controller specification.

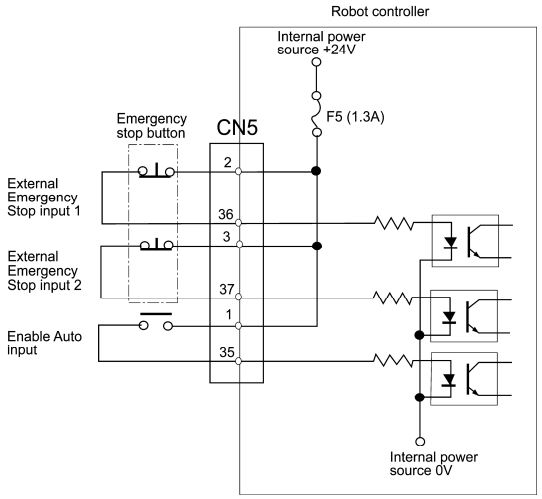
Chapter 5
Wire Connection for System Input Signals

5.1 Wire Connection Required in Starting Up the Robot

This section shows the minimum wire connection required for the stand-alone robot unit to turn the motor power ON or run in Auto or Manual mode during adjustment in starting up the robot system.

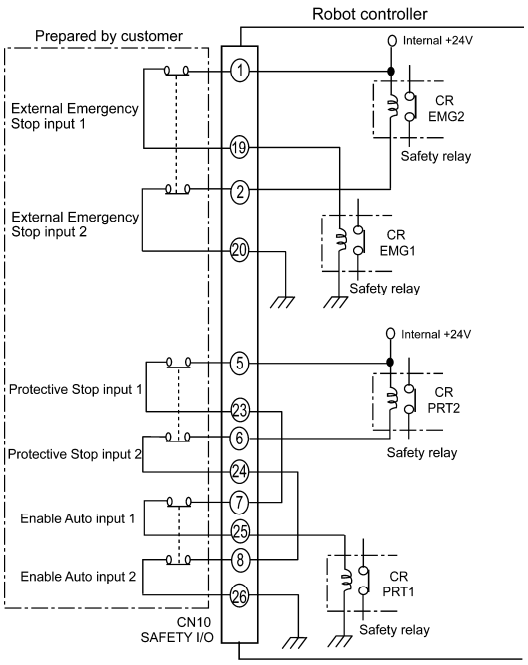
5.1.1 Configuration of Emergency Stop Circuitry (Standard type of controller)

The *External Emergency Stop* and *Enable Auto* input signals are important for safety. Be sure to configure their circuits with contacts as shown below.



5.1.2 Configuration of Safety Circuit (Global type of controller)

Input signals to the safety circuit are important for safety. Be sure to configure their circuits with contacts as shown below, observing the notes given below.



Note: For the overall configuration sample of a safety circuitry, refer to the CONTROLLER MANUAL, Section 4.2.5.2 "Safety Circuit."

5.2 Wire Connection Required for Motor ON

5.2.1 Function

Short-circuiting both the *Emergency Stop* input circuits (dual line) only enables the motor to turn ON.

5.2.2 Standard Type of Controller

Input signal name	Terminal number
External Emergency Stop 1	#2 and #36 on connector CN5
External Emergency Stop 2	#3 and #37 on connector CN5

Note: The different status between two emergency stop circuits, if kept for at least approx. one second, will be interpreted as an occurrence of trouble, triggering an error "279E: Inconsistent robot stop input."

5.2.3 Global Type of Controller

Input signal name	Terminal number
External Emergency Stop 1	#1 and #19 on connector CN10
External Emergency Stop 2	#2 and #20 on connector CN10

Note: Two *External Emergency Stop* input signals must be controlled with separate contacts. Two circuits connected in parallel using a single contact or an always-shorted circuit will be interpreted as an external circuit failure so that the emergency stop state cannot be reset.

5.3 Wire Connection Required for Automatic Operation

5.3.1 Function

(1) Turning this signal ON (shorting) enables switching to Auto mode.
(2) Turning this signal OFF (opening) enables switching to Manual or Teach check mode.

5.3.2 Standard Type of Controller

Input signal name	Terminal number
Enable Auto	#1 and #35 on connector CN5

5.3.3 Global Type of Controller

Input signal name	Terminal number
Enable Auto 1	#7 and #25 on connector CN10
Enable Auto 2	#8 and #26 on connector CN10
Protective Stop 1	#5 and #23 on connector CN10
Protective Stop 2	#6 and #24 on connector CN10

Note (1) Two *Enable Auto* and two *Protective Stop* input signals must be controlled with separate contacts. Two circuits connected in parallel using a single contact or an always-shorted circuit will be interpreted as an external circuit failure so that the circuit will not operate.

(2) The *Enable Auto* and *Protective Stop* input signal circuits are connected in series in the controller. They are used as an automatic operation permission signal (when closed) and enable two types of signal inputs.

(3) If no *Protective Stop* input signals are needed, their circuits can be always short-circuited by terminal connection with jumpers between #5 and #23 and between terminals #6 and #24 on connector CN10.

Part 2

Robot Running

Chapter 6
Coordinates

6.1 Coordinates in 4-Axis Robots

The following three coordinates are available for running the 4-axis robot.

- Base coordinates
- Work coordinates
- Tool coordinates

6.2 Base Coordinates in 4-Axis Robots

The base coordinates are so-called world coordinates which refer to 3-dimensional Cartesian coordinates whose origin is at the center of the robot basement. It has components Xb, Yb, and Zb which are identical with X, Y, and Z in X-Y mode.

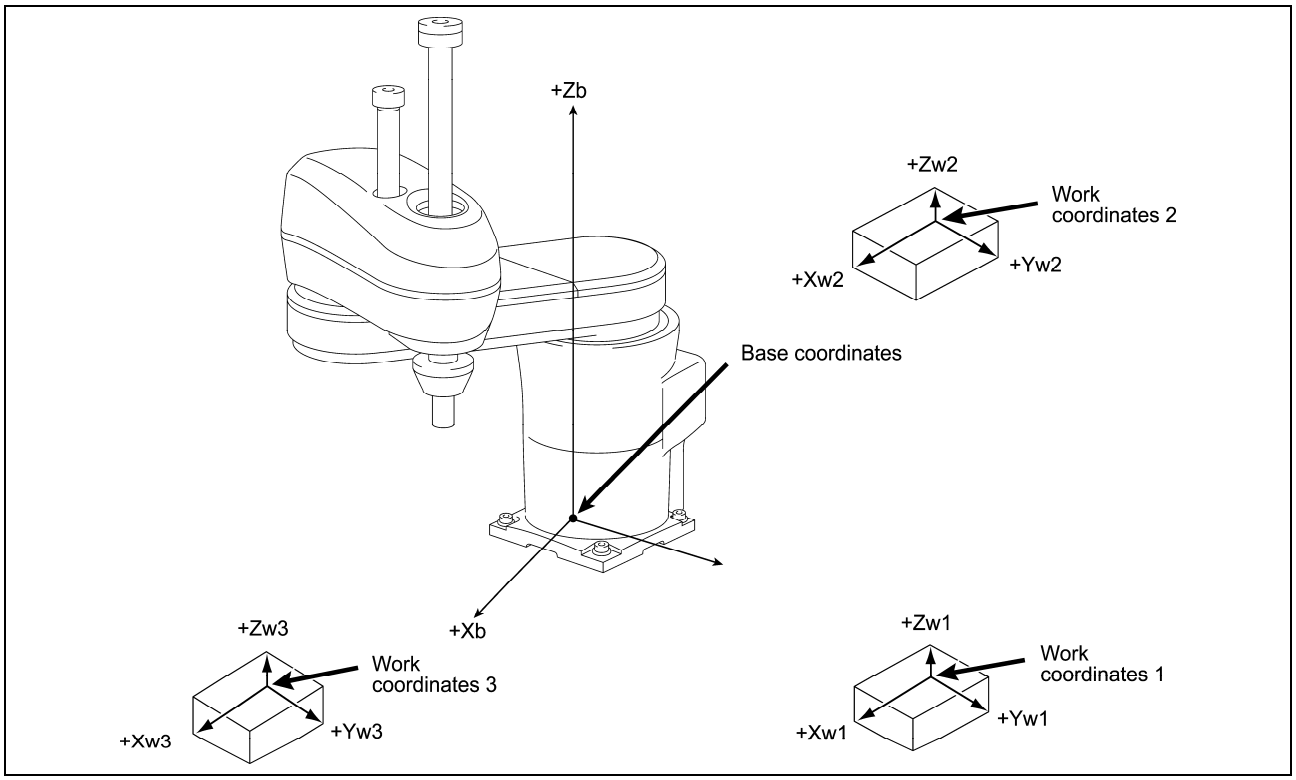
6.3 Work Coordinates in 4-Axis Robots

Work coordinates are 3-dimensional Cartesian coordinates defined for each operation space of workpiece. The origin can be defined anywhere and as much as needed. It lies at a corner of the rectangular parallelepiped envelope of an object workpiece as shown below. Work coordinates are expressed by the coordinate origin (X, Y, Z) corresponding to the base coordinates and the angles of rotation (Rx, Ry, Rz) around X, Y and Z axes of base coordinates.

Up to seven work coordinates can be defined and assigned work coordinates #1 to #7.

If work coordinates are not defined, base coordinates go into effect.

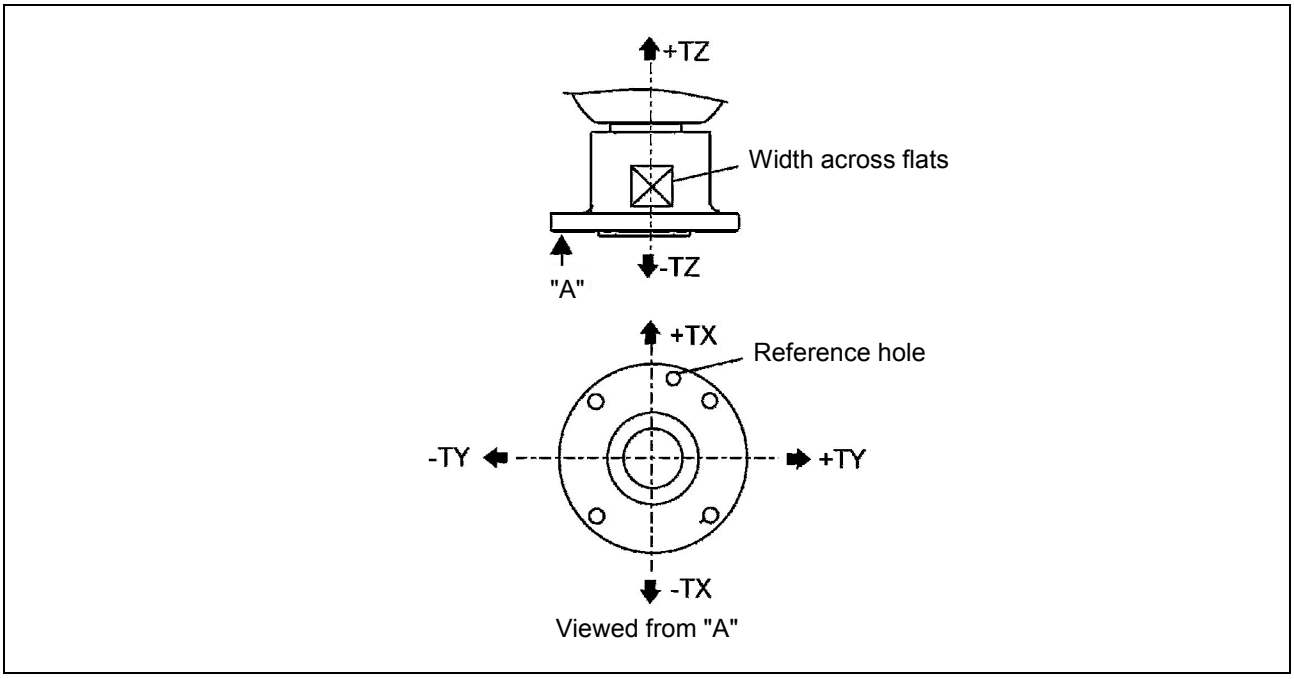
Note: To use work coordinates, it is necessary to define them beforehand. For details, refer to the SETTING-UP MANUAL, Section 4.2.1 "[1.3] Defining work coordinates."



Base Coordinates and Work Coordinates

6.4 Tool Coordinates in 4-Axis Robots

The tool coordinates are 3-dimensional Cartesian coordinates defined with reference to the origin of the mechanical interface coordinates shown below and with the offset distance components and axis rotation angles. Up to 63 tool coordinates can be defined and assigned tool coordinates #1 to #63.

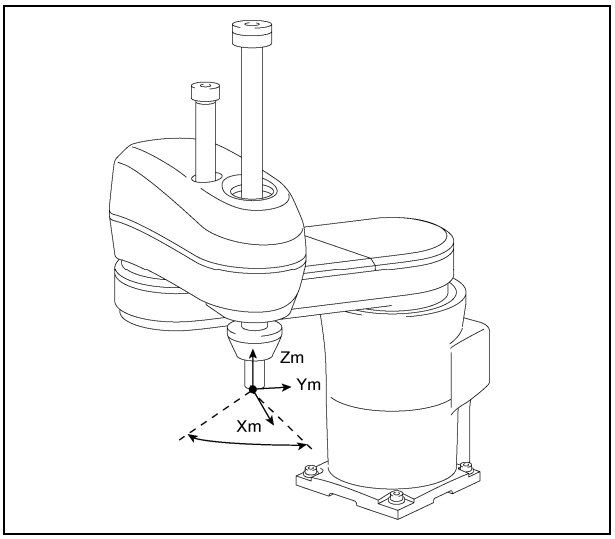


Mechanical Interface Coordinates

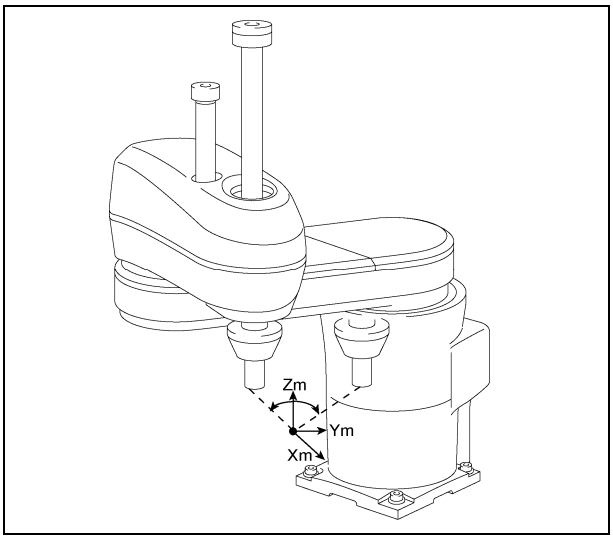
Note: To use tool coordinates, it is necessary to define them beforehand. For details, refer to the SETTING-UP MANUAL, Section 4.2.1 "[2.2] Tool definition procedure."

6.5 Advantages of Tool Coordinates in 4-Axis Robots

Using tool coordinates in Manual mode allows the tool end to move centering on the point that has been offset in the tool definition.



Manual Rotation of 4th Axis in X-Y mode, w/o Tool Definition

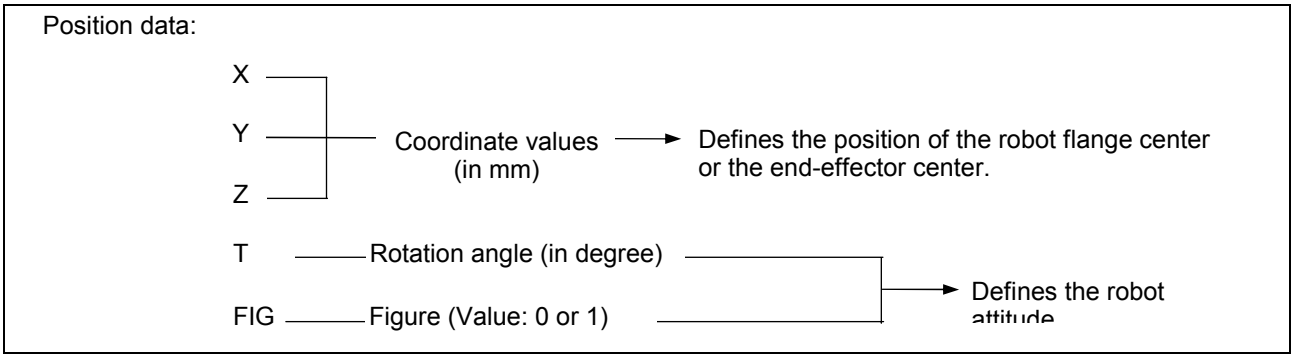


Manual Rotation of 4th Axis in X-Y mode, w/ Tool Definition

6.6 Position Data Handled by 4-Axis Robots

Position data refers to a set of data which includes five components of base coordinates. Of these five components, three are robot flange center coordinates (the end-effector tip coordinates if an end-effector is defined) and two are current robot attitude components, as shown below.

Position data allows you to represent the current position of the robot flange center and object points.



Components of Position Data

A set of X, Y, and Z coordinate values represents the position of the robot flange center (or tip of the end-effector if defined) expressed in base coordinates (Xb, Yb, and Zb) in units of mm.

The rotation angle expressed by T refers to an angle formed by the X axis of the TOOL0 coordinates and the Xb axis of the base coordinates. The angle is expressed in units of degree.

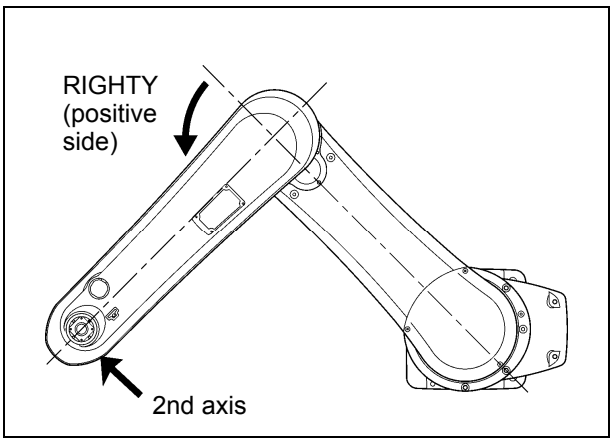
Figure represented by the FIG value refers to a figure of robot arm joints.

6.6.1 Shoulder Figures of 4-Axis Robots

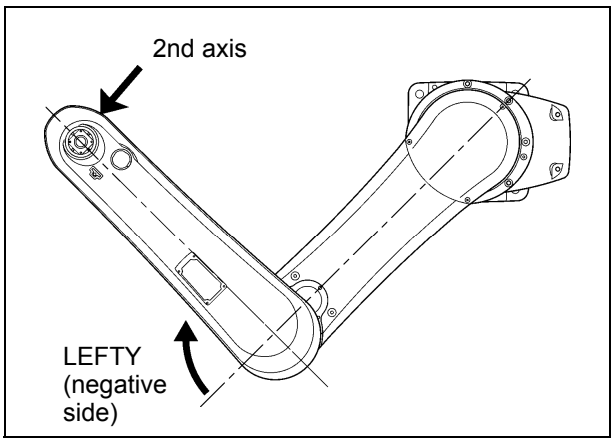
The 4-axis robot can take two figures when positioning as shown below.

Available Figures

Value	Figures
0	RIGHTY
1	LEFTY



RIGHTY



LEFTY

If the 2nd axis is positioned at the positive side on the X axis of the base coordinates as shown above left, the figure is called "RIGHTY"; if at the negative side as shown above right, it is called "LEFTY."

6.7 Coordinates in 6-Axis Robots

The following three coordinates are available for running the 6-axis robot.

- Base coordinates
- Work coordinates
- Tool coordinates

6.8 Base Coordinates in 6-Axis Robots

The base coordinates are so-called world coordinates which refer to 3-dimensional Cartesian coordinates whose origin is at the center of the robot basement. It has components Xb, Yb, and Zb which are identical with X, Y, and Z in X-Y mode.

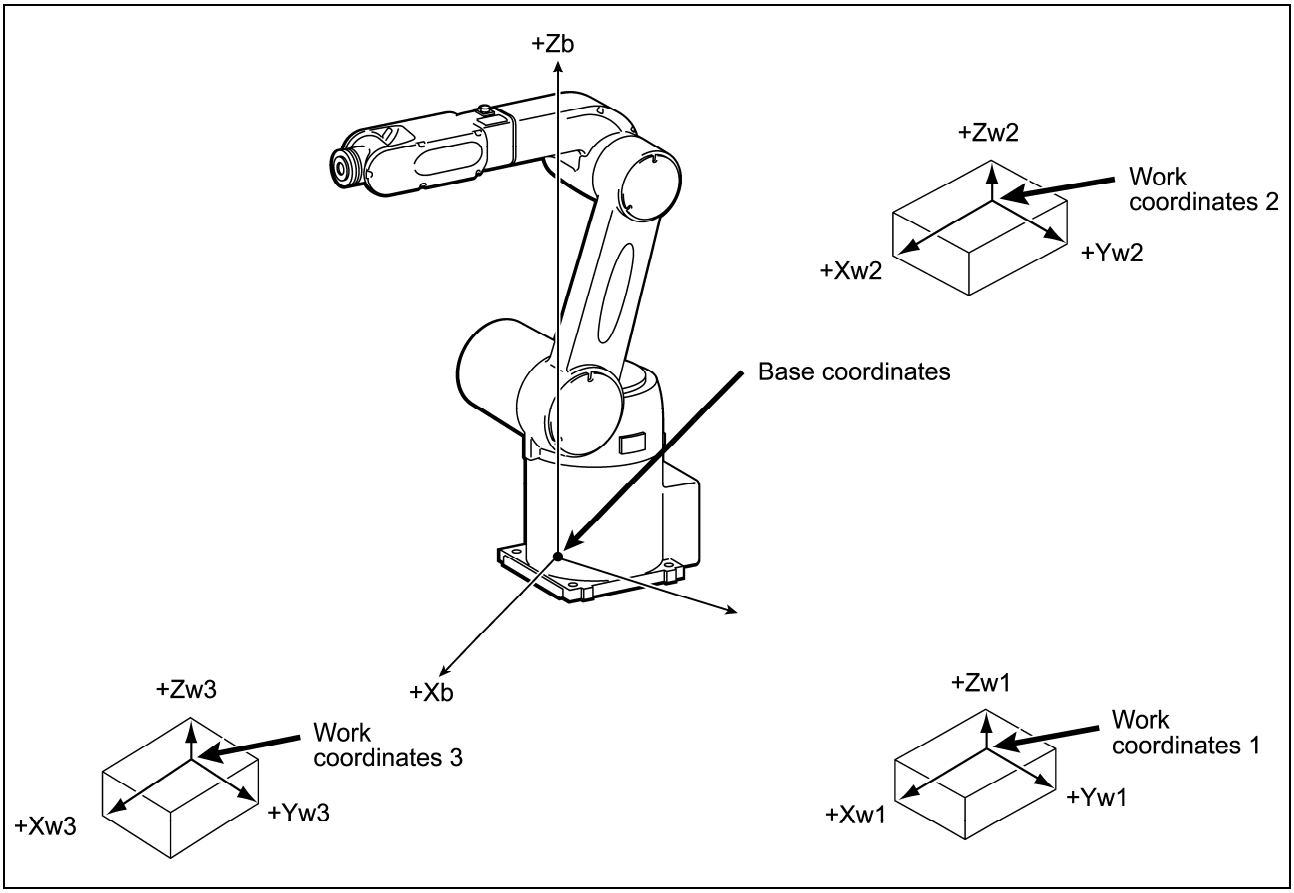
6.9 Work Coordinates in 6-Axis Robots

Work coordinates are 3-dimensional Cartesian coordinates defined for each operation space of workpiece. The origin can be defined anywhere and as much as needed. It lies at a corner of the rectangular parallelepiped envelope of an object workpiece as shown below. Work coordinates are expressed by the coordinate origin (X, Y, Z) corresponding to the base coordinates and the angles of rotation (Rx, Ry, Rz) around X, Y and Z axes of base coordinates.

Up to seven work coordinates can be defined and assigned work coordinates #1 to #7.

If work coordinates are not defined, base coordinates go into effect.

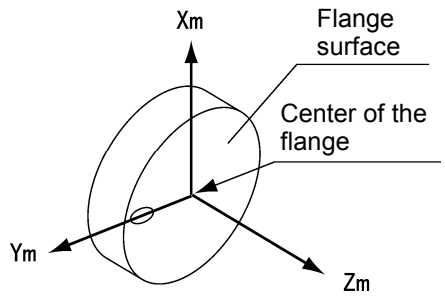
Note: To use work coordinates, it is necessary to define them beforehand. For details, refer to the SETTING-UP MANUAL, Section 4.1.1 "[1.3] Defining work coordinates."



Base Coordinates and Work Coordinates

6.10 Tool Coordinates in 6-Axis Robots

The tool coordinates are 3-dimensional Cartesian coordinates defined with reference to the origin of the mechanical interface coordinates shown below and with the offset distance components and axis rotation angles. Up to 63 tool coordinates can be defined and assigned tool coordinates #1 to #63.



Zm: Normal axis on the center of the flange surface

Ym: Axis passing through the flange center and orientation key hole

Xm: Axis passing through the flange center and crossing Zm and Ym at right angles

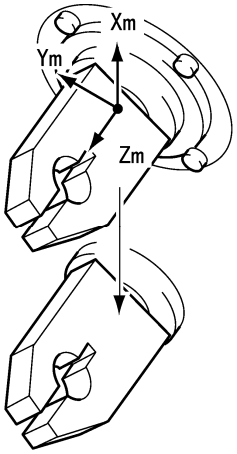
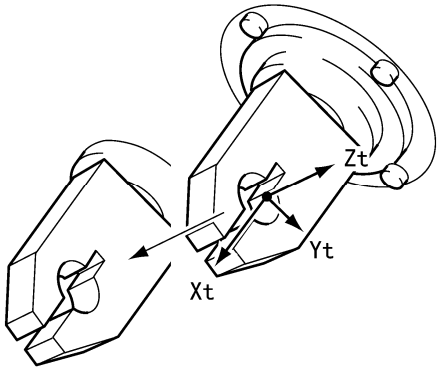
Definition of Mechanical Interface Coordinates

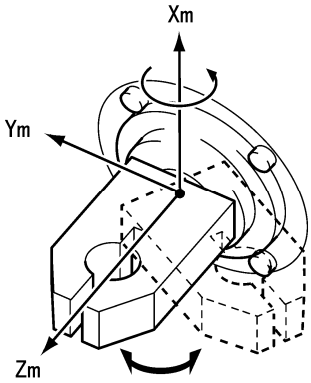
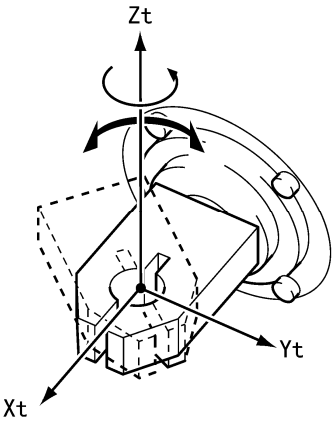
Note: To use tool coordinates, it is necessary to define them beforehand. For details, refer to the SETTING-UP MANUAL, Section 4.1.1 "[2.4] Creating tool coordinates."

6.11 Advantages of Tool Coordinates in 6-Axis Robots

When running the robot in tool coordinates, you can directly handle the hand mounted on the flange, making teaching easier.

The figure below shows the comparison of robot moving paths between in mechanical interface coordinates and in tool coordinates.

<table>
<tr><th>In mechanical interface coordinates (TOOL0)</th><th>In tool coordinates (TOOLn where n is any of 1 to 63)</th></tr>
<tr><td>If X- key is pressed:
 
</td><td>If Z- key is pressed:
 

Enables you to move the end-effector to your object point in teaching.</td></tr>
<tr><td>If RX+ key is pressed:
 
</td><td>If RZ+ is pressed:
 

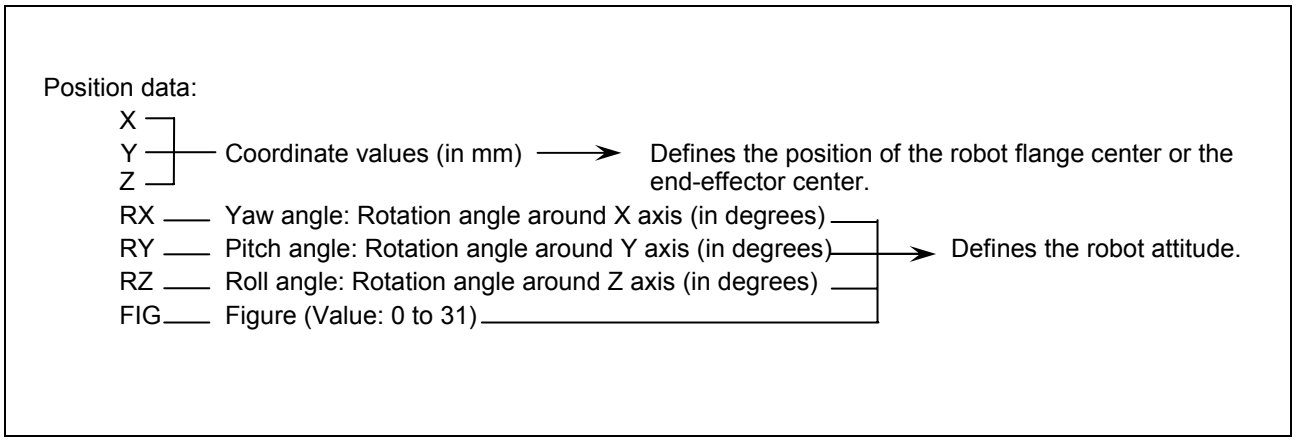
Enables you to rotate the end-effector around the Zt axis.</td></tr>
</table>

Example of Manual Robot Running in Tool Coordinates

6.12 Position Data Handled by 6-Axis Robots

Position data refers to a set of data which includes seven components of base coordinates. Of these seven components, three are robot flange center coordinates (the end-effector tip coordinates if an end-effector is defined) and four are current robot attitude components, as shown below.

Position data allows you to represent the current position of the robot flange center and object points.



Components of Position Data

A set of X, Y, and Z coordinate values represents the position of the robot flange center (or tip of the end-effector if defined) expressed in base coordinates (Xb, Yb, and Zb) in units of mm.

The yaw, pitch, and roll angles, which are expressed by RX, RY, and RZ, refer to rotation angles around the respective axes of the base coordinate system defined by the mechanical interface coordinate system whose origin is at the center of the flange surface. These angles are expressed in units of degree.

With respect to the positive (+) direction on axes of the base coordinates, clockwise rotation is treated as positive (+).

You should always preserve the rotation order of RZ, RY, and RX. Changing it will cause the robot to take a different attitude in spite of the same rotation angle defined.

Figure represented by the FIG value refers to a figure of robot arm joints.

6.12.1 Figures of the Shoulder, Elbow, and Wrist in 6-Axis Robots

A 6-axis robot can take different figures for its shoulder, elbow, wrist, 6th axis, and 4th axis for a single point and attitude (X, Y, Z, RX, RY, and RZ) at the end of the end-effector.

Items (1) through (5) given on the following pages show how the robot can take different figures for its shoulder, elbow, wrist, 6th axis, and 4th axis, respectively.

Combining these different figures allows the robot to take 32 different figures for its single position and attitude, as listed below.

Available Figures

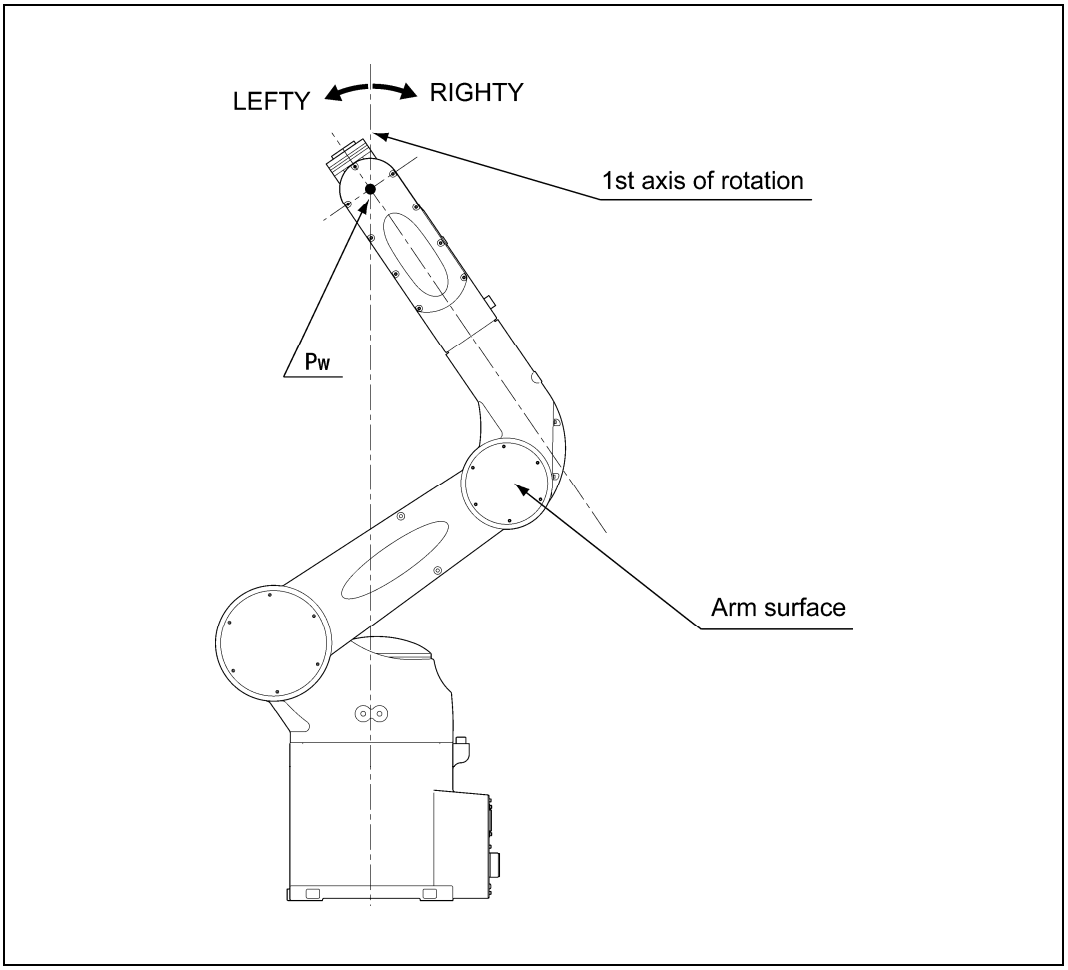
Value	4th-Axis Figure	6th-Axis Figure	Wrist Figure	Elbow Figure	Shoulder Figure
0	SINGLE 4	SINGLE	FLIP	ABOVE	RIGHTY
1	SINGLE 4	SINGLE	FLIP	ABOVE	LEFTY
2	SINGLE 4	SINGLE	FLIP	BELOW	RIGHTY
3	SINGLE 4	SINGLE	FLIP	BELOW	LEFTY
4	SINGLE 4	SINGLE	NONFLIP	ABOVE	RIGHTY
5	SINGLE 4	SINGLE	NONFLIP	ABOVE	LEFTY
6	SINGLE 4	SINGLE	NONFLIP	BELOW	RIGHTY
7	SINGLE 4	SINGLE	NONFLIP	BELOW	LEFTY
8	SINGLE 4	DOUBLE	FLIP	ABOVE	RIGHTY
9	SINGLE 4	DOUBLE	FLIP	ABOVE	LEFTY
10	SINGLE 4	DOUBLE	FLIP	BELOW	RIGHTY
11	SINGLE 4	DOUBLE	FLIP	BELOW	LEFTY
12	SINGLE 4	DOUBLE	NONFLIP	ABOVE	RIGHTY
13	SINGLE 4	DOUBLE	NONFLIP	ABOVE	LEFTY
14	SINGLE 4	DOUBLE	NONFLIP	BELOW	RIGHTY
15	SINGLE 4	DOUBLE	NONFLIP	BELOW	LEFTY
16	DOUBLE 4	SINGLE	FLIP	ABOVE	RIGHTY
17	DOUBLE 4	SINGLE	FLIP	ABOVE	LEFTY
18	DOUBLE 4	SINGLE	FLIP	BELOW	RIGHTY
19	DOUBLE 4	SINGLE	FLIP	BELOW	LEFTY
20	DOUBLE 4	SINGLE	NONFLIP	ABOVE	RIGHTY
21	DOUBLE 4	SINGLE	NONFLIP	ABOVE	LEFTY
22	DOUBLE 4	SINGLE	NONFLIP	BELOW	RIGHTY
23	DOUBLE 4	SINGLE	NONFLIP	BELOW	LEFTY
24	DOUBLE 4	DOUBLE	FLIP	ABOVE	RIGHTY
25	DOUBLE 4	DOUBLE	FLIP	ABOVE	LEFTY
26	DOUBLE 4	DOUBLE	FLIP	BELOW	RIGHTY
27	DOUBLE 4	DOUBLE	FLIP	BELOW	LEFTY
28	DOUBLE 4	DOUBLE	NONFLIP	ABOVE	RIGHTY
29	DOUBLE 4	DOUBLE	NONFLIP	ABOVE	LEFTY
30	DOUBLE 4	DOUBLE	NONFLIP	BELOW	RIGHTY
31	DOUBLE 4	DOUBLE	NONFLIP	BELOW	LEFTY

(1) Shoulder figure

The rotary axis of the 1st axis is defined as the boundary between LEFTY and RIGHTY.

When viewed from the normal line on the side of the arm link, if point Pw exists in the left-hand side of the rotary axis of the 1st axis, the figure is LEFTY; if point Pw exists in the right-hand side, it is RIGHTY. In the figure shown below, the boundary is drawn with alternate long and short dash lines.

Note: If point Pw exists on the rotary axis of the 1st axis, that is, on the boundary between LEFTY and RIGHTY, then it is called a singular point.

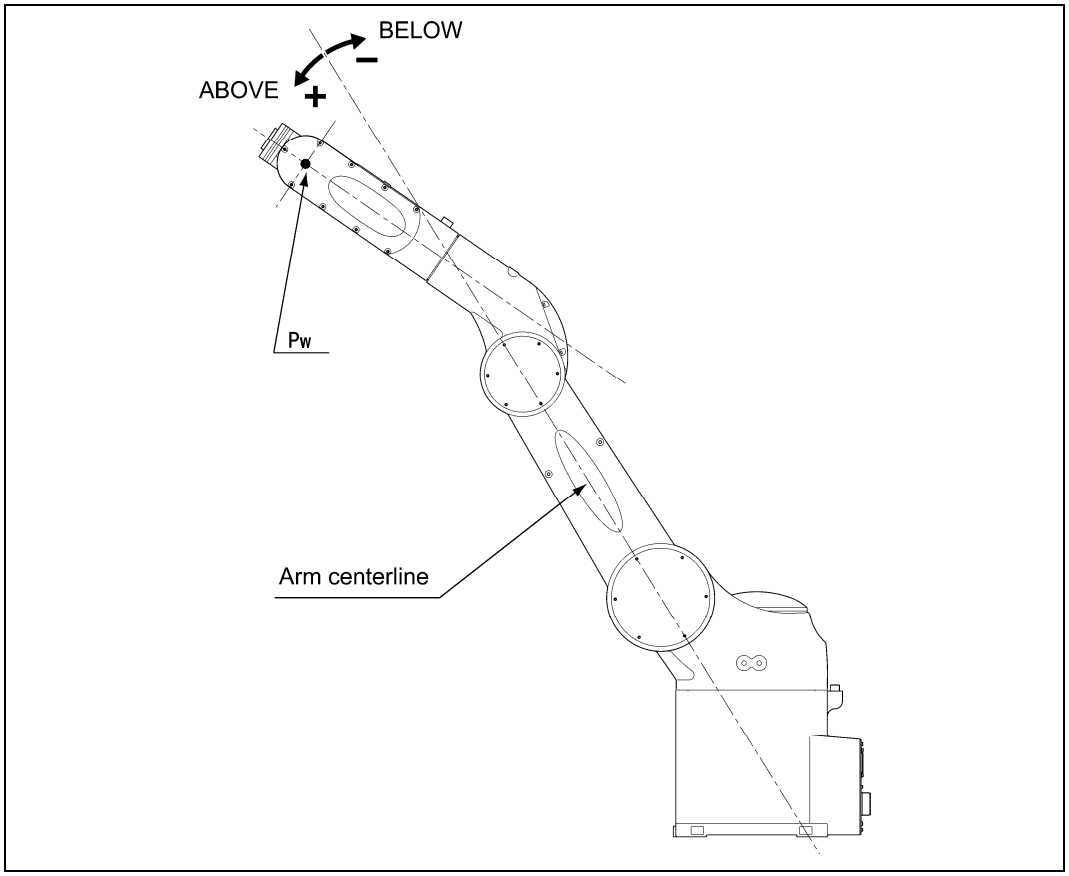


Boundary between LEFTY and RIGHTY

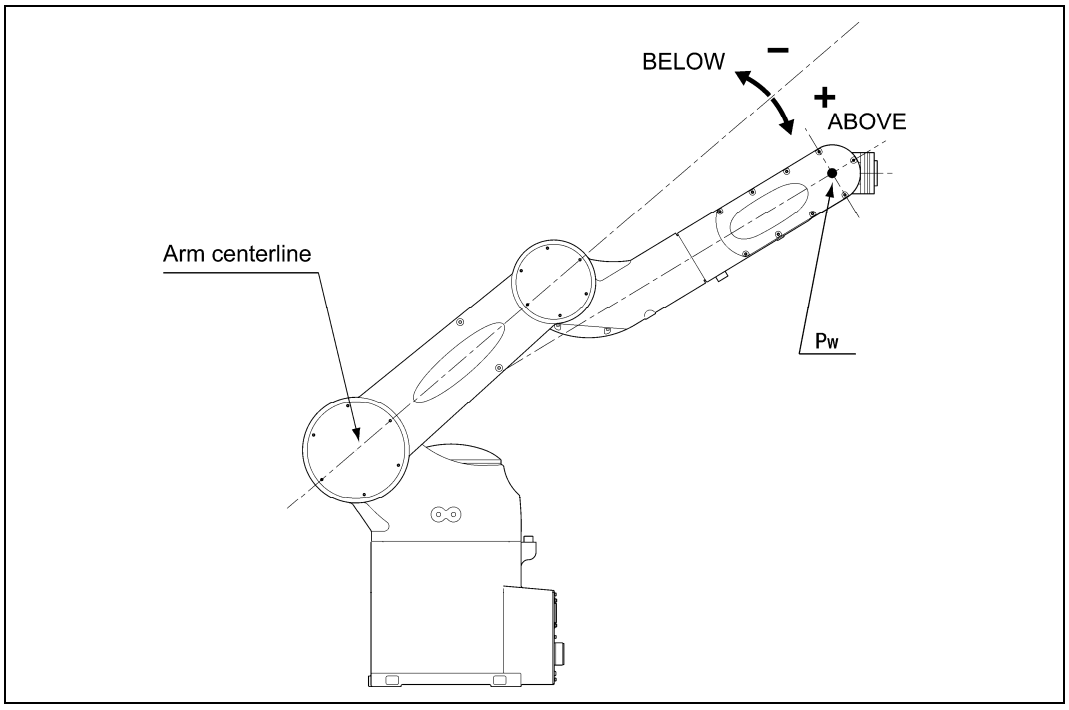
(2) Elbow figure

The centerline of the arm link (connecting the shoulder with elbow) is defined as the boundary between ABOVE and BELOW.

If point Pw exists in the + side of the centerline, the figure is ABOVE; if point Pw exists in the -side, it is BELOW. In the figures shown below, the boundary is drawn with alternate long and short dash lines.



Boundary between ABOVE and BELOW for LEFTY

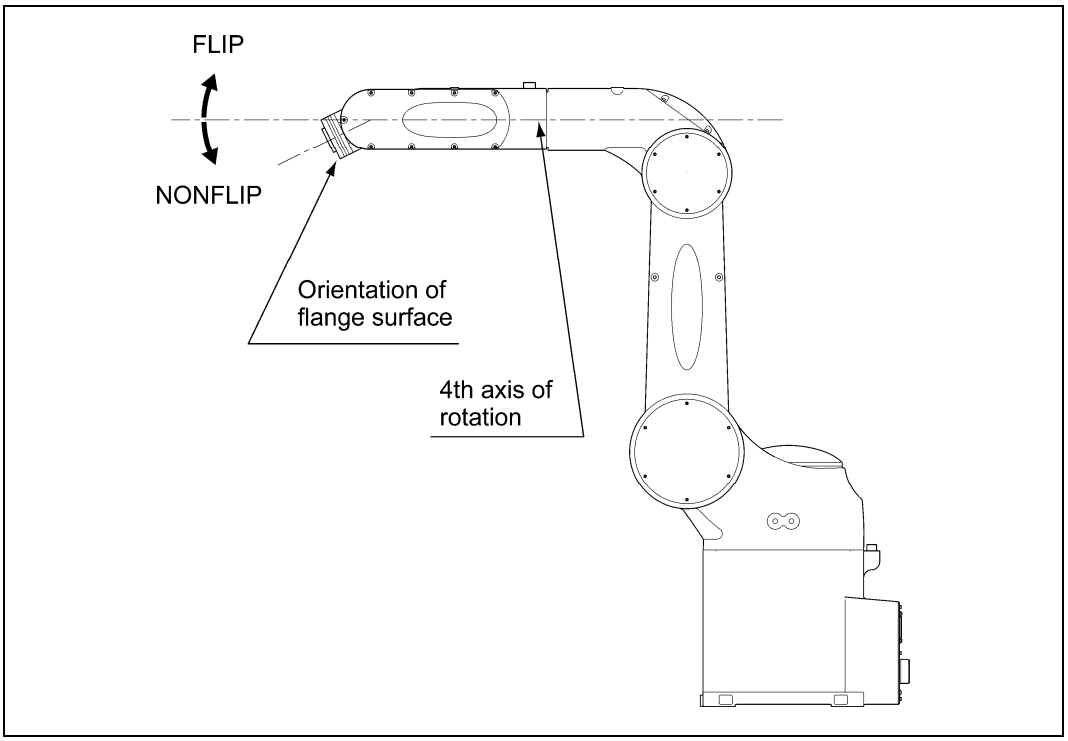


Boundary between ABOVE and BELOW for RIGHTY

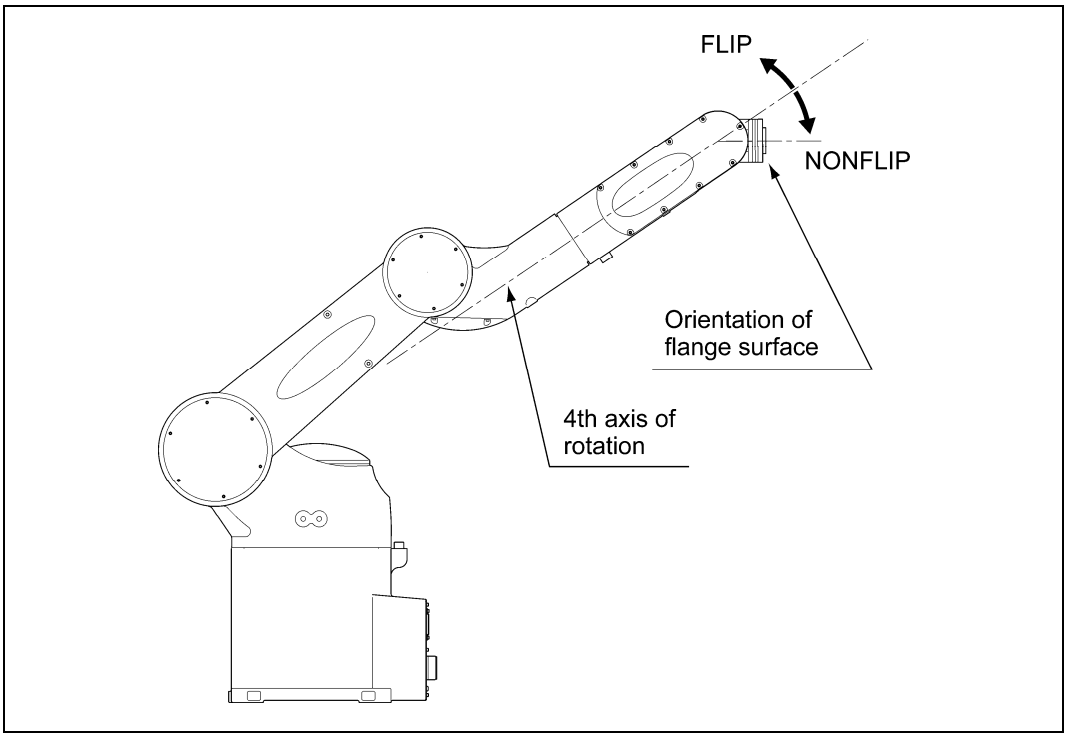
(3) Wrist figure

The rotary axis of the 4th axis is defined as the boundary between FLIP and NONFLIP.

If the normal line on the flange surface tilts up the rotary axis of the 4th axis, the figure is FLIP; if it tilts down the rotary axis, it is NONFLIP. In the figures shown below, the boundary is drawn with alternate long and short dash lines.



Boundary between FLIP and NONFLIP for LEFTY



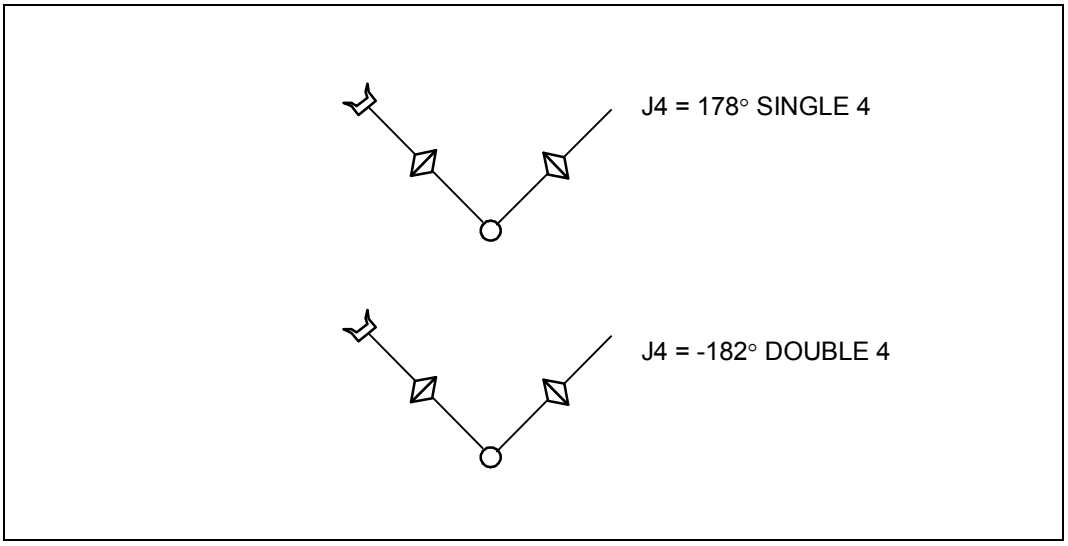
Boundary between FLIP and NONFLIP for RIGHTY

(4) 4th-axis figure

The 4th-axis figure is defined by the value of the 4th-axis component.

The robot can take two different 4th-axis figures--SINGLE 4and DOUBLE 4. If the 4th axis rotates by -180°<θ4≤180° in mechanical interface coordinates, the figure is SINGLE 4; if it rotates by 180°<θ4≤185° or -185°<θ4≤-180°, the figure is DOUBLE 4.

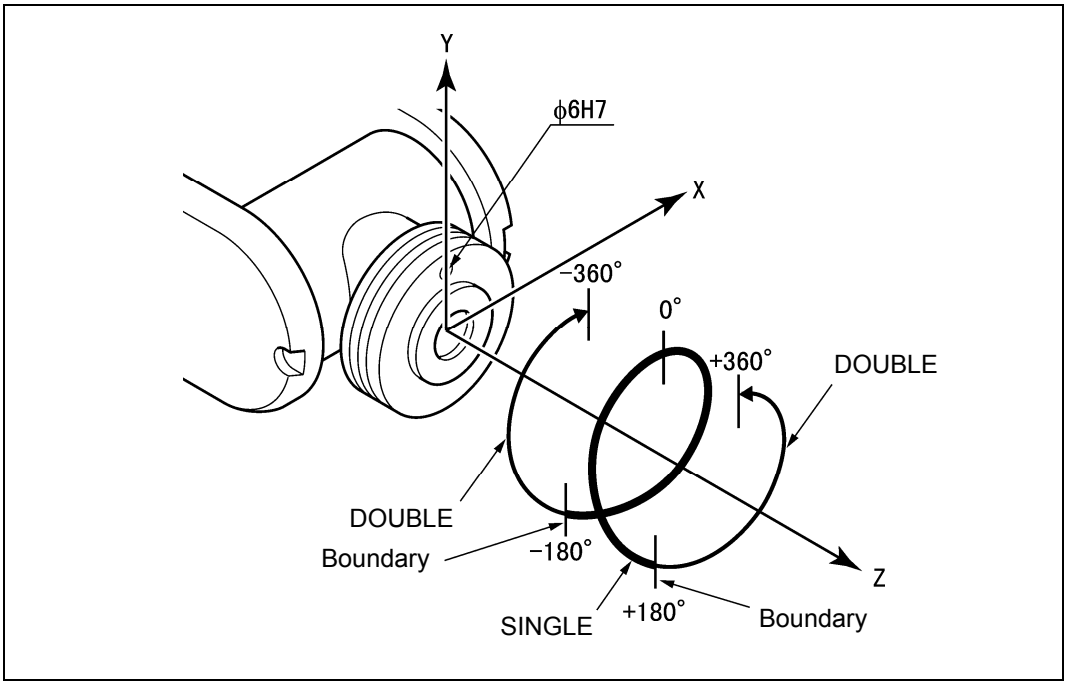
The robot takes quite different figures when θ4 is 180° or 181°. Take special care when changing any position data fort the 6th-axis figure. For example, supposing that you want to change the 4th-axis figure at θ4=181°, the robot will take the 4th-axis figure at θ4=-179° if you make no figure modification.



4th-Axis Figure

(5) 6th-axis figure

If the rotation angle (θ6) of the 6th axis is within the range of -180°<θ6≤180° around the Z axis in mechanical interface coordinates, the figure is SINGLE; if it is within the range of 180°<θ6≤360° or -360°<θ6≤-180°, the figure is DOUBLE. Boundaries exist at -180° and +180°.



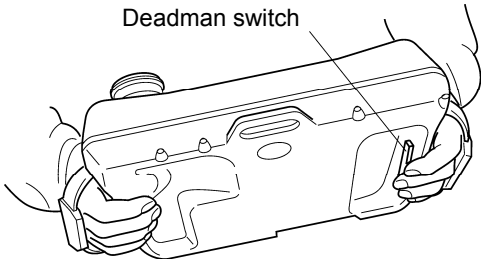
Boundary between SINGLE and DOUBLE

Chapter 7
Preparations for Teaching

7.1 Handling the Teach Pendant

7.1.1 Holding the Teach Pendant and the Deadman Switch

Grasp the teach pendant when operating it, as shown below. The teach pendant has a deadman switch(es) for ensuring safety.



★**Tip**★ The deadman switch is provided to stop the robot automatically and safely when the operator can no longer operate the robot correctly due to unforeseen circumstances such as the operator suffering a blackout or dying while running the robot manually with the teach pendant. If a situation such as this arises, the strength with which the operator is pressing the deadman switch will become either decrease or increase markedly. The deadman switch is a 3-position switch which is able to recognize and react to the following 3 operating statuses.

1) When the switch is not being pressed or is being pressed lightly
→ Switch: OFF
2) When the switch is being pressed with correct pressure
→ Switch: ON
3) When the switch is being pressed too strongly
→ Switch: OFF

If the switch is OFF or goes OFF, the robot cannot run or the running robot will stop, respectively.

In order to ensure safety, the robot is so designed that in manual mode the deadman switch should be held down for example when the operator presses any of the arm traverse keys.

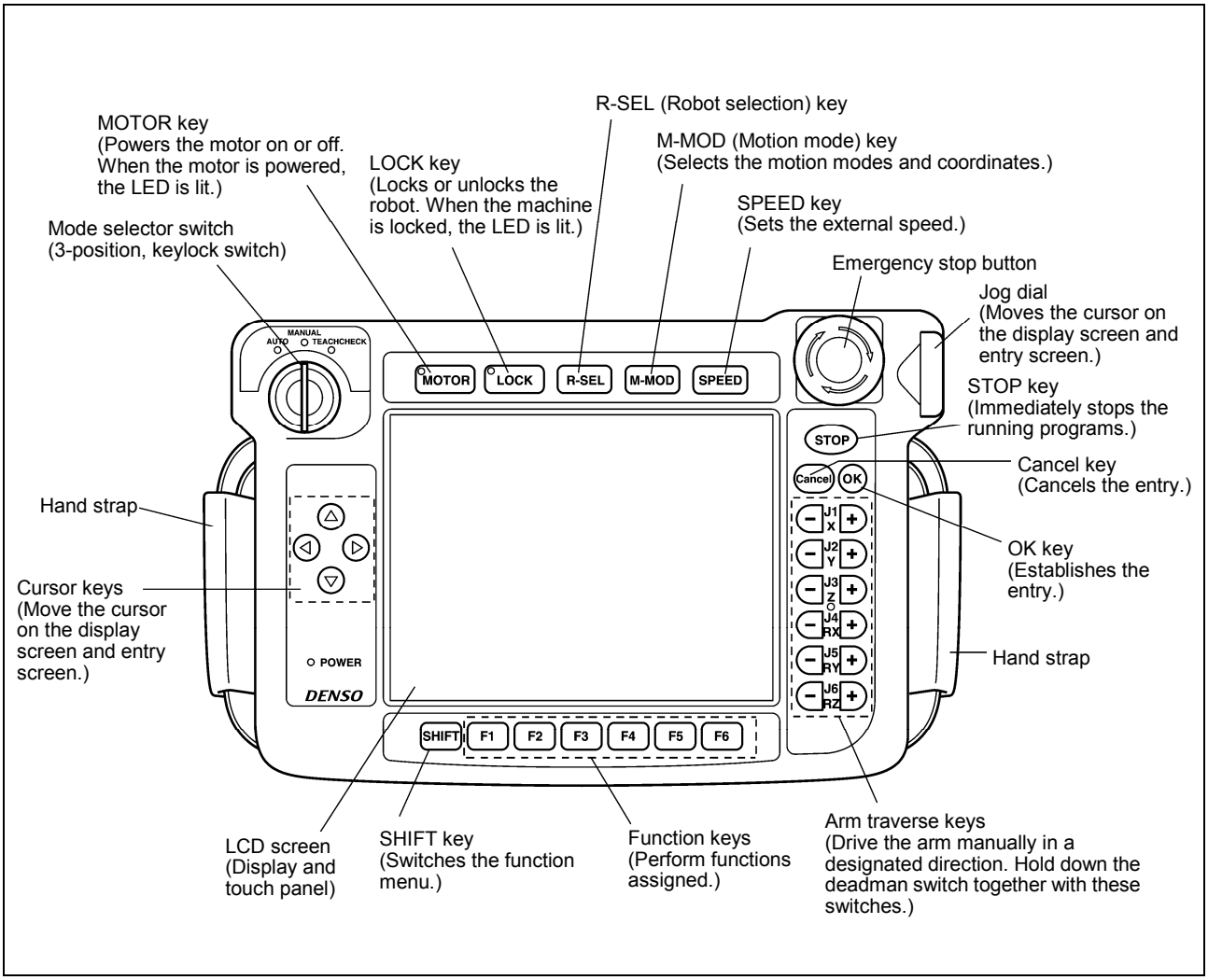
Note: The deadman switch is also called "Enable switch."

7.1.2 Names of Keys, Buttons, and Switches on the Teach Pendant

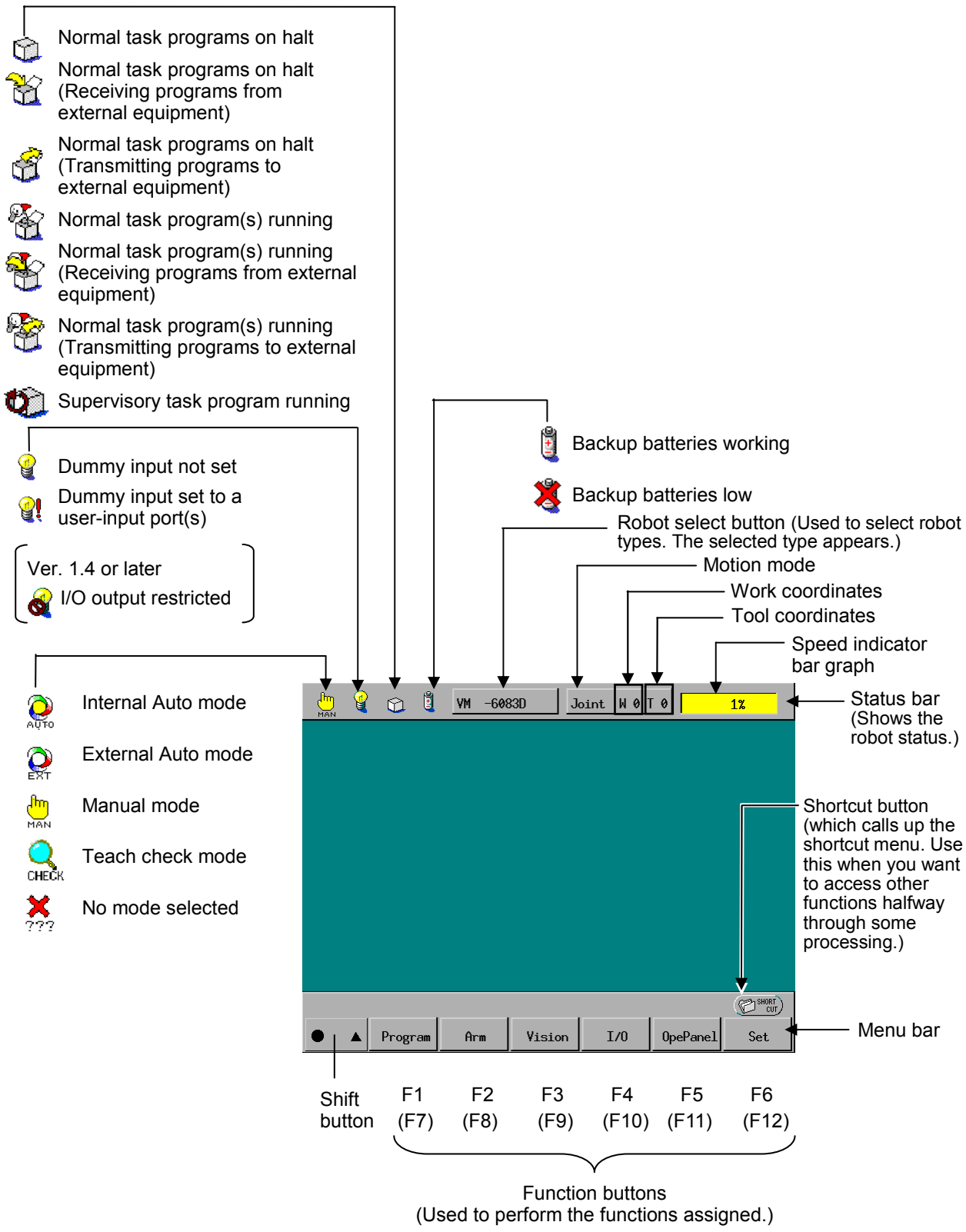
The figure below shows the names of keys, buttons, switches, and other sections of the teach pendant. On the LCD screen are function buttons, shortcut button, and icons which are shown on the next page.

Before running the robot, learn the location of those keys, buttons, and switches, which will help you run the robot smoothly and safely.

Note: On the teach pendant designed for the RC7M controller, the mode selector switch is a keylock type and the "robot stop button" is name-changed to the "emergency stop button."



Names of Keys, Buttons, and Switches on the Teach Pendant



Top screen

Names of Keys, Buttons, and Switches on the Teach Pendant Screen

7.2 Operation Modes

The robot offers three operation modes--Manual mode, Teach check mode, and Auto mode.

7.2.1 Manual Mode

Manual mode allows you to run the robot manually from the teach pendant or mini-pendant.

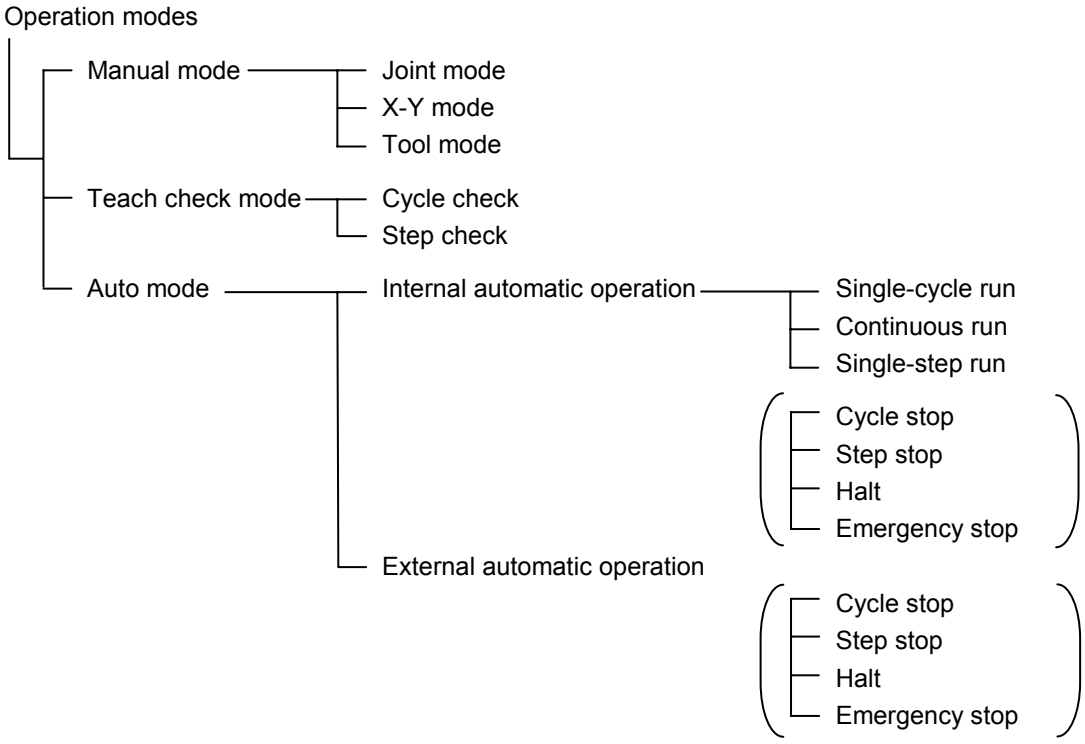
7.2.2 Teach Check Mode

Teach check mode provides restricted automatic operation in which you can make a final check of programs with the teach pendant after teaching.

7.2.3 Auto Mode

Auto mode allows the robot to run automatically.

The teach pendant or mini-pendant supports all of the above three modes.



In each of the above three operation modes, you can lock the robot (so called "machine lock") so that it is possible to perform simulations with the robot controller without running the robot practically.

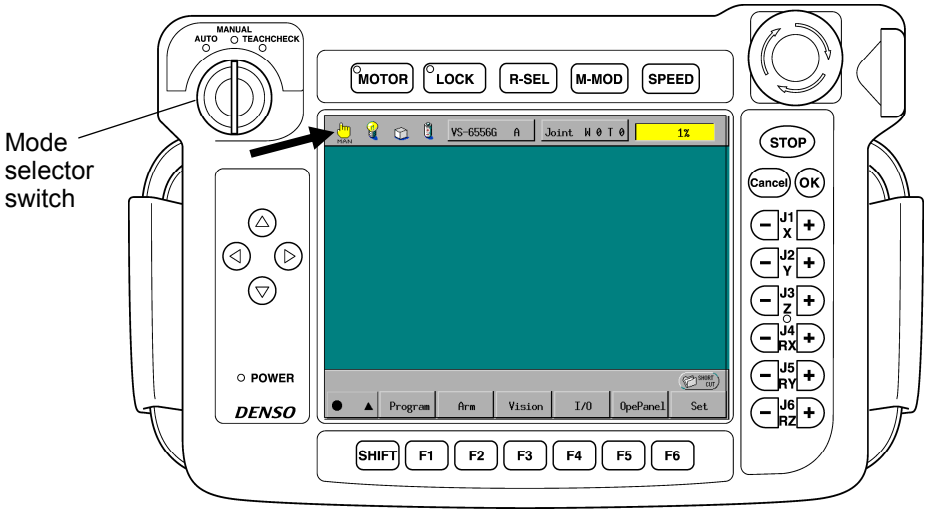
When the robot is in machine lock, you can restrict the I/O output. For details, refer to the SETTING-UP MANUAL, Section 5.5, "Displaying I/O Signals and Simulating Robot Motion."

