Robot and Machine Tool Integration Function

OPERATOR'S MANUAL

B-75114EN/04

- **Original Instructions**

Thank you very much for purchasing FANUC Robot.

Before using the Robot, be sure to read the "FANUC Robot SAFETY HANDBOOK (B-80687EN)" and understand the content.

The products in this manual are controlled based on Japan's "Foreign Exchange and Foreign Trade Law". The export of Series 30*i*-MODEL A/B, Series 31*i*-MODEL A5/B5 from Japan is subject to an export license by government of Japan. Other models in this manual may also be subject to export controls.

Further, re-export to another country may be subject to the license of the government of the country from where the product is re-exported. Furthermore, the product may also be controlled by re-export regulations of the United States government.

Should you wish to export or re-export these products, please contact FANUC for advice.

In this manual, we endeavor to include all pertinent matters. There are, however, a very large number of operations that must not or cannot be performed, and if the manual contained them all, it would be enormous in volume. It is, therefore, requested to assume that any operations that are not explicitly described as being possible are "not possible".

SAFETY PRECAUTIONS

In this section, the safety instructions for use in a system that Machine Tool equipped with CNC (hereinafter called Machine Tool) and Robot are connected are described. In design of a system that consists of Machine Tool and Robot, adequate risk assessment is necessary and it is need to take safety measures according to the result of risk assessment. Please read carefully this section to understand the safety instructions for use.

If the description in this manual is different from this section, the description in this section is effective. Refer to "RELATED MANUAL" for the following manual numbers.

- About the safety instructions for use and usage of CNC, refer to Common to Lathe System/Machining Center System OPERATOR'S MANUAL corresponding to your using CNC.
- About the safety instructions for use of Robot, refer to "FANUC Robot SAFETY HANDBOOK".
- About usage of Robot, refer to the following manuals corresponding to your using robot controller.
  - FANUC Robot Series R-30*i*A CONTROLLER HANDLING TOOL OPERATOR'S MANUAL
  - FANUC Robot Series R-30*i*A Mate CONTROLLER LR HANDLING TOOL OPERATOR'S MANUAL
  - FANUC Robot Series R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER OPERATOR'S MANUAL (Basic Operation)
  - FANUC Robot Series R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER OPERATOR'S MANUAL (Alarm Code List)

  If necessary, refer to the following manuals.
  - FANUC Robot Series R-30*i*A CONTROLLER MAINTENANCE MANUAL
  - FANUC Robot Series R-30*i*A Mate CONTROLLER MAINTENANCE MANUAL
  - FANUC Robot Series R-30*i*B/R-30*i*B Plus CONTROLLER MAINTENANCE MANUAL
  - FANUC Robot Series R-30*i*B Mate/R-30*i*B Mate Plus CONTROLLER MAINTENANCE MANUAL

  And, refer to the operator's manual for mechanical unit corresponding to your using mechanical unit, too.
- About the safety instructions for use and usage of Machine Tool, refer to the manual published by Machine Tool Builder.

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DEFINITION OF SAFETY NOTATIONS

This manual contains safety precautions against injury and property damage. Those precautions are labeled "Warning" or "Caution", according to the degree of importance. Supplementary explanation is given under "Note". Before starting to use a machine and a robot, carefully read the "Warning", "Caution" and "Note".

⚠WARNING
Failure to follow the instruction given under "Warning" can cause fatal or serious injury to the user. This information is indicated in bold type in a box so that it can be easily distinguished from the main body of this manual.

⚠CAUTION
Failure to follow the instruction given under "Caution" can cause injury to the user or property damage. This information is indicated in a box so that it can be easily distinguished from the main body of this manual.

NOTE
The information given under "Note" is a supplementary explanation, which is neither a warning nor a caution.

- Read this manual carefully, and store it in a safe place.

RELATED MANUAL

The related manuals with this function are as follows. Refer to these manuals according to need.

Name	Drawing No.
FANUC Series 30*i*/31*i*/32*i* -MODEL B CONNECTION MANUAL (HARDWARE)	B-64483EN
FANUC Series 30*i*/31*i*/32*i* -MODEL B MAINTENANCE MANUAL	B-64485EN
FANUC Series 30*i*/31*i*/32*i* -MODEL B Common to Lathe System/Machining Center System OPERATOR'S MANUAL	B-64484EN
FANUC Series 35*i* -MODEL B CONNECTION MANUAL (HARDWARE)	B-64523JA
FANUC Series 35*i* -MODEL B MAINTENANCE MANUAL	B-64525EN
FANUC Series 35*i* -MODEL B OPERATOR'S MANUAL	B-64524EN
FANUC Power Motion *i* -MODEL A CONNECTION MANUAL (HARDWARE)	B-64573EN
FANUC Power Motion *i* -MODEL A MAINTENANCE MANUAL	B-64575EN
FANUC Power Motion *i* -MODEL A OPERATOR'S MANUAL	B-64574EN
FANUC Series 30*i*/31*i*/32*i* -MODEL A CONNECTION MANUAL (HARDWARE)	B-63943EN
FANUC Series 30*i*/31*i*/32*i* -MODEL A MAINTENANCE MANUAL	B-63945EN
FANUC Series 30*i*/31*i*/32*i* -MODEL A Common to Lathe System/Machining Center System OPERATOR'S MANUAL	B-63944EN

Name	Drawing No.
FANUC Series 30*i*/31*i*/32*i* -MODEL A PMC PROGRAMMING MANUAL	B-63983EN
FANUC PICTURE OPERATOR'S MANUAL	B-66284EN (NOTE1)
FANUC Series 0*i* -MODEL D CONNECTION MANUAL (HARDWARE)	B-64303EN
FANUC Series 0*i* -MODEL D MAINTENANCE MANUAL	B-64305EN
FANUC Series 0*i* -MODEL D Common to Lathe System/Machining Center System OPERATOR'S MANUAL	B-64304EN
FANUC Series 0*i* -MODEL D FL-net Board CONNECTION MANUAL	B-64453EN
FANUC Series 0*i* -MODEL D PMC PROGRAMMING MANUAL	B-64393EN
FANUC Series 0*i* -MODEL F CONNECTION MANUAL (HARDWARE)	B-64603EN
FANUC Series 0*i* -MODEL F MAINTENANCE MANUAL	B-64605EN
FANUC Series 0*i* -MODEL F Common to Lathe System/Machining Center System OPERATOR'S MANUAL	B-64604EN
FANUC Series 30i-MODEL A/B, Series 31i-MODEL A/B, Series 32i-MODEL A/B, Series 35i-MODEL B, Power Motion i-MODEL A, Series 0i-MODEL F FL-net Board CONNECTION MANUAL	B-64163EN
FANUC Series 30i-MODEL B, Series 31i-MODEL B, Series 32i-MODEL B, Series 35i-MODEL B, Power Motion i-MODEL A, FANUC Series 0i-MODEL F PMC	B-64513EN
FANUC Robot SAFETY HANDBOOK	B-80687EN
FANUC Robot Series R-30*i*A CONTROLLER MAINTENANCE MANUAL	B-82595EN
FANUC Robot Series R-30*i*A Mate CONTROLLER MAINTENANCE MANUAL	B-82725EN
FANUC Robot Series R-30*i*B/R-30*i*B Plus CONTROLLER MAINTENANCE MANUAL	B-83195EN
FANUC Robot Series R-30*i*B Mate/R-30*i*B Mate Plus CONTROLLER MAINTENANCE MANUAL	B-83525EN
FANUC Robot Series R-30*i*A CONTROLLER HANDLING TOOL OPERATOR'S MANUAL	B-82594EN-2 or B-83124EN-2
FANUC Robot Series R-30*i*A Mate CONTROLLER LR HANDLING TOOL OPERATOR'S MANUAL	B-82724EN-1 or B-83134EN-1
FANUC Robot Series R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER OPERATOR'S MANUAL (Basic Operation)	B-83284EN
FANUC Robot Series R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER OPERATOR'S MANUAL (Alarm Code List)	B-83284EN-1
FANUC Robot Series R-30*i*A/R-30*i*A Mate/R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER FL-net Interface OPERATOR'S MANUAL	B-82674EN
FANUC Robot Series R-30*i*A/ R-30*i*A Mate/R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER Ethernet Function OPERARTOR'S MANUAL	B-82974EN
FANUC Robot Series R-30*i*A/ R-30*i*A Mate CONTROLLER Dual Check Safety Function (ISO 13849-1:2006 COMPLIANT) Operation Manual	B-83104EN
FANUC Robot Series R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER Dual Check Safety Function Operation Manual	B-83184EN
FANUC Robot Series R-30*i*A CONTROLLER Integrated PMC OPERARTOR'S MANUAL	B-82614EN
FANUC Robot Series R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER Integrated PMC OPERARTOR'S MANUAL	B-83254EN

NOTE
1 FANUC PICTURE OPERARTOR'S MANUAL (B-66284EN) is common to 30*i*/31*i*/32*i*-A/B, 35*i*-B, Power Motion *i* –A, 0*i*-D and 0*i*-F .
2 About the manual of the robot mechanical unit, the manuals for every robot type exist. Refer to the operator's manual for mechanical unit corresponding to your using mechanical unit.

CONNECTION TO EMERGENCY STOP CIRCUIT

Connect emergency stop circuit so that both the machine tool and the robot are in emergency stop status, when the emergency stop button of either machine tool or the robot is pressed.

- As the method of emergency stop of the system, the emergency stop of both the machine tool and the robot are used. If only the shut down of servo power is required, use the servo off signal in the robot controller.
- Connect the emergency stop signal to the EES1, EES11, EES2, EES21 (for dual chain controller) or EXEMGIN1, EXEMGIN2 (for single chain controller) input signal in the robot controller.
- Connect the servo off signal to the EGS1, EGS11, EGS2, EGS21 (for dual chain controller) or SVOFF1, SVPFF2 (for single chain controller) input signal in the robot controller.
- For explanation about how to connect, refer to one of the following manuals corresponding to your using robot controller.
  - FANUC Robot Series R-30*i*A CONTROLLER MAINTENANCE MANUAL
  - FANUC Robot Series R-30*i*A Mate CONTROLLER MAINTENANCE MANUAL
  - FANUC Robot Series R-30*i*B/R-30*i*B Plus CONTROLLER MAINTENANCE MANUAL
  - FANUC Robot Series R-30*i*B Mate/R-30*i*B Mate Plus CONTROLLER MAINTENANCE MANUAL

CONNECTION TO SAFETY FENCE SIGNAL

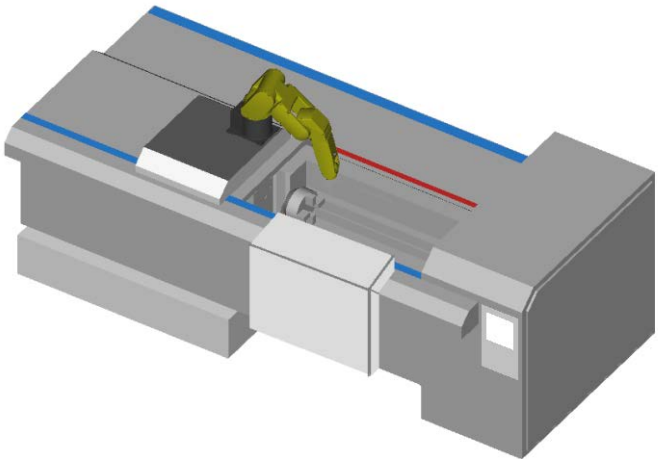
Place the safety fence so that the motion range of the robot is surrounded completely, and connect the signal which indicates the open/close status of the fence to the robot controller.

