

DENSO ROBOT

Horizontal articulated
HM/HS-D-T02

OWNER'S MANUAL
(Supplement)

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Preface

This manual has been prepared exclusively for the horizontal articulated robot, HM/HS-D-T02. It is a supplement to the H*-D SERIES Owner's Manuals. Together with those manuals, use this supplement.

Robot series and/or models covered by this manual

- HM-40***D-T02
- HS-40***D-T02

where *** is a numeric value representing strokes of axes.

HM/HS-D-T02 features:

1. Individual mode that allows you to operate the robot from the external equipment
 2. DeviceNet-compliant (The robot controller has a built-in DeviceNet board as a slave station.)
 3. Brake releaser as standard
-

Related publications

H*-D SERIES Owner's Manuals—"BEGINNER'S GUIDE," "INSTALLATION & MAINTENANCE GUIDE," "SETTING-UP MANUAL," "PROGRAMMER'S MANUAL," "ERROR CODE TABLES," and "WINCAPSII GUIDE."

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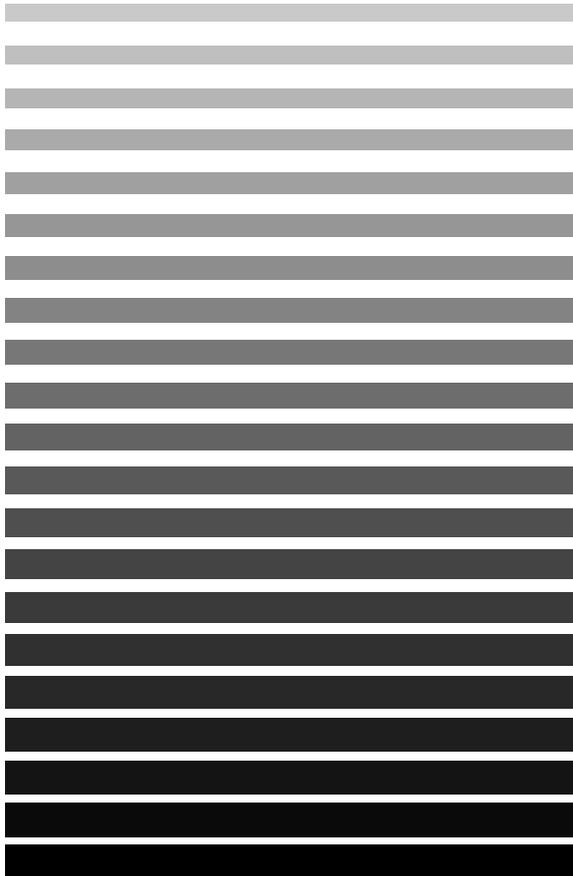
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Chapter 1



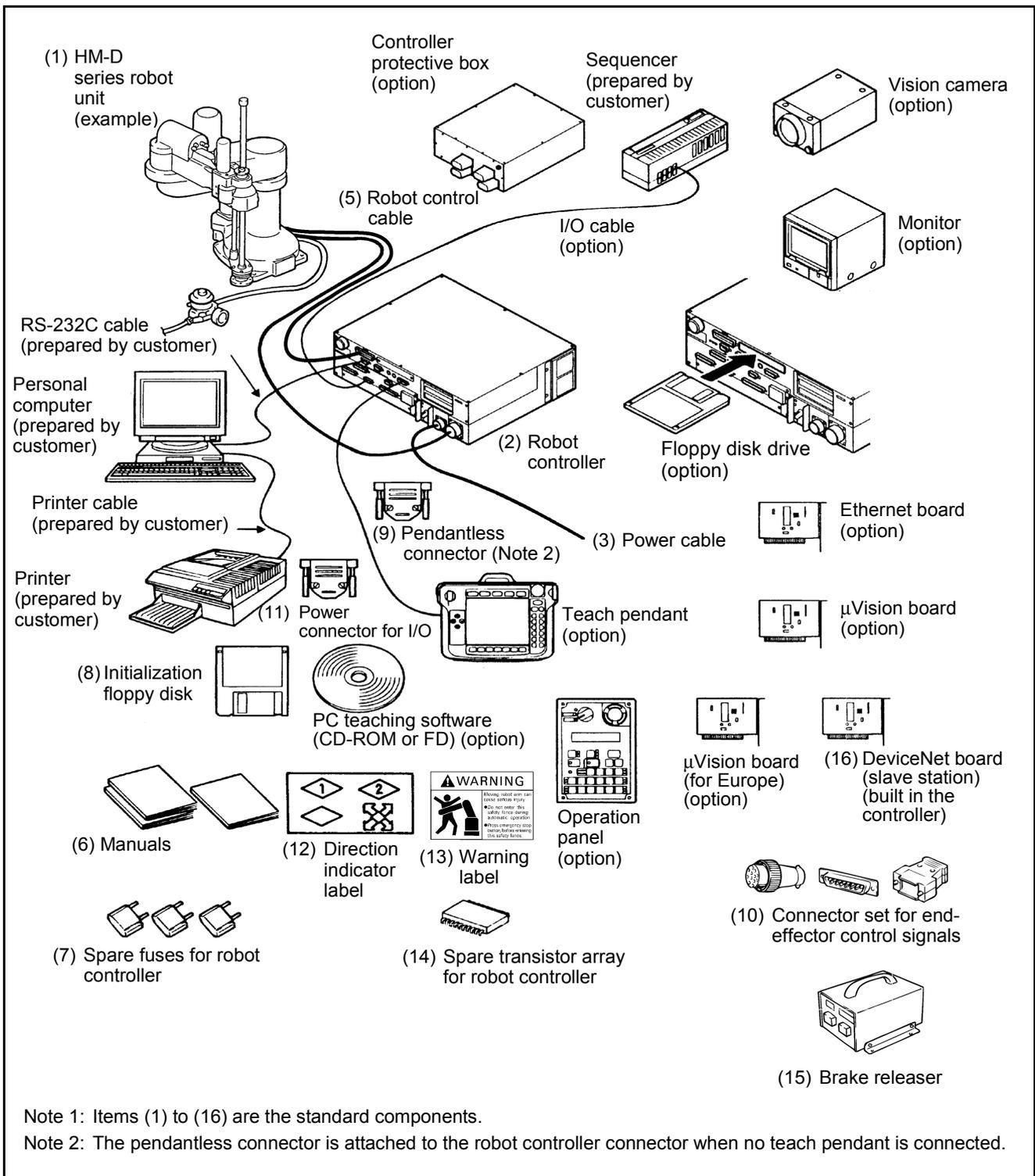
Robot System Configuration



1.1 Configurators

The figure below shows the entire configuration of the robot system.

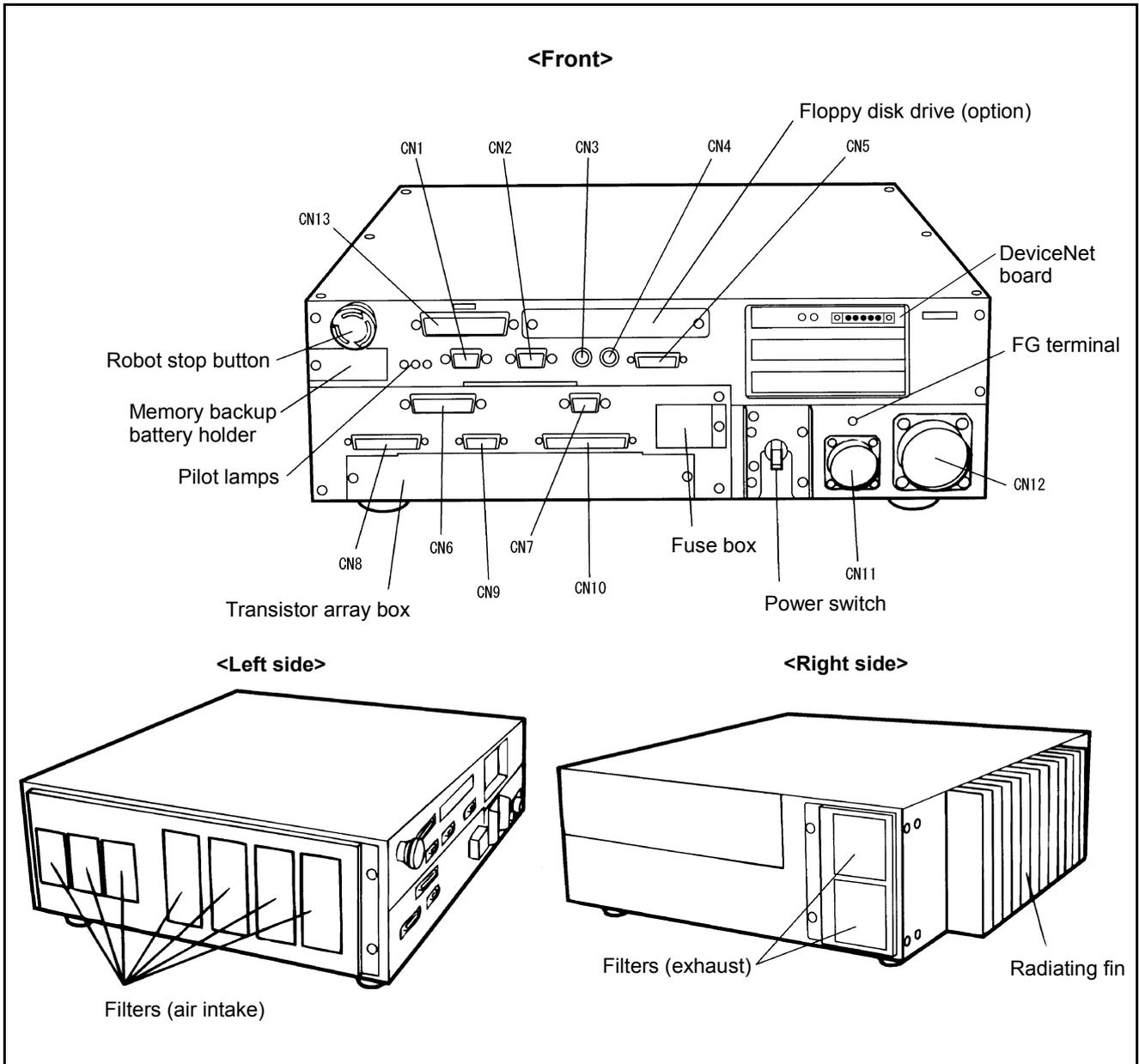
The robot system is equipped with a brake releaser and DeviceNet board as standard.



Configurators of the Robot System

1.2 Names of the Robot Controller Components

The figure below shows the names of the robot controller components.



Names of Robot Controller Components

Connector Names

| Connector No. | Marking | Name | Connector No. | Marking | Name |
|---------------|-----------|-----------------------------|---------------|----------|--|
| CN1 | RS232C | Serial interface connector | CN8 | INPUT | Connector for user input or system input |
| CN2 | CRT | CRT connector | CN9 | HAND I/O | Connector for end-effector I/O |
| CN3 | KEYBD | Keyboard connector | CN10 | OUTPUT | Connector for user output or system output |
| CN4 | MOUSE | Connector for PS/2 mouse | CN11 | INPUT AC | Power connector |
| CN5 | PENDANT | Connector for teach pendant | CN12 | MOTOR | Motor connector |
| CN6 | PRINTER | Printer connector | CN13 | ENCODER | Encoder connector |
| CN7 | I/O POWER | Power connector for I/O | | | |

1.3 Brake Releaser

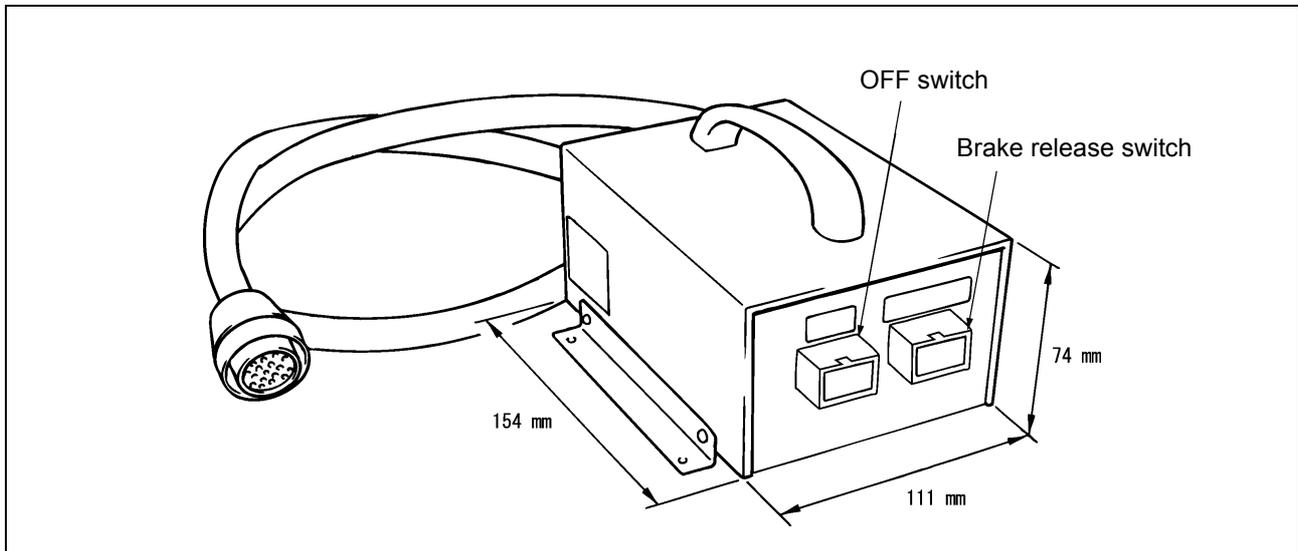
The brake releaser forces the brake of the "Horizontal articulated robot□HM/HS-D-T02" to release its Z axis, enabling you to move the Z-axis arm by hand.

[1] Specifications

The table below lists the specifications of the brake releaser and the figure below shows the external appearance.

Specifications of the Brake Releaser

| Item | Description |
|---|---|
| Model | BK4T |
| Power requirements | 24 VDC (Fed through the motor cable from the robot controller) |
| Access | Brake release switch and OFF switch |
| Environmental conditions | Temperature: 0 to 40°C Relative humidity: 90% or less without condensation |
| External dimensions (H × W × D) | 74 × 111 × 154 mm (excluding handle, rubber feet and cable) |
| Weight | Approx. 2 kg |
| Cable length | To the controller: 1 m |
| NOTE: This brake releaser is exclusively designed for the "Horizontal articulated robot HM/HS-D-T02." Never use it for any other models. | |



External Appearance of the Brake Releaser

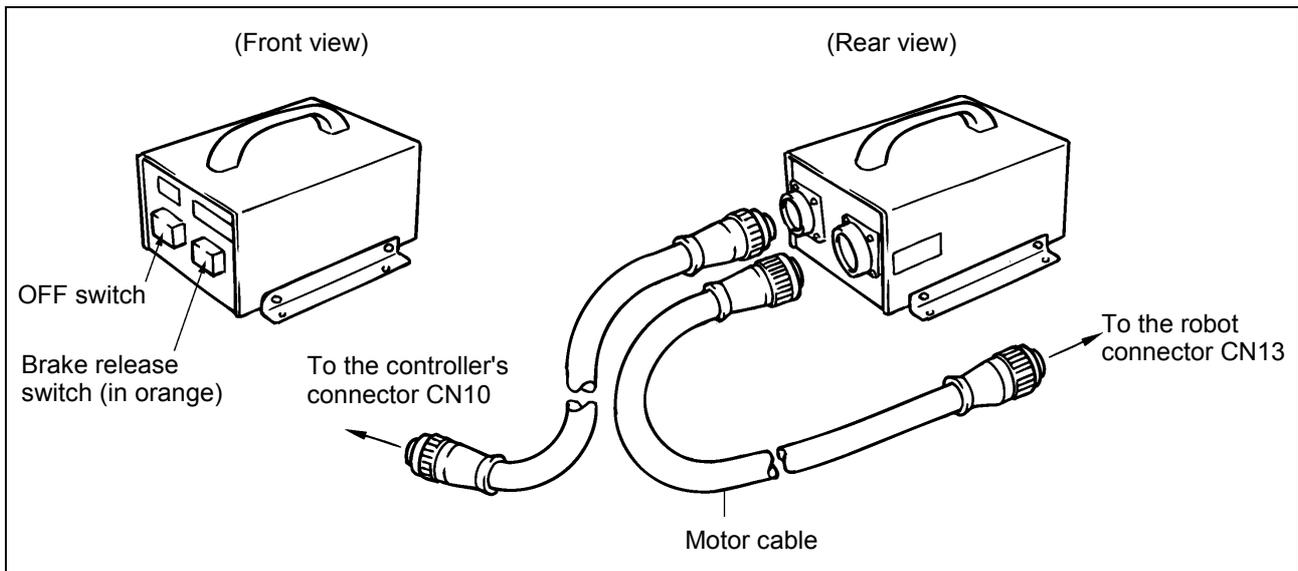
[2] Using the brake releaser

⚠ WARNING: Before releasing the brake, always check that there is no equipment which will interfere with the Z-axis arm and its tools within the working area of the Z-axis arm.

If you release the brake without adjusting the air balance for the Z-axis, the Z-axis arm may move up or down unexpectedly. It is **DANGEROUS**.

NOTE: If the motor is powered on, pressing the Brake release switch or OFF switch will have no effect since the controller ignores the brake releaser.

(1) Connect the brake releaser with the related equipment as shown below.



Connecting the Brake Releaser

(2) To release the Z-axis arm when braked (with the motor power OFF), press the Brake release switch. The orange lamp will come on and the Z-axis arm will be released.

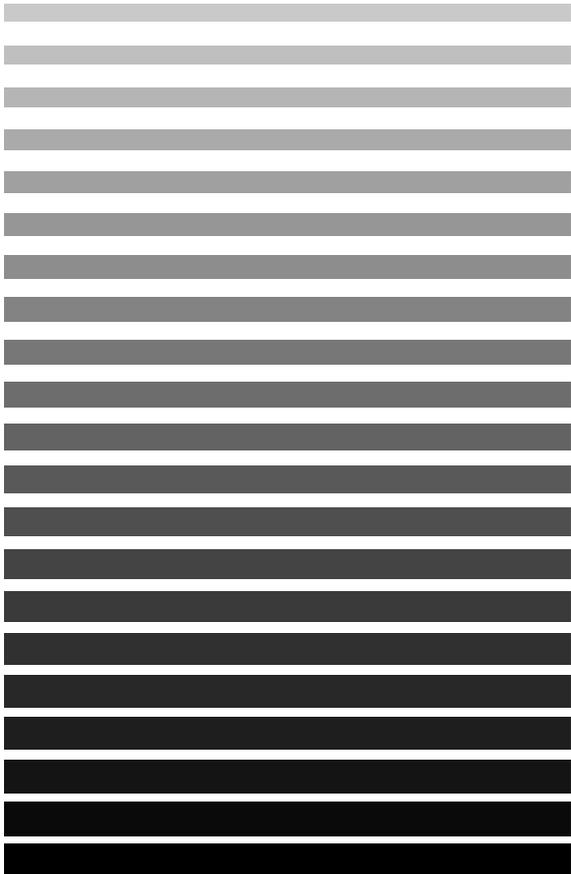
To apply brake to the Z-axis arm again, press the OFF switch. The orange lamp will go off.

(3) If you turn on the motor power when the Z-axis arm is not braked (when the orange lamp lights), the robot controller will ignore the switch status of the brake releaser and make the robot enter the normal operation mode. The orange lamp will go off.

Chapter 2



Signals Needed for Managing the Robot in Individual Mode



2.1 Individual Mode

[1] What is individual mode?

The individual mode is a mode where you may manage the robot with signals sent from external equipment (e.g., user-provided sequencer), without using the operating panel or teaching pendant.

[2] When is the individual mode needed?

Use this mode if you want to manage the robot with programs written in your external system controller connected with the robot system. In the individual mode, you may apply your programs to inching in the joint mode, X-Y mode, and tool mode, as well as to the single program step and single program cycle operation.

[3] Dedicated input signals and their functions

The table below lists the input signals exclusively used in the individual mode.

Input Signals and Their Functions

| Objectives | Signal names | Functions |
|--------------------------------|--|---|
| Starting up | <i>Teaching disable</i> | Enables the robot system to switch to the individual mode. |
| | <i>Switch to individual mode</i> + <i>Operation ready start</i> | Switches the robot system to the individual mode. |
| | <i>Power on motor</i> + <i>Operation ready start</i> | Powers on the motor. |
| Inching | <i>Enter joint mode</i> + <i>Select axis (+J1 to -J6)</i> | Inches the selected axis. |
| | <i>Enter X-Y mode</i> + <i>Inching direction (+X to -T)</i> | Inches the selected axis. |
| | <i>Enter tool mode</i> + <i>Tool moving direction (+TX to -TT)</i> | Inches the tool in the selected direction. |
| Single-step program operation | <i>Enter single-step mode</i> + <i>Step forwards</i> | Steps forwards. (You can choose any of your programs by instructing " <i>Select program number + Reset program</i> " for the step operation.) |
| | <i>Enter single-step mode</i> + <i>Step backwards</i> | Steps backwards. (You can choose any of your programs in the same way as above.) |
| Single-cycle program operation | <i>Enter single-cycle mode</i> + <i>Select program number</i> + <i>Start program</i> | Executes the first single cycle of the selected program. |

| Objectives | Signal names | Functions |
|---------------|--|---|
| Speed control | <i>Increase speed in individual mode</i> | Increases the current robot speed by 10 points per signal. (Max. 100 points) |
| | <i>Decrease speed in individual mode</i> | Decreases the current robot speed by 10 points per signal. (Min. 10 points) |
| Stop | <i>Robot stop</i> | Stops the robot by opening the signal line. |
| | <i>Cycle stop</i> | <i>Stops</i> the program cycle being executed, by opening the signal line. |
| | <i>Step stop</i> | <i>Stops</i> the program step being executed, by opening the signal line. |
| | <i>Halt</i> | Stops the operation being executed immediately and temporarily, by opening the signal line. |

[4] Dedicated output signals and their functions

The table below lists the output signals exclusively used in the individual mode.

Output Signals and Their Functions

| Objectives | Signal names | Functions |
|----------------------|--|--|
| Robot status signals | <i>Robot on halt</i> | Tells that the robot operation is interrupted in externally controlled automatic mode. |
| | <i>In individual mode</i> | Tells that the robot is in individual mode. |
| | <i>Speed setting (2⁰ to 2³) in individual mode</i> | Tells the current speed of the robot in individual mode by 10-point resolution. |
| | <i>In single-cycle mode</i> | Tells that the robot is in single-cycle program mode. |
| | <i>In single-step mode</i> | Tells that the robot is in single-step program mode. |
| | <i>In joint mode</i> | Tells that the robot is inching in joint mode. |
| | <i>In X-Y mode</i> | Tells that the robot is inching in X-Y mode. |
| | <i>In tool mode</i> | Tells that the robot is inching in tool mode. |

2.2 Individual Mode Signals

I/O signal assignments dedicated to the Individual Mode are shown below.