7.3 Switching Between Operation Modes

To perform teaching, it is necessary to switch to the Manual mode beforehand.

7.3.1 Operating Procedure

Turn the mode selector switch to the desired mode position.



The selected mode icon appears in the leftmost area of the status bar.

: Internal Auto mode,

: External Auto Mode

: Manual mode,

: Teach check mode

7.3.2 Relationship between Operation Modes and *Enable Auto* Input Signal

As listed below, the signal state of *Enable Auto* (system input signal) should match the operation mode selected.

Change the wiring of the *Enable Auto* signal circuit if necessary, referring to Section 5.3 "Wire Connection Required for Automatic Operation."

Operation mode	*Enable Auto* input signal
Manual mode	OFF (opened)
Teach check mode	OFF (opened)
Auto mode	ON (short-circuited)

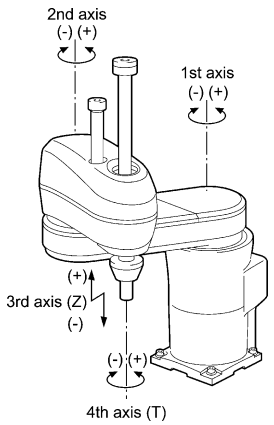
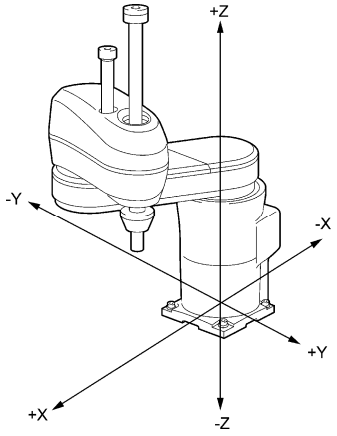
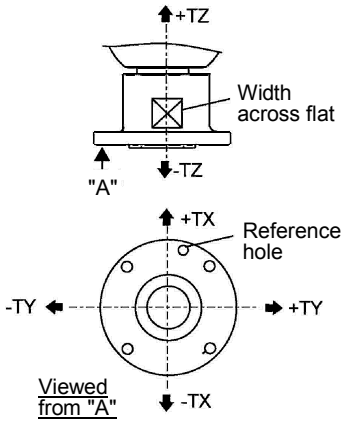
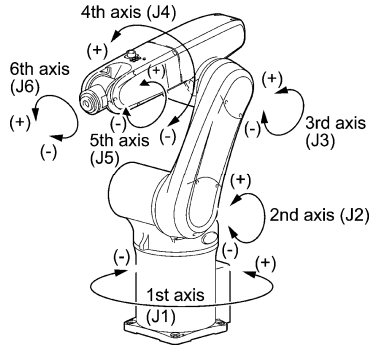
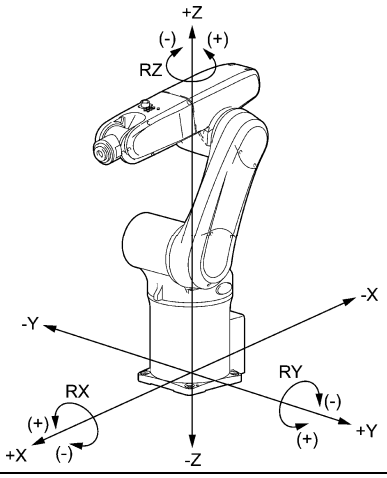
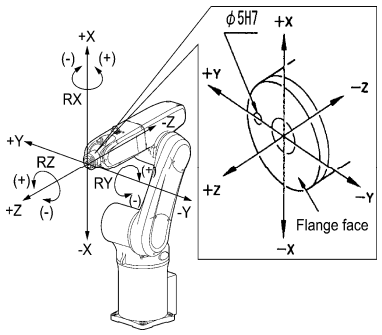
If the *Enable Auto* input signal status does not match the operation mode, ERROR21F2 (*Enable Auto* ON) or ERROR 21F3 (*Enable Auto* OFF) occurs, allowing no more operation.

7.4 Manual Modes

You can run the robot manually from the teach pendant or mini-pendant in any of the three modes--Joint mode, X-Y mode, and Tool mode.

NOTE: To run the robot manually, *Enable Auto* (system input signal) is required to be OFF (opened).

7.4.1 Running the Robot in Joint, X-Y, or Tool Mode

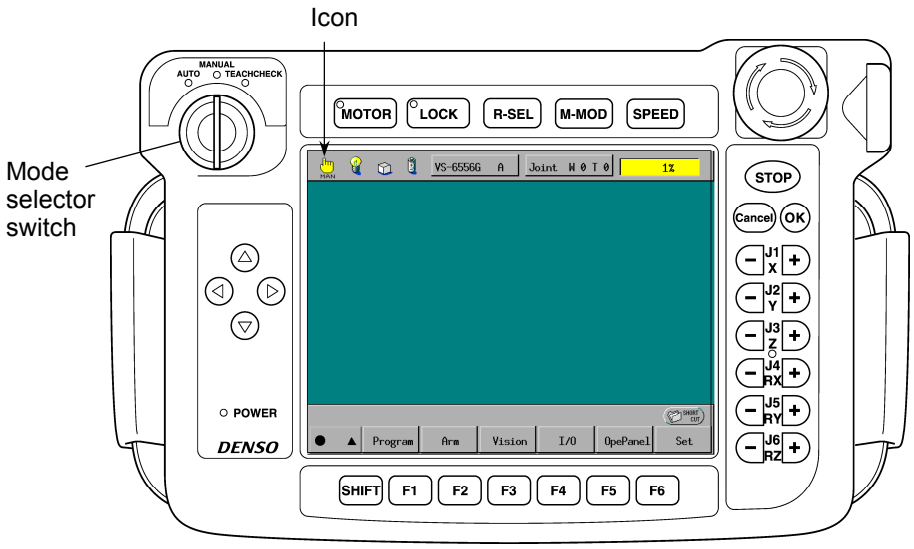
	<Joint mode >	<X-Y mode>	<Tool mode>
Action	Drives each of the four joints independently.	Drives the robot flange linearly in base coordinates.	Drives the robot flange linearly along the Cartesian coordinates of the 4th axis.
4-axis robot			
Action	Drives each of the six joints independently.	Drives the robot flange linearly in base coordinates.	Drives the robot flange linearly along the X-, Y-, and Z-axes of the flange face.
6-axis robot			

7.4.2 Switching to Manual Mode

⚠**CAUTION**: At the start, set the reduced ratio of the programmed speed to 20% or less. If you run the robot manually at high speeds from the beginning, you may mistakenly strike the robot against the surrounding objects.

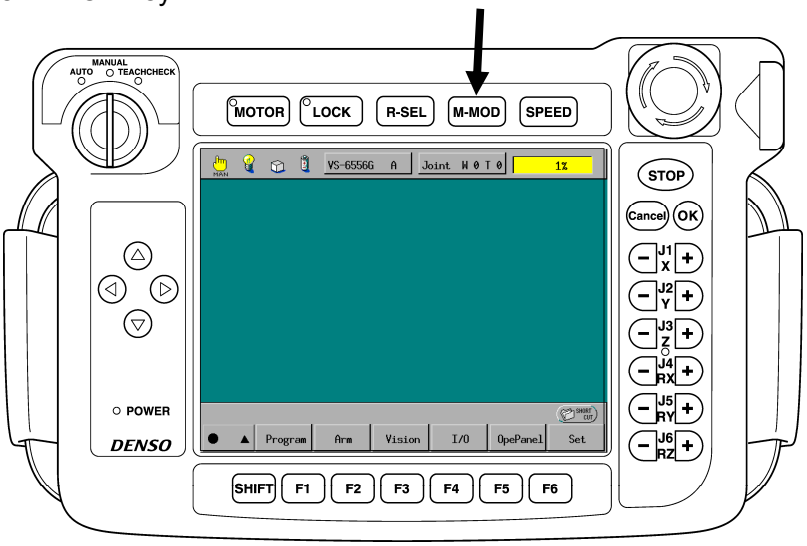
■ ***From the teach pendant***

Step 1 Set the mode selector switch to the MANUAL position.



Step 2 Press the MOTOR key to turn the motor on.

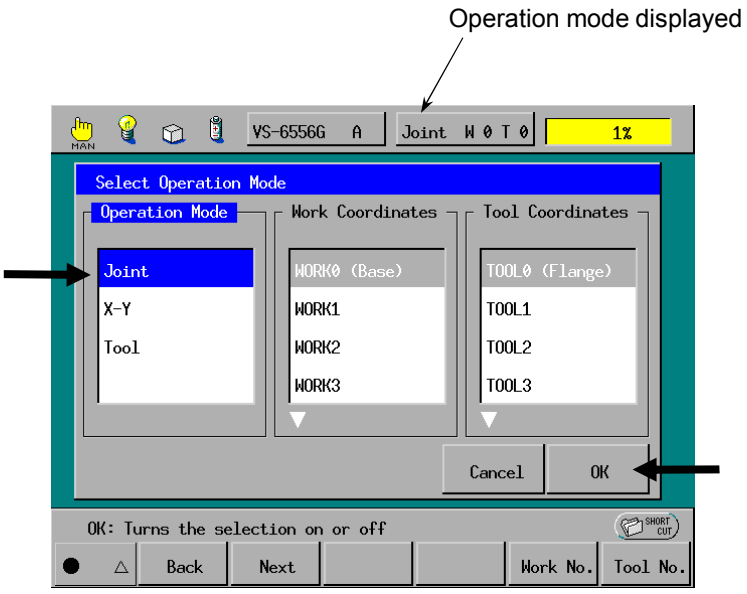
Step 3 Press the M-MOD key.



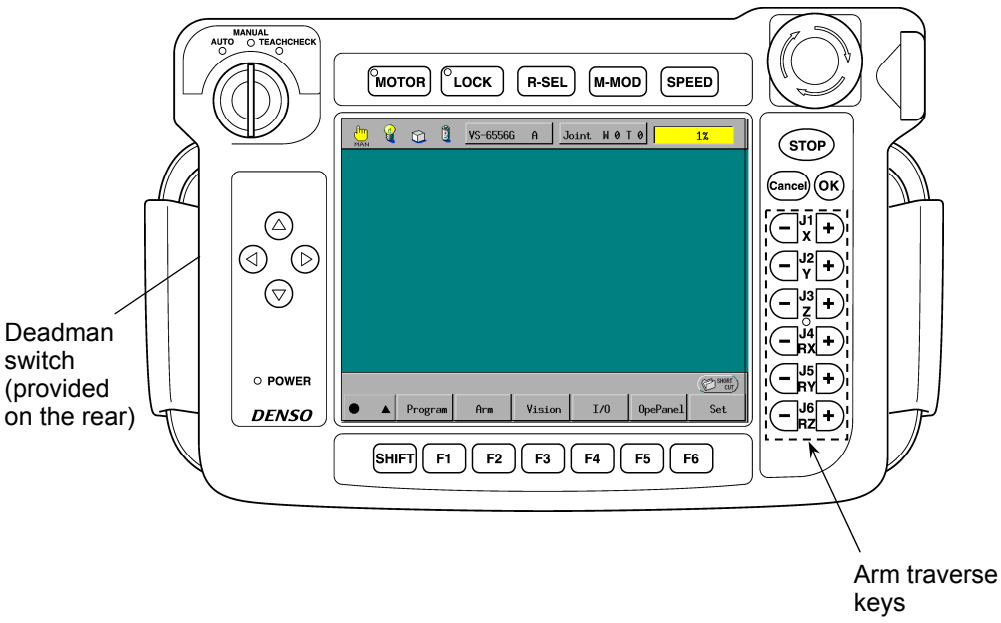
The Select Operation Mode window appears as shown in the next step.

Step 4 Select the desired operation mode by using the cursor keys or touching the screen directly, then press the OK key.

In the mode area of the status bar appears the selected operation mode.



Step 5 While holding down the deadman switch, press one of the arm traverse keys to drive the robot arm. For details regarding the relationship between the arm traverse keys and driven axes, refer to Section 7.4.1 "Running the Robot in Joint, X-Y, or Tool Mode."



7.5 Running the Robot Manually

Turn the robot controller and motor ON and run the robot manually with the teach pendant.

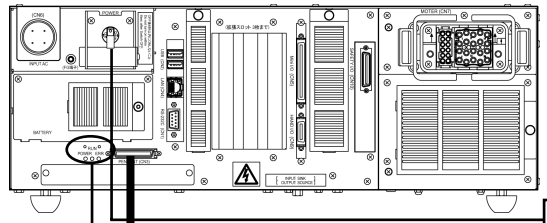
Step 1

Checking that it is safe to proceed

- Check that the robot is installed correctly.
- Check that there is no one within the robot's restricted space.

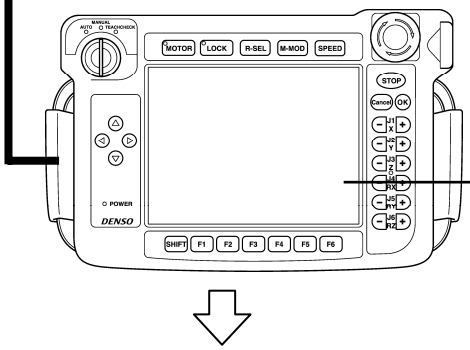
Step 2

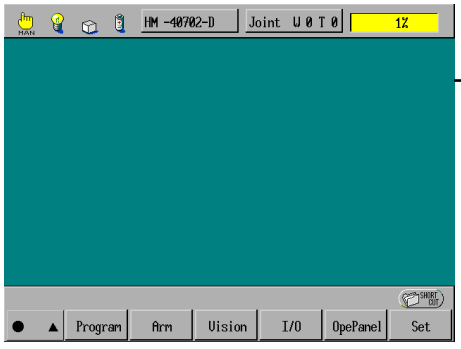
Turning the robot controller ON



① Flip the controller power switch upward.

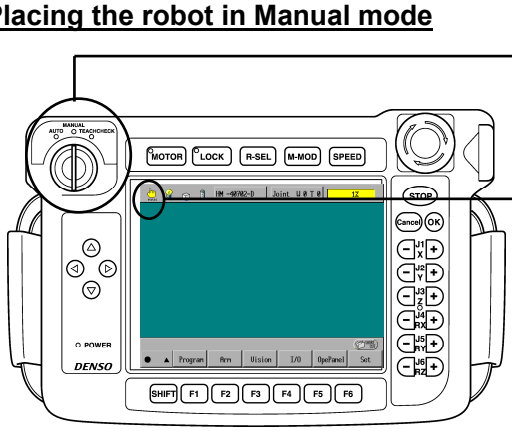
The power lamp (furthest left one of the 3 pilot lamps) will light and the remaining 2 lamps will flash momentarily.





The top screen will appear on the teach pendant soon after.

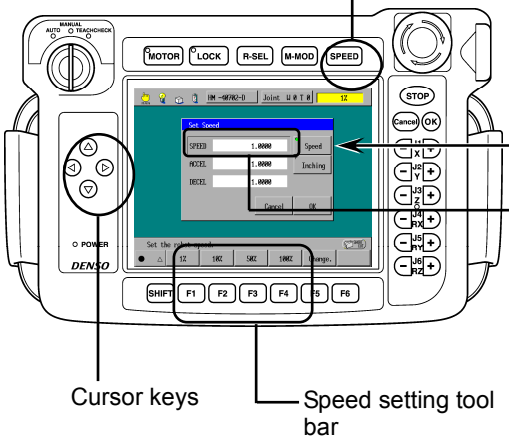
Step 3 Placing the robot in Manual mode



① Set the Mode Selector switch to MANUAL.

In the leftmost area of the status bar, an icon indicating Manual mode will be displayed.

Step 4 Setting the speed and acceleration



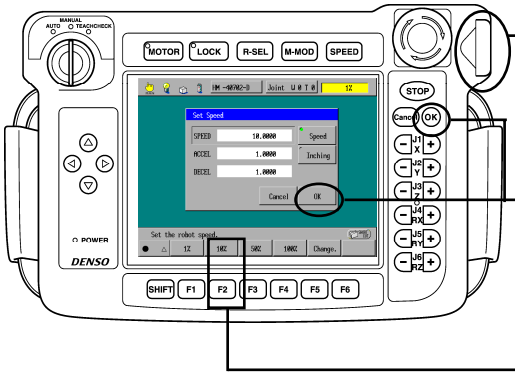
① Press [SPEED].

The [Set Speed] window is displayed.

The SPEED box should be selected, however if either the ACCEL or DECEL box has been selected, use the UP and DOWN cursor keys to select the SPEED box.

Cursor keys

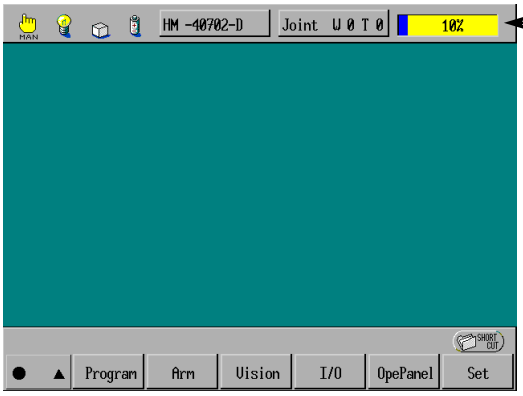
Speed setting tool bar



② Press [F2 10%]. (The SPEED value can also be changed with the Jog dial.)
(SPEED will be set at 10% and ACCEL and DECEL at 1%.)

③ Press [OK].

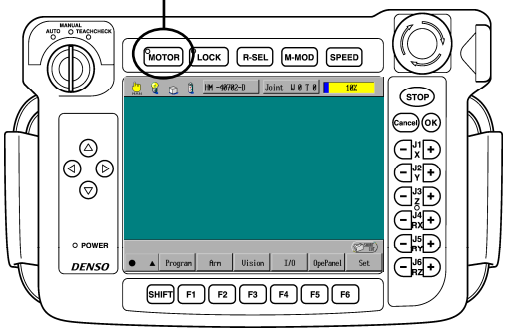
★**Remarks**★ At the beginning, leave these settings as they are, as you will be running the robot slowly to ensure safety. The settings can be changed later on, after you have become accustomed to running the robot with the teach pendant.



The SPEED display will become 10%.

Step 5

Turning the motor ON



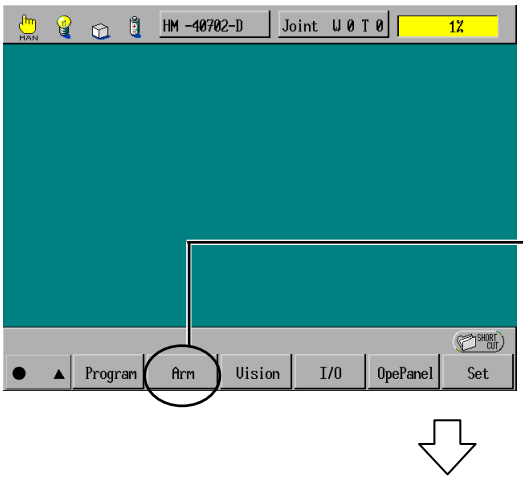
① Press [MOTOR].
The power to the motor and the [MOTOR] lamp come on.

Step 6

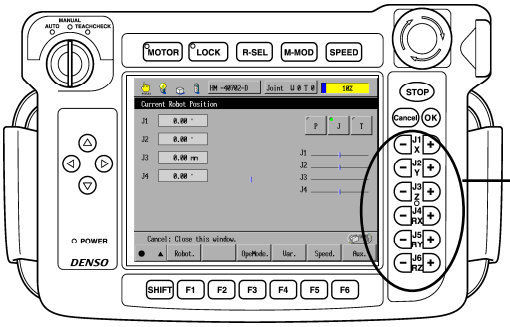
Caution

Moving each arm of the robot manually

When this operation is performed, the robot arm will move. Any workers should leave the robot's restricted space.



① Press [F2 Arm].



② While observing the robot, press the deadman switch and the arm traverse keys.

The arm corresponding with the operation of the J1 to J4 (4-axis robot) or J1 to J6 (6-axis robot) arm traverse keys will move. In the Current Robot Position window the angle of each axis will be displayed.

Step 7

Performing CAL (calibration) (for **-D series and XYC series only)

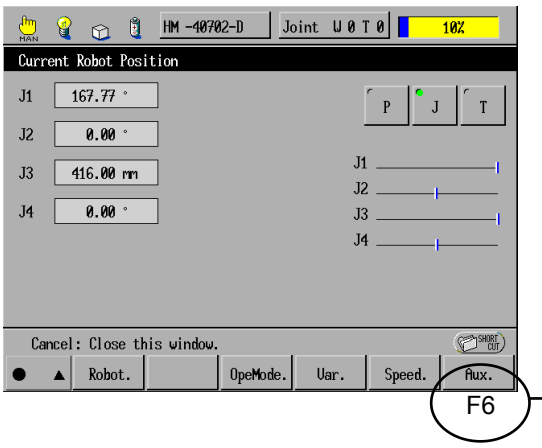
CAL stands for calibration, which actuates all robot axes to move the robot arm in small motions in order to confirm the current arm position after the controller power is turned ON.

The CAL procedure is described below.

★Remarks★ For the **-E/-F/-G series (except XYC series) and VM-6083D/-60B1D robots, skip Step 7 since no CAL is required. (Performing CAL even for those robots generates no problem.)

Only the **-D series and XYC series require CAL to run the robot using accurate values.

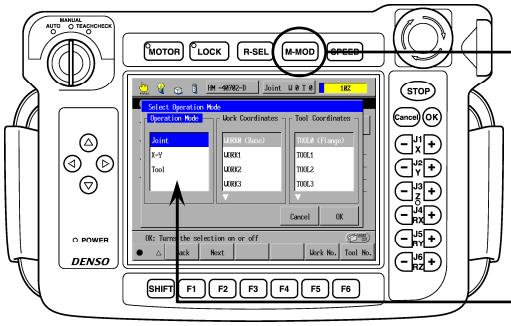
Caution Performing CAL will move the robot arm. Before proceeding, be sure that all workers have left the robot's restricted space and that there are no obstacles in the robot's restricted space.



① Press [F6 Aux.] with the [Current Robot Position] window displayed.

Step 8

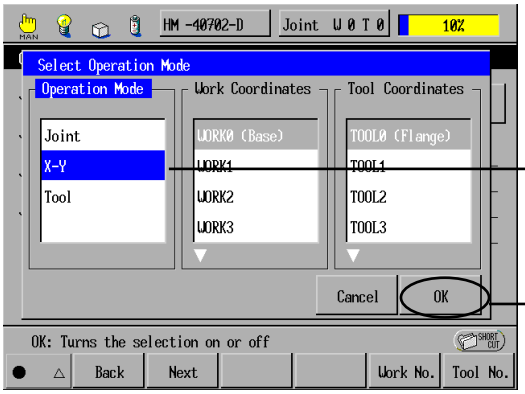
Selecting Manual mode and running the robot manually



① Press [M-MOD].

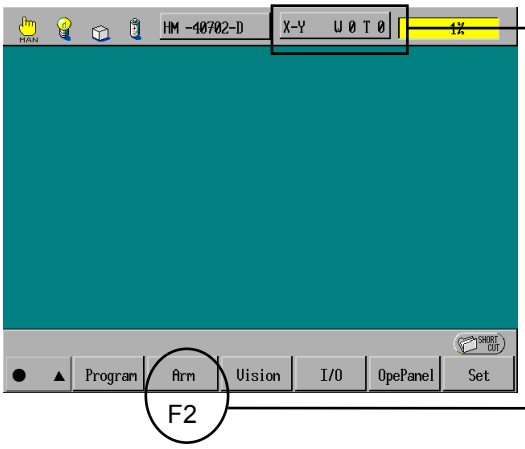
The [Operation Mode] window is displayed.

In this lesson, you will practice running the robot in X-Y mode.



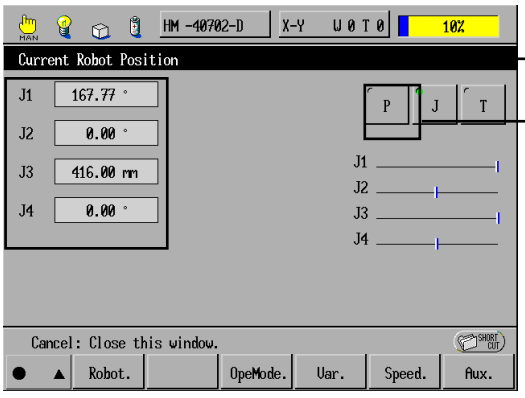
② In the [Select Operation Mode] window, select "X-Y" (use the UP and DOWN cursor keys or the Jog dial).

③ Press [OK].



X-Y appears on the status bar.

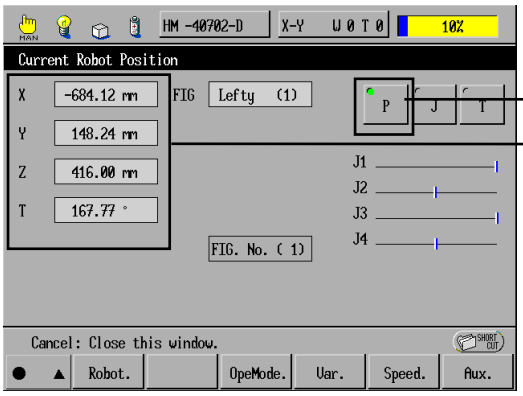
④ Press [F2 Arm].



The Current Robot Position window appears.

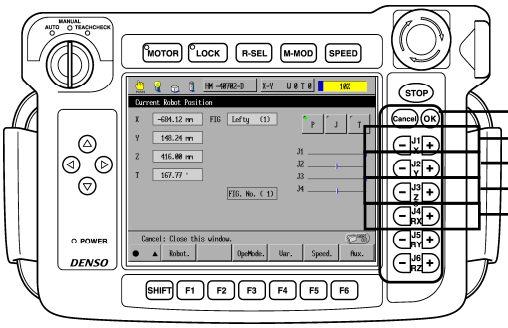
⑤ Press the P (position variable) button to show the current robot position. You may press the shift key and [F7 Show P] in the menu bar, instead of the P button.

(This is necessary to run the robot in X-Y mode.)

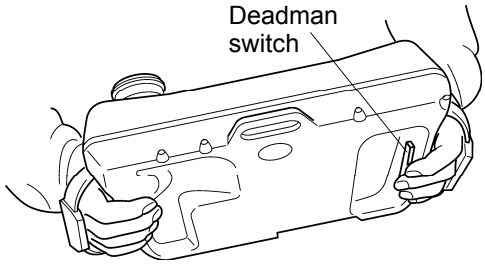


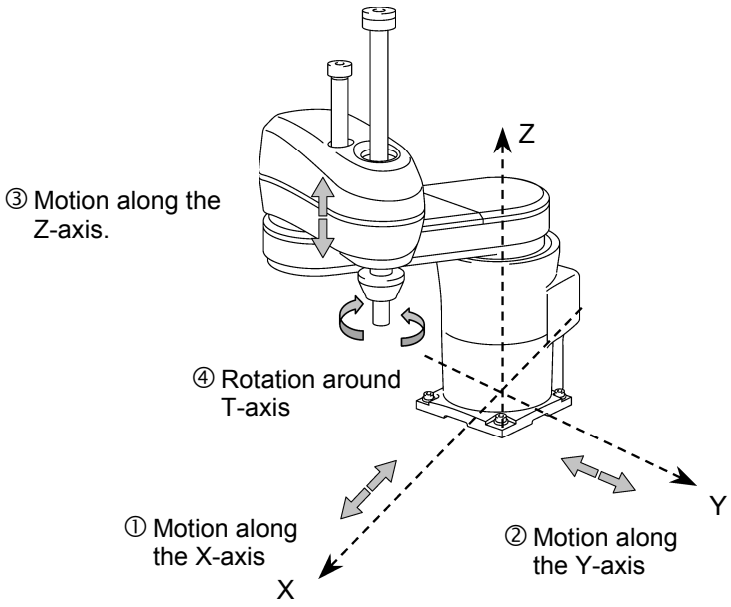
The P lamp comes on and the screen changes to one where the current robot position is expressed in position variables.

⑥ Run the robot by pressing the arm traverse keys with the deadman switch held down.



Arm traverse keys
① Motion in X direction
② Motion in Y direction
③ Motion in Z direction
④ Rotation around T-axis





Chapter 8
Teaching

8.1 What is Teaching?

Teaching refers to a method of programming in which you guide a robot through its motions using the teach pendant. In teaching, the robot is taught its motion.

In programming, you can specify positions as constants. However, in order to make the robot accurately learn the relative positional relationship between itself and objective point, you need to move the robot actually on site. Consequently, you write positions as variables in programming and assign actual values to those variables by on-site teaching.

8.2 Global Variables Available in Teaching

A variable refers to a program identifier for a storage location which can contain any number or characters and which can vary in a program. The following three types of variables are available in teaching.

Pos. (Position variable)	X, Y, Z, RX, RY, RZ, and FIG for 6-axis robots
	Z, Y, Z, T, and FIG for 4-axis robots
Joint. (Joint variable)	J1, J2, J3, J4, J5, and J6 for 6-axis robots
	J1, J2, J3, and J4 for 4-axis robots
Tran. (Homogeneous transform matrix variable)	
	X, Y, Z, 0x, 0y, 0z, Ax, Ay, Az, and FIG for 6- and 4-axis robots

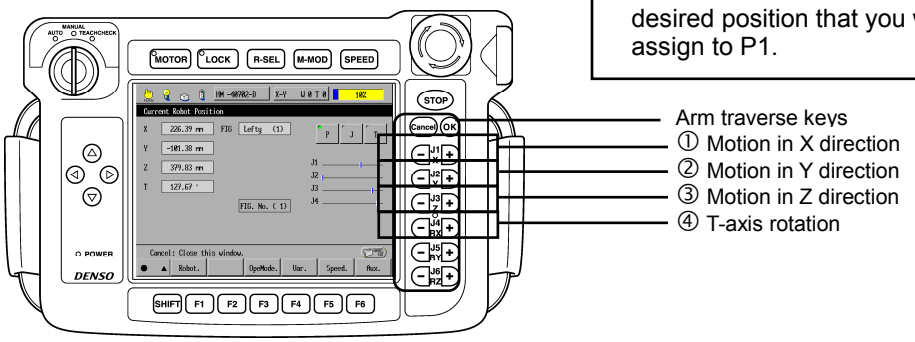
Up to 32766 variables can be used per variable type, but the actual number available may be smaller depending on the controller memory size available.

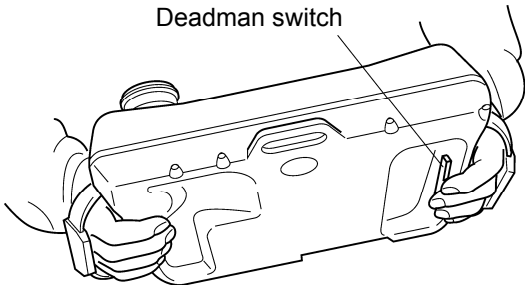
8.3 Teaching to Position Variables

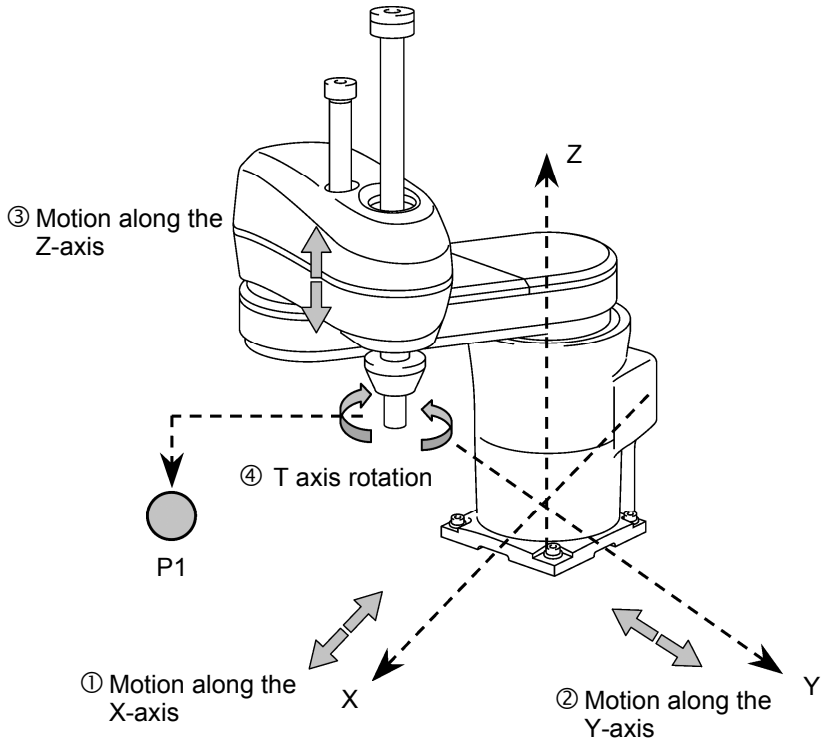
This section describes how to teach to position variables P1 and P2.

Step 1 Teaching the robot position P1

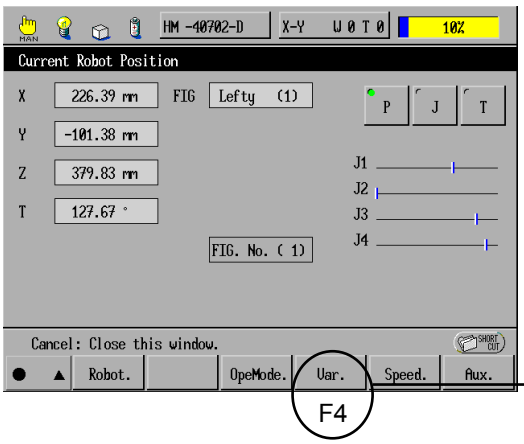
① While holding down the deadman switch, press the appropriate arm traverse keys to move the robot arm to the desired position that you want to assign to P1.



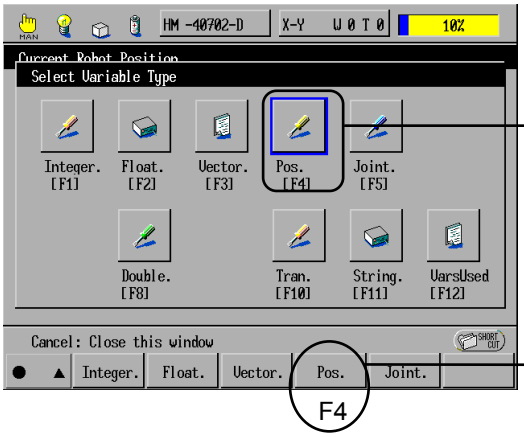




Step 2 Assigning the taught value to [Variable P1]



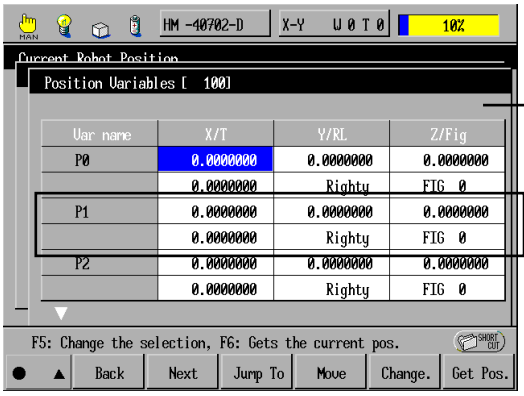
① Press [F4 Var.].



② Select the variable type in the [Select Variable Type] window.

At this point, press [F4 Pos.] to assign a value to a position variable.

(It is also possible to touch [Pos.] in the window.)

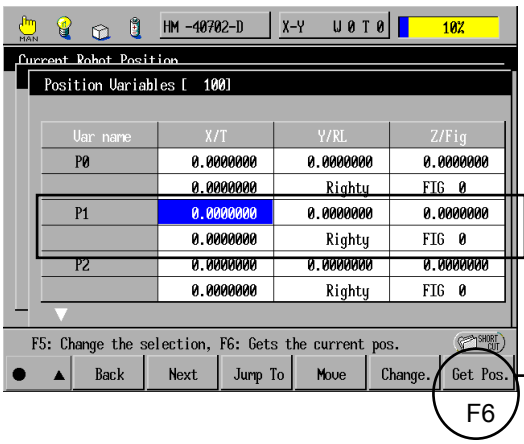


The [Position Variables] window appears.

③ Select the [P1] box using the cursor keys or jog dial.

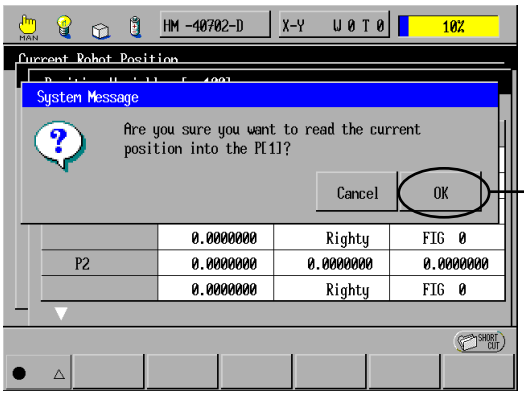
For 4-axis robots, the [Position Variables] window shows five types of data for each variable name.

If you select and highlight any one of them, for example, any in the [Var name P1] box, then it means that the [Var name P1] is selected.

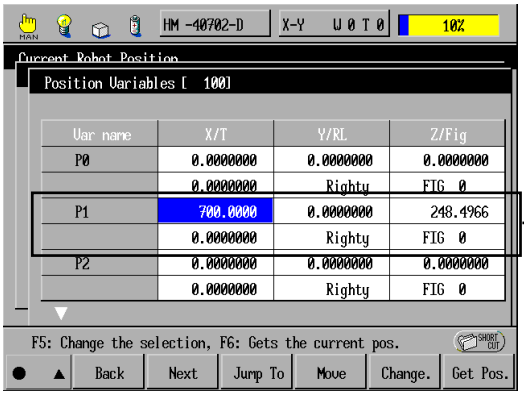


④ Check that the [Var name P1] is selected.

⑤ Press [F6 Get Pos.].

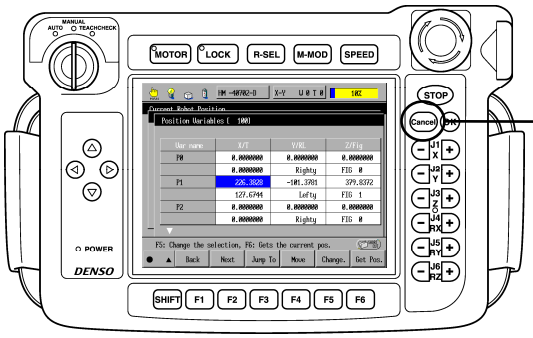


⑥ Check the system message and if all is correct, press [OK].

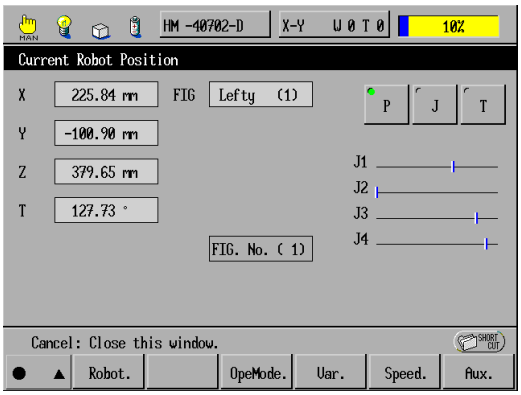


The current position will be read into variable P1.

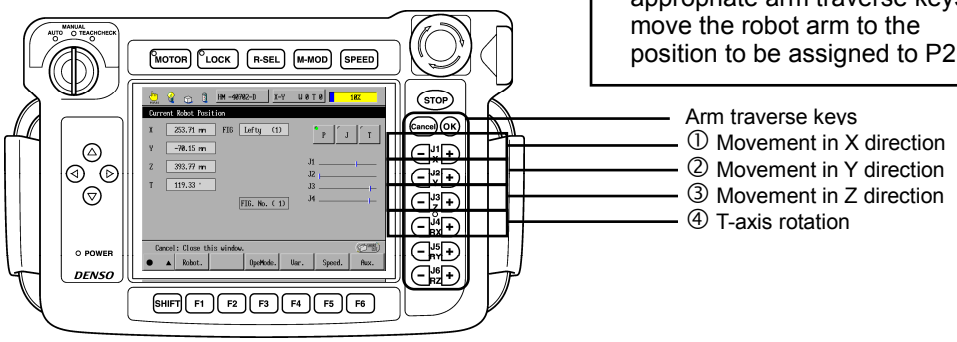
Step 3 Teaching robot position P2 and assigning it to [Var name P2]

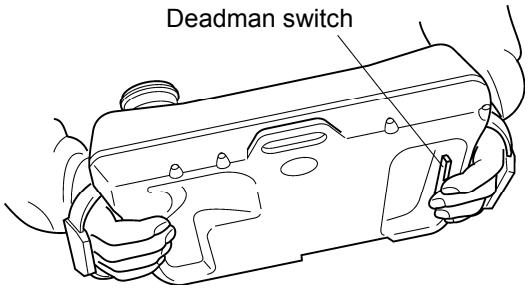


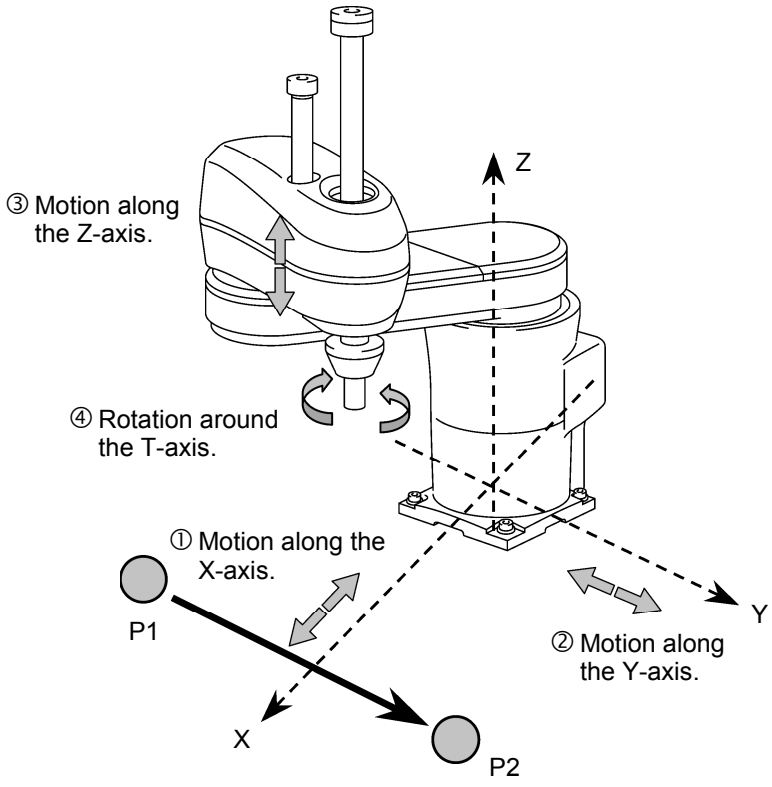
① Press [Cancel] twice to return to the [Current Robot Position] window.



② While holding down the deadman switch, press the appropriate arm traverse keys to move the robot arm to the position to be assigned to P2.







③ Assign the value taught for P2 to [Var name P2] in the same way as in Step 2, "Assigning the taught value to [Variable P1]."

This completes the teaching of P1 and P2.

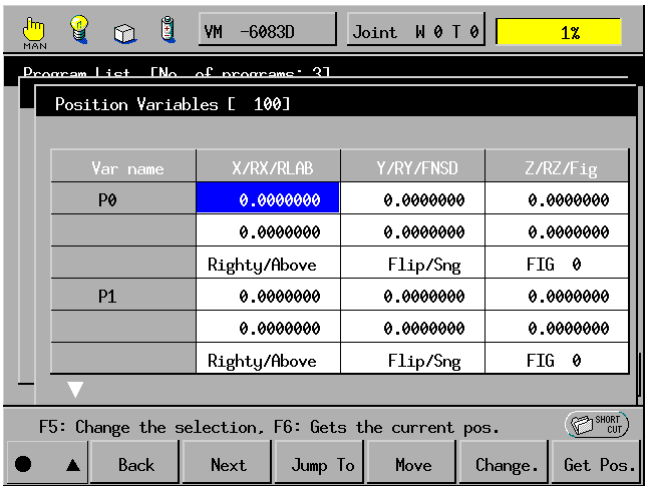
8.4 Moving the Robot Arm to the Position Taught to the Position Variable

In Manual or Teach check mode, you can move the robot arm directly to the position stored in the specified position variable.

Access: [F2 Arm]—[F4 Var.]—[F4 Pos.]

Pressing [F4 Pos.] calls up the Position Variables window as shown below.

Move the cursor to the target variable number.



Pressing [F4 Move] displays the system message "Will move to the position specified by the variable xx." Holding down the OK with the deadman switch held down moves the robot arm to the specified position. For this motion, you can also specify PTP (where the motion path to the target position is robot-dependent) or CP movement (where the robot arm moves straight ahead to the target position).

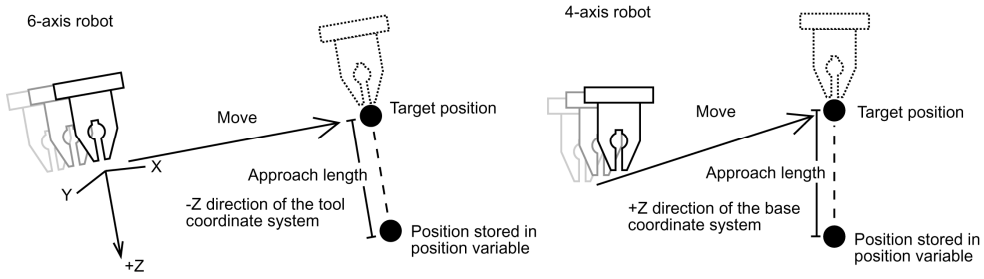
Note: Releasing the deadman switch or OK button while the robot arm is in motion will stop the robot arm.

Restart of movement (Version 2.61 or later)

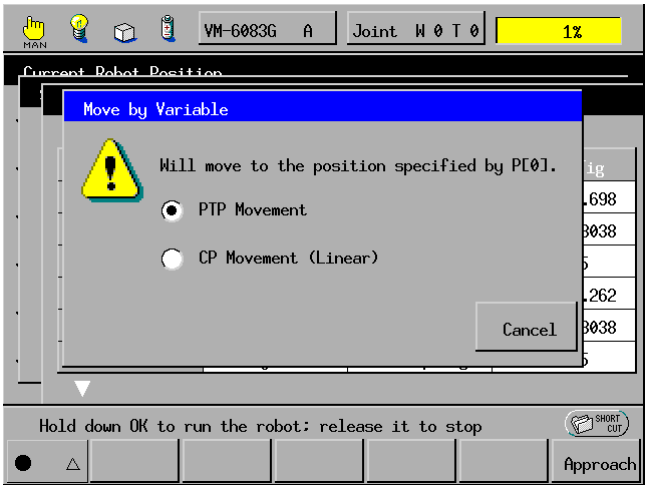
Releasing [OK] interrupts halfway the robot arm's movement, retaining the target position setting. Pressing [OK] with either one of the deadman switches held down again restarts the movement to the target position. Pressing [CANCEL] returns the screen to the Position Variables screen.

8.5 Moving the Robot Arm to the Target Position Specified with Approach Length [Version 2.61 or later]

A target position can be specified with a position variable stored plus an offset (called an approach length) from that stored position. In 6-axis robots, an offset is made in the -Z direction on the tool coordinates; in 4-axis robots, it is in the +Z direction on the base coordinates.
Moving the arm end to a target position specified with an approach length easily realizes the movement closer to the programmed one in Manual mode.
For details about the approach length, refer to APPROACH command in the PROGRAMMER'S MANUAL I.



On the "Move by Variable" window shown below, press [F6 Approach]. The numerical keypad appears where you enter the desired approach length and press [OK].



The following window appears showing that the target position is specified with the position variable plus approach length (offset).

Part 3

Simple Programming

Chapter 9
Basic Knowledge of Programming

9.1 Features of PAC Language

A programming language used to describe robot motion and work is called a robot language. The robot language used for DENSO robots is called PAC (Programming language for Assembly Cell). PAC was newly developed to increase efficiency in the development and maintenance of robot control programs over conventional languages. The major features are described below.

- It is upwardly compatible with the industrial robot language SLIM that conforms to JIS.
- Easy to read because it is a structured programming language, and this also makes development and maintenance easy.
- Not only robot programs can be described but also vision device control is universal with PAC.
- Program processing is effective as a result of a multitasking function.
- As a result of an interruption process function, exceptional processing, such as when an error occurs, can be described efficiently.

9.2 Statement and Line

- A PAC language program is configured with multiple lines.
- One statement can be described on an arbitrary line.
- The length of a line may be up to 255 bytes.
- A statement is the minimum unit to describe a process in the PAC language and it is comprised of one command.
- A command is comprised of a command name and the information (parameter) given to the command.

9.3 Name

The PAC language has regulations for identifying various elements in a program. This chapter provides an explanation of these regulations. Names that express commands, variables, functions, labels and programs follow the conventions described below.

- A name must begin with a character (one-byte alphabet, no discrimination between uppercase and lowercase letters) or ruled symbol.
- Characters, numerals and underscores can be used for names.
- The first character of a name must be an alphabet letter.
- A period, slash, back slash, blank, colon, semicolon, single quote, double quotation, and asterisk cannot be used.
- Characters such as +, -, *, /, (,) that are used as operators cannot be used.
- To distinguish the name from other words, place a blank character between the name and the other words.
- The maximum number of characters that can be used for a name is 64.

9.4 Maximum Number of Loadable Programs

The controller has room for a limited number of programs. The table below lists the maximum number for each file type. Note that the maximum number of actually loadable programs may be smaller depending on the memory capacity available.

File type	File format	Maximum number of programs
PAC program	***.pac	256
Header file	***.h	256 (total of header files and TP panel files)
TP panel file	***.pnl	
Folder		256

9.5 Overview of Program Configuration

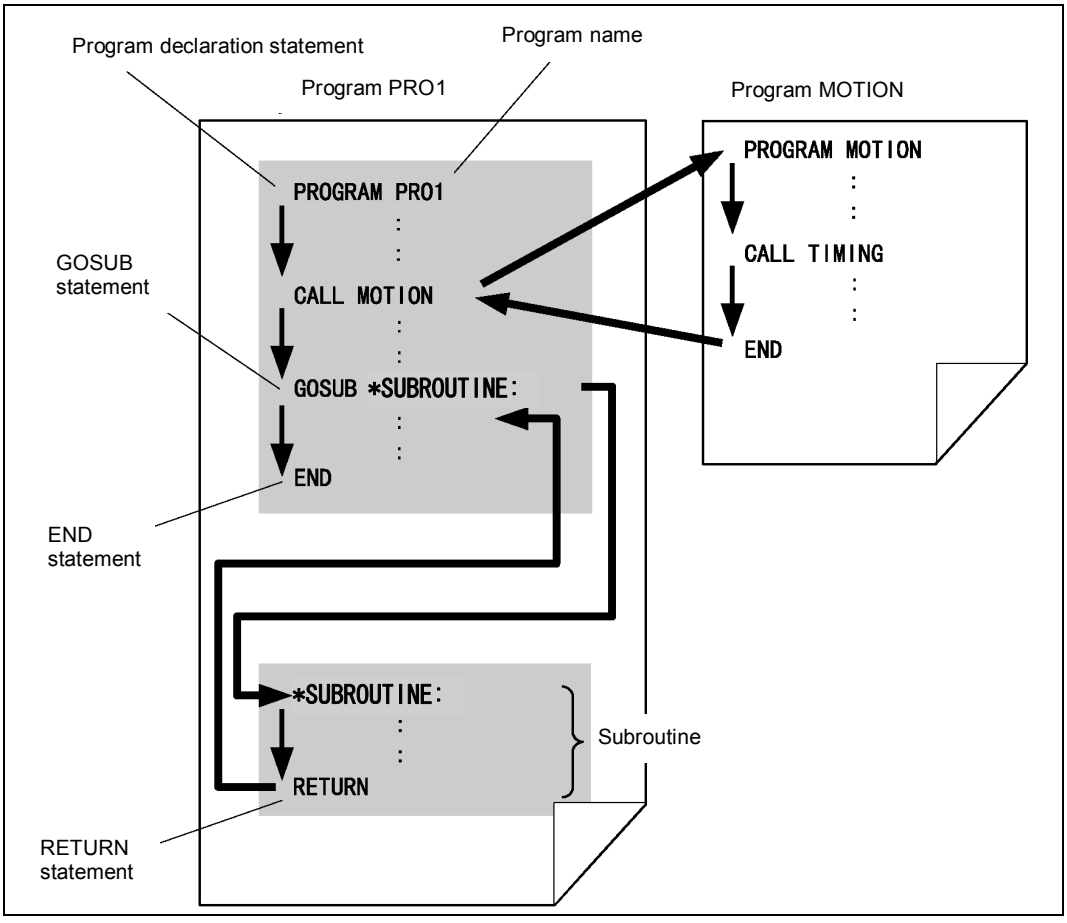
A section of a program that repeats a specific motion can be put out of the program and called if required.

The method of putting this section in the same program is called a subroutine. If this section is independently put in a separate file as another program and that program is called, this is referred to as calling a program.

A subroutine must be included in the same file as the calling program.

The program of an independent separate file can be called from various programs and commonly used.

If a series of work is organized as a unit of a subroutine or another program the same contents do not have to be described repeatedly. This is effective for correcting descriptions, reducing the creation time and otherwise improving the ease of reading programs.



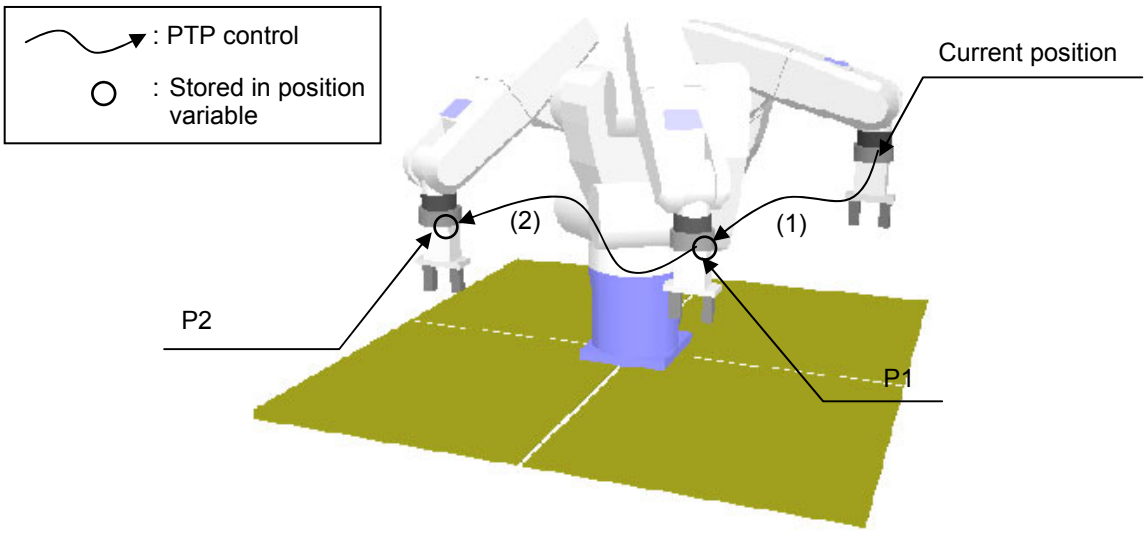
Difference Between Calling a Program and Calling a Subroutine

9.6 Main Commands Used in Programs

This section describes the minimum commands required in programming, using a simple motion program.

9.6.1 Program Example

In the example shown below, the robot arm moves from the current position to P2 via P1 under PTP control.



Program	Description
'TITLE "Program PRO1"	'Program title
PROGRAM PRO1	'Declare program name
TAKEARM	'Obtain the arm control priority
SPEED 100	'Set the arm motion speed (internal speed) to 100%
MOVE P, P1	'(1) Move to the specified position P1
MOVE P, P2	'(2) Move to the specified position P2
END	'End of program

9.6.2 Notational Conventions Used in Command Syntax

The following notational conventions are used in syntax of program commands.

- An underscore "_" indicates a space.
- Items enclosed in angle brackets < > must be described.
- Items enclosed in square brackets [ ] are optional, which can be omitted.
- Alphabets are not case-sensitive.

9.6.3 Declaring Program Names (PROGRAM command)

Description This command declares items required for program execution such as program names and variables prior to execution. A program name must be declared on the first valid line of the program. This statement is called a PROGRAM declaration statement.

Syntax PROGRAM_<program name>

Note: Programs to initiate from external equipment should have a name of "PRO <number>"

9.6.4 Obtaining an Arm Semaphore (TAKEARM command)

Description Under multi-tasking control, it is necessary to transfer/receive the arm semaphore (robot control priority). When using a motion command that moves the robot arm, be sure to insert a TAKEARM command so that the program can obtain the control priority.

Syntax TAKEARM

9.6.5 Stopping a Program (END command)

Description Executing this command ends the robot motion commanded by the program.

Syntax END

9.6.6 Specifying the Arm Speed (SPEED command)

Description The internal speed is specified in percentage (from 1 to 100).

Actual arm speed (%) = External speed (%) x Internal speed (%)

The external speed is the speed specified from external equipment such as the teach pendant or PLC.

A SPEED command is effective until the next SPEED command is executed.

Syntax SPEED_<motion speed>

9.6.7 Comment (REM command)

Description This statement declares the remainder of a program line to be remarks or comments.

Syntax '[<comment>](or, REM_[<comment>]

9.6.8 Movement to the Specified Coordinates (MOVE command)

Description This statement moves the robot from the current position to the target position specified by <pose>.

Syntax MOVE_<interpolation method>,[@<pass start displacement>]_<pose>
[,<motion option>]

9.6.8.1 Interpolation method

<interpolation method> is P, L, or C.

P: PTP (Point to Point) control

When moving the robot arm from the current position to the target position, the robot decides the route.

L: CP (Continuous Path) control--linear interpolation

When moving the robot arm from the current position to the target position, the robot keeps the pose and speed of the hand constant.

C: CP (Continuous Path) control--arc interpolation

When moving the robot arm from the current position to the target position, the robot moves its hand along the 3-point curve.

9.6.8.2 Pose

<pose> can have any of the position, joint, or homogeneous transform matrix type to which a target position should be assigned.

The configuration of variables differs depending upon the number of the robot axes.

Although inputting values for coordinates is possible, the formats Pxx or Jxx are often used.

Robot	Variable Name	Configuration of variables						
4-axis	Position variable	X	Y	Z	T	FIG		
	Joint variable	J1	J2	J3	J4			
6-axis	Position variable	X	Y	Z	RX	RY	RZ	FIG
	Joint variable	J1	J2	J3	J4	J5	J6	

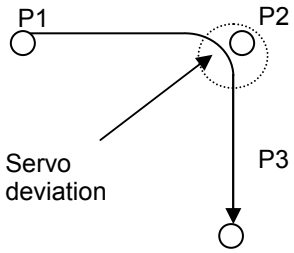
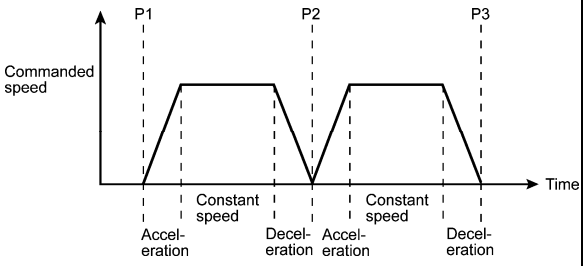
Example

```
PROGRAM PRO5    'Declare program name
   TAKEARM      'Obtain arm semaphore (arm control priority)
   SPEED 80     'Set the internal speed at 80%
   MOVE P,P1    'Move to P1 position under PTP control
   MOVE L,P2    'Move to P2 position under CP control
   MOVE L,P3    'Move to P3 position under CP control
END             'End of program
```

9.6.8.3 Pass start displacement

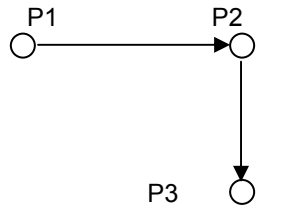
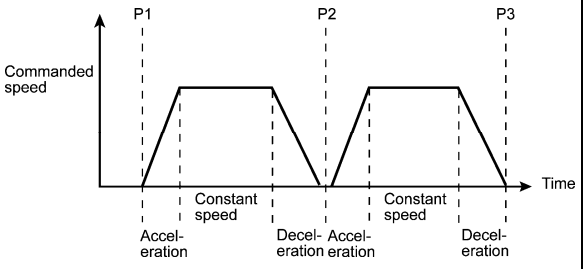
<pass start displacement> is the radius of a sphere whose center is located at the destination position, and it is expressed in units of mm. When the commanded motion value reaches the sphere, control passes to the next one. In other words, this value determines how to stop at the specified point. End motion, encoder value check motion, or pass motion can be selected as control transfer to the next statement.

End motion (@0, or when omitted)

Program	Motion diagram	Motion waveform
PROGRAM PRO*** TAKEARM MOVE P, @0 P2 MOVE P, @0 P3 :		

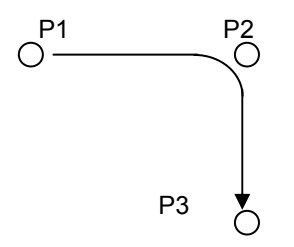
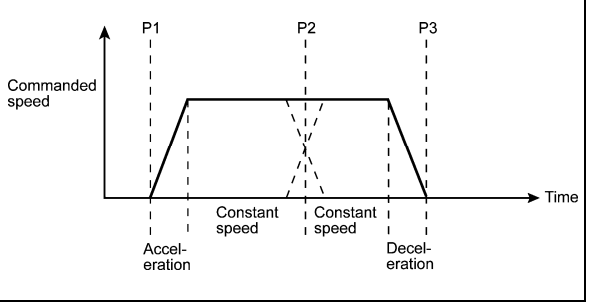
In the end motion, the robot judges that the tool end has arrived at the target position when it reaches the taught position P2 (called as the end position) and the command value to the servo system becomes the target one.

Encoder value check motion (@E)

Program	Motion diagram	Motion waveform
PROGRAM PRO** TAKEARM MOVE P, @E P2 MOVE P, @0 P3 :		

In the encoder value check motion, the robot judges that the tool end has arrived at the target position when the encoder value reaches the specified pulse range (default value is 20). Although this motion offers higher accuracy of stopping, it takes longer time than the end motion to eliminate the servo deviation.

Pass motion (@P)

Program	Motion diagram	Motion waveform
PROGRAM PRO*** TAKEARM MOVE P, @P P2 MOVE P, @0 P3 :		

In the pass motion, the tool end passes near the taught position P2 (called as the passing point).

Specifying the motion type

Motion type	Description format	Meaning
End motion	Omitted	Treated as the default value @0.
	@0	When the motion command value reaches the target position (specified coordinates), the robot moves on to the next motion. This is the commonly used end motion.
Encoder value check motion	@E	The robot checks the arrival at the target position with the encoder value and then proceeds to the next motion. The robot comes to a complete stop once.
Pass motion	@P	The tool end passes near the target position. (The controller automatically determines the radius.) This is the commonly used pass motion.
	@1 to @255	When the motion command value reaches the point away from the target position by the specified radius (1 to 255 mm), the tool end moves on to the next motion. **Note:** The radius is only a guide value, not the guaranteed value.

9.6.8.4 Motion option

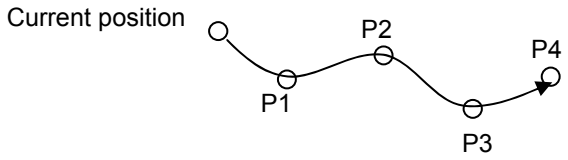
<motion option> is any of SPEED, ACCEL, or DECEL. Specification of <motion option> is effective only for motion commands such as MOVE to be executed.

Motion option	Meaning
SPEED (or S)	Specifies the motion speed.
ACCEL	Specifies the acceleration.
DECEL	Specifies the deceleration.

9.6.8.5 Other input examples

A continuous motion specified with two points or more can be written in one line.

```
MOVE P, @P P1, @P P2, @P P3, @E P4
```



Note: A single step contains all motions up to P4. A Step forward or Step stop operation, therefore, cannot stop the motion in midstream, such as at P1, P2, or P3.

Example

```
MOVE L, P1, SPEED = 100          'Move to P1 position at the internal speed 100%
                                 'under CP control
MOVE P, @30 P2, P3, S = 80       'Move to P2 (@30) and then P3 at the internal speed
                                 '80% under PTP control
MOVE L, @20 P4, @50 P5, @100 P6  'Move to P4 (@20), P5 (@50), and P6 (@100) in this
                                 'order under CP control
MOVE L, @P P[6 TO 15], P16       'Move to P[6] through P[15] in pass motion,
                                 'then to P16 position under CP control
MOVE C, P1, @P P2                'Move to P2 via P1 in arc interpolation.
                                 'Move near P2 in pass motion and then transfer control
                                 'to the next statement
```

9.7 Movement in the Z-Axis Direction (APPROACH and DEPART commands)

If the robot hand moves from any point directly to the target point in order to pick or place a workpiece, it may collide with other surrounding objects. To prevent such collision, in most cases, the robot hand should move once to a position above the workpiece and then move down and up straight. This section describes the motions dedicated to the Z-axis direction.

9.7.1 Approach in the Hand Direction (APPROACH command)

This command moves the tool end to the approach point that is specified in the Z-axis direction and `<approach length>` away from the target point.

Syntax

```
APPROACH_<interpolation method>,<base position>,
[@<pass start displacement>]_<approach length>[,<motion option>]
```

Description

(1) `<interpolation method>` is either `P` (PTP control) or `L` (CP control).

(2) `<base position>` can have the position, joint, or homogeneous transform matrix type of data.

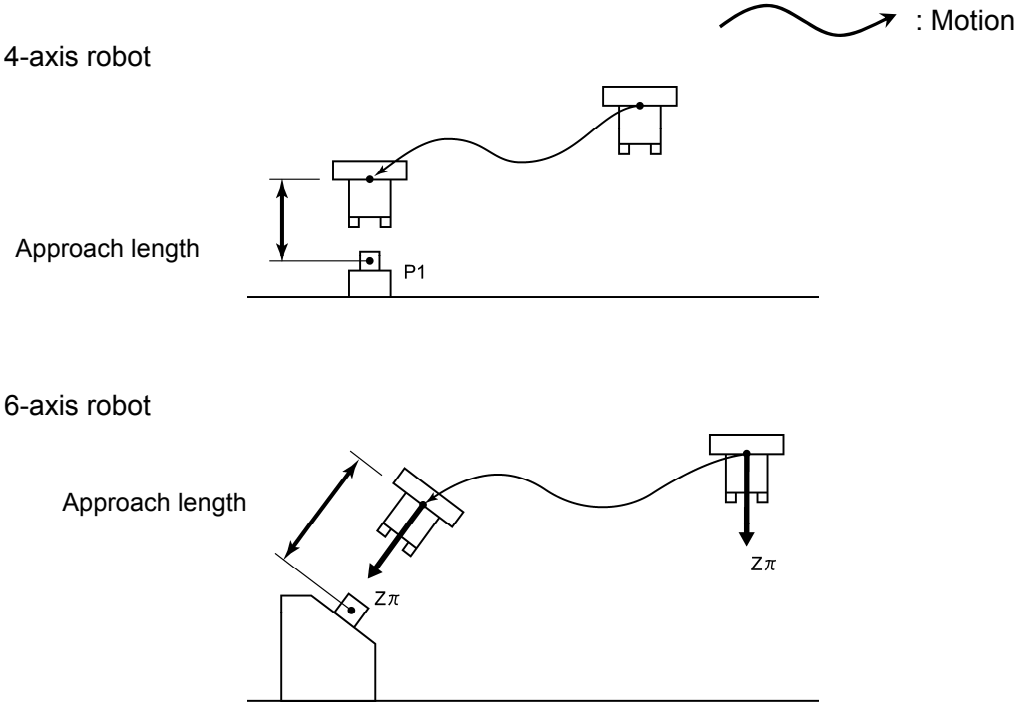
(3) The approach direction differs depending upon the robot type.