- Connect the safety fence signal to EAS1, EAS11, EAS2, EAS21 (for dual chain controller) or FENCE1, FENCE2 (for single chain controller) in the robot controller so that the robot is stopped immediately when the safety fence is opened during automatic operation of the robot. When the robot controller is T1 mode or T2 mode, even if the safety fence is opened, it is possible to operate the robot by the robot teach pendant. When the robot controller is T2 mode, because the special speed limitation at program execution is none, it is need to take safety measures adequately.
- By Dual Check Safety (DCS) position check function, it is possible to narrow the motion range of the robot safely. In order to narrow the motion range of the robot by DCS position check function, read "FANUC Robot Series R-30*i*A / R-30*i*A Mate CONTROLLER Dual Check Safety Function (ISO 13849-1:2006 COMPLIANT) Operation Manual" or "FANUC Robot Series R-30*i*B / R-30*i*B Mate / R-30*i*B Plus / R-30*i*B Mate Plus CONTROLLER Dual Check Safety Function Operation Manual" carefully, and adequate risk assessment is required. For DCS position check function, special hardware for DCS is needed, and DCS position check function is software option of the robot controller.
- If it is need to stop not only the robot but also the machine tool when the safety fence is opened during automatic operation, connect the signal which indicates the open/close status of the safety fence to CNC.

SAFETY DOOR OF MACHINE TOOL

Connect the signal which indicates the open/close state of safety door of the machine tool to CNC.

- In the system that the safety door of the machine tool limits the operator entering into the motion range of the robot, connect the signal which indicates the open/close state of safety door of the machine tool to the robot controller as the safety fence signal in the robot controller.

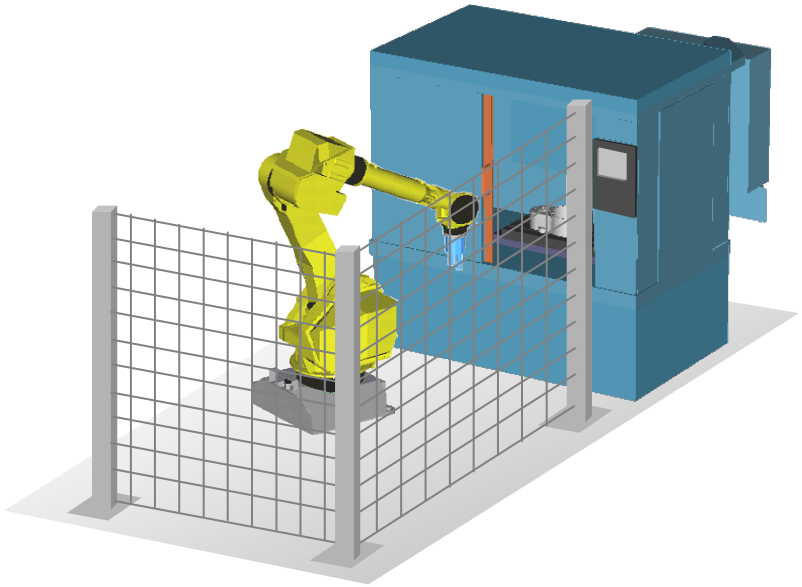


Machine Tool and Robot (1)

IN CASE THAT ROBOT IS OPERATED ON CNC OPERATOR'S PANEL

In case that the robot is operated on CNC operator's panel, place the CNC operator's panel out of the motion range of the robot and the safety fence.

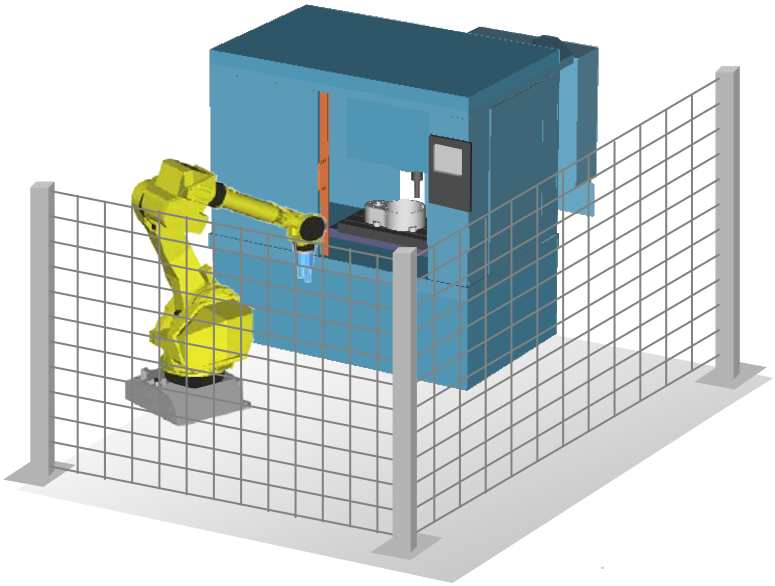
- In order to operate the robot on CNC operator's panel, it is required that the robot controller is AUTO mode and the safety fence is closed.



Machine Tool and Robot (2)

IN CASE THAT CNC OPERATOR'S PANEL IS PLACED INSIDE SAFETY FENCE

- In case that CNC operator's panel is placed inside the safety fence, it is not possible to operate the robot by CNC operator's panel. Do not display Robot Remote Operation Screen on CNC operator's panel.



Machine Tool and Robot (3)

ABOUT LADDER PROGRAM IN CNC

About following 2 functions, a sample ladder program is provided.

- The ladder program for system running to operate CNC interlocking with the robot.
- The ladder program for remote operation screen to operate the robot by the operation on CNC screen.

Customize these ladder programs in accordance with the specification of the machine applied this ladder program. And, test the performance of these ladder programs adequately.

ABOUT DIFFERENCE BY TYPE OF CNC

In this book, 30*i* is used for the explanation of CNC. The display color and word might be somewhat different for other CNC.

ABOUT TOUCH PANEL

Please be careful of the following points about the touch panel on CNC operator's panel and the robot teach pendant.

- Please operate the touch panel using finger or the special pen for touch panel. The operation by the instrument which tip is sharp like as a writing pen may cause the trouble of touch panel.
- When two or more points on touch panel are touched at the same time, the detected point may be different from the touched points. Please touch only one point on touch panel per one action.

Caution about CNC operator's panel

- Please do not make the touch panel operation screen where two points or more are pushed at the same time. When two points or more are pushed at the same time, the touch panel might work as if the

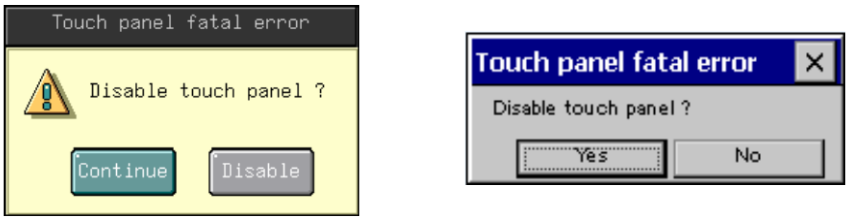
center of the points was pushed. In this case, there is a possibility of the accident due to the mis-output and the malfunction.

- Please do not include the following operations to the touch panel screen.
  - Operation related to safeties of life and significant damage, etc.
  - Operation that requires emergency and real-time action

  There is a possibility of the accident due to the mis-output and the malfunction when the main body, the unit, and the cable, etc. break down.
  Moreover, there is no guarantee of the real time action of the screen.

Caution about robot teach pendant

When the following window is displayed on the robot teach pendant, the touch panel of the robot teach pendant may break down. In this case, please turn off the power of the robot controller, then replace the robot teach pendant.



Warning display for the touch panel error

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1 OVERVIEW

This function enables you to connect the machine tool with the robot, and to make them cooperate.
It is composed of the following three functions.

Function to connect CNC with robot (CNC and robot)

- Easy connection of CNC and Robot
  The standard interface signal is defined in both CNC and the robot to connect CNC and the robot easily, and the ladder program based on the standard interface signal is provided.

Please refer to the following chapters.
- About the connection and the setting of CNC and the robot
  - ・2. CONNECTION OF CNC AND ROBOT
  - ・3. SETTING AND CUSTOMIZING IN CNC
  - ・4. SETTING IN ROBOT
- About the standard interface signal between CNC and the robot, NC program and robot program
  - ・7. INTERFACE BETWEEN CNC AND ROBOT
  - ・8. NC PROGRAM
  - ・9. ROBOT PROGRAM
  - ・10. ROBOT LADDER PROGRAM

Function to display the robot status and to operate robot at CNC（CNC）

- Robot status display
  The state of I/O and the alarm of the robot are displayed in CNC.
- Robot program management
  The robot program is managed in the combination of the NC program.
- Robot remote operation
  The sample screen and the sample ladder program are provided. They are used for operating the robot remotely from CNC.

Please refer to the following chapter.
- ・5. ROBOT SCREEN ON CNC

Function to display CNC status and to operate CNC at robot (robot)

- CNC status display
  The status of CNC is displayed on the robot teach pendant.
- CNC operation
  Machine Tool Operation and Input of Tool Offset in CNC can be done on the robot teach pendant.

Please refer to the following chapter.
- ・6. CNC SCREEN ON ROBOT

1.1 NECESSARY SOFTWARE OPTION

To use this function, a software option is necessary in both CNC and the robot controller. Table 1.1(a) shows a supported model and necessary software option in each of CNC and the robot controller.

Table1.1 (a) Supported model and necessary option

	Supported model	option
CNC	Series 30*i*/31*i*/32*i*/35*i*-B Power Motion *i*-A	・Robot connection function（A02B-xxxx-R683） where “xxxx” is 0323 : FANUC Series 30*i* -MODEL B 0326 : FANUC Series 31*i* -MODEL B5 0327 : FANUC Series 31*i* -MODEL B 0328 : FANUC Series 32*i* -MODEL B 0333 : FANUC Series 35*i* -MODEL B 0334 : FANUC Power Motion *i* -MODEL A
	Series 30*i*/31*i*/32*i*-A	・Robot connection function（A02B-xxxx-R683） where “xxxx” is 0303 : FANUC Series 30*i* -MODEL A 0306 : FANUC Series 31*i* -MODEL A5 0307 : FANUC Series 31*i* -MODEL A 0308 : FANUC Series 32*i* -MODEL A
	Series 0*i*-D	・Robot connection function（A02B-xxxx-R683） where “xxxx” is 0319 : FANUC Series 0*i* MODEL-TD 0320 : FANUC Series 0*i* MODEL-MD
	Series 0*i*-F	・Robot connection function（A02B-xxxx-R683） where “xxxx” is 0339 : FANUC Series 0*i* MODEL-TF 0340 : FANUC Series 0*i* MODEL-MF
Robot controller	R-30*i*B/R-30*i*B Mate or later	・Machine Tool Easy Setup & Connection（A05B-2600-R808）
	R-30*i*A/R-30*i*A Mate	・Machine Tool connection function（A05B-2500-J984）

Moreover, the following options are necessary depending on the connection method between CNC and the robot controller and the function to use.
About the value and the meaning of middle number xxxx in drawing number in the following description, please refer to the column corresponding to CNC model in above table 1.1(a).