[1] DeviceNet input signals assignment

| Port | Signal names | Port | Signal names | Port | Signal names |
|------|------------------------------|------|---------------------------------------|------|--------------------------------|
| 512 | <i>Step stop (all tasks)</i> | 520 | <i>Select program number (Bit 0)</i> | 528 | <i>Power on motor</i> |
| 513 | Not used. | 521 | <i>Select program number (Bit 1)</i> | 529 | <i>Execute CAL</i> |
| 514 | <i>Halt (all tasks)</i> | 522 | <i>Select program number (Bit 2)</i> | 530 | Not used. |
| 515 | <i>Operation ready start</i> | 523 | <i>Select program number (Bit 3)</i> | 531 | <i>SP100</i> |
| 516 | <i>Skip interrupt</i> | 524 | <i>Select program number (Bit 4)</i> | 532 | <i>Switch to external mode</i> |
| 517 | <i>Start program</i> | 525 | <i>Select program number (Bit 5)</i> | 533 | <i>Reset program</i> |
| 518 | Not used. | 526 | <i>Select program number (Bit 6)</i> | 534 | <i>Clear robot error</i> |
| 519 | Not used. | 527 | <i>Select program number (Parity)</i> | 535 | Not used. |

| Port | Signal names | Port | Signal names | Port | Signal names |
|------|-------------------------------|------|---------------------------|------|--|
| 536 | <i>Select +J1 (X) inching</i> | 544 | <i>Select +J5 inching</i> | 552 | <i>Increase speed in individual mode</i> |
| 537 | <i>Select -J1 (X) inching</i> | 545 | <i>Select -J5 inching</i> | 553 | <i>Decrease speed in individual mode</i> |
| 538 | <i>Select +J2 (Y) inching</i> | 546 | <i>Select +J6 inching</i> | 554 | <i>Switch to individual mode</i> |
| 539 | <i>Select -J2 (Y) inching</i> | 547 | <i>Select -J6 inching</i> | 555 | <i>Enter single-cycle mode</i> |
| 540 | <i>Select +J3 (Z) inching</i> | 548 | <i>Step forwards</i> | 556 | <i>Enter single-step mode</i> |
| 541 | <i>Select -J3 (Z) inching</i> | 549 | <i>Step backwards</i> | 557 | <i>Enter joint mode</i> |
| 542 | <i>Select +J4 (T) inching</i> | 550 | Not used. | 558 | <i>Enter X-Y mode</i> |
| 543 | <i>Select -J4 (T) inching</i> | 551 | Not used. | 559 | <i>Enter tool mode</i> |

| Port | Signal names | Port | Signal names | Port | Signal names |
|------|--------------|------|--------------|------|--------------|
| 560 | USER-INPUT | 568 | USER-INPUT | 760 | USER-INPUT |
| 561 | USER-INPUT | . | . | 761 | USER-INPUT |
| 562 | USER-INPUT | . | . | 762 | USER-INPUT |
| 563 | USER-INPUT | . | . | 763 | USER-INPUT |
| 564 | USER-INPUT | . | . | 764 | USER-INPUT |
| 565 | USER-INPUT | . | . | 765 | USER-INPUT |
| 566 | USER-INPUT | . | . | 766 | USER-INPUT |
| 567 | USER-INPUT | 759 | USER-INPUT | 767 | USER-INPUT |

Note 1: The inverse notation $\overline{\quad}$ means negative truth logic.

Note 2: The input data is handled in bytes. Default is 64 points. Up to 256 points can be used.

[2] DeviceNet output signals assignment

| Port | Signal names | Port | Signal names | Port | Signal names |
|------|------------------------------------|------|-----------------------------------|------|--|
| 768 | Not used. | 776 | <i>Robot powering-on complete</i> | 784 | <i>Error code, unit, 2⁰</i> |
| 769 | <i>Robot running</i> | 777 | <i>Motor on</i> | 785 | <i>Error code, unit, 2¹</i> |
| 770 | <i>Robot alarm</i> | 778 | <i>CAL complete</i> | 786 | <i>Error code, unit, 2²</i> |
| 771 | <i>In automatic operation mode</i> | 779 | <i>In teaching</i> | 787 | <i>Error code, unit, 2³</i> |
| 772 | <i>In external mode</i> | 780 | <i>Single-cycle end</i> | 788 | <i>Error code, tens, 2⁰</i> |
| 773 | <i>Program start reset</i> | 781 | <i>Low battery warning</i> | 789 | <i>Error code, tens, 2¹</i> |
| 774 | Not used. | 782 | <i>Robot warning</i> | 790 | <i>Error code, tens, 2²</i> |
| 775 | Not used. | 783 | <i>Auto enable switching</i> | 791 | <i>Error code, tens, 2³</i> |

| Port | Signal names | Port | Signal names | Port | Signal names |
|------|--|------|--|------|----------------------|
| 792 | <i>Error code, hundreds, 2⁰</i> | 800 | <i>Robot on halt</i> | 808 | <i>In joint mode</i> |
| 793 | <i>Error code, hundreds, 2¹</i> | 801 | <i>In individual mode</i> | 809 | <i>In X-Y mode</i> |
| 794 | <i>Error code, hundreds, 2²</i> | 802 | <i>Speed in individual mode, tens, 2⁰</i> | 810 | <i>In tool mode</i> |
| 795 | <i>Error code, hundreds, 2³</i> | 803 | <i>Speed in individual mode, tens, 2¹</i> | 811 | Not used. |
| 796 | Not used. | 804 | <i>Speed in individual mode, tens, 2²</i> | 812 | Not used. |
| 797 | Not used. | 805 | <i>Speed in individual mode, tens, 2³</i> | 813 | Not used. |
| 798 | Not used. | 806 | <i>In single-cycle mode</i> | 814 | Not used. |
| 799 | Not used. | 807 | <i>In single-step mode</i> | 815 | Not used. |

| Port | Signal names | Port | Signal names | Port | Signal names |
|------|--------------|------|--------------|------|--------------|
| 816 | USER-OUTPUT | 824 | USER-OUTPUT | 1016 | USER-OUTPUT |
| 817 | USER-OUTPUT | . | . | 1017 | USER-OUTPUT |
| 818 | USER-OUTPUT | . | . | 1018 | USER-OUTPUT |
| 819 | USER-OUTPUT | . | . | 1019 | USER-OUTPUT |
| 820 | USER-OUTPUT | . | . | 1020 | USER-OUTPUT |
| 821 | USER-OUTPUT | . | . | 1021 | USER-OUTPUT |
| 822 | USER-OUTPUT | . | . | 1022 | USER-OUTPUT |
| 823 | USER-OUTPUT | 1015 | USER-OUTPUT | 1023 | USER-OUTPUT |

Note 1: The inverse notation $\bar{}$ means negative truth logic.

Note 2: The input data is handled in bytes. Default is 64 points. Up to 256 points can be used.

[3] Parallel user-/system-input signals assignment on CN8

| Pin No. | Signal names | Port No. | Pin No. | Signal names | Port No. |
|---------|-----------------------------------|----------|---------|--------------|----------|
| 1 | <i>Power for robot stop</i> | - | 26 | USER-INPUT | 21 |
| 2 | <i>Robot on halt</i> | - | 27 | USER-INPUT | 22 |
| 3 | <i>Power for teaching disable</i> | - | 28 | USER-INPUT | 23 |
| 4 | <i>Teaching disable</i> | - | 29 | USER-INPUT | 24 |
| 5 | Not used. | 0 | 30 | USER-INPUT | 25 |
| 6 | Not used. | 1 | 31 | USER-INPUT | 26 |
| 7 | Not used. | 2 | 32 | USER-INPUT | 27 |
| 8 | Not used. | 3 | 33 | USER-INPUT | 28 |
| 9 | Not used. | 4 | 34 | USER-INPUT | 29 |
| 10 | Not used. | 5 | 35 | USER-INPUT | 30 |
| 11 | Not used. | 6 | 36 | USER-INPUT | 31 |
| 12 | Not used. | 7 | 37 | USER-INPUT | 32 |
| 13 | Not used. | 8 | 38 | USER-INPUT | 33 |
| 14 | Not used. | 9 | 39 | USER-INPUT | 34 |
| 15 | Not used. | 10 | 40 | USER-INPUT | 35 |
| 16 | Not used. | 11 | 41 | USER-INPUT | 36 |
| 17 | Not used. | 12 | 42 | USER-INPUT | 37 |
| 18 | Not used. | 13 | 43 | USER-INPUT | 38 |
| 19 | Not used. | 14 | 44 | USER-INPUT | 39 |
| 20 | Not used. | 15 | 45 | USER-INPUT | 40 |
| 21 | Not used. | 16 | 46 | USER-INPUT | 41 |
| 22 | Not used. | 17 | 47 | USER-INPUT | 42 |
| 23 | Not used. | 18 | 48 | USER-INPUT | 43 |
| 24 | Not used. | 19 | 49 | USER-INPUT | 44 |
| 25 | Not used. | 20 | 50 | USER-INPUT | 45 |

Note 1: The inverse notation $\bar{\quad}$ means negative truth logic.

Note 2: *Auto enable* signal used for standard robots is changed to *Teaching disable*. For details, refer to "2.3.1 Teaching disable (input)."

[4] Parallel output signals assignment on CN10

| Pin No. | Signal names | Port No. | Pin No. | Signal names | Port No. |
|---------|-------------------|----------|---------|-------------------------|----------|
| 1 | <i>CPU normal</i> | 72 | 35 | USER-OUTPUT | 106 |
| 2 | Not used. | 73 | 36 | USER-OUTPUT | 107 |
| 3 | Not used. | 74 | 37 | USER-OUTPUT | 108 |
| 4 | Not used. | 75 | 38 | USER-OUTPUT | 109 |
| 5 | Not used. | 76 | 39 | USER-OUTPUT | 110 |
| 6 | Not used. | 77 | 40 | USER-OUTPUT | 111 |
| 7 | Not used. | 78 | 41 | USER-OUTPUT | 112 |
| 8 | Not used. | 79 | 42 | USER-OUTPUT | 113 |
| 9 | Not used. | 80 | 43 | USER-OUTPUT | 114 |
| 10 | Not used. | 81 | 44 | USER-OUTPUT | 115 |
| 11 | Not used. | 82 | 45 | USER-OUTPUT | 116 |
| 12 | Not used. | 83 | 46 | USER-OUTPUT | 117 |
| 13 | Not used. | 84 | 47 | USER-OUTPUT | 118 |
| 14 | Not used. | 85 | 48 | USER-OUTPUT | 119 |
| 15 | Not used. | 86 | 49 | USER-OUTPUT | 120 |
| 16 | Not used. | 87 | 50 | USER-OUTPUT | 121 |
| 17 | Not used. | 88 | 51 | USER-OUTPUT | 122 |
| 18 | Not used. | 89 | 52 | USER-OUTPUT | 123 |
| 19 | Not used. | 90 | 53 | USER-OUTPUT | 124 |
| 20 | Not used. | 91 | 54 | USER-OUTPUT | 125 |
| 21 | Not used. | 92 | 55 | USER-OUTPUT | 126 |
| 22 | Not used. | 93 | 56 | USER-OUTPUT | 127 |
| 23 | Not used. | 94 | 57 | Not used. | - |
| 24 | Not used. | 95 | 58 | Not used. | - |
| 25 | Not used. | 96 | 59 | Not used. | - |
| 26 | Not used. | 97 | 60 | Not used. | - |
| 27 | Not used. | 98 | 61 | Not used. | - |
| 28 | Not used. | 99 | 62 | Not used. | - |
| 29 | Not used. | 100 | 63 | Not used. | - |
| 30 | Not used. | 101 | 64 | Not used. | - |
| 31 | Not used. | 102 | 65 | Emergency stop (+) | - |
| 32 | Not used. | 103 | 66 | Emergency stop (-) | - |
| 33 | USER-OUTPUT | 104 | 67 | Deadman switch (output) | - |
| 34 | USER-OUTPUT | 105 | 68 | Deadman switch (output) | - |

Note 1: The inverse notation $\bar{\quad}$ means negative truth logic.

[5] Hand I/O signals assignment on CN9

| Pin No. | Signal names | Port No. | Pin No. | Signal names | Port No. |
|---------|--------------|----------|---------|---------------------|----------|
| 1 | Hand output | 64 | 11 | Hand input | 50 |
| 2 | Hand output | 65 | 12 | Hand input | 51 |
| 3 | Hand output | 66 | 13 | Hand input | 52 |
| 4 | Hand output | 67 | 14 | Hand input | 53 |
| 5 | Hand output | 68 | 15 | Hand input | 54 |
| 6 | Hand output | 69 | 16 | Hand input | 55 |
| 7 | Hand output | 70 | 17 | Power E24V for hand | - |
| 8 | Hand output | 71 | 18 | Power E0V for hand | - |
| 9 | Hand input | 48 | 19 | NC | - |
| 10 | Hand input | 49 | 20 | NC | - |

[6] I/O power signals assignment on CN7

| Pin No. | Signal names |
|---------|----------------------------|
| 1 | Internal power output +24V |
| 2 | Internal power output +24V |
| 3 | Internal power output +24V |
| 4 | Internal power output +24V |
| 5 | Frame ground |
| 6 | Power input E24V |
| 7 | Power input E24V |
| 8 | Power input E0V |
| 9 | Power input E0V |

Note: You may select internal or external power sources for input and output circuits.

2.3 Application of Dedicated Input Signals

This section describes the input signals relating to the individual mode.

2.3.1 *Teaching disable* (input)

■ Function

- (1) Turning this signal line ON (closed) makes the robot ready to switch to the automatic mode or individual mode.
- (2) Turning this signal line OFF (open) makes the robot ready to switch to the manual mode or teaching-check mode.

■ Pin No.

No. 4 on connector CN8

■ Application

- (1) You use this signal to switch the robot operation mode to the automatic mode, individual mode, manual mode, or teaching-check mode.
- (2) You may AND-gate this signal with signals sent from the safety fence.

■ Signal operation and conditions

- (1) As listed below, the available operation modes will be limited according to this signal status (open or closed).
- (2) If this signal line changes from ON (closed) to OFF (open) when the robot is in operation, the robot controller stops the current operation and goes out of the current individual mode.
- (3) If this signal line changes from OFF (open) to ON (closed) when the robot is in operation, the robot controller stops the current operation and goes out of the current individual mode and displays error code ERROR21FC.

Relationship between the *Teaching Disable* Input and the Operation Modes

| Operation mode | Description | <i>Teaching disable</i> input status | |
|-------------------------|--|--------------------------------------|------------|
| | | ON (closed) | OFF (open) |
| Manual mode | Allows you to operate the robot manually from the operating panel or teaching pendant. | NA | A |
| Teaching-check mode | Allows you to check the programmed running with the teaching pendant. | NA | A |
| Individual mode | Allows you to operate the robot manually, check the running program, or run the robot in automatic mode from the external equipment. | A | NA |
| Internal automatic mode | Allows you to run the robot in the automatic mode from the operating panel or teaching pendant. | A | NA |
| External automatic mode | Allows you to run the robot in the automatic mode from the external equipment. | A | NA |

A: Available, NA: Not available

2.3.2 *Switch to individual mode (input)*

■ **Function**

- (1) Turning this signal line ON (closed) makes the robot ready to switch to the individual mode.
- (2) Turning this signal line OFF (open) makes the robot ready to switch to the automatic mode.

■ **Port address**

554

■ **Application**

You use this signal to switch the robot operation mode to the automatic mode or individual mode.

■ **Signal operation and conditions**

- (1) As listed below, opening or closing this signal line limits the available operation modes.
- (2) You can use this signal line effectively only if the *Teaching disable* signal line is ON (closed). If OFF (open), this signal line does not go into effect.
- (3) If this signal line changes from ON (closed) to OFF (open) when the robot is in operation, the robot controller stops the current operation and goes out of the current individual mode and displays error code ERROR1997.
- (4) If this signal line changes from OFF (open) to ON (closed) when the robot is in operation, the robot controller stops the current operation and goes out of the current individual mode and displays error code ERROR1998.

Relationship between the *Teaching Disable* Input and the Operation Modes

| Operation mode | Description | <i>Switch to individual mode</i> input status | |
|-------------------------|--|---|------------|
| | | ON (closed) | OFF (open) |
| Individual mode | Allows you to operate the robot manually, check the running program, or run the robot in automatic mode from the external equipment. | A | NA |
| Internal automatic mode | Allows you to run the robot in the automatic mode from the operating panel or teaching pendant. | NA | A |
| External automatic mode | Allows you to run the robot in the automatic mode from the external equipment. | NA | A |

A: Available, NA: Not available

2.3.3 Operation ready start (input)

■ Function

Turning this signal line ON (closed) allows the robot controller to detect signals shown in the figure below and switch the robot to the individual mode.

■ Port address

515

■ Application

Before turning on *Operation ready start* signal line, turn the following signal lines ON (closed):

(1) *Teaching disable* signal (input)

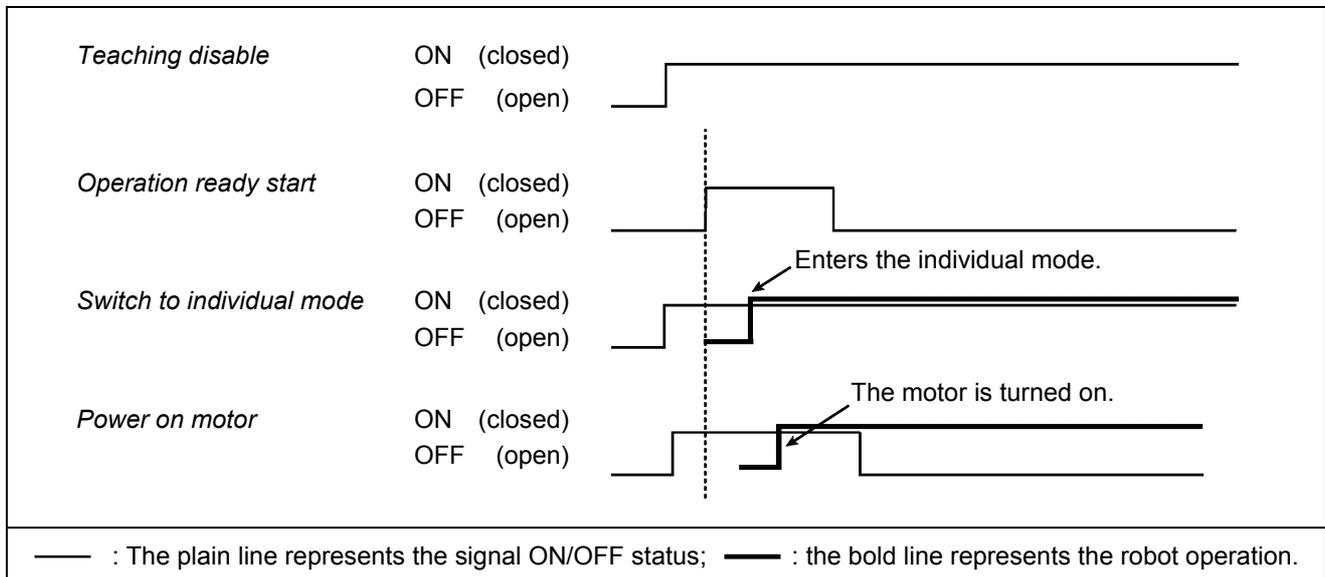
If this signal is OFF (open), the robot controller cannot enter the individual mode.

(2) *Switch to individual mode* signal (input)

If this signal is OFF (open), the robot controller cannot enter the individual mode.

NOTE: If *Switch to individual mode* signal is OFF (open) in powering-on sequence, the robot may start in the default automatic mode. (Refer to the INSTALLATION & MAINTENANCE GUIDE, P. 5-76.)

The figure below shows the input timing scheme of these signals.



2.3.4 *Select axis, +J1 to –J6 (input)*

■ **Function**

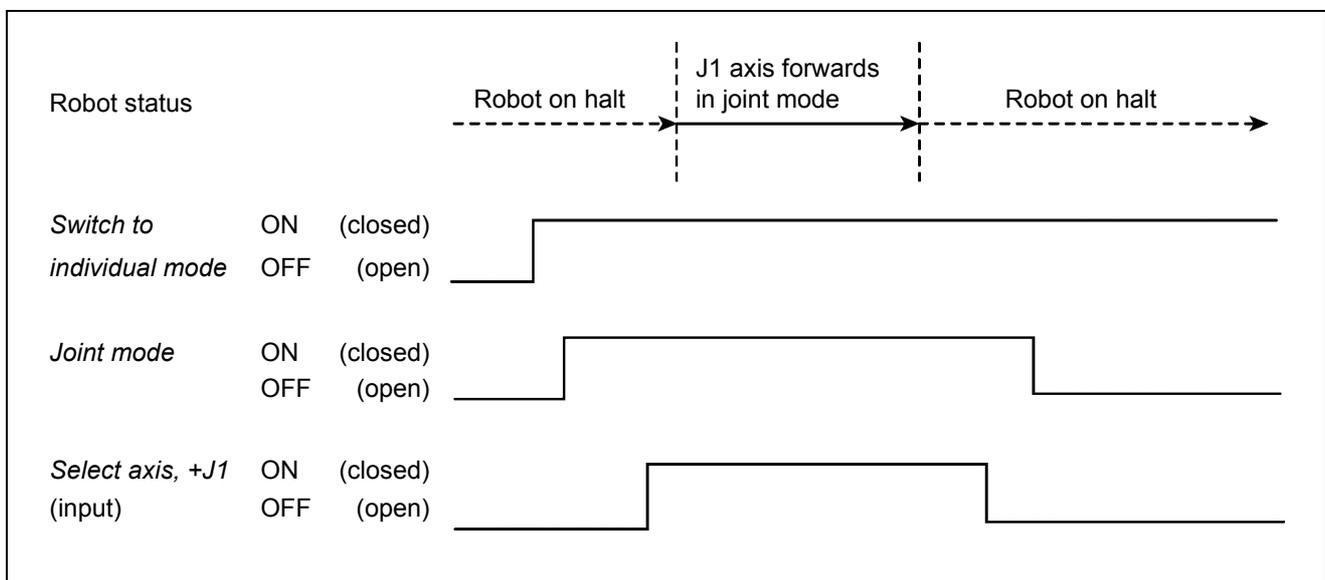
Each of these signals manually inches the robot in joint mode, X-Y mode or tool mode from the external control panel.

■ **Port address**

536 to 547

■ **Application**

In the individual mode, turning this signal ON (closed) inches the corresponding axis, provided that any of the inching signals (in the joint mode, X-Y mode, or tool mode) should be turned ON (closed).



Inching Signals

2.3.5 *Step forwards* (input) *Step backwards* (input)

■ Function

Step forwards or *Step backwards* signal runs the robot by a single step of the currently pointed program or by the immediately preceding program step, respectively.

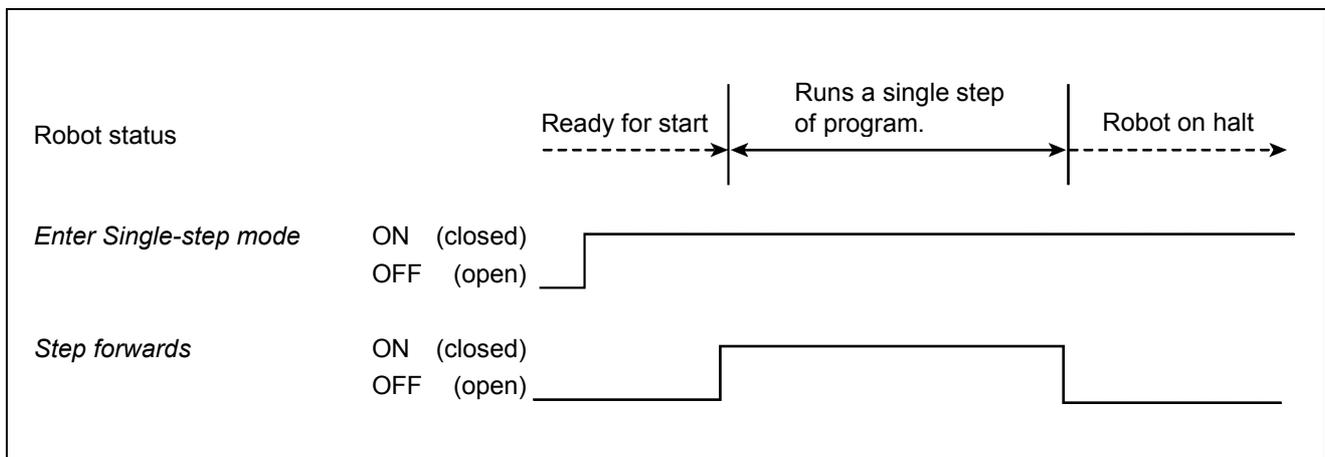
■ Port address

548

■ Application

- (1) Turning *Step forwards* or *Step backwards* signal ON (closed) in the individual mode executes a single step of the currently selected program or the immediately preceding program step, respectively.
- (2) Even if the robot is in midway of the execution of the single step, opening the signal line immediately stops the robot.
- (3) To make these signals effective, Enter *single-step mode* signal should be ON (closed) beforehand.

Shown below is an example of the timing scheme between these lines.



Step Forwards (Backwards) Signal Lines

NOTE 1: If *Step forwards* signal remains ON (closed), the robot can not start to run the next step. It is needed to switch the signal OFF and ON for the next step.

NOTE 2: If an ERROR2031 error (program number not selected) occurs, make the robot enter the individual mode again, select the program number, close the program reset line, and then turn on *Step forwards* or *Step backwards* signal.

NOTE 3: If any program is selected when the "END" line of a program is executed after repetition of *Step forwards* signals, the robot runs from the beginning of the selected program.