- 4-axis: The tool end moves to a position `<approach length>` away from the `<base position>` in the +Z direction of the base coordinate system.
- 6-axis: The tool end moves to a position `<approach length>` away from the `<base position>` in the -Z direction of the tool coordinate system.

(4) `<pass start displacement>` and `<motion option>` are the same as in the `MOVE` command.

Example

```
APPROACH P,P1,@P 50      'Move the tool end 50 mm above the position specified by the
                         'position variable P1 in path motion under PTP control
```



9.7.2 Dodging Movement in the Hand Direction (DEPART command)

This command moves the tool end to the depart point that is specified in the Z-axis direction and <depart length> away from the current position.

Syntax

```
DEPART_<interpolation method>,[@<pass start displacement>]
_<depart length>[,<motion option>]
```

Description

(1) <interpolation method> is either P (PTP control) or L (CP control).

(2) The depart direction differs depending upon the robot type.

4-axis: The tool end moves <approach length> mm from the current position in the +Z direction of the base coordinate system.

6-axis: The tool end moves <approach length> mm from the current position in the -Z direction of the tool coordinate system.

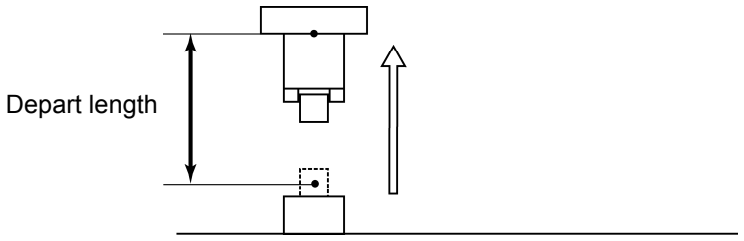
(3) <pass start displacement> and <motion option> are the same as in the MOVE command.

Example

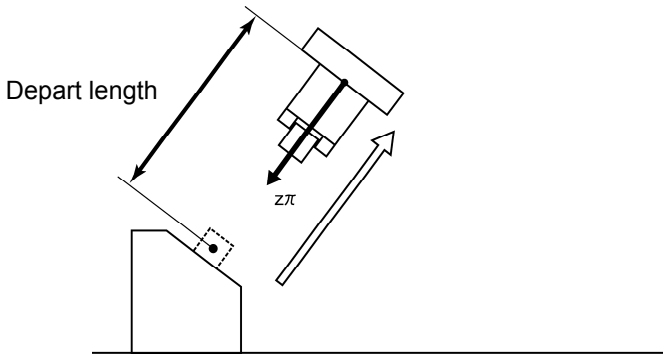
```
DEPART L,@P 50      'Move the tool end 50 mm above the current position in path motion
                    'under CP control
```

: Motion

4-axis robot



6-axis robot

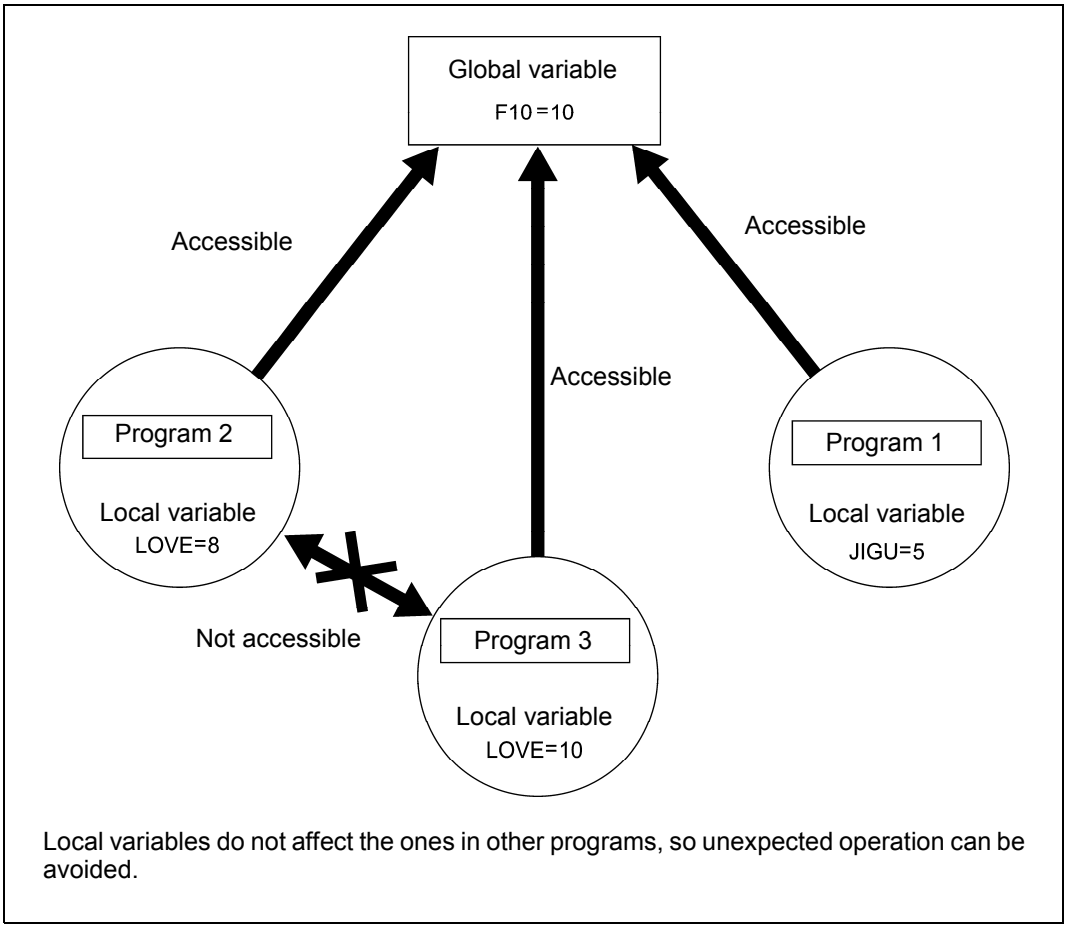


9.8 Scope of Variables

A variable refers to a temporary storage area for data used in a program. Global and local variables are available.

A global variable can be accessed by any programs (tasks) to share information between those programs.

A local variable can only be accessed in a program where it is defined. Since local variables are restricted in access, they can be defined with a same name in different programs. Those variables do not affect each other.



Global Variables and Local Variables

• Properties of global variables

(1) Accessible from any programs (shared by all programs).

(2) Available without declaration.

(3) Can be assigned a macro name.

• Properties of local variables

(1) No interference with variables in other programs.

(2) Their values will be initialized when compiled.

(3) Their names can be decided freely. (Max. 32 characters)

(4) Up to three-dimensional array can be declared. (maximum 32767 elements)

9.8.1 Global Variable

The name of a global variable is expressed with an alphabet letter(s) (I, F, D, S, V, P, J, T, IO) that expresses the type and an integer expression. Only an I/O variable has two letters (IO).

For example, F0001, F1, and F[1] all express the same floating-point variable of type real.

Since names of global variables are reserved by the system, they can be used without declaration. The following types can be used as global variables.

- Type I: Integer variable (range: -2147483648 to + 2147483647)
  Example) I0001, I1, I[1]
- Type F: Floating-point variable of type real (-3.402823E + 38 to 3.402823E + 38)
  Example) F0001, F1, F[1]
- Type D: Double-precision variable of type real
  (-1.79769313486231D + 308 to 1.79769313486231D + 308)
  Example) D0001, D1, D[1]
- Type S: String variable (maximum of 247 characters)
  Example) S0001, S1, S[1]
- Type V: Vector variable (X, Y, Z)
  Example) V0001, V1, V[1]
- Type P: Position variable (X, Y, Z, RX, RY, RZ, FIG) (6 axes)
  Example) P0001, P1, P[1]
- Type J: Joint variable (J1, J2, J3, J4, J5, J6) (6 axes)
  Example) J0001, J1, J[1]
- Type T: Homogeneous transform variable
  (Px, Py, Pz, Ox, Oy, Oz, Ax, Ay, Az, FIG)
  Example) T0001, T1, T[1]
- Type IO: I/O variable
  Example) IO0001, IO1, IO[1]

Example:

```
I[1]=I[2]*I[3]
F[10]=50.3
S[3]="DENSO"+S[5]
J[5]=(10,20,30,40,50,60)
P[1]=P[4]
```

9.8.2 Local Variable

The following variable types can be used as local variables in the same manner as global variables.

- Type I: Integer variable (range: - 2147483648 to + 2147483647)
- Type F: Floating-point variable of type real (-3.402823E + 38 to 3.402823E + 38)
- Type D: Double-precision variable of type real (- 1.79769313486231D + 308 to 1.79769313486231D + 308)
- Type S: String variable (maximum of 247 characters)
- Type V: Vector variable (X, Y, Z)
- Type P: Position variable (X, Y, Z, RX, RY, RZ, FIG) (6 axes)
- Type J: Joint variable (J1, J2, J3, J4, J5, J6) (6 axes)
- Type T: Homogeneous transform variable (Px, Py, Pz, Ox, Oy, Oz, Ax, Ay, Az, FIG)
- Type IO: I/O variable

Local variables can be used after type declaration is executed using type declaration commands.

Type declaration can also be executed using the type declaration characters for numeric value type and character string type local variables.

Declaring local variables

There are three ways to declare local variables as shown below.

Type	Declaration example 1	Declaration example 2	Declaration example 3
Type I	`DEFINT denso`	`DIM denso As INTEGER`	`denso%`
Type F	`DEFSNG denso`	`DIM denso AS SINGLE`	`denso!`
Type D	`DEFDBL denso`	`DIM denso AS DOWBLE`	`denso#`
Type S	`DEFSTR denso`	`DIM denso AS STRING`	`denso$`
Type V	`DEFVEC denso`	`DIM denso AS VECTOR`	
Type P	`DEFPOS denso`	`DIM denso AS POSITION`	
Type J	`DEFJNT denso`	`DIM denso AS JOINT`	
Type T	`DEFTRN denso`	`DIM denso AS TRANS`	
Type IO	`DEFIO denso`		

Example:

```
DEFINT Denso, Robo                  'Declare integer variables Denso and Robo
DEFDBL AA                           'Declare double-precision variable AA
DEFIO Port = BYTE,104,&B00101011    'Declare the IO variable Port and use 8 bits (BYTE)
                                    'starting from input port 104
CC% = Denso * 2                     'Declare the integer variable CC and assign
                                    'the calculation result of Denso*2 to it
DD$ = "Denso Robot"                 'Declare the string variable DD and assign the
                                    'string "Denso Robot" to it
AA = F[5] / 5                       'Assign the result of the right side to the double-
                                    'precision variable AA
IN Robo = Port                      'Convert I/O data of Port into decimal and
                                    'assign it to the integer variable Robo
```

9.9 Initiating from External Equipment

In external automatic mode, a program can be initiated with input signals from external I/O.

Programs executable from external equipment are limited to the ones with a program name of the "PRO< number >."

Depending upon the I/O allocation mode selected, the number of programs executable from external equipment differs as listed below.

I/O Allocation Mode	PRO <number> executable
Mini I/O dedicated mode	PRO0 to PRO7
Standard mode	PRO0 to PRO32767
Compatible mode	PRO0 to PRO127

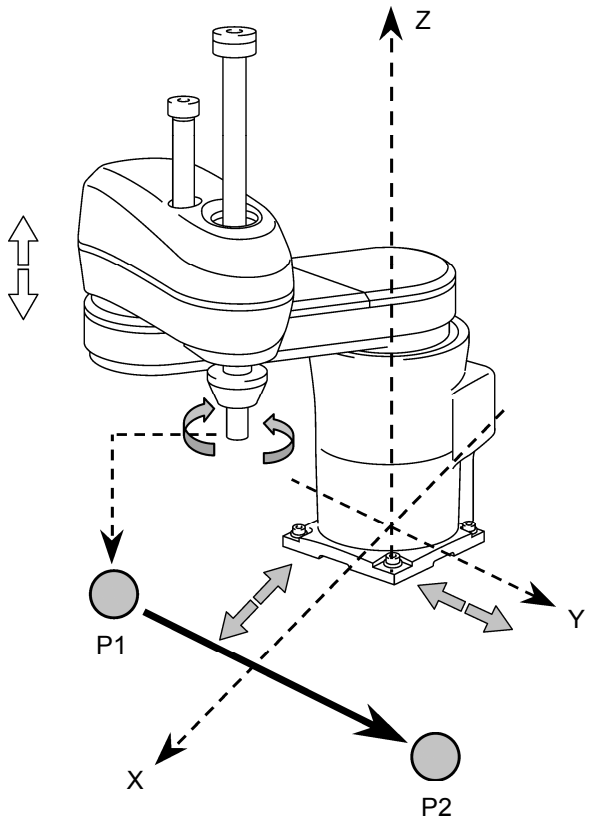
Note: External equipment can initiate only programs located in the root folder in the controller. When creating programs with a folder function, be careful about the storage location.

Chapter 10
Programming with Teach Pendant

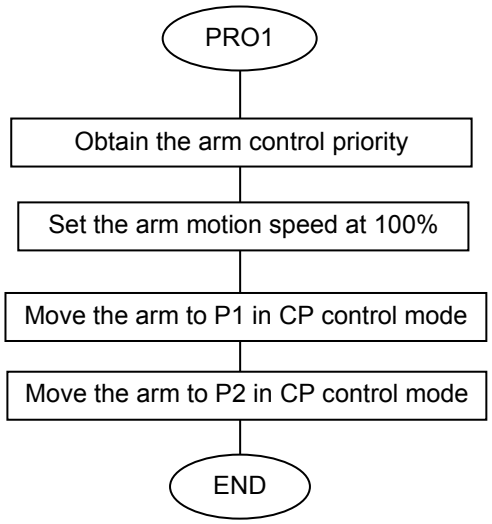
This chapter describes how to create a program using the teach pendant.

10.1 Overview of Sample Program

The sample program created in the following sections is for moving the robot arm from the current position to P1 and then P2.



Program Flow Chart

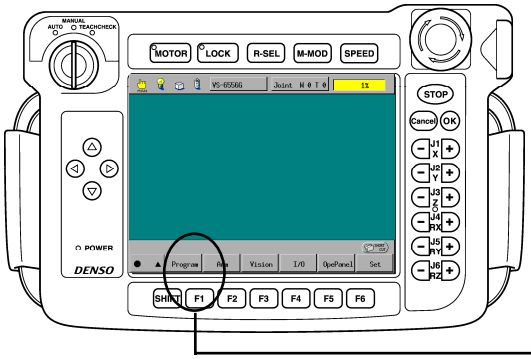


10.2 Creating a Program

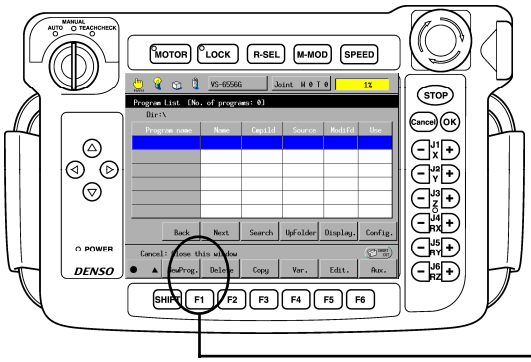
This section shows how to create a program using the teach pendant, with a simple example. When creating and editing a program, turn the operation mode to Manual.

10.2.1 Entering a New Program Name

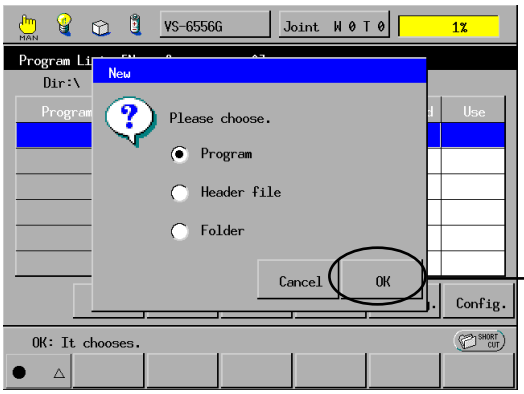
To create a new program, it is necessary to open the window for editing programs on the teach pendant screen.



① Press [F1 Program] on the top screen.

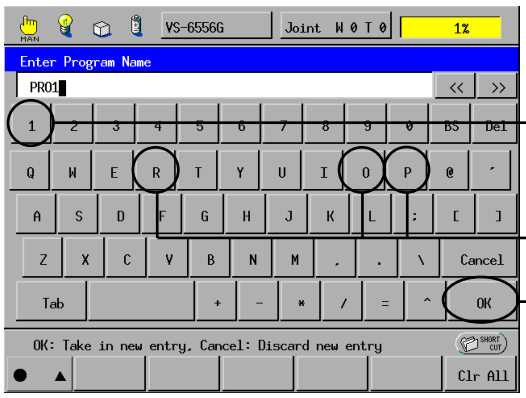


② Press [F1 NewProg.].



③ Select [Program] and press [OK].

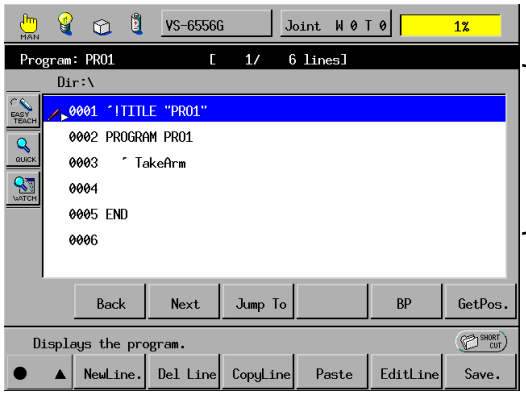
Next, type the file name of the program (here we will use PRO1) to be created.



④ Type PRO1 using the letter and numeric buttons.

⑤ After typing PRO1 correctly, press [OK].

This ends the preparation for program editing.



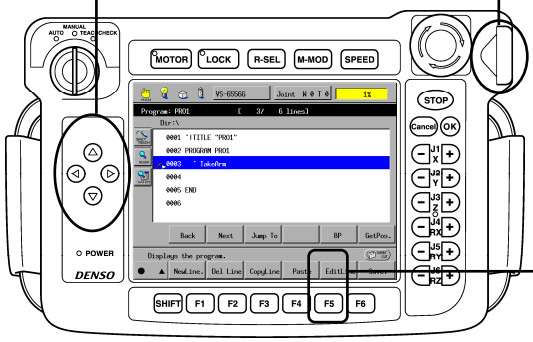
The preset program codes are displayed.

10.2.2 Entering Program Codes

In this step, you will create a program to move from P1 to P2. Enter the program codes listed in the table below.

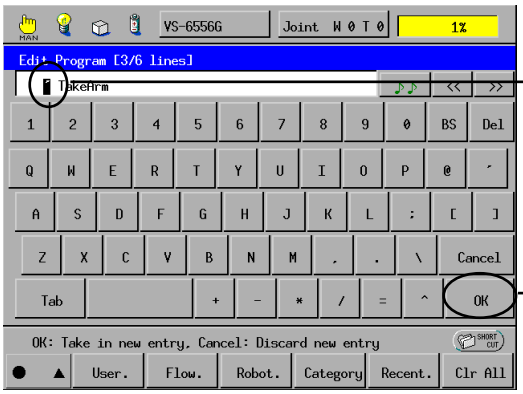
Coding List for "PRO1"

```
PROGRAM  PRO1
    TAKEARM          'Acquires the arm semaphore
    SPEED 100        'Specifies internal speed
    MOVE L, P1       'Moves to specified coordinates for P1
    MOVE L, P2       'Moves to specified coordinates for P2
    GIVEARM          'Releases the arm semaphore
END
```



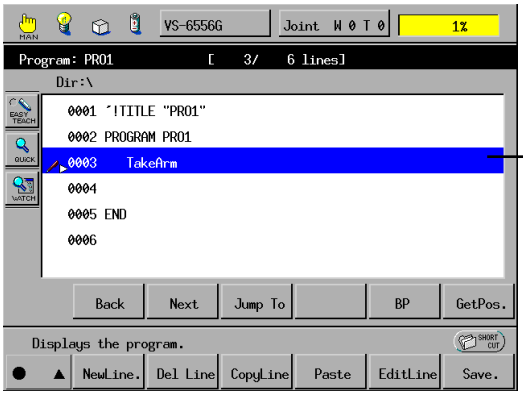
① In the "Program: PRO1" window, move the cursor to the 3rd line using the cursor keys or jog dial.

② Press [F5 EditLine].

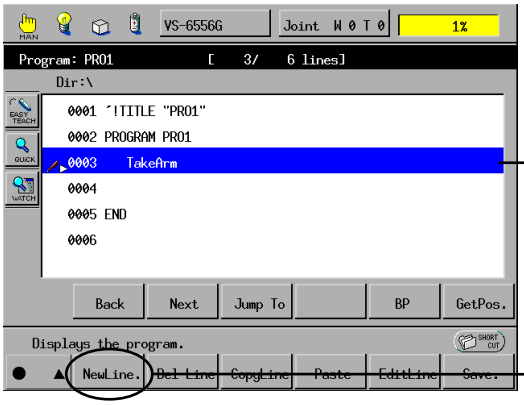


③ Delete the apostrophe (') from the head of the line using the cursor keys and [Del].

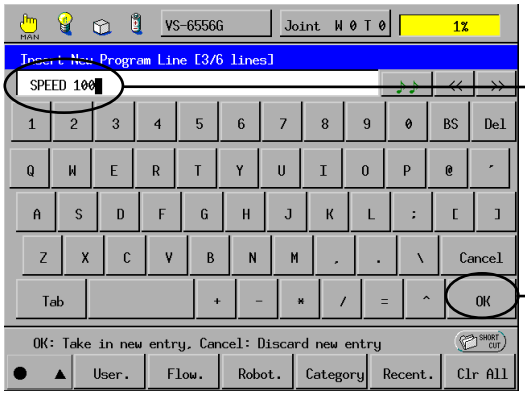
④ Press [OK].



The screen shows the program edit window [Program: PRO1] again where the 3rd line has been modified.

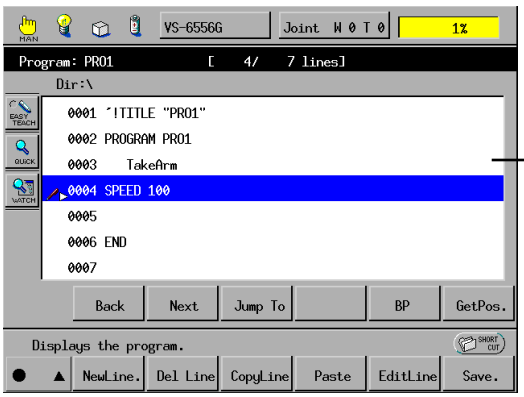


⑤ Move the cursor to the 3rd line and press [F1 NewLine.].

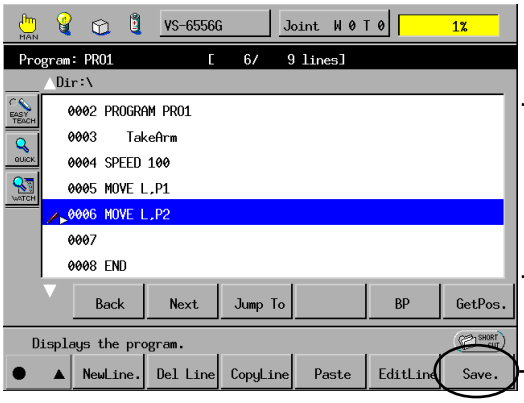


⑥ Enter "SPEED 100" from the keyboard. This is displayed in this window.

⑦ Press [OK].

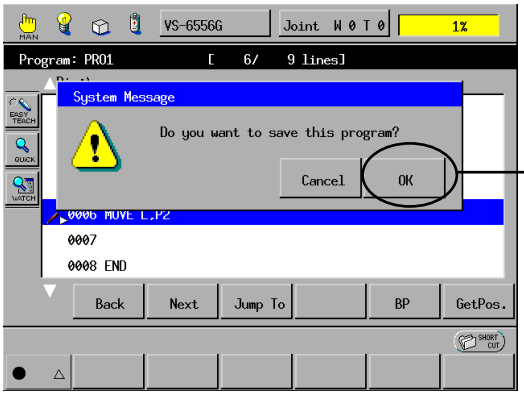


The program edit window "Program: PRO1" is displayed and "SPEED 100" is displayed in the 4th line.



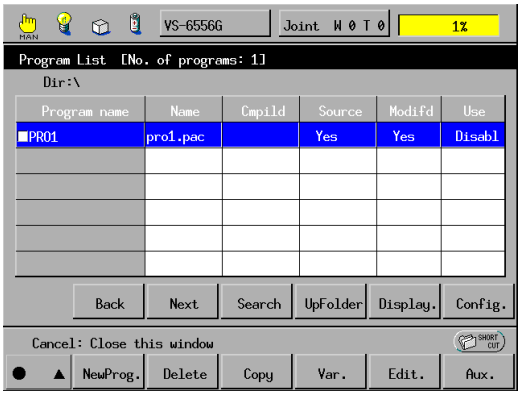
⑧ Enter all of the program codes given on p.10-3 in the same way used to enter "SPEED 100".

⑨ After completing entry of all codes, press [F6 Save.].



⑩ Press [OK] to save the newly entered program.

The display will return to the Program List window.



★**Caution**★

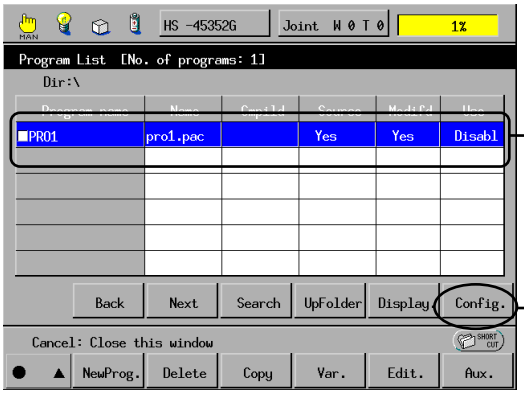
(1) If you do not want to save the changes made, press [Cancel] instead of [OK] and the display will return to the program edit screen without the changes being saved.

(2) To create a new program, return to Step 1.

10.2.3 Compiling the Program

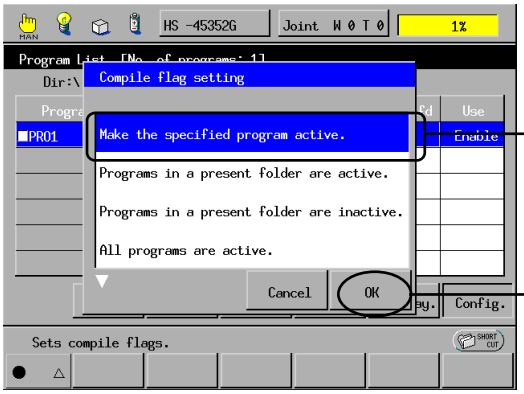
After editing a program, you need to compile it; that is, transform the edited program into run-time format which is executable by the robot controller.

During compiling, syntax errors will be detected if contained in the edited program. You need to correct all syntax errors since programs containing them cannot be loaded or executed.



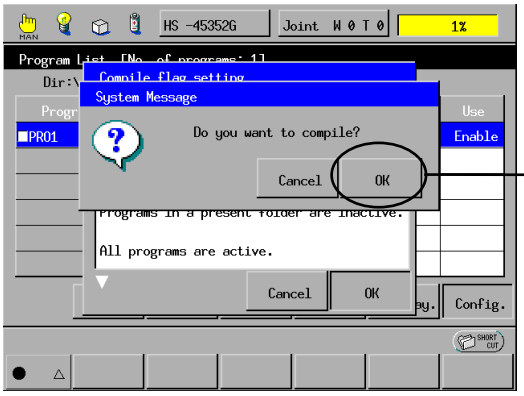
① Select "PRO1" in the Program List window.
(You may select it by using the cursor keys or jog dial, or by touching the screen directly.)

② Press [F12 Config.].



③ Select "Make the specified program active".
Selecting "All programs are active." is also possible.

④ Press [OK].



⑤ Press [OK].
Compiling will start.

★**Caution**★

(1) If you press [Cancel] instead of [OK] at this point, the screen will return to the [Program List] window without performing the compiling operation.

(2) There is one other way with which you may compile programs into run-time format.

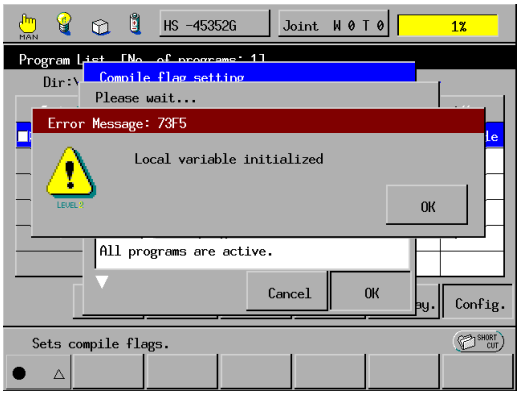
Press [F6 Aux.] in the [Program List] window to call up the [Auxiliary Functions (Programs)] window. In the window, press [F12 Compile].

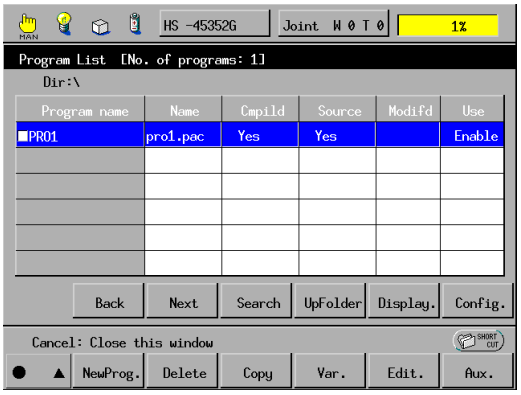
⇩

After the compiling is completed, loading of projects automatically starts.

⇩

If there is no syntax error, the message "Local variable initialized" is displayed.

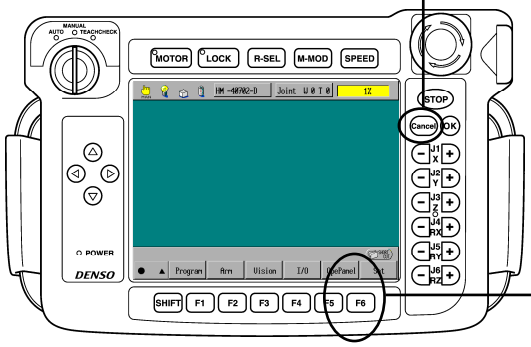




10.2.4 Loading the Program

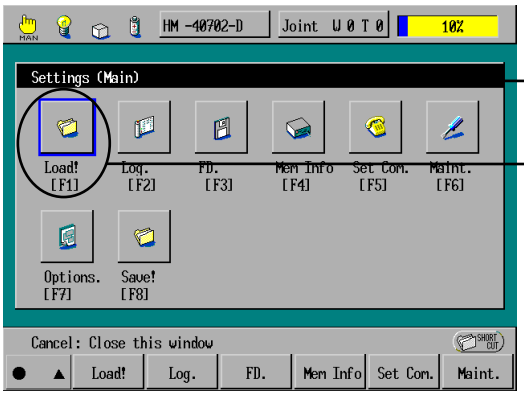
You need to load the compiled program so that the robot controller can execute it.

Even if compiled programs are transferred from the PC connected to the robot controller, they cannot execute. They need to be loaded to the memory area where the program can be executed.



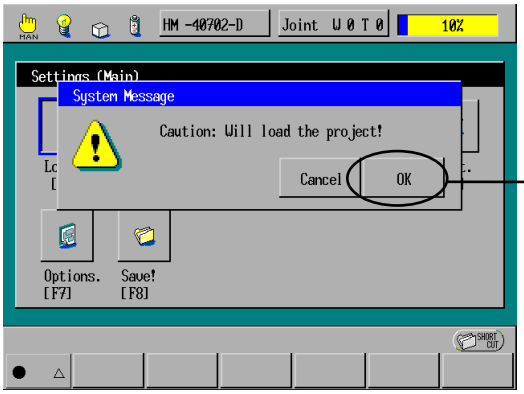
① Display the top screen.
(If any other screen is displayed, press [Cancel] as many times as necessary until the top screen appears.)

② Press [F6 Set] on the top screen.

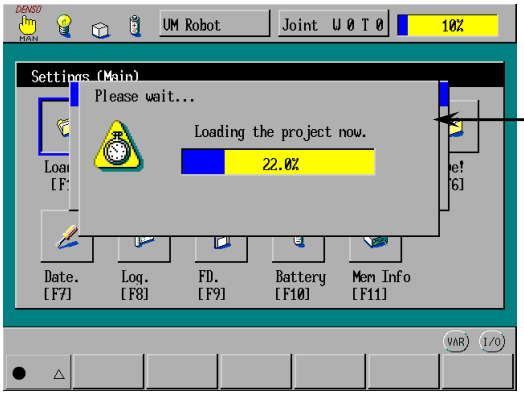


The [Settings (Main)] window appears.

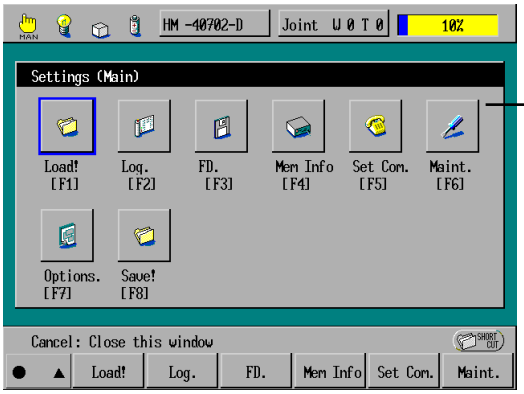
③ Press [F1 Load].



④ Press [OK].



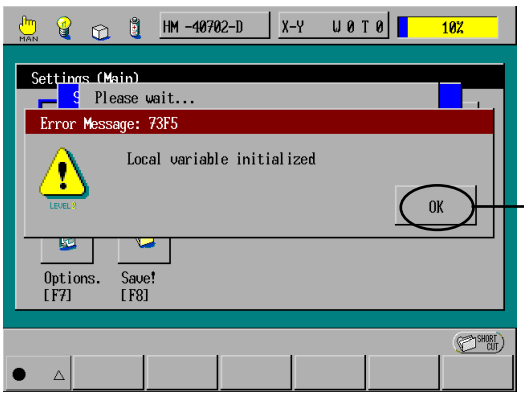
The message "Please wait... Loading the project now." is displayed.



Upon completion of loading, the screen returns to the [Setting (Main)] window.

★**Caution**★ If you load a project using local variables different from those used in the previous project, the error message "Local variable initialized" is displayed.

Press [OK] to continue.



⑤ Press [OK].

Now, the program is ready to execute.

Press [Cancel] to return to the top screen.

This completes the creation of the program to run the robot.

Chapter 11
Programming with WINCAPSIII

This chapter describes how to create a program using WINCAPSIII.

11.1 Preparation

This section provides the preparation items required for programming.

11.1.1 WINCAPSIII Available in Three Versions

WINCAPSIII is available in three versions as shown below. Depending upon the version, the functions are restricted.

(1) Trial version that comes with the robot. Printing, arm player Plus, 3D data import, monitoring interval, and a part of program bank are not available. Only one program named "PRO01.pac" is editable.

(2) Light version that comes with an optional mini-pendant. Printing, arm player Plus, 3D data import, monitoring interval, and a part of program bank are not available.

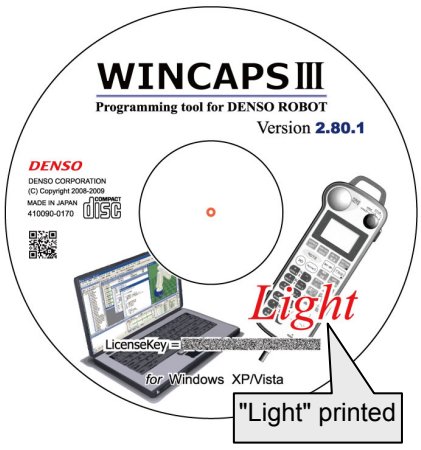
(3) Product version that is provided as an option. This product version CD is accomplished by the WINCAPSIII License Certificate.

Tip: If you purchase the robot set, optional mini-pendant, and optional WINCAPSIII product version at a time, all the three CD-ROMs will be delivered.

11.1.2 Appearance of CD-ROMs (CD Label)

Trial version

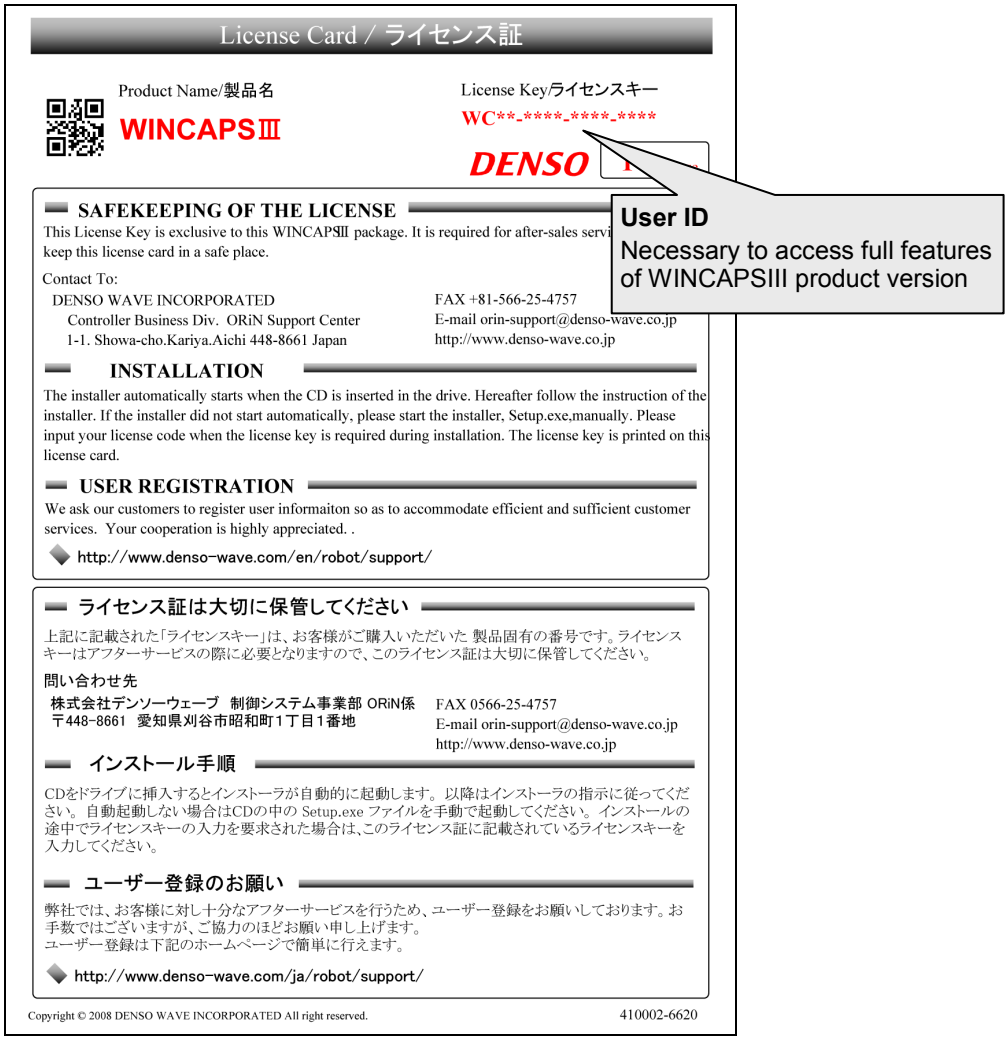
Light version



Product version

11.1.3 License Certificate (with User ID)

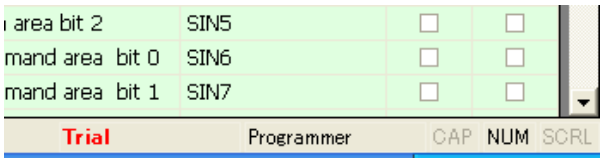
The WINCAPSIII product version package includes the license certificate. The light version or trial version has a license certificate printed on the CD surface.



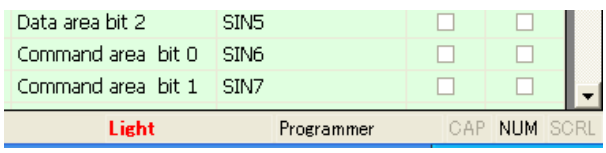
11.1.4 Checking the WINCAPSIII Version on PC Screen

The version of the currently installed WINCAPSIII can be checked on a PC screen as shown below.

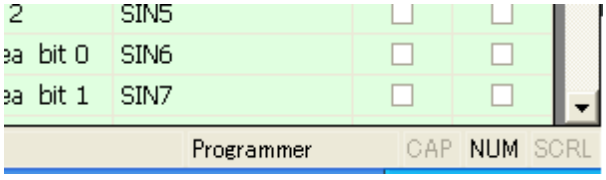
Trial version



Light version



Product version



11.1.5 Notes on Updating

WINCAPSIII is available in the trial, light, and product versions which are upgraded from trial to product versions.

Updating of those versions is possible with any version of the WINCAPSIII CD-ROM.

In the PC in which the *product* version has been installed, for example, using the *trial* version of the WINCAPSIII CD-ROM can update the existing *product* version to the newer one.

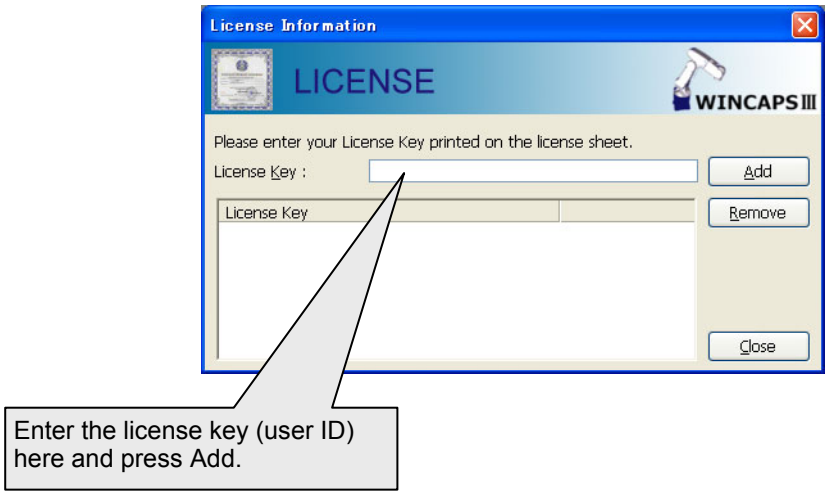
In the PC in which the *trial* version has been installed, using the *light* version of the WINCAPSIII CD-ROM can update and upgrade the existing *trial* version to the newer *light* version.

> **Tip:** Entering a license key (user ID) upgrades even the trial or light version to the product version.

11.1.6 Entry of License Key

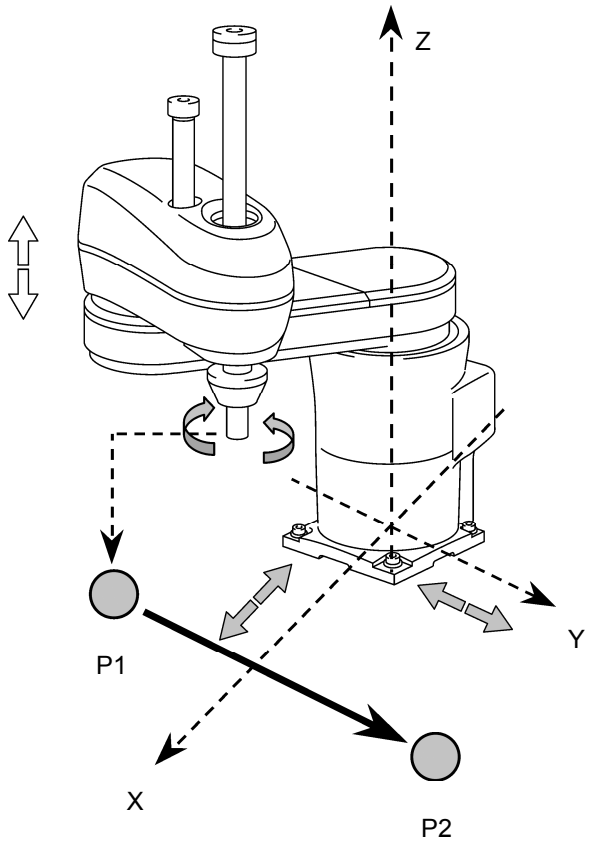
To upgrade your WINCAPSIII to the product version, enter the license key given on the license certificate into the License Information window.

To display the License Information window, choose Help | License.

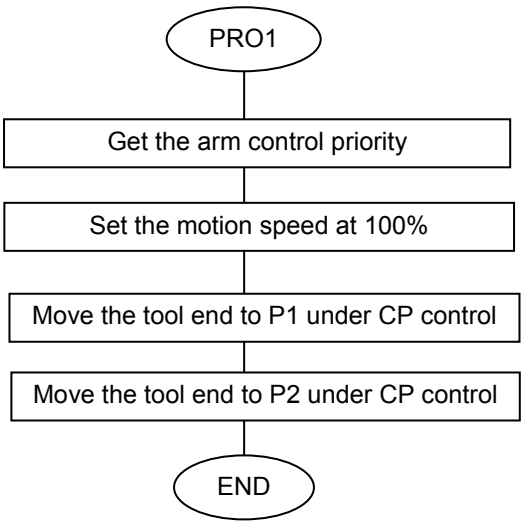


11.2 Overview of Sample Program

The sample program created in the following sections is for moving the robot arm from the current position to P1 and then P2.



Program Flow Chart



11.3 Creating a Program

This section shows how to create a program in WINCAPSIII, using a simple example.

11.3.1 Starting up WINCAPSIII

Start up the programming support tool "WINCAPSIII," using the following procedure.

Step 1 **On the Start menu, choose All Programs | DENSO FACTORY WARE | WINCAPSIII | WINCAPSIII to display the dialog box for logging in.**

Step 2 **To log on as an Operator, select "0-Operator" in User level and press Log in.**

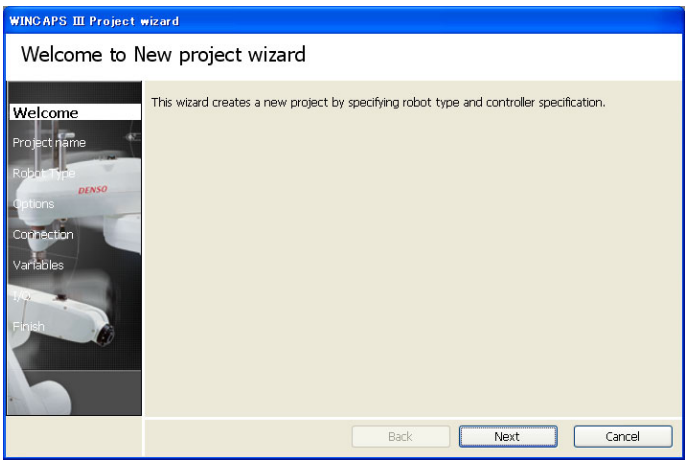
Note:	To modify settings, select "1-Programmer." Logging on as a Programmer requires a password (which should be configured at the first time of logging on as a Programmer).

11.3.2 Creating a New Project

WINCAPSIII manages more than one robot program in projects. Creating more than one program in a project and using a set of programs combined facilitates program management.

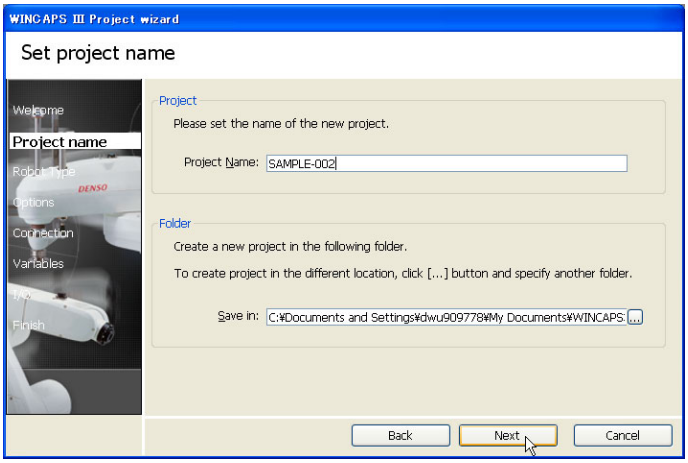
For creating a robot program, first create a new project.

Step 1 **Choose File | New Project to run the WINCAPSIII Project wizard.**

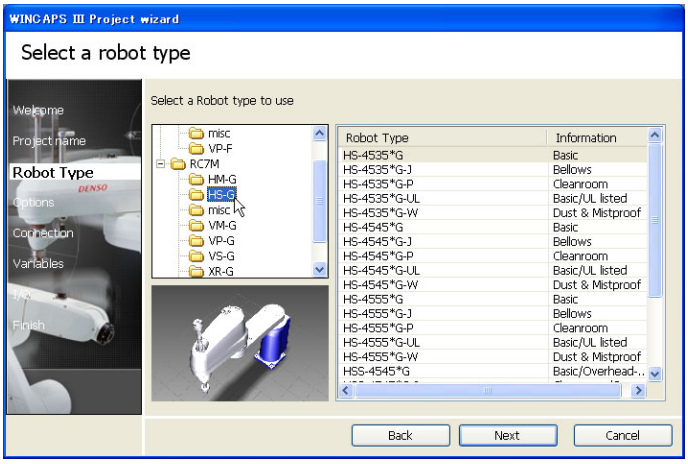


Press Next.

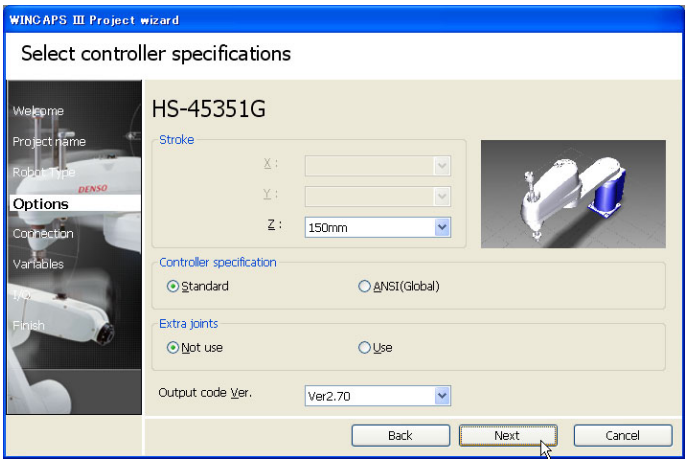
Step 2 **Enter the name of a new project and specify the location to save the project folder. Then press Next.**



Step 3 **Select your robot controller and robot type, then press Next.**



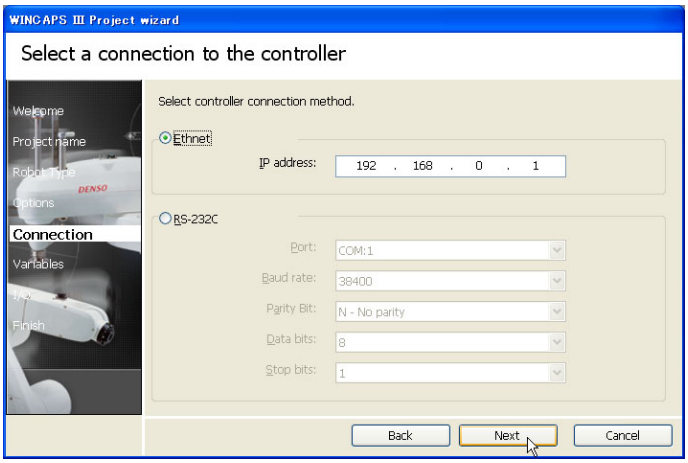
Step 4 **Select whether your robot controller is Standard or ANSI (Global) and whether extended-joints are used or not, and then press Next.**



Step 5

Select the interface (Ethernet or RS-232C) between the controller and PC (WINCAPSIII) and specify the details, then press Next.

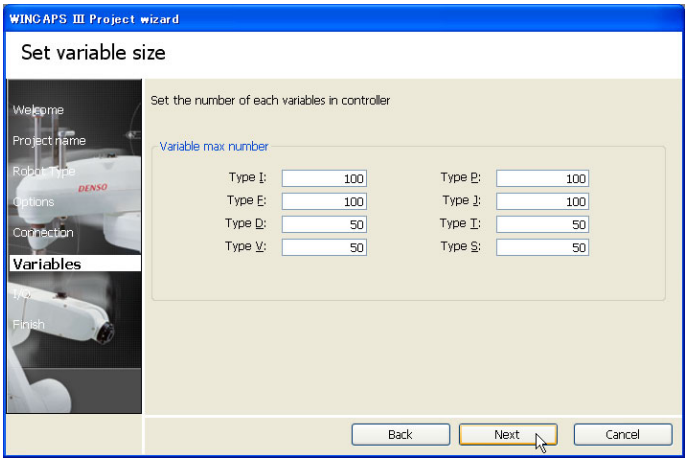
The interface can be changed even after creation of a project.



Step 6

Enter the number of variables to use for each variable type, and then press Next.

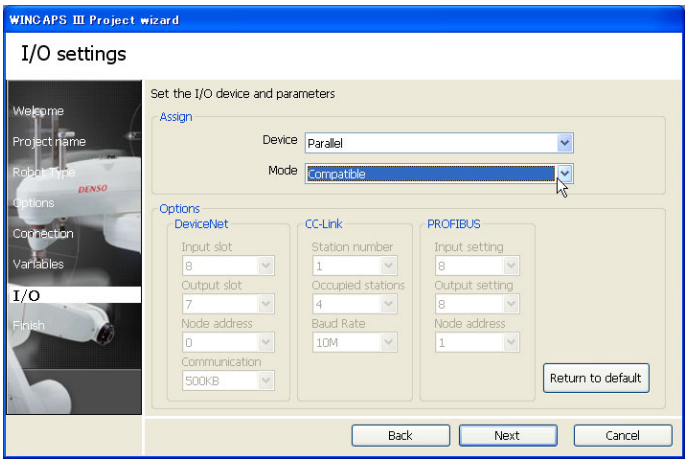
The number of variables can be changed even after creation of a project.



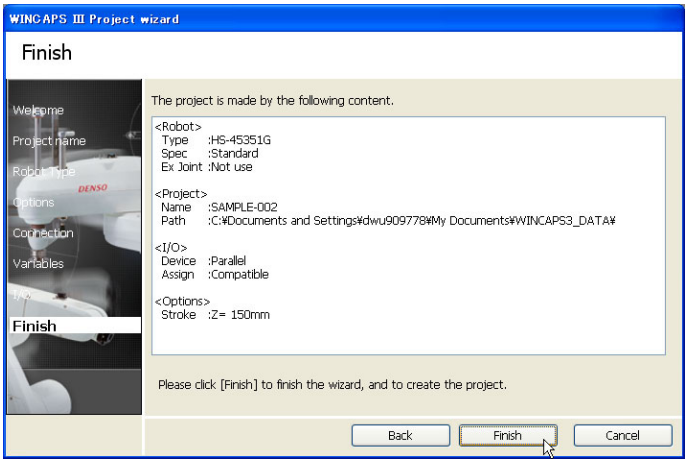
Step 7

Select the device connected to the controller and the assignment mode.

Configure the detailed device parameters according to your needs.
Then press Next.



Step 8 **Confirm your settings. If they are correct, press Finish to terminate the wizard.**

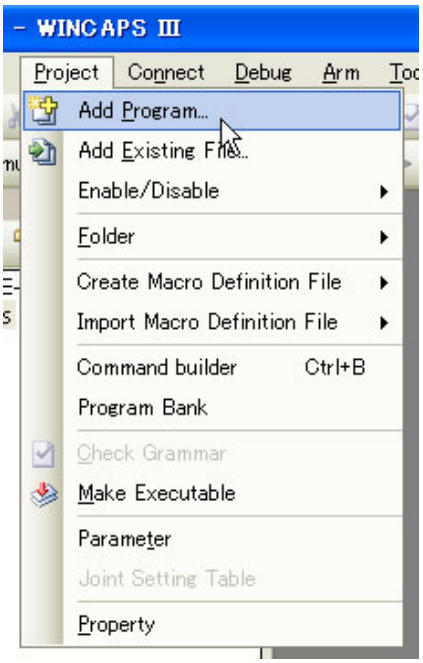


This procedure has created a new project.

11.3.3 Creating a Program

Create a program in the project, using the following procedure.

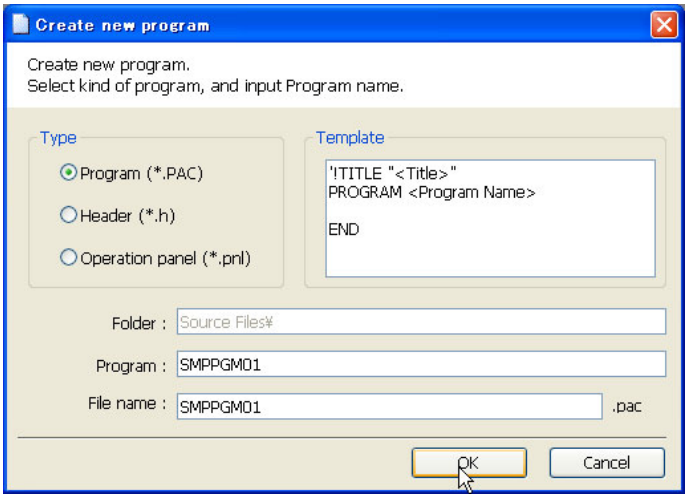
Step 1 **Choose Project | Add Programs to display the Create new program window.**



Step 2

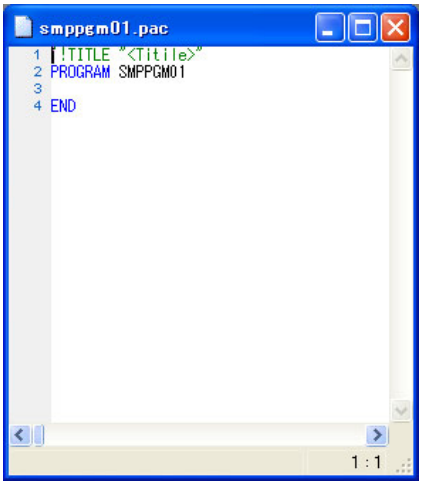
Select Program (*.PAC) in Type and enter the program name and file name.

The program name should be a maximum of 64 alphanumeric characters beginning with an alphabet.
Entering a program name automatically enters the same name into the file name field. To give a different name to the file, enter the desired name.
Then press OK.



Step 3

Wait for a program to be created and the program entry window to appear.



11.3.4 Entering and Saving Program Code

Enter the following sample code to the program entry window.

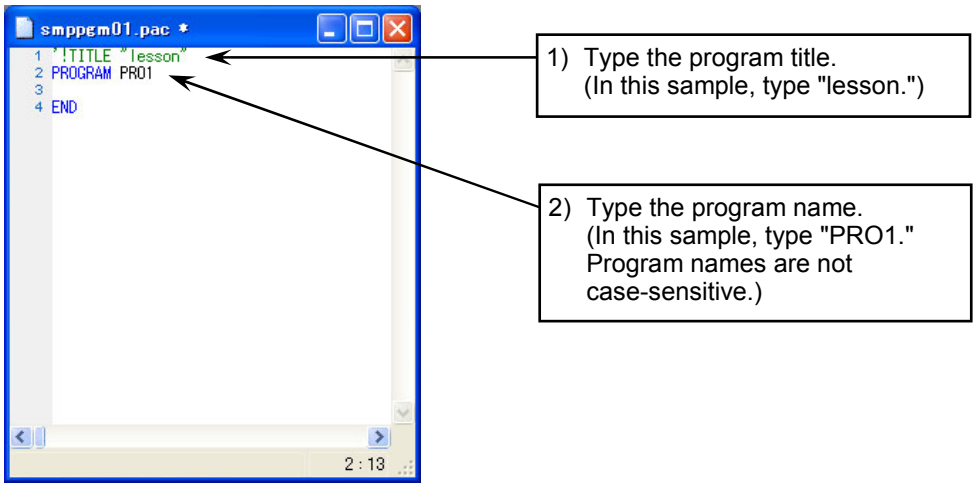
This sample code moves the end-of-arm tooling from the predetermined point P1 to P2.

Sample coding for "PRO1"

```
PROGRAM  PRO1        'Declare the program name "PRO1."
  TAKEARM            'Get the arm semaphore
  SPEED 100          'Set the internal speed of the end-of-arm tooling
                     to 100%.
  MOVE L, P1         'Move to P1.
  MOVE L, P2         'Move to P2.
END
```

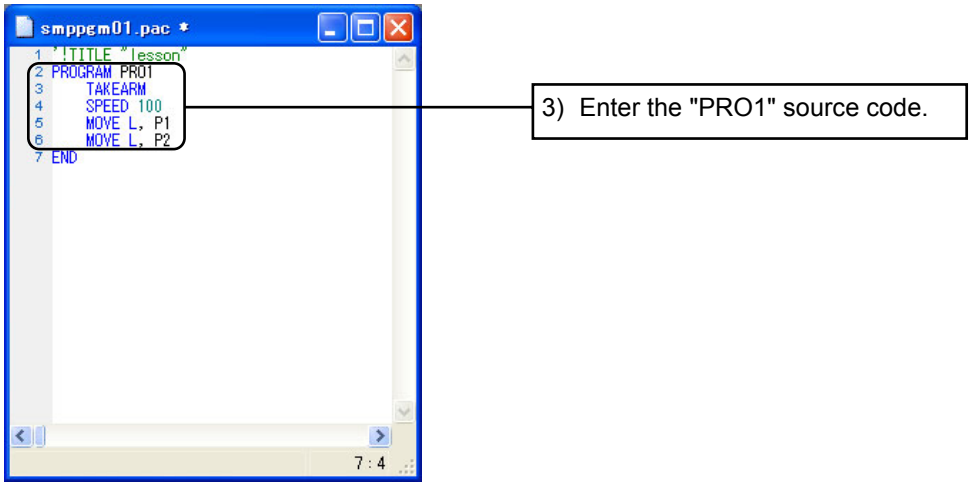
Step 1

Typing the program title and program name



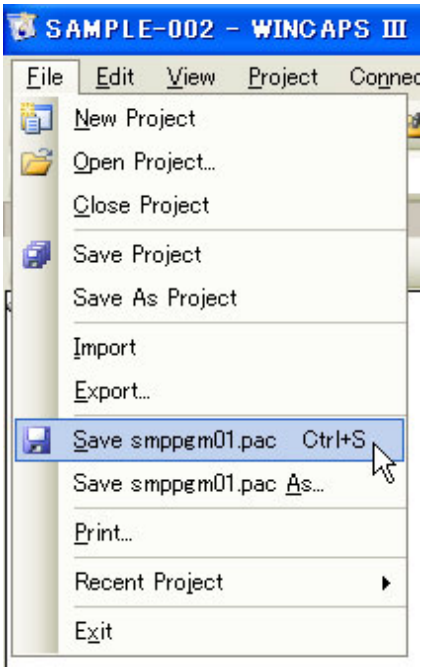
Step 2

Entering the source code



Step 3 **Saving the program code**

Choose File | Save smppgm01.pac to save the program code.

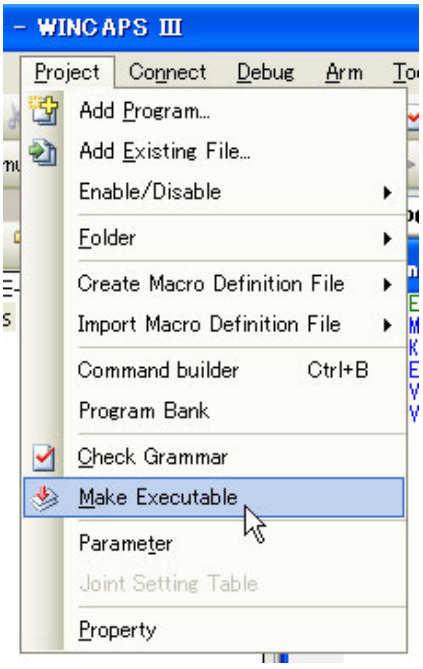


11.3.5 Compiling the Program

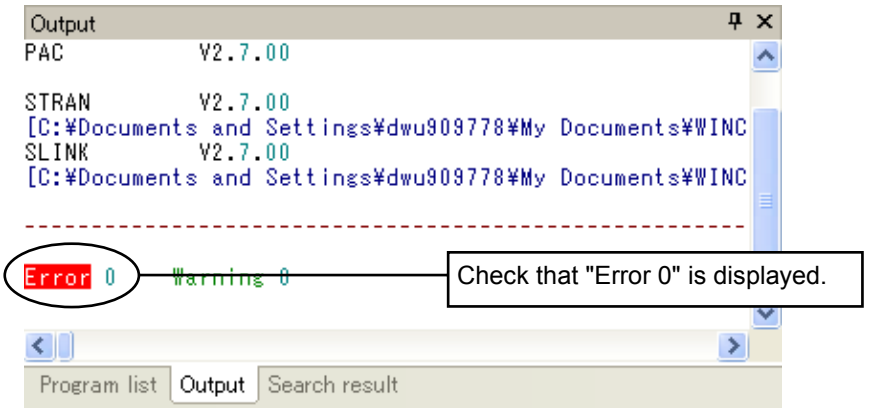
To execute a program written in PAC language, it is necessary to convert (compile) it into the run-time format that is executable by the robot controller. The compiled program is referred to as an executable.

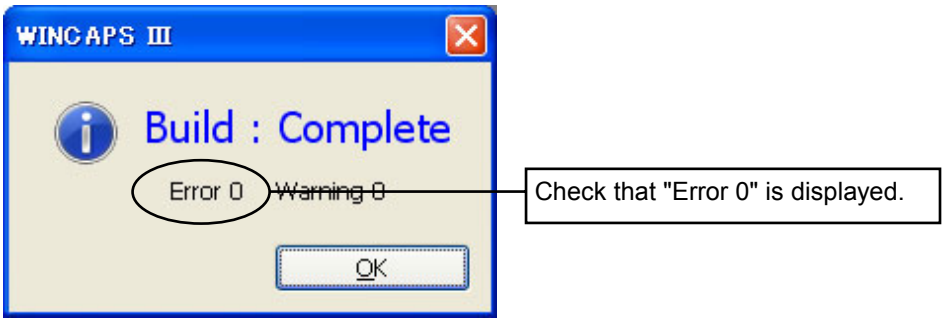
Step 1 **Compiling the program**

Choose Project | Make Executable to convert all programs included in the Program list window.

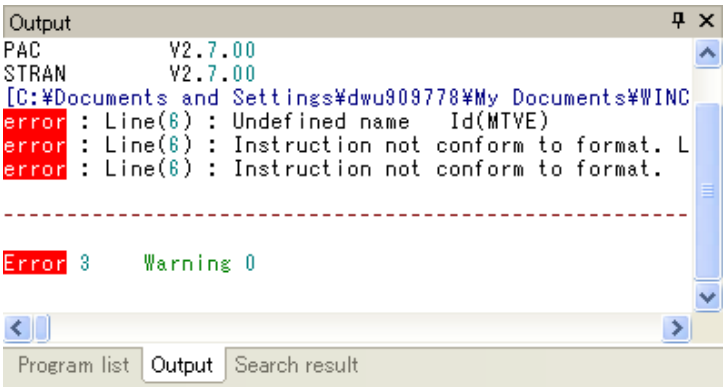


Step 2 Checking that no error has occurred





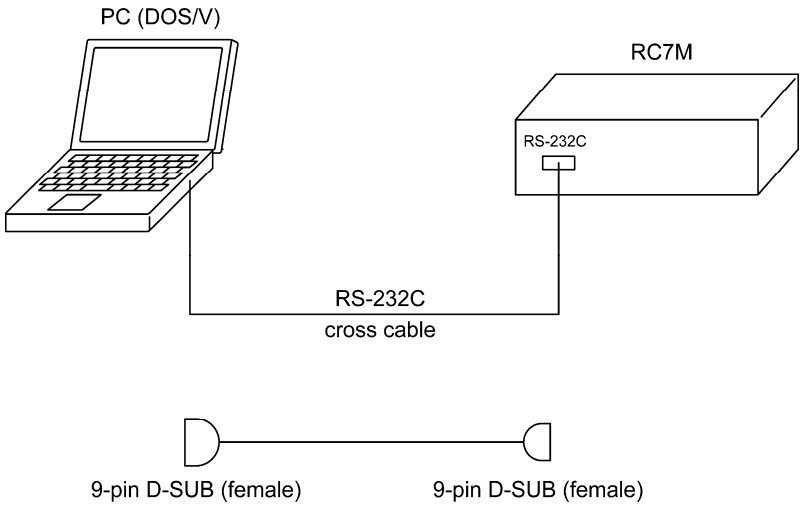
If an error is showing, any program command(s) entered is wrong. In the Output window, check the error location and contents and correct the wrong command(s).