Robot Controller

Table 1.1(b) shows the type of I/O transmission and necessary option.

Table 1.1 (b) Type of I/O transmission and necessary option

Type of I/O transmission	Necessary option in robot controller
I/O Link	<None>
FL-net	・FL-net Interface (A05B-2600-J759 : R-30*i*B/R-30*i*B Mate or later) (A05B-2500-J759 : R-30*i*A/R-30*i*A Mate)

The Ethernet is a standard function in robot controller. Therefore, option is unnecessary.

Series 30*i*/31*i*/32*i*-B

Table 1.1(c) shows the type of I/O transmission and necessary option.

Table 1.1 (c) Type of I/O transmission and necessary option

Type of I/O transmission	Necessary option in CNC
I/O Link	<None>
FL-net	・FL-net function (A02B-xxxx-J692)

Table 1.1(d) shows a type of Ethernet communication in CNC and necessary option.

Table 1.1 (d) Type of Ethernet communication in CNC and necessary option

Type of Ethernet communication	Necessary option in CNC
Embedded Ethernet	<None>
Multi-function Ethernet or FAST Ethernet board	・Ethernet function (A02B-xxxx-S707) ・Fast Ethernet software (A02B-0323-J561#658K)

When the ROBOT REMOTE OPERATION screen provided as a sample program of FANUC PICTURE is used in CNC, the option shown in Table 1.1(e) is necessary.

Table 1.1 (e) Necessary option for ROBOT REMOTE OPERATION screen

Function to use	Necessary option in CNC
ROBOT REMOTE OPERATION screen	・ FANUC PICTURE function (A02B-xxxx-S879) or FANUC PICTURE function for non-touch panel display (A02B-xxxx-S944) or FANUC PICTURE Executor (A02B-xxxx-R644)

Series 35*i*-B, Power Motion *i*-A

Table 1.1(f) shows the type of I/O transmission and necessary option.

Table 1.1 (f) Type of I/O transmission and necessary option

Type of I/O transmission	Necessary option in CNC
I/O Link	<None>
FL-net	・FL-net function (A02B-xxxx-J692)

Table 1.1(g) shows a type of Ethernet communication in CNC and necessary option.

Table 1.1 (g) Type of Ethernet communication in CNC and necessary option

Type of Ethernet communication	Necessary option in CNC
Embedded Ethernet	<None>
Multi-function Ethernet or FAST Ethernet board	・Ethernet function (A02B-xxxx-S707) ・Fast Ethernet software (A02B-xxxx-J561#658K)

When the ROBOT REMOTE OPERATION screen provided as a sample program of FANUC PICTURE is used in CNC, the option shown in Table 1.1(h) is necessary.

Table 1.1 (h) Necessary option for ROBOT REMOTE OPERATION screen

Function to use	Necessary option in CNC
ROBOT REMOTE OPERATION screen	・ FANUC PICTURE function (A02B-xxxx-R708) or FANUC PICTURE Executor (A02B-xxxx-R644)

Series 30*i*/31*i*/32*i*-A

Table 1.1(i) shows the type of I/O transmission and necessary option.

Table 1.1 (i) Type of I/O transmission and necessary option

Type of I/O transmission	Necessary option in CNC
I/O Link	<None>
FL-net	・FL-net function (A02B-xxxx-J692)

Table 1.1(j) shows a type of Ethernet communication in CNC and necessary option.

Table 1.1 (j) Type of Ethernet communication in CNC and necessary option

Type of Ethernet communication	Necessary option in CNC
Embedded Ethernet	<None>
FAST Ethernet board	・Ethernet function (A02B-xxxx-S707) ・Control software function for Fast Ethernet (A02B-0303-J561#6569)
FL-net/Ethernet coexisting function	・Ethernet function (A02B-xxxx-S707) ・FL-net/Ethernet coexisting function (A02B-xxxx-R951)

When the ROBOT REMOTE OPERATION screen provided as a sample program of FANUC PICTURE is used in CNC, the option shown in Table 1.1(k) is necessary.

Table 1.1 (k) Necessary option for ROBOT REMOTE OPERATION screen

Function to use	Necessary option in CNC
ROBOT REMOTE OPERATION screen	・ FANUC PICTURE function (A02B-xxxx-S879) or FANUC PICTURE function for non-touch panel display (A02B-xxxx-S944)

Series 0*i*-D

Table 1.1(l) shows the type of I/O transmission and necessary option.

Table 1.1 (l) Type of I/O transmission and necessary option

Type of I/O transmission	Necessary option in CNC
I/O Link	<None>
FL-net	・FL-net function (A02B-xxxx-J692)

Table 1.1(m) shows a type of Ethernet communication in CNC and necessary option.

Table 1.1 (m) Type of Ethernet communication in CNC and necessary option

Type of Ethernet communication	Necessary option in CNC
Embedded Ethernet	<None>
FAST Ethernet board	・Ethernet function (A02B-xxxx-S707) ・Control software function for Fast Ethernet (A02B-0319-J561#658W)

When the ROBOT REMOTE OPERATION screen provided as a sample program of FANUC PICTURE is used in CNC, the option shown in Table 1.1(n) is necessary.

Table 1.1 (n) Necessary option for ROBOT REMOTE OPERATION screen

Function to use	Necessary option in CNC
ROBOT REMOTE OPERATION screen	・ FANUC PICTURE function (A02B-xxxx-R644) ・ Custom software size (Equal to or more than 4MB) (A02B-xxxx-J738#?M) where "?" is Custom software size.

Series 0*i*-F

Table 1.1(o) shows the type of I/O transmission and necessary option.

Table 1.1 (o) Type of I/O transmission and necessary option

Type of I/O transmission	Necessary option in CNC
I/O Link	<None>
FL-net (Type 1 only)	・FL-net function (A02B-xxxx-J692)

Table 1.1(p) shows a type of Ethernet communication in CNC and necessary option.

Table 1.1 (p) Type of Ethernet communication in CNC and necessary option

Type of Ethernet communication	Necessary option in CNC
Embedded Ethernet	<None>
FAST Ethernet board (Type 1 only)	・Ethernet function (A02B-xxxx-S707)

When the ROBOT REMOTE OPERATION screen provided as a sample program of FANUC PICTURE is used in CNC, the option shown in Table 1.1(q) is necessary.

Table 1.1 (q) Necessary option for ROBOT REMOTE OPERATION screen

Function to use	Necessary option in CNC
ROBOT REMOTE OPERATION screen	・ FANUC PICTURE function (A02B-xxxx-R644) ・ Custom software size (Equal to or more than 4MB) (A02B-xxxx-J738#?M) where "?" is Custom software size.

1.2 CONNECTION OF CNC AND ROBOT

To use this function, CNC and the robot controller are connected by I/O transmission and data communication.

- FL-net or I/O Link is used for I/O transmission.
- Ethernet is used for the data communication. The data communication is dispensable. But when the data communication is not used, there is a limitation of the function. The following functions cannot be used.
  - Transmission of I/O comment from the robot controller to CNC
  - Display of alarm message generated in the robot controller on the ROBOT STATUS screen of CNC
  - Display of CNC status on the teach pendant of robot controller
  - Machine Tool operation by the teach pendant of robot controller
  - Input of Tool Offset in CNC on the teach pendant of robot controller
- Up to four CNCs can be connected to one robot.

1.3 NECESSARY ITEMS FOR CNC

To use this function, the following items are necessary for CNC.

1. PMC data area from 1:R7000 to 1:R7999
   This function uses PMC data area from 1:R7000 to 1:R7999 as a default. When this area has already been using, other area can be used.
2. Button on machine operator's panel
   Please prepare the following three buttons and switch on the machine operator's panel.
   - ・ Selection switch of interlock mode / stand-alone mode
   - ・ Robot operation button

・ Cycle stop button

3. M code
   Three M codes, M60, M61 and M62 are used in NC program to request the operation to the robot. When these M codes have already been using, other M codes can be used.

For details, please refer to "3. SETTING AND CUSTOMIZING IN CNC".

1.4 NOTE IN THE ROBOT CONTROLLER

1.4.1 Note in R-30*i*A/R-30*i*A Mate Controller

In R-30*i*A/R-30*i*A Mate controller, there are following notes according to the software series and version.

Series 7DA5

- This option is supported at version 03.
- The connection with Series 0*i*-D is supported at version 06.
- The Tool Offset Screen is added at version 07. (About Tool Offset Screen, please refer to “6.2.2 Tool Offset Screen”.)
- The connection with Series 35*i*-B and the connection with Power Motion *i*-A are not supported.

Series 7DA7

- This option is supported from first version.
- The connection with Series 35*i*-B and the connection with Power Motion *i*-A are not supported.

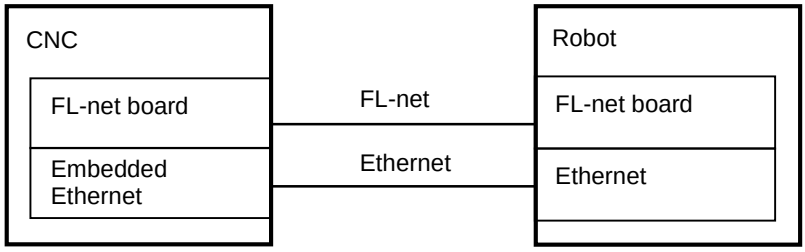
1.4.2 Note in R-30*i*B Mate Controller or Later

In R-30*i*B Mate controller or later, the main board with PMC is required in order to use this function.

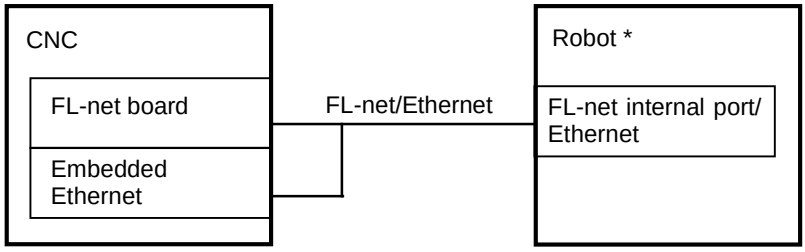
2 CONNECTION OF CNC AND ROBOT

CNC and the robot controller are connected by using I/O transmission and data communication.