2.3.6 *Increase speed in individual mode (input)* *Decrease speed in individual mode (input)*

■ Function

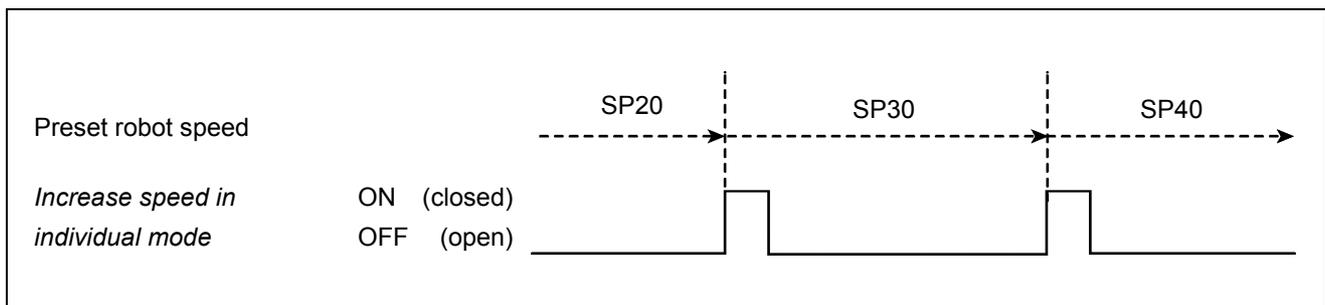
Increase speed in individual mode or *Decrease speed in individual mode* signal increases or decreases the current robot speed manually from the external equipment, respectively.

■ Port address

552 and 553

■ Application

- (1) Turning *Increase speed in individual mode* (*Decrease speed in individual mode*) signal ON (closed) and OFF (open) in the individual mode increases (decreases) the current robot speed by 10 points.
- (2) The speed change range is from 10 to 100 points in 10 point increments.
- (3) SP100 in the individual mode is equivalent to SP10 in the automatic mode.
- (4) To make these signals effective, all of the mode selection signal lines should be OFF (open) beforehand.



Increasing Preset Robot Speed in Individual Mode

2.3.7 *Select program number (input)*

■ Function

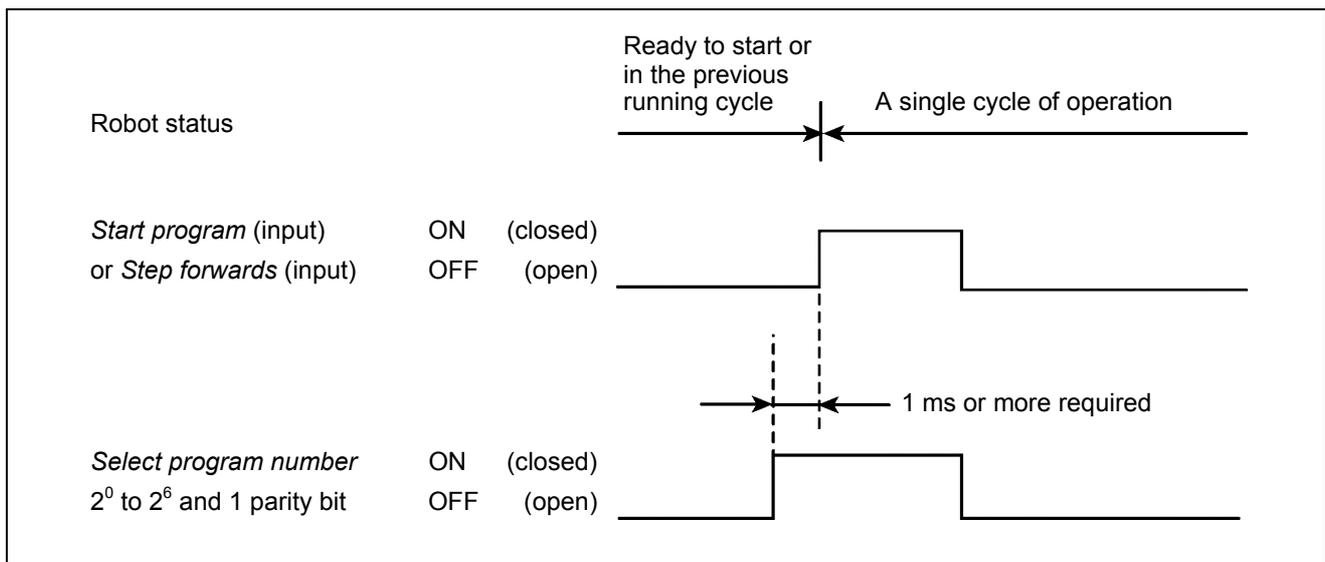
Allows you to choose a program to be run from the external equipment.

■ Port address

520 to 527

■ Application

- (1) As shown in the INSTALLATION & MAINTENANCE GUIDE, Table 5-13 on P. 5-79, the program number is defined by 8 bits of 2^0 to 2^6 plus a parity bit.
- (2) You should interpret a program number in decimal notation as that in binary notation for entering the program number.
- (3) Closing the signal line yields a binary value "1": opening it yields "0." The parity is odd.
- (4) As shown below, you should enter a program number before at least 1 ms from the start of program (or entry of *Step forwards* signal) and keep the signal status until the robot controller starts the robot. Otherwise, ERROR2033 (parity error in the program number) occurs and the robot no longer runs.



Select program number Signal

2.3.8 Start program (input)

■ **Function**

Starts the program from the external equipment.

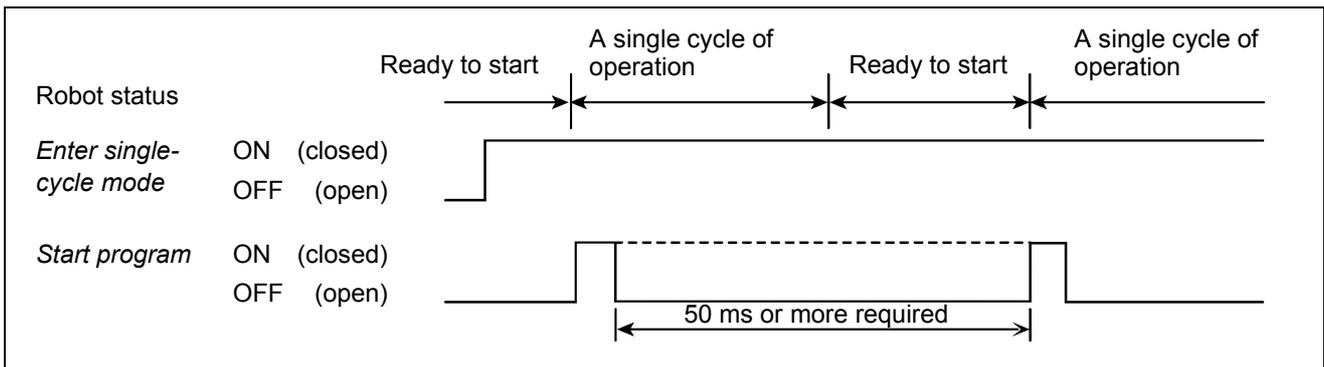
■ **Port address**

517

■ **Application**

In the individual mode, turning this signal line from OFF (open) to ON (closed) with *Enter single-cycle mode* signal being ON will control the robot in any of the following four manners (① through ④) depending upon the current robot status. It is mandatory to change this signal line from OFF to ON once.

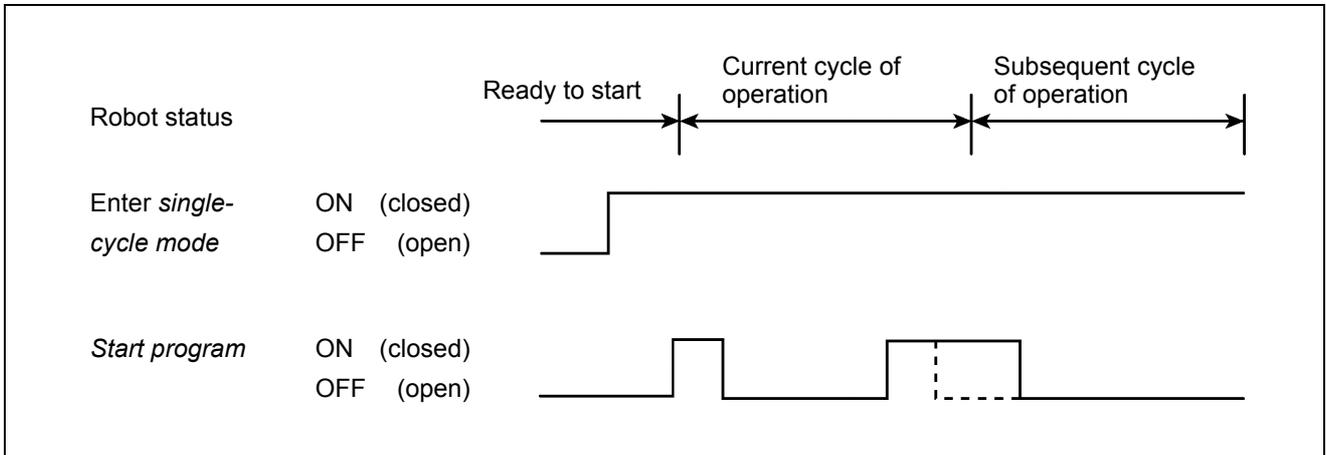
- ① If you turn *Start program* signal ON when the robot is ready to start or on halt after execution of a single cycle of program, the robot controller reads a program number preset by *Select program number* signal, executes the program by one cycle, then stops.



Operation ① by Start program Signal

NOTE: If *Start program* signal remains ON as shown by a dotted line, the subsequent cycle will not run. You need to turn this signal OFF and then ON for every running cycle.

- ② If you turn *Start program* signal from OFF to ON in the current execution cycle and keep it ON at the start of the subsequent cycle, the robot controller executes the subsequent cycle immediately following the current cycle. As in operation ①, this requires a new program number preset by *Select program number* signal.



Operation ② by *Start program* Signal

NOTE 1: In both of operations ① and ②, you should enter *Select program number* signal at least 1 ms before turning *Start program* signal ON. If the program number entry delays, the robot controller detects an abnormal state, displays error code ERROR2033 (Parity error for imported program selection) on the operating panel or the teaching pendant, and then stops the robot.

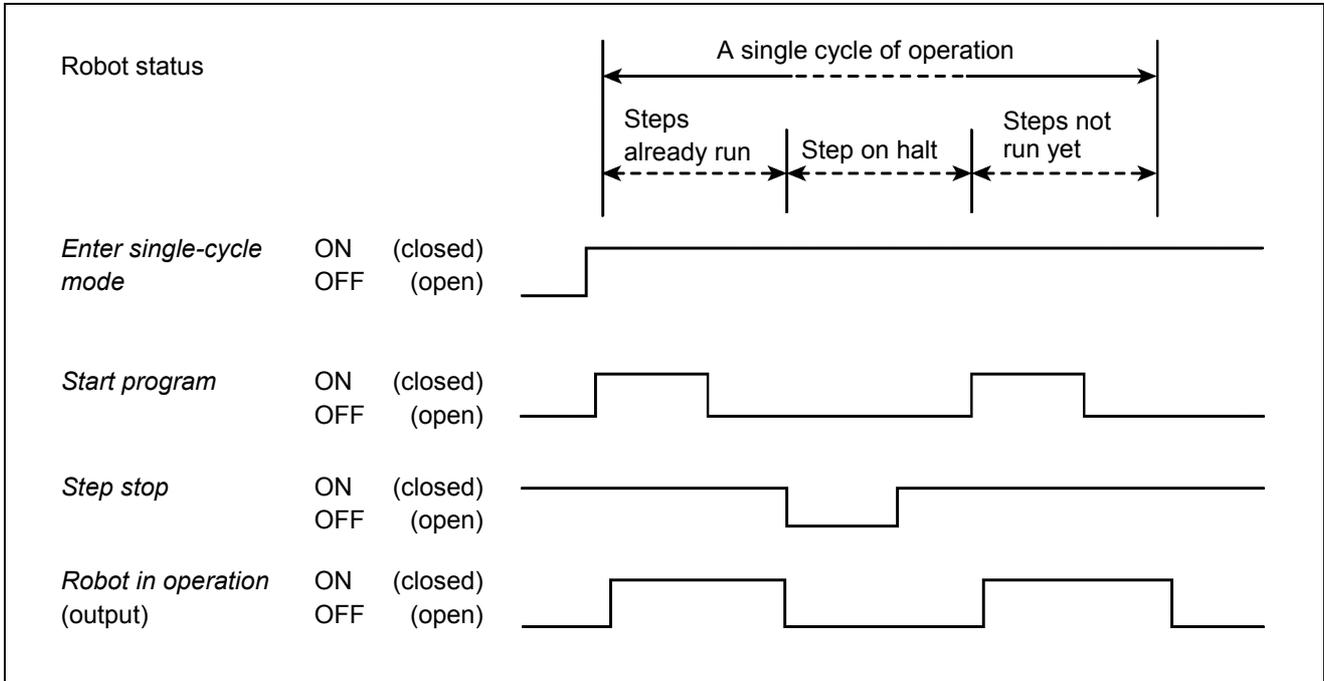
To prevent this type of error, the circuitry for outputting *Start program* signal should include an AND-gate in your sequencer to check that the program number entry has been ready so that *Start program* signal will follow *Select program number* signal. For details, refer to the INSTALLATION & MAINTENANCE GUIDE, Subsection 5.5.4.3 “Program No. Select (INPUT)” on P. 5-78.

NOTE 2: *Start program* signal should be kept ON until the start of the subsequent cycle. If the signal is OFF at the start time of the subsequent cycle as shown above by a dotted line, the subsequent cycle will not start. *Select program number* signal should also be kept ON until the start of the subsequent cycle.

Chapter 2 Signals Needed for Managing the Robot in Individual Mode

- ③ If you turn *Start program* signal from OFF to ON when the robot is on halt due to *Step stop* signal given during execution of program, the robot controller restarts the program from the Halt following the current on-halt step and then stops upon execution of the end step.

In this operation, no *Select program number* signal is required. If you enter any program number different from the current one, it will be ignored.

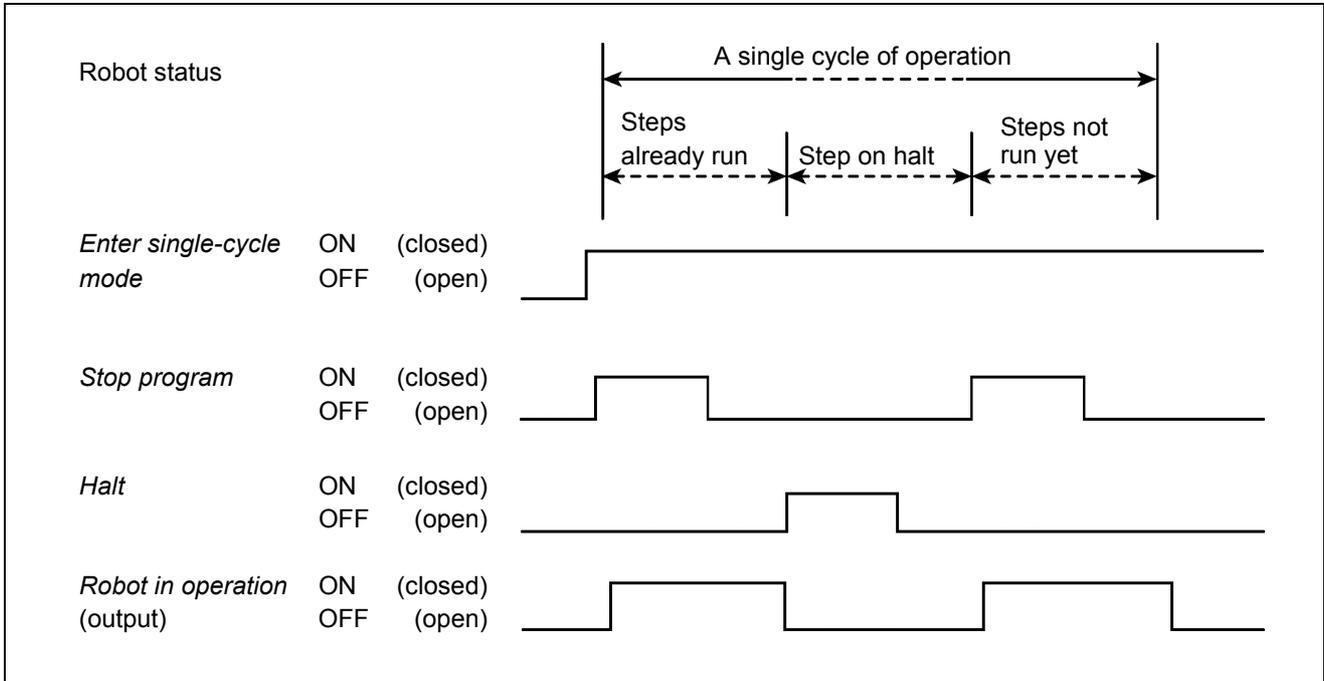


Operation ③ by *Start program* Signal

NOTE: If you want to quit steps following the on-halt step and start an arbitrary program from the first step, enter *Reset program*, *Select program number*, and *Start program* signals. For details, refer to the INSTALLATION & MAINTENANCE GUIDE, Subsection 5.5.4.5 "Program Reset (INPUT)" on P. 5-87.

- ④ If you turn *Start program* signal from OFF to ON when the robot is on halt due to *Halt* signal given during execution of program, the robot controller restarts the program from the step immediately following the current on-halt step and then stops upon execution of the end step.

In this operation, no *Select program number* signal is required. If you enter any program number different from the current one, it will be ignored.



Operation ④ by *Start program* Signal

NOTE: If you want to quit steps following the on-halt step and start an arbitrary program from the first step, enter *Reset program*, *Select program number*, and *Start program* signals. For details, refer to the INSTALLATION & MAINTENANCE GUIDE, Subsection 5.5.4.5 "Program Reset (INPUT)" on P. 5-87.

2.4 Application of Dedicated Output Signals

This section describes the output signals relating to the individual mode.

2.4.1 Robot on halt (output)

■ **Function**

Tells the external equipment that the robot is on halt.

■ **Port address**

800

■ **Application**

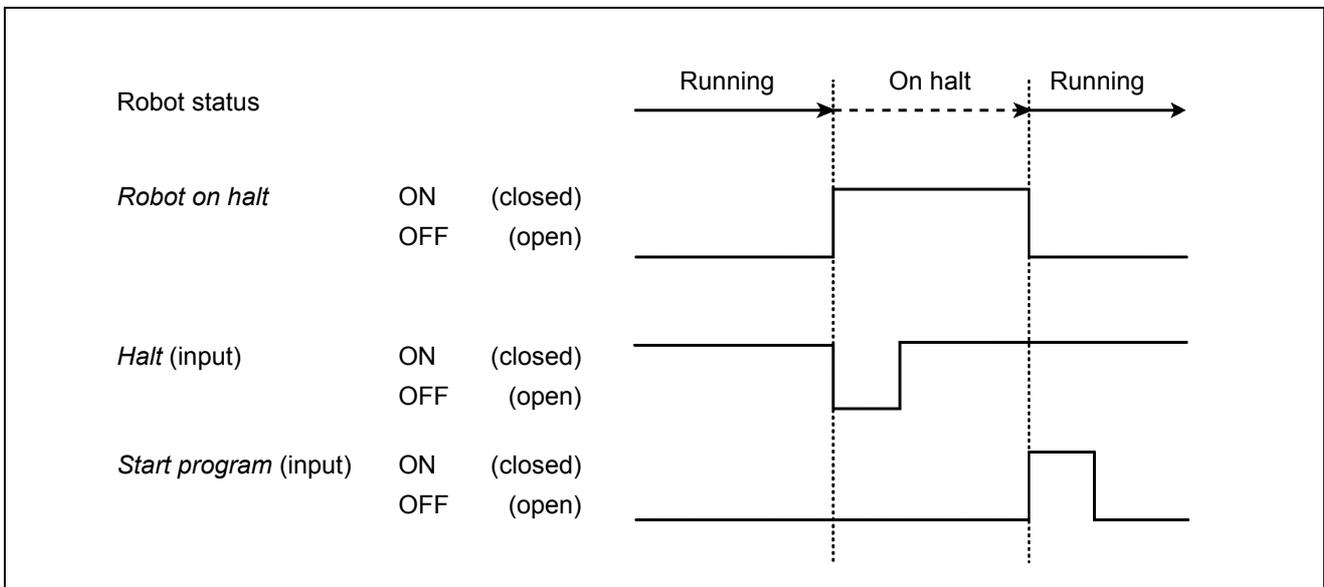
You use this signal to tell the external equipment that the robot is on halt and ready to start.

■ **Comes ON when:**

The robot stops since the running program is interrupted by some signals such as *Halt*.

■ **Goes OFF when:**

The robot restarts, the current mode is changed, or the current program number is changed.



Timing Scheme of Robot on halt Signal

2.4.2 Robot individual mode (output)

■ Function

Tells the external equipment that the robot is in the individual mode.

■ Port address

801

■ Application

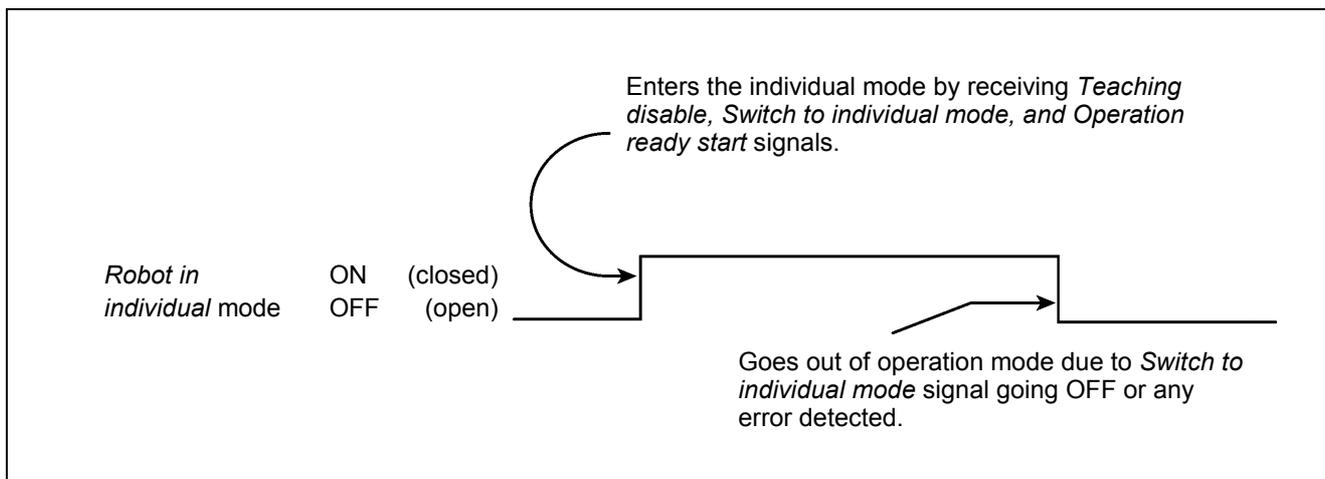
You use this signal to tell the external equipment that the robot is in the individual mode.

■ Comes ON when:

The robot enters the individual mode by receiving *Teaching disable*, *Switch to individual mode*, and *Operation ready start* input signals.

■ Goes OFF when:

The robot goes out of the current individual mode due to *Switch to individual mode* signal going OFF or any error detected.



Timing Scheme of *Robot in individual mode* Signal

2.4.3 Speed in individual mode, tens, 2^0 to 2^3 (output)

■ Function

Tells the external equipment the current speed preset in the individual mode.

■ Port address

802 to 805

■ Application

You use these signals to tell the external equipment the current speed preset in the robot controller.

■ Comes ON when:

The current speed is preset in the controller. These signal lines post the current speed in increments of 10 points as listed below.

Relationship between the Robot Speed and their Signal Values

| SP (%) | Speed in the individual mode (output) | | | |
|--------|---------------------------------------|-------|-------|-------|
| | 2^3 | 2^2 | 2^1 | 2^0 |
| 10 | 0 | 0 | 0 | 1 |
| 20 | 0 | 0 | 1 | 0 |
| 30 | 0 | 0 | 1 | 1 |
| 40 | 0 | 1 | 0 | 0 |
| 50 | 0 | 1 | 0 | 1 |
| 60 | 0 | 1 | 1 | 0 |
| 70 | 0 | 1 | 1 | 1 |
| 80 | 1 | 0 | 0 | 0 |
| 90 | 1 | 0 | 0 | 1 |
| 100 | 1 | 0 | 1 | 0 |

NOTE: "1" denotes ON (binary value 1).

■ Goes OFF when:

The robot goes out of the individual mode.

When the speed (SP) is set at 50, these four signal lines are as shown below.