11.4 Connecting WINCAPSIII and Controller with Communications Cables

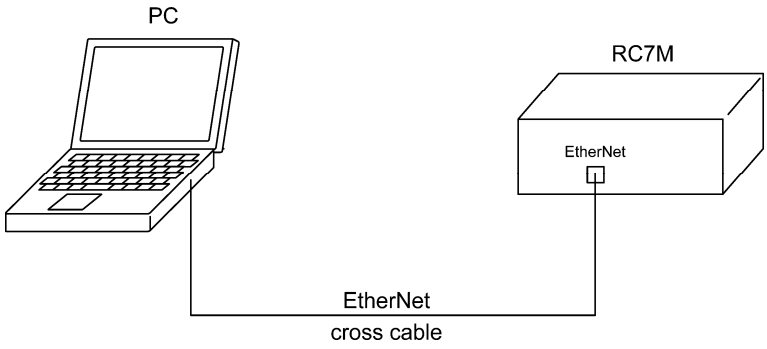
For data communication between WINCAPSIII and the controller, connecting the PC to the controller with communications cables is required. For cable connections, see the following.

11.4.1 For RS-232C Communication

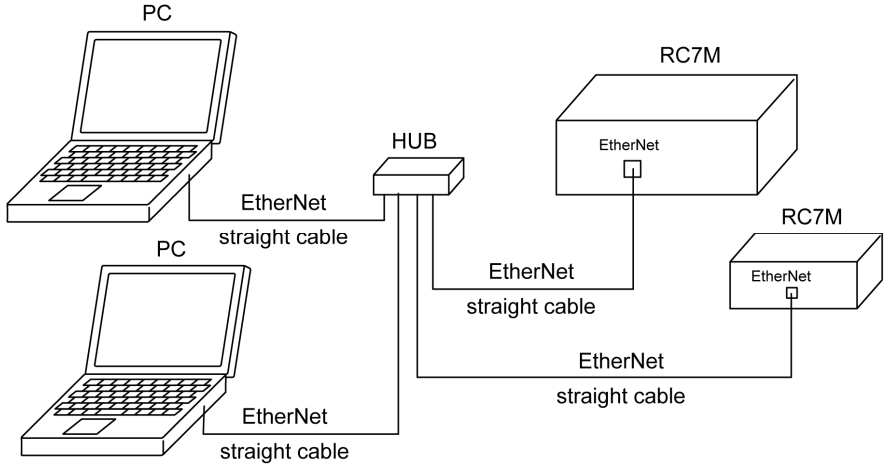


11.4.2 For EtherNet Communication

One-to-one connection



N-to-N connection



11.5 Preparation for Establishing Communications Link with Controller

11.5.1 For RS-232C Communication

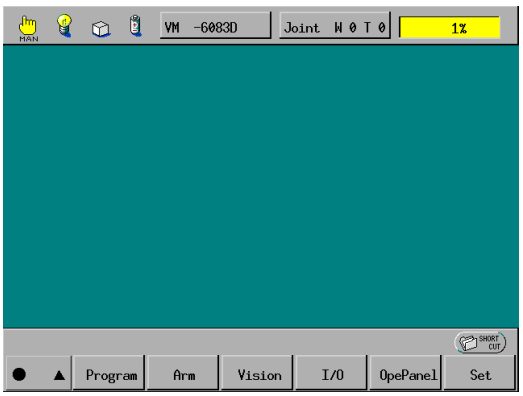
11.5.1.1 RS-232C (Configuring the robot controller)

Configure the robot controller from the teach pendant to communicate with WINCAPSIII via the RS-232C interface.

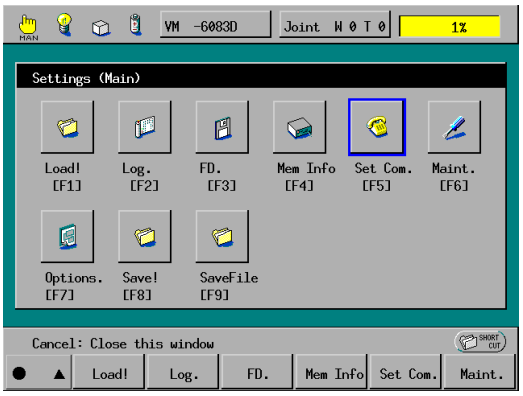
Step 1

F6

Press [F6 Set] on the teaching pendant basic screen.



The Settings (Main) window will appear on the screen.

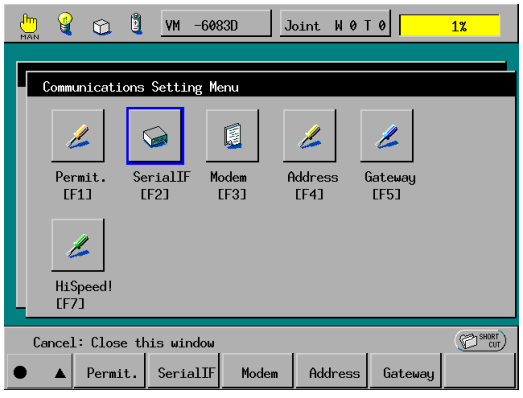


Step 2

F5

Press [F5 Set Com.].

The Communications Setting Menu appears on the screen.



Step 3

Press [F2 Serial IF].

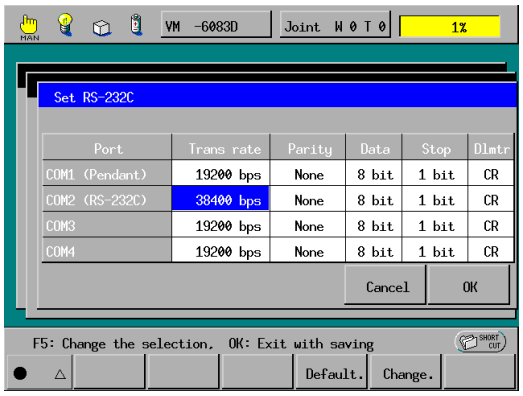
The Set RS-232C window appears on the screen.

F2

Step 4

Select COM2 and press [F5 Change.].

F5

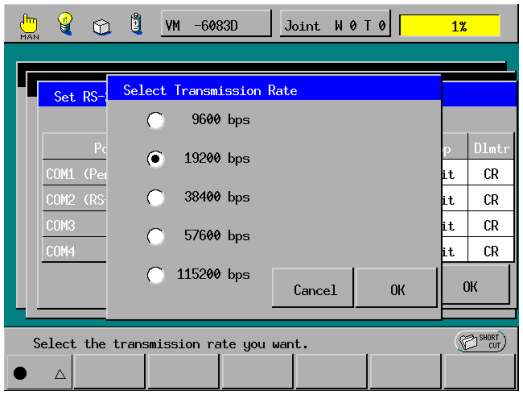


The Select Transmission Rate window appears on the screen.

Step 5

Select the transmission rate and press OK.

OK



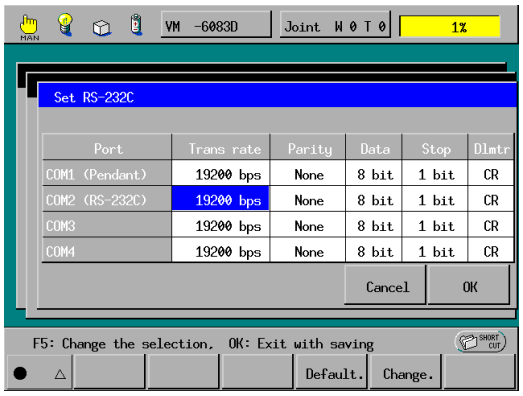
The screen returns to the Set RS-232C window.

Step 6

Check the display contents and press OK.

The set transfer rate becomes valid.

OK

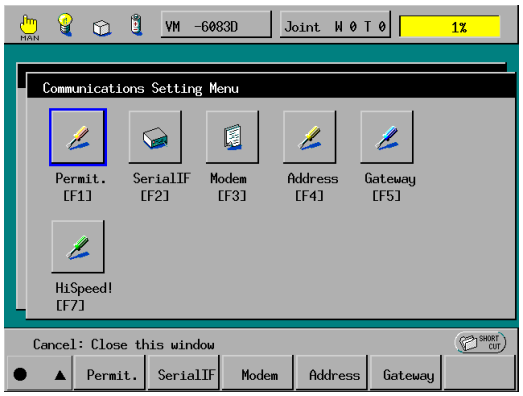


The screen returns to the Communications Setting Menu window.

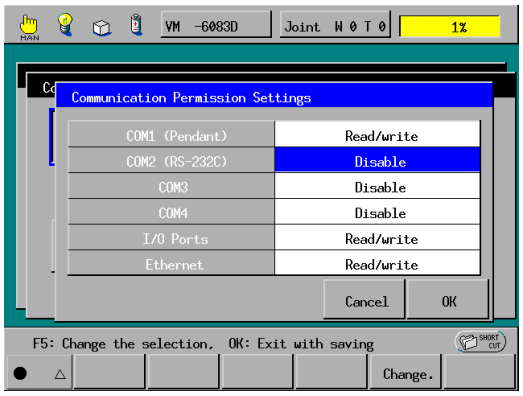
Step 7

F1

Press [F1 Permit.] in the Communications Setting Menu window.



The Communication Permission Settings window appears on the screen.



Step 8

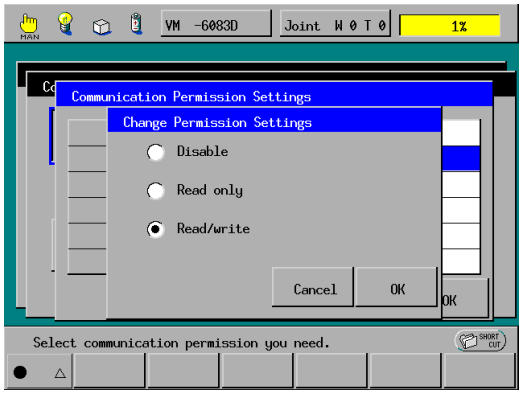
F5

Select COM2 and press [F5 Change.].

The Change Permission Settings window appears on the screen.

Step 9

Select the necessary permission settings.



The meanings of the permission settings are as follows:

- Disable: Communication port is not used.
- Read only: Personal computer is enabled to read the robot controller data. It is not allowed to send data to the robot controller.
- Read/Write: Data exchange is allowed between the personal computer and robot controller.

When creating a program, select Read/Write.

When supervising only variables or I/O values by automatic operation of a ready program, select Read only.

Upon making a selection, press OK.

The screen returns to the Communication Permission Settings window.

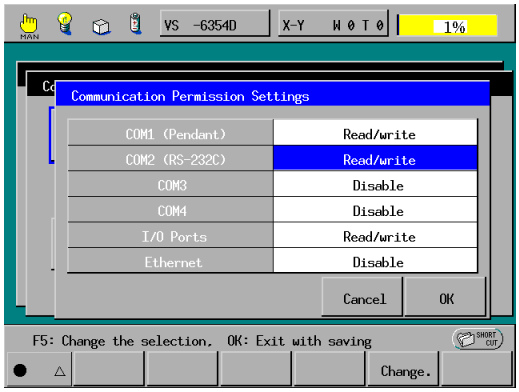
> **Note:** You cannot select Read/Write Enabled for both RS232C and Ethernet simultaneously.

Step 10

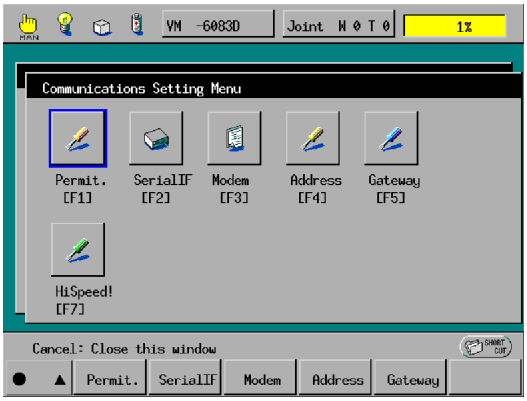
OK

Check the display contents and press OK.

The permission setting is enabled.



The screen returns to the Communications Setting Menu window.



Step 11

Cancel

Press Cancel twice.

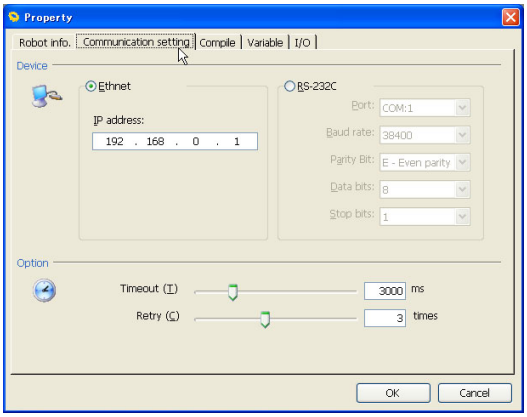
The display returns to the basic screen.

11.5.1.2 RS-232C (Configuring WINCAPSIII)

Configure the PC in WINCAPSIII so that WINCAPSIII can communicate with the robot controller via the RS-232C interface.
The interface can be also specified with the WINCAPSIII Project wizard (see Section 11.3.2, step 5). Even after the wizard is finished, the interface can be changed with the procedure given below.

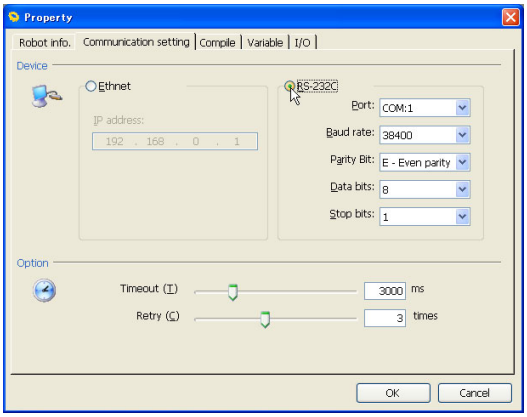
Step 1

Choose Project | Properties to display the Property window and then choose the Communications setting tab.



Step 2

Select RS-232C and make the detailed communication settings.



In the Port pull-down menu, select the communications port that the PC uses. In the Baud rate, Parity bit, Data bits, and Stop bits pull-down menu, select the settings that match the ones specified in the robot controller.

Step 3

Specify the timeout period and the number of retries, and then press OK.

The communications setting for the PC has been completed.

11.5.2 For Ethernet Communication

11.5.2.1 Ethernet (Configuring the robot controller)

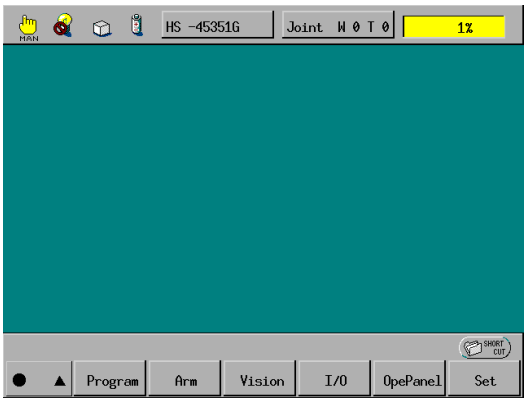
Configure the robot controller from the teach pendant so that WINCAPSIII can communicate with the robot controller via Ethernet.

Make settings for the communication permission and IP address.

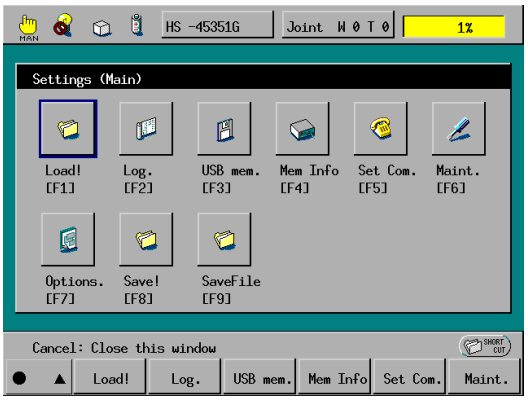
Step 1

F6

Press [F6 Set] on the basic screen of the teach pendant.



The Settings (Main) window appears on the screen.

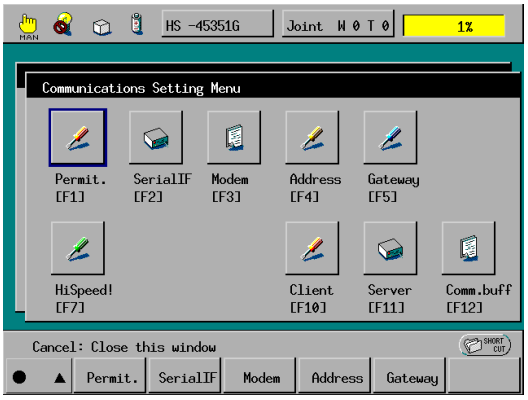


Step 2

F5

Press [F5 Set Com.].

The Communications Setting Menu window appears on the screen.

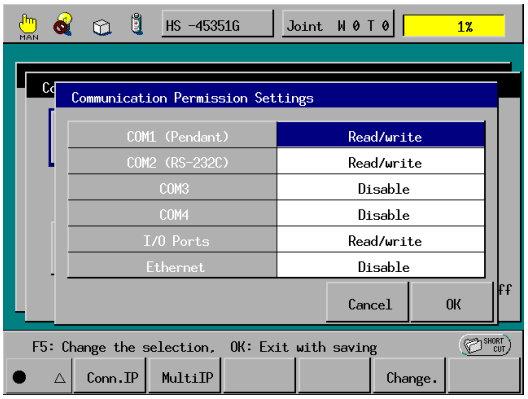


Step 3

Press [F1 Permit.].

The Communication Permission Settings window appears on the screen.

F1



Step 4

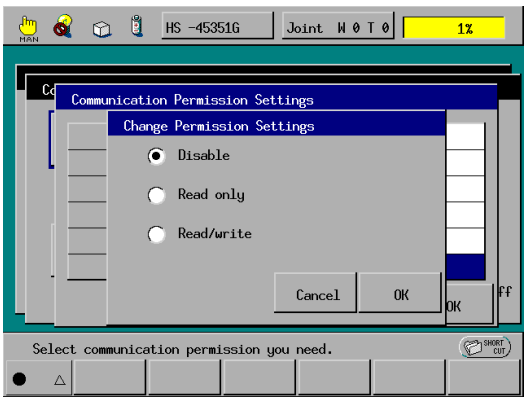
Select Ethernet and press [F5 Change.].

The Change Permission Settings window appears on the screen.

F5

Step 5

Select Read/Write.



The meanings of the permission settings are as follows:

When using Ethernet, select Read/Write.

- Disable: Communication port is not used.
- Read only: Personal computer is enabled to read the robot controller data. It is not allowed to send data to the robot controller.
- Read/Write: Data exchange is allowed between the personal computer and robot controller.

Upon making section, press OK.

The screen returns to the Communication Permission Settings window.

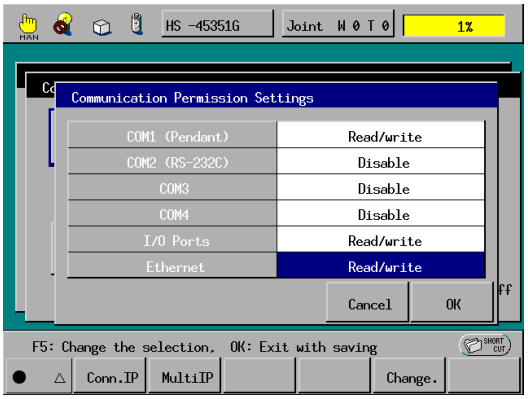
Note: It is not possible to select Read/Write for both COM2 (RS-232C) and Ethernet concurrently. To select Read/Write for Ethernet, therefore, select Disable or Read only for COM2 (RS-232C).

Step 6

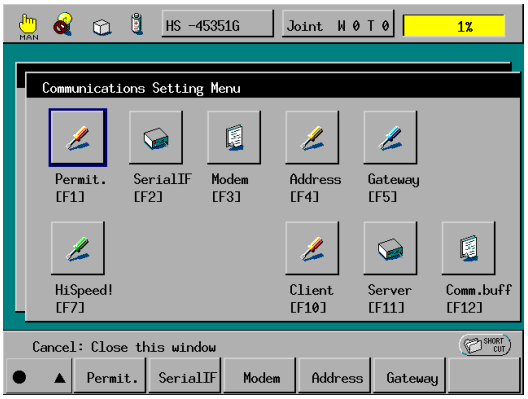
OK

Check the display contents and press OK.

The permission setting becomes valid.



The screen returns to the Communications Setting Menu window.

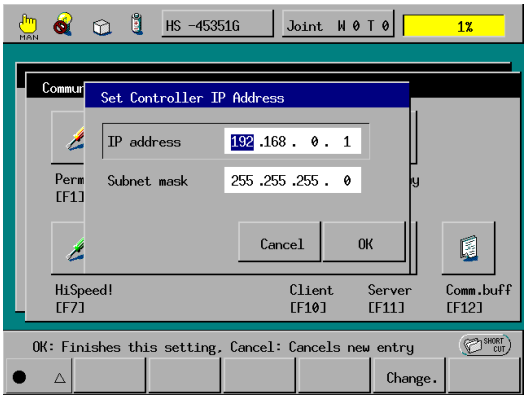


Step 7

Press [F4 Address].

The Set Controller IP Address window appears.

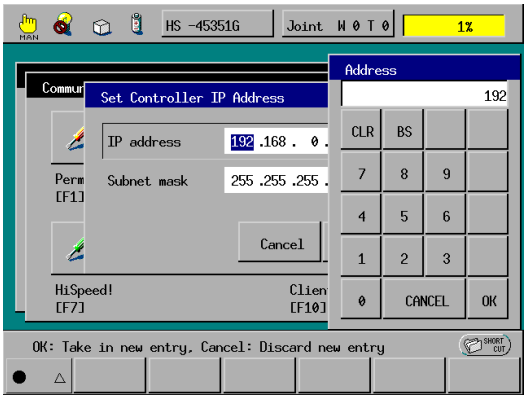
F4



Step 8

Press [F5 Change.] and enter a required address.

F5



Step 9

Press Cancel twice.

The display returns to the basic screen.

11.5.2.2 Setting Network Environment

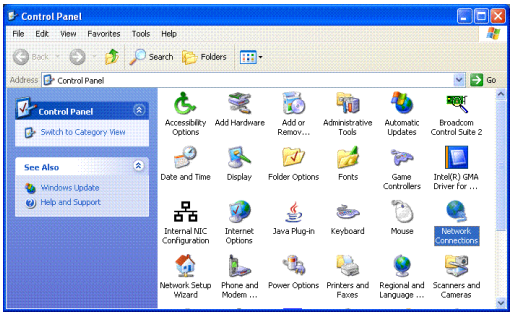
To effect connection by EtherNet, it is necessary to set up Windows. The network environment setting procedures will be described here preconditioned on the fact that the network card (adapter) is installed and that the Internet protocol (RCP/IP) is effective.

First, check that the local area connection is effective.

Next, set up an IP address for the TCP/IP property.

Step 1 Select Settings and Control Panel in this order from the START of Windows.

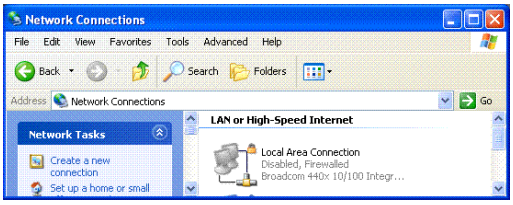
The Control Panel window will appear on the screen.



Step 2 On the above screen, click the icon "Network Connections."

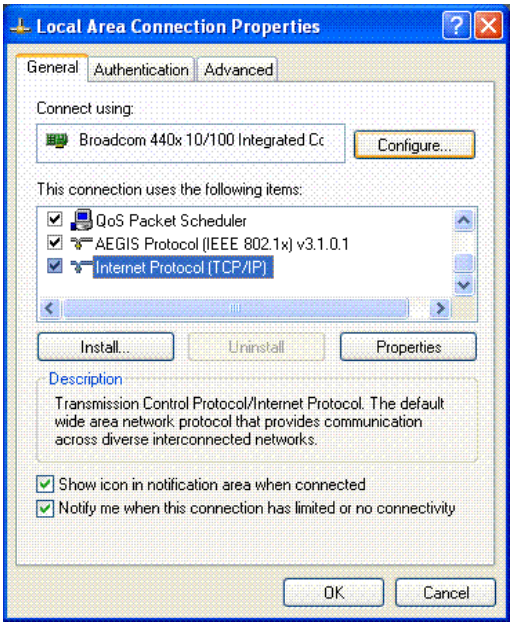
The Local Area Connection icon appears as shown below.

If "Disabled" is displayed with the icon, move the pointer to the icon, click the right mouse button, and then select "Enable."



Step 3 Place the pointer on the "Local Area Connection Properties" icon, click the right mouse button and select "Property."

The Local Area Connection Properties appears.



Step 4

In the Local Area Connection Properties window, select the General tab.

In the "This connection uses the following item:" area, press the Properties button with the Internet Protocol [TCP/IP] selected. The Internet Protocol (TCP/IP) Properties window appears.

Step 5

Select the General tab and click the "Use the following IP address:".

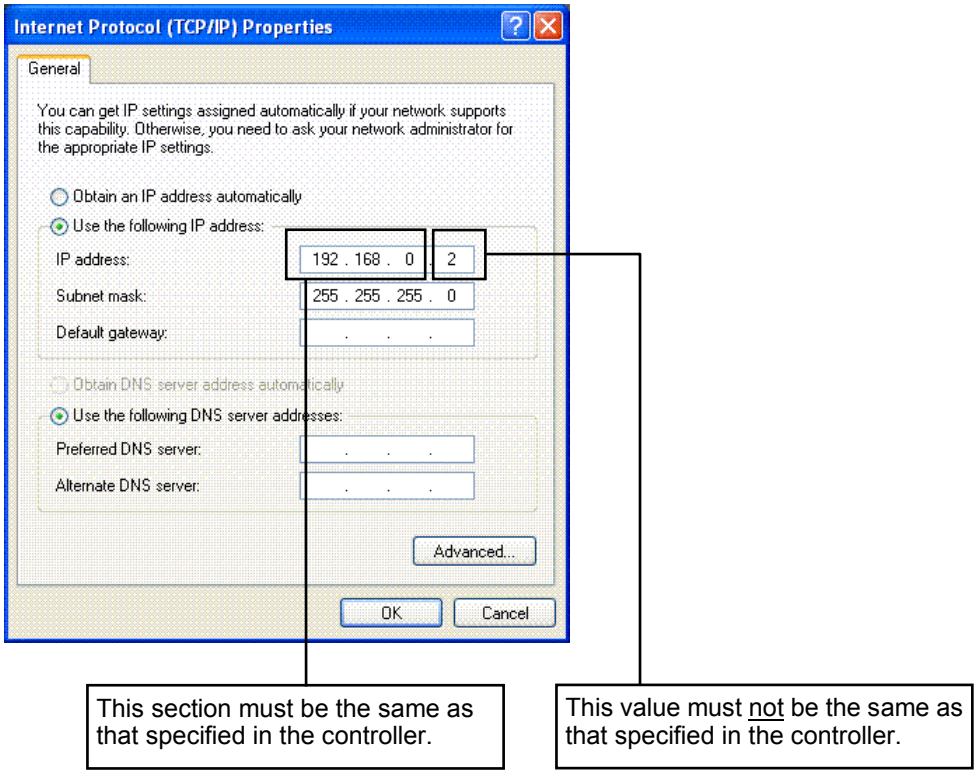
Then enter the IP address and the Subnet mask.

For the actual values of the IP address and subnet address, inquire to the network administrator in charge of the pertinent network.

If the network is local (for example, an environment for connecting the personal computer and the robot controller only), the IP address can be set as desired. Therefore, the IP address will be tentatively set here to 192.168.0.1 and the subnet address to 255.255.255.0.

Click on **OK** and the IP address setting is completed.

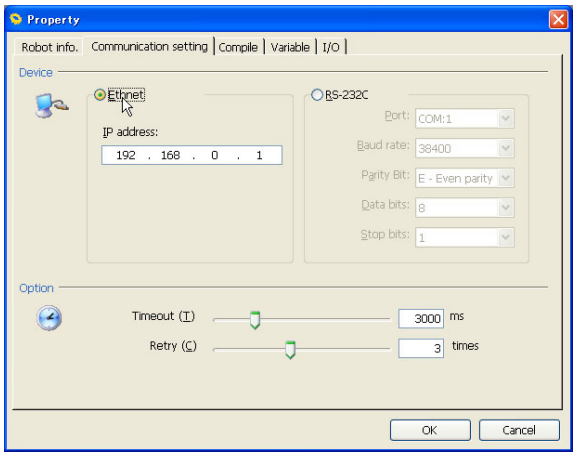
Note (1):	When making connection to a wide area network (for example an in-house network), always inquire to the network administrator before setting the IP address and subnet mask. If an IP address used for the local area network is connected to the wide area network (for example the in-house network) without first invalidating it, confusion may be occur in the connected network.
Note (2):	No redundant IP addresses are allowed within the same network. When making a connection to a widely shared network, care should be taken not to allow an IP address to be redundant with another terminal. The following are examples of IP addresses that have the least probability of redundancy with another terminal: 192.168.0.2 to 192.168.0.xxx (xxx represent 003 to 999.)



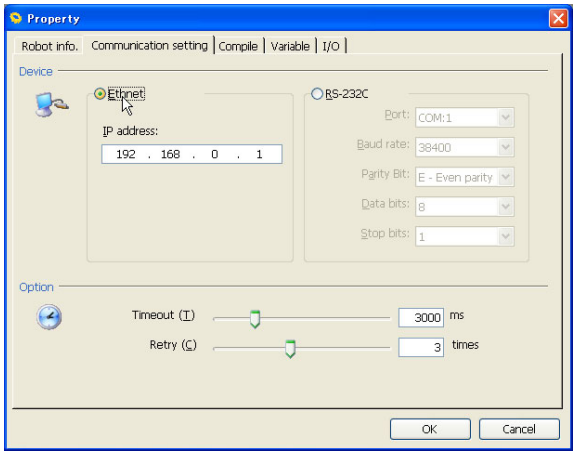
11.5.2.3 Ethernet (Configuring WINCAPSIII)

Configure the PC in WINCAPSIII so that WINCAPSIII can communicate with the robot controller via Ethernet.
The interface can be also specified with the WINCAPSIII Project wizard (see Section 11.3.2, step 5). Even after the wizard is finished, the interface can be changed with the procedure given below.

STEP 1 Choose Project | Properties to display the Property window and then choose the Communications setting tab.



STEP 2 Make sure that Ethernet is selected and enter the IP address of the robot controller.



STEP 3 Specify the timeout period and the number of retries, and then press OK.

The communications setting for the PC has been completed.

11.6 Transmitting Data with WINCAPSIII

Before transmitting data (sending/receiving data between the robot controller and WINCAPSIII), it is necessary to make the communication permission settings and to check the controller operation status. Depending on the controller status, data transmission may fail.

11.6.1 Preparation in the Controller (Precautions for Transferring Data)

(1) Check that no error message is displayed on the teach pendant screen.

(2) Check that the permission settings for the communications port to be used (for RS232C or EtherNet) is "Read/write."

> **Note:** If "Read only" is selected, transmitting data will cause the ERROR200B ("Configuration transmission failure").

(3) Depending on the combination of ON/OFF status of the robot controller motor and the operation mode selected, transmitting data may not be possible, as shown in the table below.

Status	Motor	Controller operation mode				Remarks
		External Auto	Internal Auto	Manual	Teach	
PAC programs	ON	N	N	N	N	Y[1]: Programs are not saved automatically.
	OFF	N	Y[1]	Y	Y[1]	
Variable	ON	N	Y	Y	Y	
	OFF	N	Y	Y	Y	
I/O	ON	N	N	N	N	
	OFF	N	Y	Y	Y	
Arm	ON	N	Y[2]	Y[2]	Y[2]	Y[2]: Only tool, work, and area data can be transmitted.
	OFF	N	Y	Y	Y	

Y: Transmission possible, N: Transmission impossible

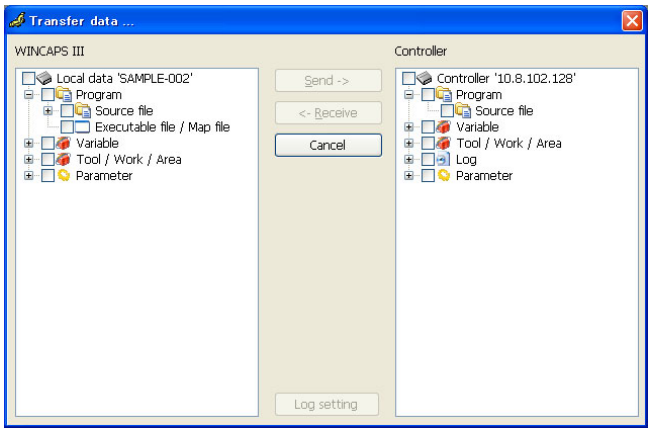
> **Note (1):** WINCAPSIII can receive data regardless of the ON/OFF status of the controller motor and the controller operation mode.
> **Note (2):** Receiving data during program execution will slow down the program execution.

(4) Check that neither the Program list window nor Select Variable type window is displayed on the teach pendant screen.

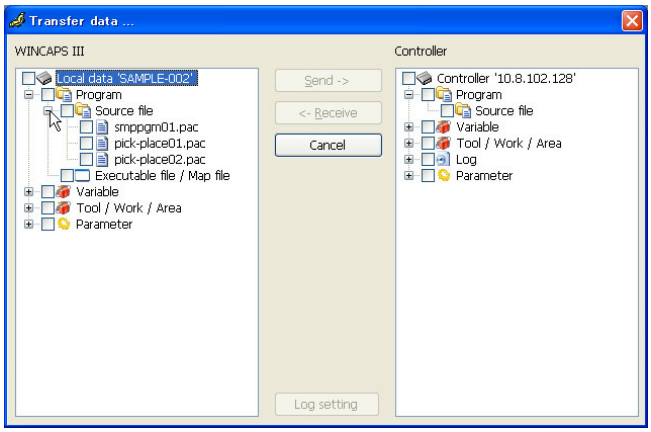
11.6.2 Transferring Program Data to the Robot Controller

At present, the execution program complied in this Chapter so far is still in the PC. To run the program, it is necessary to transmit (upload) it to the robot controller.

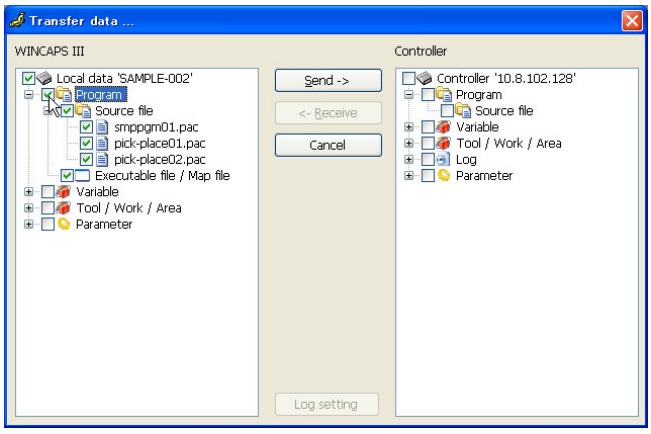
STEP 1 **In WINCAPSIII, choose Connect | Transfer data to display the following window.**



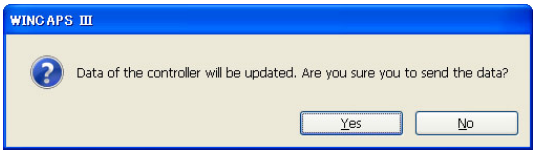
STEP 2 **In the WINCAPSIII pane, choose Program | Source file to display the programs held in WINCAPSIII.**



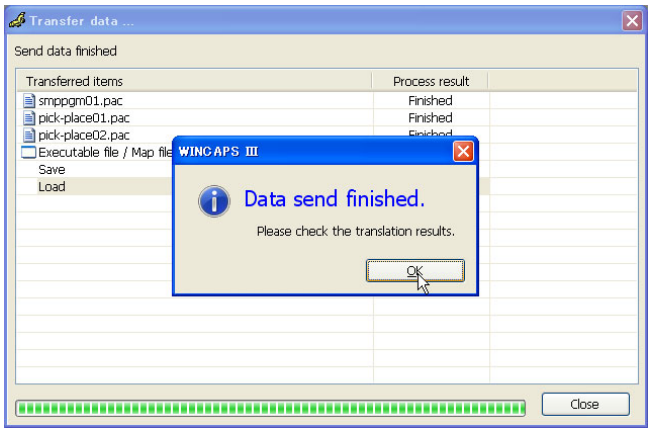
STEP 3 **Select Program and press Send.**



STEP 4 **Wait for the confirmation dialog to appear. Press Yes to transfer the data to the robot controller.**



STEP 5 **Confirm that all of the data transfer results are Finished.**



STEP 6 **On the teach pendant, press [F1 Program] to display the Program List window. Check that programs transferred are shown in the list.**

The program transfer to the robot controller has been completed.

Part 4

Program Verification

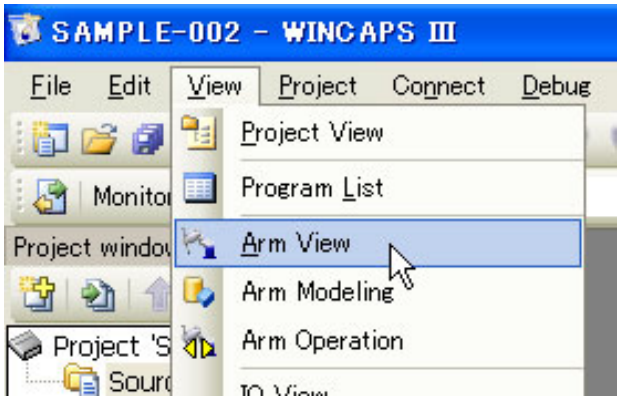
Chapter 12
Starting a Program

12.1 Simulating a Program Operation with WINCAPSIII

Run the program, which you have created on a PC and uploaded to the robot controller, in machine lock in order to simulate the robot motion on the PC screen.

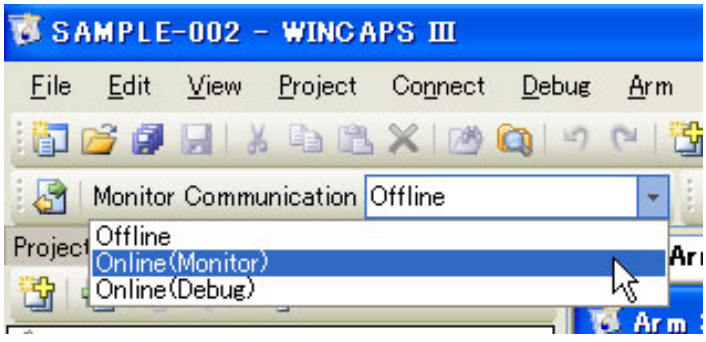
12.1.1 Opening an Arm View

Choose View | Arm View to display the Arm view window where the simulated robot images appear.



12.1.2 Monitoring the Robot Controller from WINCAPSIII

Choose Connect | Motor Communication | Online (Monitor) to connect WINCAPSIII to the robot controller and display its internal data.

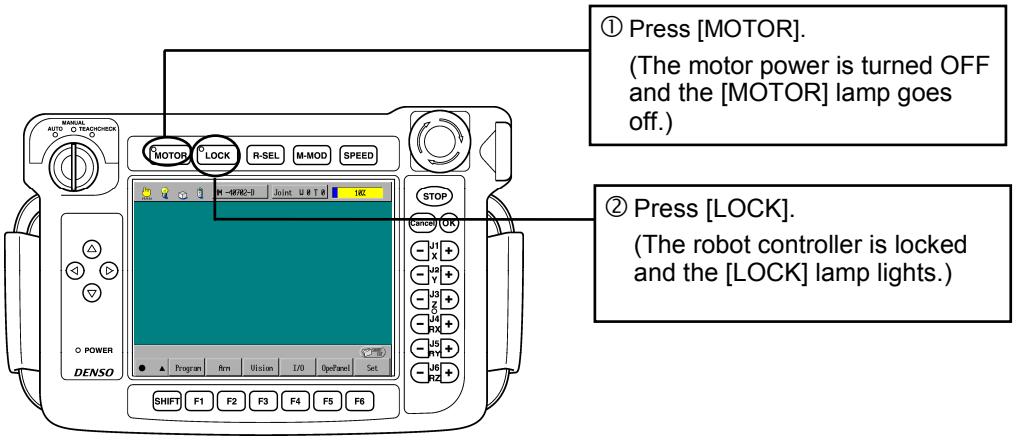


12.1.3 Placing the Robot Controller in Machine Lock

You will now place the robot controller in machine lock. This enables you to simulate the programmed robot motion on the PC screen without actually running the robot.

Step 1 Turn the motor power OFF.

Step 2 **Placing the robot in machine lock**



★Caution★ Before placing the robot controller in machine lock, ensure that the motor power is OFF; that is, check that the [MOTOR] lamp is off.

★Tip★ [Version. 1.4 or later]

If the machine is locked, you may restrict I/O output. For details, refer to the SETTING-UP MANUAL, Section 5.5 "Displaying I/O Signals and Simulating Robot Motion."

The dummy input icon on the status bar changes according to the I/O output restriction condition.

 : No I/O output restricted  : I/O output restricted

12.1.4 Starting the Program

Start a program in either of Teach Check mode or Auto mode.

Start the program with the controller being placed in machine lock, referring to either Section 12.2 "Starting a Program in Teach Check Mode" or Section 12.3 "Starting a Program in Internal Auto Mode."

The robot arm displayed in the WINCAPSIII Arm View window moves according to the program.

12.2 Starting a Program in Teach Check Mode

"Teach check" refers to checking the teaching results by running the program manually. You may take the teach check procedure in Teach check mode.

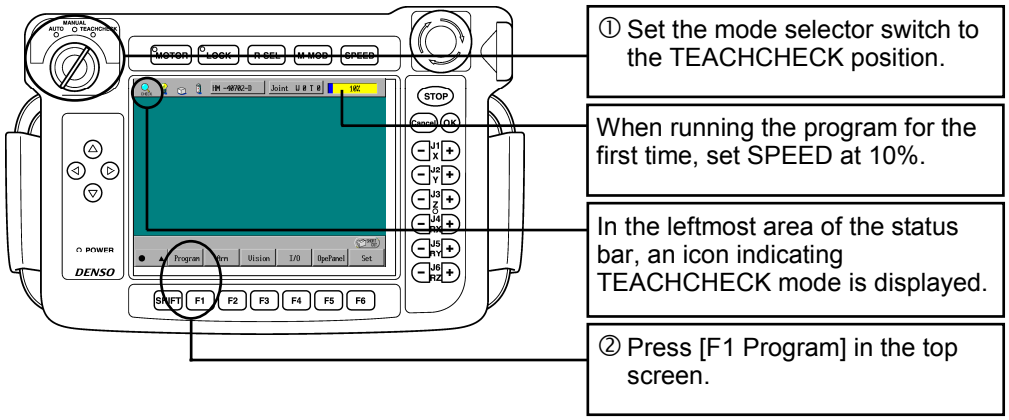
12.2.1 Teach Check

Step 1

Turn the motor power ON.

Do not turn the motor power ON if you start a program with the controller being placed in machine lock.

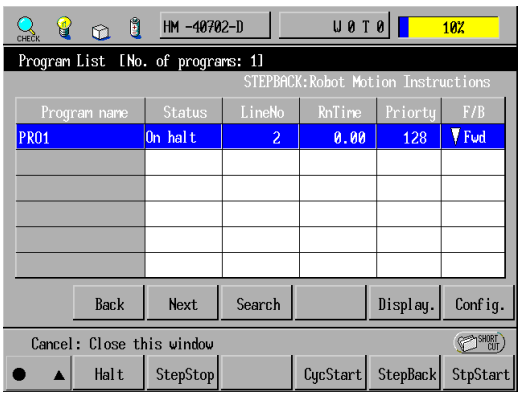
Step 2



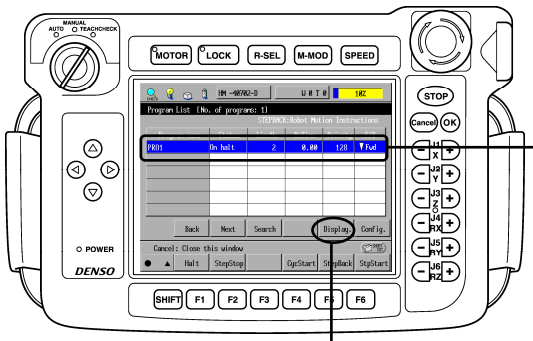
★Tip★

If ERROR21F2 (Enable Auto ON) occurs, see Section 7.3.2 "Relationship between Operation Modes and Enable Auto Input Signal."

The Program List window appears.



12.2.2 Selecting a Program to be Executed



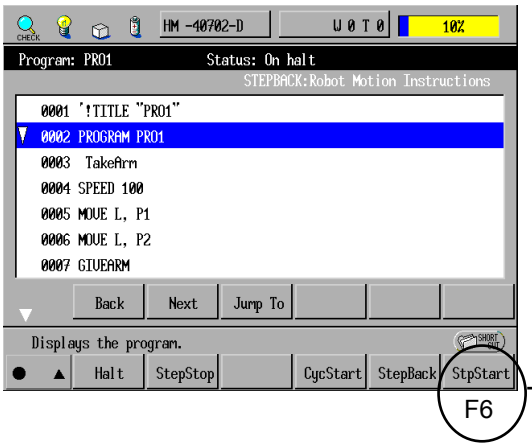
① Select "PRO1" in the Program List window.
(Selection can be made using the cursor keys or jog dial, or by touching the screen directly.)

② Press [Display.] to display the PRO1 program codes.

The program codes of PRO1 are displayed on the Program window.

12.2.3 Step Check

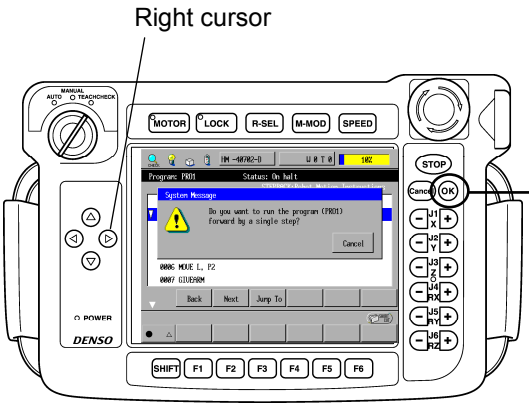
In the step check, the program executes a single step at a time.



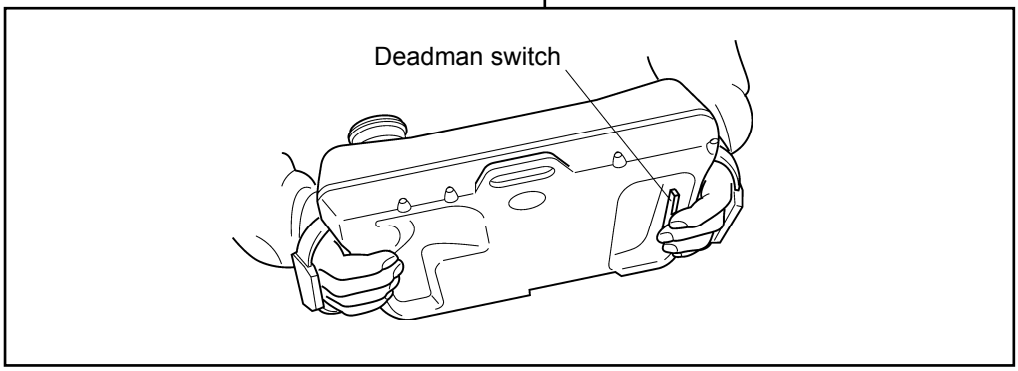
③ Press [F6 StpStart].
(This is also possible with the right cursor.)

This system message is displayed.

★Caution★ During teach check, always keep one hand free and ready to press the STOP key.



④ While holding down the deadman switch, press [OK].
(To cancel step operation, press [Cancel].)



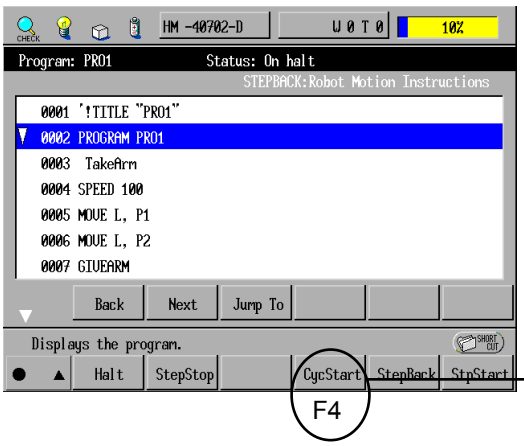
In Teach check mode, keep both the deadman switch and OK key depressed until the execution is completed. If either of them is released, the robot comes to a halt instantly.

⇩

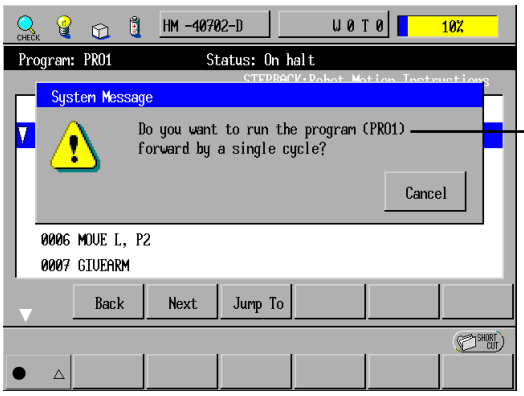
Perform the procedure above repeatedly to execute all codes in PRO1, checking that each motion is safe.

12.2.4 Cycle Check

Next, check the program you have just checked with Step check, this time with Cycle check. The Cycle check executes the selected program from the current program line to the end as a single cycle.



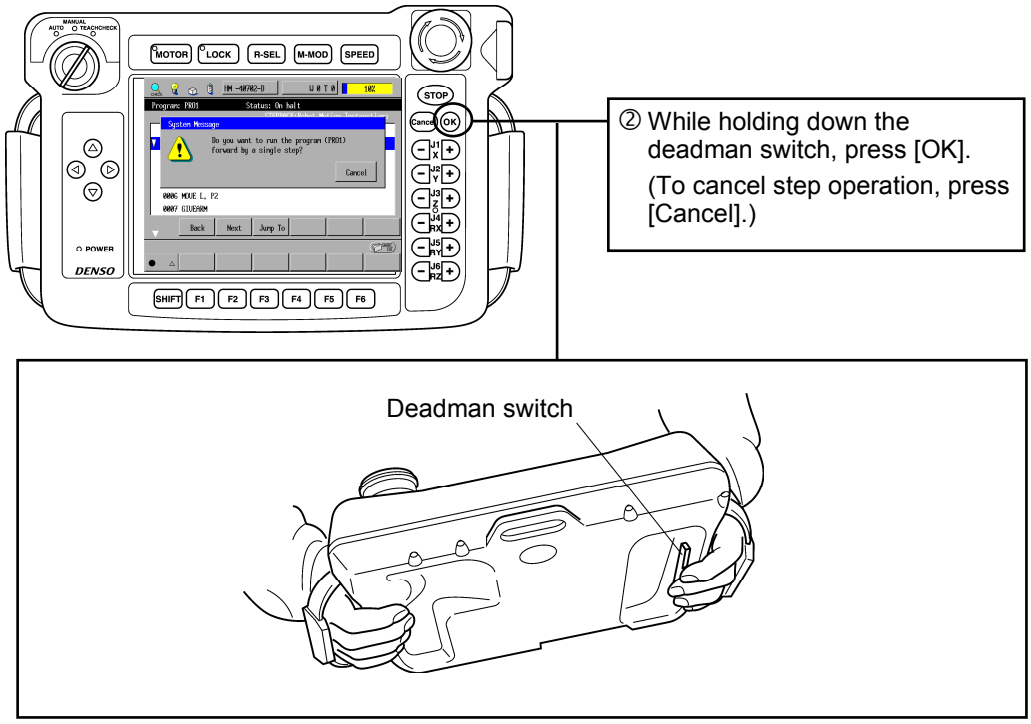
① Press [F4 CycStart].



This system message appears.

★Caution★

During teach check, always keep one hand free and ready to press the STOP key.



In Teach check mode, keep both the deadman switch and OK key depressed until the execution is completed. If either of them is released, the robot comes to a halt instantly.

⇩

As the program starts to execute cycle check so that the robot runs, the highlighted section on the coding list window will proceed in order.

When the program has been executed through to the end, it will stop.

12.3 Starting a Program in Internal Auto Mode

After the teach check, now you will run the program in Auto mode.

Caution: For programs that will be executed for the first time in Auto mode, set the reduced ratio of the programmed speed at 10% or less. In Auto mode, the robot may run at full speed, while in Manual mode or Teach check mode the robot speed is automatically reduced to 10% of the full speed.

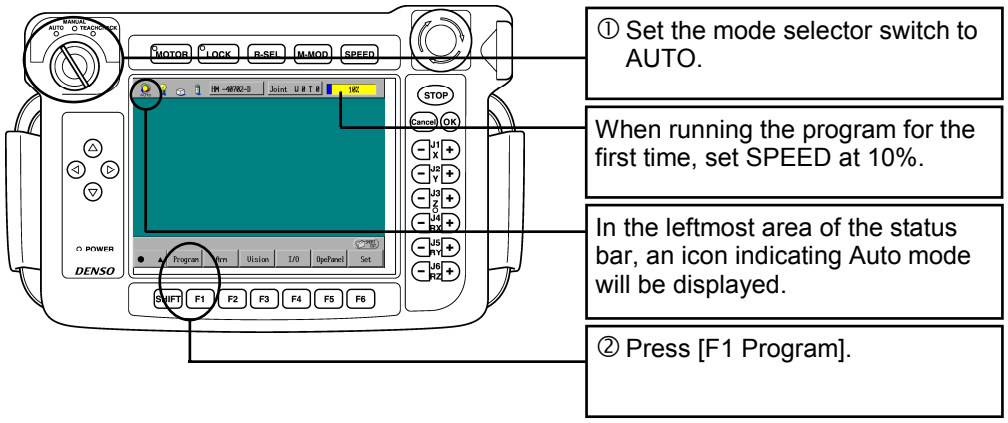
12.3.1 Placing the Robot in Auto Mode

Step 1

Turn the motor power ON.

Do not turn the motor power ON if you start a program with the controller being placed in machine lock.

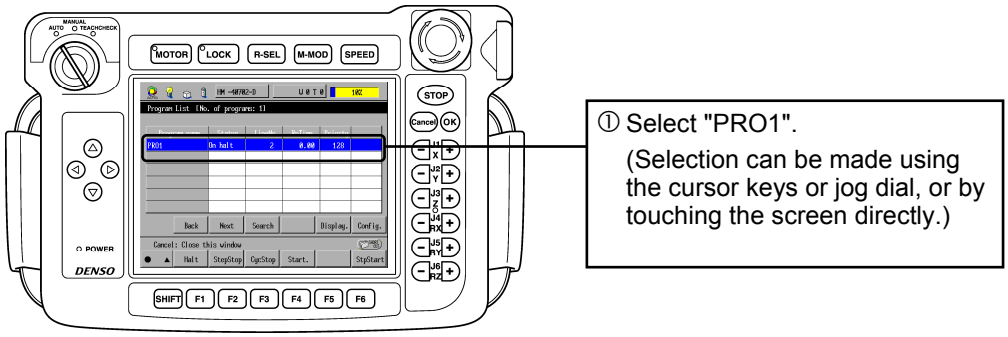
Step 2



★Tip★ If ERROR21F3 (Enable Auto OFF) occurs, see Section 7.3.2 "Relationship between Operation Modes and Enable Auto Input Signal."

12.3.2 Selecting the Program to be Executed

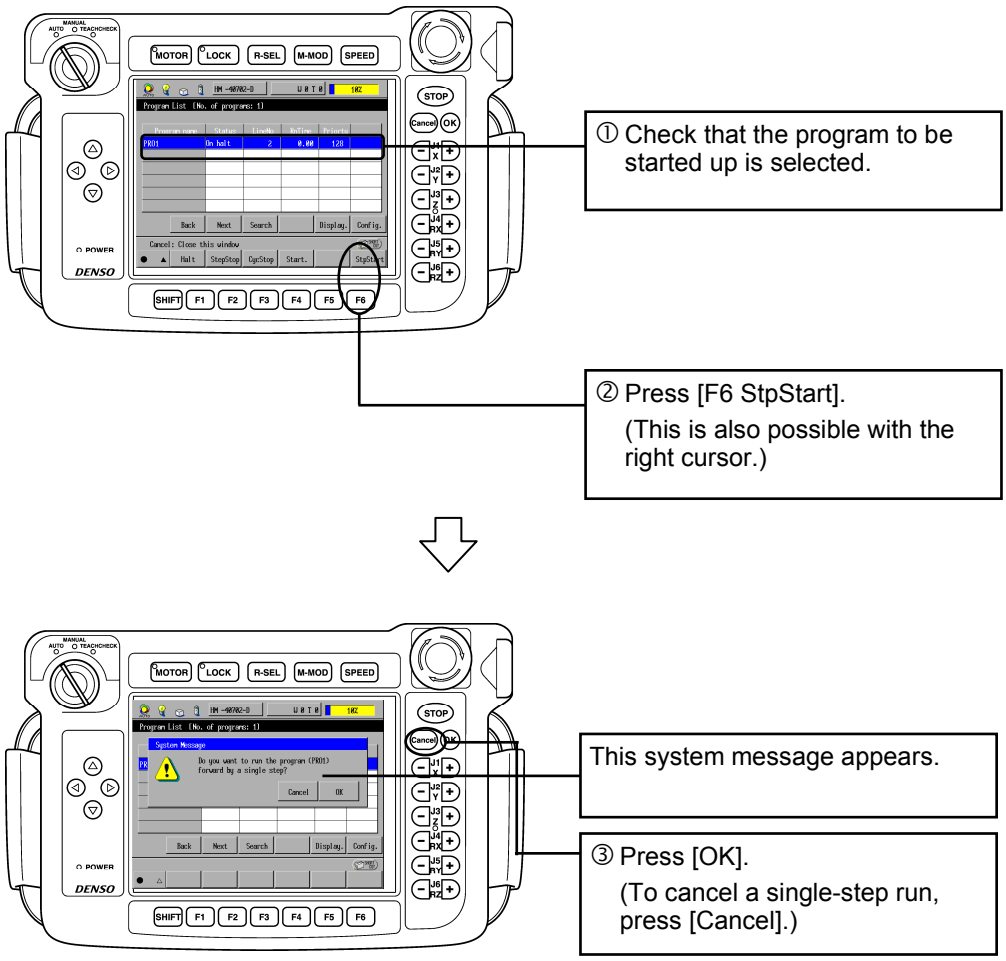
In the [Program List] window, select the program to be run in Auto mode.



12.3.3 Single-Step Start

★Note★

If you want to display the program during a single-step run, press [F11 Display] beforehand.



★Caution★

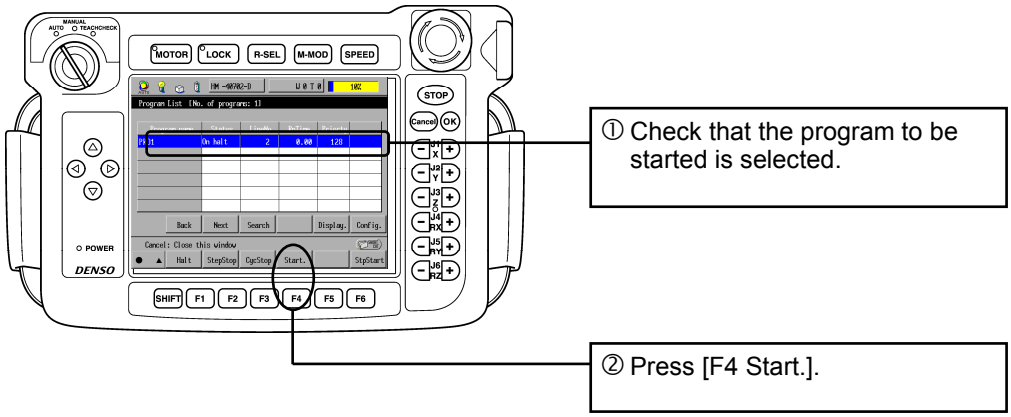
During program running, always keep one hand free and ready to press the STOP key.

The PRO1 program will start a single-step run in Auto mode.

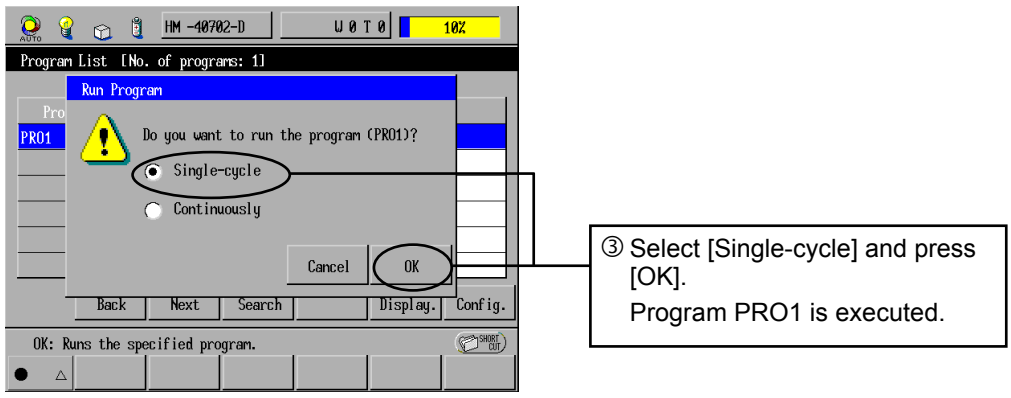
Perform the procedure above repeatedly through to the end of the program, checking that each motion is safe.

12.3.4 Single-Cycle Start

After running a single-step run, start a single-cycle run.



★Caution★ During program running, always keep one hand free and ready to press the STOP key.

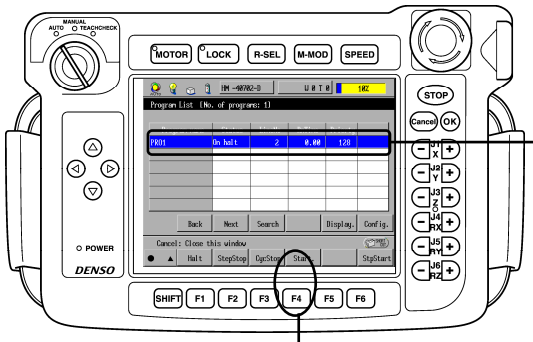


Once the program has been run to the end, it will stop.

★Caution★ The elapsed time on display refers to the length of time from the start to end of the program including temporary stop time caused by Step stop or Halt.

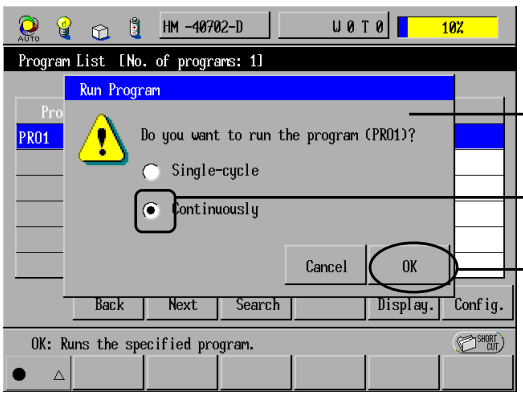
12.3.5 Continuous Start

Start a continuous run of the program.



① Check that the program to be started is selected.

② Press [F4 Start.].



The selection screen for [Single-cycle] and [Continuously] is displayed.

③ Select [Continuously].

④ Press [OK].
Program PRO1 will be executed continuously.
(You may stop continuous run by Halt (Stop) or Step stop.)

★Caution★

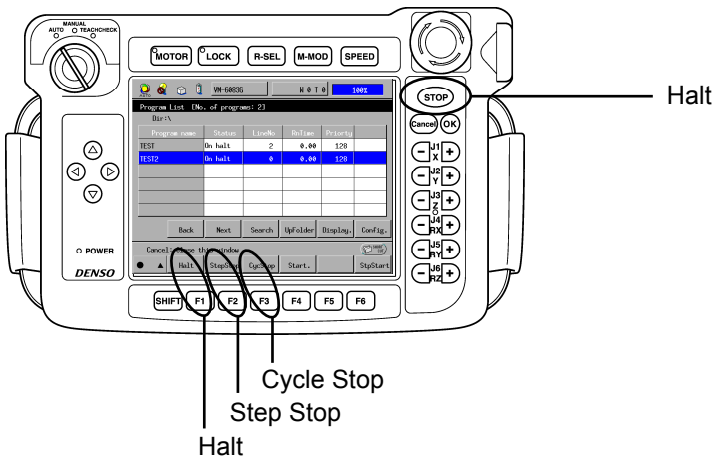
During program running, always keep one hand free and ready to press the STOP key.

⇩

This completes the procedures required to run the robot with the teach pendant.

12.4 Robot Stop

This section describes the four ways to stop the robot.



12.4.1 Cycle Stop [F3]

Executing the cycle stop stops the robot after executing the last step of the task program. This is used when the robot is continuously started. This operation does not turn the motor power OFF.

12.4.2 Step Stop [F2]

Executing the step stop interrupts the running task program midway after executing the step in which the step stop key is pressed. This operation does not turn the motor power OFF.

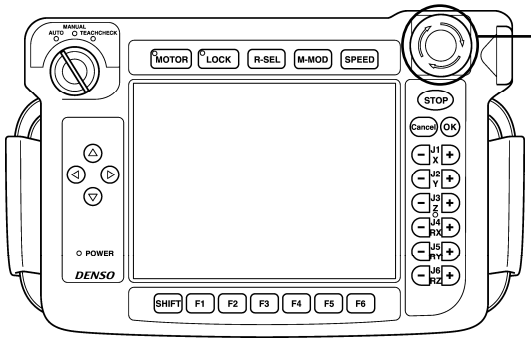
12.4.3 Halt [F1], [STOP]

Executing the halt immediately interrupts the running task program selected or all running task programs midway the moment [F1 Halt] or STOP key is pressed, respectively. This operation does not turn the motor power OFF.

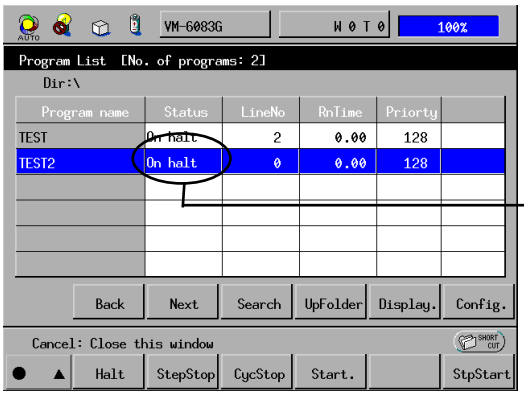
12.4.4 Emergency Stop (Robot Stop)

Pressing the emergency stop button immediately stops all running task programs midway and turns the motor power off the moment the emergency stop button is pressed.

Step 1 Press the emergency stop button.



Emergency stop button



The program(s) is (are) aborted and [On halt] is displayed in the [Status] column.

Restarting the robot after an emergency stop executes the selected program from the first line.

To restart the robot, first turn the motor power ON, then execute any of the "step start," "cycle start," or "continuous start."