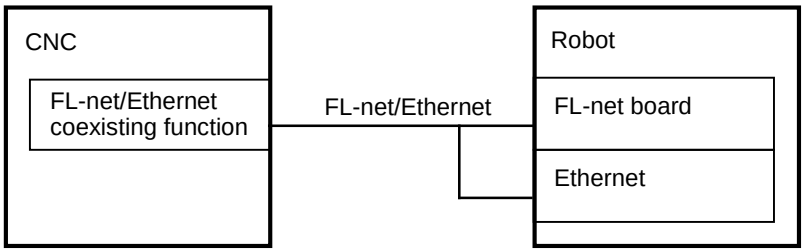
- FL-net or I/O Link is used for I/O transmission.
- Ethernet is used for data communication.
- The example of the connection between CNC and the robot is shown below.



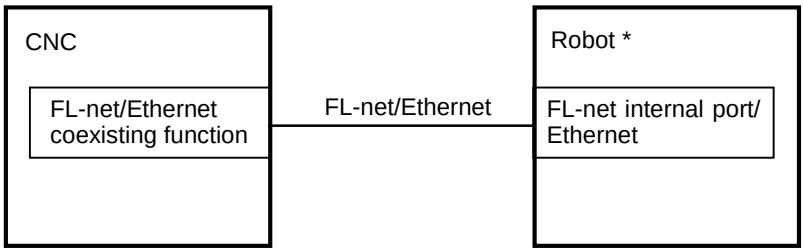
FL-net is used for I/O transmission (1)



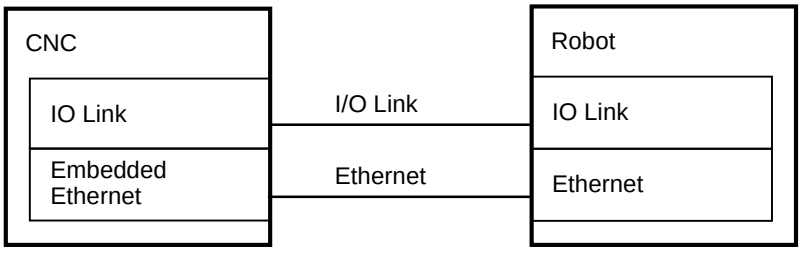
FL-net is used for I/O transmission (2)



FL-net is used for I/O transmission (3)



FL-net is used for I/O transmission (4)



I/O Link is used for I/O transmission

Fig.2 Example of the connection of CNC and robot

* In the robot controller, R-30*i*A/R-30*i*A Mate controller do not support FL-net internal port.

This chapter explains the following content necessary for I/O transmission and data communication between CNC and the robot.

- Connection of I/O transmission between CNC and the robot controller
- Setting of CNC and the robot controller for I/O transmission
- Connection of data communication between CNC and the robot controller
- Setting of CNC and the robot controller for data communication

2.1 CNC NUMBER

Up to four CNCs can be connected with one robot controller. The robot controller identifies connected four CNCs by the CNC number.
The robot controller allocates the CNC number to connected CNC in order of the I/O ALLOCATION, and outputs CNC number to each CNC by I/O signals.
CNC number is also used in data communication. In the setting of the data communication of the robot controller, it is necessary to set the CNC number.

2.2 CONNECTION AND SETTING OF I/O TRANSMISSION

By using FL-net or I/O Link between CNC and the robot controller, I/O signals are connected as follows. I/O signals used between one CNC and the robot controller are 256 points (bit) for each In/Out.

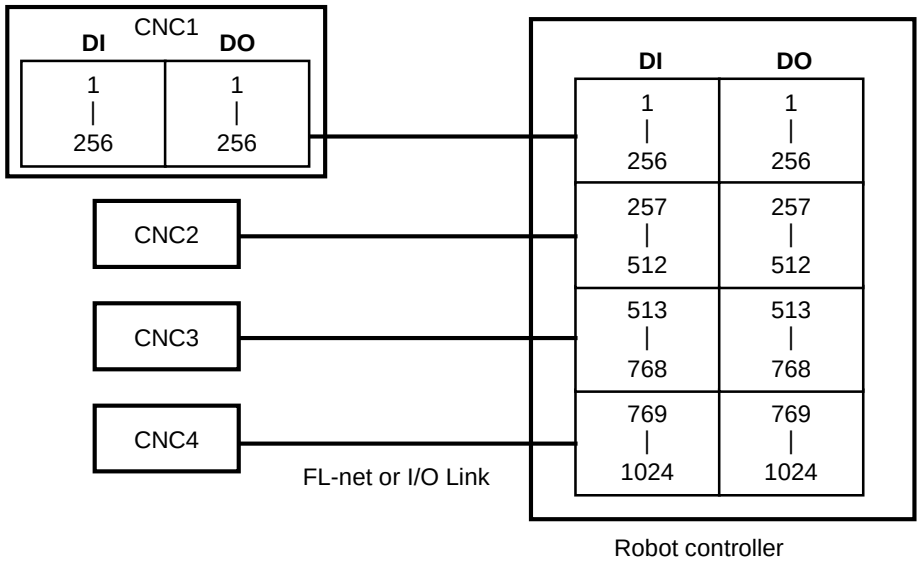


Fig. 2.2 I/O connection of CNC and robot controller

2.2.1 Wiring when FL-net is Used

When FL-net is used, the following devices are necessary.

Table 2.2.1 Devices for FL-net connection

Devices	Explanation
FL-net board	The FL-net board is necessary in either CNC or the robot controller, or both CNC and the robot controller according to the I/O connection of CNC and the robot controller.
Hub	One hub is necessary. However, if there are not any branches between CNC and the robot controller, the hub is not necessary by using cross cable to connect CNC and the robot controller.
Ethernet cable	The cable is necessary for each CNC and the robot controller.

Please connect CNC and the robot controller as shown in the following figure.
For details, please refer to FL-net board CONNECTION MANUAL corresponding to your using CNC. About the FL-net connection in the robot controller, please refer to FANUC Robot series R-30*i*A/R-30*i*A Mate/R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER FL-net interface OPERATOR'S MANUAL(B-82674EN).

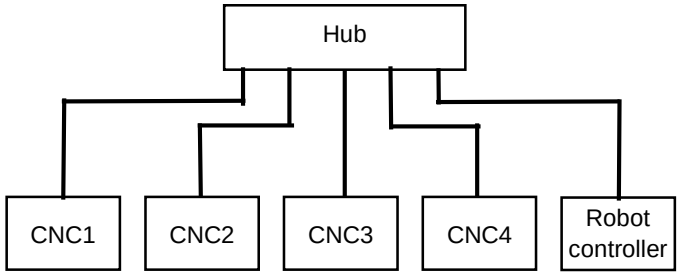


Fig. 2.2.1 Wiring of FL-net

2.2.2 Wiring when I/O Link is Used

When the robot controller and CNC are connected by I/O Link, both CNC and the robot controller are I/O link master. In this case, I/O Link connecting unit is necessary. When I/O Link is used, the following devices are necessary.

Table 2.2.2 Devices for I/O Link connection

Devices	Explanation
I/O Link Connecting Unit	The I/O Link Connecting Unit for the number of connected CNC is necessary.
Cable	The signal cable and the power supply cable are necessary.

Please connect CNC and the robot controller as shown in the following figure.
For details, please refer to CONNECTION MANUAL (HARDWARE) corresponding to your using CNC.

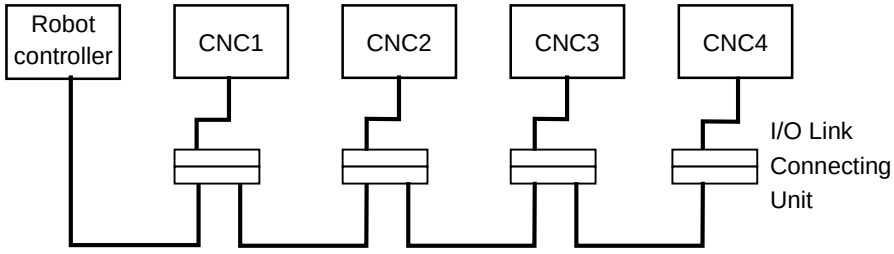


Fig. 2.2.2 Wiring of I/O Link

The DI/DO signal cannot be exchanged directly between CNCs. When the signal is exchanged between CNCs, it is necessary to transmit signals through the robot controller.

2.2.3 Settings of FL-net

When CNC and the robot controller are connected by FL-net, necessary settings are as follows.

Node number

The node number of each equipment is fixed.
The end figure of IP address shows the node number. The node number for the robot controller is fixed as one. The node number for CNC is assigned to be the order of the CNC number from two.
When standard 192.168.250 is used as a network address, IP address is as follows.

Table 2.2.3 Node number and IP address

Equipment	Node number	IP address
Robot	1	192.168.250.1
CNC1	2	192.168.250.2
CNC2	3	192.168.250.3
CNC3	4	192.168.250.4
CNC4	5	192.168.250.5

Allocation of common memory area

Common memory area 1 of FL-net is used for the communication of the data between CNC and the robot controller. Common memory area 2 is not used.
The signals that the robot controller outputs are 1024 points (64 words), and signals for four CNCs are included. Signals for one CNC are 256 points (16 words). 1024 points are reserved.
The signals that one CNC outputs are 256 points (16 words), and 256 points are reserved.
The ALLOCATION of the robot and CNC in the common memory area is shown as the following figure.

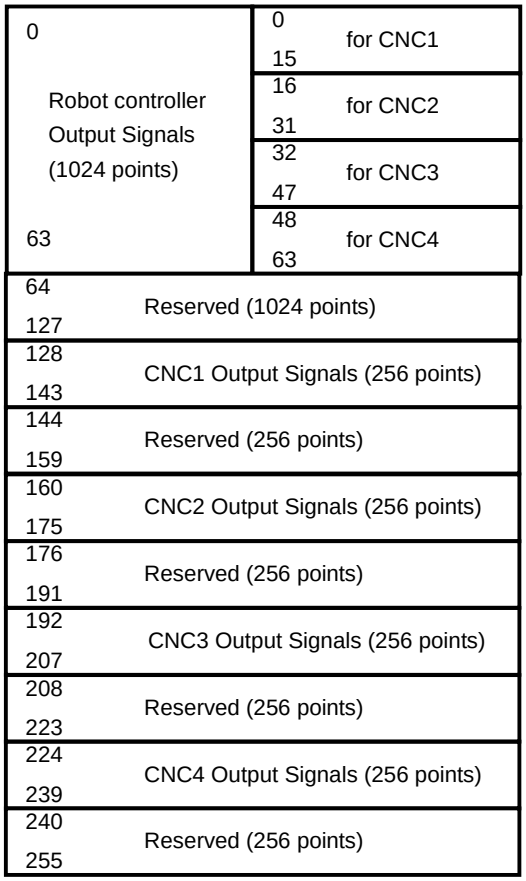


Fig. 2.2.3 Allocation of FL-net common memory area

2.2.3.1 Setting in CNC

Correspondence of common memory area and PMC area

With the standard setting, common memory area of FL-net is allocated from 1:R7400 to 1:R7911 of PMC area. In this case, correspondence of common memory area and PMC area is as follows.