Speed in individual mode, tens, 2^0

Speed in individual mode, tens, 2^1

Speed in individual mode, tens, 2^2

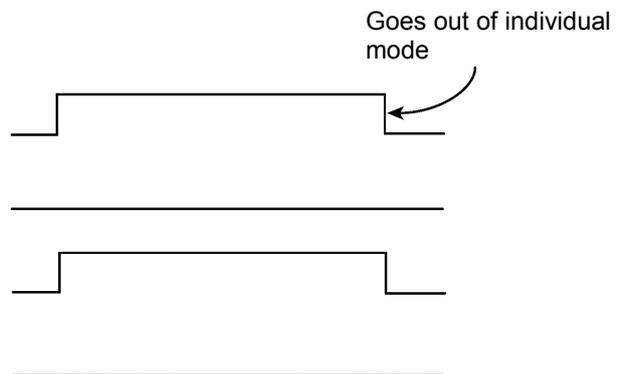
Speed in individual mode, tens, 2^3

ON (closed)
OFF (open)

ON (closed)
OFF (open)

ON (closed)
OFF (open)

ON (closed)
OFF (open)



Speed Expressed by Speed in individual mode Signals

2.4.4 *In single-cycle mode (output)*

■ Function

Tells the external equipment that the robot is in the single-cycle program mode.

■ Port address

806

■ Application

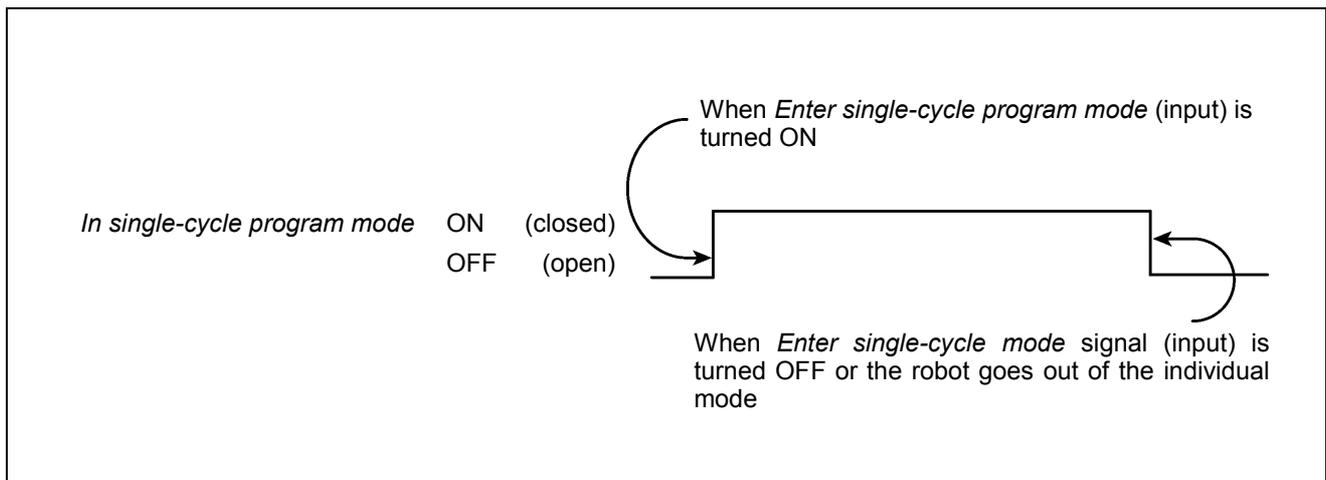
You use this signal to tell the external equipment that the robot in the individual mode enters the single-cycle program mode.

■ Comes ON when:

The robot enters the single-cycle program mode by receiving *Enter the single-cycle mode* signal (input) in the individual mode.

■ Goes OFF when:

The robot goes out of the single-cycle program mode or individual mode.



In single-cycle mode Signal

2.4.5 *In single-step mode (output)*

■ **Function**

Tells the external equipment that the robot is in the single-step program mode.

■ **Port address**

807

■ **Application**

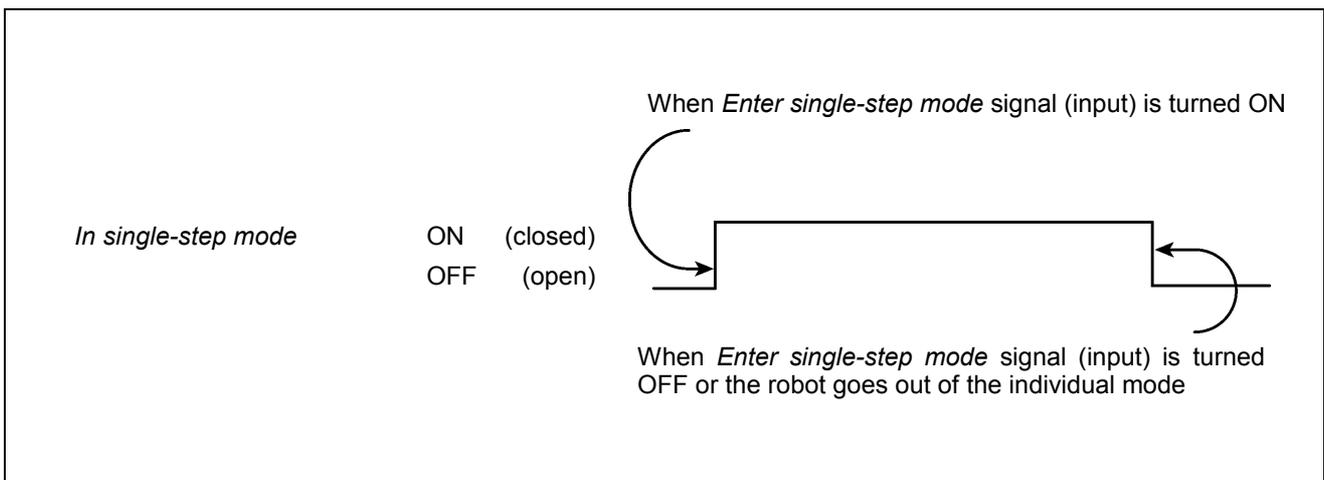
You use this signal to tell the external equipment that the robot in the individual mode enters the single-step program mode.

■ **Comes ON when:**

The robot enters the single-step program mode by receiving *Enter single step mode* signal (input) in the individual mode.

■ **Goes OFF when:**

The robot goes out of the single-step program mode or individual mode.



***In single-step mode* Signal**

2.4.6 In joint mode (output)

■ Function

Tells the external equipment that the robot is in the joint mode.

■ Port address

808

■ Application

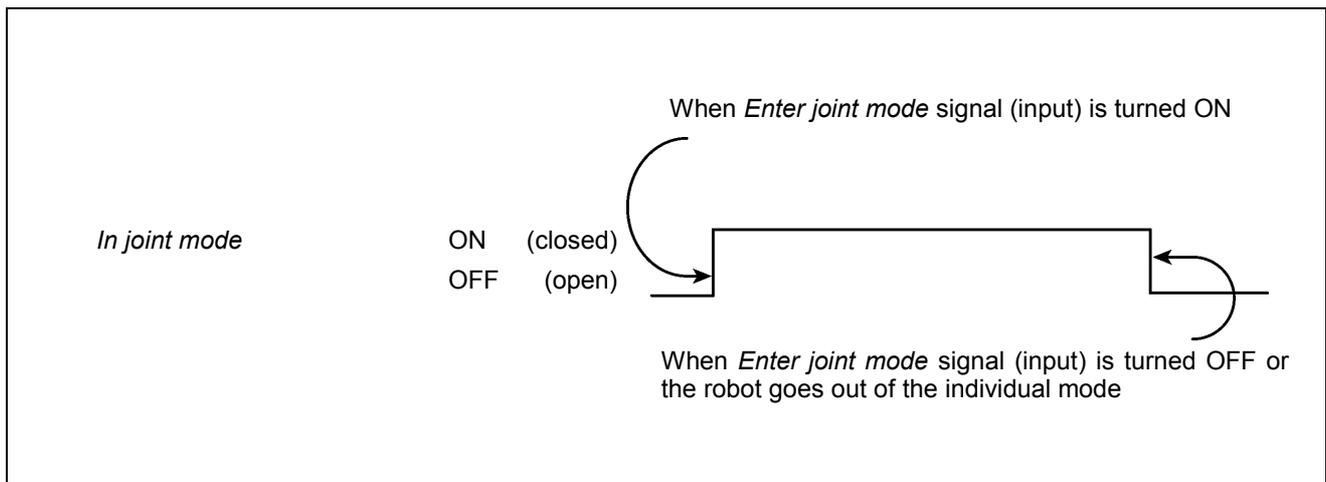
You use this signal to tell the external equipment that the robot in the individual mode enters the joint mode.

■ Comes ON when:

The robot enters the joint mode by receiving *Enter joint mode* signal (input) in the individual mode.

■ Goes OFF when:

The robot goes out of the joint mode or individual mode.



***In joint mode* Signal**

2.4.7 In X-Y mode (output)

■ **Function**

Tells the external equipment that the robot is in the X-Y mode.

■ **Port address**

809

■ **Application**

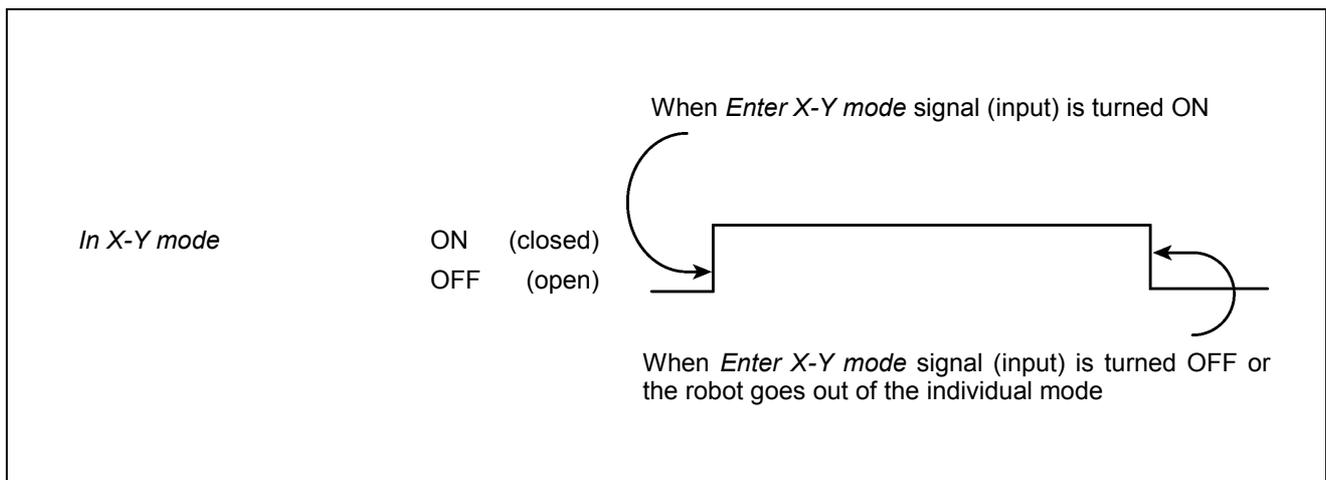
You use this signal to tell the external equipment that the robot in the individual mode enters the X-Y mode.

■ **Comes ON when:**

The robot enters the X-Y mode by receiving *Enter X-Y mode* signal (input) in the individual mode.

■ **Goes OFF when:**

The robot goes out of the X-Y mode or individual mode.



***In X-Y mode* Signal**

2.4.8 *In tool mode* (output)

■ Function

Tells the external equipment that the robot is in the tool mode.

■ Port address

810

■ Application

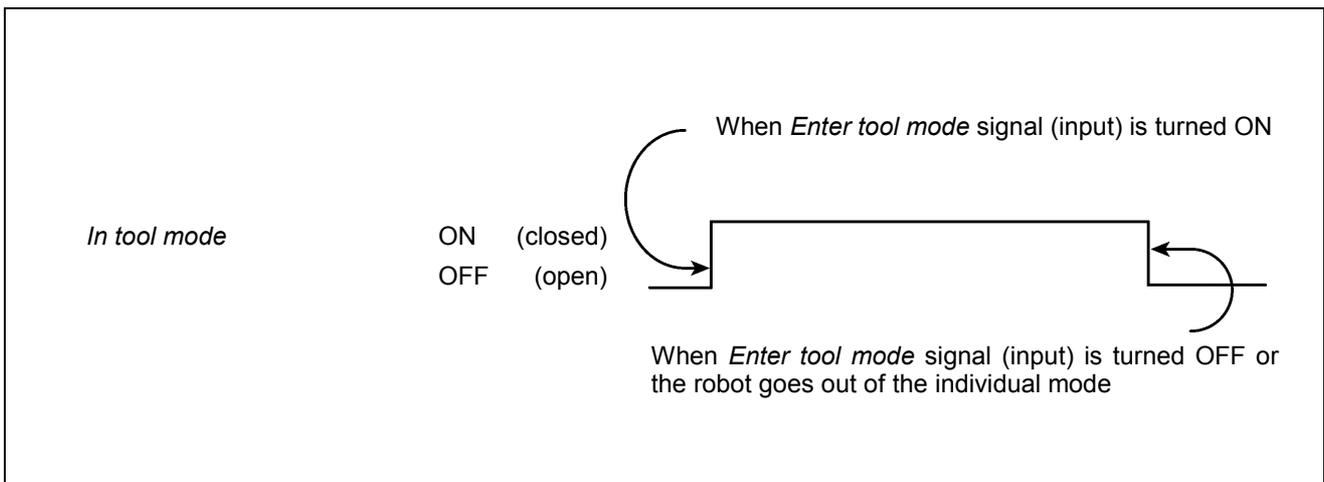
You use this signal to tell the external equipment that the robot in the individual mode enters the tool mode.

■ Comes ON when:

The robot enters the tool mode by receiving *Enter tool mode* signal (input) in the individual mode.

■ Goes OFF when:

The robot goes out of the tool mode or individual mode.



***In tool mode* Signal**

2.5 Basic for the Individual Mode

2.5.1 Entering the Individual Mode

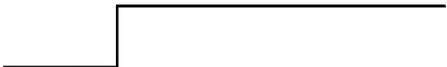
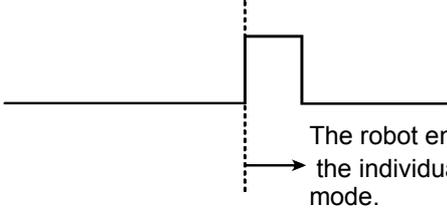
■ **The operation is required when:**

You want to handle the robot from the external equipment (e.g., sequencer).

■ **How to enter the individual mode**

Manage the signals as shown below.

Signal Management for Entering the Individual Mode

| Step | Signal status |
|---|--|
| ① Turn <i>Teaching disable</i> signal ON. | <p><i>Teaching disable</i></p> <p>ON (closed)</p> <p>OFF (open)</p>  |
| ② Turn <i>Switch to individual mode</i> signal ON. | <p><i>Switch to individual mode</i></p> <p>ON (closed)</p> <p>OFF (open)</p>  |
| ③ Turn <i>power on motor</i> signal ON. | <p><i>Power on motor</i></p> <p>ON (closed)</p> <p>OFF (open)</p>  |
| ④ Turn <i>Operation ready start</i> signal ON. | <p><i>Operation ready start</i></p> <p>ON (closed)</p> <p>OFF (open)</p>  |
| <p>NOTE: If any error is detected in the robot controller before you turn <i>Operation ready start</i> signal ON, remove the error and then repeat the above steps from the beginning.</p> | |

2.5.2 Setting the Reduced Ratios of the Programmed Speed, Acceleration, and Deceleration

■ Purpose of this operation

This operation allows you to set the reduced ratios (%) of the maximum programmed speed, acceleration, and deceleration, to be applied in the individual mode from the external control panel. The entry unit is expressed in percentage of the maximum speed.

- (1) The reduced ratio default in the individual mode is 10% of the maximum speed.
- (2) Once you set the reduced ratios, they will remain in effect until any other speed setting is made.
- (3) In the individual mode, the robot will run at the (maximum speed x reduced ratio% x 10%). Refer to the graph given below.
- (4) If you set the reduced ratio of the maximum speed, the robot controller automatically calculates the reduced ratios of the programmed acceleration and deceleration according to the formulas below.

$$\text{Reduced ratio for acceleration} = (\text{Reduced ratio for speed})^2/100$$

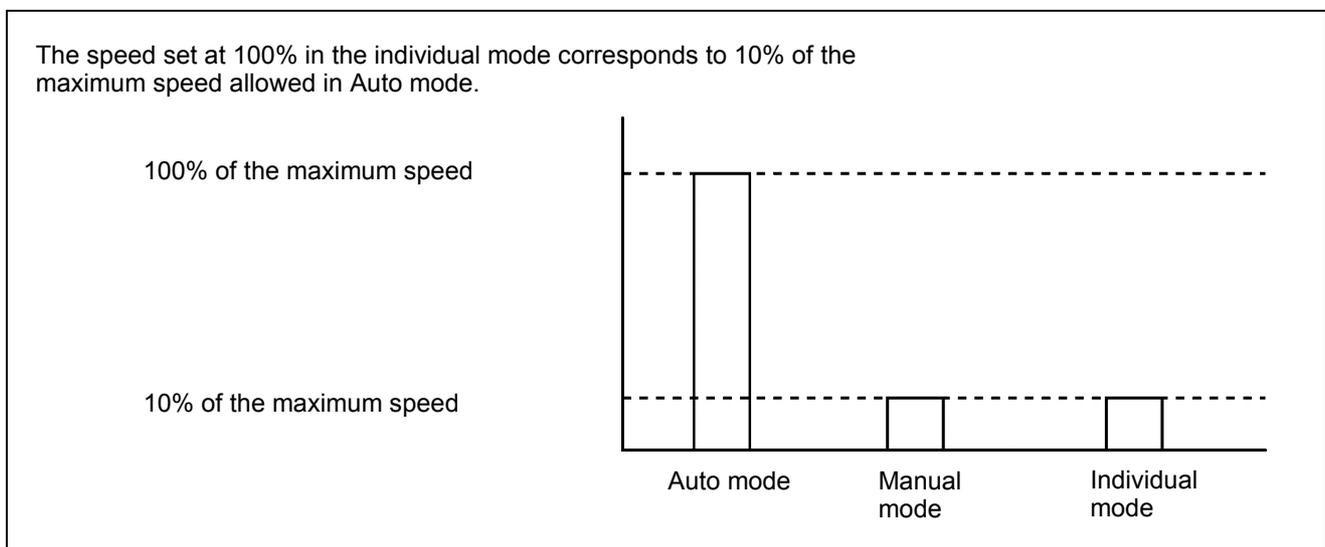
$$\text{Reduced ratio for deceleration} = (\text{Reduced ratio for speed})^2/100$$

Where, the calculated value will be rounded up to 1% if it is less than 1%.

(Example) If the reduced ratio for speed is 20%

$$\text{Reduced ratio for acceleration} = 20^2/100 = 4\%$$

NOTE: If the individual mode is switched to any other mode, the speed is always set to 10% (SP10).



Speed Rates Different in Each Mode

■ This operation is required when:

You want to change the robot speed in the individual mode.

Chapter 2 Signals Needed for Managing the Robot in Individual Mode

■ How to change the robot speed

Manage the signals as shown below.

Signal Management for Changing the Robot Speed

| Step | Signal status |
|---|--|
| <p>① Turn OFF all signal lines relative to the mode selection.</p> <p>② Turn <i>Increase speed in individual mode</i> or <i>Decrease speed in individual mode</i> signal from OFF to ON. The speed increases (decreases) by 10.</p> | <p><i>Increase speed in individual mode</i></p> <p>ON (closed) OFF (open)</p> <p>SP10 SP20</p> |
| <p>NOTE: If you want to increase or decrease the speed further, repeat step ②. The speed increases or decreases in increments of 10 per step ②. The speed should be within the range from 10 to 100.</p> | |

2.5.3 Powering the Motor ON

■ Purpose of this operation

This operation allows you to power the motor on.

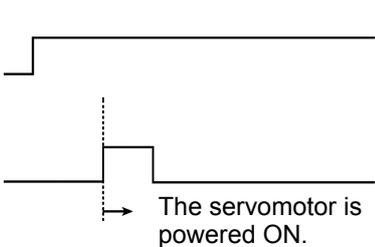
■ This operation is required when:

You want to run the robot in any of the inching, single-step program, and single-cycle program operation.

■ How to power the motor ON

Manage the signals as shown below.

Signal Management for Powering the Motor ON

| Step | Signal status |
|---|--|
| ① Turn <i>Power on motor</i> signal ON. ② Turn <i>Operation ready start</i> signal ON. | <div style="display: flex; flex-direction: column; align-items: flex-start;"> <div style="margin-bottom: 10px;"> <p><i>Power on motor</i></p> <p>ON (closed)</p> <p>OFF (open)</p> </div> <div style="margin-bottom: 10px;"> <p><i>Operation ready start</i></p> <p>ON (closed)</p> <p>OFF (open)</p> </div> <div style="margin-bottom: 10px;">  </div> </div> |

2.5.4 Inching in the individual mode

■ **Purpose of this operation**

This operation allows you to run the robot directly from the external control panel. In this operation are the joint mode, X-Y mode and tool mode available.

NOTE: The running directions in these three modes are explained in the INSTALLATION & MAINTENANCE GUIDE P.1-6 and 1-7.

■ **This operation is required when:**

You want to travel the robot to the desired position.

⚠ CAUTION

Set the robot speed below 20% of the maximum speed. Running the robot at high speed may cause the robot to collide against something, resulting in a damaged robot.

■ **How to inch the robot in joint mode**

Manage the signals as shown below.

The robot should be placed in the individual mode beforehand.

Signal Management for Inching the Robot in Joint Mode

| Step | Signal status |
|---|---|
| <p>① Turn <i>Enter Joint mode</i> signal ON.</p> | <p><i>Enter joint mode</i> ON (closed) OFF (open)</p> |
| <p>② Turn <i>Select axis</i> signal ON. (for example, <i>Select axis, +J1</i>)</p> | <p><i>Select axis, +J1</i> ON (closed) OFF (open)</p> |
| <p>③ Turn <i>Select axis</i> signal OFF. (for example, <i>Select axis, +J1</i>)</p> | <p><i>Select axis, +J1</i> ON (closed) OFF (open)</p> |

NOTE: When running in the + or - direction, the robot will ignore the opposite direction signal on the same axis if received. If the robot is in +J1 operation, it will ignore *Select axis, -J1* signal if received, so no -J1 operation will take place.

Signal Definition in Inching for the Axis, Mode and Running Direction

| | Available modes | Axis | Inching forward | Inching backward |
|---|-----------------|----------|-----------------|------------------|
| 1 | Joint mode | 1st axis | [+J1] | [-J1] |
| | | 2nd axis | [+J2] | [-J2] |
| | | 3rd axis | [+J3] | [-J3] |
| | | 4th axis | [+J4] | [-J4] |
| 2 | X-Y mode | X axis | [+J1] | [-J1] |
| | | Y axis | [+J2] | [-J2] |
| | | Z axis | [+J3] | [-J3] |
| | | T axis | [+J4] | [-J4] |
| 3 | Tool mode | TX axis | [+J1] | [-J1] |
| | | TY axis | [+J2] | [-J2] |
| | | TZ axis | [+J3] | [-J3] |
| | | TT axis | [+J4] | [-J4] |

2.5.5 Running the robot by a single program step

■ **Purpose of this operation**

This operation allows you to run the robot forwards or backwards by a single program step. For details about forward/backward and the restrictions, see the tables given below.

 **WARNING:**

Before starting this operation, be sure to make everyone get out of the robot moving area. Upon start of this operation, the robot may run.

Forward or Backward Movement in Single-step Program Operation

| | Forward or backward | Function |
|---|---------------------|---|
| 1 | Step forwards | Executes any single step of your program (PRO) forwards. |
| 2 | Step backwards | Returns to the most recently executed program step (and executes it if it contains a motion command). |

NOTE: You can return execution of your program by a maximum of 100 steps including non-action program steps.