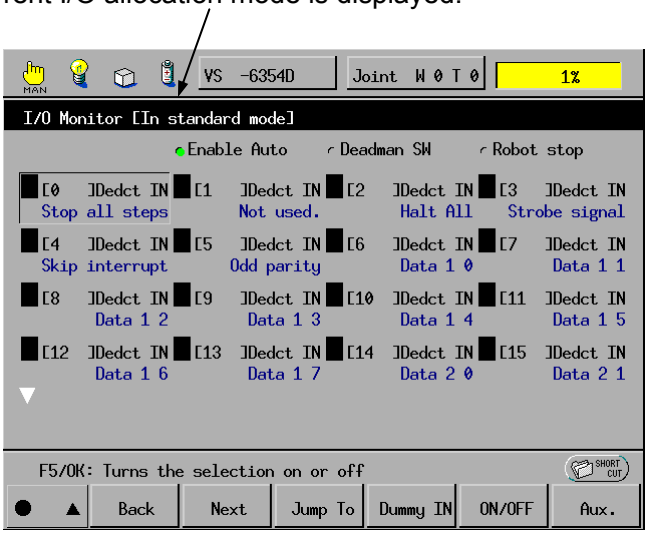
Chapter 13
Running the Robot from External Equipment

13.1 Checking the I/O Allocation Mode

How to run the robot from external equipment (PLC, etc.) differs depending upon the I/O allocation mode specified in the robot controller. It is, therefore, necessary to check the current allocation mode beforehand. Use the I/O monitor called up with [F4 I/O] on the top screen of the teach pendant.

Access: [F4 I/O]

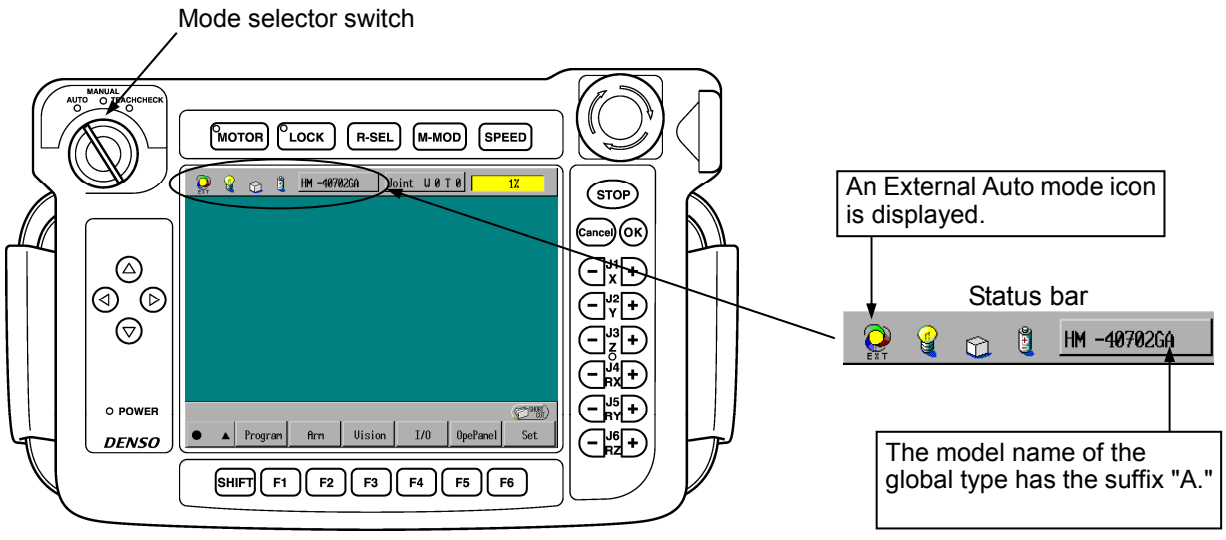
The current I/O allocation mode is displayed.



13.2 Notes on Using the Global Type of Controller

To run the robot from external equipment (PLC, etc.), it is necessary to set the "single point of control function" to the External Automatic mode. For details about the "single point of control function," see Section 2.2.2.

Check that turning the mode selector switch to the AUTO position turns the operation mode icon in the status bar to the external auto mode one.



13.3 Running in Mini I/O Dedicated Mode

In the mini I/O dedicated mode, I/O commands including program start are issued as the bit combination of the command area (3 bits) and data area (3 bits).

Those I/O commands are executed by a strobe signal.

13.3.1 Types and Functions of System Input Signals in Mini I/O Dedicated Mode

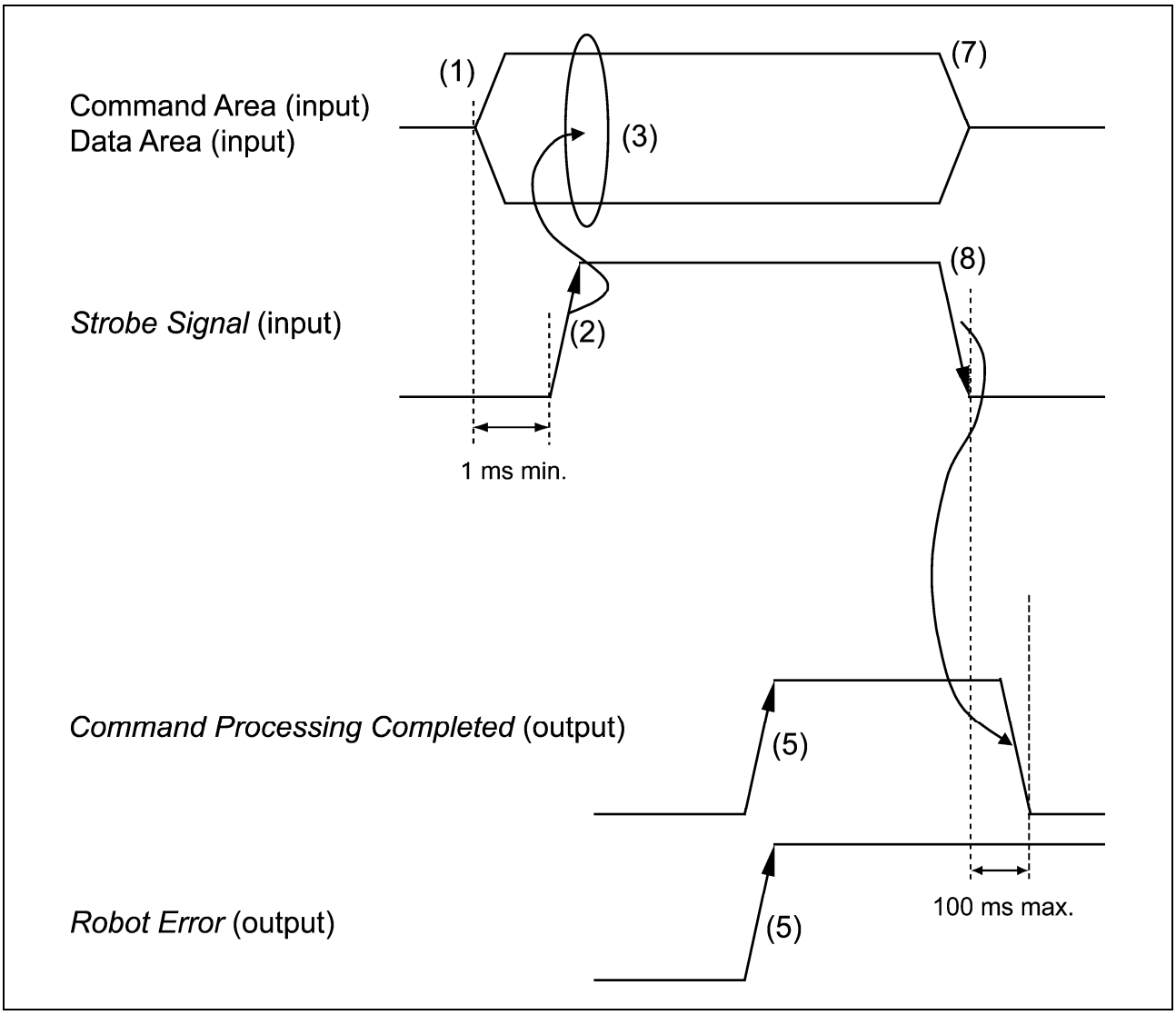
The mini I/O dedicated mode supports the following system input signals.

Purpose		System input signal			Used to:
		Command area (3 bits)	Data area (3 bits)		
Start-up	*Motor Power ON* *CAL Execution*	000	001	+ Strobe signal	Turn the motor power ON.
	External Speed (SP)100	000	010		Set the external speed to 100%.
	External Mode Switching	000	100		Switch to the external mode.
	Motor Power ON *CAL Execution* *External Speed (SP)100* *External Mode Switching*	000	111		Start up. (Perform the above start-up steps.)
Program Execution		010	Program number (0 to 7)		Execute the specified program.
Continue Start		011	---		Execute Continue Start.
Specified Program Reset		100	Program number (0 to 7)		Immediately stop the specified program and reset it (initialization).
All Programs Reset		101	---		Immediately stop all programs and reset them (initialization).
Clear Robot Error		001	---		Clear errors.
Stop		---	---	Step Stop (all tasks)	Step-stop all running programs when the signal is turned OFF.

Note: The "+ Strobe signal" indicates that the command area (3 bits) and data area (3 bits) should be used in combination.

13.3.2 Processing I/O Commands in Mini I/O Dedicated Mode

I/O commands are executed according to the following process.



Outline of I/O Command Processing (Mini I/O Dedicated Mode)

(1) Set a command area and a data area (if necessary) for the command execution I/O signal from the external equipment to the robot controller.

Note: The data to be set must be defined at least 1 ms before the Strobe Signal is turned ON

(2) After completion of setting, turn the *Strobe Signal* ON.

Note: The command input with a *Strobe Signal* should be preceded by the output of the *Robot Initialized*. If a *Robot Error* signal has been issued, however, execute a *Clear Robot Error* (001) since no *Robot Initialized* will be issued.

(3) The controller reads the command area and the data area according to the input of *Strobe Signal*.

(4) The controller starts processing based on the command read.

(5) After completion of command processing, the controller turns ON the *Command Processing Completed* signal.

If an error has occurred during processing, a *Robot Error* signal will be outputted together with the *Command Processing Completed* signal.

Note: If the *Strobe Signal* is turned OFF before the *Command Processing Completed* signal is turned ON, the controller outputs the *Command Processing Completed* signal once and then turns it OFF within 100 ms.

(6) The PLC waits until the *Command Processing Completed* signal is input. In this case, confirm that no error exists with the robot.

(7) The PLC turns OFF the command and data areas and the *Strobe Signal*.

(8) As soon as the *Strobe Signal* is turned OFF, the controller turns OFF the *Command Processing Completed* signal.

The *Robot Error* signal, which is outputted due to a command processing error, remains ON until *Clear Robot Error* (001) is executed.

Note: The maximum allowable time from when the *Strobe Signal* is turned OFF until the *Command Processing Completed* signal is turned OFF, is 100 ms.

13.3.3 Types and Functions of System Output Signals in Mini I/O Dedicated Mode

The table below lists the system output signals in the mini I/O dedicated mode.

Purpose	System output signal	Used to tell external equipment:
Start-up	*Robot Initialized*	That the OPERATION PREPARATION command is executable.
	Auto Mode	That the robot is in Auto mode.
	Operation Preparation Completed	That the motor power is turned on and the robot is in External auto mode.
Program Execution	*Robot Running*	That the robot is in operation (one or more tasks are being executed).
Error/Warning	*CPU Normal*	That the CPU hardware of the robot controller is normal.
	Robot Error	That a servo error, program error, or any other serious error has occurred.
	Battery Warning	That the voltage of the encoder or memory backup battery has dropped below the specified level.
Continue	*Continue Start Permission* Note: It is necessary to specify this output signal by I/O hardware setting beforehand.	That Continue Start is permitted.
Emergency Stop Circuit (Standard type of controller)	*Emergency Stop* (dual line)	That the robot is emergency-stopped.
	Pendant Emergency Stop (dual line)	The status of the emergency stop button on the teach pendant or mini-pendant.
	Deadman SW [*Enable SW*] (dual line)	The status of the deadman switch (enable switch) on the teach pendant or mini-pendant.
Safety Circuit (Global type of controller)	*Pendant Emergency Stop* (dual line)	The status of the emergency stop button on the teach pendant or mini-pendant.
	Deadman SW [*Enable SW*] (dual line)	The status of the deadman switch (enable switch) on the teach pendant or mini-pendant.
	Contactor Contact Monitor	The status of the auxiliary contact of the motor contactor in the robot controller. This signal comes on when the motor is turned on; it comes off when the motor is turned off.

13.4 Running in Standard Mode

In the standard mode, I/O commands including program start are issued as the bit combination of the command area (4 bits), data area 1 (8 bits), and data area 2 (16 bits). Those I/O commands are executed by a strobe signal.

13.4.1 Types and Functions of System Input Signals in Standard Mode

The standard mode supports the following system input signals.

Purpose		System input signal				Used to:
		Command area (4 bits)	Data area 1 (8 bits)	Data area 2 (16 bits)		
Program Execution	*Program Reset & Start*	0001	00000001	Program number (0 to 32767)	+Odd parity (if necessary) + Strobe signal	Reset the specified program and then start.
	Program Start	0001	00000010	Program number (0 to 32767)		Start the specified program. If the program is stopped with *Step Stop* or *Instantaneous Stop*, the program restarts at the step immediately following the step containing *Step Stop* or *Instantaneous Stop*.
	Continue Start	0001	00000100	---		Restart all programs stopped with *Continue Stop*.
	Step Stop	0001	00010000	Program number (0 to 32767)		Step-stop the specified program.
	Instantaneous Stop	0001	00100000	Program number (0 to 32767)		Stop the specified program instantaneously.
	Reset	0001	01000000	Program number (0 to 32767)		Stop the specified program instantaneously and then reset (initialize) the program.
External Speed and Acceleration Setting	*Set Speed*	0010	00000001	Speed setting (1 to 100)		Change the speed to the specified setting (1 to 100).
	Set Acceleration	0010	00000010	Acceleration setting (1 to 100)		Change the acceleration to the specified setting (1 to 100).
	Set Deceleration	0010	00000100	Deceleration setting (1 to 100)		Change the deceleration to the specified setting (1 to 100).
Read Error		0100	---	---		Output the number of a currently existing error to the status area.
Write Integer Variable		0101	Variable number (0 to 255)	Variable value (-32768 to 32768)		Assign the variable value (-32768 to 32768) to the specified integer variable (0 to 255).
Read Integer Variable		0110	Variable number (0 to 255)	---		Output the current value assigned to the specified integer variable (0 to 255) to the status area.
Start-up	*Motor Power ON*	0111	00000001	---		Turn the motor power ON.
	External Speed (SP)100	0111	00000010	---		Set the external speed to 100%.
	External Mode Switching	0111	10000000	---		Switch to the external mode.
	Motor Power ON *CAL Execution* *External Speed (SP)100* *External Mode Switching*	0111	10000011	---		Start up. (Perform the above start-up steps.)
Clear Robot Error		1000	---	---		Clear errors.
Write I/O		1001	00000000 to 11111111	Internal IO number (128 to 504)		Assign the state of data area 1 to the internal IO area starting with the number specified in data area 2.
Read I/O		1010	---	Internal IO number (128 to 504)		Output the state of the internal IO area starting with the number specified in data area 2 to the lower 8 bits of the status area.

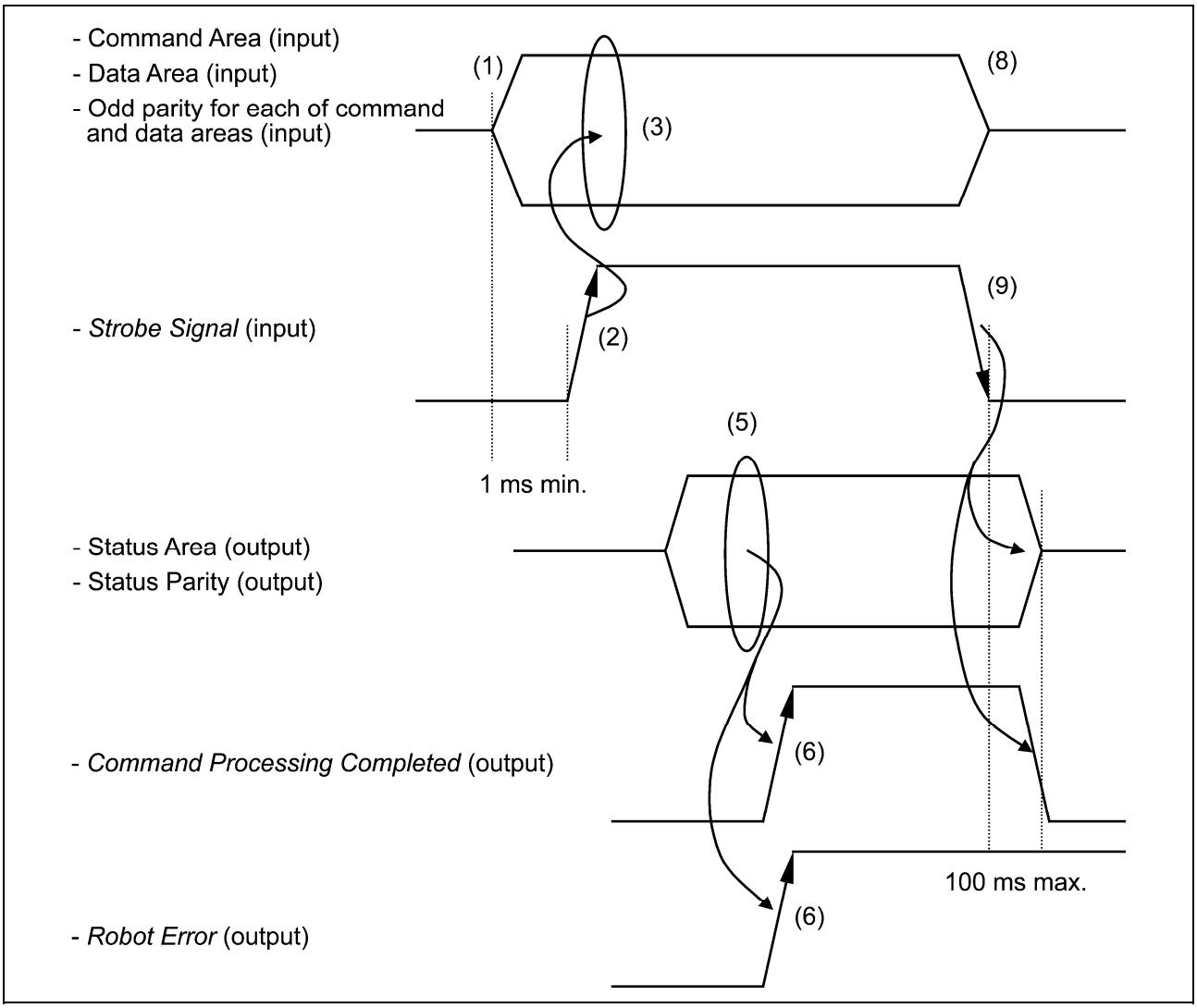
Purpose	System input signal				Used to:
	Command area (4 bits)	Data area 1 (8 bits)	Data area 2 (16 bits)		
Stop	---	---	---	*Robot Stop*	Stop the robot when the signal is turned OFF.
	---	---	---	*Instantaneous Stop (All tasks)*	Stop all running programs instantaneously when the signal is turned OFF.
	---	---	---	*Step Stop (All tasks)*	Step-stop all running programs when the signal is turned OFF.

Note: The "+Odd parity" indicates that when the total number of bits of the command area and data areas 1 and 2 is even, an odd parity signal should be entered to make the total an odd.

Note: The "+ Strobe signal" indicates that the command area, data areas 1 and 2, and odd parity should be used in combination.

13.4.2 Processing I/O Commands in Standard Mode

I/O commands are executed according to the following process.



Outline of I/O Command Processing (Standard Mode)

(1) Set a command area, data areas (if necessary) and odd parity (to each of command and data areas) for the command execution I/O signal from the external equipment to the robot controller.

Note: The data to be set must be defined at least 1 ms before the *Strobe Signal* is turned ON.

(2) After completion of setting, turn the *Strobe Signal* ON.

Note: The command input with a *Strobe Signal* should be preceded by the output of the *Robot Initialized*. If a *Robot Error* signal has been issued, however, execute a *Clear Robot Error* (001) since no *Robot Initialized* will be issued.

(3) The controller reads the command area, data areas, and odd parities according to the input of *Strobe Signal*.

(4) The controller starts processing based on the command read.

(5) If the command is to output the status, the controller sets the status area and parity.

(6) After completion of command processing, the controller turns ON the *Command Processing Completed* signal.

If an error has occurred during processing, a *Robot Error* signal will be outputted together with the *Command Processing Completed* signal.

Note: If the *Strobe Signal* is turned OFF before the *Command Processing Completed* signal is turned ON, the controller outputs the *Command Processing Completed* signal and the state of the status area once and then turns them OFF within 100 ms.

(7) The PLC waits until the *Command Processing Completed* signal is input. If necessary, it gets the state of the status area. In this case, confirm that no error exists with the robot.

(8) After completion of reading of the status, the PLC turns OFF the command and data areas and the *Strobe Signal*.

(9) As soon as the *Strobe Signal* is turned OFF, the controller turns OFF the *Command Processing Completed* signal.

The *Robot Error* signal, which is outputted due to a command processing error, remains ON until *Clear Robot Error* (001) is executed.

Note: The maximum allowable time from when the *Strobe Signal* is turned OFF until the *Command Processing Completed* signal is turned OFF, is 100 ms.

13.4.3 Types and Functions of System Output Signals in Standard Mode

The standard mode supports the following system output signals.

Purpose	Output signal name	Used to tell external equipment:
Start-up	*Robot Initialized*	That the OPERATION PREPARATION command is executable.
	Auto Mode	That the robot is in Auto mode.
	External Mode	That the robot is in External mode.
	Servo ON	That the motor power is ON.
Program Execution	*Robot Running*	That the robot is in operation (one or more tasks are being executed).
Error/Warning	*CPU Normal*	That the CPU hardware of the robot controller is normal.
	Robot Error	That a servo error, program error, or any other serious error has occurred.
	Robot Warning	That a minor error has occurred.
	Battery Warning	That the voltage of the encoder or memory backup battery has dropped below the specified level.
Continue	*Continue Start Permission*	That Continue Start is permitted.
SS Function	*SS Mode*	That the robot is in SS mode. (See the SETTING-UP MANUAL, Section 3.4.6 "SS (Safe Start) Function."
Emergency Stop	*Emergency Stop*	The output from the contact exclusive to the emergency stop circuit.
I/O Command Processing	*Command Processing Completed*	That the I/O command processing has completed.
	Status area odd parity	An odd parity when the total number of output bits of the status area (16 bits) is even.
	Status area (16 bits)	The processing result of *Rear Error*, *Read Integer Variable*, and *Write I/O* signals.

13.5 Running in Compatible Mode

In the compatible mode, I/O commands including program start are identified by setting the corresponding bits.

13.5.1 Types and Functions of System Input Signals in Compatible Mode

The compatible mode supports the following system input signals.

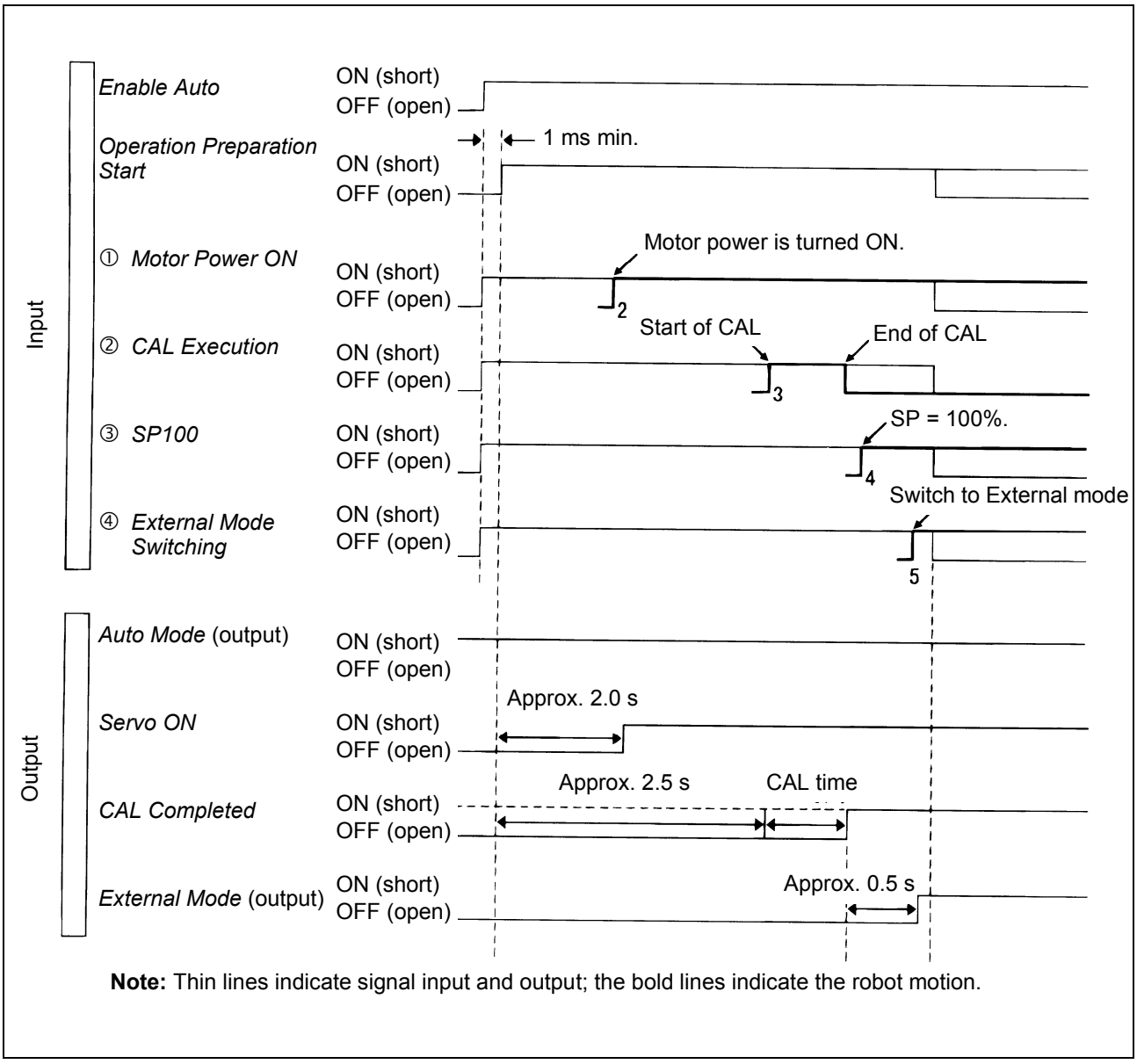
Purpose	System input signal	Used to:
Start-up	*Enable Auto*	Enable the robot to switch to the Auto mode.
	Motor Power ON + *Operation Preparation Start*	Turn the motor power ON.
	CAL Execution + *Operation Preparation Start*	Execute CAL operation.
	SP100 + *Operation Preparation Start*	Set the external speed to 100%.
	External Mode Switching + *Operation Preparation Start*	Switch to the external mode.
	Program Reset + *Operation Preparation Start*	Initialize all programs stopped. Program start after initialization executes the program from the beginning.
	Program Number Selection + *Operation Start*	Execute the specified program.
Program Execution	*Program Reset* + *Program Number Selection* + *Program Start*	Cancel the current program and execute the specified program from the beginning.
	Robot Stop	Stop the robot when the signal is turned OFF.
Stop	*Robot Stop*	Stop the robot when the signal is turned OFF.
	Step Stop	Step-stop all programs when the signal is turned OFF.
	Instantaneous Stop	Stop all programs instantaneously when the signal is turned OFF.
Clear Error	*Clear Robot Error* + *Operation Preparation Start*	Clear errors.
Program Interrupt	*Interruption Skip*	Stop execution of the current stop and execute the next step.
Continue Start	*Continue Start* + *Program Start*	Execute *Continue Start*.

Note: Two or more signals added with a plus sign (+) indicate that they should be used in combination.

13.5.2 Processing I/O Commands in Compatible Mode

I/O commands are executed according to the following process.

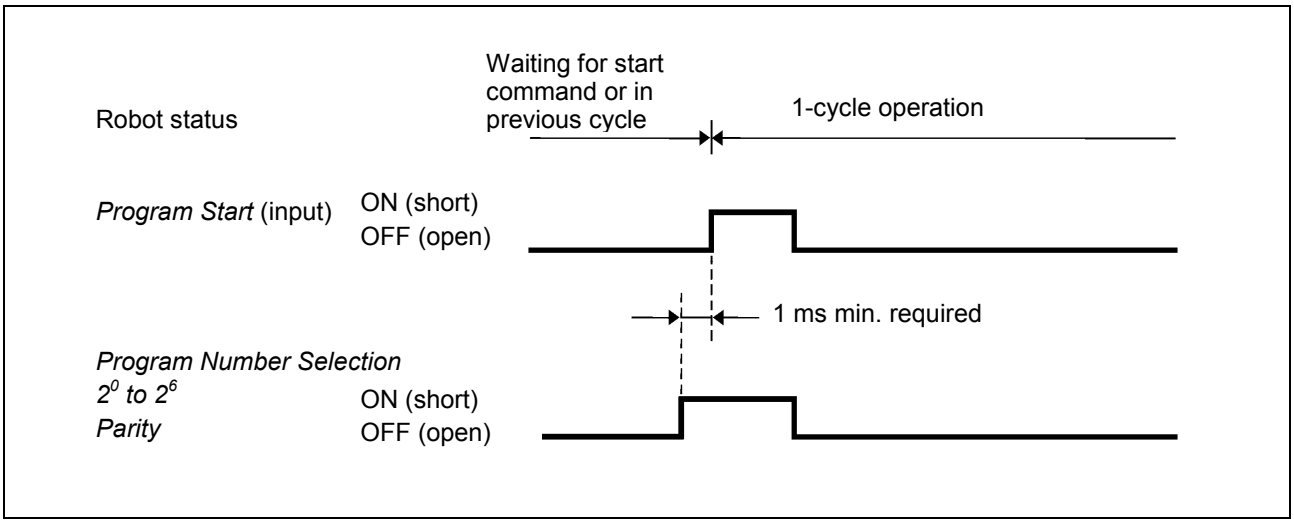
Example: *Operation Preparation Start*



Note: Thin lines indicate signal input and output; the bold lines indicate the robot motion.

Timing Scheme of *Operation Preparation Start* (Compatible Mode)

Example: *Program Start*



Timing Scheme of *Program Start* (Compatible Mode)

13.5.3 Types and Functions of System Output Signals in Compatible Mode

The table below lists the system output signals in the compatible mode.

Purpose	Output signal name	Used to tell external equipment:
Start-up	*Robot Initialized*	That the OPERATION PREPARATION command is executable.
	Auto Mode	That the robot is in Auto mode.
	Servo ON	That the motor power is ON.
	CAL Completed	That the CAL operation is completed.
	External Mode	That the robot is in External mode.
Check Before Start of Program Execution	*Teaching ON*	That the robot is in Manual mode or Teach check mode.
Program Execution	*Program Start Reset*	That the program starts executing upon receipt of *Program Start* signal.
	Robot Running	That the robot is in operation (one or more tasks are being executed).
Program Termination	*1-Cycle End*	That a single cycle of program is terminated.
Error/Warning	*CPU Normal*	That the CPU hardware of the robot controller is normal.
	Robot Error	That a servo error, program error, or any other serious error has occurred.
	Robot Warning	That a minor error has occurred.
	Battery Warning	That the voltage of the encoder or memory backup battery has dropped below the specified level.
	Error Number	The error number in BCD code when an error has occurred.
Continue	*Continue Start Permission*	That Continue Start is permitted.
SS Function	*SS Mode*	That the robot is in SS mode. (See the SETTING-UP MANUAL, Section 3.4.6 "SS Function.")
Emergency Stop	*Emergency Stop*	The output from the contact exclusive to the emergency stop circuit.

13.6 I/O Allocation Tables

Out of I/O allocation tables given in this section, select an allocation table suited to your I/O allocation mode, referring the "I/O Allocation of Extension Boards in Individual Allocation Modes" table in Chapter 3, Section 3.3.1. For allocation of I/O extension boards, refer to "I/O Extension Boards for RC7M" in the OPTIONS MANUAL.

Note: In the "I/O conversion box compatible mode" or "I/O conversion box standard mode," the I/O allocations differ from the ones given in this section, so refer to the RC7M CONTROLLER MANUAL, Chapter 8 "I/O Allocation for I/O Conversion Box (only for standard type of controller)."

13.6.1 Hand I/O (CN9): Common to All Modes

The RC7M controller has a hand I/O (CN9) as standard, which is common to all modes independent of the allocation mode selected.

HAND I/O (CN9): NPN type I/O

Terminal No.	Name	Port No.	Wire color		Terminal No.	Name	Port No.	Wire color	
			Standard	Reinforced				Standard	Reinforced
1	Hand output	64	Black	Blue	11	Hand input	50	Pink	White
2	Hand output	65	Brown	Yellow	12	Hand input	51	Pink	White
3	Hand output	66	Black	Green	13	Hand input	52	White	White
4	Hand output	67	Brown	Red	14	Hand input	53	White	White
5	Hand output	68	Red	Violet	15	Hand input	54	White	White
6	Hand output	69	Orange	Blue	16	Hand input	55	White	Brown
7	Hand output	70	Yellow	Yellow	17	Internal power source output +24V	—	White	Brown
8	Hand output	71	Green	Green	18	Internal power source output 0V	—	White	Brown
9	Hand input	48	Blue	Red	19	NC	—	White	Brown
10	Hand input	49	Violet	Violet	20	NC	—	White	Brown

HAND I/O (CN9): PNP type I/O

Terminal No.	Name	Port No.	Wire color		Terminal No.	Name	Port No.	Wire color	
			Standard	Reinforced				Standard	Reinforced
1	Hand output	64	Black	Blue	11	Hand input	50	Pink	White
2	Hand output	65	Brown	Yellow	12	Hand input	51	Pink	White
3	Hand output	66	Black	Green	13	Hand input	52	White	White
4	Hand output	67	Brown	Red	14	Hand input	53	White	White
5	Hand output	68	Red	Violet	15	Hand input	54	White	White
6	Hand output	69	Orange	Blue	16	Hand input	55	White	Brown
7	Hand output	70	Yellow	Yellow	17	Internal power source output 0V	—	White	Brown
8	Hand output	71	Green	Green	18	Internal power source output +24V	—	White	Brown
9	Hand input	48	Blue	Red	19	NC	—	White	Brown
10	Hand input	49	Violet	Violet	20	NC	—	White	Brown

13.6.2 Mini I/O Board (CN5 on standard type of controller) in Mini I/O Dedicated Mode

Terminal No.	Signal name	Port No.	Wire color	Terminal No.	Signal name	Port No.	Wire color
1	*Enable Auto* (Internal +24V) (input)	—	Black	35	*Enable Auto* (input)	—	Pink
2	*External Emergency Stop 1*, b-1 (input) (Internal +24V)	—	Brown	36	*External Emergency Stop 1*, b-2 (input)	—	Pink
3	*External Emergency Stop 2*, b-1 (input) (Internal +24V)	—	Red	37	*External Emergency Stop 2*, b-2 (input)	—	Pink
4	Reserved.	—	Orange	38	Reserved.	—	Pink
5	Reserved.	—	Yellow	39	Reserved.	—	Pink
6	*Emergency Stop 1*, -1 (output) (Mini relay)	—	Black	40	*Emergency Stop 1*, -2 (output) (Mini relay)	—	White
7	*Emergency Stop 2*, -1 (output) (Mini relay)	—	Brown	41	*Emergency Stop 2*, -2 (output) (Mini relay)	—	White
8	*Deadman SW 1*, -1 (output) [*Enable SW 1*, -1] (Mini relay)	—	Red	42	*Deadman SW 1*, -2 (output) [*Enable SW 1*, -2] (Mini relay)	—	White
9	*Deadman SW 2*, -1 (output) [*Enable SW 2*, -1] (Mini relay)	—	Orange	43	*Deadman SW 2*, -2 (output) [*Enable SW 2*, -2] (Mini relay)	—	White
10	—	—	Yellow	44	—	—	White
11	*Step Stop (All tasks)* (input)	0	Green	45	*CPU Normal* (output)	16	White
12	*Strobe Signal* (input)	1	Blue	46	*Robot Running* (output)	17	White
13	Data area bit 0 (input)	2	Violet	47	*Robot Error* (output)	18	White
14	Data area bit 1 (input)	3	Gray	48	*Robot Initialized* (output)	19	White
15	Data area bit 2 (input)	4	Pink	49	*Auto Mode* (output)	20	White
16	Command area bit 0 (input)	5	Black	50	*Operation Preparation Completed* (output)	21	Gray
17	Command area bit 1 (input)	6	Black	51	*Battery Warning* (output)	22	Violet
18	Command area bit 2 (input)	7	Brown	52	*Command Processing Completed* (output)	23	Violet
19	User input	8	Red	53	User output/ *Continue Start Permission* (output)	24	Violet
20	User input	9	Orange	54	User output	25	Violet
21	User input	10	Yellow	55	User output	26	Violet
22	User input	11	Green	56	User output	27	Violet
23	User input	12	Blue	57	User output	28	Violet
24	User input	13	Gray	58	User output	29	Violet
25	User input	14	Pink	59	User output	30	Violet
26	User input	15	Brown	60	User output	31	Gray
27	—	—	Red	61	—	—	Gray
28	*Pendant Emergency Stop 1,* b-1 (output) (Dry output)	—	Orange	62	*Pendant Emergency Stop 1*, b-2 (output) (Dry output)	—	Gray
29	*Pendant Emergency Stop 2,* b-1 (output) (Dry output)	—	Yellow	63	*Pendant Emergency Stop 2*, b-2 (output) (Dry output)	—	Gray
30	Power for conveyor tracking board (when JP12 on mini I/O board is shorted. DC power output +24V)	—	Green	64	Power for conveyor tracking board (when JP13 on mini I/O board is shorted. DC power output 0V)	—	Gray
31	—	—	Blue	65	—	—	Gray
32	DC power input +24V (when external power source is used)	—	Pink	66	DC power input 0V (when external power source is used)	—	Gray
33	DC power output +24V (when internal power source is used)	—	Black	67	DC power output 0V (when internal power source is used)	—	Blue
34		—	Brown	68		—	Blue

13.6.3 Mini I/O Board (CN5 on global type of controller) in Mini I/O Dedicated Mode

Terminal No.	Signal name	Port No.	Wire color	Terminal No.	Signal name	Port No.	Wire color
1	Reserved.	—	Black	35	Reserved.	—	Pink
2	Reserved.	—	Brown	36	Reserved.	—	Pink
3	Reserved.	—	Red	37	Reserved.	—	Pink
4	Reserved.	—	Orange	38	Reserved.	—	Pink
5	Reserved.	—	Yellow	39	Reserved.	—	Pink
6	Reserved.	—	Black	40	Reserved.	—	White
7	Reserved.	—	Brown	41	Reserved.	—	White
8	Reserved.	—	Red	42	Reserved.	—	White
9	Reserved.	—	Orange	43	Reserved.	—	White
10	—	—	Yellow	44	—	—	White
11	*Step Stop (All tasks)* (input)	0	Green	45	*CPU Normal* (output)	16	White
12	*Strobe Signal* (input)	1	Blue	46	*Robot Running* (output)	17	White
13	Data area bit 0 (input)	2	Violet	47	*Robot Error* (output)	18	White
14	Data area bit 1 (input)	3	Gray	48	*Robot Initialized* (output)	19	White
15	Data area bit 2 (input)	4	Pink	49	*Auto Mode* (output)	20	White
16	Command area bit 0 (input)	5	Black	50	*Operation Preparation Completed* (output)	21	Gray
17	Command area bit 1 (input)	6	Black	51	*Battery Warning* (output)	22	Violet
18	Command area bit 2 (input)	7	Brown	52	*Command Processing Completed* (output)	23	Violet
19	User input	8	Red	53	User output / *Continue Start Permission* (output)	24	Violet
20	User input	9	Orange	54	User output	25	Violet
21	User input	10	Yellow	55	User output	26	Violet
22	User input	11	Green	56	User output	27	Violet
23	User input	12	Blue	57	User output	28	Violet
24	User input	13	Gray	58	User output	29	Violet
25	User input	14	Pink	59	User output	30	Violet
26	User input	15	Brown	60	Reserved.	31	Gray
27	—	—	Red	61	—	—	Gray
28	Reserved.	—	Orange	62	Reserved.	—	Gray
29	Reserved.	—	Yellow	63	Reserved.	—	Gray
30	Power for conveyor tracking board (when JP12 on mini I/O board is shorted. DC power output +24V)	—	Green	64	Power for conveyor tracking board (when JP13 on mini I/O board is shorted. DC power output 0V)	—	Gray
31	—	—	Blue	65	—	—	Gray
32	DC power input +24V (when external power source is used)	—	Pink	66	DC power input 0V (when external power source is used)	—	Gray
33		—	Black	67		—	Blue
34	DC power output +24V (when internal power source is used)	—	Brown	68	DC power output 0V (when internal power source is used)	—	Blue

13.6.4 Mini I/O Board (CN5 on standard type of controller) in Compatible, Standard and All User I/O Modes

Terminal No.	Signal name	Port No.	Wire color	Terminal No.	Signal name	Port No.	Wire color
1	*Enable Auto* (Internal +24V) (input)	—	Black	35	*Enable Auto* (input)	—	Pink
2	*External Emergency Stop 1*, b-1 (input) (Internal +24V)	—	Brown	36	*External Emergency Stop 1*, b-2 (input)	—	Pink
3	*External Emergency Stop 2*, b-1 (input) (Internal +24V)	—	Red	37	*External Emergency Stop 2*, b-2 (input)	—	Pink
4	Reserved.	—	Orange	38	Reserved.	—	Pink
5	Reserved.	—	Yellow	39	Reserved.	—	Pink
6	*Emergency Stop 1*, -1 (output) (Mini relay)	—	Black	40	*Emergency Stop 1*, -2 (output) (Mini relay)	—	White
7	*Emergency Stop 2*, -1 (output) (Mini relay)	—	Brown	41	*Emergency Stop 2*, -2 (output) (Mini relay)	—	White
8	*Deadman SW 1*, -1 (output) [*Enable SW 1*, -1] (Mini relay)	—	Red	42	*Deadman SW 1*, -2 (output) [*Enable SW 1*, -2] (Mini relay)	—	White
9	*Deadman SW 2*, -1 (output) [*Enable SW 2*, -1] (Mini relay)	—	Orange	43	*Deadman SW 2*, -2 (output) [*Enable SW 2*, -2] (Mini relay)	—	White
10	—	—	Yellow	44	—	—	White
11	User input	0	Green	45	User output	16	White
12	User input	1	Blue	46	User output	17	White
13	User input	2	Violet	47	User output	18	White
14	User input	3	Gray	48	User output	19	White
15	User input	4	Pink	49	User output	20	White
16	User input	5	Black	50	User output	21	Gray
17	User input	6	Black	51	User output	22	Violet
18	User input	7	Brown	52	User output	23	Violet
19	User input	8	Red	53	User output	24	Violet
20	User input	9	Orange	54	User output	25	Violet
21	User input	10	Yellow	55	User output	26	Violet
22	User input	11	Green	56	User output	27	Violet
23	User input	12	Blue	57	User output	28	Violet
24	User input	13	Gray	58	User output	29	Violet
25	User input	14	Pink	59	User output	30	Violet
26	User input	15	Brown	60	User output	31	Gray
27	—	—	Red	61	—	—	Gray
28	*Pendant Emergency Stop 1,* b-1 (output) (Dry output)	—	Orange	62	*Pendant Emergency Stop 1*, b-2 (output) (Dry output)	—	Gray
29	*Pendant Emergency Stop 2,* b-1 (output) (Dry output)	—	Yellow	63	*Pendant Emergency Stop 2*, b-2 (output) (Dry output)	—	Gray
30	Power for conveyor tracking board (when JP12 on mini I/O board is shorted. DC power output +24V)	—	Green	64	Power for conveyor tracking board (when JP13 on mini I/O board is shorted. DC power output 0V)	—	Gray
31	—	—	Blue	65	—	—	Gray
32	DC power input +24V (when external power source is used)	—	Pink	66	DC power input 0V (when external power source is used)	—	Gray
33	DC power output +24V (when internal power source is used)	—	Black	67	DC power output 0V (when internal power source is used)	—	Blue
34		—	Brown	68		—	Blue

13.6.5 Mini I/O Board (CN5 on global type of controller) in Compatible, Standard, and All User I/O Modes

Terminal No.	Signal name	Port No.	Wire color	Terminal No.	Signal name	Port No.	Wire color
1	Reserved.	—	Black	35	Reserved.	—	Pink
2	Reserved.	—	Brown	36	Reserved.	—	Pink
3	Reserved.	—	Red	37	Reserved.	—	Pink
4	Reserved.	—	Orange	38	Reserved.	—	Pink
5	Reserved.	—	Yellow	39	Reserved.	—	Pink
6	Reserved.	—	Black	40	Reserved.	—	White
7	Reserved.	—	Brown	41	Reserved.	—	White
8	Reserved.	—	Red	42	Reserved.	—	White
9	Reserved.	—	Orange	43	Reserved.	—	White
10	—	—	Yellow	44	—	—	White
11	User input	0	Green	45	User output	16	White
12	User input	1	Blue	46	User output	17	White
13	User input	2	Violet	47	User output	18	White
14	User input	3	Gray	48	User output	19	White
15	User input	4	Pink	49	User output	20	White
16	User input	5	Black	50	User output	21	Gray
17	User input	6	Black	51	User output	22	Violet
18	User input	7	Brown	52	User output	23	Violet
19	User input	8	Red	53	User output	24	Violet
20	User input	9	Orange	54	User output	25	Violet
21	User input	10	Yellow	55	User output	26	Violet
22	User input	11	Green	56	User output	27	Violet
23	User input	12	Blue	57	User output	28	Violet
24	User input	13	Gray	58	User output	29	Violet
25	User input	14	Pink	59	User output	30	Violet
26	User input	15	Brown	60	Reserved.	31	Gray
27	—	—	Red	61	—	—	Gray
28	Reserved.	—	Orange	62	Reserved.	—	Gray
29	Reserved.	—	Yellow	63	Reserved.	—	Gray
30	Power for conveyor tracking board (when JP12 on mini I/O board is shorted. DC power output +24V)	—	Green	64	Power for conveyor tracking board (when JP13 on mini I/O board is shorted. DC power output 0V)	—	Gray
31	—	—	Blue	65	—	—	Gray
32	DC power input +24V (when external power source is used)	—	Pink	66	DC power input 0V (when external power source is used)	—	Gray
33		—	Black	67		—	Blue
34	DC power output +24V (when internal power source is used)	—	Brown	68	DC power output 0V (when internal power source is used)	—	Blue

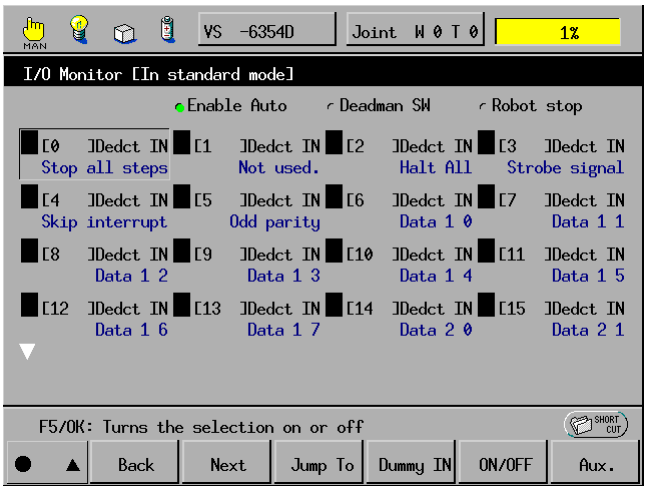
Chapter 14
Monitoring and Manipulating the I/Os

You can monitor the status of system inputs and outputs, user inputs and outputs, and internal I/O in real time. Also, you can simulate robot motions by forcibly turning on the user output signal, hand output signal, and internal I/O signal, or by turning on the dummy signals of user inputs and hand inputs.

14.1 Operation Using the Teach Pendant

14.1.1 Monitoring the I/Os

Pressing [F4 I/O] on the top screen will display the I/O Monitor window as shown below. In this window, you can check the ON/OFF status of I/Os.



Function keys available	
[F1 Back]	Displays the previous page of the I/O signal list.
[F2 Next]	Displays the next page of the I/O signal list.
[F3 Jump To]	Displays the Jump to I/O No. window where you may type an I/O port address you want to see with the numerical keys and press OK. Doing so will display the target input or output signal.
[F4 Dummy IN]	Allows the selected system-input port to accept a dummy input. That input port will be marked with "!" and the dummy I/O icon will appear in the status bar of the top of the screen. This command is useful for testing programs.
[F5 ON/OFF]	Displays the system message "Are you sure you want to turn the I/O xxxx on (or off)?" Pressing the OK button will turn the selected input port on (or off). This function is available for user outputs, hand outputs, and internal I/Os. If an invalid number is specified, the ERROR 21FB ("Reserved output area writing error") or ERROR 73E4 ("Out of I/O range") occurs.
[F10 ClrDummy]	Clears the dummy input setting.

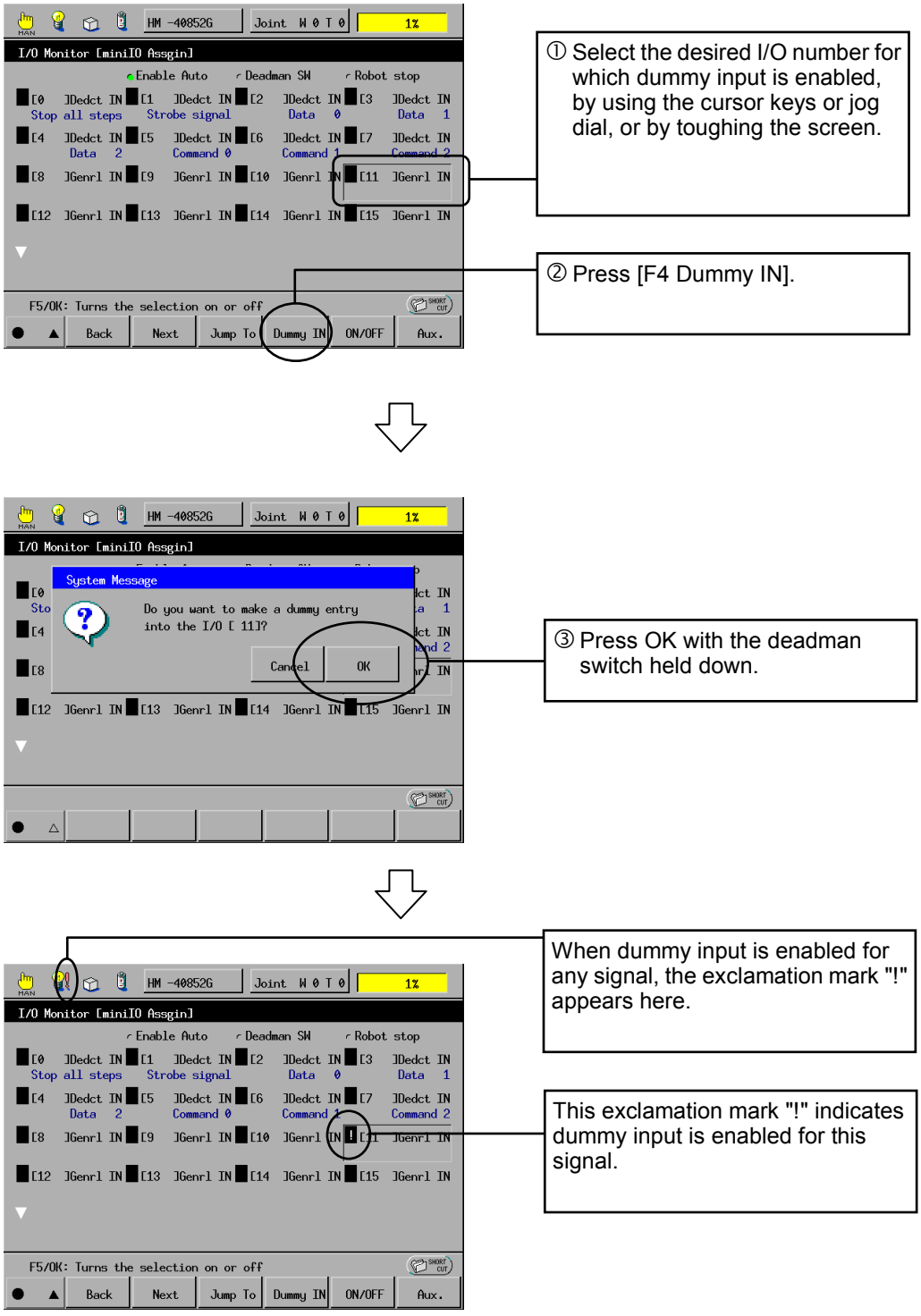
14.1.2 Turning Dummy Inputs ON/OFF

Only for user inputs and hand inputs, dummy inputs can be enabled.

When dummy inputs is enabled, you can turn the signal ON or OFF with the teach pendant.

Enabling dummy inputs

Pressing [F4 I/O] on the top screen will display the I/O Monitor window as shown below.

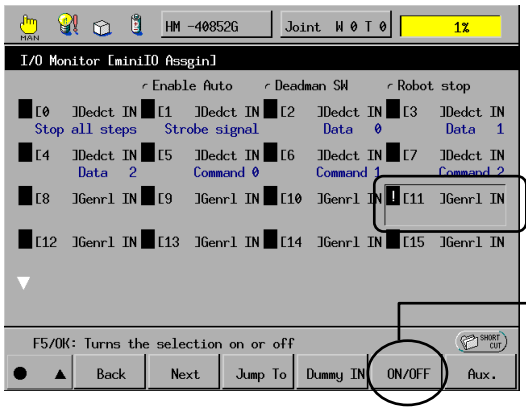


This completes the setting for enabling dummy inputs.

★**Remarks**★ To disable dummy inputs, repeat the steps ① to ③ or press [F10 ClrDummy].

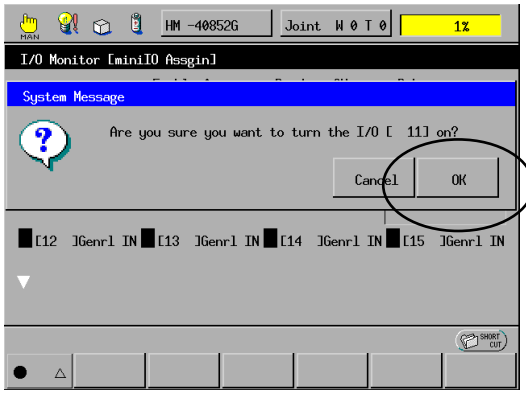
Turning ON/OFF Dummy Inputs

How to turn ON the dummy inputs is shown below.



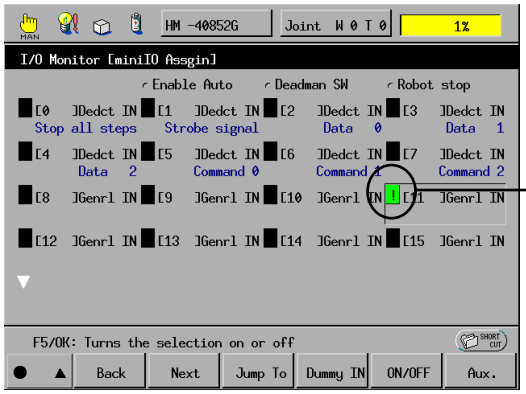
① Select the desired I/O number for which dummy input is turned ON or OFF, by using the cursor keys or jog dial, or by toughing the screen.

② Press [F5 ON/OFF].



③ Press OK with the deadman switch held down.

★Caution★ If an I/O number without the exclamation mark "!" is turned ON or OFF, ERROR 73E4 ("Out of I/O range") occurs.



The I/O number for which dummy input turned ON lights green.
ON: green
OFF: black

★Remarks★ To turn the dummy input OFF, repeat the steps ① to ③

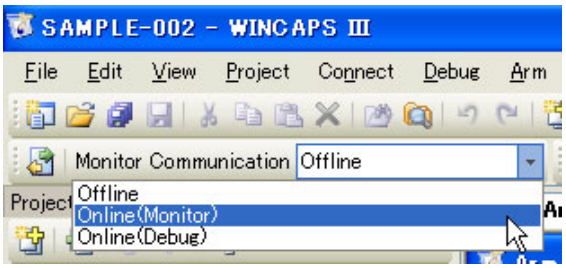
14.2 Operation Using WINCAPSIII

WINCAPSIII can monitor the I/O status of the robot controller or verify programs using dummy I/O function.

14.2.1 Monitoring I/O Status

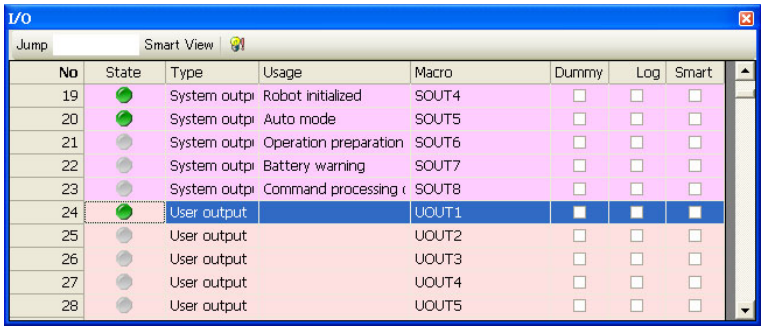
Monitor the I/O status in WINCAPSIII with the following procedure.

Step 1 **Open the target project and choose Connect | Monitor Communication | Online (Monitor).**



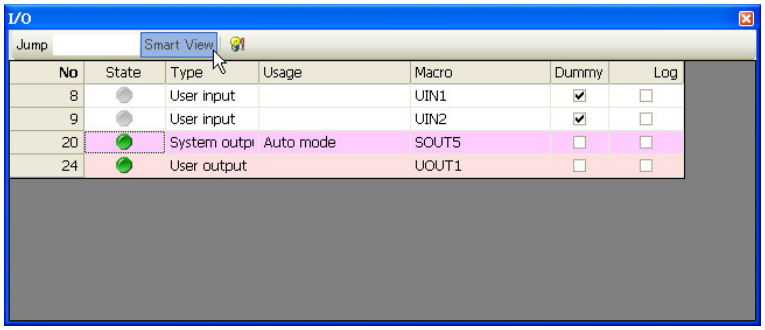
Step 2 **Choose View | IO View to display an I/O window in the Docking view area.**

Scroll the screen to the I/O to monitor, then check the I/O status.



In the State column, green circles denote "ON."

Step 3 **Use the smart view function to display the desired I/Os only, with the following procedure.**



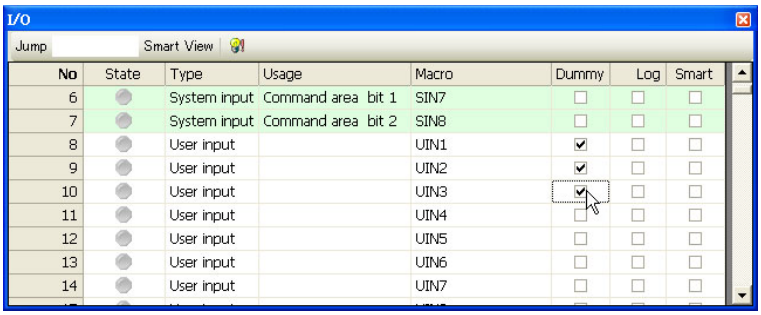
In the Smart column, select I/Os to display and then press the Smart View button.

14.2.2 Using Dummy I/Os

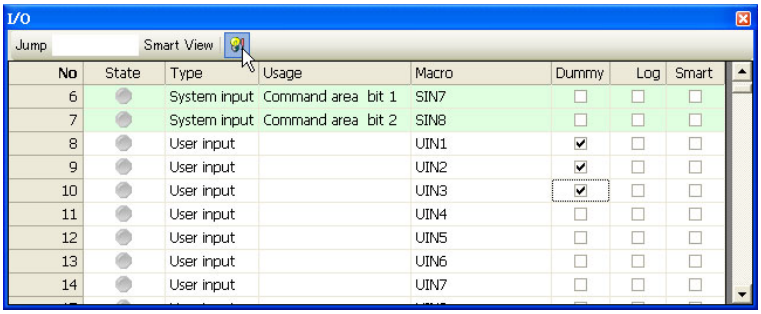
Only for user inputs and hand inputs, the dummy I/O function is available. Using the function enables you to turn I/Os from ON to OFF or from OFF to ON in the WINCAPSIII I/O window.

Step 1 **Open the target project and choose Connect | Monitor Communication | Online (Monitor) (see Section 14.2.1, Step 1). Then choose View | IO View to display an I/O window (see Section 14.2.1, Step 2).**

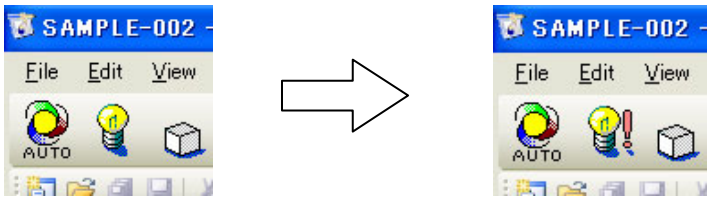
In the Dummy column, select I/Os that the dummy I/O function should apply.



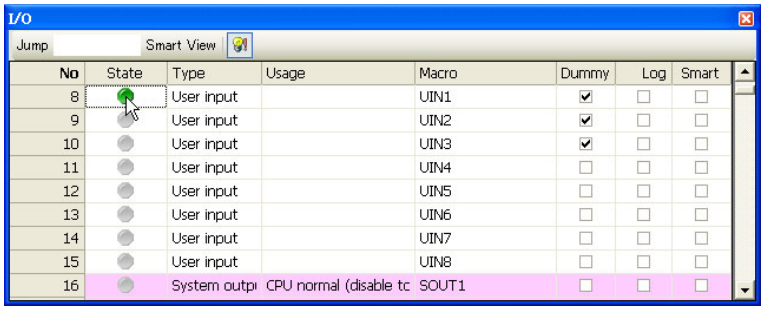
Step 2 **Press the dummy input button to allow the selected I/Os to be controlled from WINCAPSIII.**



In the dummy I/O mode, the I/O icon with an exclamation mark (!) appears.



Step 3 **To toggle the selected I/O on and off, press the corresponding field in the State column.**



Chapter 15
Monitoring and Modifying Variables

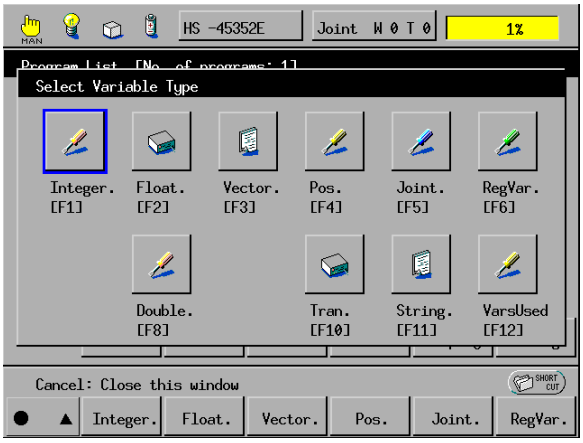
15.1 Operation Using the Teach Pendant

15.1.1 Monitoring and Modifying Global Variables

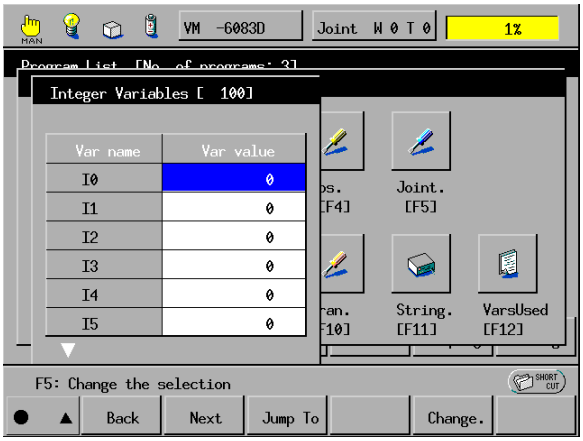
Access: [F1 Program]—[F4 Var.]

Monitor values assigned to various types of variables, the number of variables used, and/or modifies them.

(1) Press [F4 Var.] in the Program List window, and the Select Variable Type window will appear as shown below.



(2) Select the desired type of variable to monitor or modify.
Pressing [F1 Integer.] will display the Integer Variables window as shown below.

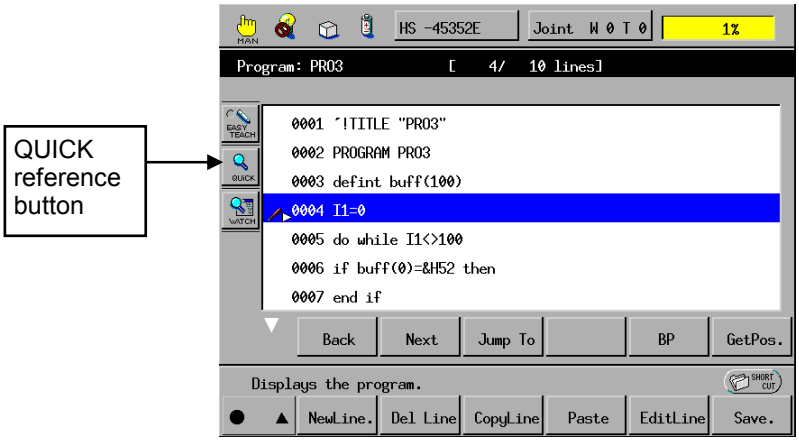


Function keys available	
[F1 Back]	Displays the previous page of the variables list.
[F2 Next]	Displays the next page of the variables list.
[F3 Jump To]	Displays the Jump To Variable Number window where you may type a variable name you want to see with the numerical keys and press OK. Doing so will display the target variable name.
[F5 Change.]	Displays the numeric keypad where you may enter a variable value you want to assign with the numerical keys and then press OK. Doing so will assign the newly entered value to the variable.
[F7 Copy Var]	Copies the currently selected variable.
[F12 Register]	Adds the currently selected variable to the watch list.

NOTE : Variable values cannot be modified in External Auto mode.

15.1.2 Monitoring and Modifying Local Variables

You may immediately refer to local variables defined in a program. To do so, specify a desired program line and press the **QUICK** reference button that is newly provided in the coding list window as shown below.

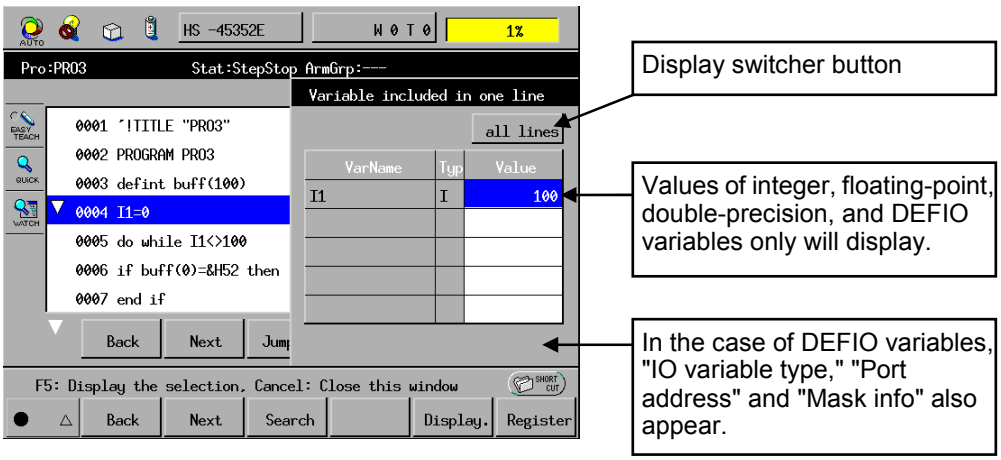


NOTE: Only in manual mode, you can highlight a desired program line or move the cursor to a desired line.

The "Variables included in one line" window (see below) appears where local variables involved in the currently highlighted line and global variables are displayed. The sample window below displays variable "I1" in the STEP STOP program line.

Integer, floating-point, double-precision, or DEFIO variables, if any, will display with their values.

If DEFIO variables are referred to, "IO variable type," "Port address" and "Mask info" also appear.



NOTE 1: If the index of the referred-to variable is out of range (Example 1 below) or not a numerical value (Example 2 below), then the index field of the variable name will show "?."

(Example 1) Although the number of integer variables defined is 200, you attempt to refer to integer variable I201 written in a program line.

(Example 2) You attempt to display a variable with macro name index like `I[slotnum]`.

If the index field shows "?," then no value will display even for integer, floating-point, double-precision, and DEFIO variables. Press the [Display.] and choose the index you want to refer to.