Common memory area 1 (Unit is word)		PMC area (Unit is byte)	
0 Robot Controller (1024 points) 63	0 15 for CNC1	1:R7400 1:R7431	Robot to CNC1
	16 31 for CNC2	1:R7432 1:R7463	Robot to CNC2
	32 47 for CNC3	1:R7464 1:R7495	Robot to CNC3
	48 63 for CNC4	1:R7496 1:R7527	Robot to CNC4
64 127	Reserved (1024 points)	1:R7528 1:R7655	Reserved
128 143	CNC1 (256 points)	1:R7656 1:R7687	CNC1 to Robot
144 159	Reserved (256 points)	1:R7688 1:R7719	Reserved
160 175	CNC2 (256 points)	1:R7720 1:R7751	CNC2 to Robot
176 191	Reserved (256 points)	1:R7752 1:R7783	Reserved
192 207	CNC3 (256 points)	1:R7784 1:R7815	CNC3 to Robot
208 223	Reserved (256 points)	1:R7816 1:R7847	Reserved
224 239	CNC4 (256 points)	1:R7848 1:R7879	CNC4 to Robot
240 255	Reserved (256 points)	1:R7880 1:R7911	Reserved

Fig. 2.2.3.1(a) Correspondence of common memory area and PMC area

Confirmation of power supply of robot controller

Even if the power supply of the robot controller becomes off, the output signals of the robot controller connected via FL-net are not turned off. Therefore, the function of FL-net, "List of Participating Nodes", is used to confirm whether the power supply of the robot is ON or OFF. This function outputs to PMC area the signals indicating whether each node is now participating in the network or not. This function uses 32 bytes of PMC area.

With the standard setting, list of participating nodes is allocated in 1:R7956. The relation of node and PMC address using the standard setting is as follows.

Bit	7	6	5	4	3	2	1	0
1:R7956	Node 7	Node 6	Node 5 CNC4	Node 4 CNC3	Node 3 CNC2	Node 2 CNC1	Node 1 Robot	Reserved
. . .	. . .							
1:R7986	Node 247	Node 246	Node 245	Node 244	Node 243	Node 242	Node 241	Node 240
1:R7987	Reserved	Node 254	Node 253	Node 252	Node 251	Node 250	Node 249	Node 248

Fig. 2.2.3.1(b) List of participating nodes and PMC data area

With the standard setting, bit 1 of 1:R7956 shows the power supply of the robot controller.

Procedure to set-up I/O in CNC

The procedure of setting-up FL-net in CNC is as follows.

1. Press function key. 

2. Press the continuous menu key  until soft key [FL-net] appears.
3. Press the soft key [FL-net], and then, press the soft key [PARAMETER].
4. Move cursor to the item to set, and enter the value.

For details of setting-up FL-net parameters, please refer to FL-net board CONNECTION MANUAL corresponding to your using CNC.

Set-up value for each item

The set-up value for FL-net items is as follows.

IP ADDRESS

The end figure of IP address shows the node number.
The value is decided by the CNC number. When standard 192.168.250 is used as a network address, IP address is as follows.

Table 2.2.3.1(a) IP address

Item	CNC1	CNC2	CNC3	CNC4
IP ADDRESS	192.168.250.2	192.168.250.3	192.168.250.4	192.168.250.5

AREA1 ADDERSS

It is the first address in common memory area 1 where the output signal of own node is allocated.
The value is decided by the CNC number.

Table 2.2.3.1(b) AREA1 ADDRESS

Item	CNC1	CNC2	CNC3	CNC4
AREA1 ADDRESS	128	160	192	224

AREA1 SIZE

It is a data size of common memory area 1 where the output signal of own node is allocated. The unit is word. The value is 16 (256 points) and it is fixed.

AREA2 ADDRESS, AREA2 SIZE

It is unnecessary to set-up items "AREA2 ADDRESS" and "AREA2 SIZE" because they are not used.

TOKEN WATCHDOG TIME, MINIMUM FRAME TIME

The value of "TOKEN WATCHDOG TIME" is 30 and "MININUM FRAME TIME" is 0 and they are fixed. However, if FL-net/Ethernet coexistence function is used, it is recommended that "MININUM FRAME TIME" is equal or more than 10.

OWN STATUS

It is unnecessary to set-up item "OWN STATUS" because it is not used.

ENTRY NODE

It is an address in the PMC area to notify the participation of other nodes in the network.
The value of standard setting is 1:R7956. If the PMC data area from 1:R7956 to 1:R7986 can not be used, please specify the first address of 32 bytes empty area.

NOTE
When the value of item "ENTRY NODE" is changed from a standard setting, it is necessary to modify the ladder program. For details, please refer to the material included in CD "Robot connection function sample program" (A08B-9510-J550).

PARAMETER 1, PARAMETER 2

The value of “PARAMETER 1” is “0000 0001” and “PARAMETER 2” is “0000 0000”. They are fixed.

PMC ADDRESS of AREA1 DI/DO

It is the first address of PMC area allocated to common memory area 1.
The value of standard setting is 1:R7400. If the PMC data area from 1:R7400 to 1:R7911 can not be used, please specify the first address of 512 bytes empty area.

NOTE
When the value of item "PMC ADDRESS" of “AREA1 DI/DO” is changed from a standard setting, it is necessary to modify the ladder program. For details, please refer to the material included in CD "Robot connection function sample program" (A08B-9510-J550).

AREA1 ADDRESS of AREA1 DI/DO

It is the first address of common memory area 1 allocated to the PMC area.
The value is zero and it is fixed. The common memory area is allocated to the PMC area from the first byte.

ALLOCATED SIZE of AREA1 DI/DO

It is a data size in which data is exchanged. The unit is word.
The value is 256 and it is fixed. The area of robot controller and four CNC is allocated to PMC data area.

Items of AREA2 DI/DO and MESSAGE

It is unnecessary to set-up items in "AREA2 DI/DO" and “MESSAGE” because they are not used.

2.2.3.2 Setting in robot controller

In the robot controller, a standard setting concerning the I/O transmission including the setting of FL-net can be read.
The setting concerning the I/O transmission is decided by the number of connected CNC. Therefore, a standard setting is read specifying the number of connected CNC. By reading the standard setting, the following settings are set in addition to FL-net settings.

- Allocation of DI/DO, UI/UO, and GI/GO to connect to specified number CNC (Existing ALLOCATION is overwritten.)
- Allocation of I/O internally used (Existing ALLOCATION is overwritten.)
- Robot ladder program to connect to CNC (Existing program is overwritten.)
- Setting of keep relay related to the specified number CNC
- Setting of I/O comment
- IP address, subnet mask and router IP address (When I/O device type is “Fl-net (Port#1)” or “FL-net (Port#2)”.)

The robot controller internally uses 56 points of DI (DI[1025]-DI[1080]) and 8 points of DO (, DO[1025]-DO[1032]) in addition to the signals for connecting to CNC. These signals are automatically allocated by reading a standard setting. Please do not change the ALLOCATION of these signals.

Procedure to read the standard setting in robot controller

1 While holding the PREV key and the NEXT key of teach pendant, turn on the power of the robot controller. Configuration menu is displayed.
2 Select "Controlled start". The initial screen of controlled start menu appears after a while.
3 Press the MENU key to display the screen menu.
4 Select the item “Machine I/F”. The setting screen of Machine I/F appears.

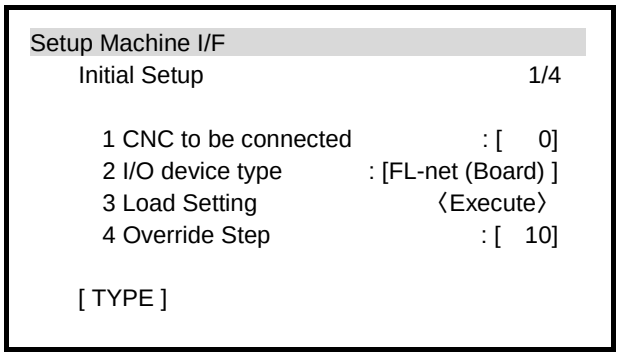


Fig. 2.2.3.2 Machine tool interface screen

5 Enter the number of CNC connected with the robot controller to the item "CNC to be connected". When this function is not used, please set zero.
6 Move the cursor to “I/O device type” and press F4 [CHOICE] to set I/O device type. If the items in the menu for I/O device type are “FL-net” and “I/O Link”, select "FL-net". In case that the item “FL-net(Board)”, “FL-net(Port#1)” and “FL-net(Port#2)” exist in the menu for I/O device type, select one of these items according to the FL-net port. If FL-net has not been ordered, “FL-net”, “FL-net(Board)”, “FL-net(Port#1)” and “FL-net(Port#2)” cannot be selected.
7 Move the cursor to the item <Execute> of "Load Setting" and press ENTER key. Press OK for the confirmation message. When load setting is executed, an existing setting is overwritten.
8 Press FCTN key and select "START (COLD)" from the Functions menu. The robot controller is started by the cold start.

> ⚠ **CAUTION**
> When standard I/O setting is read, not only the ALLOCATION and comment of I/O, but also the ladder program is replaced. In case that “FL-net(Port#1)” or “FL-net(Port#2)” is selected as the I/O device type, Ethernet IP address and subnet mask are set and router IP address is initialized.

When connected number of CNC is increased, the setting of DI/DO and GI area corresponding to increased CNC is overwritten. When connected number of CNC is decreased, the setting corresponding to decreased CNC is cleared.

If you return the setting to former value, set the connected CNC to zero, and then read the settings. The ALLOCATION and comment of I/O is cleared and the ladder program is replaced by the standard ladder program. But, IP address, subnet mask, router IP address in TCP/IP parameter cannot be returned.

When the I/O device is changed, it is recommended to delete the I/O ALLOCATION in I/O Link screen of robot controller. For details, please refer to one of the following manuals corresponding to your using robot controller.

- FANUC Robot Series R-30*i*A CONTROLLER HANDLING TOOL OPERATOR'S MANUAL
- FANUC Robot Series R-30*i*A Mate CONTROLLER LR HANDLING TOOL OPERATOR'S MANUAL
- FANUC Robot Series R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER OPERATOR'S MANUAL (Basic Operation)

For the setting value read by the above-mentioned procedure, please refer to "Appendix A.2.2 Standard Setting Value List in Robot Controller" and "Appendix A.3.3 FL-net Parameters in Robot Controller".

2.2.3.3 Connection retry of data communication

If the robot controller attempt to connect CNC but it fails, the robot controller can repeat this action at some intervals for a specified period. This behavior can be enabled at Machine interface screen (Communication detail screen). The period of connection retry is three minutes and interval of connection retry is ten seconds.

Procedure to set

1 Press MENU key to display the screen menu.
2 Select “SETUP”.
3 Press TYPE (F1) key to display the screen change menu.
4 Select “Machine I/F” in the menu. Machine Interface screen is displayed.
5 Press OTHER (F3) key, then select “MTCOM” in the menu. The following screen is displayed.