Restrictions on Single-step Program Operation

| | Restrictions |
|---|---|
| 1 | The maximum speed is restricted to 10% (SP10) or below of the maximum speed allowed in the automatic mode. |
| 2 | Each run signal should be kept ON until completion of the single-step program operation; otherwise, the robot will not run. |

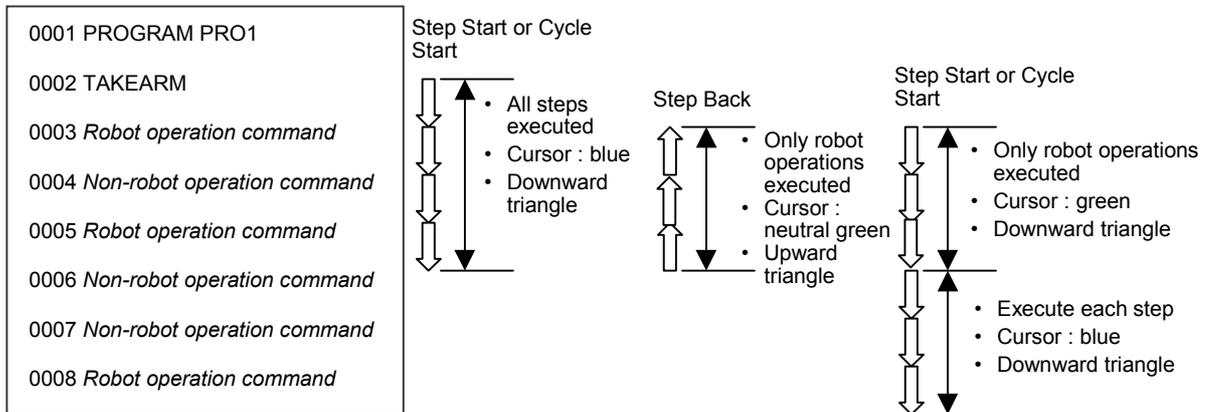
■ **This operation is required when:**

You want to check whether your program is correctly written or taught for positioning (PTP) or continuous path (CP) of your robot.

■ Step Back Function

This function steps backwards the current program executed by Step Start or Cycle Start, one instruction at a time.

The Step Back function is diagrammatically shown below.



Executing Step Back command steps backwards the program. During Step Back operation, only robot motion commands, TAKEARM, and GIVEARM (Refer to the PROGRAMMER'S MANUAL.) will be executed. Other commands will not be actually executed, and only the line number will step back. The settings relating to end-effector, workpiece, and speed made when Step Start or Cycle Start was executed will be reflected on Step Back operation.

If control returns to TAKEARM, GIVEARM will be executed; if it returns to GIVEARM, TAKEARM will be executed.

If Step Start or Cycle Start is executed after Step Back, only robot motion commands, TAKEARM, and GIVEARM are executed until the step at which Step Back was executed (Tool, work and speed settings are as for Step Back). At subsequent steps, all commands will be executed.

Cursor color in the Program List window and in the coding table

- Neutral green in Step Back operation
- Green in Step Start and Step Start operation from Step Back until the Step Back started step
- Blue in cases other than the above two.

The triangle on the left of line number shows the direction of operation. Downward triangle indicates forward stepping and the upward triangle indicates backward stepping.

NOTE 1: Restrictions on Step Back

This function traces the commands when Step Start or Cycle Start is executed. Based on that data, the Step Back function executes those commands. However, there is a limit for recording data. A maximum of 100 commands can be recorded and when the limit is exceeded the old commands will be erased in sequence and new ones recorded.

The Step Back function can work only within a program, since data that has been recorded will be cleared if any other program is selected and executed. Note that programs that are called by CALL or GOSUB will not be treated as other programs, so the Step Back function can work within those programs.

If a specified line is executed, the control cannot return to the lines preceding the specified line.

■ How to run the robot forwards by a single program step

Manage the signals as shown below.

You should set the robot speed *with Increase speed in individual mode or Decrease speed in individual mode* signal beforehand.

Signal Management for Running the Robot Forwards by a Single Program Step

| Step | Signal status |
|--|--|
| ① Turn <i>Enter single-step mode</i> signal ON. | <p><i>Enter single-step mode</i></p> <p>ON (closed) </p> <p>OFF (open)</p> |
| ② Select the desired program number with <i>Select program number</i> signals. | <p><i>Select program number 2⁰ to 2⁶</i></p> <p>ON (closed) </p> <p>OFF (open)</p> <p><i>Reset program</i></p> <p>ON (closed) </p> <p>OFF (open)</p> |
| ③ Turn <i>Reset program</i> signal ON. | <p><i>Step forwards</i></p> <p>ON (closed) </p> <p>OFF (open)</p> |
| ④ Turn <i>Step forwards</i> signal ON. | <p><i>Step forwards</i></p> <p>ON (closed) </p> <p>OFF (open)</p> <p>Start of step forwards operation</p> <p>End of step forwards operation</p> <p>Execution of one step</p> |

NOTE: Every time a sequence of step forwards operation is completed, the robot controller waits for *Step forwards* signal to go off. Unless you turn *Step forwards* signal from OFF to ON again, the controller cannot advance to the next step of the program.

NOTE: Even if you repeat the step forwards operation with keeping *Reset program* signal ON, the controller can execute only the beginning step of the program.

NOTE: If the number of a program you want to run next has been selected before the robot executes the ending step of the current program by the step forwards operation, the controller will execute the selected program subsequently.

Chapter 2 Signals Needed for Managing the Robot in Individual Mode

■ How to run the robot backwards by a single program step

Manage the signals as shown below.

You should run the robot forwards in the step forwards operation beforehand.

Signal Management for Running the Robot Backwards by a Single Program Step

| Step | Signal status |
|--|---|
| ① Advance the program with <i>Step forwards</i> signal. ② Turn <i>Step forwards</i> signal OFF and <i>Step backwards</i> signal ON. | <p>The diagram shows two signal waveforms. The top waveform, labeled 'Step forwards', is a pulse that goes from OFF (open) to ON (closed) and then back to OFF (open). A double-headed arrow under the pulse is labeled 'Execution of one step'. The bottom waveform, labeled 'Step backwards', is OFF (open) until the 'Start of step backwards operation', where it goes to ON (closed). It remains ON (closed) until the 'End of step backwards operation', where it returns to OFF (open). Arrows point from the text labels to the corresponding transitions in the waveforms.</p> |
| <p>NOTE: Every time a sequence of step backwards operation is completed, the robot controller waits for <i>Step backwards</i> signal to go off. Unless you turn <i>Step backwards</i> signal from OFF to ON again, the controller cannot return to the previous step of the program.</p> <p>NOTE: During step backwards operation, <i>Enter single-step mode</i> signal should be kept ON.</p> | |

2.5.6 Running the robot by a single program cycle

■ Purpose of this operation

This operation allows you to run the robot by a single program cycle from the external equipment.

■ This operation is required when:

You want to check how your robot runs in your program from the external equipment (e.g., sequencer).

■ How to run the robot by a single program cycle

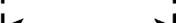
Manage the signals as shown below.

You should set the robot speed beforehand.

CAUTION

Set the robot speed below 20% of the maximum speed. Running the robot at high speed may cause the robot to collide against something, resulting in a damaged robot.

Signal Management for Running the Robot by a Single Program Cycle (Example: Executing the beginning step of program No. 2)

| Step | Signal status |
|--|--|
| ① Turn <i>Enter single-cycle mode</i> signal ON. | <p><i>Enter single-cycle mode</i></p> <p>ON (closed) </p> <p>OFF (open) </p> |
| ② Select the desired program number with <i>Select program number</i> signals. (Example: Selecting program No. 2) | <p><i>Select program number 2¹</i></p> <p>ON (closed) </p> <p>OFF (open) </p> <p><i>Parity bit 2¹</i></p> <p>ON (closed) </p> <p>OFF (open) </p> |
| ③ Turn <i>Reset program</i> signal ON. | <p><i>Reset program</i></p> <p>ON (closed) </p> <p>OFF (open) </p> |
| ④ Turn <i>Start program</i> signal ON. | <p><i>Start program</i></p> <p>ON (closed) </p> <p>OFF (open) </p> <p>Start of program </p> <p>Single program cycle operation </p> |
| <p>NOTE: To run the program again, repeat ④ above.</p> | |

2.5.7 Escaping from individual mode

■ **Purpose of this operation**

This operation allows the robot to escape from the individual mode and become ready to enter any other mode.

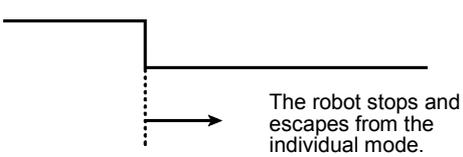
■ **This operation is required when:**

You want to place the robot in any other mode (automatic mode, external mode or manual mode).

■ **How to escape from the individual mode**

Manage the signals as shown below.

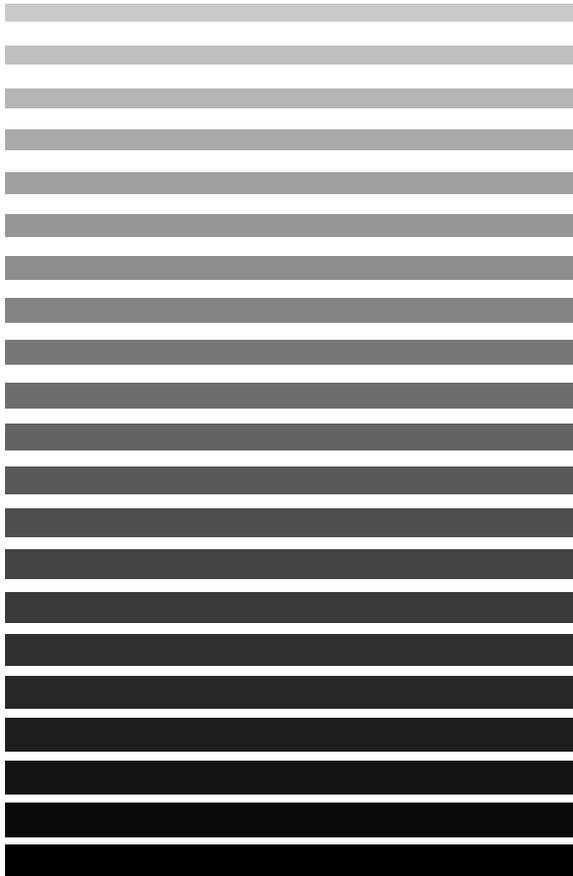
Signal Management for Escaping the Robot from the Individual Mode

| Step | Signal status |
|--|---|
| <p>① Turn <i>Switch to individual mode</i> signal OFF.</p> | <div style="text-align: center;"> <p><i>Switch to individual mode</i></p> <p>ON (closed) —————</p> <p>OFF (open) —————</p> </div>  <p style="text-align: right;">The robot stops and escapes from the individual mode.</p> |
| <p>NOTE: If <i>Switch to individual mode</i> signal goes OFF, the controller tells the external equipment the mode switching by issuing error code ERROR1989.</p> | |

Chapter 3



DeviceNet Communications and its Interface



3.1 DeviceNet Communications

3.1.1 Overview

The robot controller is a slave unit for serial communications which is compliant with the open network DeviceNet. It may easily exchange I/O data with a variety of DeviceNet-compliant control devices of many manufacturers.

[1] Features

(1) DeviceNet-compliant board

The DeviceNet is an internationally open network developed by Allen-Bradley and is designed to allow control devices (e.g., sensors and actuators) to communicate with each other.

(2) Can be networked with control devices of various manufacturers

The robot controller equipped with DeviceNet board can be networked with DeviceNet-compliant control devices of various domestic and foreign manufacturers since the communications specifications are open.

(3) Easy wiring and maintenance

The 5-core special cable and detachable connector of the DeviceNet board make it easy to install wiring between nodes (communications units) and disassembly/restructure the network. This will sharply reduce cost in wiring and maintenance, as well as making replacement of units easy at the time of failure.

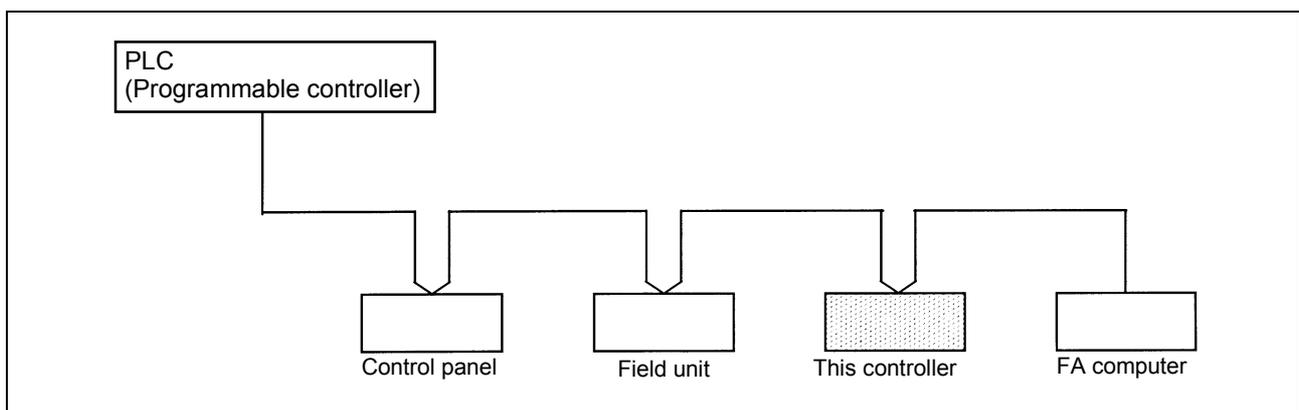
(4) Sufficient number of I/Os

The controller is capable of handling a large quantity of I/O data as listed below. Further, increase or decrease of the number of user-input I/Os is possible in the 8 steps.

| Number of I/Os | |
|----------------|-----------|
| Transmission | 24 to 224 |
| Reception | 40 to 232 |

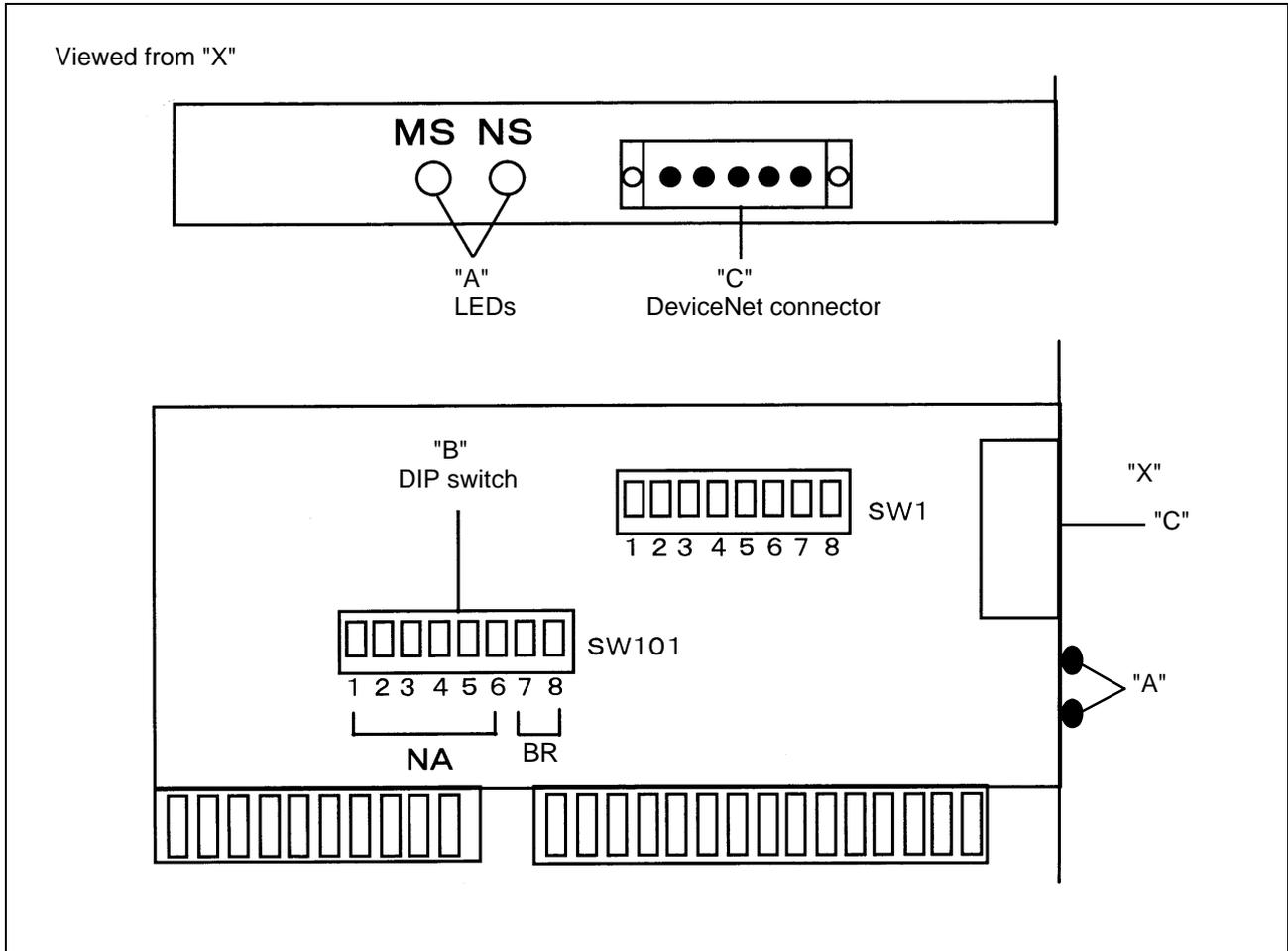
[2] Typical Network

The figure below illustrates a typical network.



3.2 Product Specifications

The figure below shows the location of the LEDs, DIP switches, and DeviceNet connector on the DeviceNet board.



[1] Components and Functions

(1) Status indicator LEDs

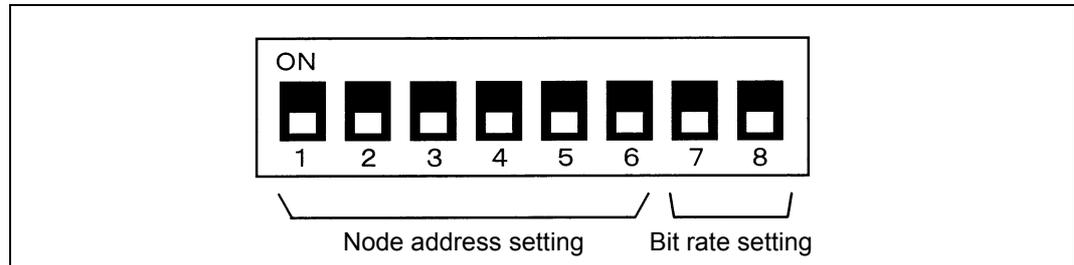
The status indicators MS and NS ("A" in the figure given on the previous page) can light or flash in green or red. Each of the ON, flashing, and OFF states of those indicators shows the module or network status as listed below.

The flashing interval is once per second (0.5 second of ON and 0.5 second of OFF).

| LED name | Color | State | Definition | Explanation |
|---|-------|---|-------------------------------------|--|
| MS (Module Status) | Green |  | Normal state | <ul style="list-style-type: none"> The unit works normally. |
| | |  | Setup not completed | <ul style="list-style-type: none"> Reading the DIS switch settings. |
| | Red |  | Fatal error | <ul style="list-style-type: none"> Hardware failure. |
| | |  | Recoverable error | <ul style="list-style-type: none"> Wrong DIP switch settings, etc. |
| | - |  | No power supplied | <ul style="list-style-type: none"> No power is supplied to the DeviceNet module. Resetting data. Waiting for initialization. |
| NS (Network Status) | Green |  | Communications link established | The network is working normally. (The line is connected.) |
| | |  | Communications link not established | The network is working normally, but the line is not connected yet. |
| | Red |  | Fatal communications error | The unit detects any error disabling communication on the network. <ul style="list-style-type: none"> Node address double-assigned. "Bus off" detected.. |
| | |  | Recoverable communications error | <ul style="list-style-type: none"> A communications timeout has occurred. |
| | |  | Offline | <ul style="list-style-type: none"> Mismatch with the baud rate on the network. |
|  : ON  : Flashing  : OFF | | | | |

(2) DIP switch

Use the DIP switch ("B" in the figure on p. 3-2) for setting the node address and bit rate as shown below.



DIP Switch Setting

NOTE: Always turn off the controller power (including the network power) before setting the DIP switch.

Setting the node address

Set the node address of the robot controller using selectors 1 through 6 of the DIP switch, referring to the table below. You may freely set any of 0 through 63 to a node address unless the address is double-assigned on the same network including the master and slaves. Double assignment will cause an address double-assignment error, disabling the network.

Node Address Setting by the DIP Switch

| DIP switch | | | | | | Node address | DIP switch | | | | | | Node address |
|------------|-----------|----------|----------|----------|----------|--------------|------------|-----------|----------|----------|----------|----------|--------------|
| 1 (32) | 2 (16) | 3 (8) | 4 (4) | 5 (2) | 6 (1) | | 1 (32) | 2 (16) | 3 (8) | 4 (4) | 5 (2) | 6 (1) | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 | |
| 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 33 | |
| 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 34 | |
| 0 | 0 | 0 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 35 | |
| 0 | 0 | 0 | 1 | 0 | 0 | 4 | 0 | 0 | 0 | 1 | 0 | 36 | |
| 0 | 0 | 0 | 1 | 0 | 1 | 5 | 0 | 0 | 0 | 1 | 0 | 37 | |
| 0 | 0 | 0 | 1 | 1 | 0 | 6 | 0 | 0 | 0 | 1 | 1 | 38 | |
| 0 | 0 | 0 | 1 | 1 | 1 | 7 | 0 | 0 | 0 | 1 | 1 | 39 | |
| 0 | 0 | 1 | 0 | 0 | 0 | 8 | 0 | 0 | 1 | 0 | 0 | 40 | |
| 0 | 0 | 1 | 0 | 0 | 1 | 9 | 0 | 0 | 1 | 0 | 1 | 41 | |
| 0 | 0 | 1 | 0 | 1 | 0 | 10 | 0 | 0 | 1 | 0 | 0 | 42 | |
| 0 | 0 | 1 | 0 | 1 | 1 | 11 | 0 | 0 | 1 | 0 | 1 | 43 | |
| 0 | 0 | 1 | 1 | 0 | 0 | 12 | 0 | 0 | 1 | 1 | 0 | 44 | |
| 0 | 0 | 1 | 1 | 0 | 1 | 13 | 0 | 0 | 1 | 1 | 0 | 45 | |
| 0 | 0 | 1 | 1 | 1 | 0 | 14 | 0 | 0 | 1 | 1 | 1 | 46 | |
| 0 | 0 | 1 | 1 | 1 | 1 | 15 | 0 | 0 | 1 | 1 | 1 | 47 | |
| 0 | 1 | 0 | 0 | 0 | 0 | 16 | 0 | 1 | 0 | 0 | 0 | 48 | |
| 0 | 1 | 0 | 0 | 0 | 1 | 17 | 0 | 1 | 0 | 0 | 1 | 49 | |
| 0 | 1 | 0 | 0 | 1 | 0 | 18 | 0 | 1 | 0 | 1 | 0 | 50 | |
| 0 | 1 | 0 | 0 | 1 | 1 | 19 | 0 | 1 | 0 | 1 | 1 | 51 | |
| 0 | 1 | 0 | 1 | 0 | 0 | 20 | 0 | 1 | 0 | 1 | 0 | 52 | |
| 0 | 1 | 0 | 1 | 0 | 1 | 21 | 0 | 1 | 0 | 1 | 1 | 53 | |
| 0 | 1 | 0 | 1 | 1 | 0 | 22 | 0 | 1 | 0 | 1 | 0 | 54 | |
| 0 | 1 | 0 | 1 | 1 | 1 | 23 | 0 | 1 | 0 | 1 | 1 | 55 | |
| 0 | 1 | 1 | 0 | 0 | 0 | 24 | 0 | 1 | 1 | 0 | 0 | 56 | |
| 0 | 1 | 1 | 0 | 0 | 1 | 25 | 0 | 1 | 1 | 0 | 1 | 57 | |
| 0 | 1 | 1 | 0 | 1 | 0 | 26 | 0 | 1 | 1 | 0 | 0 | 58 | |
| 0 | 1 | 1 | 0 | 1 | 1 | 27 | 0 | 1 | 1 | 0 | 1 | 59 | |
| 0 | 1 | 1 | 1 | 0 | 0 | 28 | 0 | 1 | 1 | 1 | 0 | 60 | |
| 0 | 1 | 1 | 1 | 0 | 1 | 29 | 0 | 1 | 1 | 1 | 0 | 61 | |
| 0 | 1 | 1 | 1 | 1 | 0 | 30 | 0 | 1 | 1 | 1 | 1 | 62 | |
| 0 | 1 | 1 | 1 | 1 | 1 | 31 | 0 | 1 | 1 | 1 | 1 | 63 | |

Note 1 : Selector OFF and ON are expressed by 0 and 1, respectively. (Before shipment from the factory, all switches are set to 0 by default.)