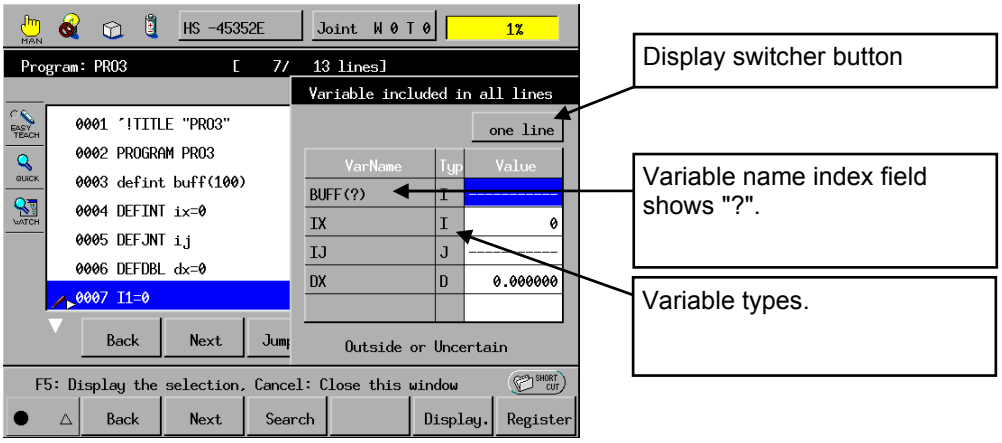
NOTE 2: If the port address of a referred-to DEFIO variable is out of the specified I/O range, then the DEFIO variable will display in gray. Also, if the content of I/O cannot be expressed as a single precision real number, "NaN" is displayed for the SINGLE type DEFIO variable.

NOTE 3: An array variable assigned to an argument cannot be displayed.

(Example) `PROGRAM SUB1 (li%, li2%(10))`

The `li2` cannot be displayed since the argument is an array variable.

With the display switcher button, you may switch from the "Variables included in one line" to "Variables included in all lines." The sample window below shows variables included in all program lines in the currently selected program.

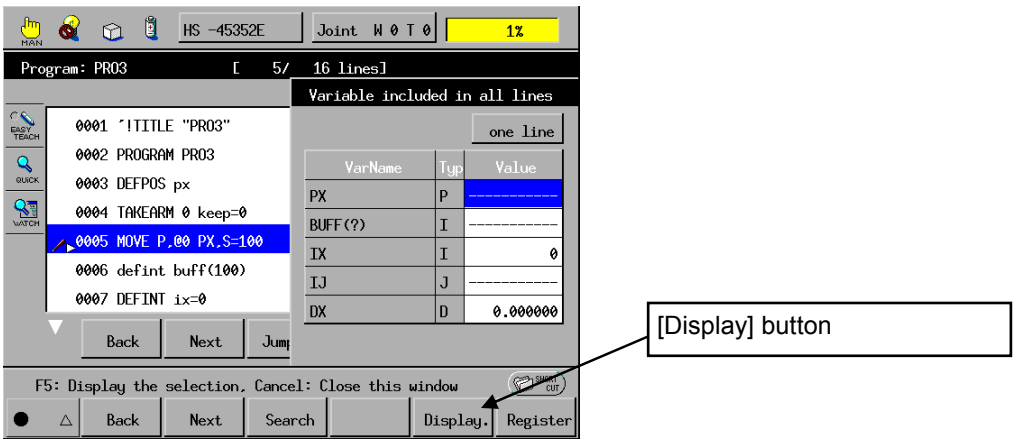


NOTE 1: While the "Variables included in one line" window displays not only local variables but global variables, the "Variables included in all lines" window cannot display global variables.

NOTE 2: In the "Variables included in all lines" window, all array variables will display with "?" in their indexes. Press the [Display] and choose the index you want to refer to.

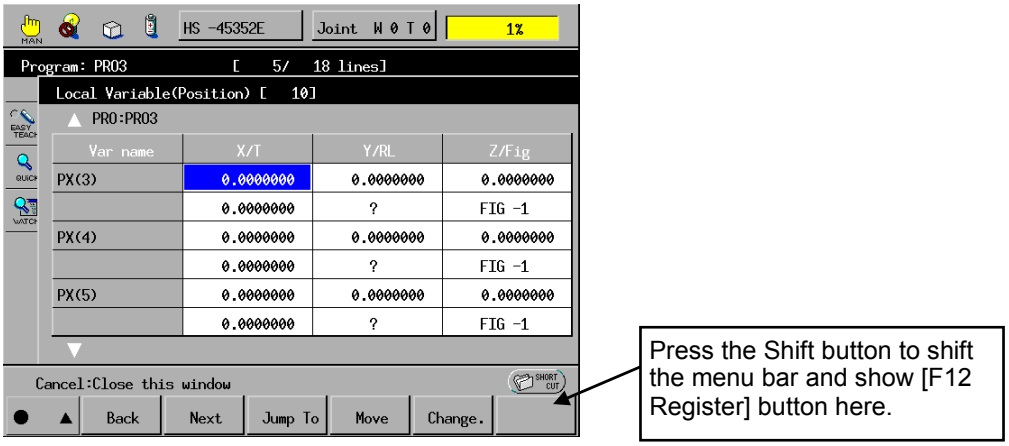
Press [Display] shown below to display the values of the selected variable.

NOTE: If you select a DEFIO variable whose port address is out of the specified range, its details cannot be displayed.



The next sample screen shows the values of locally defined position variable PX (3).

On this screen, you may modify the local variable values or replace local variables as well as for global variables. To register the modified variables, press [F12 Register].



NOTE 1: When a variable's index field is "?," pressing [Display] will display a variable whose index is 0. Move the cursor to that index.

NOTE 2: To modify the current value of a DEFIO variable, you need to hold down the deadman switch, same way as modifying I/Os.

NOTE 3: This quick reference facility cannot take position data into local variables.

To modify the value, press [F5 Change.] on this screen, and the numerical keypad will appear. Enter a value to assign to the variable using the numerical keypad and press the OK button. The newly entered value will be assigned to the variable.

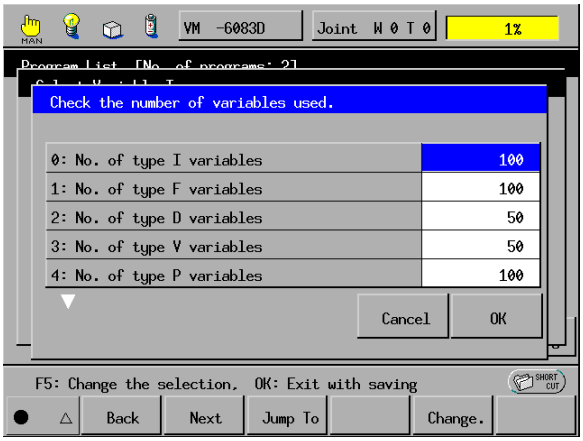
NOTE: Variable values cannot be modified in External Auto mode.

15.1.3 Modifying the Number of Variables Used

Access: [F1 Program]—[F4 Var.]—[F12 VarsUsed.]

Modifies the number of global variables used for each type of variables.

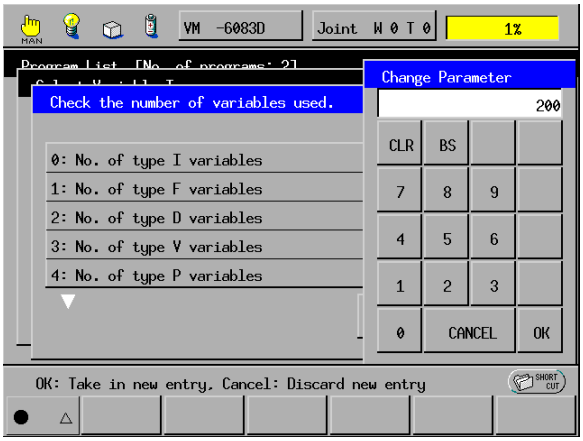
(1) Press [F12 VarsUsed.] to display the following window.

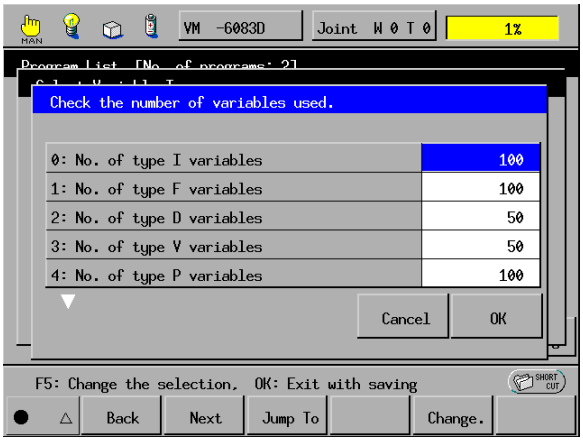


F5

(2) Select the item whose number of variables you want to change, then press [F5 Change.]. The numeric keypad will appear.

(3) Enter the desired value and press the OK button. The newly entered value will appear in the selected item box in the "Check the number of variables used" window.



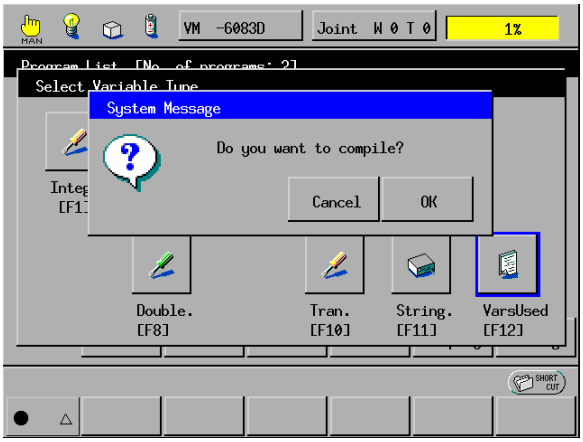


F5

(4) Check the entered value and press the OK button.

The following system message will appear. Press the OK button, and compiling will start.

Upon successful completion of compiling and loading, the number of variables you have entered becomes effective.



If you press the Cancel button in the above window, the entered value does not become effective until compiling and loading takes place next time.

NOTE: Regarding the number of global variables

In this controller, the number of variables used can be modified only when the execution program is loaded.

When the number of variables used is modified, depending on the compiler, first a file indicating the modification of the number of variables used is created and then the program is loaded. The new setting becomes effective from when loading is completed.

15.2 Operation Using WINCAPSIII

WINCAPSIII monitors global and local variables used in the robot controller and edits them.

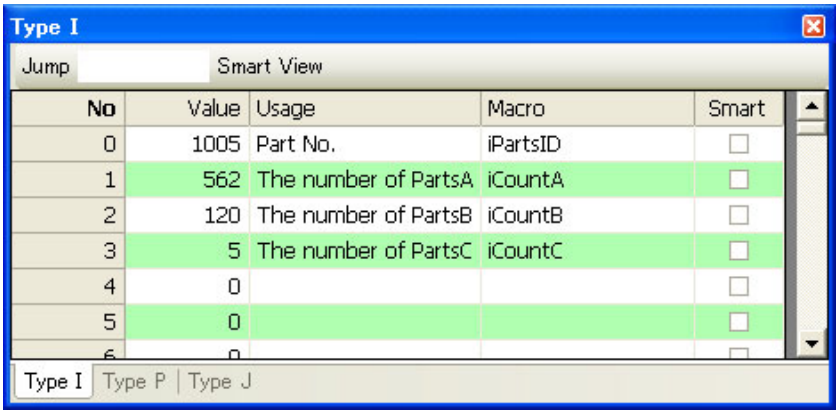
15.2.1 Monitoring and Modifying Global Variables

Monitor global variables used in the robot controller and edit their values, using the procedure given below.

Step 1

Open the target project and choose Connect | Monitor Communication | Online (Monitor) (see Section 14.2.1, Step 1). Then choose View | Variable View and select the type of variables to monitor.

The window for the selected type of variables appears as shown below.



Step 2

Edit a variable value(s) assigned in the robot controller by entering the desired value(s) in the Value column.

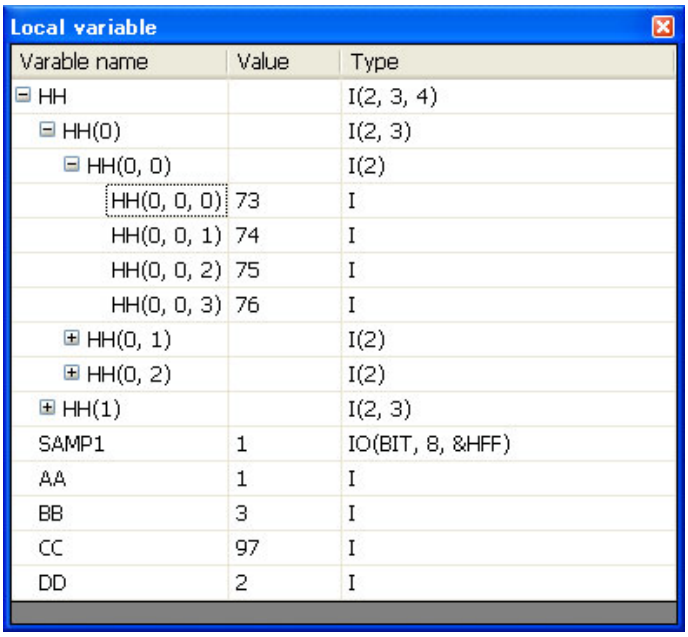
This variable editing procedure modifies the variable data held in the robot controller, but it does not modify the data in the WINCAPSIII project. To save the newly edited variable data in the WINCAPSIII project, receive the data from the robot controller in the Transfer data window.

15.2.2 Monitoring and Modifying Local Variables

Monitor global variables allocated in the robot controller and edit their values, using the procedure given below.

Step 1

Open the target project and choose Connect | Monitor Communication | Online (Monitor) (see Section 14.2.1, Step 1). Then choose View | Local Variables to display local variables in the program selected in the Project window or Program List window.



Step 2

Edit a variable value(s) assigned in the robot controller by entering the desired value(s) in the Value column.

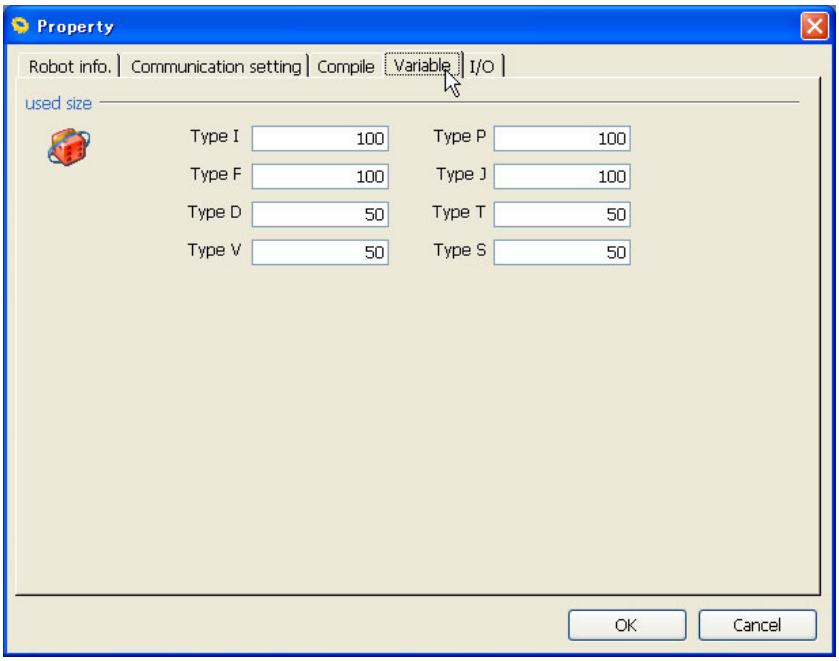
Note: If a user input port or hand input port is declared by DEFIO, the I/O should be set as a dummy one.

15.2.3 Modifying the Number of Variables to be Used

WINCAPSIII can modify the number of variables to be used.

Step 1

Open the target project and choose Project | Properties to display the Property window, then choose the Variable tab.

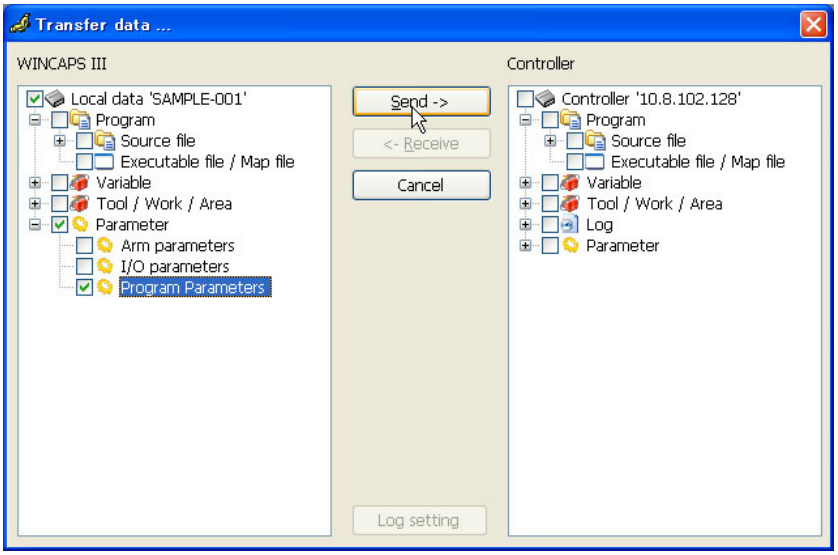


Modify the number of variables of the desired variable type, then press OK.

Step 2

Transfer the data to the robot controller using the procedure given below.

Choose Connect | Transfer data to display the following window. In the WINCAPSIII pane, select Parameters | Program parameters and then press Send.



Step 3

From the teach pendant, choose [F1 Program]—[F6 Aux.]—[F12 Compile] to compile the current program and load the project to the robot controller. Thus, the modification of the number of variables made in WINCAPSIII applies to the robot controller.

Part 5

Advanced Usage

Chapter 16
Optimizing Use Conditions

16.1 Setting the Robot Installation Condition (Floor-mount or Overhead-mount, for 6-axis robots)

Six-axis robots require the robot installation parameter (floor-mount or overhead-mount) to be specified.
For floor-mount, set "0"; for overhead-mount, set "1".
At the time of shipping, the parameter is set to "0" (floor-mount). To overhead-mount the robot, change the parameter setting.

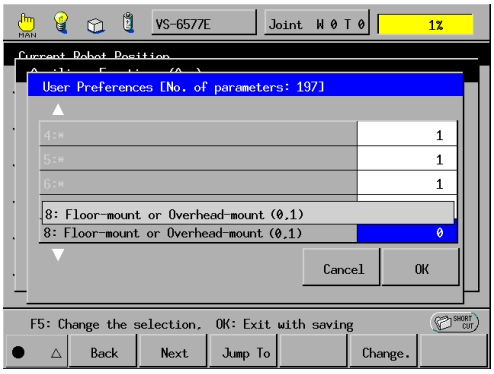
16.1.1 Purpose of Setting Robot Installation Condition

To use the current limit function or compliance control, it is necessary to enable efficiency of gravity effect. Its direction is determined by the robot installation condition (floor-mount or overhead-mount).

16.1.2 Setting with the Teach Pendant

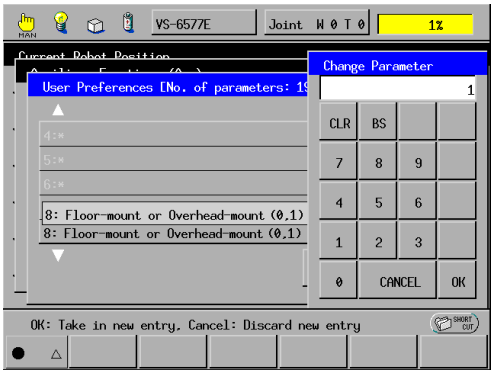
Operation flow: Main screen—[F2 Arm]—[F6 Aux.]—[F7 Config.]

If you use the teach pendant and follow the above procedure, the User Preferences window will appear.



Select the "Floor-mount or Overhead-mount" item in this User Preferences window, then press [F5 Change.] to call up the numeric keypad where you can enter new values.

Enter "0" or "1". Entry of any other value causes the error "6003 Excess in effective value range".

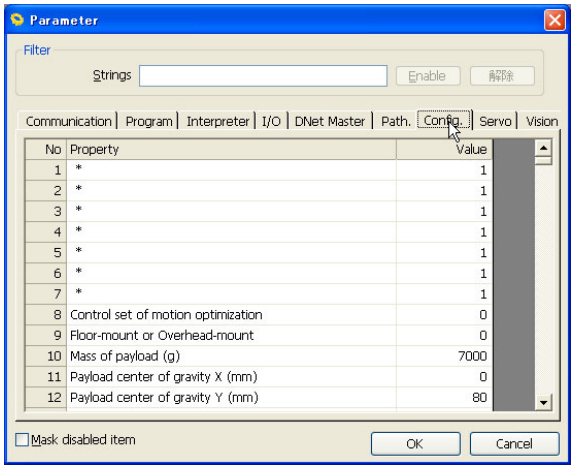


Note: After modifying the user preferences with the teach pendant, use WINCAPSIII to receive the modified data from the robot controller. (In the Transfer data window in WINCAPSIII, select Parameters | Arm parameters in the Controller pane and press Receive.)

16.1.3 Setting with WINCAPSIII

This section describes how to specify the robot installation condition ("0" for floor-mount or "1" for overhead-mount) with WINCAPSIII.

Choose Project | Parameters to display the Parameter window and then choose the Config. tab.



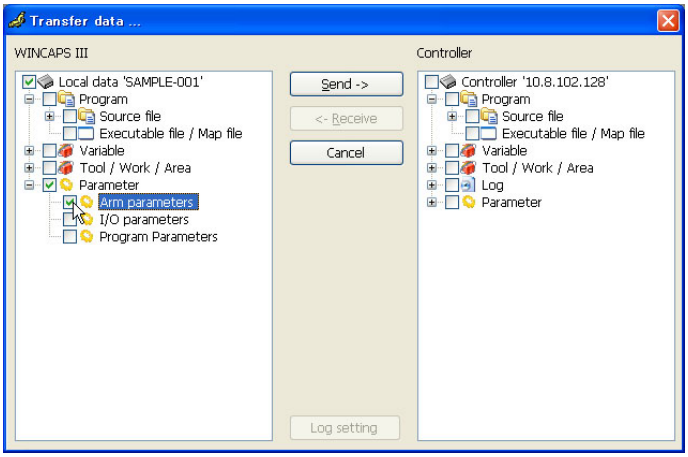
Double-click the Value field of the "Floor-mount or Overhead-mount" line to toggle the parameter value between 0 and 1.

Note: After modifying the configuration with WINCAPSIII, be sure to transfer the arm parameters using the data transfer function.

After completion of parameter setting, transfer the data to the robot controller using the following procedure.

First, turn the motor power off with the MOTOR key on the teach pendant. In WINCAPSIII, choose Connect | Transfer data to display the following window.

Select Parameters | Arm parameters and then press Send.



16.2 Control Sets of Motion Optimization

This function is to set proper speed and acceleration according to the mass of payload and the posture of the robot. You can select a control set of motion optimization among 4 sets listed in Table 16-1.

Table 16-1 Control Sets of Motion Optimization

Control set	Setting condition	Description	
		PTP motion	CP motion
0	Mass of payload	Maximum acceleration	Maximum acceleration
1	Mass of payload and robot posture	Maximum speed, acceleration	Same as control set 0
2		Same as control set 0	Maximum speed, acceleration
3		Same as control set 1	Same as control set 2

16.2.1 Control Set 0

This control set is the default when you boot the controller. Set the maximum acceleration of PTP motion and CP motion according to the robot load condition value.

For robot positioning time, refer to the GENERAL INFORMATION ABOUT ROBOT, Chapter 3, Section 3.3 "Robot Positioning Time."

16.2.2 Control Set 1

Set the maximum speed and acceleration for the 1st, 2nd and 3rd axes in PTP motion according to the load condition value of the robot and the robot figure in motion. For the 4th, 5th and 6th axes in PTP motion, and for CO motion, this is the same as that of control set 0.

Using Control Set 1

If you need to reduce the motion time in PTP motion, select control set 1.

Precautions for Using Control Set 1

An overload error or excess deviation error may occur in motion. For the load factor, check the overload estimation value on the pendant. (Refer to the SETTING-UP MANUAL, Section 5.3, "Displaying anticipated overloads to the capacity of motors and brake resistance of the robot controller, [F2]—[F6]—[F10].") Or, check the load factor using the log function of WINCAPSIII.

If an overload error occurs, adjust the motor load by setting appropriate values of the timer, internal speed, and acceleration.

If an excess deviation occurs, adjust the speed and acceleration.

Depending on the motion speed, the pass locus may change by approximately 20 mm. Therefore, because the pass motion near an obstacle may possibly interfere with the obstacle, execute the motion in control set 0.

16.2.3 Control Set 2

Set the maximum speed and acceleration in CP motion according to the load condition value of the robot and the robot figure in motion. This is the same as that of control set 0 in PTP motion.

Using Control Set 2

Use control set 2 in the following two cases.

(1) If you need to reduce the motion time in CP motion.

(2) If you need to avoid the command speed limit over error

If an error of command speed limit over (6081 to 6086) occurs in CP motion, the robot may stop. If the path passes near a singular point (refer to the SETTING-UP MANUAL, Section 4.1.3, "[2] Boundaries of Robot Figures") or the vicinity of the motion range limit, an error of command speed limit over may occur, stopping the robot.

In control set 2, however, the speed automatically falls within the command speed limit, allowing you to operate the robot without the above error.

Precautions for Using Control Set 2

- In this control set, an overload error may occur during the robot motion. When you adjust the speed, check the load rate using the log function of the load estimation value on the pendant. (Refer to the SETTING-UP MANUAL, Section 5.3, "Displaying anticipated overloads to the capacity of motors and brake resistance of the robot controller, [F2]—[F6]—[F10].") Or, check the load rate using the log function of WINCAPSIII. If an overload error occurs, adjust the motor load by setting appropriate values of the timer or internal speed and acceleration.
- Depending on the motion speed, the path may possibly change by approximately 20 mm. Therefore, because in the pass motion near obstacles, the robot may interfere with them, execute control set 0.
- Because the speed may change in the constant speed movement section in CP motion, perform work that requires constant speed movement in control set 0 or 1.
- Errors of command acceleration limit over (6761 to 6766) and excessive deviation (6111 to 6116) may occur in CP motion. If such an error occurs, adjust the acceleration with internal speed and internal acceleration. A path shift of up to approximately 5 mm may also occur in high-speed motion. Therefore, use the robot by reducing the speed if there is an obstacle near the motion.
- If you stop the robot instantaneously during speed reduction near the vicinity of a singular point (refer to the SETTING-UP MANUAL, Section 4.1.3, "[2] Boundaries of Robot Figures"), the instantaneous stop time may extend. The instantaneous stop distance, however, remains unchanged.

16.2.4 Control Set 3

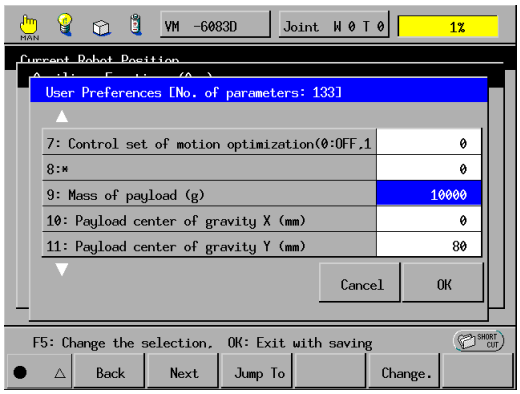
In this control set, the robot moves the same as in control set 1 in PTP motion and control set 2 in CP motion.

16.3 How to Set Optimal Load Capacity Initializing

16.3.1 Setting with Teach Pendant

Operation flow: Main Screen—[F2 Arm]—[F6 Aux.]—[F7 Config.]

If you use the teach pendant and follow the above procedure, the User Preferences window will appear where you can set master control parameters such as the control set of motion optimization and the mass of payload.



Select the following items in this User Preferences window, then press [F5 Change.] to call up the numeric keypad where you can enter new values.

Setting item:
"7: Control set of motion optimization"
"9: Mass of load (g)"
"10: Payload center of gravity X (mm)"
"11: Payload center of gravity Y (mm)"
"12: Payload center of gravity Z (mm)" or "12: Inertia of payload ($kgcm^2$)"
(for 4-axes robot in Version 1.9 or later)

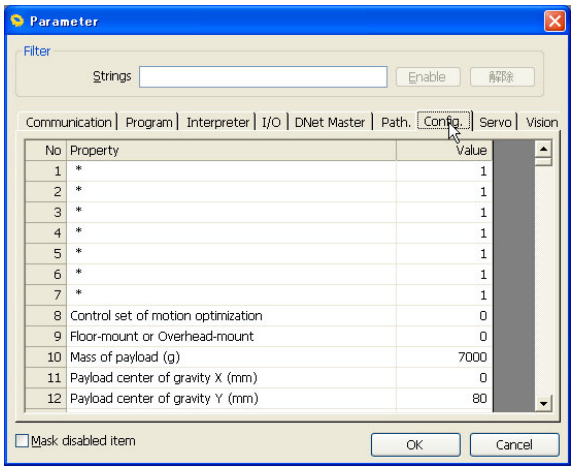
- The entry range of "Control set of motion optimization" is from 0 to 3. If you enter any value out of this range, the following error may appear: ERROR 6003 "Excess in effective value range."
- The entry range of "Mass of load" is specified in each robot model. If you enter any value out of this range, the following error will occur: ERROR 60d2 "Mass of payload out of setting range."
- For "Payload center of gravity," enter a value that conforms to the following range. If the value is out of the following range, ERROR 60d2 "Mass of payload out of setting range."

16.3.2 Setting with WINCAPSIII

This section describes how to configure the external load condition values (Mass of payload and Payload center of gravity) and the external mode with WINCPSIII.

Select [Tools]—[Options] from Arm Manager, and the Options window appears.

Choose Project | Parameters to display the Parameter window and then choose the Config. tab.



Double click each of the setting items listed below in the above window, and you can change the parameter value for each item.

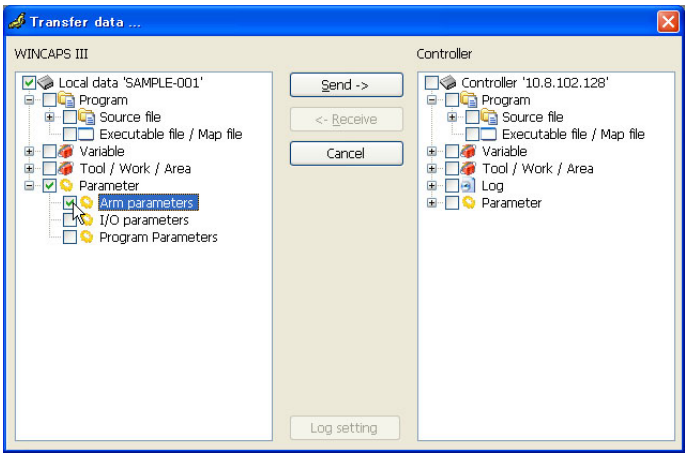
Setting item:
"Control set of motion optimization"
"Mass of payload (g)"
"Payload center of gravity X (mm)"
"Payload center of gravity Y (mm)"
"Payload center of gravity Z (mm)" or "Inertia of payload ($kgcm^2$)"
(for 4-axes robot in Version 1.9 or later)

After each parameter value is set, transmit the data to the robot controller.

First, turn OFF the motor power with the MOTOR key on the teach pendant. Click the Connect button to establish a connection between the Arm Manager and the robot controller, and then click the Transfer button to display the Transfer Environment Table window shown below.

Choose Connect | Transfer data to display the following window.

In the WINCAPSIII pane, select Parameters | Arm parameters and then press Send.



16.4 How to Set Optimal Load Capacity Initializing [Version 1.4 or later]

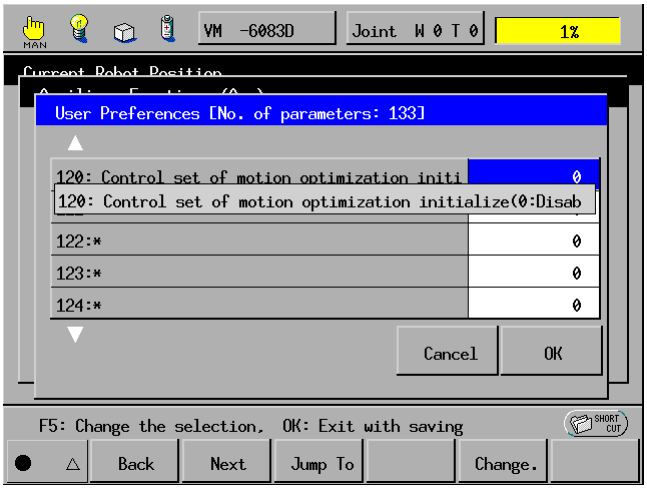
This section describes how to set the optimal load capacity initializing mode to the mode 0 or how to maintain the current setting after the controller is turned on.

Set Value	Description
0	Initializes the optimal load capacity setting mode to the mode 0 after the controller is turned on.
1	Does not initialize the optimal load capacity setting mode after the controller is turned on (maintains the current setting).

16.4.1 Setting with Teach Pendant

Operation flow: Main Screen—[F2 Arm]—[F6 Aux.]—[F7 Config.]

The [User Preference (No. of Parameters:)] screen appears after you use the teach pendant to go through the operation flow above. On the screen, you will see the current internal load condition values and the internal mode.



On the [User Preference (No. of Parameters:)] screen, select [Set Optimal Load Capacity Initializing] and press [F5 Set change]. The [Parameter change] screen will appear and you will be able to change individual parameter values.

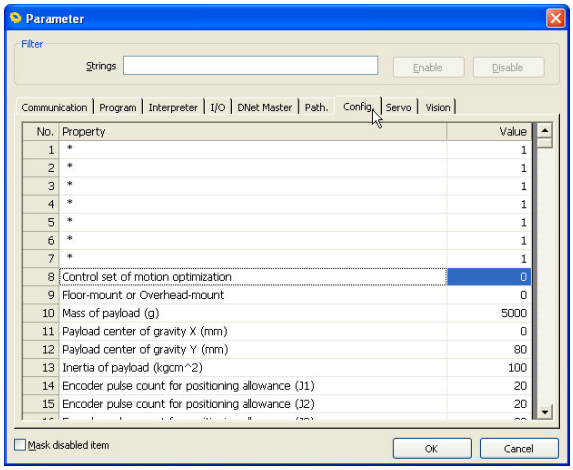
0: Disabled→ Initializes after the controller is turned on. (Factory default)

1: Enabled→ Does not initialize after the controller is turned on. (maintains the current values)

16.4.2 Setting with WINCAPSIII

This section describes how to configure the control set of motion optimization.

Choose Project | Parameters to display the Parameter window and then choose the Config. tab.

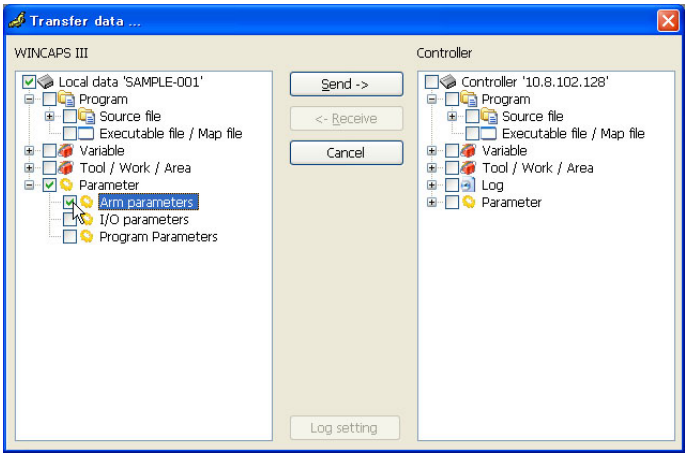


Double click the "Control set of motion optimization initialize," and you can change the parameter value.

After completion of parameter setting, transfer the data to the robot controller using the following procedure.

First, turn the motor power off with the MOTOR key on the teach pendant. In WINCAPSIII, choose Connect | Transfer data to display the following window.

Select Parameters | Arm parameters and then press Send.



Chapter 17
Robot Control Statements

17.1 Robot Motion

17.1.1 Absolute Motion and Relative Motion

Absolute Motion

An absolute motion is a motion to move a taught position.

An absolute motion always moves to a taught position without being affected by the previous motion.

The commands to execute an absolute motion are as follows.

APPROACH, MOVE, GOHOME, DRIVEA

Relative Motion

A relative motion is a motion to move by a taught distance from the current position.

Since a relative motion sets its reference to the current position of the result of executing the previous motion command, the previous motion command affects the motion.

The commands to execute a relative motion are as follows.

DEPART, DRAW, DRIVE, ROTATE, ROTATEH

17.1.2 Interpolation Control

When the robot arm moves, there is not just one path. You can create various paths together with the operation of each axis. You can also control the robot so that it creates line or circle paths. An explanation of the control methods, according to the types of motion paths, is as follows.

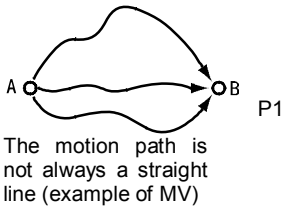
Use the commands shown below to designate an interpolation method (PTP control, CP control or Arc interpolation control).

The commands to designate an interpolation method :
APPROACH, DEPART, DRAW, MOVE

PTP Control

PTP (Point to Point) can be defined as the movement from one point to another point. The path on which the robot moves depends on the robot posture and is not always a straight line.

If you designate "P" when you designate the interpolation method with the motion control command, the robot executes the PTP motion.



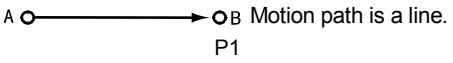
Example: MOVE P, P1

If you designate a Type P or Type T variable as the PTP motion destination position and also designate robot figure, the robot moves so that the robot becomes the designated robot figure. If you do not designate any robot figure, it will be the current robot figure.

CP Control

CP control manages interpolation so that the path to reach the motion destination position will be a straight line.

If you designate "L" for designation of the interpolation method with the motion control command, the robot executes the CP motion.



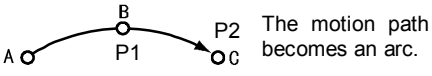
Example: MOVE C, P1

- The robot cannot simply move the position of a different figure from the current figure. If you designate a different figure, an error of "607F robot figure mismatch" may occur. However, if the movement is available, the error may not occur.
- A figure similar to the current one is selected as the robot figure. Therefore, even if you designate the robot figure with a Type P or Type T variable, the figure may not become the one designated. If the figure is different from the figure designated, a warning "601C change figure" may occur.
- If you execute the first motion command in a program with CP control the, motion may not be available depending on the robot position. PTP control is recommended for the first motion command in the program.

Arc Interpolation Control

Arc interpolation controls interpolation so that the path to reach the motion destination position will be an arc.

If you designate "C" for designation of the interpolation method with the motion control command, the robot executes an arc interpolation motion.



Example: MOVE C, P1, P2

- The robot cannot simply move to the position of a different figure from the current figure in the same manner as in CP control. If you designate a different figure, an error of "607F robot figure mismatch" may occur. However, if the movement is possible, the error may not occur.
- A figure similar to the current one is selected for the robot figure. Therefore, even if you designate the robot figure with a Type P and Type T variable, the figure may not become the one designated. If the figure is different from the figure designated, a warning "601C change figure" may occur.
- If you execute the first motion command in a program with arc interpolation control, the motion may not be available depending on the robot position. PTP control is recommended for the first motion command in the program.

17.2 Robot Control Command

17.2.1 DRIVEA

Execute an absolute motion of each axis.

Syntax

```
DRIVEA_[@<pass start displacement>_](<axis number>,<axis coordinate>)
[,(<axis number>,<axis coordinate>)...][,<motion option>][,NEXT]
```

Description

The DRIVEA statement moves the axis specified by <axis number> to the angle (DEG) specified by <axis coordinate>.

If you specify the same axis more than one time, the last specification takes effect.

<pass start displacement> is any of @0, @P (@1 to @255), and @E.

Pass start displacement	Meaning
@0	The robot moves in the end motion. (If omitted, the default @0 applies.)
@P (or @1 to @255)	The robot moves in the pass motion. **Note:** The specified numeric value is the radius of a sphere whose center is located at the destination position, and it is expressed in units of mm. when the motion command value enters the sphere range, control passes to the next one. This is merely used as a guide value for changing the pass start timing, not a guaranteed value.
@E	The robot checks the arrival at the destination position with the encoder value.

<motion option> is any of SPEED, ACCEL, and DECEL.

Motion option	Meaning
SPEED (or S)	Specifies the motion speed.
ACCEL	Specifies the acceleration.
DECEL	Specifies the deceleration.

If the NEXT option is specified, control passes to the next non-motion command without waiting for the current motion to finish. Note that the following instructions are not executed until the current robot motion finishes (pass start).

- Robot motion commands (CHANGETOOL, CHANGEWORK, SPEED, JSPEED, ACCEL, JACCEL, DECEL, JDECEL)
- Motion optimization libraries (aspACLD, aspChange)
- Arm motion libraries (mvSetPulseWidth, etc.)

If specified together with <motion option>, the NEXT option becomes invalid.

When the NEXT option is specified and the program waits for the next motion command to execute, executing a Step stop first executes that next motion command and then interrupts the running program. Therefore, the tool end moves a long distance until it stops.

Note: The NEXT option is invalid in Teach check mode.

Example

Ex. 1

```
DEFINT li1, li2, li3
DEFSNG lf1, lf2, lf3
DRIVEA (li1, 30)          'Move li1 axis to 30 degree position from the current position
DRIVEA (li1, lf1)         'Move li1 axis to the lf1 degree position from the current
                          'position
DRIVEA @P (li1, 0.78RAD),(li2, lf2),(li3, lf3)
                          'Move li1 axis to 0.78 (rad), li2 axis to lf2 degree position,
                          'and li3 axis to lf3 degree position from the current position
```

17.2.2 DRIVE

Execute a relative motion of each axis.

Syntax

```
DRIVE_[@<pass start displacement>_](<axis number>,<relative movement>)
[,(<axis number>,<relative movement>)...][,<motion option>][,NEXT]
```

Description

The DRIVE statement moves the axis specified by <axis number> by the angle (DEG) specified by <relative movement>. If <relative movement> is positive, the specified axis moves in the positive direction and if negative, in the negative direction.

If you specify the same axis more than one time, the last specification takes effect.

<pass start displacement> is any of @0, @P (@1 to @255), and @E.

Pass start displacement	Meaning
@0	The robot moves in the end motion. (If omitted, the default @0 applies.)
@P (or @1 to @255)	The robot moves in the pass motion. **Note:** The specified numeric value is the radius of a sphere whose center is located at the destination position, and it is expressed in units of mm. when the motion command value enters the sphere range, control passes to the next one. This is merely used as a guide value for changing the pass start timing, not a guaranteed value.
@E	The robot checks the arrival at the destination position with the encoder value.

<motion option> is any of SPEED, ACCEL, and DECEL.

Motion option	Meaning
SPEED (or S)	Specifies the motion speed.
ACCEL	Specifies the acceleration.
DECEL	Specifies the deceleration.

If the NEXT option is specified, control passes to the next non-motion command without waiting for the current motion to finish. Note that the following instructions are not executed until the current robot motion finishes (pass start).

- Robot motion commands (CHANGETOOL, CHANGEWORK, SPEED, JSPEED, ACCEL, JACCEL, DECEL, JDECEL)
- Motion optimization libraries (aspACLD, aspChange)
- Arm motion libraries (mvSetPulseWidth, etc.)

If specified together with <motion option>, the NEXT option becomes invalid.

When the NEXT option is specified and the program waits for the next motion command to execute, executing a Step stop first executes that next motion command and then interrupts the running program. Therefore, the tool end moves a long distance until it stops.

Note: The NEXT option is invalid in Teach check mode.

Example

Ex. 1

```
DEFINT li1, li2, li3
DEFSNG lf1, lf2, lf3
DRIVE (li1, 30)           'Move li1 axis 30 degrees from the current position
DRIVE (li1, lf1)          'Move li1 axis by lf1 degrees from the current position
DRIVE (li1, 0.78RAD),(li2, lf2),(li3, lf3)
                          'Move li1 axis by 0.78 (rad), li2 axis by lf2 degrees,
                          'and li3 axis by lf3 degrees from the current position
```

17.2.3 DRAW

Execute a relative motion specified in the work coordinate system.

Syntax

```
DRAW_<interpolation method>,[@<pass start displacement>_]
<translation movement>[,<motion option>][,NEXT]
```

Description

The DRAW statement moves the tool end from the current position by a distance specified by <translation movement>.

<interpolation method> is either P (or PTP) or L.

Interpolation	Meaning
P (or PTP)	Move under PTP control.
L	Move under CP control.

<pass start displacement> is any of @0, @P (@1 to @255), and @E.

Pass start displacement	Meaning
@0	The robot moves in the end motion. (If omitted, the default @0 applies.)
@P (or @1 to @255)	The robot moves in the pass motion. **Note:** The specified numeric value is the radius of a sphere whose center is located at the destination position, and it is expressed in units of mm. when the motion command value enters the sphere range, control passes to the next one. This is merely used as a guide value for changing the pass start timing, not a guaranteed value.
@E	The robot checks the arrival at the destination position with the encoder value.

<motion option> is any of SPEED, ACCEL, and DECEL.

Motion option	Meaning
SPEED (or S)	Specifies the motion speed.
ACCEL	Specifies the acceleration.
DECEL	Specifies the deceleration.

If the NEXT option is specified, control passes to the next non-motion command without waiting for the current motion to finish. Note that the following instructions are not executed until the current robot motion finishes (pass start).

- Robot motion commands (CHANGETOOL, CHANGEWORK, SPEED, JSPEED, ACCEL, JACCEL, DECEL, JDECEL)
- Motion optimization libraries (aspACLD, aspChange)
- Arm motion libraries (mvSetPulseWidth, etc.)

If specified together with <motion option>, the NEXT option becomes invalid.

When the NEXT option is specified and the program waits for the next motion command to execute, executing a Step stop first executes that next motion command and then interrupts the running program. Therefore, the tool end moves a long distance until it stops.

Note: The NEXT option is invalid in Teach check mode.

Tip The DRAW statement can be replaced with the MOVE statement.
Example: `DRAW L, (50, 10, 50) 'Equivalent to MOVE L, P0+(50, 10, 50)`

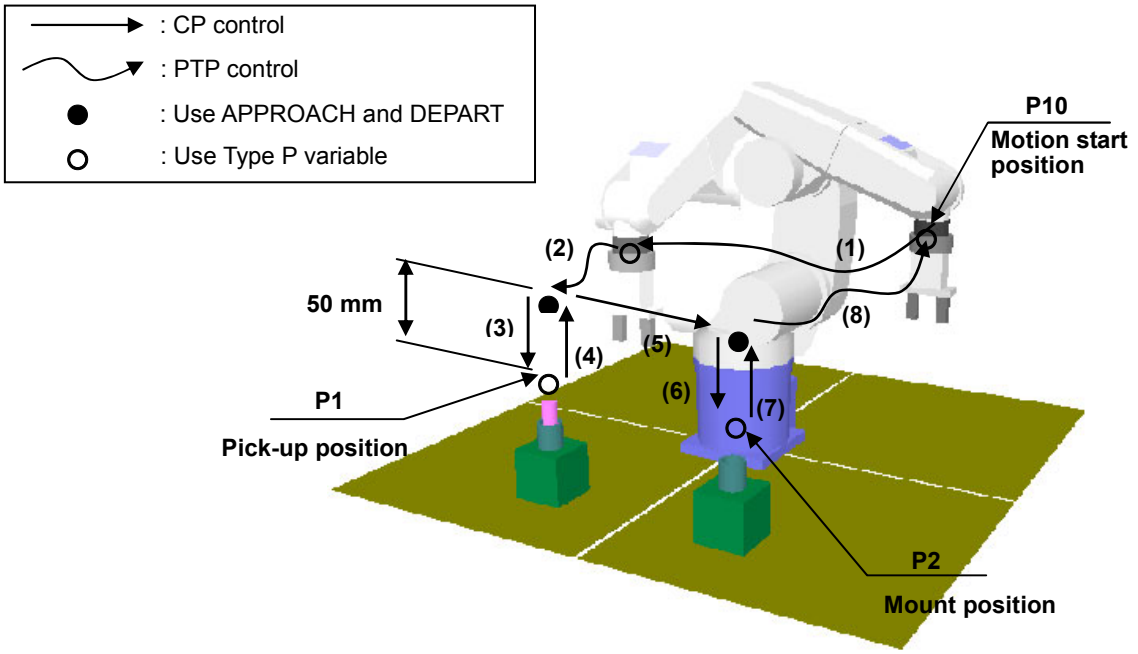
Example

```
DEFVEC lv1, lv2
DRAW L, (50, 10, 50)          'Move to a position (X = 50, Y = 10, Z = 50) away
                              'from the current position under CP control
DRAW L, lv1, SPEED = 90       'Move to a position lv1 mm away from the current position
                              'at 90% of the internal speed under CP control
DRAW L, lv2, S = 50           'Move to a position lv2 mm away from the current position
                              'at 50% of the internal speed under CP control
```

Notes The figure in the destination position becomes the same as the one that is at the start of `DRAW` motion.

17.3 Practice Exercises

Exercise 1
Create a program with robot control sentences to move the robot hand from the motion start position to the workpiece pick-up position and then to the mount position.



■ Motion specification
① For the motion (1), use a command that moves only J1 axis to the position at 0 degree.
② Use pass motions at the approach and departure points.
③ Set the speed for moving down to P1 and P2 at 20%.
④ For the travel to P1 and P2, specify the encoder value check motion.

Code	Comment
’TITLE "Practice program 1"	’Program title
PROGRAM PRO1	’Declare program name
TAKEARM	'Obtain the arm control priority
SPEED 100	’Internal speed 100%
_____	’(1)Move the J1 axis to the position at 0 deg.
_____	’(2)Move the arm to the position 50 mm above P1 in the direction of the hand.
_____	’(3)Move the arm to P1
_____	’(4)Move the arm to the position 50 mm above P1 in the direction of the hand.
_____	’(5)Move the arm to the position 50 mm above P2 in the direction of the hand.
_____	’(6)Move the arm to P2
_____	’(7)Move the arm to the position 50 mm above P2 in the direction of the hand.
MOVE P,@0 P10	’(8) Move the arm to P10
END	'Declare the end of the program

Chapter 18
Flow Control Statements

18.1 Types of Flow Control Statements

Use a flow control statement to control the execution sequence of each statement in a program. Using flow control statement enables sophisticated programming.

The flow control can be roughly classified into the following 4 statements.

① Call

- CALL
- GOSUB

② Unconditional branch

- GOTO

③ Conditional branch

- IF…END IF
- SELECT CASE…END SELECT

④ Repeat

- FOR…NEXT
- DO…LOOP
  (DO WHILE…LOOP, DO…LOOP WHILE, DO UNTIL…LOOP and DO…LOOP UNTIL)

18.2 Calling Commands

18.2.1 CALL

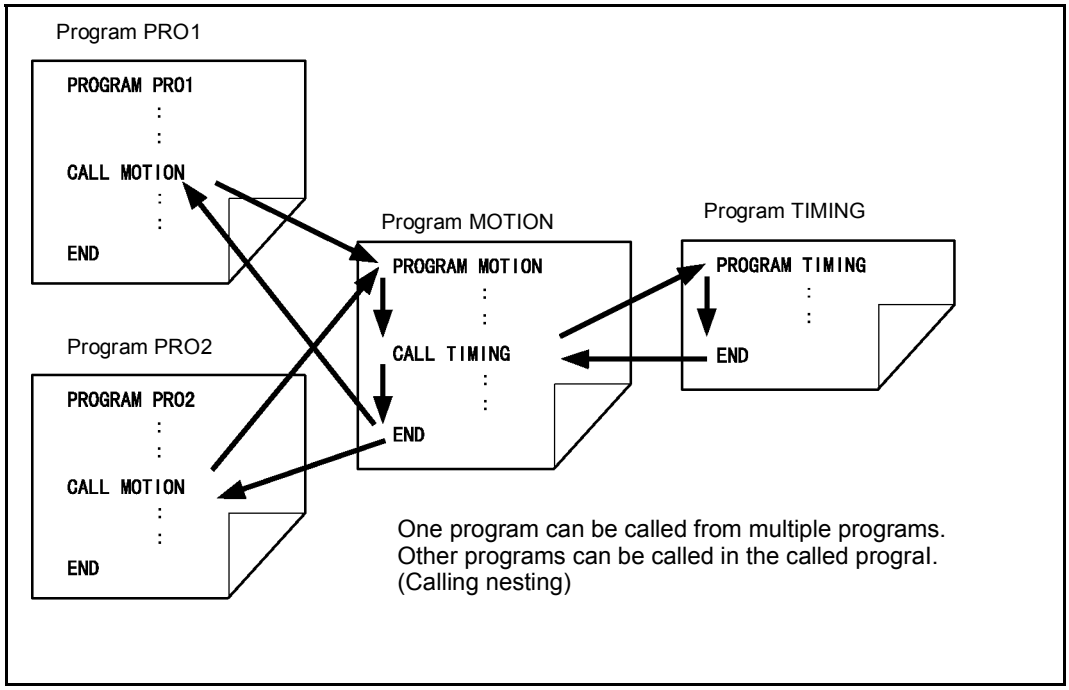
Call a program and execute it.

Syntax `CALL_<programname>`

Description If a program is created separately from the one that is mainly executed, the program can be used by calling it like a subroutine.

When a CALL statement calls a program, control moves to the program that is called. If control executes an END statement on the last line of the called program, control returns to the next line in the calling program.

The called program can also call another program, which is called "calling nesting." However, the called program cannot call the calling program.



Note: Callings can be nested up to 31 times including `GALL` and `GOSUB`.

Example

```
CALL PRO1                  'Call and execute the program named PRO1
CALL SampleProgram         'Call and execute the program named SampleProgram
```

18.2.2 GOSUB

Call a subroutine.

Syntax `GOSUB_<*labelname>`

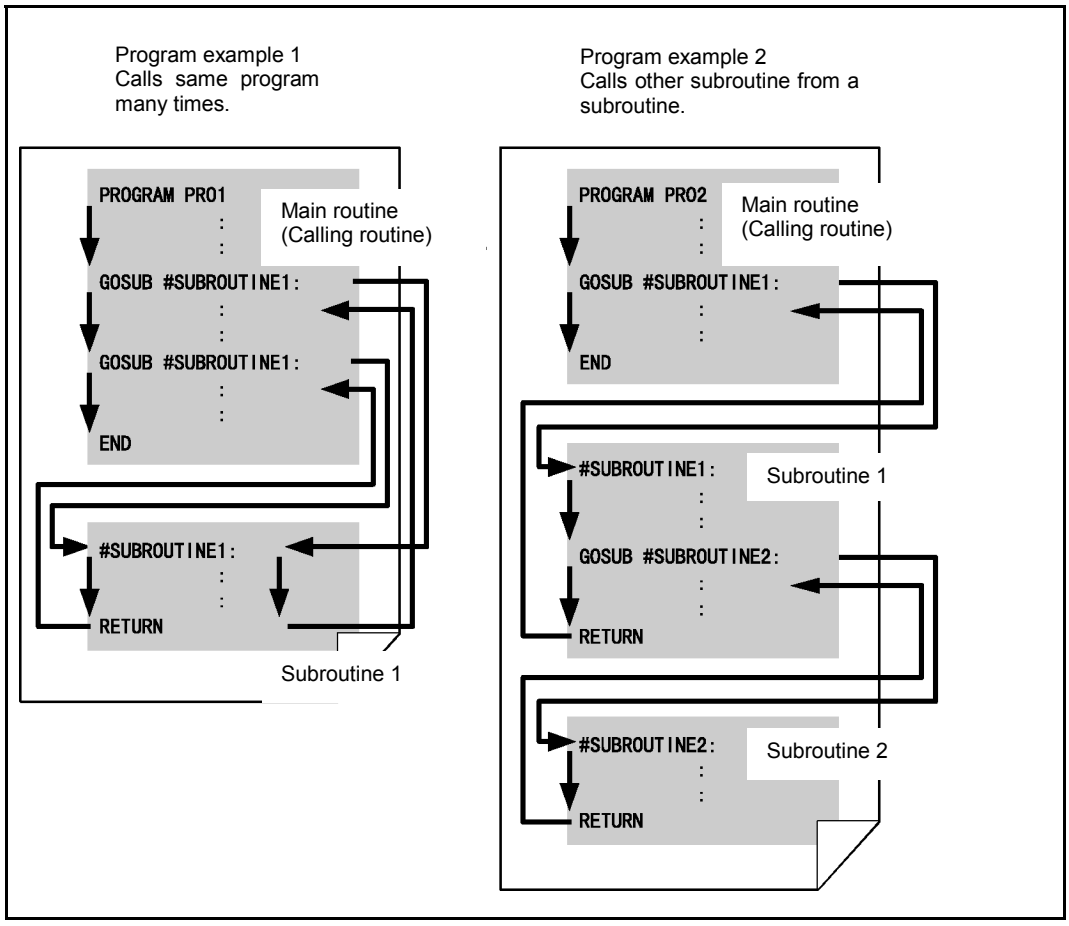
Description To use the same program at different positions in one program describe the process as a subroutine. The subroutine can be used by calling it from the different positions.

The subroutine must be described in the same file as the calling program.

If a subroutine is called using a GOSUB statement, control moves to the subroutine. If control executes a RETURN statement on the last line of the subroutine, it returns to the next line of the program that called the subroutine.

A subroutine can be called from another subroutine, which is called "calling nesting."

> **Note:** Callings can be nested up to 31 times including `GALL` and `GOSUB`. For rules about program label, refer to Section 18.3.1 "GOTO."



Example

```
IF IO[128]=ON THEN GOSUB *Line1    'If IO[128] is ON, jump to the label *Line1:
IF I2=5 THEN                       'If I2 is 5
  GOSUB *Lavel2                    'jump to the label name <*Label2:>
END IF
```

18.3 Unconditional Branch Commands

18.3.1 GOTO

Unconditionally branch a program.

Syntax `GOTO_<*labelname>` (or `GO_TO_<*labelname>`)

Description The `GOTO` statement unconditionally transfers control to a label specified by `<labelname>` and continues execution there.

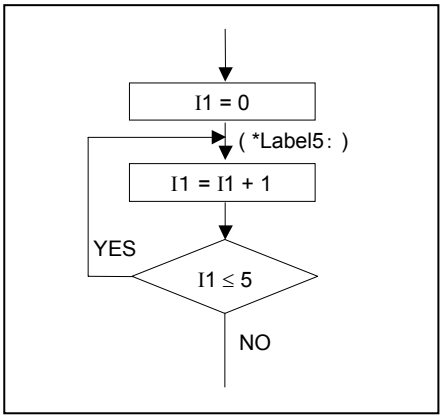
Rules when using a label

- A label name starts with an asterisk (*).
- The second letter of a label name must be an arbitrary alphabet letter.
- Any combination of alphabet letters and numerals can be used for the third letter and the following letters in a label name.
- A reserved word cannot be used as a label name.
- The range in which a label can be referred to is only in the program where the label is present.
- The last letter of a label name must be a colon (:).

Example

Ex.) If the value of I5 is 5 or less, jump to the specified label.

```
IF I1 = 0
*Label5:
I1 = I1 + 1
IF I1 <= 5 THEN     'If I1 is 5 or less
  GO TO *Label5     'jump to the label name <*Label5:>
END IF              'Declare the end of the IF statement
```



18.4 Conditional Branch Commands

18.4.1 IF…END IF

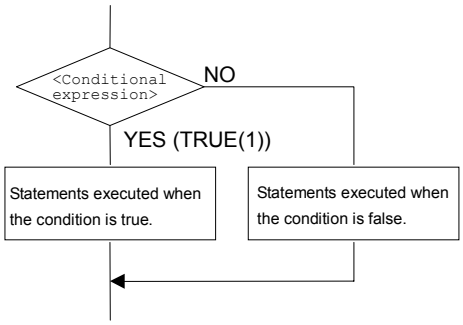
Conditionally execute specified statement blocks depending upon the evaluation of a conditional expression.

Syntax

```
IF_<conditional expression>_THEN
 :      'Executes the statements if <conditional expression> is true
[ELSE]
 :      'Executes the statements if <conditional expression> is false
ENDIF (or END_IF)
```

Description

If `<conditional expression>` of the `IF` statement is true (1), the statement block following `IF` and preceding `ELSE` is executed; if false (0), the statement block following `ELSE` and preceding `ENDIF` is executed.



In `<conditional expression>`, the following operators can be used.

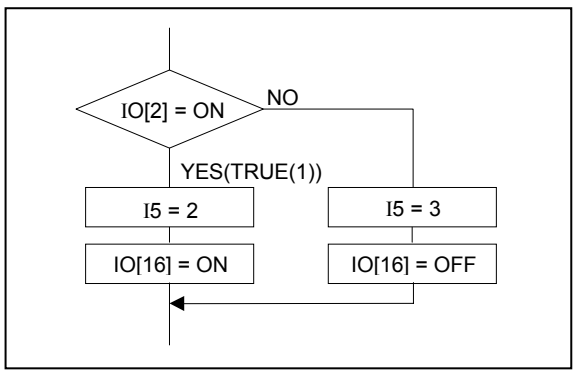
Relational operator	Operation description
=	Equal to
=.	Nearly equal (Approximation comparison)
<>	Not equal to
<	Less than
>	Greater than
<=	Less than or equal to
>=	Greater than or equal to

Remark:
The comparison precision of the approximation comparison operator (=.) can be specified with "Approximation comparison precision" in PRJ setting.

Example

Ex.) If IO[2] is ON, assign 2 to I5 and turn IO[16] ON. Otherwise, assign 3 to I5 and then turn IO[16] OFF.

```
IF IO[2] = ON THEN  'If IO[2] is ON
   I5 = 2
   SET IO[16]
ELSE                'If IO[2] is OFF
   I5 = 3
   RESET IO[16]
END IF
```



18.4.2 SELECT CASE

Execute the statement block associated with the matching condition out of multiple conditions.

Syntax

```
SELECT_CASE <expression>
   CASE_<item>
    :  'Executes the statements if the value of <expression> matches
       '<item> in the CASE sentence
   [CASE_ELSE]
    :  'Executes the statements if the value of <expression> matches
       '<item> in all of the CASE sentences
END_SELECT
```

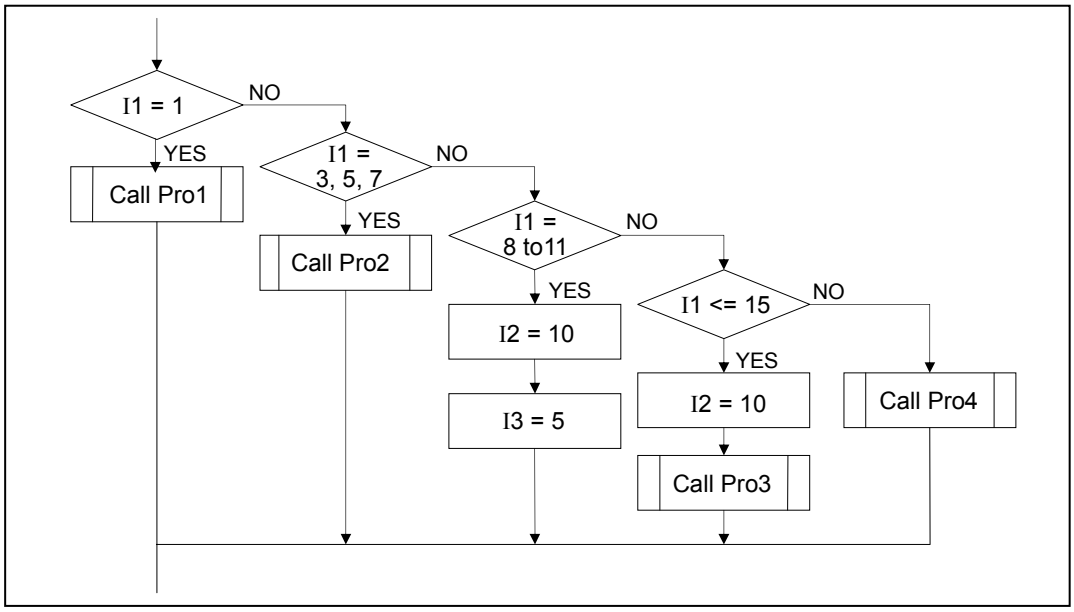
Description

In a `SELECT_CASE` statement, `<expression>` is placed after the `SELECT_CASE`. If the value of `<expression>` matches `<item>` of the `CASE` statement, the statement block following the `CASE` and preceding the next `CASE` is executed.

If the value of `<expression>` does not match `<item>` of any `CASE` statements, the statement block following the `CASE` and preceding the next `CASE` is executed.

Example

Ex.) If the value of I1 matches each condition, the corresponding statements are executed.




```
SELECT CASE I1
CASE 1                  'If I1 is 1
  CALL PRO1
CASE 3, 5, 7            'If I1 is 3, 5, or 7
  CALL PRO2
CASE 8 to 11            'IF I1 is 8 to 11 (For specifying the range, "** to **" is used.)
  I2 = 10
  I3 = 5
CASE IS <= 15           'If I1 is 15 or less
                        '(Comparison format: IS<comparison operator><compared value>)
  I2 = 10
  CALL PRO3
CASE ELSE               'If I1 does not match any condition above
  CALL PRO4
END SELECT
```

18.5 Repeat Commands

18.5.1 FOR…NEXT

Repeatedly execute a block of statements in a FOR…NEXT loop.

Syntax

```
FOR <variablename> = <initial value> TO <final value> [STEP <increment>]
 :      'Executes the statements if the condition of FOR statement
        'is true
NEXT
```

Description

The FOR…NEXT statement repeatedly executes a block of statements in a FOR…NEXT loop according to the condition specified in the FOR line.

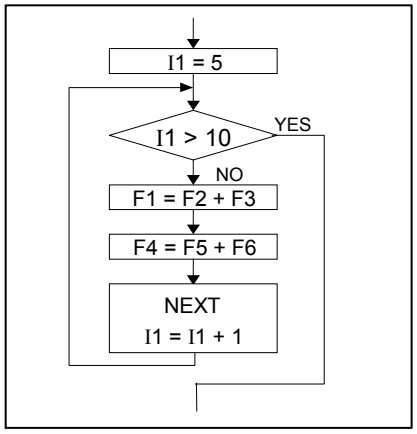
<initial value> and <final value> specify the initial and final values of the variable specified by <variablename>, respectively.

<increment> specifies the increment from the initial to the final values. If STEP is omitted, the increment is regarded as 1.

Example

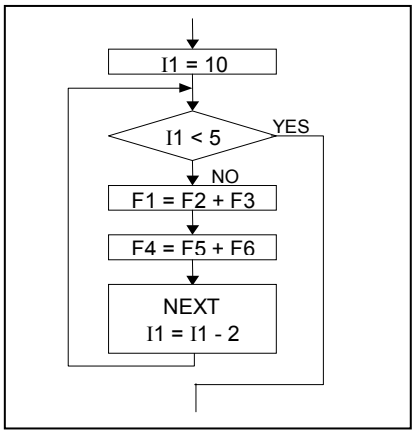
Ex. 1) Continue incrementing I1 by 1 starting 5 until I1 exceeds 10. When I1 becomes 11, end the repeating execution.

```
FOR I1 = 5 TO 10   'Specify 5 for the initial value of I1 (increment is 1)
                   'If I1 is 10 or below, continue the execution of below statements
   F1 = F2 + F3
   F4 = F5 + F6
NEXT               'Increment I1 by 1
```



Ex. 2) Continue subtracting 2 from I1 starting 10 until I1 becomes smaller than 5. When I1 becomes 4, end the repeating execution.

```
FOR I1 = 10 TO 5 STEP -2  'Specify 10 for the initial value of I1 (subtracter is 2)
                          'If I1 is 5 or above, continue the execution of below statements
   F1 = F2 + F3
   F4 = F5 + F6
NEXT                      'Subtract 2 from I1
```



18.5.2 DO…LOOP

Repeat a block of statements while a condition is True or until a condition becomes True.

Syntax

```
DO_[WHILE (or UNTIL)_<conditional expression>]
 :   'A WHILE statement executes the statement block between DO and
     'Loop repeatedly while a condition is true (not 0); an UNTIL
     'statement, until a condition becomes true.

LOOP
```

Or

```
DO
 :   'A WHILE statement executes the statement block between DO and
 :   'Loop repeatedly while a condition is true (not 0); an UNTIL
     'statement, until a condition becomes true.
LOOP_[WHILE (or UNTIL)_<conditional expression>]
```

Description

`DO WHILE` and `DO UNTIL` are pretest loops.