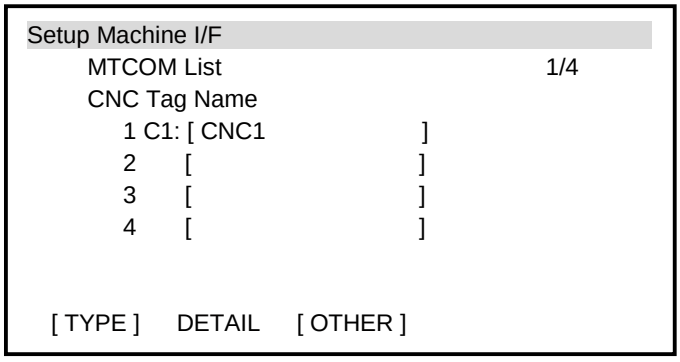


Fig. 2.2.3.3(a) Machine interface screen (Communication list screen)

6 Set the cursor to the client tag that you want to set, then press DETAIL (F2) key. The following screen is displayed.

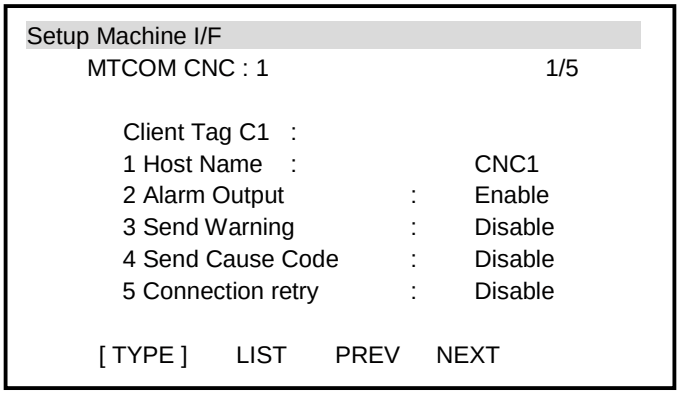


Fig.2.2.3.3(b) Machine interface screen (Communication detail screen)

7 Set the cursor to "Connection retry" and select Enable.

2.2.4 Settings of I/O Link

When CNC and robot controller are connected by I/O Link, necessary settings are as follows.

2.2.4.1 Setting in CNC

Allocation of I/O Link connecting unit to PMC

The I/O Link connecting unit is allocated to an empty area of X and Y of PMC. Allocation size is 32 bytes (256 points) for both X and Y area. As a result, it becomes possible to read and write DO and DI signal of the robot from CNC.

The next figure shows the example that two CNCs are connected to one robot and that interface signals are allocated in X80 and Y80 of PMC area.

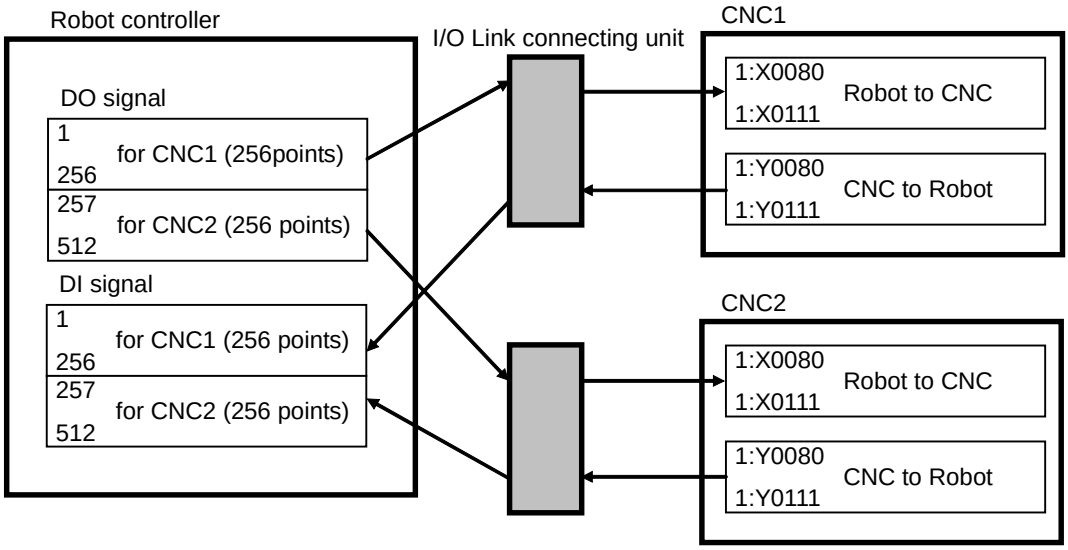


Fig. 2.2.4.1 Example of connection using I/O Link connecting unit

Confirmation of power supply of robot controller

If the power supply of the robot controller becomes off, all output signals of the robot controller connected via I/O Link becomes off. Therefore, Robot Power On signal (DO[61]) is used to confirm whether the power supply of the robot controller is ON or OFF. While the power supply of robot controller is on, this signal turns on.

Procedure to set-up I/O in CNC

The procedure of allocating 32 byte area for I/O Link connecting unit to PMC is as follows.

1. Press function key. 

2. Press the continuous menu key  until soft key [PMC CONFIG] appears.
3. Press the soft key [PMC CONFIG].
4. Press the continuous menu key  until soft key [MODULE] appears.
5. Press the soft key [MODULE] and then, press the soft key [(OPRT)].
6. Press the soft key [EDIT].
7. Allocate the I/O Link connecting unit to X and Y address of PMC area.
8. When the ALLOCATION procedure ends, press the soft key [EXIT EDIT].
9. Press the soft key [YES] to the confirmation of saving the setting to FROM.

The procedure for allocating the I/O Link connecting unit to X address and Y address of PMC is as follows.

1. Move the cursor to the address of allocating I/O Link connecting unit. 32byte continuous empty area is necessary.
2. Input the following string with MDI key, and then, press INPUT key.
   <Group No.>.0.1./32
   Where <Group No.> shows the numerical order of I/O Link connecting unit in the connected I/O Link devices.
3. Execute the procedure 1 and 2 for both X and Y address.

For details of setting I/O Link, please refer to PMC PROGRAMMING MANUAL corresponding to your using CNC.

2.2.4.2 Setting in robot controller

In the robot controller, a standard setting concerning the I/O transmission can be read as well as FL-net.
The setting concerning the I/O transmission is decided by the number of connected CNC. Therefore, a standard setting is read specifying the number of connected CNC. By reading the standard setting, the following settings are read.

- Allocation of DI/DO, UI/UO, and GI/GO to connect to specified number CNC (Existing ALLOCATION is overwritten.)
- Allocation of I/O internally used (Existing ALLOCATION is overwritten.)
- Robot ladder program to connect to CNC (Existing program is overwritten.)
- Setting of keep relay related to the specified number CNC
- Setting of I/O comment

The robot controller internally uses 56 points of DI (DI[1025]-DI[1080]) and 8 points of DO (DO[1025]-DO[1032]) in addition to the signals for connecting to CNC. These signals are automatically allocated by reading a standard setting. Please do not change the ALLOCATION of these signals.

Procedure to read the standard setting in robot controller

1. While holding the PREV key and the NEXT key of the teach pendant, turn on the power. Configuration menu is displayed.
2 Select "Controlled start". The initial screen of controlled start menu appears after a while.
3 Press the MENU key to display the screen menu.
4 Select the item “Machine Tool I/F”. The setting screen of Machine Tool I/F appears.

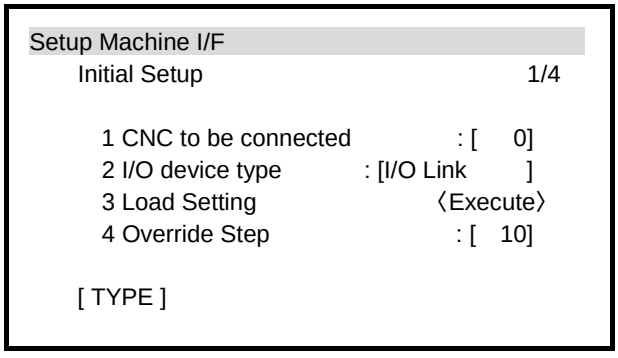


Fig. 2.2.4.2 Machine tool interface screen

5 Enter the number of CNC connected with the robot controller to the item "CNC to be connected". When this function is not used, please set zero.
6 Select "I/O Link" for "I/O device type".
7 Move the cursor to the item <Execute> of "Load Setting" and press ENTER key. Press OK for the confirmation message. When load setting is executed, an existing setting is overwritten.

8 Press FCTN key and select "START (COLD)" from the Functions menu. The robot controller is started by the cold start.

> ⚠ **CAUTION**
> When standard I/O setting is read, not only the ALLOCATION and comment of I/O, but also the ladder program is replaced.

When connected number of CNC is increased, the setting of DI/DO and GI area corresponding to increased CNC is overwritten. When connected number of CNC is decreased, the setting corresponding to decreased CNC is cleared.

If you return the setting to former value, set the connected CNC to zero, and then read the settings. The ALLOCATION and comment of I/O is deleted and the ladder program is replaced by the standard ladder program.

When the I/O device is changed, it is recommended to delete the I/O ALLOCATION in I/O Link screen of the robot controller. For details, please refer to one of the following manuals corresponding to your using robot controller.

- FANUC Robot Series R-30*i*A CONTROLLER HANDLING TOOL OPERATOR'S MANUAL
- FANUC Robot Series R-30*i*A Mate CONTROLLER LR HANDLING TOOL OPERATOR'S MANUAL
- FANUC Robot Series R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER OPERATOR'S MANUAL (Basic Operation)

For the setting value read by the above-mentioned procedure, please refer to “Appendix A.2.2 Standard Setting Value List in Robot Controller".

2.2.4.3 Connection retry of data communication

If the robot controller attempt to connect CNC by CNC Power On signal (See section 7.4) changes to ON but it fails, the robot controller can repeat this action at some intervals for a specified period. This behavior can be enabled at Machine interface screen (Communication detail screen). The period of connection retry is three minutes and interval of connection retry is ten seconds.

Procedure to set

1 Press MENU key to display the screen menu.
2 Select “SETUP”.
3 Press TYPE (F1) key to display the screen change menu.
4 Select “Machine I/F” in the menu. Setup Machine I/F screen is displayed.
5 Press OTHER (F3) key, then select “MTCOM” in the menu. The following screen is displayed.

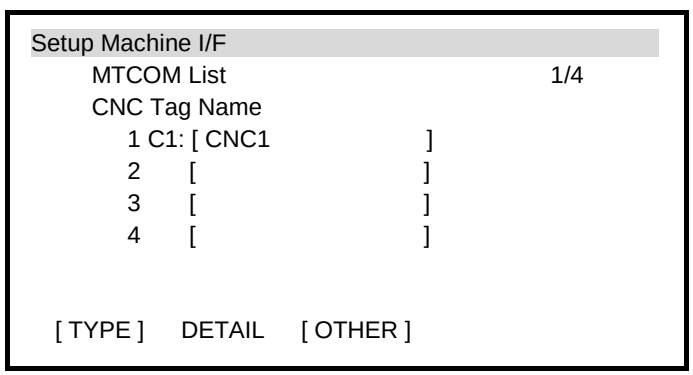


Fig. 2.2.4.3(a) Setup Machine I/F screen (Communication list screen)

6 Set the cursor to the client tag that you want to set, then press DETAIL (F2) key. The following screen is displayed.

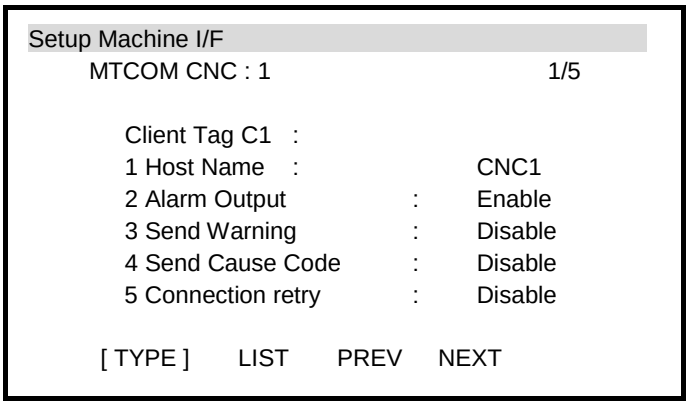


Fig. 2.2.4.3(b) Setup Machine I/F screen (Communication detail screen)

7 Set the cursor to "Connection retry" and select Enable.

2.3 CONNECTION AND SETTING OF DATA COMMUNICATION

When the data communication is used, the robot controller is connected with CNC by Ethernet.
The data communication is dispensable. However, when the data communication is not done, a part of function cannot be used.