Chapter 3 DeviceNet Communications and its Interface

Setting the bit rate

To match the bit rate of the robot controller with that of the network, use selectors 7 and 8 of the DIP switch, referring to the table below:

Bit Rate Setting By DIP Switch

| Selectors on the DIP switch | | Bit rate |
|-----------------------------|------------|----------|
| Selector 7 | Selector 8 | |
| 0 | 0 | 125 kbps |
| 0 | 1 | 250 kbps |
| 1 | 0 | 500 kbps |
| 1 | 1 | 500 kbps |

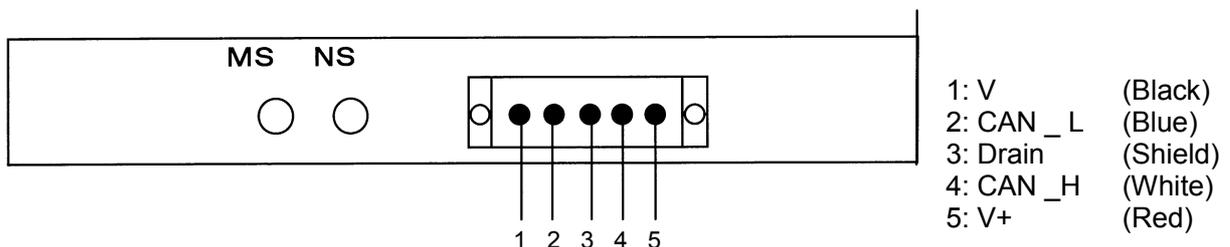
Note 1: Selector OFF and ON are expressed by 0 and 1, respectively. (Before shipment from the factory, both of these selectors are set to 0 (=500 kbps) by default.)

Note 2: On the same network, set the same bit rate to all nodes (master and slaves). Otherwise, slaves whose bit rate is different from that of the master cannot communicate only, but also they may cause a communications error between correctly set nodes.

(3) DeviceNet connector ("C" in the figure on p. 3-2)

The new robot controller uses an open type screw connector whose pin arrangement is shown below.

NOTE: When the controller power (including the network power) is on, do not disconnect/connect the communication connector or touch its pins. Doing so will result in a failure.



It is recommended that either of the following crimp terminals be used for the communication cable.

| No. | Crimp terminal | Tools required |
|-----|--|-----------------------|
| (1) | AI series (Phoenix Contact) | ZA3 (Phoenix Contact) |
| (2) | TC series (Nichifu) For thin cables: TME TC-0.5 For thick cables: TME TC-2-11 (for power supply) TME TC-1.25-11 (for communication) | NH-32 |

[2] General Specifications

The following tables list the controller environmental and communication specifications.

(1) Environmental requirements

| Item | Specifications |
|-----------------------------|---|
| Power requirements | 5 VDC (supplied via the controller ISA bus) |
| Operating temperature | 0 to 40°C |
| Operating relative humidity | 90% RH or less (without condensation) |

(2) DeviceNet communications specifications

| Item | Specifications | | | |
|--|---|------------------------|---------------|---------------------|
| Communications protocol | DeviceNet-compliant | | | |
| Connection supported | Master/slave connection : Polling I/O function Compliant with DeviceNet communications rules | | | |
| Connection type (Note1) | Multi-drop type with possible combination of T-branch (to trunk and branch lines) | | | |
| Bit rate | 500, 250, 125 kbps (selection by switch) | | | |
| Communications media | Special cable with 5 wires (2 for signals, 2 for power supply and 1 as a shield wire) | | | |
| Communications cable length | Bit rate | Max. network length | Branch length | Total branch length |
| | 500 kbps | 100 m or less (Note 2) | 6 m or less | 39 m or less |
| | 250 kbps | 250 m or less (Note 2) | 6 m or less | 78 m or less |
| | 125 kbps | 500 m or less (Note 2) | 6 m or less | 156 m or less |
| Communication power supply | External supply of 24 VDC \pm 10% | | | |
| Max. number of connectable nodes | 64 nodes (including configurator (converter) if connected) | | | |
| Number of I/Os | New assignment 48 points for system input 48 points for system output 24 to 208 points for user input 24 to 208 points for user output No. of I/Os can be set in unit of 8 points. | | | |
| Error check | CRC | | | |
| Note 1: Terminator resistors are needed at both ends of the trunk line. | | | | |
| Note 2: These values may apply when a special thick cable is used as a trunk line. If a special fine cable is used, the max. network length is 100 m or less. | | | | |

(3) I/O signal assignments

① DeviceNet input signals

| Port | Signal names | Port | Signal names | Port | Signal names |
|------|------------------------------|------|---------------------------------------|------|--------------------------------|
| 512 | <i>Step stop (all tasks)</i> | 520 | <i>Select program number (Bit 0)</i> | 528 | <i>Power on motor</i> |
| 513 | Not used. | 521 | <i>Select program number (Bit 1)</i> | 529 | <i>Execute CAL</i> |
| 514 | <i>Halt (all tasks)</i> | 522 | <i>Select program number (Bit 2)</i> | 530 | Not used. |
| 515 | <i>Operation ready start</i> | 523 | <i>Select program number (Bit 3)</i> | 531 | <i>SP100</i> |
| 516 | <i>Skip interrupt</i> | 524 | <i>Select program number (Bit 4)</i> | 532 | <i>Switch to external mode</i> |
| 517 | <i>Start program</i> | 525 | <i>Select program number (Bit 5)</i> | 533 | <i>Reset program</i> |
| 518 | Not used. | 526 | <i>Select program number (Bit 6)</i> | 534 | <i>Clear robot error</i> |
| 519 | Not used. | 527 | <i>Select program number (Parity)</i> | 535 | Not used. |

| Port | Signal names | Port | Signal names | Port | Signal names |
|------|-------------------------------|------|---------------------------|------|--|
| 536 | <i>Select +J1 (X) inching</i> | 544 | <i>Select +J5 inching</i> | 552 | <i>Increase speed in individual mode</i> |
| 537 | <i>Select -J1 (X) inching</i> | 545 | <i>Select -J5 inching</i> | 553 | <i>Decrease speed in individual mode</i> |
| 538 | <i>Select +J2 (Y) inching</i> | 546 | <i>Select +J6 inching</i> | 554 | <i>Switch to individual mode</i> |
| 539 | <i>Select -J2 (Y) inching</i> | 547 | <i>Select -J6 inching</i> | 555 | <i>Enter single-cycle mode</i> |
| 540 | <i>Select +J3 (Z) inching</i> | 548 | <i>Step forwards</i> | 556 | <i>Enter single-step mode</i> |
| 541 | <i>Select -J3 (Z) inching</i> | 549 | <i>Step backwards</i> | 557 | <i>Enter joint mode</i> |
| 542 | <i>Select +J4 (T) inching</i> | 550 | Not used. | 558 | <i>Enter X-Y mode</i> |
| 543 | <i>Select -J4 (T) inching</i> | 551 | Not used. | 559 | <i>Enter tool mode</i> |

| Port | Signal names | Port | Signal names | Port | Signal names |
|------|--------------|------|--------------|------|--------------|
| 560 | USER-INPUT | 568 | USER-INPUT | 760 | USER-INPUT |
| 561 | USER-INPUT | . | . | 761 | USER-INPUT |
| 562 | USER-INPUT | . | . | 762 | USER-INPUT |
| 563 | USER-INPUT | . | . | 763 | USER-INPUT |
| 564 | USER-INPUT | . | . | 764 | USER-INPUT |
| 565 | USER-INPUT | . | . | 765 | USER-INPUT |
| 566 | USER-INPUT | . | . | 766 | USER-INPUT |
| 567 | USER-INPUT | 759 | USER-INPUT | 767 | USER-INPUT |

Note 1: The inverse notation $\overline{\quad}$ means negative truth logic.

Note 2: The input data is handled in bytes. Default is 64 points. Up to 256 points can be used.

② DeviceNet output signals

| Port | Signal names | Port | Signal names | Port | Signal names |
|------|------------------------------------|------|-----------------------------------|------|--|
| 768 | Not used. | 776 | <i>Robot powering-on complete</i> | 784 | <i>Error code, unit, 2⁰</i> |
| 769 | <i>Robot running</i> | 777 | <i>Motor on</i> | 785 | <i>Error code, unit, 2¹</i> |
| 770 | <i>Robot alarm</i> | 778 | <i>CAL complete</i> | 786 | <i>Error code, unit, 2²</i> |
| 771 | <i>In automatic operation mode</i> | 779 | <i>In teaching</i> | 787 | <i>Error code, unit, 2³</i> |
| 772 | <i>In external mode</i> | 780 | <i>Single-cycle end</i> | 788 | <i>Error code, tens, 2⁰</i> |
| 773 | <i>Program start reset</i> | 781 | <i>Low battery warning</i> | 789 | <i>Error code, tens, 2¹</i> |
| 774 | Not used. | 782 | <i>Robot warning</i> | 790 | <i>Error code, tens, 2²</i> |
| 775 | Not used. | 783 | <i>Auto enable switching</i> | 791 | <i>Error code, tens, 2³</i> |

| Port | Signal names | Port | Signal names | Port | Signal names |
|------|--|------|--|------|----------------------|
| 792 | <i>Error code, hundreds, 2⁰</i> | 800 | <i>Robot on halt</i> | 808 | <i>In joint mode</i> |
| 793 | <i>Error code, hundreds, 2¹</i> | 801 | <i>In individual mode</i> | 809 | <i>In X-Y mode</i> |
| 794 | <i>Error code, hundreds, 2²</i> | 802 | <i>Speed in individual mode, tens, 2⁰</i> | 810 | <i>In tool mode</i> |
| 795 | <i>Error code, hundreds, 2³</i> | 803 | <i>Speed in individual mode, tens, 2¹</i> | 811 | Not used. |
| 796 | Not used. | 804 | <i>Speed in individual mode, tens, 2²</i> | 812 | Not used. |
| 797 | Not used. | 805 | <i>Speed in individual mode, tens, 2³</i> | 813 | Not used. |
| 798 | Not used. | 806 | <i>In single-cycle mode</i> | 814 | Not used. |
| 799 | Not used. | 807 | <i>In single-step mode</i> | 815 | Not used. |

| Port | Signal names | Port | Signal names | Port | Signal names |
|------|--------------|------|--------------|------|--------------|
| 816 | USER-OUTPUT | 824 | USER-OUTPUT | 1016 | USER-OUTPUT |
| 817 | USER-OUTPUT | . | . | 1017 | USER-OUTPUT |
| 818 | USER-OUTPUT | . | . | 1018 | USER-OUTPUT |
| 819 | USER-OUTPUT | . | . | 1019 | USER-OUTPUT |
| 820 | USER-OUTPUT | . | . | 1020 | USER-OUTPUT |
| 821 | USER-OUTPUT | . | . | 1021 | USER-OUTPUT |
| 822 | USER-OUTPUT | . | . | 1022 | USER-OUTPUT |
| 823 | USER-OUTPUT | 1015 | USER-OUTPUT | 1023 | USER-OUTPUT |

Note 1: The inverse notation $\bar{\quad}$ means negative truth logic.

Note 2: The input data is handled in bytes. Default is 64 points. Up to 256 points can be used.

Chapter 3 DeviceNet Communications and its Interface

③ Parallel user-/system-input signals on CN8

| Pin No. | Signal names | Port No. | Pin No. | Signal names | Port No. |
|---------|-----------------------------------|----------|---------|--------------|----------|
| 1 | <i>Power for robot stop</i> | - | 26 | USER-INPUT | 21 |
| 2 | <i>Robot on halt</i> | - | 27 | USER-INPUT | 22 |
| 3 | <i>Power for teaching disable</i> | - | 28 | USER-INPUT | 23 |
| 4 | <i>Teaching disable</i> | - | 29 | USER-INPUT | 24 |
| 5 | Not used. | 0 | 30 | USER-INPUT | 25 |
| 6 | Not used. | 1 | 31 | USER-INPUT | 26 |
| 7 | Not used. | 2 | 32 | USER-INPUT | 27 |
| 8 | Not used. | 3 | 33 | USER-INPUT | 28 |
| 9 | Not used. | 4 | 34 | USER-INPUT | 29 |
| 10 | Not used. | 5 | 35 | USER-INPUT | 30 |
| 11 | Not used. | 6 | 36 | USER-INPUT | 31 |
| 12 | Not used. | 7 | 37 | USER-INPUT | 32 |
| 13 | Not used. | 8 | 38 | USER-INPUT | 33 |
| 14 | Not used. | 9 | 39 | USER-INPUT | 34 |
| 15 | Not used. | 10 | 40 | USER-INPUT | 35 |
| 16 | Not used. | 11 | 41 | USER-INPUT | 36 |
| 17 | Not used. | 12 | 42 | USER-INPUT | 37 |
| 18 | Not used. | 13 | 43 | USER-INPUT | 38 |
| 19 | Not used. | 14 | 44 | USER-INPUT | 39 |
| 20 | Not used. | 15 | 45 | USER-INPUT | 40 |
| 21 | Not used. | 16 | 46 | USER-INPUT | 41 |
| 22 | Not used. | 17 | 47 | USER-INPUT | 42 |
| 23 | Not used. | 18 | 48 | USER-INPUT | 43 |
| 24 | Not used. | 19 | 49 | USER-INPUT | 44 |
| 25 | Not used. | 20 | 50 | USER-INPUT | 45 |

Note 1: The inverse notation $\bar{\quad}$ means negative truth logic.

Note 2: *Auto enable* signal used for standard robots is changed to *Teaching disable*. For details, refer to "2.3.1 Teaching disable (input)."

④ Parallel user-/system-output signals on CN10

| Pin No. | Signal names | Port No. | Pin No. | Signal names | Port No. |
|---------|-------------------|----------|---------|-------------------------|----------|
| 1 | <i>CPU normal</i> | 72 | 35 | USER-OUTPUT | 106 |
| 2 | Not used. | 73 | 36 | USER-OUTPUT | 107 |
| 3 | Not used. | 74 | 37 | USER-OUTPUT | 108 |
| 4 | Not used. | 75 | 38 | USER-OUTPUT | 109 |
| 5 | Not used. | 76 | 39 | USER-OUTPUT | 110 |
| 6 | Not used. | 77 | 40 | USER-OUTPUT | 111 |
| 7 | Not used. | 78 | 41 | USER-OUTPUT | 112 |
| 8 | Not used. | 79 | 42 | USER-OUTPUT | 113 |
| 9 | Not used. | 80 | 43 | USER-OUTPUT | 114 |
| 10 | Not used. | 81 | 44 | USER-OUTPUT | 115 |
| 11 | Not used. | 82 | 45 | USER-OUTPUT | 116 |
| 12 | Not used. | 83 | 46 | USER-OUTPUT | 117 |
| 13 | Not used. | 84 | 47 | USER-OUTPUT | 118 |
| 14 | Not used. | 85 | 48 | USER-OUTPUT | 119 |
| 15 | Not used. | 86 | 49 | USER-OUTPUT | 120 |
| 16 | Not used. | 87 | 50 | USER-OUTPUT | 121 |
| 17 | Not used. | 88 | 51 | USER-OUTPUT | 122 |
| 18 | Not used. | 89 | 52 | USER-OUTPUT | 123 |
| 19 | Not used. | 90 | 53 | USER-OUTPUT | 124 |
| 20 | Not used. | 91 | 54 | USER-OUTPUT | 125 |
| 21 | Not used. | 92 | 55 | USER-OUTPUT | 126 |
| 22 | Not used. | 93 | 56 | USER-OUTPUT | 127 |
| 23 | Not used. | 94 | 57 | Not used. | - |
| 24 | Not used. | 95 | 58 | Not used. | - |
| 25 | Not used. | 96 | 59 | Not used. | - |
| 26 | Not used. | 97 | 60 | Not used. | - |
| 27 | Not used. | 98 | 61 | Not used. | - |
| 28 | Not used. | 99 | 62 | Not used. | - |
| 29 | Not used. | 100 | 63 | Not used. | - |
| 30 | Not used. | 101 | 64 | Not used. | - |
| 31 | Not used. | 102 | 65 | Emergency stop (+) | - |
| 32 | Not used. | 103 | 66 | Emergency stop (-) | - |
| 33 | USER-OUTPUT | 104 | 67 | Deadman switch (output) | - |
| 34 | USER-OUTPUT | 105 | 68 | Deadman switch (output) | - |

Note 1: The inverse notation $\bar{\text{—}}$ means negative truth logic.

Chapter 3 DeviceNet Communications and its Interface

⑤ Hand I/O signals on CN9

| Pin No. | Signal names | Port No. | Pin No. | Signal names | Port No. |
|---------|--------------|----------|---------|---------------------|----------|
| 1 | Hand output | 64 | 11 | Hand input | 50 |
| 2 | Hand output | 65 | 12 | Hand input | 51 |
| 3 | Hand output | 66 | 13 | Hand input | 52 |
| 4 | Hand output | 67 | 14 | Hand input | 53 |
| 5 | Hand output | 68 | 15 | Hand input | 54 |
| 6 | Hand output | 69 | 16 | Hand input | 55 |
| 7 | Hand output | 70 | 17 | Power E24V for hand | - |
| 8 | Hand output | 71 | 18 | Power E0V for hand | - |
| 9 | Hand input | 48 | 19 | NC | - |
| 10 | Hand input | 49 | 20 | NC | - |

⑥ I/O power signals on CN7

| Pin No. | Signal names |
|---------|----------------------------|
| 1 | Internal power output +24V |
| 2 | Internal power output +24V |
| 3 | Internal power output +24V |
| 4 | Internal power output +24V |
| 5 | Frame ground |
| 6 | Power input E24V |
| 7 | Power input E24V |
| 8 | Power input E0V |
| 9 | Power input E0V |

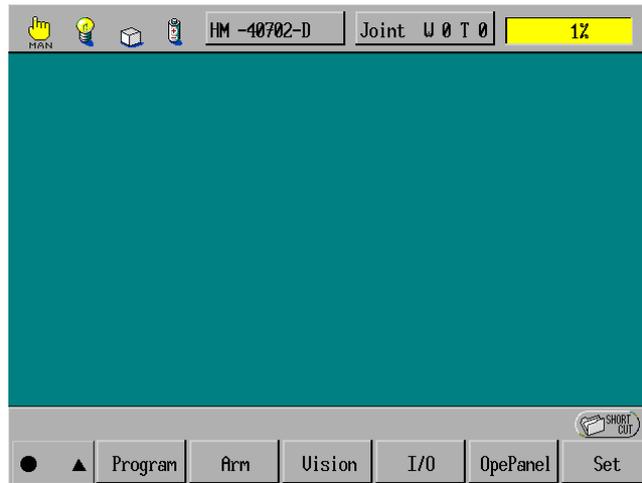
Note: You may select internal or external power sources for input and output circuits.

3.3 Parameter Entry Procedure

[1] Entering the Number of Input/Output Slots

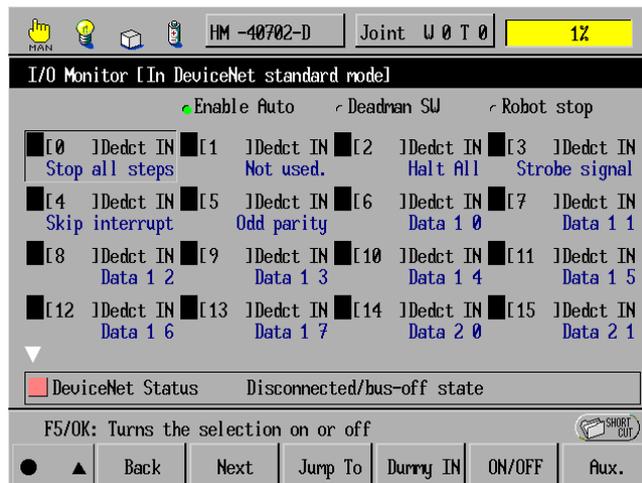
This controller allows you to increase or decrease the number of input/output slots in bytes. The number of input slots can be set in the range from 8 (default) to 32 (max), and the number of output slots in the range from 7 (default) to 32 (max). The setting method is as follows:

Step 1 Press [F4 I/O] on the following screen.



F4

Step 2 Press [F6 Aux.] on the following screen.



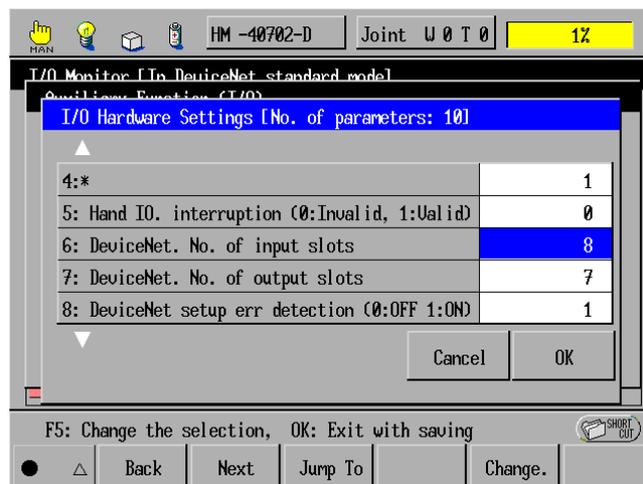
F6

Step 3 Press [F1 Set H/W] on the following screen.



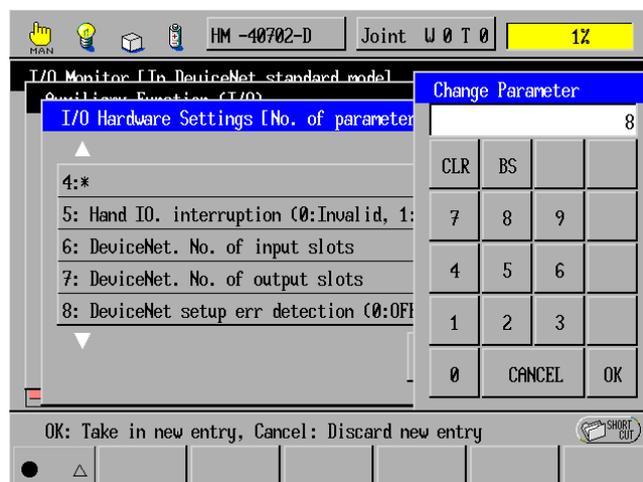
F1

Step 4 Select the grid for changing the number of DeviceNet input/output slots and press [F5 Change].

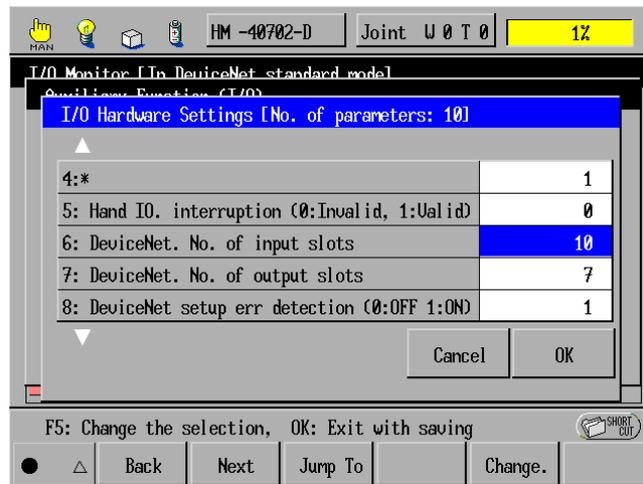


F5

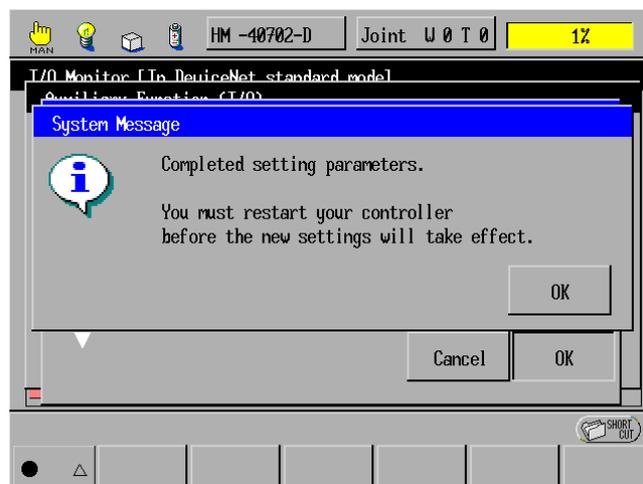
Step 5 Enter a required number of slots on the following screen and press OK. The quick reference table in the next subsection will be helpful for you to determine the number of input/output slots.