`LOOP WHILE` and `LOOP UNTIL` are posttest loops.

A `WHILE` statement executes repeatedly while a condition is true (not 0); an `UNTIL` statement, until a condition becomes true.

- `DO…LOOP` : Omitting `WHILE` or `UNTIL` is possible but causes an infinite loop.
- `DO WHILE…LOOP` : While the condition is true, execution is repeated. (pretest)
- `DO…LOOP WHILE` : While the condition is true, execution is repeated. (posttest)
- `DO UNTIL…LOOP` : Execution is repeated until the condition becomes true. (pretest)
- `DO…LOOP UNTIL` : Execution is repeated until the condition becomes true. (posttest)

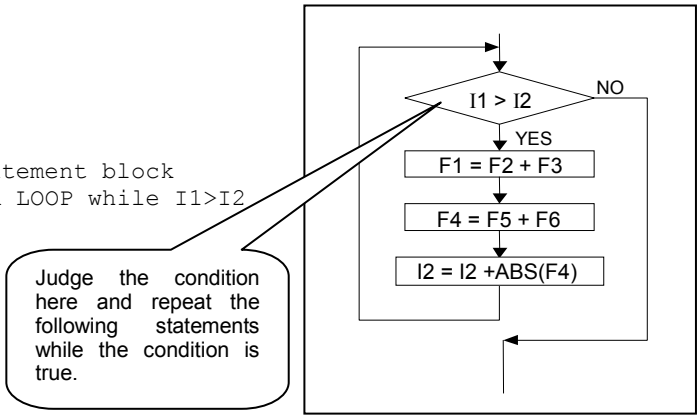
> **Note:** To exit from `DO…LOOP` and move on to the next statement, use the `EXT DO` command.

Example

• DO WHILE…LOOP (pretest)

Example 1) Repeat the execution while I1 > I2.

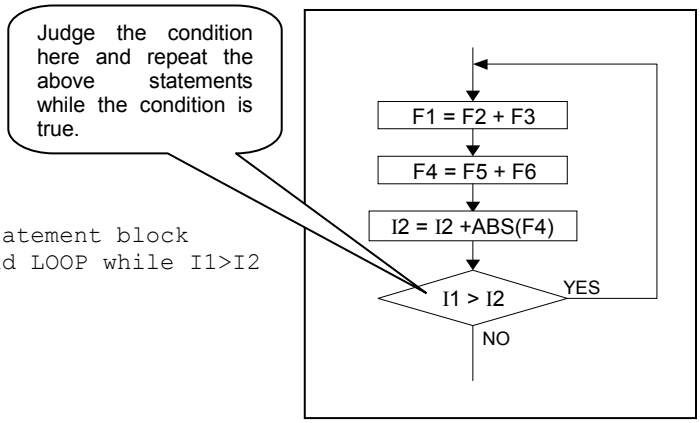
```
DO WHILE I1 > I2      'Repeat the statement block
                      'between DO and LOOP while I1>I2
   F1 = F2 + F3
   F4 = F5 + F6
   I2 = I2 + ABS(F4)
LOOP
```



• DO…LOOP WHILE (posttest)

Example 2) Repeat the execution while I1 > I2.

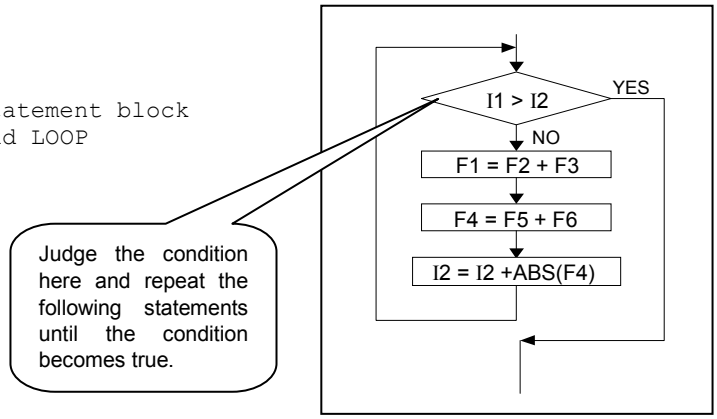
```
DO
   F1 = F2 + F3
   F4 = F5 + F6
   I2 = I2 + ABS(F4)
LOOP WHILE I1 > I2     'Repeat the statement block
                       'between DO and LOOP while I1>I2
```



- **DO UNTIL…LOOP (pretest)**

Example 3) Repeat the execution until I1 > I2.

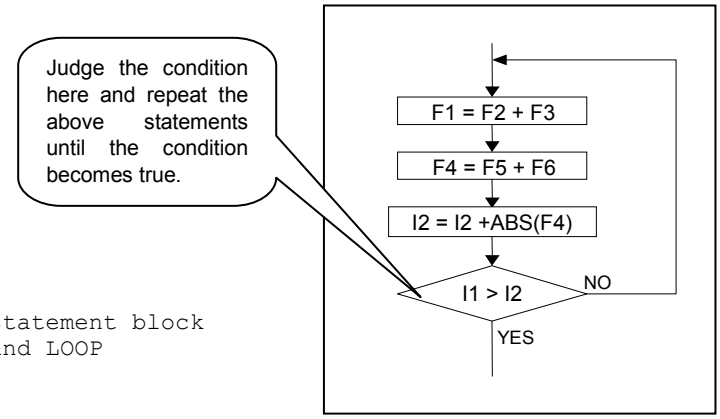
```
DO UNTIL I1 > I2      'Repeat the statement block
                      'between DO and LOOP
                      'until I1>I2
   F1 = F2 + F3
   F4 = F5 + F6
   I2 = I2 + ABS(F4)
LOOP
```



- **DO…LOOP UNTIL (posttest)**

Example 4) Repeat the execution until I1 > I2.

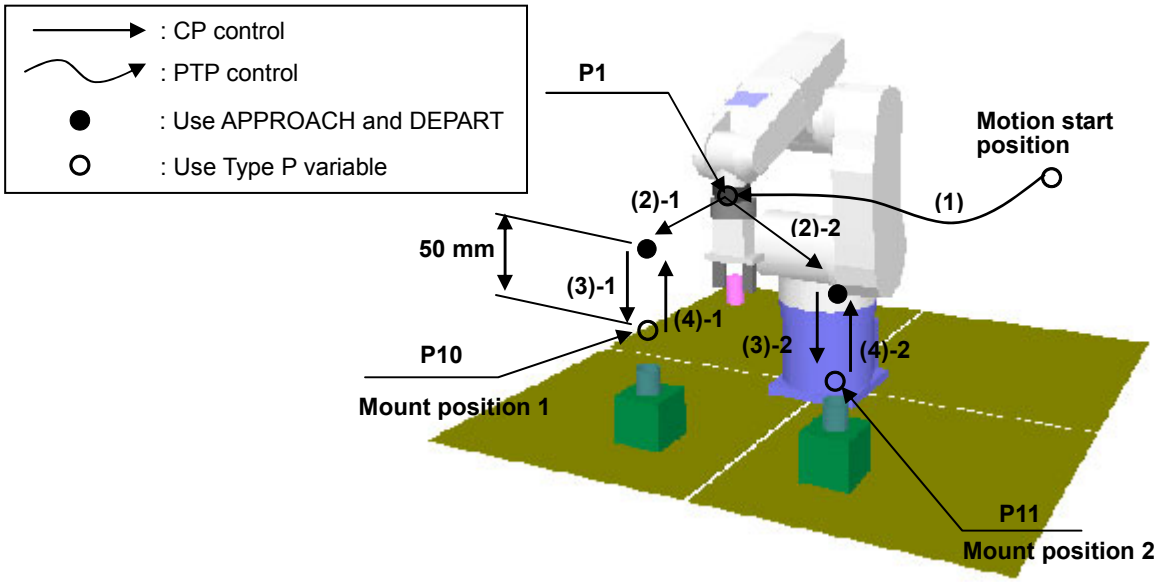
```
DO
   F1 = F2 + F3
   F4 = F5 + F6
   I2 = I2 + ABS(F44)
LOOP UNTIL I1 > I2      'Repeat the statement block
                        'between DO and LOOP
                        'until I1>I2
```



Note: In the case of posttest, the statement block between DO and LOOP is executed at least once.

18.6 Practice Exercise

Exercise 2
Create a program with the flow control statement (`IF…ENDIF`) so that the robot judges the positions where workpieces are mounted.



■ Motion specification

① After moving the arm to P1, the robot checks the value of I[5] with `IF` statement.
If I[5] = 0, go to (2)-1; if I[5] = 1, go to (2)-2. And complete the workpiece mounting operation there.

② At the position reached after (3)-1 and (3)-2 motions, call the program to open the robot hand (`HAND_OPEN`).

Code	Comment
`'TITLE "Practice program 2"`	`'Program title`
`PROGRAM PRO2`	`'Declare program name`
`TAKEARM`	`'Obtain the arm control priority`
`  SPEED 100`	`'Internal speed 100%`
`  MOVE P,P1`	`'(1): Move the arm to P1`
`  _____`	`'(2): If I5=0 is true, go to the next command`
`    APPROACH L,P10 50`	`'(2)-1: Move the arm to the position 50 mm above P10 in the direction of the hand`
`    MOVE L,P10`	`'(3)-1: Move the arm to P10`
`  _____`	`'(2): IF I5=0 is false, go to the next command`
`    APPROACH L,P11 50`	`'(2)-2: Move the arm to the position 50 mm above P11 in the direction of the hand`
`    MOVE L,P11`	`'(3)-2: Move the arm to P11`
`  _____`	`'(2): End of IF statement`
`  _____`	`'Call the HAND_OPEN program`
`  DEPART L,50`	`'(4)-1 and(4)-2 : Move the arm to the position 50 mm above P10 and P11 in the direction of the hand`
`END`	`'Declare the end of the program`

Chapter 19
Input/Output Control Statements

19.1 Time Control

This section describes robot suspend commands that make the robot wait during the specified time.

19.1.1 DELAY

Suspend program execution during a given time.

Syntax `DELAY_<delay time>`

Description The `DELAY` statement suspends program execution until the time specified by `<delay time>` elapses.

`<delay time>` is expressed in ms. Enter 1000 for 1 second for example.

Example

```
DELAY 300              'Suspend until 300 ms (0.3 s) elapses.
DELAY I15              'Suspend until the time specified by I15 elapses.
```

19.1.2 WAIT

Suspend program execution according to a given conditional expression.

Syntax `WAIT_<conditional expression> [,<timeout>] [,<storage variable>]]`

Description The `WAIT` statement suspends program execution until `<conditional expression>` is satisfied.

If `WAIT` is not executed within the period specified by `<timeout>`, a timeout occurs and control passes to the next command. Using the timeout avoids an infinite stop. `<timeout>` is expressed in ms.

Specifying `<storage variable>` assigns TRUE (1) or FALSE (0) to the variable specified by `<storage variable>` when control passes out of the `WAIT` by the satisfied `<conditional expression>` or by timeout, respectively.

Example

```
DEFINT li1
WAIT li1 = 1            'Wait until expression li1 = 1 is satisfied.
WAIT IO[10] = ON        'Wait until IO10 is turned ON.
WAIT IO[5] = 0, 2000    'Wait until IO5 is turned OFF. If IO5 is not turned ON
                        'within 2 seconds, pass control to the next statement.
WAIT I3 = 5, 1000, I4   'Wait until expression I3 = 5 is satisfied.
                        'If the expression is satisfied, set I4 to 1.
                        'If the expression is not satisfied within one second,
                        'set I4 to 0 and pass control to the next statement.
```

19.2 I/O Port Control

This section describes output commands, taking a robot chuck motion as an example. The example below uses a SET command to turn the output port ON, and a RESET command, to turn it OFF.

19.2.1 SET

Set an I/O port to ON.

Syntax `SET_<I/O variable>[,<output time>]`

Description This statement turns the port specified by `<I/O variable>` ON.

`<I/O variable>` has a port number or I/O variable.

If `<output time>` is specified, pulses are output for the specified time during which control will not be transferred to the next statement.

The unit of `<output time>` is ms. `<output time>` is the minimum output time, so the actual output time varies depending on the task priority and other conditions.

Example

```
SET IO[64]        '(or SET IO64) Turn port 64 ON
SET IO[128],50    '(or SET IO128,50) Turn port 128 ON. After 50 ms, turn it OFF
                  'and pass control to the next statement.
```

19.2.2 RESET

Set an I/O port to OFF.

Syntax `RESET_<I/O variable>`

Description This statement turns the port specified by `<I/O variable>` OFF.

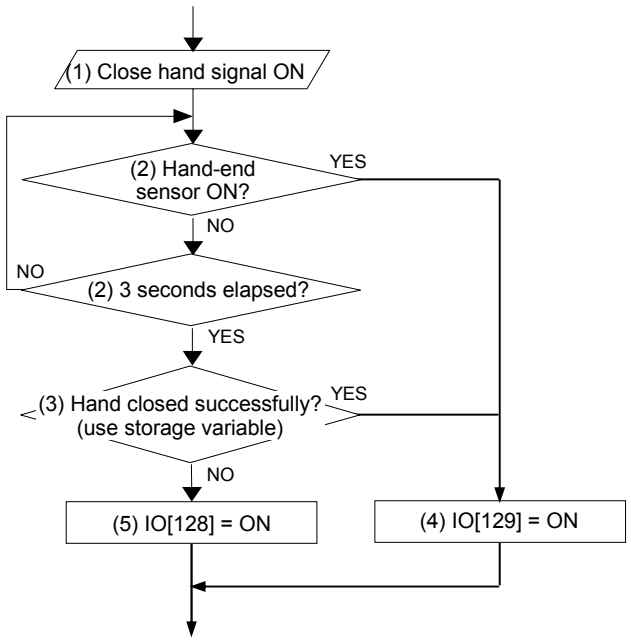
`<I/O variable>` has a port number or I/O variable.

Example

```
RESET IO[64]      '(or RESET IO64) Turn port 64 OFF.
```

19.3 Practice Exercises

Exercise 3
Use I/O port control statements to create a motion program controlling the robot hand as shown in the flowchart below.



■ Motion specifications
- For Close hand signal, use IO[64].
- For hand-end sensor signal, use IO[48].
- For the decision of successful hand closing, use storage variable (I[20]) in `WAIT` statement.

Code	Comment
`'TITLE "Practice program 3"`	`'Program title`
`PROGRAM PRO3`	`'Declare program name`
`   _____`	`'(1) Turn Close hand signal IO[64] ON`
`   _____`	`'(1) Wait for input to IO[48] for 3 seconds` `'    Use storage variable I20`
`   IF I[20] = 1 THEN`	`'(3) If I20 = 1 (successful),` `'    pass control to the next statement`
`   _____`	`'(4) Turn IO[129] ON`
`   ELSE`	`'(3) If not I20 = 1, pass control to the` `'    next statement`
`   _____`	`'(5) Turn IO[128] ON`
`   ENDIF`	`'(3) End of IF statement`
`END`	`'End program`

Chapter 20
Library

20.1 Using Library Programs

20.1.1 What are Library Programs?

The program library is used to collect all-purpose programs like parts and use them accordingly. In the PAC language, since other programs can be called from a program, programs can be developed more efficiently using the programs in the library or by registering a created program to the library.

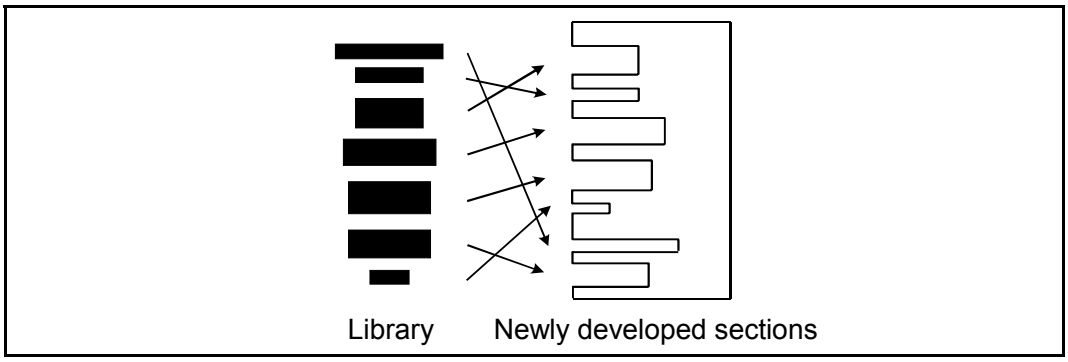


Image of Program Development Using the Library

20.1.2 Program Bank

WINCAPSIII provides a program bank for using the library. The program bank is a tool used to register a program as a library, or to add registered programs to a project.

To use the library programs registered in the program bank, it is necessary to import the library. For operation of the program bank, refer to Section 20.1.4 "Importing a Library Program."

20.1.3 Library Classifications

The standard program library is classified into the following 7 classes.

Standard Program Library Class

	Class name	Description
1	Conventional language	Provides functions similar to conventional language commands.
2	Palletizing	Provides a palletizing function.
3	Tool operation	Provides tool operation related functions.
4	Input/output	Provides DIO and RS232C input/output related functions.
5	Arm motion	Provides arm motion related functions except for the above described.
6	Vision	Provides vision operation related functions.
7	Version 1.2 compatible	Provides the version 1.2 compatible library that can be used in Controller Software Version 1.2* or earlier. This library contains three programs--ndVcom, pltMove, and pltMove0. If in Version 1.2* or earlier any of those programs not in this library but in classes 1 to 6 above is used, a compilation error will result. Use libraries in classes 1 to 6 above except for those three programs.

20.1.4 Importing a Library Program

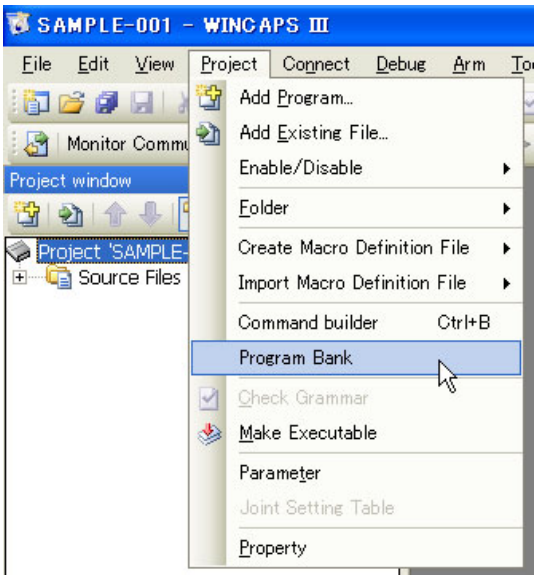
This section describes how to import the program dioSetAndWait from the program bank to a program project.

Step 1

Open a target project in WINCAPSIII.

Step 2

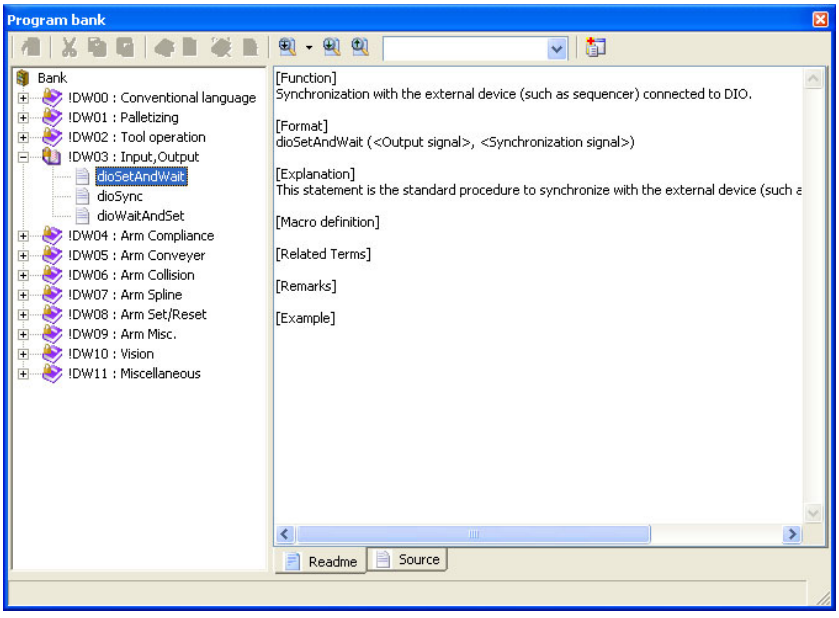
Choose Project | Program Bank to display the Program bank window.



Step 3

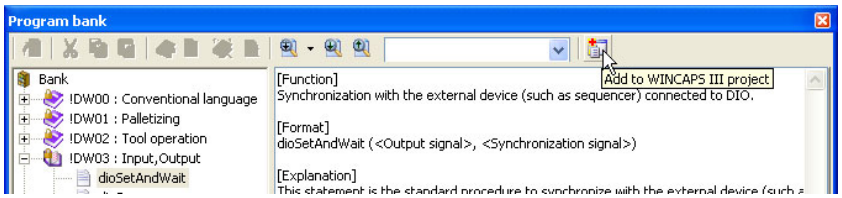
Select the program to import.

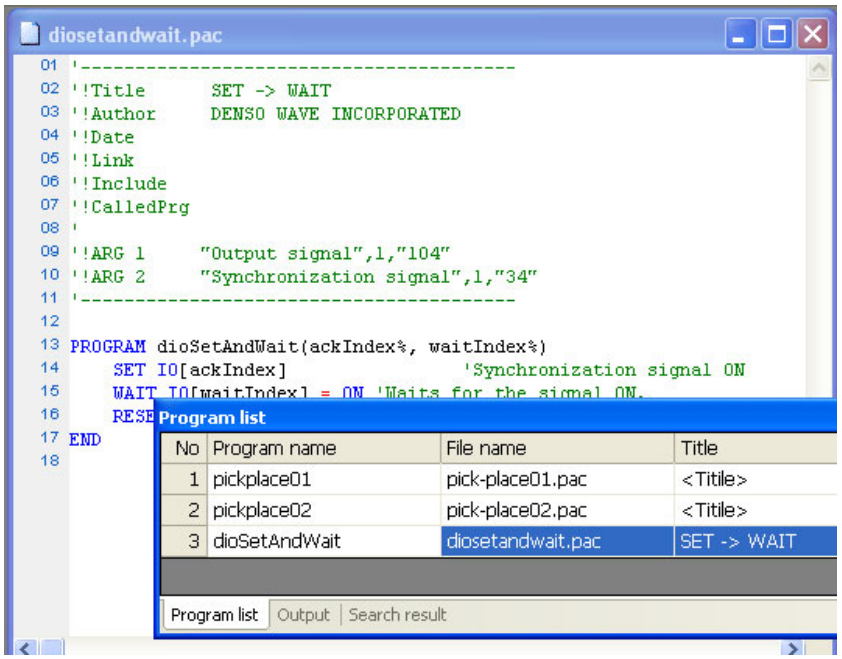
The dioSetAndWait is located in "!DW03: Input, Output," so open the "!DW03: Input, Output" and select the dioSetAndWait.



Press Readme and Source tabs to check their contents.

Step 4 **Press the "Add to WINCAPSIII project" button to import the currently displayed program to the project.**





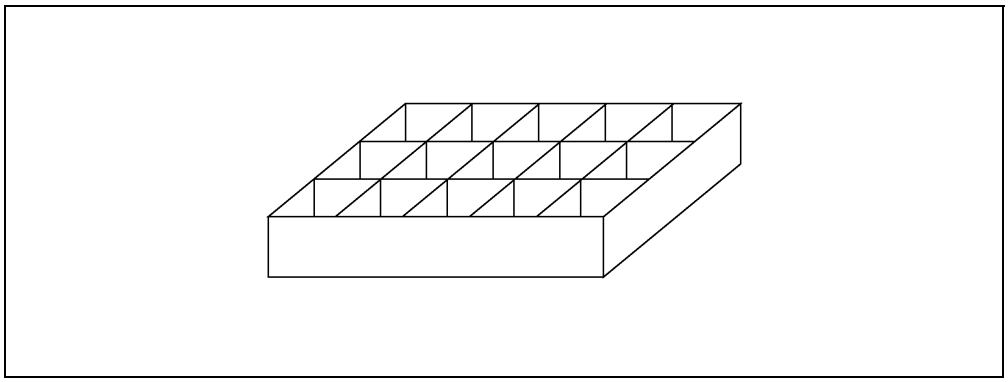
20.2 Using Palletizing Library

20.2.1 What Is Palletizing?

Palletizing refers to placing parts in/removing parts from a partitioned pallet (shown below) in programmed order.

You can easily use library programs for palletizing. To use these programs you have to only know the number of partitions provided in the pallet and the positions of each of the 4 corners of the pallet, and teach this information to the robot.

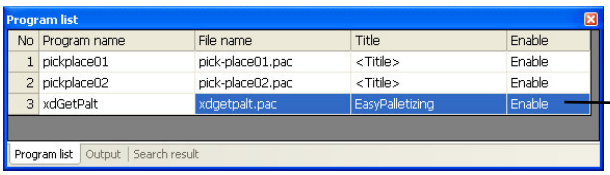
The palletizing programs update the partition information as each position is called to enable the robot to know which partition it should place the next part in/remove the next part from.



Partitioned Pallet

20.2.2 Simplified Palletizing Library

To perform palletizing, it is necessary to import the xdGetPalt library from the program bank into the project beforehand.



The Simplified Palletizing Library (xdGetPalt) has been imported.

Palletizing parameters

Figures-1), -2), -3) and Table-4) show the parameters needed for palletizing. PAC language retains these parameters as value sets of variables.

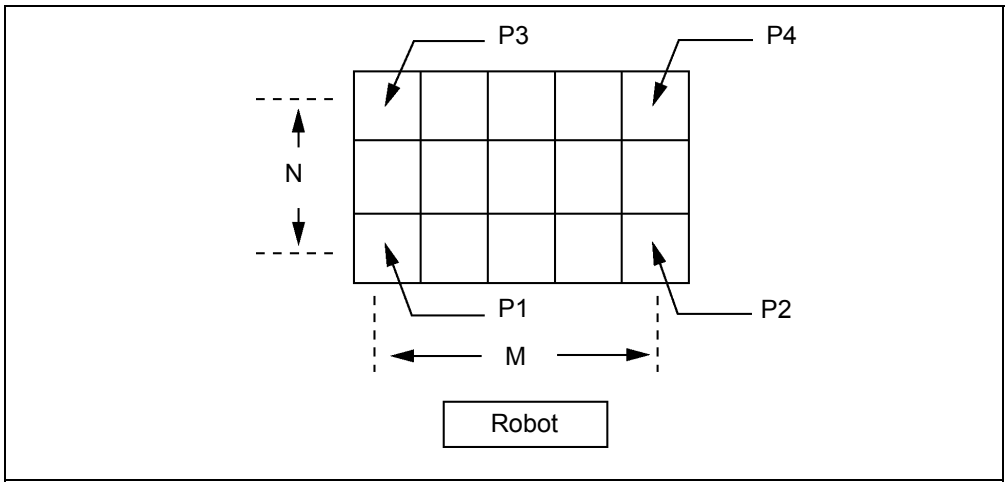


Figure-1) Upper view of pallet

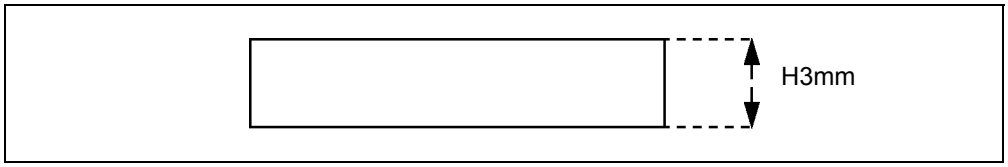


Figure-2) Side view of pallet

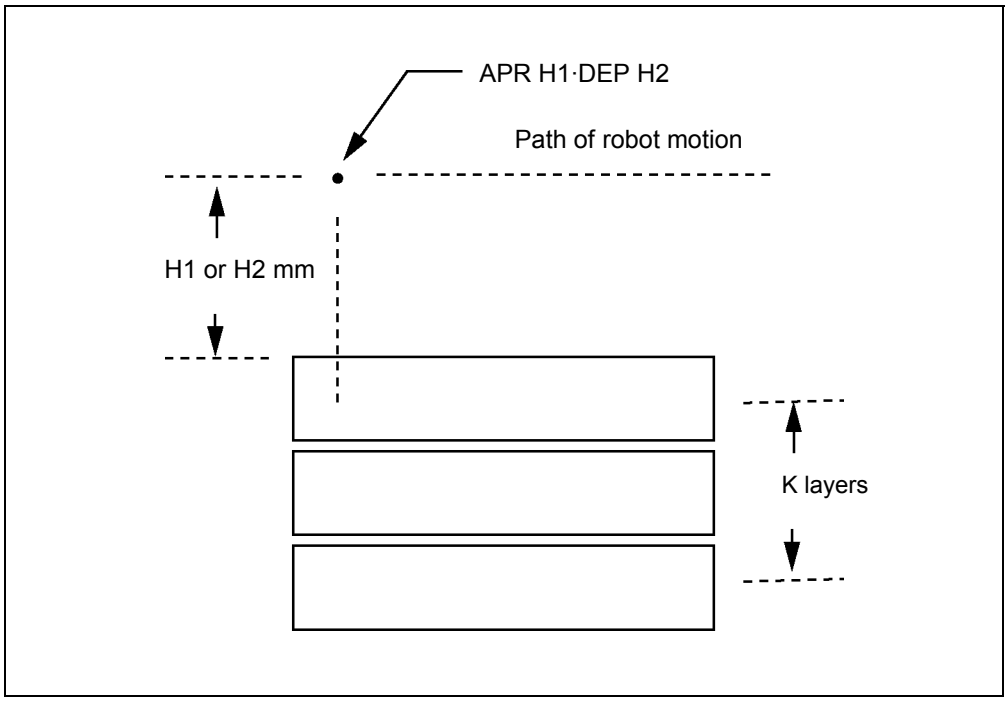


Figure-3) Stacked pallets

Table-4) Parameters needed for palletizing

Symbol	Name	Description	Unit
	Palletizing number	Index of palletizing	None (Integer)
N	No. of row parts	Number of partitions from P1 to P3	Count (Integer)
M	No. of column parts	Number of partitions from P1 to P2	Count (Integer)
K	No. of stacked pallets	Number of stacked pallets	Count (Integer)
H1	Approach clearance	Approach clearance where the robot approaches a pallet	mm (Single precision FPT)
H2	Depart clearance	Departure clearance where the robot departs from a pallet	mm (Single precision FPT)
H3	Height of a pallet	Height of a pallet	mm (Single precision FPT)
	Where H1 and H2 satisfy the conditions below. H1 > {H3 x K-1)}+5 H2 > {H3 x K-1)}+5		
P1 P2 P3 P4	Positions of the 4 corners of the pallet as shown in Figure-1). It is not possible to exchange the relative positioning of any of the corners. The robot maintains its orientation from where the position P1 was taught previously, for all points in the program.		

N Number of partitions in row
Expresses the number of partitions in each row of the pallet.
If this is 3, it reflects 3 rows as in the example in Figure-1).

M Number of partitions in column
This expresses the number of partitions in each column of the pallet.
If this is 5, it reflects 5 rows as in the example in Figure-1).

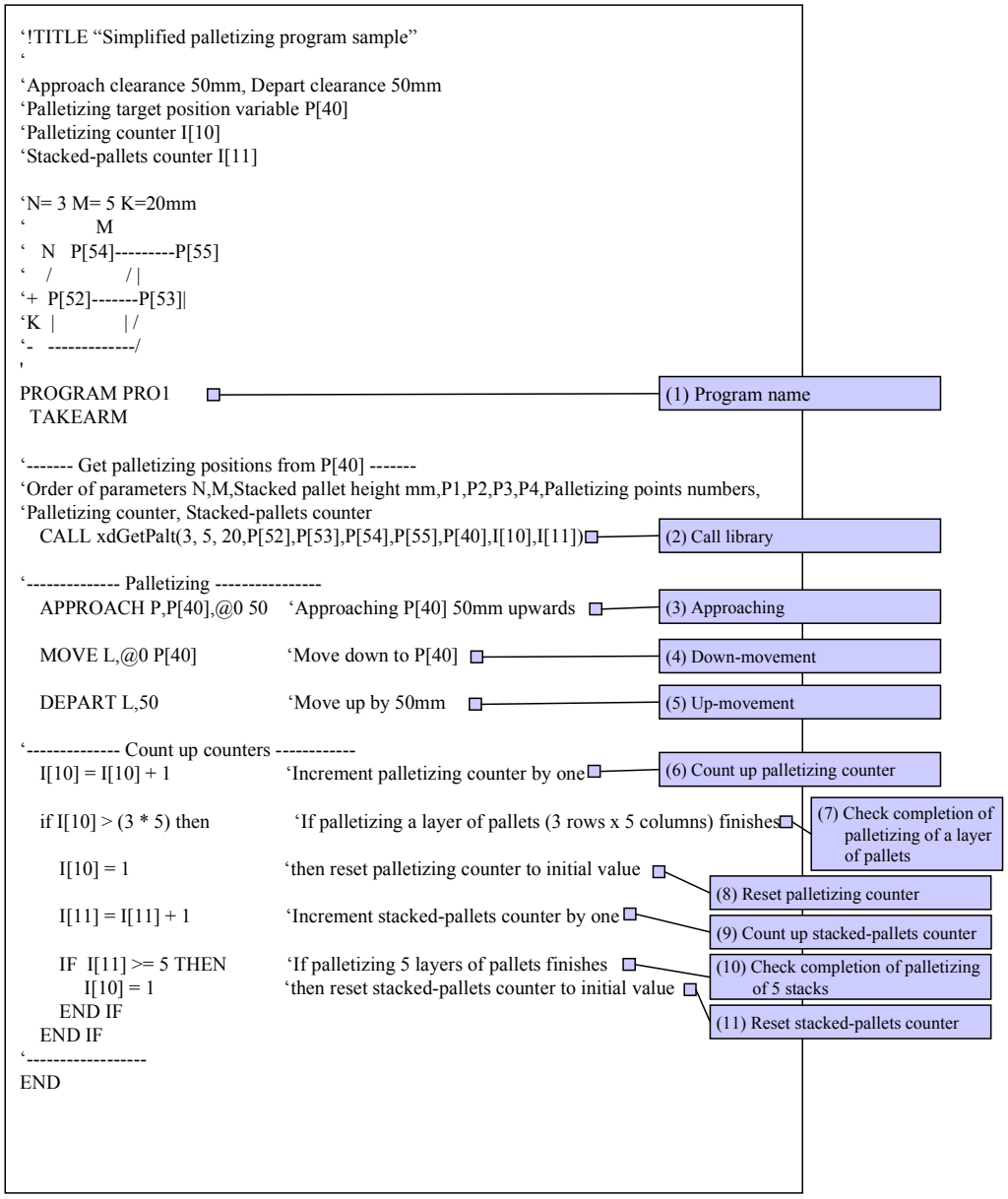
K Number of stacked pallets
This expresses the number of pallets in the pallet stack.
If this is 3, it reflects 3 stacked pallets as in the example on Figure-3).

H1 Approach clearance
Expresses the length of the approach path as the robot approaches the pallets.
A program applies the single approach path length at every call of the same palletizing program.

H2 Departure path clearance
Expresses the length of the departure path as the robot departs from the pallets.
A program applies the single departure path length at every call of the same palletizing program.

H3 Pallet unit heights
Expresses height of each pallet.
For every pallet added to a stack, a plus unit value is added.
For every pallet removed from a stack, a minus

20.2.3 Simplified Palletizing Program "PRO1"



■ **Simplified palletizing program "PRO1"**

In simplified palletizing, you need to specify addition and resetting of the palletizing counter and stacked-pallets counter.

Variables used in PRO1

- Palletizing target position variable (Position variable, P40 in this example)
- Palletizing counter variable (Integer variable, I10 in this example)
- Stacked-pallets counter (Integer variable, I11 in this example)
- Corner partition variables (Position variables, P52 to P55 in this example)

What to do before execution of PRO1

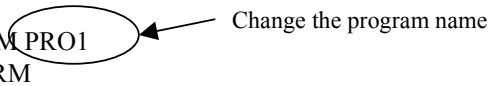
Before start of PRO1, you need to:

- Assign the initial value "1" to each of the palletizing counter I10 and stacked-pallets counter I11 and
- Teach the positions of four corner partitions in the pallet to corner partition variables P1 to P4.

On the following pages are detailed explanation of each part of the program PO1.

(1) Program name

```
‘
PROGRAM PRO1
  TAKEARM
```



(2) Call library

```
‘------- Get palletizing positions from P[40] --------
‘Order of parameters N,M,Stacked pallet height mm,P1,P2,P3,P4,Palletizing points numbers
‘Palletizing counter, Stacked-pallets counter
   CALL xdGetPalt (3, 5, 20,P[52],P[53],P[54],P[55],P[40],I[10],I[11])
```

Setting the following parameters to the called library will assign the target position to the palletizing target position variable specified by the 8th parameter.

1st parameter — No. of rows, which should be 1 or greater.
(3 rows in this example)

2nd parameter — No. of columns, which should be 1 or greater.
(5 columns in this example)

3rd parameter — Height of stacked pallets in mm.
Specify a positive value when increasing the layers of pallets; a negative value when decreasing them.
(20 mm specified in this example)

4th to 7th parameters — Position variables to which four corner partition positions of the pallet are assigned.
(P52 to P55 in this example)

8th parameter — Palletizing target position variable to which the target position will be assigned. This position may be calculated from the current counter values.
(P40 in this example)

9th parameter — Palletizing counter, which should be 1 or greater and M*N or less. According to this value, the corner partition positions may be specified.

10th parameter — Stacked-pallets counter, which should be 1 or greater. According to this value, the layer number may be specified.

(3) Approaching

(4) Down-movement

(5) Up-movement

```
'------- Palletizing -------------------------
   APPROACH P,P[40],@0 50     'Approaching P[40] 50mm upwards
   MOVE L,@0 P[40]            'Move down to P[40]
   DEPART L,50                'Move up by 50mm
```

As a result of execution of "(2) Call library," the palletizing target position is assigned to P40. Then some operations should be carried out to P40.

Usually, during those operation, chuck and unchuck processes will be inserted.

(6) Count up palletizing counter

(7) Check completion of palletizing of a layer of pallets

(8) Reset palletizing counter

(9) Count up stacked-pallets counter

(10) Check completion of palletizing of 5 layers of pallets

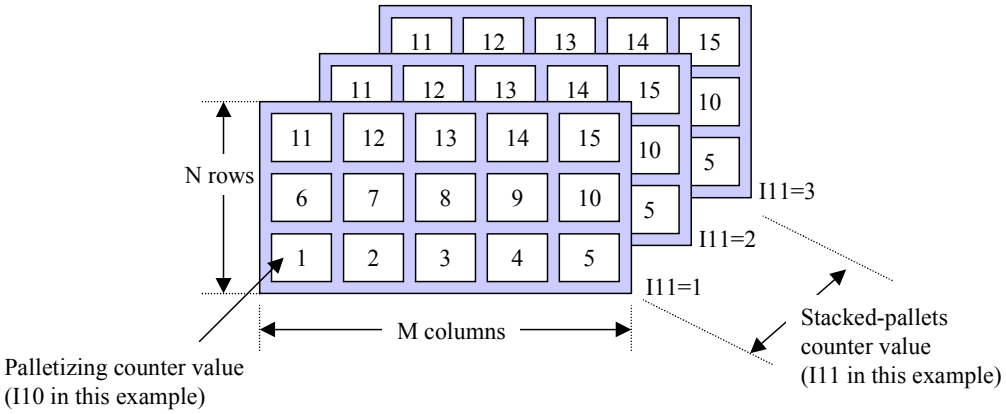
(11) Reset stacked-pallets counter

```
'------- Count up counters------------------
   I[10] = I[10] + 1            'Increment palletizing counter by one

 IF I[10] > (3 * 5) then        'If palletizing a layer of pallets (3 rows x 5 columns) finishes
      I[10] = 1                 'then reset palletizing counter to initial value
      I[11] = I[11] + 1         'Increment stacked-pallets counter by one
      IF  I[11] >= 5 THEN       'If palletizing 5 layers of pallets finishes
          I[10] = 1             'then reset stacked-pallets counter to initial value
      END IF
   END IF
```

This part of the PRO1 counts up the palletizing counter and stacked-pallets counter and checks the completion of palletizing operation for a layer of pallets.

Unlike usual palletizing programs, the simplified palletizing program uses integer variables (I10 and I11 in this example) as a palletizing counter and stacked-pallets counter.

According to the values assigned to I10 and I11, the "(2) Call library" calculates the palletizing target position and assigns it to P40.

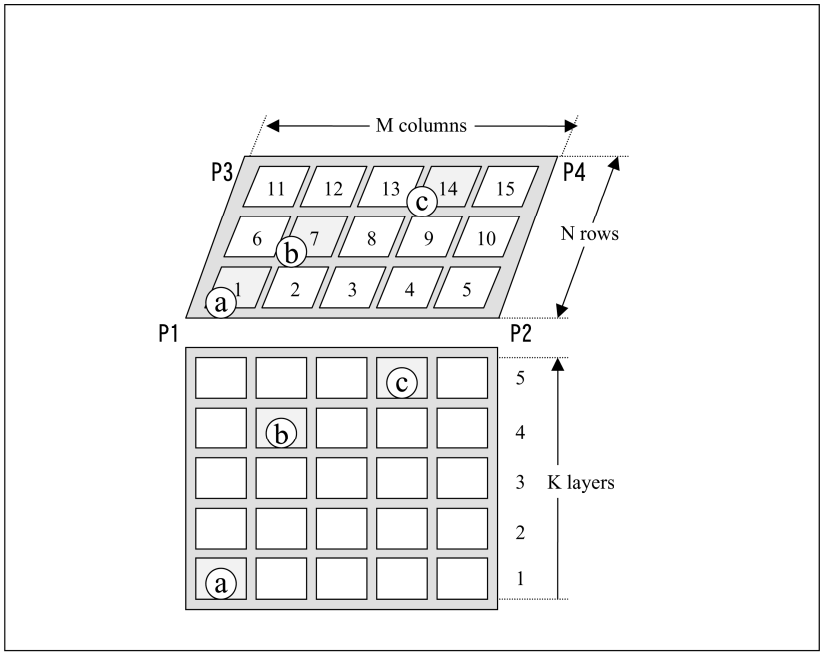


For a single layer of pallet, you may simplify the program further as shown below.

```
'------- Count up counters-----------------
  I[10] = I[10] + 1              'Increment palletizing counter by one

IF  I[10] > (3 * 5) then         'If palletizing a layer of pallets (3 rows x 5 columns) finishes
    I[10] = 1                    'then reset palletizing counter to initial value
    I[11] = I[11] + 1            'Increment stacked-pallets counter by one
    IF  I[11] >= 5 THEN          'If palletizing 5 layers of pallets finishes
        I[10] = 1                'then reset stacked-pallets counter to initial value
    END IF
  END IF
```

Delete these lines for a single layer of pallet.

■ **Relationship between the palletizing positions and counter values in the simplified palletizing program**



If each pallet consists of 3 rows x 5 columns (N=3, M=5), palletizing counter is I10 and stacked-pallets counter is I11, then

Position ⓐ: I10=1, I11=1

Position ⓑ: I10=7, I11=4

Position ⓒ: I10=14, I11=5

Appendices

Appendix 1 Sample Answers to Practice Exercises

■ Practice Exercise 1 (In Section 17.3, for robot control statements)

Code	Comment
'TITLE "Practice program 1"	'Program title
PROGRAM PRO1	'Declare program name
TAKEARM	'Obtain the arm control priority
SPEED 100	'Internal speed 100%
DRIVEA @0 (1 , 0)	'(1)Move the J1 axis to the position at 0 deg.
APPROACH P, P1, @P 50	'(2)Move the arm to the position 50 mm above P1 in the direction of the hand.
MOVE L, @E P1, S=20	'(3)Move the arm to P1
DEPART L, @P 50	'(4)Move the arm to the position 50 mm above P1 in the direction of the hand.
APPROACH P, P2, @P 50	'(5)Move the arm to the position 50 mm above P2 in the direction of the hand.
MOVE L, @E P1, S=20	'(6)Move the arm to P2
DEPART L, @P 50	'(7)Move the arm to the position 50 mm above P2 in the direction of the hand.
MOVE P, @0 P10	'(8) Move the arm to P10
END	'Declare the end of the program

■ Practice Exercise 2 (In Section 18.6, for flow control statements)

Code	Comment
'TITLE "Practice program 2"	'Program title
PROGRAM PRO2	'Declare program name
TAKEARM	'Obtain the arm control priority
SPEED 100	'Internal speed 100%
MOVE P,P1	'(1): Move the arm to P1
IF I[5] = 0 THEN	'(2): If I5=0 is true, go to the next command
APPROACH L,P10 50	'(2)-1: Move the arm to the position 50 mm above P10 in the direction of the hand
MOVE L,P10	'(3)-1: Move the arm to P10
ELSE	'(2): If I5=0 is false, go to the next command
APPROACH L,P11 50	'(2)-2: Move the arm to the position 50 mm above P11 in the direction of the hand
MOVE L,P11	'(3)-2: Move the arm to P11
ENDIF	'(2): End of IF statement
CALL HAND_OPEN	'Call the HAND_OPEN program
DEPART L,50	'(4)-1 and(4)-2 : Move the arm to the position 50 mm above P10 and P11 in the direction of the hand
END	'Declare the end of the program

■ **Practice Exercise 3** (In Section 19.3, for input/output control statements)

Code	Comment
'TITLE "Practice program 3"	'Program title
PROGRAM PRO3	'Declare program name
SET IO[64]	'(1) Turn Close hand signal IO[64] ON
WAIT IO[48],3000,I[20]	'(1) Wait for input to IO[48] for 3 seconds ' Use storage variable I20
IF I[20] = 1 THEN	'(3) If I20 = 1 (successful), ' pass control to the next statement
SET IO[129]	'(4) Turn IO[129] ON
ELSE	'(3) If not I20 = 1, pass control to the ' next statement
SET IO[128]	'(5) Turn IO[128] ON
ENDIF	'(3) End of IF statement
END	'End program

Appendix 2 Commands Listed According to Functions

In the command list on the following pages are reference pages that are the ones in the PROGRAMMER'S MANUAL I. See the PROGRAMMER'S MANUAL I.

Commands Listed According to Functions

4-axis	6-axis	Vision device	
⊙	⊙	⊙	Available with all series of robots and vision device.
○	○	○	Available with all series of robots. The command specifications differ between the 4-axis, 6-axis robot, and vision device.
⊙	V1.2		Available with the 4-axis robots and the 6-axis robots of Version 1.2 or later.

Classified by functions	Commands	Functions	4-axis	6-axis	Vision device	Refer to:
Declaration Statements						
Program Name	PROGRAM	Declare a program name.	⊙	⊙	⊙	9-1
Interference Area Coordinates	AREA	Declare an interference check area.	○	○		9-2
User Function	DEF FN	Declare a user-defined function.	⊙	⊙	⊙	9-4
Home Coordinates	HOME	Declare arbitrary coordinates as a home position.	○	○		9-5
Tool Coordinates	TOOL	Declare a tool coordinate system.	○	○		9-6
Work Coordinates	WORK	Declare a work coordinate system.	○	○		9-7
Local Variable	DEFINT	Declare an integer variable.	⊙	⊙	⊙	9-8
Integer						
Floating-point	DEFSNG	Declare a floating-point variable.	⊙	⊙	⊙	9-8
Double-precision	DEFDBL	Declare a double-precision variable.	⊙	⊙	⊙	9-9
String	DEFSTR	Declare a string variable.	⊙	⊙	⊙	9-9
Vector	DEFVEC	Declare a vector variable.	⊙	⊙		9-10
Position	DEFPOS	Declare a position variable.	○	○		9-10
Joint	DEFJNT	Declare a joint variable.	○	○		9-11
Homogeneous transform matrix	DEFTRN	Declare a variable in homogeneous transform matrix.	⊙	⊙		9-11
I/O	DEFIO	Declare an I/O variable corresponding to the input/output port.	⊙	⊙	⊙	9-12
Array	DIM	Declare an array variable.	⊙	⊙	⊙	9-13
Folder Feature	FOLDER	Declare local variables that are accessible from external programs.	V2.2	V2.2		9-14
	EXTERN	Declare access to a FOLDER variable defined in another program.	V2.2	V2.2		9-17

4-axis	6-axis	Vision device	
⊙	⊙	⊙	Available with all series of robots and vision device.
○	○	○	Available with all series of robots. The command specifications differ between the 4-axis, 6-axis robot, and vision device.
⊙	V1.2		Available with the 4-axis robots and the 6-axis robots of Version 1.2 or later.

Classified by functions	Commands	Functions	4-axis	6-axis	Vision device	Refer to:
Assignment Statements						
Variables	LET	Assign a value to a given variable.	○	○	○	10-1
Vector	LETA	Assign a value to an approach vector variable of homogeneous transform type.		⊙		10-2
	LETO	Assign a value to an orientation vector variable of homogeneous transform type.	⊙	⊙		10-2
	LETP	Assign a value to a position vector variable of position or homogeneous transform type.	⊙	⊙		10-3
Figure	LETF	Assign a value to a figure component of the position variable or variable in homogeneous transform type.	⊙	⊙		10-4
Link Angle	LETJ	Assign a value to a specified link angle of the joint variable.	⊙	⊙		10-5
Posture	LETR	Assign a value to the posture (three rotation components) of the position variable.		⊙		10-6
Rotation Component	LETRX	Assign a value to the X-axis rotation component of the position variable.		⊙		10-7
	LETRY	Assign a value to the Y-axis rotation component of the position variable.		⊙		10-7
	LETRZ	Assign a value to the Z-axis rotation component of the position variable.		⊙		10-8
	LETT	Assign a value to the T-axis component of the position variable.	⊙			10-8
Axis Component	LETX	Assign a value to the X-axis component of the vector variable, position variable, or variable in homogeneous transform matrix.	⊙	⊙		10-9
	LETY	Assign a value to the Y-axis component of the vector variable, position variable, or variable in homogeneous transform matrix.	⊙	⊙		10-9
	LETZ	Assign a value to the Z-axis component of the vector variable, position variable, or variable in homogeneous transform matrix.	⊙	⊙		10-10
Flow Control Statements						
Program Stop	END	Declare the end of motion executed by a program.	⊙	⊙	⊙	11-1
	STOP	Stop program execution.	⊙	⊙	⊙	11-2

4-axis	6-axis	Vision device	
⊙	⊙	⊙	Available with all series of robots and vision device.
○	○	○	Available with all series of robots. The command specifications differ between the 4-axis, 6-axis robot, and vision device.
⊙	V1.2		Available with the 4-axis robots and the 6-axis robots of Version 1.2 or later.

Classified by functions	Commands	Functions	4-axis	6-axis	Vision device	Refer to:
	STOPEND	Cycle-stop a program started with a continuous run or with a cycle option.	⊙	⊙		11-3
Call	CALL	Call a program and execute it.	⊙	⊙	⊙	11-4
	GOSUB	Call a subroutine.	⊙	⊙	⊙	11-6
	ON-GOSUB	Call a subroutine depending upon the value of an expression.	⊙	⊙	⊙	11-7
	RETURN	Return control from a subroutine.	⊙	⊙	⊙	11-8
Repeat	DO-LOOP	Repeat a block of statements while a condition is True or until a condition becomes True.	⊙	⊙	⊙	11-9
	EXIT DO	Forcibly exit from DO-LOOP.	⊙	⊙	⊙	11-11
	FOR-NEXT	Repeatedly execute a block of statements in a FOR-NEXT loop.	⊙	⊙	⊙	11-12
	EXIT FOR	Forcibly exit from FOR-NEXT.	⊙	⊙	⊙	11-14
	REPEAT-UNTIL	Repeat a block of statements in a posttest loop.	⊙	⊙	⊙	11-15
	WHILE-WEND	Repeat a block of statements in a pretest loop.	⊙	⊙	⊙	11-16
Conditional Branch	IF-END IF	Conditionally execute specified statement blocks depending upon the evaluation of a conditional expression.	⊙	⊙	⊙	11-17
	IF-THEN-ELSE	Conditionally execute specified statement depending upon the evaluation of a conditional expression.	⊙	⊙	⊙	11-18
	SELECT CASE	Execute the statement block associated with the matching condition out of multiple conditions.	⊙	⊙	⊙	11-19
Unconditional Branch	GOTO	Unconditionally branch a program.	⊙	⊙	⊙	11-21
	ON-GOTO	Unconditionally branch to the specified label depending upon the value of an expression.	⊙	⊙	⊙	11-22
Comment	REM	Declare the remainder of a program line to be remarks or comments.	⊙	⊙	⊙	11-23
Robot Control Statements						
Motion Control	APPROACH	Executes the absolute movement designated in the tool coordinate system.	○	○		12-1
	DEPART	Executes the relative motion in the tool coordinate system.	○	○		12-4
	DRAW	Executes the relative movement designated in the work coordinate system.	⊙	⊙		12-7
	DRIVE	Executes the relative motion of each axis.	⊙	⊙		12-9

4-axis	6-axis	Vision device	
⊙	⊙	⊙	Available with all series of robots and vision device.
○	○	○	Available with all series of robots. The command specifications differ between the 4-axis, 6-axis robot, and vision device.
⊙	V1.2		Available with the 4-axis robots and the 6-axis robots of Version 1.2 or later.

Classified by functions	Commands	Functions	4-axis	6-axis	Vision device	Refer to:
	DRIVEA	Executes the absolute motion of each axis.	⊙	⊙		12-11
	GOHOME	Moves to the position (home position) defined by the HOME statement.	⊙	⊙		12-13
	MOVE	Moves to the designated coordinate.	○	○		12-14
	ROTATE	Executes a rotation movement around the designated axis.	○	○		12-19
	ROTATEH	Executes rotary motion by taking an approach vector as an axis.	⊙	⊙		12-22
	CURJNT	Obtains the current angle of the robot using type J.	○	○		12-24
	CURPOS	Obtains the current position in the tool coordinate system using type P.	○	○		12-25
	CURTRN	Obtains the current position in the tool coordinate system using type T.	⊙	⊙		12-26
	CUREXJ	Gets the current angle of an extended-joint into a floating-point variable.	V1.5	V1.6		12-27
	DESTJNT	Obtains the current movement instruction destination position using type J. The current position (instruction value) is obtained when the robot stops.	○	○		12-28
	DESTPOS	Obtains the current movement instruction destination position with type P. When the robot stops, the current value (instruction value) is obtained.	○	○		12-29
	DESTTRN	Obtains the current movement instruction destination position with type T. When the robot stops, the current position (instruction value) is obtained.	⊙	⊙		12-30
	DESTEXJ	Gets the target position of an extended-joint invoked by the current motion command into a floating-point variable. If the robot is on halt, this command will get the current position (commanded value).	V1.5	V1.6		12-31
	ARRIVE	Defines the motion ratio relative to the programmed full travel distance to the target point in order to make the current program stand by to execute the next step until the robot reaches the defined motion ratio.	⊙	V1.2		12-32

4-axis	6-axis	Vision device	
⊙	⊙	⊙	Available with all series of robots and vision device.
○	○	○	Available with all series of robots. The command specifications differ between the 4-axis, 6-axis robot, and vision device.
⊙	V1.2		Available with the 4-axis robots and the 6-axis robots of Version 1.2 or later.

Classified by functions	Commands	Functions	4-axis	6-axis	Vision device	Refer to:
	POSCLR	Forcibly restores the current position of a joint to 0 mm or 0 degree.	V1.5	V1.6		12-34
	SETSPLINEPOINT	Registers viapoints in the free curve motion.	V2.3	V2.3		12-35
	CLRSPLINEPOINT	Clears all viapoints for free curve motion.	V2.3	V2.3		12-36
	GETSPLINEPOINT	Gets the viapoints for a registered free curve motion.	V2.3	V2.3		12-37
Figure Control	CURFIG	Obtains the current value of the robot figure.	⊙	⊙		12-38
	FIGAPRL	Calculates figures at an approach position and a standard position available to move in CP motion.	○	○		12-40
	FIGAPRP	Calculates an approach position where the PTP motion is available, and a reference position figure.	○	○		12-42
Stop Control	HOLD	Holds program processing for a time.	⊙	⊙		12-43
	HALT	Stops executing a program.	⊙	⊙		12-44
	INTERRUPT ON/OFF	Interrupts a robot motion.	⊙	⊙		12-45
Speed Control	SPEED	Specifies the internal composite speed of joints included in a currently held arm group.	⊙	⊙		12-47
	JSPEED	Specifies the internal speed of individual joints included in a currently held arm group.	⊙	⊙		12-49
	ACCEL	Designates internal acceleration and internal deceleration.	⊙	⊙		12-50
	JACCEL	Specifies the internal acceleration and deceleration of individual joints included in a currently held arm group.	⊙	⊙		12-51
	DECEL	Specifies the internal composite deceleration of joints involved in a currently held arm group.	⊙	⊙		12-52
	JDECEL	Specifies the internal deceleration ratio of individual joints included in a currently held arm group.	⊙	⊙		12-53
	CURACC	Gets the current internal composite acceleration of joints included in a currently held arm group.	⊙	⊙		12-54
	CURJACC	Gets the current internal acceleration of individual joints included in a currently held arm group.	⊙	⊙		12-55

4-axis	6-axis	Vision device	
⊙	⊙	⊙	Available with all series of robots and vision device.
○	○	○	Available with all series of robots. The command specifications differ between the 4-axis, 6-axis robot, and vision device.
⊙	V1.2		Available with the 4-axis robots and the 6-axis robots of Version 1.2 or later.

Classified by functions	Commands	Functions	4-axis	6-axis	Vision device	Refer to:
	CURDEC	Gets the current internal composite deceleration of joints included in a currently held arm group.	⊙	⊙		12-56
	CURJDEC	Gets the current internal deceleration of individual joints included in a currently held arm group.	⊙	⊙		12-57
	CURJSPD	Gets the current internal speed of individual joints included in a currently held arm group.	⊙	⊙		12-58
	CURSPD	Gets the current internal composite speed of joints included in a currently held arm group.	⊙	⊙		12-59
	CUREXTACC	Obtains the current external acceleration value.	V1.4	V1.4		12-60
	CUREXTDEC	Obtains the current external deceleration value.	V1.4	V1.4		12-61
	CUREXTSPD	Obtains the current external speed value.	V1.4	V1.4		12-62
	EXTSPEED	Sets the external speed.	V1.98	V1.98		12-62
Time Control	DELAY	Suspends program processing for a designated period time.	⊙	⊙	⊙	12-63
	WAIT	Stops program processing based on a condition.	⊙	⊙		12-64
Coordinate Transformation	CHANGETOOL	Changes the tool coordinate system.	⊙	⊙		12-65
	CHANGEWORK	Changes the user coordinate system.	⊙	⊙		12-66
	CURTOOL	Obtains the currently designated TOOL number.	V1.4	V1.4		12-67
	CURWORK	Obtains the currently designated WORK number.	V1.4	V1.4		12-68
Interference Check	SETAREA	Selects the area where an interference check is performed.	⊙	⊙		12-69
	RESETAREA	Initializes an interference check.	⊙	⊙		12-70
Internal Servo Data	GetSrvData	Gets the internal servo data of robot joints.	V1.5	V1.5		12-71
	GetJntData	Gets the internal servo data of a specified joint.	V1.5	V1.5		12-72
Motor Power	MOTOR {ON|OFF}	Turns the motor power on or off.	V1.5	V1.5		12-73
Calibration Statement	EXECAL	Executes CAL operation.	V1.5	V1.5		12-74
Particular Control	ST_aspACLD	Changes the internal load condition values. There are the mass of payload, noted in grams (g), and the payload center of gravity, noted in millimeters (mm), for the load condition values. Designate both of them. (See Note1.)	V1.9	V1.9		12-75

4-axis	6-axis	Vision device	
⊙	⊙	⊙	Available with all series of robots and vision device.
○	○	○	Available with all series of robots. The command specifications differ between the 4-axis, 6-axis robot, and vision device.
⊙	V1.2		Available with the 4-axis robots and the 6-axis robots of Version 1.2 or later.

Classified by functions	Commands	Functions	4-axis	6-axis	Vision device	Refer to:
	ST_aspChange	Selects the internal mode for proper control setting of motion optimization.	V1.9	V1.9		12-76
	ST_SetGravity	Compensates for the static load (gravity torque) applied to each joint and attains balance with gravity torque.	V1.9	V1.9		12-77
	ST_ResetGravity	Disables the balance setting between the limited motor torque and gravity torque, which is made with ST_SetGravity.	V1.9	V1.9		12-78
	ST_SetGrvOffset	Compensates the torque of each joint programmed with ST_SetGravity for gravity torque.	V1.9	V1.9		12-79
	ST_ResetGrvOffset	Disables the gravity offset function.	V1.9	V1.9		12-80
	ST_SetCurLmt	Sets the limit of motor current to be applied to the specified axis.	V1.9	V1.9		12-81
	ST_ResetCurLmt	Resets the motor current limit of the specified axis.	V1.9	V1.9		12-83
	ST_SetEralw	Modifies the allowable deviation of the specified axis.	V1.9	V1.9		12-84
	ST_ResetEralw	Resets the allowable deviation value of the specified axis to the initial value.	V1.9	V1.9		12-85
	ST_OnSrvLock	Servo-locks a specified axis.	V1.9			12-86
	ST_OffSrvLock	Releases servo lock for the specified axis.	V1.9			12-87
	ST_SetCompControl	Enables the compliance function.		V1.9		12-88
	ST_SetCompFControl	Enables the compliance control function.		V1.9		12-90
	ST_ResetCompControl	Disables the compliance control function.		V1.9		12-91
	ST_SetFrcCoord	Selects a force limiting coordinate system.		V1.9		12-92
	ST_SetFrcLimit	Sets the force limiting rates.		V1.9		12-93
	ST_ResetFrcLimit	Initializes the force limiting rates.		V1.9		12-94
	ST_SetCompRate	Sets the compliance rates under the compliance control.		V1.9		12-95
	ST_ResetCompRate	Initializes the compliance rates.		V1.9		12-96
	ST_SetFrcAssist	Sets the force assistance under the compliance control.		V1.9		12-97
	ST_ResetFrcAssist	Initializes the force assistance (special compliance control function statement).		V1.9		12-98
	ST_SetCompJLimit	Sets the current limit under the compliance control.		V1.9		12-99
	ST_ResetCompJLimit	Initializes the current limit under the compliance control.		V1.9		12-100

4-axis	6-axis	Vision device	
⊙	⊙	⊙	Available with all series of robots and vision device.
○	○	○	Available with all series of robots. The command specifications differ between the 4-axis, 6-axis robot, and vision device.
⊙	V1.2		Available with the 4-axis robots and the 6-axis robots of Version 1.2 or later.

Classified by functions	Commands	Functions	4-axis	6-axis	Vision device	Refer to:
	ST_SetCompVMode	Sets the velocity control mode under the compliance control.		V1.9		12-101
	ST_ResetCompVMode	Disables the velocity control mode under the compliance control.		V1.9		12-102
	ST_SetCompEralw	Sets the allowable deviation values of the position and the posture of the tool tip under the compliance control.		V1.9		12-103
	ST_ResetCompEralw	Initializes the allowable deviation values of the position and the posture of the tool end under the compliance control.		V1.9		12-104
	ST_SetDampRate	Sets the damping rates under the compliance control.		V1.9		12-105
	ST_ResetDampRate	Initializes the damping rates under the compliance control.		V1.9		12-106
	ST_SetZBalance	Sets the gravity compensation value of the Z and T axes.	V1.9			12-107
	ST_ResetZBalance	Disables the gravity compensation function.	V1.9			12-108
Input/Output Control Statements						
I/O Port	IN	Reads data from the I/O port designated by an I/O variable.	⊙	⊙	⊙	13-1
	OUT	Outputs data to the I/O port designated by an I/O variable.	⊙	⊙	⊙	13-2
	IOBLOCK ON/OFF	Concurrently executes a non-motion instruction such as an I/O or calculation instruction during execution of a motion instruction.	⊙	⊙		13-3
	SET	Sets an I/O port to ON.	⊙	⊙	⊙	13-5
	RESET	Sets an I/O port to OFF.	⊙	⊙	⊙	13-7
Command for RS-232C and Ethernet Port	INPUT	Obtains data from the RS-232C or Ethernet port.	⊙	⊙	⊙	13-8
	LINEINPUT	Reads data to a delimiter through the RS-232C or Ethernet port and assigns it to a character string type variable.	⊙	⊙	⊙	13-10
	PRINT	Outputs data from the RS-232C or Ethernet port.	⊙	⊙	⊙	13-11
	WRITE	Outputs data from the RS-232C or Ethernet port.	⊙	⊙	⊙	13-12
	FLUSH	Clears the input buffer.	⊙	⊙	⊙	13-13
Serial Binary Transmission Commands	PRINTB	Outputs a single byte of data to the RS-232C or Ethernet port.	V1.5	V1.5	V1.9	13-14
	INPUTB	Inputs one byte of data through an RS-232C or Ethernet port.	V1.5	V1.5	V1.9	13-15
	LPRINTB	Outputs multiple bytes of data to the RS-232C or Ethernet port.	V1.5	V1.5	V1.9	13-16

4-axis	6-axis	Vision device	
⊙	⊙	⊙	Available with all series of robots and vision device.
○	○	○	Available with all series of robots. The command specifications differ between the 4-axis, 6-axis robot, and vision device.
⊙	V1.2		Available with the 4-axis robots and the 6-axis robots of Version 1.2 or later.

Classified by functions	Commands	Functions	4-axis	6-axis	Vision device	Refer to:
	LINPUTB	Inputs more than one byte of data through an RS-232C or Ethernet port.	V1.5	V1.5	V1.9	13-17
	com_encom	Enables the RS-232C port only for binary transmission.	V1.5	V1.5	V1.9	13-18
	com_discom	Releases the RS-232C port from binary transmission.	V1.5	V1.5	V1.9	13-19
	com_state	Gets the status of RS-232C or Ethernet port.	V1.5	V1.5	V1.9	13-20
Pendant	PRINTMSG	Displays a message with a caption and icon on the color LCD of the teach pendant.	⊙	⊙		13-21
	PRINTDBG	Outputs data to the debug window.	⊙	⊙		13-22
	BUZZER	Sounds a buzzer.	⊙	⊙		13-23
	PRINTWARNING	Displays a message in the alarm message area on the teach pendant.	V2.2	V2.2		13-24
	PRINTLBL	Sets a label (caption) for a user definition button.	⊙	⊙		13-25
Programming a TP operation screen	set_button	Sets button parameters.	V1.5	V1.5		13-29
	set_page	Sets page parameters.	V1.5	V1.5		13-32
	change_bCap	Edits a caption for a specified button.	V1.5	V1.5		13-34
	change_pCap	Edits a caption for a specified page.	V1.5	V1.5		13-35
	disp_page	Displays a specified page of a TP operation screen.	V1.5	V1.5		13-36
Multitasking Control Statements						
Task Control	RUN	Concurrently runs another program.	⊙	⊙		14-1
	KILL	Forcibly terminates a task.	⊙	⊙		14-2
	SUSPEND	Suspends a task.	⊙	⊙		14-3
	DEFEND	Defends a task.	⊙	⊙		14-4
	STATUS	Obtains the program status.	⊙	⊙		14-5
	SUSPENDALL	Suspends all running programs except supervisory tasks.	V1.98	V1.98		14-6
	KILLALL	Forcibly terminates all tasks except supervisory tasks.	V1.98	V1.98		14-7
	CONTINUERUN	Continue-runs tasks.	V1.98	V1.98		14-8
	ROBOTSTOP	Stops the robot.	V1.98	V1.98		14-9
	TAKEARMSTATE	Returns the current acquisition status of the arm group control.	V2.2	V2.2		14-10
	LOCKSTATE	Obtains the machine lock status.	V2.2	V2.2		14-10
	DEADMANSTATE	Obtains the current deadman switch status.	V2.2	V2.2		14-11
	SEMIDSTATE	Returns the current status (enabled or disabled) of the specified semaphore ID.	V2.2	V2.2		14-12
Semaphore	CREATESEM	Creates a semaphore.	⊙	⊙		14-14

4-axis	6-axis	Vision device	
⊙	⊙	⊙	Available with all series of robots and vision device.
○	○	○	Available with all series of robots. The command specifications differ between the 4-axis, 6-axis robot, and vision device.
⊙	V1.2		Available with the 4-axis robots and the 6-axis robots of Version 1.2 or later.