2.3.1 Wiring for Data Communication

The following devices are necessary for data communication.

Table 2.3.1 Devices for data communication

Devices	Explanation
Hub	It is indispensable when two or more CNCs are connected. When the cross cable is used to connect one CNC with the robot controller as an Ethernet cable, the hub is unnecessary.
Ethernet cable	Please use the cross cable when you connect one CNC and robot controller without using the hub. When the hub is used, a straight cable is used.

Please connect CNC and the robot controller as shown in the following figure.

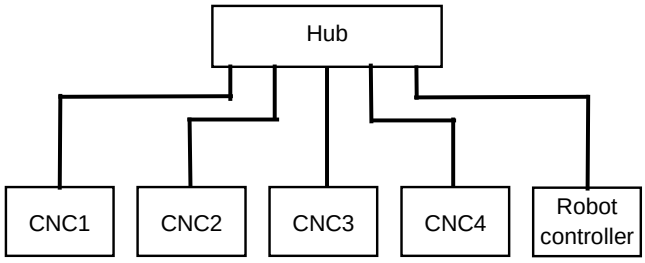


Fig. 2.3.1 Wiring of data communication

2.3.2 Setting of Data Communication

2.3.2.1 Setting in CNC

Items where the setting is necessary are IP address, subnet mask and port number. Please set the value to item router IP address if necessary.

Please match the value of IP address, the subnet mask, and router IP address to the environment of the connected network.
The value of port number is 8193.

When FL-net/Ethernet coexistence function is used, the value of IP address defined in FL-net parameter screen is used by Ethernet communication too. Therefore, IP address is not set from a setting screen of Ethernet. Moreover, the subnet mask is fixed by 255.255.255.0.

For details of embedded Ethernet, please refer to MAINTENANCE MANUAL corresponding to your using CNC. For details of FL-net/Ethernet coexistence function, please refer to "FANUC Series 30*i*/31*i*/32*i* -MODEL A/B FANUC Series 35*i*-MODEL B FL-net Board CONNECTION MANUAL(B-64163EN)".

Procedure to set-up embedded Ethernet in CNC

Procedure to set-up embedded Ethernet is as follows.

1. Press function key. 

2. Press the continuous menu key  until soft key [EMBED PORT] appears.
3. Press the soft key [EMBED PORT]. Soft key [COMMON] appears. (When soft key [COMMON] is not displayed, press the continuous key  several times.)
4. Press the soft key [COMMON]. Move the cursor to item “IP ADDRESS” and “SUBNET MASK”, and then input the value. If necessary, input the value to item “ROUTER IP ADDRESS”.
5. Press the right-side soft key. Move the cursor to item “PORT NUMBER (TCP)” and input the value 8193. The value of item “PORT NUMBER (UDP)” and “TIME INTERVAL” are zero.
6. Press the soft key [(OPRT)], [RSTART] and then [EXECUTE].

Procedure to set-up Ethernet using FL-net/Ethernet coexistence function in CNC

Procedure to set-up Ethernet using FL-net/Ethernet coexistence function is as follows.

1. Press function key. 

2. Press the continuous menu key  until soft key [ETHER BOARD] appears.
3. Press the soft key [ETHER BOARD]. Soft key [COMMON] appears. (When soft key [COMMON] is not displayed, press the continuous key  several times.)
4. Press the soft key [COMMON]. The message “IP address can be set in the FL-net Setting Screen.” is displayed. If necessary, set the value to item “ROUTER IP ADDRESS”.
5. Press the right-side soft key. Move the cursor to item “PORT NUMBER (TCP)” and input the value 8193. The value of item “PORT NUMBER (UDP)” and “TIME INTERVAL” are zero.
6. Press the soft key [(OPRT)], [RSTART] and then [EXECUTE].

2.3.2.2 Setting in robot controller

It is necessary to set the value to TCP/IP parameter and the client tag to do the data communication by the robot controller.
The data communication used by this function is based on the client server model. CNC is a server that provides services, and the robot controller is a client that receives services. The robot controller manages

the setting of the client with the client tag. The client tag is from C1 to C8, and preserves the setting of eight clients. If the client tag is defined and started, using the dealing service becomes possible.
For details of the client tag, please refer to "FANUC Robot Series R-30*i*A/R-30*i*A Mate/R-30*i*B/ R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER Ethernet function OPERATOR'S MANUAL(B-82974EN)".

Setting of TCP/IP parameter

In the TCP/IP parameter, IP address, subnet mask, and router IP address of the robot controller are set. Moreover, the host name and IP address of connected CNC are registered.

In case that I/O device type is set to FL-net by internal Ethernet port (FL-net(Port#1), FL-net(Port#2)), when the standard setting is loaded, the standard setting values for IP address, subnet mask and router IP address are set automatically.

Procedure to set-up data communication in robot controller (TCP/IP parameter)

1 Press [MENU] key to display screen menu.
2 Select [SETUP].
3 Press F1 [TYPE] to display screen menu.
4 Select [Host Comm].
5. Move the cursor to [TCP/IP] and press F3 [DETAIL]. The following screen appears.

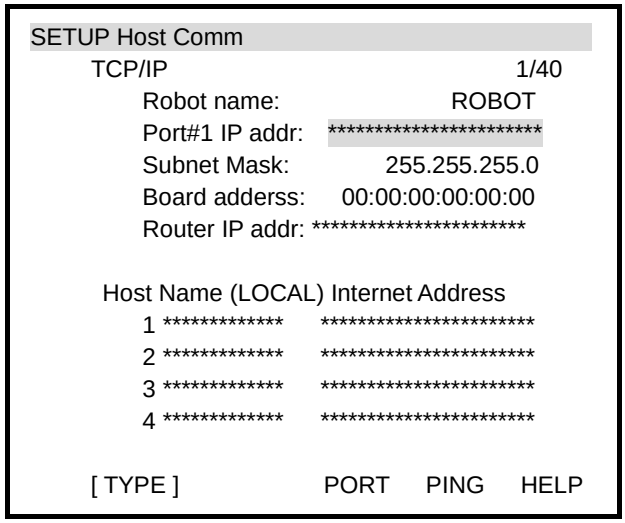


Fig. 2.3.2.2(a) TCP/IP parameter setting screen

6. Set the value to item "IP addr", "Subnet Mask" and "Router IP addr".
7. Set the value to item "Host Name" and "Internet Address". The host name defined here is used by the setting of client tag.

Setting of client tag

The client tag is set on the host communication screen. Eight client tags from C1 to C8 are displayed on the host communication screen. Please define the client tags in the number of connected CNC among these. The setting becomes effective after reactivating the power supply of the robot controller.

Procedure to set-up data communication in robot controller (client tag)

1. If Host Comm screen is being displayed, press PREV key. If another screen is being displayed, press MENU key and select SETUP, press F1 [TYPE] key and select Host Comm. (When Controlled Start is executed, press MENU and select Host Comm.)
2. Press F4 [SHOW] key and select [Clients]. Eights client tags from C1 to C8 is displayed in a list. Please setup the client tag of MTCOM protocol as needed.

3. Move the cursor to the tag for set-up, and then press F3 [DETAIL] key.
4. Move the cursor to the item "Protocol". Press F4 [CHOICE] key and select "MTCOM". The screen display changes as follows.

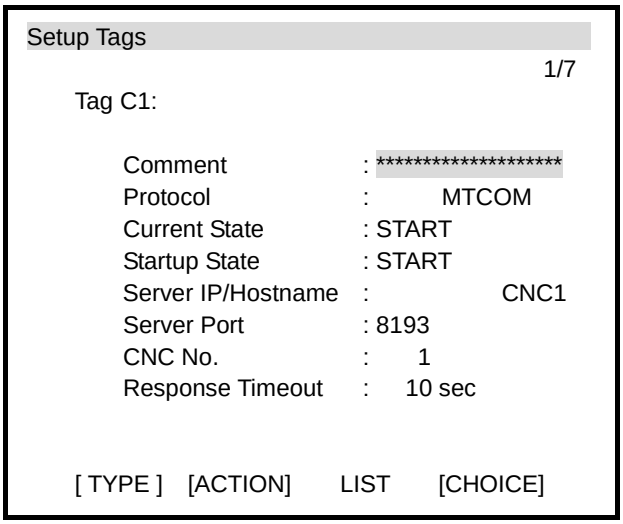


Fig. 2.3.2.2(b) Client Tag setup screen

On this screen, set the host name registered in TCP/IP setting screen to item "Server IP/Hostname". Please set the host name or IP address of connected equipment. Usually, the host name registered in TCP/IP setting screen is used.

5. Set the number of CNC (1 to 4) to the item "CNC No.". Please set the value up to the number of connected CNC. The value must not overlap by CNC connected with the robot.
6. Press F2 [ACTION] and select "DEFINE". Current setting is defined.
7. To start communication after cold start, move the cursor to the item "Startup State", press F4 [CHOICE] and select "START".
8. The setting content of other items is as follows.

Table 2.3.2.2 Other items

Item	Explanation
Server Port	Please set the port number of the server CNC. The standard value is 8193. Usually, please set the standard value.
Response Timeout	Please set the time-out seconds of the communication response.

NOTE

Even if value "START" has been selected for the item "Startup State", in case that the power supply of CNC is off when the power supply of robot becomes on, the communication is not begun because it is impossible to communicate to CNC. In that case, the communication should begin on the host communication screen of the robot controller by manual operation.

2.4 TEMPORARY SEPARATION OF CNC

CNC connected with the robot controller can temporarily be separated from the robot controller. As a result, it is possible to keep operating by remaining CNC and the robot controller while a certain CNC is maintained.

2.4.1 Separation of CNC when Using FL-net

In the FL-net setup screen of robot controller, please set the corresponding node DISABLE. As a result, even if the communication between one CNC and robot controller are not established, the robot controller can keep being operating. In this case, all I/O signals from CNC become invalid. It is the same status as setting the CNC to stand-alone mode. For detail of CNC stand-alone mode, please refer to "3. SETTING AND CUSTOMIZING IN CNC".