Step 6 Check that the number has been correctly changed (from 8 to 10 in this example) and press OK.



Step 7 Turn the controller power OFF and then turn it back ON according to the message on the following screen. Note that the internal data that you have changed will not become valid until you shut off and re-supply the power.



[2] Quick Reference Table for the Number of Input/Output Slots

The table below shows the correspondence between the number of input/output slots and the number of user input/output points (for DeviceNet only).

| Number of DeviceNet input slots | Max user input points in standard assignment |
|---------------------------------|--|
| 8 | 24 |
| 9 | 24 |
| 10 | 32 |
| 11 | 40 |
| 12 | 48 |
| 13 | 56 |
| 14 | 64 |
| 15 | 72 |
| 16 | 80 |
| 17 | 88 |
| 18 | 96 |
| 19 | 104 |
| 20 | 112 |
| 21 | 120 |
| 22 | 128 |
| 23 | 136 |
| 24 | 144 |
| 25 | 152 |
| 26 | 160 |
| 27 | 168 |
| 28 | 176 |
| 29 | 184 |
| 30 | 192 |
| 31 | 200 |
| 32 | 208 |

| Number of DeviceNet input slots | Max user input points in standard assignment |
|---------------------------------|--|
| 7 | 24 |
| 8 | 32 |
| 9 | 24 |
| 10 | 32 |
| 11 | 40 |
| 12 | 48 |
| 13 | 56 |
| 14 | 64 |
| 15 | 72 |
| 16 | 80 |
| 17 | 88 |
| 18 | 96 |
| 19 | 104 |
| 20 | 112 |
| 21 | 120 |
| 22 | 128 |
| 23 | 136 |
| 24 | 144 |
| 25 | 152 |
| 26 | 160 |
| 27 | 168 |
| 28 | 176 |
| 29 | 184 |
| 30 | 192 |
| 31 | 200 |
| 32 | 208 |

3.4 Error Code Table

The table below lists the error codes relative to DeviceNet communication errors. For other error codes, refer to the separately issued ERROR CODE TABLES.

| Error code | What has happened: | What to do: | LEDs | |
|------------|--|---|--|--|
| | | | MS | NS |
| 1201 | Preparing for communications (link not established) <ul style="list-style-type: none"> The DeviceNet module is working normally, but has not established link with the master device. | Establish the link from the master device. |  G |  G |
| 1202 | Preparing for communications (link not established) <ul style="list-style-type: none"> The DeviceNet module is working normally and has established explicit link with the master device, but not established an I/O link. | Establish the I/O link from the master device. |  G |  G |
| 1203 | Preparing for communications (communications idling) <ul style="list-style-type: none"> The DeviceNet module is working normally, but cannot receive data except empty data from the master device. | Check the contents of I/O data that the master device sends. |  G |  G |
| 1204 | Preparing for communications (I/O timeout) <ul style="list-style-type: none"> The DeviceNet module is working normally, but cannot receive data from the master device within the specified time. | Check that the DeviceNet cable is not broken or its connector is firmly plugged in. Check the DeviceNet cable length and that a terminator resistor is attached to each end of the trunk line. |  G |  R |
| 1205 | Initial setting error in the communications processor <ul style="list-style-type: none"> Failed to establish the initial link with the DeviceNet communication processor. | Turn the controller power off and then on, and do the same operation again. | - | - |
| 1210 | A DeviceNet internal communications error has occurred. | Turn the controller power off and then on, and do the same operation again. | - | - |
| 1213 | The network is broken or "bus off." <ul style="list-style-type: none"> The DeviceNet cable is broken or not connected. | Check whether the DeviceNet cable is connected with the robot controller. If this error occurs after you change the DIP switch setting, check whether the bit rate setting made with the DIP switch matches the network's bit rate. |  G |  R |
| 1215 | Preparing for communications (Initial setting error) <ul style="list-style-type: none"> No initial settings have been received from the robot. | Check whether the bit rate setting made with the DIP switch matches the network's bit rate.. |  G |  |
| 1216 | Data length setting error <ul style="list-style-type: none"> DeviceNet INSLOT or OUTSLOT is not 32 or less. | Turn the controller power off and then on. Then, set correct DeviceNet INSLOT and OUTSLOT values. |  R |  |
| 1217 | Node address double-assign error <ul style="list-style-type: none"> The same node address is double assigned to the robot controller and any other online node. | Assign an exclusive node address to each node (including the robot controller) on the same DeviceNet. |  G |  R |

 : ON

 : Flashing

 : OFF

- : Indefinite

Chapter 3 DeviceNet Communications and its Interface

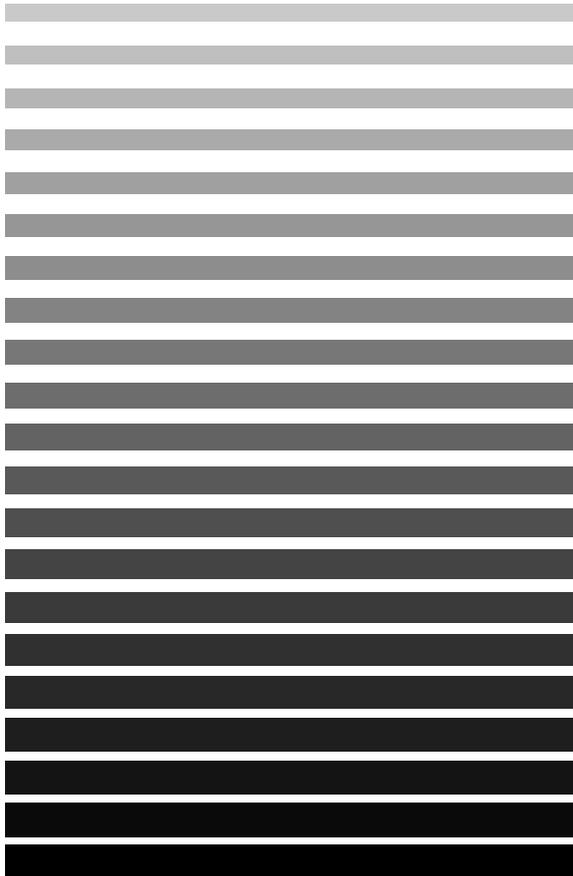
| Error code | What has happened: | What to do: | LEDs | |
|------------|---|---|--|--|
| | | | MS | NS |
| 1230 | Retry error in the DPRAM built in the robot controller | Turn the controller power off and then on, and do the same operation again. | - | - |
| 1232 | Reset command received <ul style="list-style-type: none"> • The robot controller has received a reset command from the master device. | Turn the controller power off and then on, and do the same operation again. |  G |  G |
| 1234 | DeviceNet internal RAM error | Turn the controller power off and then on, and do the same operation again. |  R |  |
| 1235 | Reserved for System | - |  R |  |
| 1236 | DeviceNet internal DPRAM error | Turn the controller power off and then on, and do the same operation again. |  R |  |
| 1237 | DeviceNet EEPROM error | Turn the controller power off and then on, and do the same operation again. |  R |  |
| 1238 | Retry error in the DeviceNet DPRAM | Turn the controller power off and then on, and do the same operation again. |  R |  |

 : ON
  : Flashing
  : OFF
 - : Indefinite

Chapter 4



Robot Controller I/O Circuits



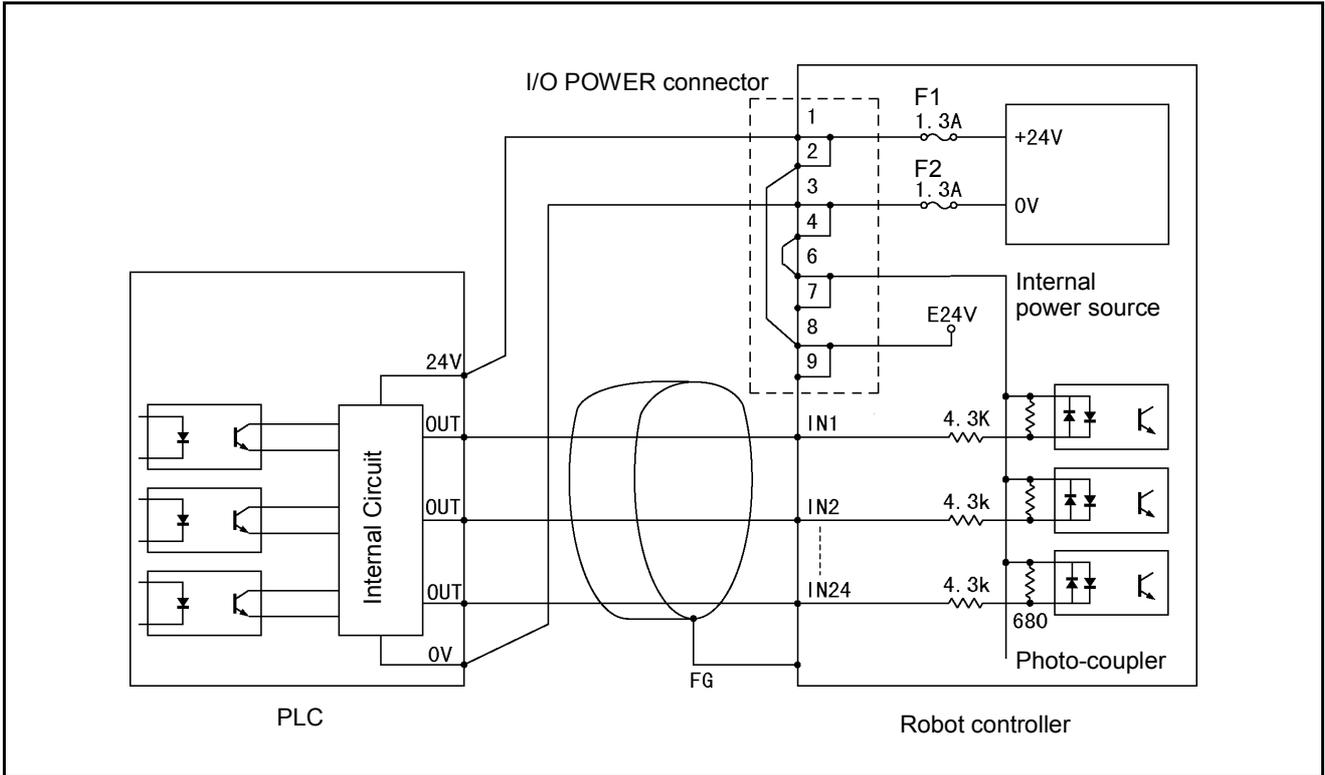
4.1 User-Input and Hand Input Circuits

The figures given on the next page show examples of the user-input and hand input circuit configurations and connections of the robot controller.

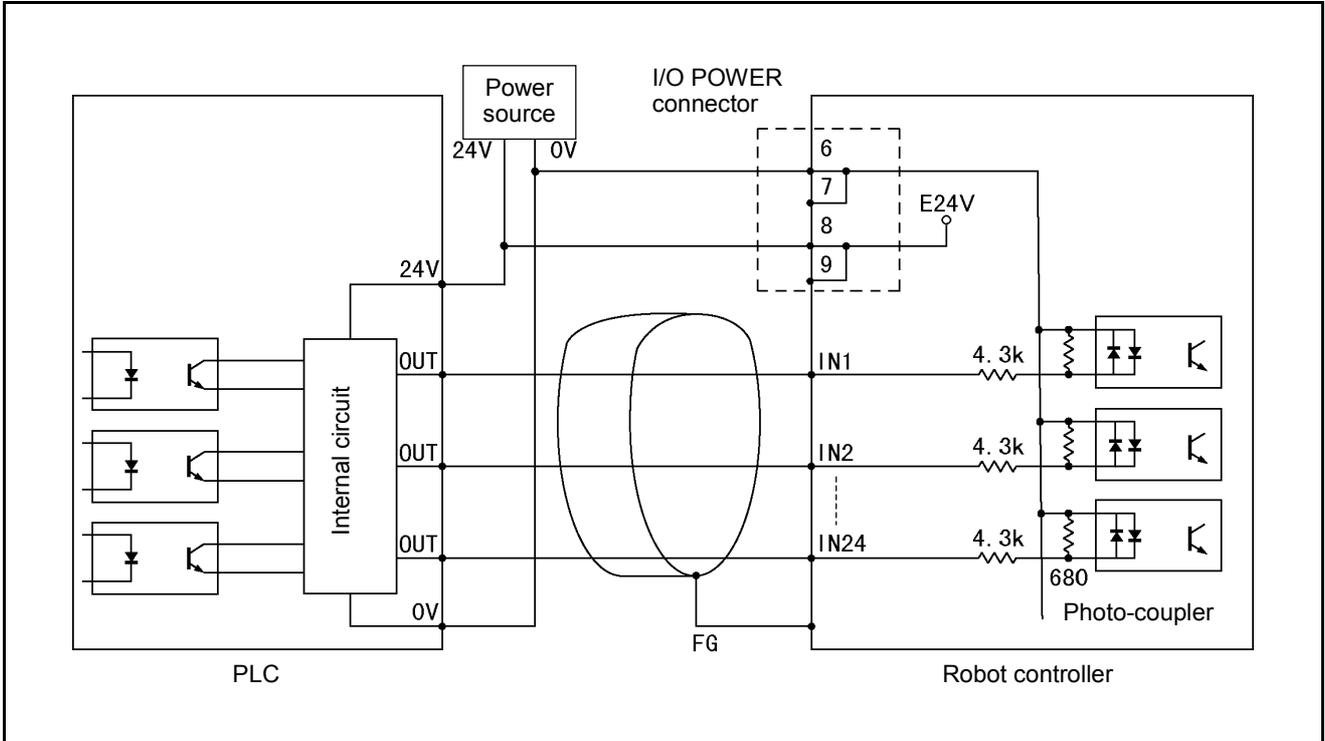
The maximum allowable current capacity of the robot controller's internal power source is 1.3 A.

Use the internal power source within this allowable range.

- | |
|---|
| <p>Caution ① Either an external power supply type or built-in power type Output card is available for the PLC. However, an external power supply type requires an additional power source (24V) to be installed. The power capacity is 15W or more.</p> <p>② When controlling two or more robots with a single PLC using the internal power source of the Robot Controller, set a PLC Output card for each robot.</p> <p>③ Other than a PLC, a proximity switch, or a relay contact may be connected directly to the input terminal of the Robot Controller. In such a case, use the power input to pins 6 to 9 of the I/O power connector. A two-wire photoelectric switch or proximity switch can be connected if its leakage current is 1 mA or less.</p> <p>④ Use a multi-core shielding cable for the purpose of protecting the Robot Controller from noise. Ground it to the robot controller.</p> |
|---|



**User-Input and Hand Input Circuits.
(When the internal power source is used)**

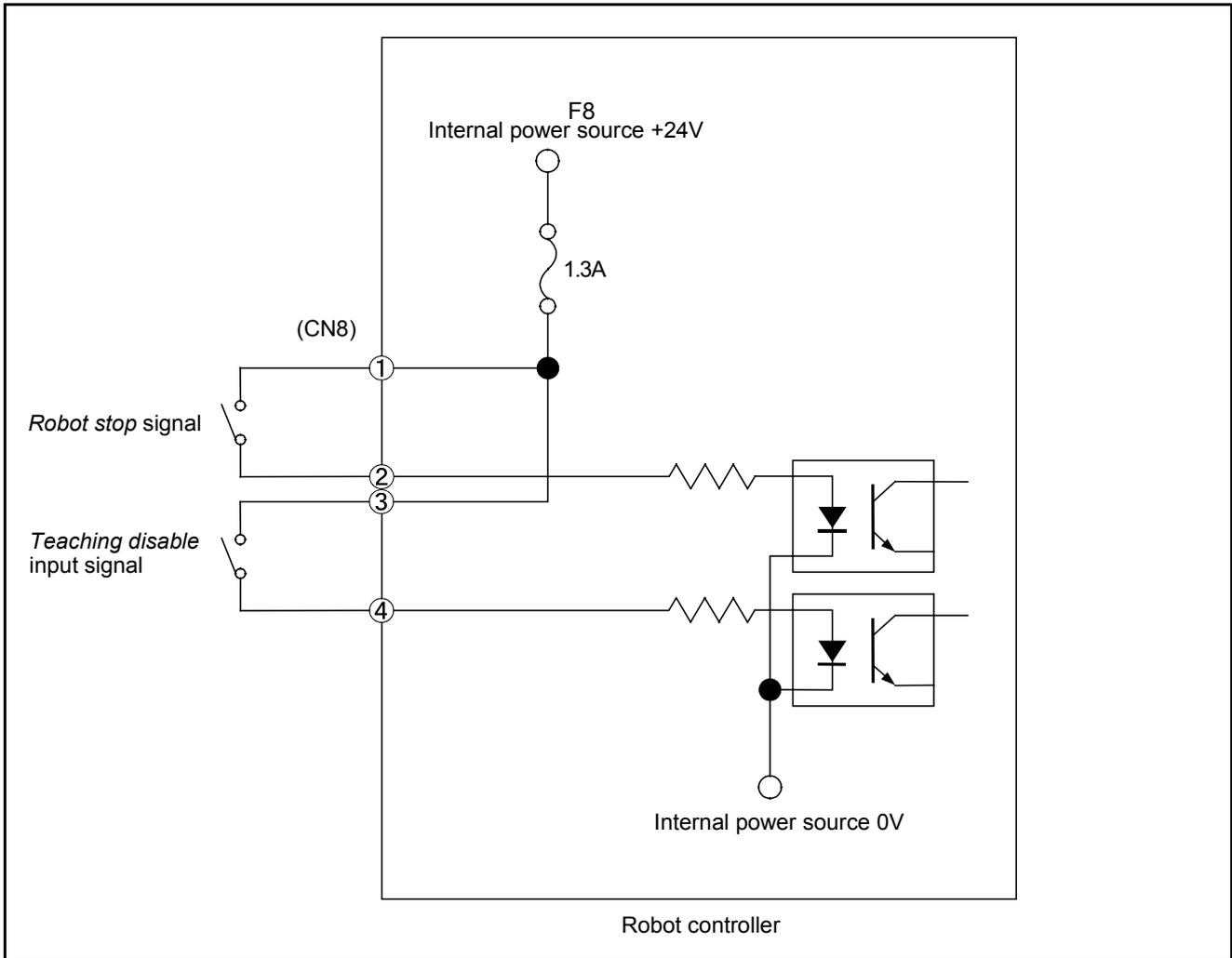


**User-Input and Hand Input Circuits
(When an external power source is used)**

4.2 Robot Stop and Teaching Disable Input Circuits

The robot stop signal and the *Teaching disable* Input signal are important for safety. The input circuit for these signals must have contacts as shown below.

Use the INPUT CN8 (pins 1 and 3) of the robot controller for the power source, irrespective of whether the power source to be used for other I/O signals is the internal power source or an external power source.



Robot Stop and Teaching Disable Input Circuit

4.3 User-Output and Hand Output Circuits

The figures given on the next page show examples of the configuration and connection of the Robot Controller's user-output and hand output circuit.

Since the initial resistance of a lamp is small, the output circuit may be damaged by rush current that flows when the lamp lights.

When directly turning a lamp ON and OFF, use a lamp whose rating is 0.5W or less.

To reduce rush current, select and connect a resistor R that allows dark current 1/3 or less of the rated current to flow when the lamp goes OFF.

An example of connecting a lamp is given on p. 4-6.

(1) The user-output circuits are open collector output circuits.

(2) The maximum allowable intake current is 70mA.

Keep the current consumption of a device to be connected to the Robot Controller, such as a PLC and a relay coil, below the allowable current.

(3) Select an induction load, such as a relay coil, which has a built-in diode (for absorbing inverse electromotive force).

To use an induction load without a built-in diode, add a diode equivalent to the 1S1888 (Toshiba) in close vicinity to the coil.

⚠ Caution: When externally attaching a diode, connect it with correct polarity. Incorrect polarity may damage the Output circuit.

(4) Connecting a lamp requires a circuit through which dark current flows.

⚠ Caution: Since the initial resistance of a lamp is small, the output circuit may be damaged by rush current that flows when the lamp lights. Refer to p. 4-6.

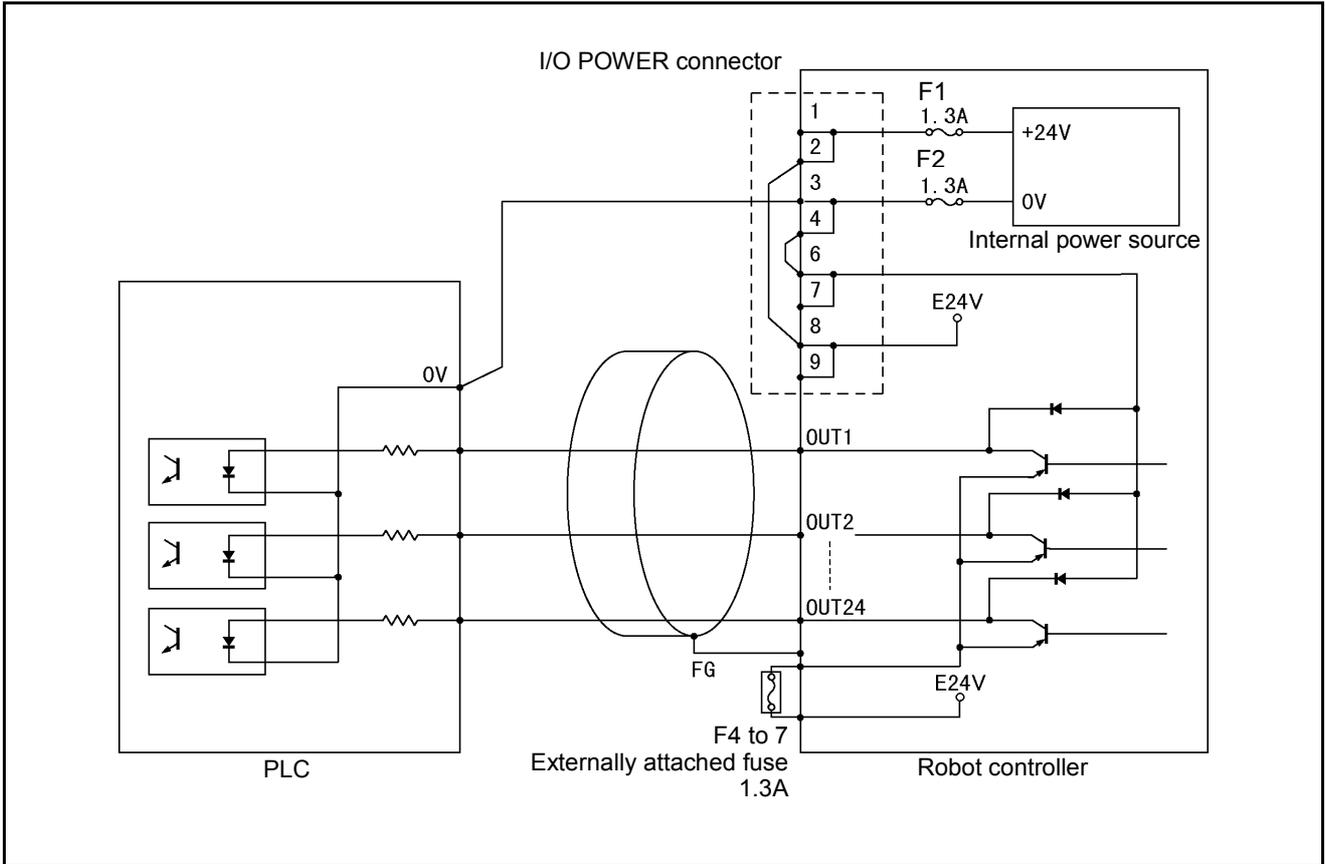
(5) When using the internal power source, prepare a PLC input circuit unit that does not contain a power source.

⚠ Caution: Keep the total current capacity of the internal power source below 1.3A.