Classified by functions	Commands	Functions	4-axis	6-axis	Vision device	Refer to:
	DELETESEM	Deletes a semaphore.	⊙	⊙		14-17
	FLUSHSEM	Releases tasks from waiting for a semaphore.	⊙	⊙		14-18
	GIVESEM	Releases a task from waiting for a semaphore.	⊙	⊙		14-19
	TAKESEM	Obtains a semaphore with a designated semaphore ID.	⊙	⊙		14-20
Arm Semaphore	TAKEARM	Gets an arm group. Upon execution of this statement, the programmed speed, acceleration and deceleration will be set to 100. If the gotten arm group includes any robot joint, this statement restores the tool coordinates and work coordinates to the origin.	⊙	⊙		14-21
	GIVEARM	Releases robot control priority.	⊙	⊙		14-26
	TAKEVIS	Obtains visual process priority.	⊙	⊙		14-27
	GIVEVIS	Releases visual process priority.	⊙	⊙		14-28
Supervisory Task	INIT	Turns on motors, carrier out CAL, and sets the speed according to the preset supervisory task parameters.	V1.7	V1.7		14-29
	SETOCCUPATIONTIME	Reconfigures the processing time to be exclusively occupied by supervisory tasks.	V2.0	V2.0		14-30
	INITWAITERR	Initializes the storage of errors detected by WAITERROR. (Exclusive to supervisory tasks)	V2.2	V2.2		14-31
	WAITERROR	Detects errors.	V2.2	V2.2		14-32
	CURERRSTATUS	Returns the current error status. (Exclusive to supervisory tasks)	V2.2	V2.2		14-33
Functions						
Arithmetic Function	ABS	Obtains the absolute value of an expression value.	⊙	⊙	⊙	15-1
	EXP	Obtains an exponential function with a natural logarithm taken as a base.	⊙	⊙	⊙	15-2
	INT	Obtains the maximum integer value possible from a designated value.	⊙	⊙	⊙	15-3
	LOG	Obtains a natural logarithm.	⊙	⊙	⊙	15-4
	LOG10	Obtains a common logarithm.	⊙	⊙	⊙	15-5
	POW	Obtains an exponent.	⊙	⊙	⊙	15-6
	MAX	Extracts the maximum value.	⊙	⊙	⊙	15-7
	MIN	Extracts the minimum value.	⊙	⊙	⊙	15-8
	RND	Generates random numbers from 0 to 1.	⊙	⊙	⊙	15-9
	SGN	Checks a sign.	⊙	⊙	⊙	15-10
	SQR	Obtains the square root.	⊙	⊙	⊙	15-11

4-axis	6-axis	Vision device	
⊙	⊙	⊙	Available with all series of robots and vision device.
○	○	○	Available with all series of robots. The command specifications differ between the 4-axis, 6-axis robot, and vision device.
⊙	V1.2		Available with the 4-axis robots and the 6-axis robots of Version 1.2 or later.

Classified by functions	Commands	Functions	4-axis	6-axis	Vision device	Refer to:
Trigonometric Function	ACOS	Obtains an arc cosine.	⊙	⊙	⊙	15-12
	ASIN	Obtains an arc sine.	⊙	⊙	⊙	15-13
	ATN	Obtains an arc tangent.	⊙	⊙	⊙	15-14
	ATN2	Obtains the arc tangent of expression 1 divided by expression 2.	⊙	⊙	⊙	15-15
	COS	Obtains a cosine.	⊙	⊙	⊙	15-16
	SIN	Obtains a sine.	⊙	⊙	⊙	15-17
	TAN	Obtains a tangent.	⊙	⊙	⊙	15-18
Angle Conversion	DEGRAD	Converts the unit to a radian.	⊙	⊙	⊙	15-19
	RAD	Converts a value set in radians to degrees.	⊙	⊙	⊙	15-20
	RADDEG	Converts the unit to degrees.	⊙	⊙	⊙	15-21
Speed Conversion	MPS	Converts an expression of speed.	⊙	⊙		15-22
Time Function	SEC	Converts a value expressed in seconds to milliseconds.	⊙	⊙	⊙	15-23
Vector	AVEC	Extracts an approach vector.	⊙	⊙		15-24
	OVEC	Extracts an orient vector.	⊙	⊙		15-25
	PVEC	Extracts a position vector.	○	○		15-26
	MAGNITUDE	Obtains the vector size.	⊙	⊙		15-27
Pose Data Type Transformation	J2P	Transforms joint type data to position type data.	○	○		15-28
	J2T	Transforms joint type data to homogeneous transformation type data.	○	○		15-29
	P2J	Transforms position type data to joint type data.	○	○		15-30
	P2T	Transforms position type data to homogeneous transformation type data.	○	○		15-31
	T2J	Transforms homogeneous transformation type data to joint type data.	⊙	⊙		15-32
	T2P	Transforms homogeneous transformation type data to position type data.	⊙	⊙		15-33
	TINV	Calculates an inverse matrix of homogeneous transformation type data.	⊙	⊙		15-34
	NORMTRN	Normalizes homogeneous-transformation data.	V1.8	V1.8		15-34
Distance Extraction	DIST	Returns the distance between two points.	○	○		15-35
Figure Component	FIG	Extracts a figure.	○	○		15-36
Angle Component	JOINT	Extracts an angle from joint type coordinates.	○	○		15-37
Axis Component	POSX	Extracts the X-component.	○	○		15-38
	POSY	Extracts the Y-component.	○	○		15-39
	POSZ	Extracts the Z-component.	○	○		15-40
Rotation Component	POSRX	Extracts the X-axis rotation component.		⊙		15-41

4-axis	6-axis	Vision device	
⊙	⊙	⊙	Available with all series of robots and vision device.
○	○	○	Available with all series of robots. The command specifications differ between the 4-axis, 6-axis robot, and vision device.
⊙	V1.2		Available with the 4-axis robots and the 6-axis robots of Version 1.2 or later.

Classified by functions	Commands	Functions	4-axis	6-axis	Vision device	Refer to:
	POSRY	Extracts the Y-axis rotation component.		⊙		15-42
	POSRZ	Extracts the Z-axis rotation component.		⊙		15-43
	POST	Extracts the T-axis rotation component.	⊙			15-44
Figure Component	RVEC	Extracts a posture.		⊙		15-45
Position Function	AREAPOS	Returns the center position and direction of a rectangular parallelepiped with the position type for an area where an interference check is performed.	⊙	⊙		15-46
	AREASIZE	Returns the size (each side length) of a rectangular parallelepiped which defines the interference check area with the vector type.	⊙	⊙		15-47
	TOOLPOS	Returns a tool coordinate system as the position type.	⊙	⊙		15-48
	WORKPOS	Returns the user coordinate system as the position type.	⊙	⊙		15-49
Character String Function	ASC	Converts to a character code.	⊙	⊙	⊙	15-50
	BIN$	Converts the value of an expression to a binary character string.	⊙	⊙	⊙	15-51
	CHR$	Converts an ASCII code to a character.	⊙	⊙	⊙	15-52
	SPRINTF$	Converts an expression to a designated format and returns it as a character string.	⊙	⊙	⊙	15-53
	HEX$	Obtains a value converted from a decimal to a hexadecimal number as a character string.	⊙	⊙	⊙	15-56
	LEFT$	Extracts the left part of a character string.	⊙	⊙	⊙	15-57
	LEN	Obtains the length of a character string in bytes.	⊙	⊙	⊙	15-58
	MID$	Extracts a character string for the designated number of characters from a character string.	⊙	⊙	⊙	15-59
	ORD	Converts to a character code.	⊙	⊙	⊙	15-60
	RIGHT$	Extracts the right part of a character string.	⊙	⊙	⊙	15-61
	STRPOS	Obtains the position of a character string.	⊙	⊙	⊙	15-62
	STR$	Converts a value to a character string.	⊙	⊙	⊙	15-63
	VAL	Converts a character string to a numeric value.	⊙	⊙	⊙	15-64
Constants						
Built-in Constants	OFF	Sets an OFF (0) value.	⊙	⊙	⊙	16-1

4-axis	6-axis	Vision device	
⊙	⊙	⊙	Available with all series of robots and vision device.
○	○	○	Available with all series of robots. The command specifications differ between the 4-axis, 6-axis robot, and vision device.
⊙	V1.2		Available with the 4-axis robots and the 6-axis robots of Version 1.2 or later.

Classified by functions	Commands	Functions	4-axis	6-axis	Vision device	Refer to:
	ON	Sets an ON (1) value.	⊙	⊙	⊙	16-1
	PI	Sets a π value.	⊙	⊙	⊙	16-2
	FALSE	Sets a value of false (0) to a Boolean value.	⊙	⊙	⊙	16-2
	TRUE	Sets a value of true (1) to a Boolean value.	⊙	⊙	⊙	16-3
Time/Date Control						
Time/Date	DATE$	Obtains the current date.	⊙	⊙		17-1
	TIME$	Obtains the current time.	⊙	⊙		17-1
	TIMER	Obtains the elapsed time.	⊙	⊙		17-2
Error Controls						
Error Information	ERRMSG$	Sets an error message.	⊙	⊙	⊙	18-1
	SETERR	Saves a specified error code into an integer variable area.	V1.98	V1.98		18-1
	GETERR	Gets the error code from the ring buffer declared by the error code saving feature.	V1.98	V1.98		18-2
	CLRERR	Clears the current error.	V1.98	V1.98		18-3
	GETERRLVL	Gets the error level.	V1.98	V1.98		18-3
System Information						
System	GETENV	Obtains the environment setting values of the system.	⊙	⊙	⊙	19-1
	LETENV	Sets the environment setting values of the system.	⊙	⊙	⊙	19-2
	VER$	Obtains the version of each module.	⊙	⊙	⊙	19-3
	GETLANGUAGE	Gets the current language setting.	V2.2	V2.2		19-3
Log	STARTLOG	Starts recording of the servo control log.	⊙	⊙		19-4
	CLEARLOG	Initializes recording of the servo control log.	⊙	⊙		19-5
Operation Mode	STOPLOG	Stops servo control log recording.	⊙	⊙		19-6
	CHGEXTMODE	Switches from internal to external auto mode.	V1.98	V1.98		19-7
	CHGINTMODE	Switches from external to internal auto mode.	V1.98	V1.98		19-8
	CUROPTMODE	Gets the current operation mode.	V1.98	V1.98		19-8
	SYSSTATE	Gets the system status of the robot controller.	V1.98	V1.98		19-9
Preprocessor						
Symbol Constants · Macro Definitions	#define	Replaces a designated constant or macro name in the program with a designated character string.	⊙	⊙	⊙	20-1
	#undef	Makes a symbol constant defined with #define or macro definition invalid.	⊙	⊙	⊙	20-2

4-axis	6-axis	Vision device	
⊙	⊙	⊙	Available with all series of robots and vision device.
○	○	○	Available with all series of robots. The command specifications differ between the 4-axis, 6-axis robot, and vision device.
⊙	V1.2		Available with the 4-axis robots and the 6-axis robots of Version 1.2 or later.

Classified by functions	Commands	Functions	4-axis	6-axis	Vision device	Refer to:
	#error	Forcibly generates a compiling error if the #error command is executed.	⊙	⊙	⊙	20-2
File Fetch	#include	Fetches the preprocessor program.	⊙	⊙	⊙	20-3
Optimization	#pragma optimize	Designates optimization to be executed for each program.	⊙	⊙	⊙	20-5
Vision Control (Option)						
Image Input and Output	CAMIN	Stores an image from the camera in the image memory (process screen).	⊙	⊙	⊙	21-3
	CAMMODE	Sets the function used to store a camera image.	⊙	⊙	⊙	21-4
	CAMLEVEL	Sets the camera image input level.	⊙	⊙	⊙	21-6
	VISCAMOUT	Displays an image from the camera on the monitor.	⊙	⊙	⊙	21-7
	VISPLNOUT	Displays an image in the storage memory on the monitor.	⊙	⊙	⊙	21-8
	VISOVERLAY	Displays draw screen information on the monitor.	⊙	⊙	⊙	21-9
	VISDEFTABLE	Reads images on the camera and sets the look-up table data for image output.	⊙	⊙	⊙	21-10
	VISREFTABLE	Refers to data on the look-up table.	⊙	⊙	⊙	21-11
Window Setting	WINDMAKE	Designates an area for image processing.	⊙	⊙	⊙	21-12
	WINDCLR	Deletes set window information.	⊙	⊙	⊙	21-17
	WINDCOPY	Copies window data.	⊙	⊙	⊙	21-18
	WINDREF	Obtains window information.	⊙	⊙	⊙	21-19
	WINDDISP	Draws a designated window.	⊙	⊙	⊙	21-20
Draw	VISSCREEN	Designates a drawing screen.	⊙	⊙	⊙	21-21
	VISBRIGHT	Designates a drawing brightness value.	⊙	⊙	⊙	21-22
	VISCLS	Fill (cleens) a designated screen, set in a mode with a designated brightness.	⊙	⊙	⊙	21-23
	VISPUTP	Draws a point on the screen.	⊙	⊙	⊙	21-24
	VISLINE	Draws a line on the screen.	⊙	⊙	⊙	21-25
	VISPTP	Draws a line connecting two points on the screen.	⊙	⊙	⊙	21-26
	VISRECT	Draws a rectangle on the screen.	⊙	⊙	⊙	21-27
	VISCIRCLE	Draws a circle on the screen.	⊙	⊙	⊙	21-28
	VISELLIPSE	Draws an ellipse on the screen.	⊙	⊙	⊙	21-29
	VISSECT	Draws a sector on the screen.	⊙	⊙	⊙	21-30
	VISCROSS	Draws a cross symbol on the screen.	⊙	⊙	⊙	21-31
	VISLOC	Designates the display position of characters.	⊙	⊙	⊙	21-32

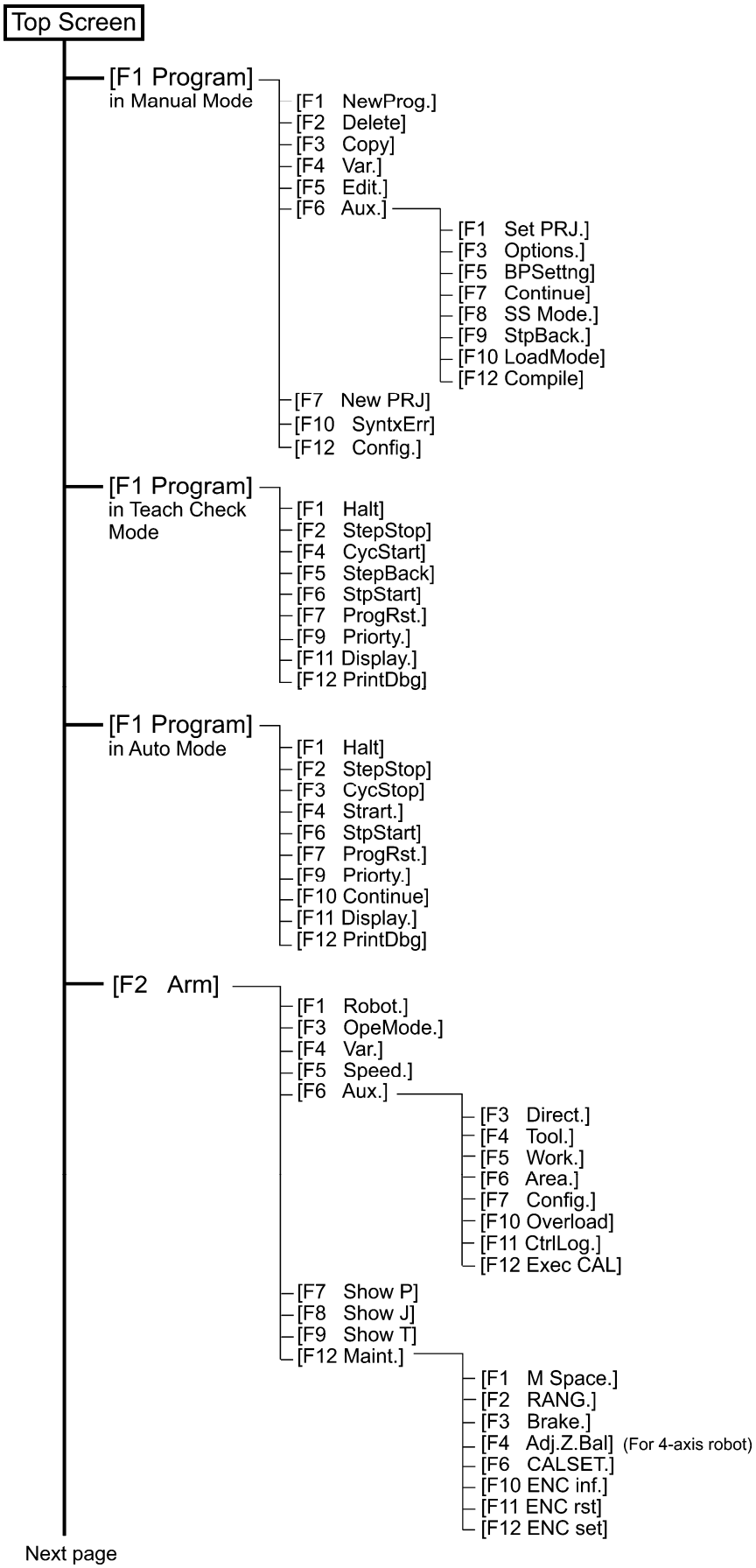
4-axis	6-axis	Vision device	
⊙	⊙	⊙	Available with all series of robots and vision device.
○	○	○	Available with all series of robots. The command specifications differ between the 4-axis, 6-axis robot, and vision device.
⊙	V1.2		Available with the 4-axis robots and the 6-axis robots of Version 1.2 or later.

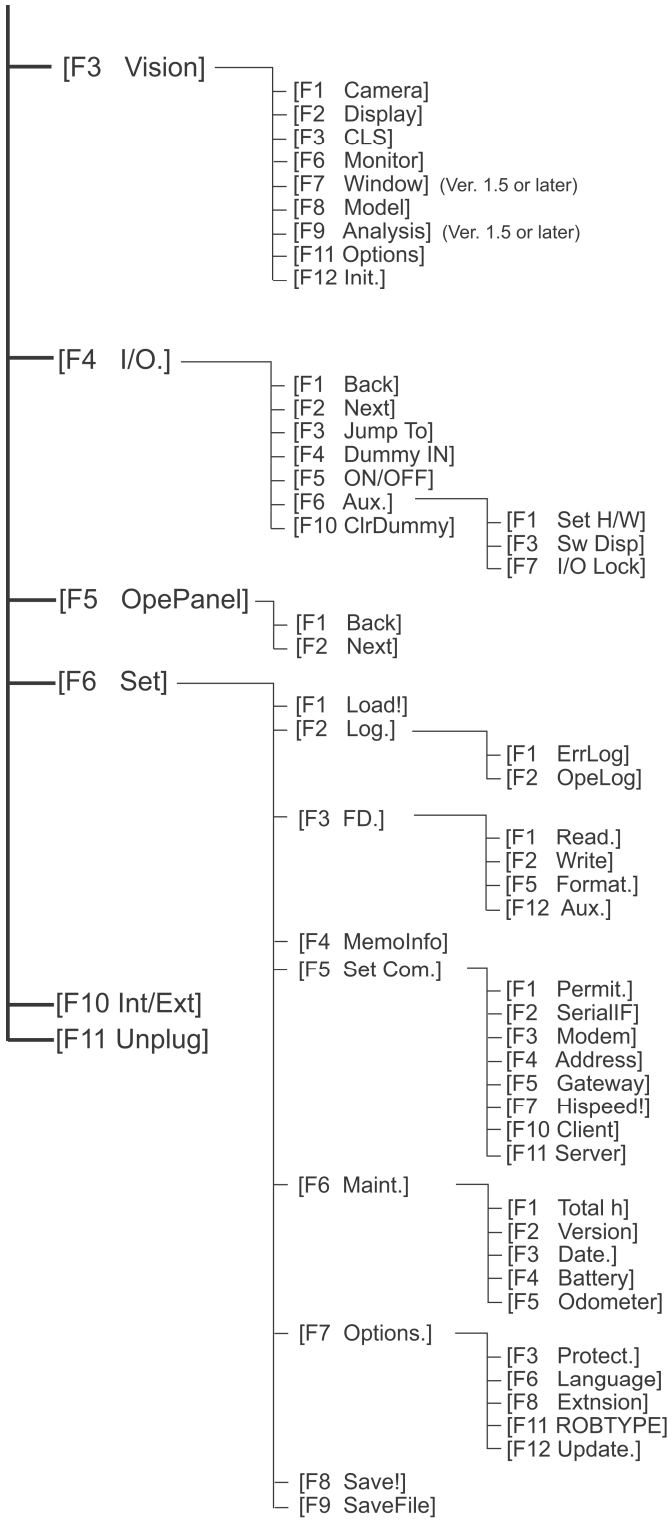
Classified by functions	Commands	Functions	4-axis	6-axis	Vision device	Refer to:
	VISDEFCHAR	Designates the size of characters and the display method.	⊙	⊙	⊙	21-34
	VISPRINT	Displays characters and figures on the screen.	⊙	⊙	⊙	21-35
Vision Processing	VISWORKPLN	Designates the storage memory (process screen) to process.	⊙	⊙	⊙	21-36
	VISGETP	Obtains designated coordinate brightness from the storage memory (processing screen).	⊙	⊙	⊙	21-37
	VISHIST	Obtains the histogram (brightness distribution) of the screen.	⊙	⊙	⊙	21-38
	VISREFHIST	Reads histogram results.	⊙	⊙	⊙	21-39
	VISLEVEL	Obtains a binarization level based on the histogram result.	⊙	⊙	⊙	21-40
	VISBINA	Binarizes the screen.	⊙	⊙	⊙	21-42
	VISBINAR	Displays a binarized screen.	⊙	⊙	⊙	21-44
	VISFILTER	Executes filtering on the screen.	⊙	⊙	⊙	21-45
	VISMASK	Executes calculations between images.	⊙	⊙	⊙	21-47
	VISCOPY	Copies the screen.	⊙	⊙	⊙	21-49
	VISMEASURE	Measures features in the window (area, center of gravity, main axis angle).	⊙	⊙	⊙	21-50
	VISPROJ	Measures the projected data in the window.	⊙	⊙	⊙	21-53
	VISEDGE	Measures the edge in a window.	⊙	⊙	⊙	21-55
Code Recognition	VISREADQR	Reads the QR code.	⊙	⊙	⊙	21-59
Labeling	BLOB	Executes labeling.	⊙	⊙	⊙	21-62
	BLOBMEASURE	Executes feature measurement of the object label number.	⊙	⊙	⊙	21-65
	BLOBLABEL	Obtains the label number for designated coordinates.	⊙	⊙	⊙	21-67
	BLOBCOPY	Copies an object label number.	⊙	⊙	⊙	21-69
Search Function	SHDEFMODEL	Registers the search model.	⊙	⊙	⊙	21-71
	SHREFMODEL	Refers to registered model data.	⊙	⊙	⊙	21-73
	SHCOPYMODEL	Copies a registered model.	⊙	⊙	⊙	21-74
	SHCLRMODEL	Deletes a registered model.	⊙	⊙	⊙	21-75
	SHDISPMODEL	Displays a registered model on the screen.	⊙	⊙	⊙	21-76
	SHMODEL	Searches for a model.	⊙	⊙	⊙	21-77
	SHDEFCORNER	Sets the conditions for a corner search.	⊙	⊙	⊙	21-81
	SHCORNER	Searches for a corner.	⊙	⊙	⊙	21-82
	SHDEFCIRCLE	Sets the condition for searching a circle.	⊙	⊙	⊙	21-84
	SHCIRCLE	Searches for a circle.	⊙	⊙	⊙	21-85

4-axis	6-axis	Vision device	
⊙	⊙	⊙	Available with all series of robots and vision device.
○	○	○	Available with all series of robots. The command specifications differ between the 4-axis, 6-axis robot, and vision device.
⊙	V1.2		Available with the 4-axis robots and the 6-axis robots of Version 1.2 or later.

Classified by functions	Commands	Functions	4-axis	6-axis	Vision device	Refer to:
Obtaining Results	VISGETNUM	Obtains an image process result from the storage memory.	⊙	⊙	⊙	21-88
	VISGETSTR	Obtains code recognition result.	⊙	⊙	⊙	21-89
	VISPOSX	Obtains an image process result (Coordinate X) from the storage memory.	⊙	⊙	⊙	21-90
	VISPOSY	Obtains an image process result (Coordinate Y) from the storage memory.	⊙	⊙	⊙	21-91
	VISSTATUS	Monitors the process result of each instruction.	⊙	⊙	⊙	21-92
	VISREFCAL	Obtains calibration data (Vision-robot coordinate transformation).	⊙	⊙	⊙	21-93

Appendix 3 Menu Tree of Commands on Teach Pendant




[F3 Vision]
[F1 Camera]
[F2 Display]
[F3 CLS]
[F6 Monitor]
[F7 Window] (Ver. 1.5 or later)
[F8 Model]
[F9 Analysis] (Ver. 1.5 or later)
[F11 Options]
[F12 Init.]
[F4 I/O.]
[F1 Back]
[F2 Next]
[F3 Jump To]
[F4 Dummy IN]
[F5 ON/OFF]
[F6 Aux.]
[F10 ClrDummy]
[F1 Set H/W]
[F3 Sw Disp]
[F7 I/O Lock]
[F5 OpePanel]
[F1 Back]
[F2 Next]
[F6 Set]
[F1 Load!]
[F2 Log.]
[F1 ErrLog]
[F2 OpeLog]
[F3 FD.]
[F1 Read.]
[F2 Write]
[F5 Format.]
[F12 Aux.]
[F4 MemoInfo]
[F5 Set Com.]
[F1 Permit.]
[F2 SerialIF]
[F3 Modem]
[F4 Address]
[F5 Gateway]
[F7 Hispeed!]
[F10 Client]
[F11 Server]
[F6 Maint.]
[F1 Total h]
[F2 Version]
[F3 Date.]
[F4 Battery]
[F5 Odometer]
[F7 Options.]
[F3 Protect.]
[F6 Language]
[F8 Extnsion]
[F11 ROBTYPE]
[F12 Update.]
[F8 Save!]
[F9 SaveFile]
[F10 Int/Ext]
[F11 Unplug]

Appendix 4 Program Samples

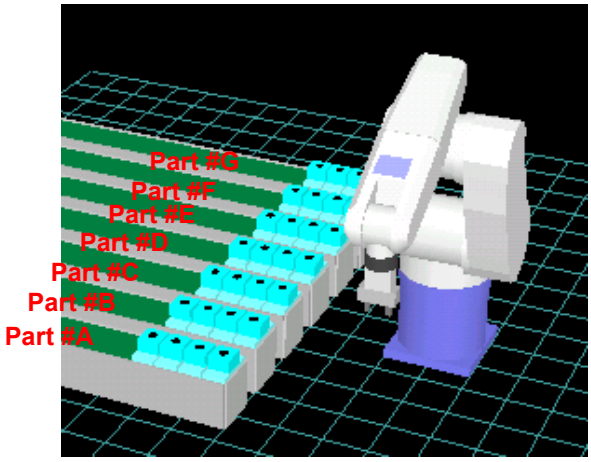
■ #1 Pick up Workpieces According to Part Number Information

Receive part number information from external equipment.

Description

The robot receives signals issued as part number information from external equipment and converts it into decimal.

Shown below is a sample program to get the part number information of workpieces sorted on conveyers and select the appropriate process from pick-up through assembly for each part number.



Program Samples

Initial input parameters (Variables to be used)

Not used.	

```
'!TITLE "Pick up Workpieces According to Part Number Information"
PROGRAM Sample

TAKEARM
DEFIO type = BYTE,14,&B00011111 'Declare I/O variable and get data into it
                                'Store the input status data of 5 bits
                                'starting from system input port [14]
                                'into the local variable "type"
WAIT IO[34] = ON                'Wait the signal indicating that part number
                                'info is ready
IN I[1] = type                  'Read data of "type" into I[1] (after
                                'converting it from binary to decimal)

SELECT CASE I[1]
  CASE 1                        'If I[1] is 1,
    CALL pick_A                 'pick-up through assembly for part #A
  CASE 4                        'If I[1] is 4,
    CALL pick_B                 'pick-up through assembly for part #B
  CASE 5                        'If I[1] is 5,
    CALL pick_C                 'pick-up through assembly for part #C
  CASE 6                        'If I[1] is 6,
    CALL pick_D                 'pick-up through assembly for part #D
  CASE 7 TO 15                  'If I[1] is 7 to 15,
    CALL pick_E                 'pick-up through assembly for part #E
  CASE 16                       'If I[1] is 16,
    CALL pick_F                 'pick-up through assembly for part #F
   CASE IS >= 20                'If I[1] is 20 or above,
    CALL pick_G                 'pick-up through assembly for part #G
CASE ELSE                       'If I[1] does not match any of the above conditions,
    PRINTMSG "Part# data read error",2,"Error"
    STOP
END SELECT

MOVE P,@0 P10                   'Return to the home position

END
```

■ #2 Mesh Gears to Insert (HS-E/-G series)

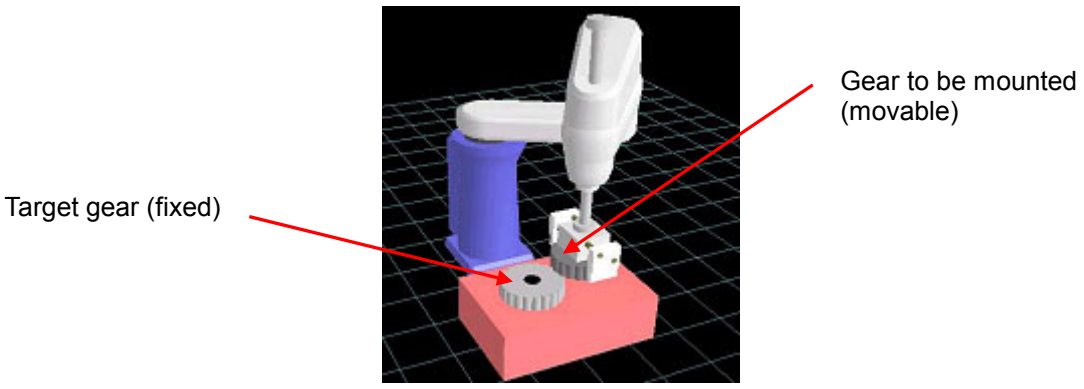
Mesh gears to insert under compliance control, making use of the current limit function.

Description

Using the current limit function of the vertical axis allows the robot to mesh a gear with the target gear (fixed) while pressing and rotating the gear (to be mounted) under compliance control. During the mesh-and-insert operation, the robot monitors the current position of the vertical axis to stop the rotation when the axis reaches the insertion completion position.

The insertion completion position can be specified at an arbitrary point.

This function is applicable not only to gears but also other parts to be mated during assembly operations.



Program Samples

Initial input parameters (Variables to be used)

F1	Insertion OK position (Z-axis coordinate value) **[Input required]**

```
'!TITLE "Mesh Gears to Insert (HS-E/-G series)"
PROGRAM Sample

TAKEARM
APPROACH P,P1,@0 50,S=10          'Move to a position above the target point
ST_SetZBalance                    'Gravity compensation for Z- and T-axes
ST_SetEralw 3,30                  'Set the allowable deviation for Z-axis
ST_SetCurLmt 3,20                 'Start current limit for Z-axis
MOVE L,@0 P1,S=10                 'Move the tool end to the gears meshing position
judge%=0                          'Initialize the gear meshing flag
  IF POSZ(CURPOS)>=F1 THEN        'Check whether the axis reaches the insertion
                                  'completion position
    judge%=1                      'Gears not meshed (judge=1)
    SPEED 5                       'Rotation speed 5%
    ROTATEH 30,NEXT               'Rotate by 30 degrees (NEXT option)
  '----- Parallel processing with ROTATEH motion -------------------------
    flg%=0                        'Initialize the flag
    DO
      IF POSZ(CURPOS)<= F1 THEN   'Check whether the axis reaches the insertion
                                  'completion position
         CALL MotionSkip          'Skip intermediate operations [use library]
         judge%=0                 'Gears meshed (judge=0)
         EXIT DO                  'Forcibly exit from DO...LOOP
      ENDIF
      CALL MotionComp(flg%)       'Check the completion of ROTATE command [library]
    LOOP UNTIL flg%=1             'Repeat DO...LOOP until the operation completes
  '-----------------------------------------------------------------------
  ENDIF
ST_ResetZBalance                  'Release gravity compensation for Z- and T-axes
ST_ResetEralw 3                   'Release the allowable deviation setting for Z-axis
ST_ResetCurLmt 3                  'Release the current limit for Z-axis
CALL HAND_OPEN                    'Unchuck the hand [User program]
DEPART L,50,S=100                 'Move Z-axis upward

IF judge%=1 THEN                  'If meshing failed,
  PRINTMSG "Mesh failed",2,"Error"          'Display the message on the teach pendant
ENDIF
MOVE L,@0 P5,S=100                'Return to the home position

END
```

Library

MotionSkip and MotionComp

■ #3 Return to Home Position 1 (After moving up Z-axis)

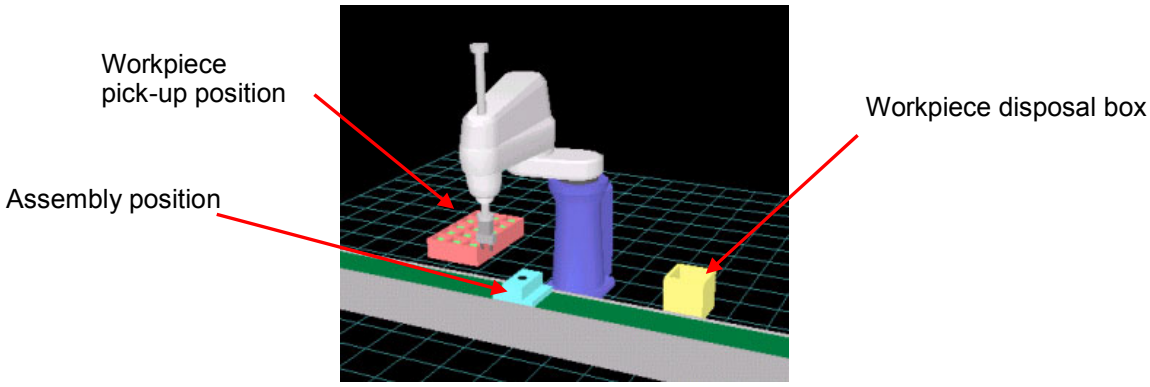
Move the arm to the home position after moving the Z-axis upward.

Description

This program moves the robot arm to the home position if the robot stops midway through a motion.

If there is no obstacle within the arm motion space as shown below, the arm can move to the home position just by moving upward to prevent interference with anything.

In the sample program below, the robot interprets the "hand chuck signal ON" as a workpiece remaining in the hand so that it ejects the workpiece into the disposal box before returning the arm to the home position.



Program Samples

Initial input parameters (Variables to be used)

P50	Variable to assign the current position obtained **[Automatically assigned]**
F1	Coordinate value of Z-axis **[Input required]**

```
'!TITLE "Return to Home Position 1 (After moving up Z-axis)"
PROGRAM Sample

TAKEARM
HOME(200,300,350,45,1)          'Declare the coordinates as the home position

P50=CURPOS                      'Get the current position and assign it to P50
LETZ P50=F1                     'Assign F1 to the Z-axis component of P50
MOVE P,@0 P50,S=30              'Move the Z-axis from the current position to the
                                'coordinates whose Z-axis component has been specified

IF IO[64]=ON THEN               'Check whether a workpiece is remaining in the hand
  CALL DiscardProduct           'If IO[64]=ON, execute the ejecting motion program
ENDIF

GOHOME                          'Return to the home position

END
```

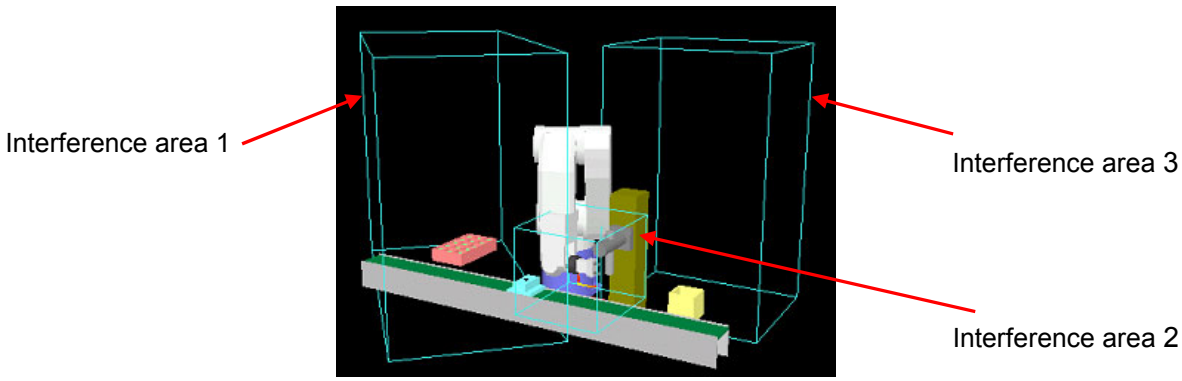
■ #4 Return to Home Position 2 (Interference Area Check)

Move the arm to the home position avoiding interference with peripheral equipment depending on the current position of arm end.

Description

This program moves the robot arm to the home position if the robot stops at an arbitrary position.

If there are obstacles within the arm motion space as shown below, interference check areas should be defined beforehand. The robot judges in which defined area the arm end has stopped and moves the arm to the home position while avoiding interference with peripheral equipment.



Program Samples

Initial input parameters (Variables to be used)

P10	Variable to assign the current position obtained **[Automatically assigned]**
IO[221]	Area 1 output signal **[Auto output signal]**
IO[222]	Area 2 output signal **[Auto output signal]**
IO[223]	Area 3 output signal **[Auto output signal]**

```
'!TITLE "Return to Home Position 2 (Interference Area Check)"
PROGRAM Sample

TAKEARM
HOME P1                                     'Declare P1 as the home position
P10=CURPOS                                  'Assign the current position to P10

IF(IO[221]=OFF) AND (IO[222]=OFF) AND (IO[223]=OFF) THEN
  PRINTMSG "Current position is out of the defined area",2,"Error"
                                            'If the arm end is out of the defined area,
                                            'the error message is displayed
  STOP                                      'Stop the program
ELSEIF(IO[221]=ON) OR (IO[223]=ON) THEN     'If the arm end is in area 1 or 3,
  LETZ P10=450                              'specify 450 mm for the Z-axis coordinates
ELSEIF IO[222]=ON THEN                      'If the arm end is in area 2,
  LETY P10=0                                'specify 0 mm for the Y-axis coordinates
ENDIF
MOVE P,@0 P10,S=50                          'Evacuate from the current position

'-----If the hand is closed (workpiece gripped), eject motion--------------
IF IO[64]=ON THEN               'If the hand is closed,
  MOVE P,@0 P22,S=50            'move to the position away from the interference area
  APPROACH P,P21,@0 100,S=50    'Move to the 100 mm above the workpiece disposal box
  MOVE P,@0 P21,S=50            'Approach the disposal box
  CALL PRPDUCT_RELEASE          'Unchuck [Program created by the user]
  DEPART P,@0 100,S=50          'Move to the 100 mm above the workpiece disposal box
  MOVE P,@0 P22,S=50            'move to the position away from the interference area
  GOHOME                        'Move to the fixed position
'----- If the hand is open (no workpiece gripped), return to home position ----
ELSEIF IO[64]=OFF THEN          'If the hand is open,
  IF IO[222]=ON THEN            'If the arm end is in area 2,
    MOVE P,@0 P22,S=50          'move to the position away from the interference area
  ENDIF
  GOHOME                        'Return to home position
ENDIF

END
```

■ #5 Measure the Workpiece Size with a Pair of Sensors

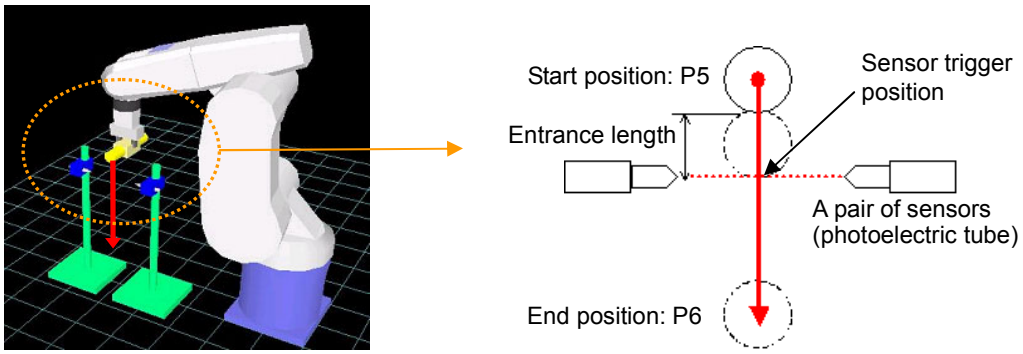
Measure the size of a workpiece with a pair of sensors.

Description

The program sample given below requires a pair of sensors to be set up for measurement. If a workpiece passes through the space between those sensors so that the sensor state changes ON and OFF, this program gets in the current robot coordinate positions. Based on the difference between those two coordinate positions detected (from ON to OFF and from OFF to ON), the workpiece size can be calculated.

For getting stabilized measurement, the start position should be specified taking into account the entrance length which is required for the robot to reach the constant speed at the sensing point.

Note: Since the measuring accuracy of this program depends on the sensor precision and robot speed, this measurement is not suitable for high-precision need.



Program Samples

Initial input parameters (Variables to be used)

P5	Motion start position (entry required)
P6	End position (entry required)
P10	For storage of the current robot position value detected when the sensor is turned from ON to OFF (automatic entry)
P11	For storage of the current robot position value detected when the sensor is turned from OFF to ON (automatic entry)
F1	Calculation result of P10-to-P11 distance (automatic entry)

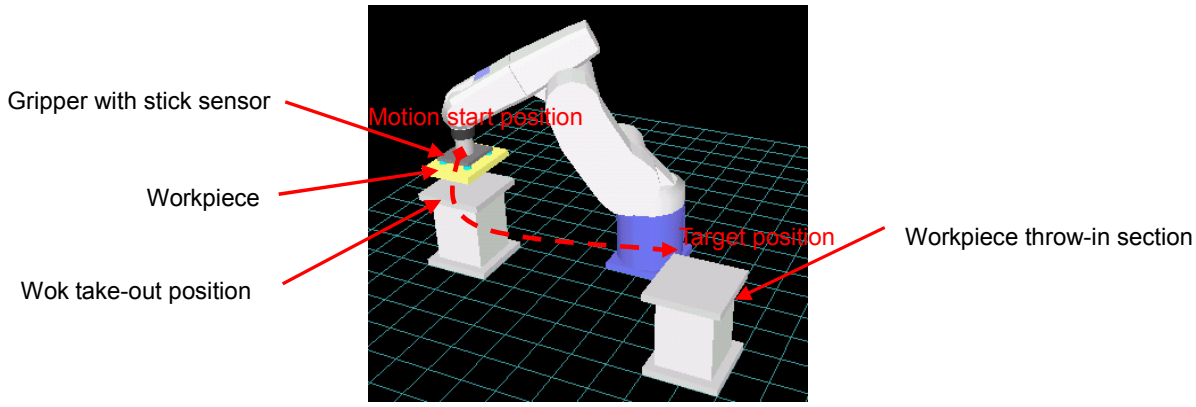
```
'!TITLE "Measure workpiece size with a pair of sensors"
PROGRAM Sample 011

TAKEARM
MOVE P,@E P5,S=100                      'Move to the start position
SPEED MPS(20)                           'Set speed to 20 mm/s
ACCEL 100,100                           'Set acceleration and deceleration to 100%
Inspect%=0                              'Initialize inspection flag
IF IO[34]=ON THEN                       'If the sensor is turned ON,
  PRINTMSG "Sensor turned ON at the start point",2,"Error"
  STOP                                  'Terminate program
ENDIF
MOVE L,@0 P6,NEXT                       'Move to the end position (with NEXT option)
'----- Parallel processing with movement to P6 -------------------------------------
DO
  IF Inspect%=0 THEN
    IF IO[34]=ON THEN                   'If the sensor is turned ON,
      P10=CURPOS                        'Get the current position value to P[10]
      Inspect%=1                        'Start size measurement (flag = 1)
    ENDIF
  ELSEIF IO[34]=OFF THEN                'If the sensor is turned OFF,
    P11=CURPOS                          'Get the current position value to P[11]
    Inspect%=2                          'Finish size measurement (flag = 2)
    EXIT DO                             'Forcedly exit DO-LOOP statement
  ENDIF
LOOP
'-----------------------------------------------------------------------------------
IF(Inspect%=0) OR (Inspect%=1) THEN
  PRINTMSG "Check the ON/OFF of the measurement failure sensor",2,"Error"
  STOP                                  'Terminate program
ENDIF
'----- Assign the calculation result of distance between 2 points ------------------
F1=DIST(P10,P11)                        'Assign P10-to-P11 distance
'-----------------------------------------------------------------------------------
DEPART L,@0 100,S=50
END
```

■ #6 Monitor Workpiece Drop in Arm Motion

Monitor a workpiece drop from the hand in arm motion with the ON/OFF state of the stick sensor.

Description

The program sample given below allows the robot to monitor the ON/OFF state of the stick sensor during arm motion. If the stick sensor is turned OFF during arm motion, the robot interprets it as a workpiece drop or displacement, stops the arm motion halfway, and outputs an error signal to external equipment. This monitor function prevents workpieces not gripped correctly from proceeding to the next production process.



Program Samples

Initial input parameters (Variables to be used)

P0	Motion start position (entry required)
P1	Target position (entry required)

```
'!TITLE "Monitor workpiece drop in arm motion"
PROGRAM Sample

TAKEARM
flg%=0                              'Initialize stick sensor status flag
comp%=0                             'Initialize motion command completion flag
MOVE P,P0                           'Move to motion start position P0
SPEED 50                            'Set speed to 50%
MOVE P,P1,NEXT                      'Move to target position P1 (with NEXT option)
'----- Parallel processing with movement to P1 --------------------------------
DO
  IF IO[35]=OFF THEN                'If stick sensor is OFF,
    flg%=1                          'store workpiece drop (flg = 1)
    CALL MotionSkip                 'Interrupt arm motion command (use library)
EXIT DO                             'Forcedly exit DO-LOOP statement
  ENDIF
  CALL MotionComp(comp%)            'Check completion of motion (use library)
LOOP UNTIL comp%=1                  'Repeat DO-LOOP until completion of motion
'-------------------------------------------------------------------------------
'----- Processing when the sensor is turned OFF (workpiece drop) halfway ------
IF flg%=1 THEN                      'Check the current state of stick sensor
  PRINTMSG "Work drop",2,"Error"    'Display error message on teach pendant
  SET IO[104]                       'Issue workpiece drop error signal (IO[104])
  STOP                              'Terminate program
ENDIF
'-------------------------------------------------------------------------------

END
```

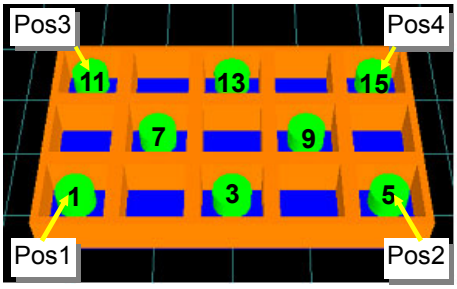
Library MotionSkip, MotionComp

■ #7 Palletize in an Alternate Checker-Pattern

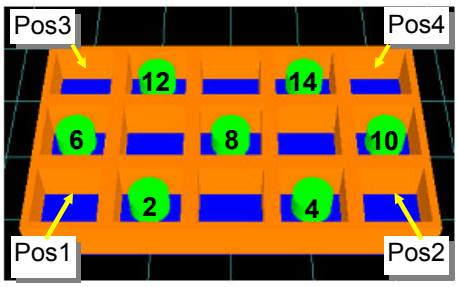
Take out workpieces from every other palletizing position on a partitioned pallet.

Description

The two program samples given below enable the robot to take out workpieces from odd- and even-numbered positions, respectively.



Palletizing from odd-numbered positions



Palletizing from even-numbered positions

Program Samples

Initial input parameters (Variables to be used)

P11	Position P1, one of the four corners of the pallet (entry required)
P12	Position P2, one of the four corners of the pallet (entry required)
P13	Position P3, one of the four corners of the pallet (entry required)
P14	Position P4, one of the four corners of the pallet (entry required)
P15	Palletizing point (automatic entry)
I1	Palletizing counter for workpiece take-out At the first execution of palletizing programs, either of the following values should be entered. 1 for palletizing from odd-numbered positions 2 for palletizing from even-numbered positions

```
'!TITLE "Palletize from odd-numbered positions"
PROGRAM Sample 003

TAKEARM
CALL xdGetPalt(3,5,0,P11,P12,P13,P14,P15,I1,1)  'Call simplified palletizing library
APPROACH P,P15,100,S=100                        'Approach the position above palletizing point
MOVE L,@E P15,S=70                              'Move down to palletizing point
CALL CloseGripper                               'Close hand (user program)
I1=I1+2                                         'Count up palletizing counter (+2 for alternate
                                                'checker-pattern)
IF I1>(3*5)THEN                                 'If work take-out is completed,
  I1=1                                          'Reset palletizing counter (initial value = 1
                                                'for palletizing from odd-numbered positions)
ENDIF
DEPART L,@P 100,S=80                            'Move up
END


'!TITLE "Palletize from even-numbered positions"
PROGRAM Sample 003

TAKEARM
CALL xdGetPalt(3,5,0,P11,P12,P13,P14,P15,I1,1)  'Call simplified palletizing library
APPROACH P,P15,100,S=100                        'Approach the position above palletizing point
MOVE L,@E P15,S=70                              'Move down to palletizing point
CALL CloseGripper                               'Close hand (user program)
I1=I1+2                                         'Count up palletizing counter (+2 for alternate
                                                'checker-pattern)
IF I1>(3*5)THEN                                 'If work take-out is completed,
  I1=2                                          'Reset palletizing counter (initial value = 2
                                                'for palletizing from even-numbered positions)
ENDIF
DEPART L,@P 100,S=80                            'Move up
END
```

Library

MotionSkip, MotionComp

Appendix 5 Glossary

A

ABOVE

One of the elbow figures of 6-axis robot. (⇔ BELOW)

ABSOLUTE MOTION

The motion to move to the motion target position set by teaching. (⇔ relative motion)

ADDRESS SETTING (IP address)

To set the controller IP address. It is required in Ethernet communication.

APPROACH VECTOR

Positive directional vector of Z-axis on the mechanical interface coordinates.

AREA

The number of white and black pixels in a window when an image data is binarized. (Vision terms)

ARM CONFIGURATION MACRO DEFINITION FILE

The file which contains the macro definition information of the arm setting data.

ARM FIGURE

The figure determined by the value of the 1st through the 3rd axes of 6-axis robot. There are two kinds of figures; RIGHTY and LEFTY.

ARM FILE

The file in which the information peculiar to the robot is recorded.

ARM SEMAFORE

The privilege of robot control. The task which has the privilege can operate the robot.

AUTOMATIC ROBOT RUN

To run the robot by executing a program.

B

BASE

The portion to install the 1st axis of the robot.

BASE COORDINATES

The three dimensional orthogonal coordinate system which has the origin on the robot base.

BASE MOUNTING SURFACE

The junction surface of the base and the installation frame.

BELOW

One of the elbow figures of 6-axis robot. (⇔ ABOVE)

BINARIZATION

To change the brightness of each pixel to either white (0) or black (1) by the threshold value (binarization level).

BINARIZATION LEVEL

The threshold value of binarization. (Vision terms)

BRAKE-OFF (releasing brakes)

To release the brake of each axis.

BRAKE-ON (locking brakes)

To apply the brake of each axis.

BRIGHTNESS

The numerical value (0-255) which shows the brightness of each pixel. (Vision terms)

BRIGHTNESS INTEGRAL VALUE

The value which is the sum of the brightness of all the pixels in the window. (Vision terms)

C

CAL

Slight movement of all axes of the robot to make the robot confirm the current position after the robot controller power on.

CALSET

Calibration of the relation between the actual robot position and the positional information of the controller.

CALSET OF A SINGLE AXIS

To perform CALSET on the specified axis only.

CENTER OF GRAVITY

The balance point on which the object weight balances on a plane. (Vision terms)

COMMAND AREA

A group of I/O ports which specify the I/O command type.

COMMAND EXECUTION I/O SIGNAL

The input/output signal fixed to the system in order to inform the execution of I/O command and the execution status to the outside.

COMMAND PROCESSING COMPLETE

The output signal to inform the completion of I/O command processing to the outside.

COMMAND

The instruction written in a program. The controller reads commands in the sequence written in a program, interprets commands and executes.

COMMENT

Explanatory notes in a program to make the program easy to understand. The controller does not execute comment.

COMMUNICATION LOG

The record of the communication condition between the PC and the robot.

COMPATIBLE MODE

The mode in which the I/O allocation is set to be compatible with the conventional series of robots. It is switched by software.

CONTINUOUS START

The start method to execute a program in iteration. The operation continues until it is forced to stop.

CONTROL LOG

The record of the specified value, the encoder value, the current value and the load ratio. They are recorded by each motion axis.

CONVENTIONAL LANGUAGE

The robot language used in Denso robot conventionally.

CP CONTROL

Compensation control to make the path from the current position to the motion target position a straight line or a circle. (⇔ PTP control)

CURRENT POSITION

The current position of the origin of the tool coordinates.

CYCLE STOP

The stop method to stop a program after one cycle execution.

D

D VARIABLE (Double-precision variable)

The variable which has a value of double precision real number (15 digits of effective precision).

DAILY INSPECTION

The inspection before the daily work.

DATA AREA

A group of I/O ports to specify the necessary data for I/O command.

DEADMAN SWITCH

The switch which moves robot as long as any of the arm traverse keys is pressed simultaneously for safety. The robot stops immediately when either the arm traverse key or the deadman switch is released. The switch is also called "enable switch."

DEFINING INTERFERENCE AREA

To define the interference area. It is set either with the teach pendant, in WINCAPSIII or with the program command.

DEFINING TOOL COORDINATES

To define tool coordinates. Origin offset amount and rotational angle amount around each axis are defined in reference to the mechanical interface coordinates. TOOL1 through TOOL63 can be defined.

DISCRIMINATION ANALYSIS METHOD

The method to set the binarization level from the histogram using statistical method. (Vision terms).

DOUBLE

One of the 6th axis figures of 6-axis robot. (⇔ SINGLE)

DOUBLE4

One of the 4th axis figures of 6-axis robot. (⇔ SINGLE4)

E

EDGE

Transition point of brightness. (Vision terms)

ELBOW FIGURE

The figure determined by the 2nd and the 3rd axis value of 6-axis robot. There are two kinds of elbow figures; ABOVE and BELOW.

ENABLE AUTO

The signal to enable auto mode in ON condition. Manual mode and teach check mode are possible in OFF condition.

ENCODER VALUE CHECK MOTION

The motion which judges that the target position is reached when the encoder value becomes within the specified pulse range toward the motion target position set by teaching.

END MOTION

The motion which judges that the target position is reached when the specified position of the servo coincides with the motion target position set by teaching.

ERROR CODE

Four digits hexadecimal code which describes error causes/conditions occurred in the robot. Refer to the error code table for the meaning of each error code.

ERROR LOG

Record of the error content and occurred time.

ETHERNET BOARD

One of the controller optional boards. It is used to communicate with WINCAPSIII through TCP/IP protocol.

EXECUTION PROGRAM

The program converted to the data format intelligible to the robot.

EXTERNAL ACCELERATION

The acceleration value set with the teach pendant. Percentage value to the maximum acceleration is inputted.

EXTERNAL AUTOMATIC RUN

To execute a program from the external equipment.

EXTERNAL DECELERATION

The deceleration value set with the teach pendant. Percentage value to the maximum acceleration is inputted.

EXTERNAL MODE

The mode in which robot operation is possible from the external equipment.

EXTERNAL SPEED

The speed set with the teach pendant. Percentage value to the maximum speed is inputted.

F

F VARIABLE (Floating-point variable)

The variable which has a value of single precision real number (7 digits of effective precision).

FIG

The number which denotes the robot figure.

FIGURE

The possible status of each axis (joint) of the robot. Multiple figures are possible for the same position and posture.

FIGURE COMPONENT

The component which determine figure. There are five components in 6-axis robot; arm, elbow, wrist, the 6th axis and the 4th axis.

FIRST ARM

The robot arm nearest to the base.

FLIP

One of the wrist figures of 6-axis robot. (⇔ NONFLIP)

FUNCTION KEYS

The buttons provided under the pendant screen. Function names are displayed on the lower part of the screen and executes the function upon pressing the button.

G

GLOBAL VARIABLE

The variable available for any task.

H

HALT

The stop method to stop the program immediately. The motor power is not turned off.

HAND (end-effector)

The portion to hold the work. The same as tool.

HISTOGRAM

The occurrence ratio of the brightness value in a window. (Vision terms)

I

I VARIABLE (Integer variable)

The variable which has an integer value.

I/O

The input and/or output signal.

I/O COMMAND

The process command given by the external equipment through the I/O port. The robot controller processes according to this command.

INSTALLATION FRAME

The platform to install the robot.

INTERFERENCE AREA

The area provided by the user to watch if the tool interferes with the installation. If the origin of the tool coordinates enters into this area, output signal is issued from the specified I/O port.

INTERNAL ACCELERATION

The acceleration set in a program.

INTERNAL AUTOMATIC RUN

To execute a program from the operating panel or the teach pendant.

INTERNAL DECELERATION

The deceleration set in a program.

INTERNAL MODE

The mode in which robot run and teaching are possible using the teach pendant.

INTERNAL SPEED

The speed set in a program.

INTERRUPT SKIP

The input signal which halts the operation of the current step when it is ON during the execution of a robot command and starts the execution of the next step.

J

J VARIABLE (Joint variable)

The variable denoted by the value of each axis.

JOG DIAL

The dial on the pendant which is used to move cursor or to select a path on the input screen.

JOINT MODE

The mode in which the robot is manually operated on each axis.

L

LABELING

To number the binarized white and black area. (Vision terms)

LEFTY

One of the arm figures of 6-axis robot. (⇔ RIGHTY)

LIBRARY

The collection of programs for reuse. They are registered and utilized using the program bank of WINCAPSIII.

LOAD

To read programs, arm data, etc. from the floppy disk into the robot controller.

LOAD CAPACITY

The mass of the sum of the tool and the work which the robot can hold.

LOCAL VARIABLE

The variable which is utilized within a task.

LOG

The record about operations, motions, etc. of the robot. There are four kinds of logs; error log, operation log, control log and communication log.

M

MACHINE LOCK

The state of simulating motion by the robot controller without actual robot motion.

MACRO

The definition of names with 12 characters in regard to variable numbers and port numbers. Names are replaced with numbers in program execution.

MACRO DEFINITION FILE

The file which defines macro.

MANUAL ROBOT OPERATION

Robot operation by the user using the teach pendant.

MECHANICAL END

The mechanical motion limit set by the mechanical stopper. (⇔ Software limit)

MECHANICAL INTERFACE

The junction surface of the flange and the tool. Mechanical interface (JIS)

MECHANICAL INTERFACE COORDINATES

Three dimensional orthogonal coordinate system which has the origin on the center of the flange.

MECHANICAL STOPPER

The mechanism to restrict the motion of the robot axes physically.

MENU TREE

The description of the functional menu of function keys in tree form. It is listed on the operational guide.

MODE METHOD

The method to set binarization level in the valley when the histogram is two hills distribution.

MODE SWITCH

The switch on the pendant. It can switch the robot run mode.

MONITOR

To display the current status of the robot.

MOTION SPACE

The range in which the robot can operate.

MULTITASKING

The state in which multiple programs are executed virtually simultaneously. It is realized in the way that CPU of the robot controller executes each program in a short interval by turns.

N

NLIM

The negative directional end value of the software limit. (⇔ PLIM)

NONFLIP

One of the wrist figures of 6-axis robot. (⇔ FLIP)

NORMAL MODE

The standard allocation mode of I/O.

NORMAL VECTOR

Positive directional vector of X-axis on the mechanical interface coordinates.

O

OPERATING MODE

The mode in which the robot is operated manually. Three are three modes; each axis mode, X-Y mode and TOOL mode.

OPERATION LOG

The record of operations triggered by the teach pendant and other operating devices.

OPERATING PANEL

The fixed operating panel connected to the controller. It has no teaching function.

OPTIMAL LOAD CAPACITY SETTING FUNCTION

The function which sets the optimal speed and acceleration in response to the load condition or the posture of the robot.

ORIENT VECTOR

Positive directional vector of Y-axis on the mechanical interface coordinates.

OVERHEAD VERSION

The robot specified to install as it hangs from the ceiling setting the base above and the arm below. As the installation space is not needed on the working platform, working space could be wider.

Operator

One of the user levels of WINCAPSIII. Important parameters cannot be changed. Password input is not necessary.

P

P TYLE METHOD

The binarization level setting method to make the area of the object and the area of the black (or white) portion to be the same. (Vision terms)

P VARIABLE (Position variable)

The variable denoted by the position, the posture and the figure.

PAC (PAC)

New robot language used in Denso robot. It is upward compatible from SLIM. (Industrial robot language of JIS)

PALLETIZING

To put in or take out parts, etc. to/from the pallet with partition.

PANEL OPERATION

To make ON/OFF operation of the internal I/O from the teach pendant screen.

PASS MOTION

The motion to pass near the motion target position set by teaching.

PENDANTLESS OPERATION

To run the robot from the external equipment when the teach pendant is not connected to the controller.

PITCH ANGLE

The rotational angle around Y-axis.

PIXEL

The point which forms the screen. (visual terms)

PLATE MECHANICAL INTERFACE

The portion to install tools located on the top end of the robot arm.

PLIM

The positive directional end value of the software limit. (⇔ NLIM)

POSITION DATA

The data of the base coordinates which describes the position of the robot flange center (the tool top end when the tool definition is effective) and the robot posture at the time.

POSTURE

The inclination of the tool determined by the roll, pitch and yaw angles in case of 6-axis robot. The tool direction determined by the angle around Z-axis in case of 4-axes robot.

POWERING OFF THE MOTOR

To turn off the motor power of the robot.

POWERING OFF THE ROBOT CONTROLLER

To turn off the power of the robot controller.

POWERING ON THE MOTOR

To turn on the motor power of the robot.

POWERING ON THE ROBOT CONTROLLER

To turn on the power of the robot controller.

PRINCIPAL AXIS

The axis which gives the minimum moment of inertia in case of rotating the object on a plane. (Vision terms)

PRINCIPAL AXIS ANGLE

The angle formed by the horizontal axis and the principal axis. (Vision terms)

PRIORITY

The sequence of task execution in order of importance. The program with higher priority is executed first.

PROGRAM RESET

The input signal to force program execution from the top of the program.

PROGRAM START

The input signal to start a program. When it is a step stop, execution begins from the next step and when it is a halt, execution begins from the following of the same step.

PROGRAM TRANSFER

To send/receive robot programs between the robot controller and WINCAPSIII (PC).

PTP CONTROL

The control which moves the robot arm to the target position without compensation. The path may not necessarily be a straight line. (⇔ CP control)

Programmer

One of the user levels of WINCAPSIII. All the common operations are possible. Password input is necessary to enter into this mode.

R

RANG

The angle which determines the relation of the robot standard position and the mechanical end.

RELATIVE MOTION

The motion to move from the current position for the motion amount set by teaching.

REMOTE OPERATION

To operate the robot arm which is displayed on the WINCAPSIII.

RIGHTY (RIGHTY)

One of the arm figures of 6-axis robot. (⇔ LEFTY)

ROBOT ERROR

The output signal which informs that an error condition occurred in the robot such as servo error, program error, etc.

ROBOT STOP

The stop method to stop programs immediately and power off the motor.

ROBOT WARNING

The output signal which informs that a slight error occurred during I/O command or servo processing.

ROLL ANGLE

The rotational angle around Z-axis.

RX COMPONENT

The amount of rotational angle around the X coordinate axis.

RY COMPONENT

The amount of rotational angle around the Y coordinate axis.

RZ COMPONENT

The amount of rotational angle around the Z coordinate axis.

S

SAVE

To save programs, arm data, etc. onto the floppy disk from the robot controller.

SEARCH

To search the space which coincides with a standardized image data (search model). (Vision terms)

SECOND ARM

The farther arm of the robot arms measured from the base.

SEMAPHORE

The task execution privilege which is used to synchronize among tasks or to do exclusive control among the tasks that must not be executed simultaneously.

SERVO ON

The signal to inform to the outside that the motor power is on.

SET COMMUNICATION

To set the usage conditions (communication speed, etc.) of each communication port of the robot controller.

SET COMMUNICATION PERMISSION

To set the usage permission of each communication port of the robot controller.

SINGLE

One of the 6th axis figures of 6-axis robot. (⇔ DOUBLE)

SINGLE-CYCLE START

The start method to make a program execute one cycle. The program stops after one cycle execution (to the last step of the program).

SINGLE-STEP START

The start method to make a program execute one step. The program stops after one step execution.

SINGLE4

One of the 4th axis figures of 6-axis robot. (⇔ DOUBLE4)

SINGULAR POINT

The position on the boundary of the two figures.

SNAPSHOT

The function to record the current status of the robot.

SOFTWARE LIMIT

The limit of the robot motion range determined by the software. (⇔ mechanical end)

STATUS AREA

A group of output signals to inform the result of I/O command processing. The status corresponding to the I/O command is set.

STEP CHECK

One step execution of a program in teach check mode.

STEP STOP

The stop method to stop a program after one step execution.

STOP KEY

One of the pendant buttons. Pressing the button makes all programs halt immediately.

STROBE SIGNAL

The input signal to instruct the start of I/O command processing.

SUBROUTINE

The program which describes a specific motion and is called from a portion of a main program.

SYSTEM I/O SIGNALS

The input/output signals fixed to the system in order to inform the run control or run condition to the outside.

SYSTEM PROJECT

Programs and related data groups.

SYSTEM VARIABLE

The variable to check the system condition in a program.

T

T VARIABLE (Homogeneous transform matrix variable)

The variable denoted by the position vector, the orient vector, the approach vector and the figure.

TASK

The motion process formed by each program when multiple programs are managed their simultaneous execution.

TEACH CHECK

To check the motion by the program.

TEACHING

To input the necessary information for operation into the robot using the teach pendant.

TOOL

The portion of the robot which affects the work immediately. It is a synonym of end-effector (JIS).

TOOL COORDINATES

The coordinate system which sets the origin on the tool and offsets the origin of the mechanical interface coordinates to any point and rotates around each axis.

TOOL MODE

The manual operation mode on the tool coordinates.

TOOL0

A special form of tool definition that has origin offset zero, i.e. it implies the mechanical interface coordinates.

TYPE DECLARATION

To declare the type of variable in a program.

U

USER COORDINATES

The coordinate system which users can define.

USER I/O SIGNALS

The input/output signals controllable by the user program.

USER LEVEL

The class provided for users to keep data management security. Access to information or operation is restricted by each class.

V

VARIABLE TABLE

A group of data which are the pair of each port number and value retained by the controller.

VISUAL DEVICE

The device to provide the robot with necessary data by processing the images inputted from the camera.

VISUAL FUNCTION

The function to provide the robot control function with necessary data by processing the images inputted from the camera.

W

WINDOW

The space to process images. (Vision terms)

WORK COORDINATES

The three dimensional orthogonal coordinate system which sets the origin on the work to be processed by the robot.

WRIST FIGURE

The figure determined by the value of the 4th and the 5th axis of the 6-axis robot. There are two kinds of wrist figures; FLIP and NONFLIP.

X

X-Y MODE

The manual operation mode on the base coordinates.

Y

YAW ANGLE

The rotational angle around X-axis.

SYMBOLS

µVision

Visual device manufactured by Denso.

Vertical Articulated V∗ Series
Horizontal Articulated H∗ Series
Cartesian Coordinate XYC Series
Integrated compact type XR Series

STARTUP HANDBOOK

First Edition	July 2007
Seventh Edition	April 2011
Eighth Edition	October 2011

DENSO WAVE INCORPORATED

10N**C

The purpose of this manual is to provide accurate information in the handling and operating of the robot. Please feel free to send your comments regarding any errors or omissions you may have found, or any suggestions you may have for generally improving the manual.