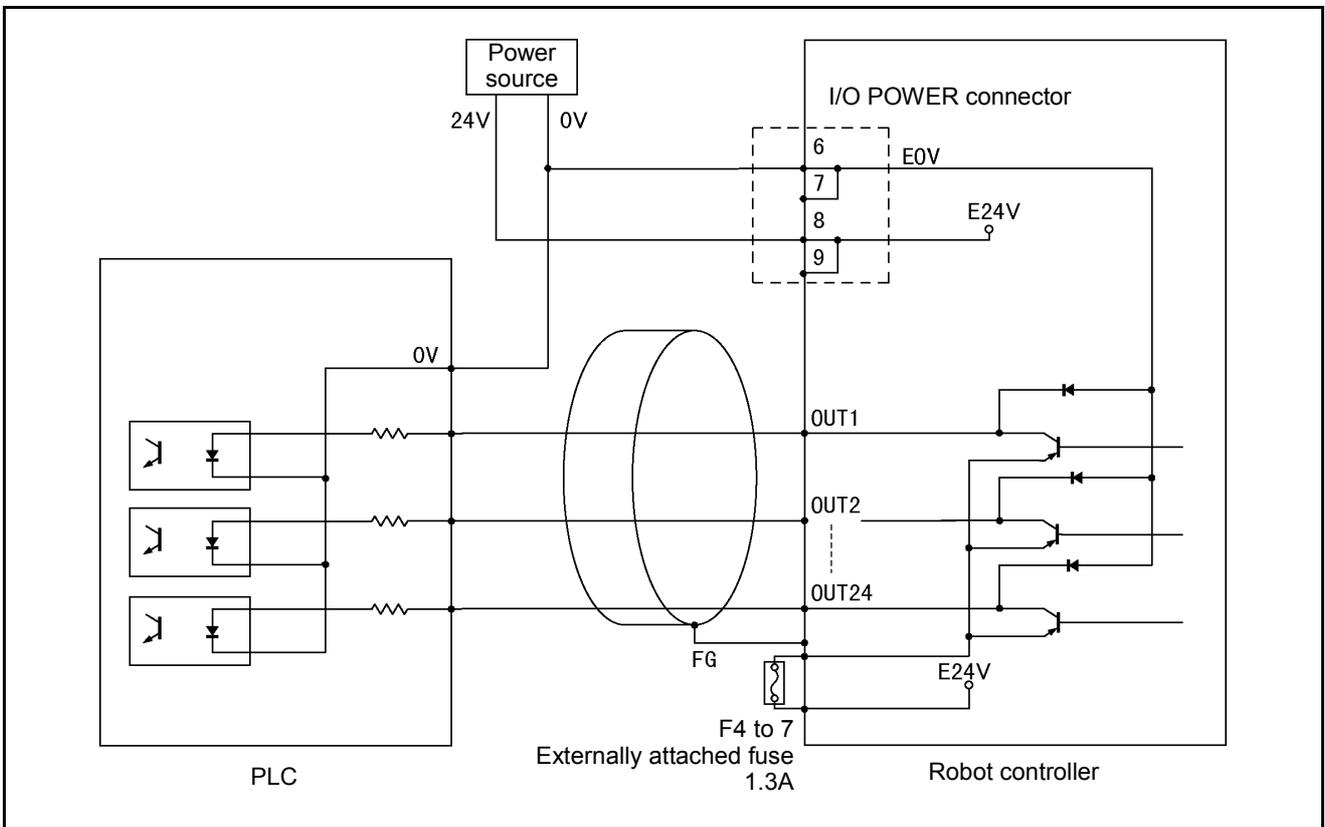
(6) Use a multi-core shielding cable for the purpose of protecting the devices from external noise. Ground it to the Robot Controller.

(7) +24V internal power source of the robot controller must not be grounded.

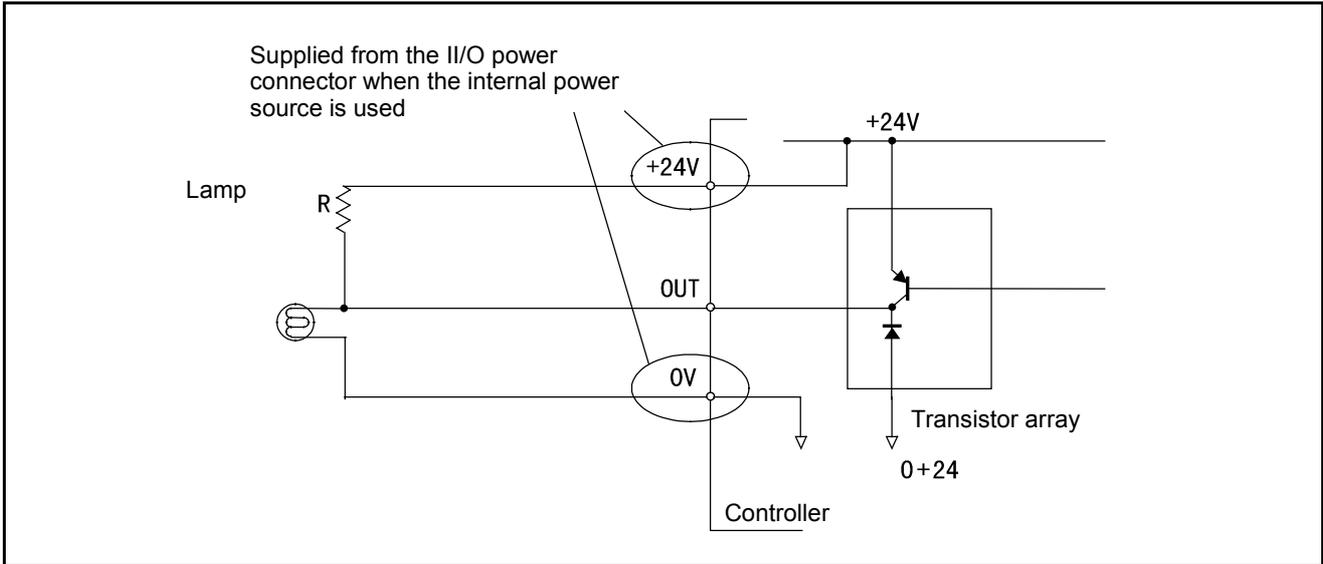
⚠ Caution: If the output terminal +24V of internal power source is grounded, there may be a case where the controller is damaged.



**User-Output and Hand-Output Circuit
(When the internal power source is used)**



**User-Output and Hand-Output Circuit
(When an external power source is used)**

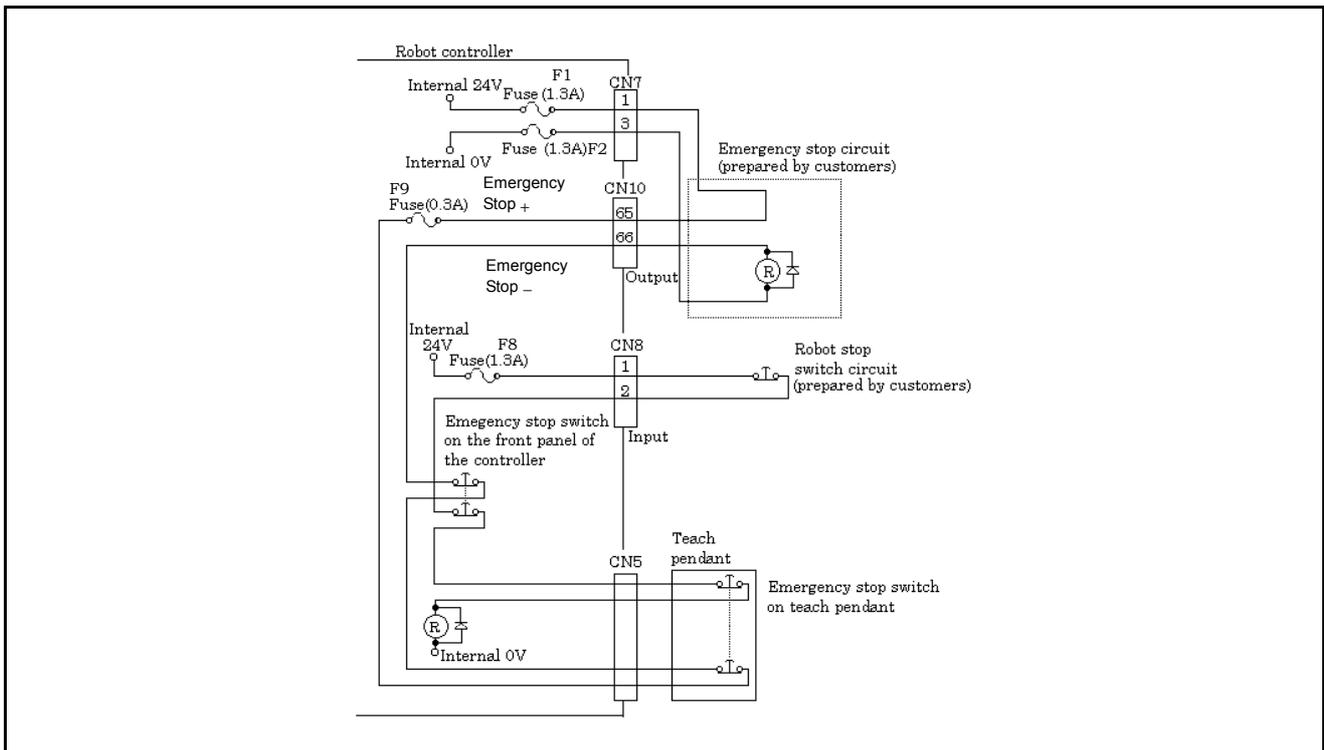


Example of Circuit with Lamp

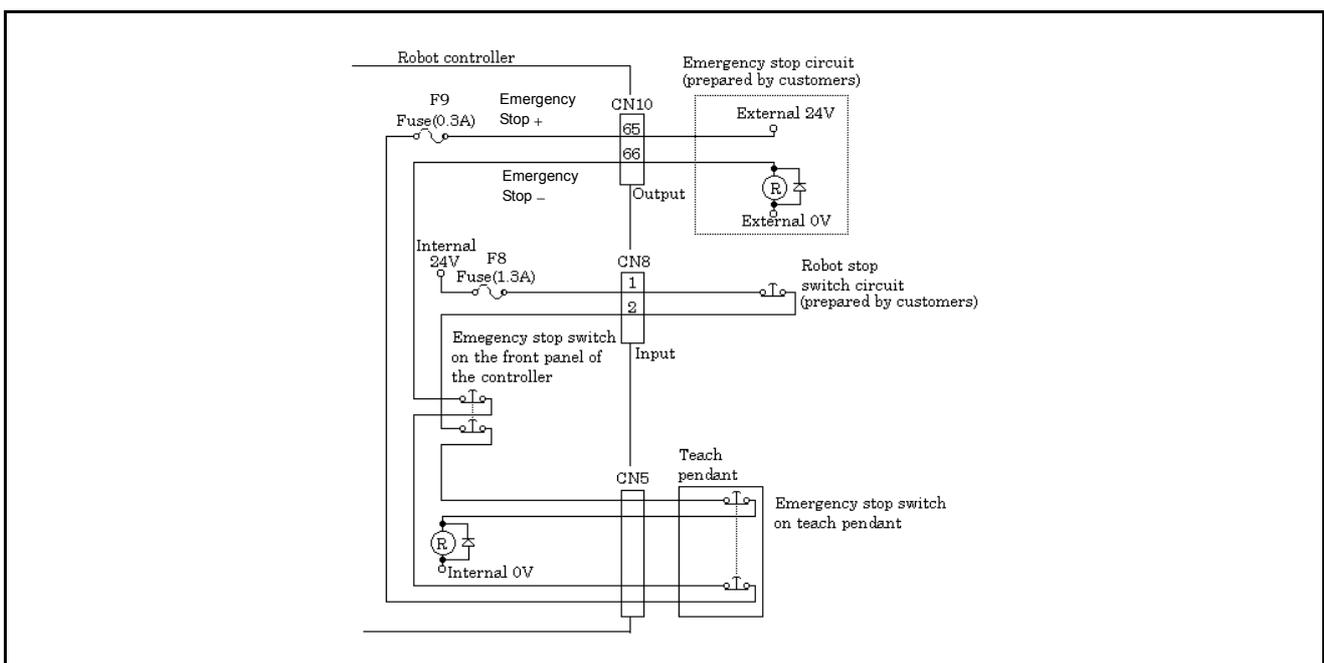
4.4 Emergency Stop Output Circuit

The figures below show the examples of configuration and connection of emergency stop circuit for the robot controller.

The red mushroom-shaped switch provided on the robot controller front panel, on the teach pendant, or on the operating panel can be used as a switch for stopping the equipment in case of emergency.



Emergency Stop Output Circuit (Activated by Internal Power Source)

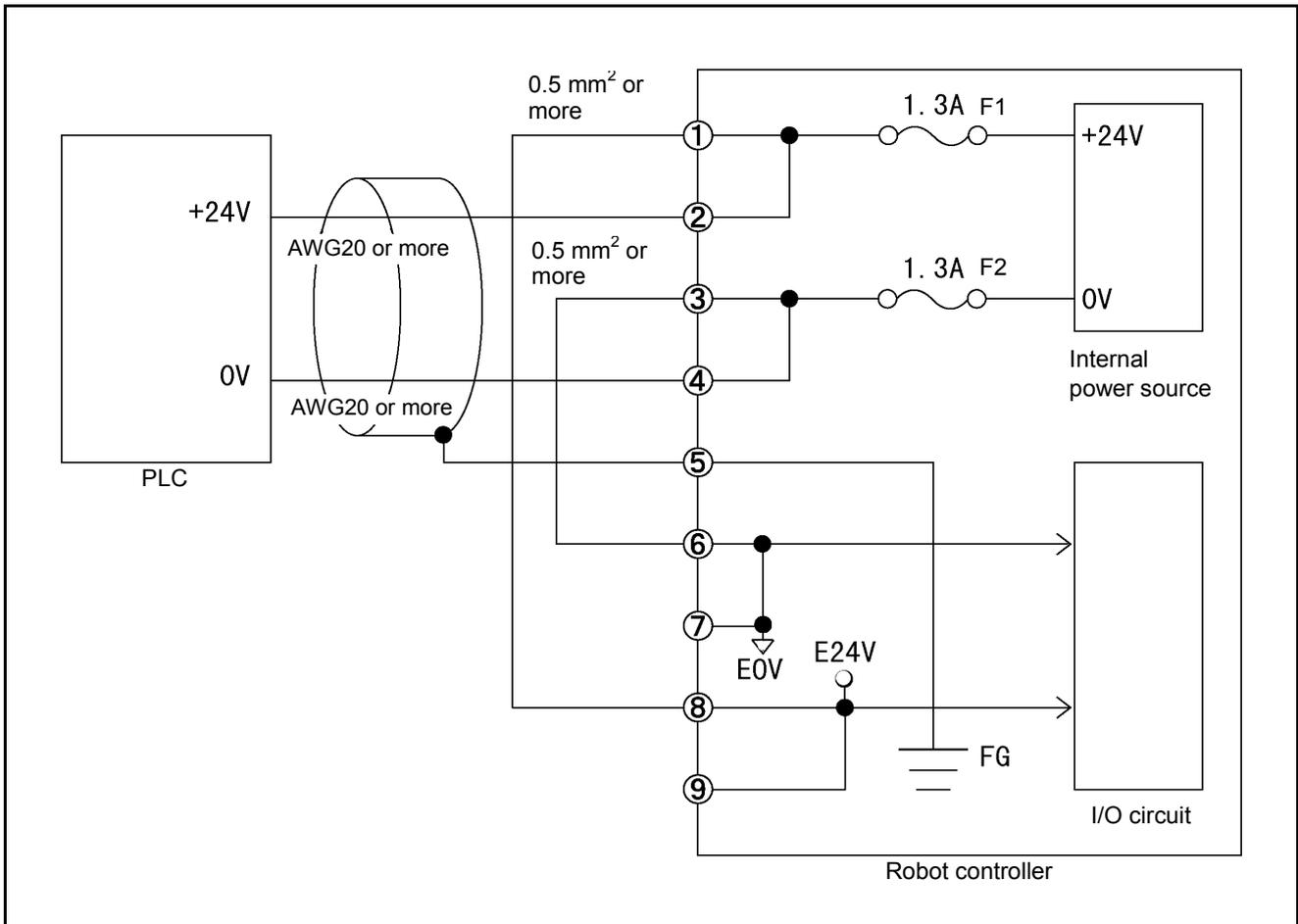


Emergency Stop Output Circuit (Activated by External Power Source)

4.5 I/O Power Connector

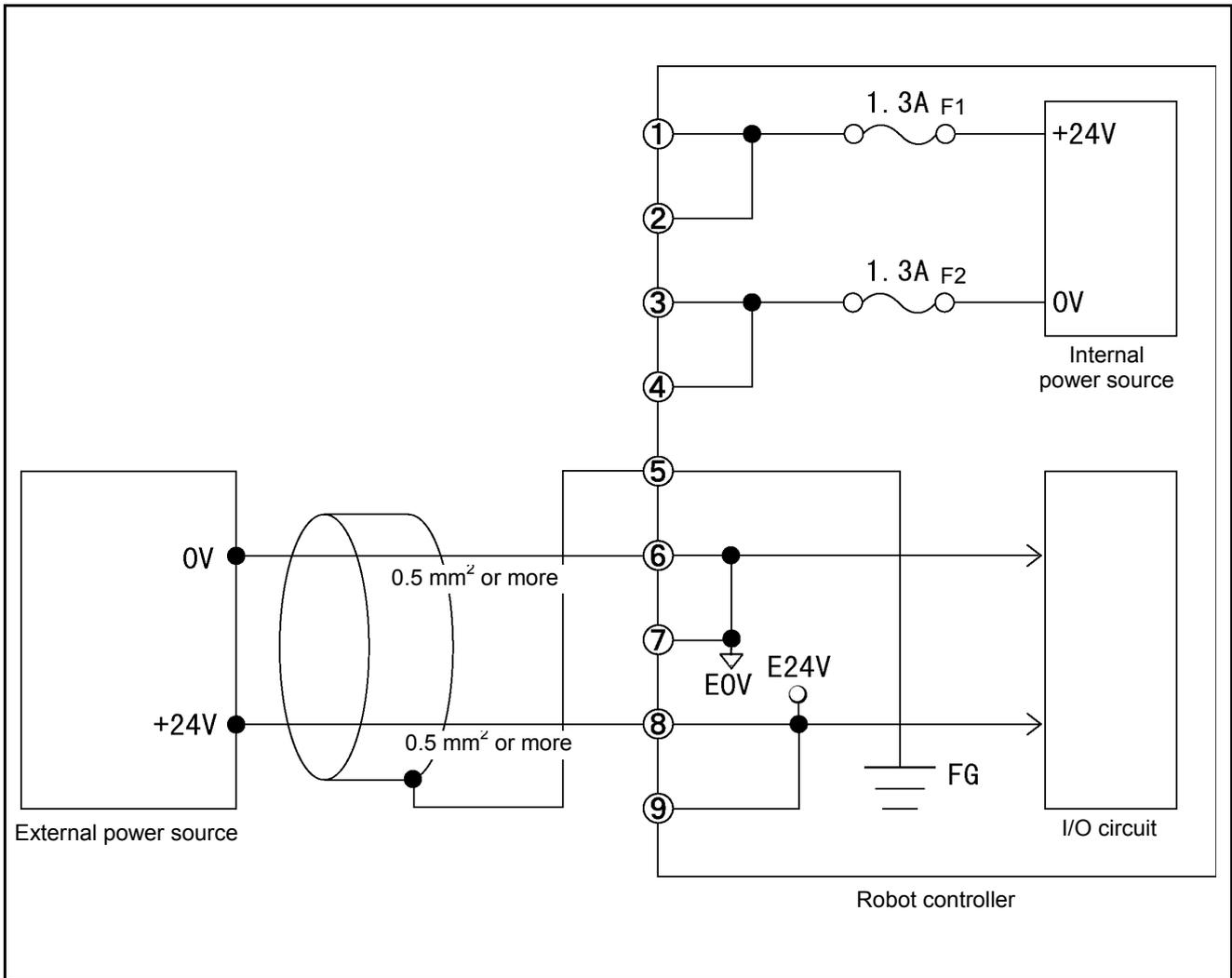
For the power source to communicate signals between the robot controller and the external device, the internal power source of the robot controller or an external power source is used.

The figure below shows an example of connecting I/O power connectors when the internal power source is used, and the figure given on the next page shows an example of connecting I/O power connectors when an external power source is used.



Example of Connecting I/O Power Connectors (When the internal power source is used)

⚠ Caution: To use the internal power source of the robot controller, connect the wiring so that the internal power source will be separate from the external power source. Improper wiring may damage the internal circuit.
+24V internal power source of the robot controller must not be grounded.

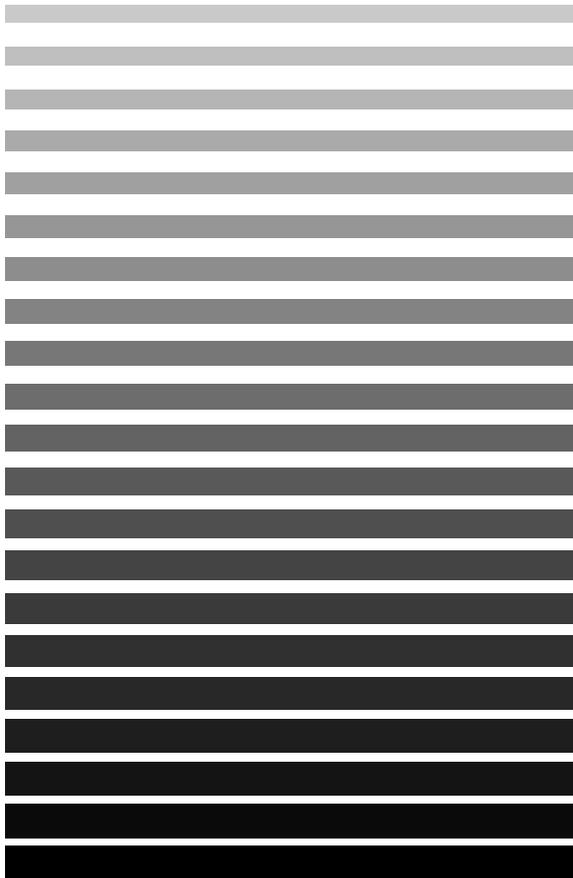


Example of Connecting I/O Power Connectors (When an external power source is used)

Caution: Use a cable of 0.5 mm² or more in size for the wiring between the external power source and the I/O power input connectors of the robot controller.

Appendix

Error Code Table Exclusive to the HM/HS-D-T02



For error codes other than those listed here, refer to the separately issued ERROR CODE TABLES.

Error Codes Exclusively Prepared for the HM/HS-D-T02

| Code | Meaning | What to do: | Motor power | Error output |
|-----------|---|--|-------------|--------------|
| 1987 | Mode switching conditions to the individual mode are not satisfied. (The <i>Teaching disable</i> signal is OFF.) | Turn the <i>Teaching disable</i> signal ON and then switch to the individual mode again. | | ON |
| 1988 | Mode switching conditions to the individual mode are not satisfied. (Input signals exclusive to the individual mode have been turned ON.) | Turn all those dedicated input signals OFF, and then switch to the individual mode again. | | ON |
| 1989 | When the robot was running in the individual mode, the operation mode selection signal was turned OFF. | With the operation mode selection signal being ON, run the robot. | Turns OFF. | ON |
| 1990 | More than one operation mode selection signal has been turned ON at the same time in the individual mode. | More than one operation mode cannot execute simultaneously. To switch the operation modes, turn all the operation mode selection signals OFF and then turn the desired operation mode ON. | Turns OFF. | ON |
| 1991-1996 | A pseudo absolute encoder has been installed to the robot designed for a full absolute encoder. | Replace the current motor with a motor equipped with a full absolute encoder. | | ON |
| 1997 | When the robot was in the individual mode, the <i>Switch to individual mode</i> signal has been turned OFF. | <ol style="list-style-type: none"> 1) For safety, the error code is displayed. To switch to the Auto mode, first clear the error state and then switch the mode. 2) To keep the robot running in the individual mode, first turn the <i>Switch to individual mode</i> ON, turn the <i>Operation ready start</i> ON and then switch to the individual mode. | Turns OFF. | ON |
| 1998 | When the robot was in Auto mode (internal or external), the <i>Switch to individual mode</i> has been turned ON. | <ol style="list-style-type: none"> 1) For safety, the error code is displayed. To switch to the Auto mode, first clear the error state and then switch the mode. 2) To keep the robot running in the individual mode, first turn the <i>Switch to individual mode</i> ON, turn the <i>Operation ready start</i> ON and then switch to the individual mode. | Turns OFF. | ON |
| 1999 | With no mode selected and <i>Switch to individual mode</i> being ON, the Auto mode signal was added. | When switching to Auto mode, first turn the <i>Switch to individual mode</i> OFF and then switch the mode. | Turns OFF. | ON |

Horizontal Articulated Robot HM/HS-D-T02

OWNER'S MANUAL (SUPPLEMENT)

First Edition September 2000

Second Edition October 2001

DENSO WAVE INCORPORATED
Factory Automation Division

10C30C

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.

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