Separation procedure in robot controller

1 Press MENU key to display screen menu.
2 Select “SETUP”.
3 Press F1 [TYPE] key to display type menu.
4 Select “FL-net”.
5. Press F3 [OTHER] and select “NODE LIST”.
6. Move the cursor to the area1 of the node to separate, and set the value to DISABLE.
7. Make the power supply of the robot controller off and then on.

To connect the separated CNC again, set item area1 to EABLE with the same procedure as shown above. And make the power supply of the robot controller off and then on.

2.4.2 Separation of CNC when Using I/O Link

A special setting by the robot controller is unnecessary when using I/O Link connecting unit. Please make the CNC stand-alone mode with the switch of interlock mode/stand-alone mode. With this operation, interlock mode signal becomes off and the robot controller regards this CNC as separated. Even if the power supply of CNC is off, the interlock mode signal becomes off. It is the same as making the CNC stand-alone mode. At this time, the alarm is not generated in the robot controller.

3 SETTING AND CUSTOMIZING IN CNC

The following functions are provided in CNC side as the integration function for intelligent robot and machine tool.

Table 3 (a) Screens for Robot connection function

Screen	Explanation
ROBOT STATUS screen	Displays the values and symbol names of signals, and alarm message of the robot. This is a standard screen displayed when the option of robot connection function is valid.
ROBOT PROGRAM SELECT screen	Relates the robot program with NC program, and manages them. This is a standard screen displayed when the option of robot connection function is valid.
ROBOT REMOTE OPERATION screen	Enables you to operate the robot remotely. This is a sample screen of FANUC PICTURE.
ROBOT CONNECTION SETTING screen	Enables you to set the parameters for ROBOT STATUS screen and ROBOT PROGRAM SELECT screen. This is a standard screen displayed when the option of robot connection function is valid.

And, the following sample ladder programs are provided for the remote operation and the automatic system operation.

Table 3 (b) Sample ladder program for Robot connection function

Sample ladder program	Explanation
For ROBOT REMOTE OPERATION screen	Sample ladder program for cooperating with ROBOT REMOTE OPERATION screen
For automatic operation	Sample ladder program necessary for automatic operation of the machine tool system with the robot

The above sample programs (FANUC PICTURE screen data and ladder programs) are provided by CD “Robot connection function sample program” (A08B-9510-J550). See document in CD for detail of these sample programs.

This section describes the settings necessary for connecting a CNC to the robot, for using the above screens and for running the sample ladder programs, and several small works that machine tool builders should customize.

Hereafter, CNC side function of the integrated function of the intelligent robot and the machine tool is called "Robot connection function".

3.1 OUTLINE

The following figure shows the outline of the robot connection function.

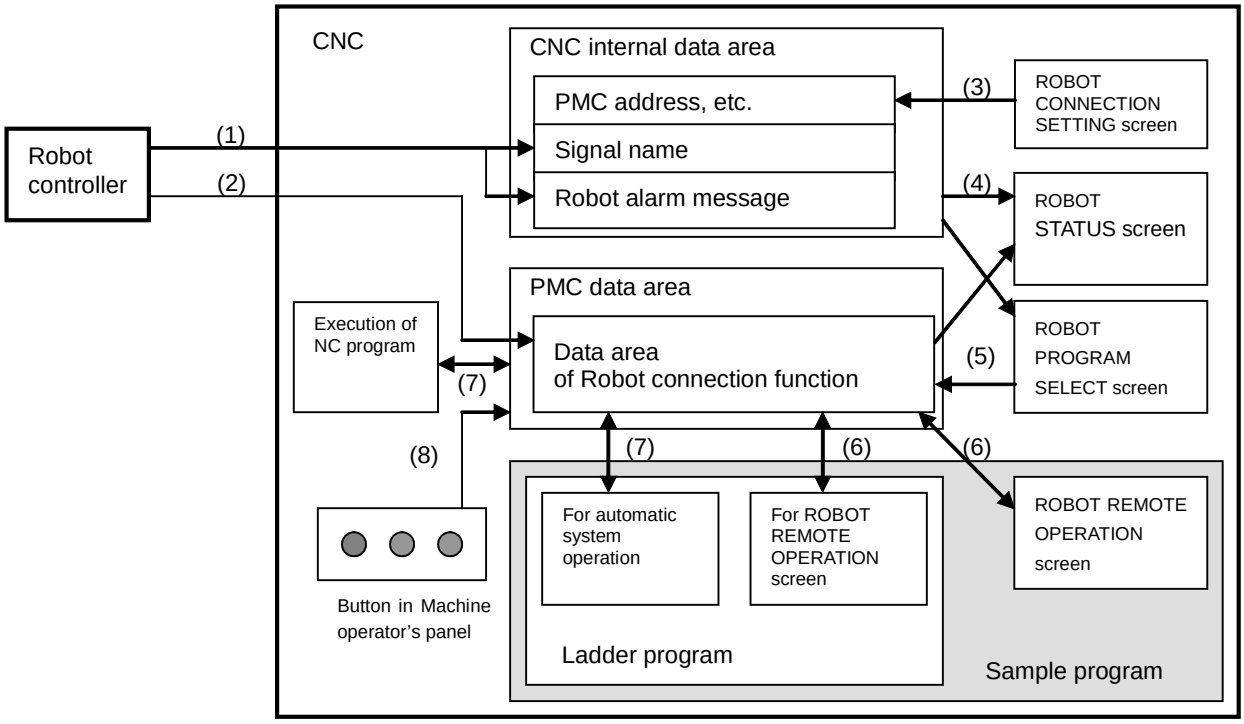


Fig. 3.1 Outline of Robot connection function

The setting value related with the robot connection function, the signal names notified by the robot and the robot alarm messages are stored in the above "CNC internal data area". And PMC data necessary for the robot connection function is packed in the above "Data area of Robot connection function".

The outline of functions is as follows.

(1) The robot controller sends the signal names and alarm message to CNC by using data communication function (Ethernet).
The signal names are sent out by the operation of the robot teach pendant.
The alarm message is sent out just when the alarm occurs at the robot.

(2) The robot controller exchanges the signals with CNC by using I/O transmission function (FL-net or I/O Link).
The signals are packed as a "Standard interface signals".
CNC handles "Standard interface signals" in "Data area of Robot connection function".
As for details of "Standard interface signals", please see "7. INTERFACE BETWEEN CNC AND ROBOT".

(3) The ROBOT CONNECTION SETTING screen enables you to register the PMC address of "Data area of Robot connection function" to "CNC internal data area".

(4) The ROBOT STATUS screen read the PMC address of "Data area of Robot connection function" from "CNC internal data area". And the screen monitors the signal value of "Data area of Robot connection function", and displays them with the signal names that are preserved in "CNC internal data area". And the robot alarm message is displayed in addition.

(5) The ROBOT PROGRAM SELECT screen enables you to specify the program number of the robot. The specified program number is written in “Standard interface signal” of “Data area of Robot connection function”.

(6) The ROBOT REMOTE OPERATION screen accesses “Data area of Robot connection function”. The ladder program (for ROBOT REMOTE OPERATION screen) writes the indication of the screen into “Standard interface signals”. And the indication is transferred to the robot as I/O data.

(7) When starting the automatic system operation, an operator executes NC program in which M codes are included. The ladder program (for automatic system operation) writes the M code command in “Standard interface signals” when it detects the execution of M code. As a result, the indication by M code is transmitted to the robot.

(8) The button on the machine operator’s panel is prepared, and it is connected to CNC via I/O Link. And the signals of these buttons are checked by ROBOT REMOTE OPERATION screen and its ladder program.

Machine tool builders should set and customize the following.

- Assignment of PMC address to “Data area of Robot connection function”
  The PMC address from 1:R7000 to 1:R7999 is assigned to “Data area of Robot connection function” as a standard setting. If this area is already used, please modify the PMC address.

- M codes that NC program uses for the automatic system operation
  The three M codes, M60, M61 and M62 are used as a standard setting. If these M codes are already used, please use the other ones. About details, please see “8. NC program”.

- The buttons on the machine operator’s panel
  Three buttons, the switch of interlock/stand-alone mode, the button for Robot remote operation and the button for cycle stop, are necessary for this function. The machine tool builder should prepare these buttons on the machine operator’s panel.

- Customizing of sample ladder program and a sample ROBOT REMOTE OPERATION screen data
  The sample program is provided by CD-ROM. A machine tool builder can customize these sample programs according to the actual system, and must check its validity sufficiently. Some PMC addresses are written in these sample programs. If the location of “Data area of Robot connection function” is customized, the default PMC addresses have to be also modified.

- Setting of Robot connection function by the setting screen
  When the location of “Data area of Robot connection function” is modified, the new PMC address must be set on the setting screen of Robot connection function.

This chapter explains these setting and customization.

3.2 DATA ARAE OF ROBOT CONNECTION FUNCTION

The PMC data used by Robot connection function is packed in “Data area of Robot connection function”. The sample of ROBOT REMOTE OPERATION screen and its ladder program is designed to assign “Data area of Robot connection function” to PMC address from 1:R7000 to1:R7999. In this case, the address map is as follows.

1:R7000 1:R7049	For ROMOTE OPERATION screen (50 bytes)
1:R7050 1:R7199	For automatic system operation (150 bytes)
1:R7200 1:R7263	For Robot interface area (64 bytes)
1:R7264 1:R7399	(Reserved 136 bytes)
1:R7400 1:R7911	For FL-net data (512 bytes)
1:R7912 1:R7955	(Reserved 44 bytes)
1:R7956 1:R7987	For FL-net participating node information (32 bytes)
1:R7988 1:R7999	(Reserved 12 bytes)

Fig.3.2(a) PMC address map

For REMOTE OPERATION screen
This area is used for ROBOT REMOTE OPERATION screen.

For automatic system operation
This area is for the automatic system operation with the robot.

Robot interface area
This area is for exchanging with the robot. It is equal to Standard interface signal.
ROBOT STATUS screen and ROBOT PROGRAM SELECTION screen reads/writes this area.

FL-net data
This area is for assigning FL-net common memory area 1.

FL-net participating node information
This area is for assigning FL-net participating node information.

The PMC address from 1:R7200 to1:R7231 is assigned to the DO signals (from Robot to CNC) and from 1:R7232 to1:R7263 is assigned to the DI signals (form CNC to Robot) as standard settings.

Connection via FL-net

In general, the output signals from the external device unit via FL-net are transferred to the FL-net common memory area in the CNC unit.

This function enables you to connect up to four CNCs with one robot. And these signals are allocated in CNC.

- The DI/DO area for one robot and four CNC is always prepared in the FL-net common memory area 1 regardless of the number of the actual CNCs.

- The robot interface area is prepared in PMC address. This area is independent from the communication protocol and the CNC number. The copy-function of ladder program, which is separated from the main ladder program, exchanges the data between the FL-net common memory area 1 and the robot interface area according to its own CNC number.
- ROBOT STATUS screen and the main ladder program use the signals of the robot interface area for their process.

The above mapping makes ROBOT STATUS screen and the main ladder program removed from the dependence upon CNC number.

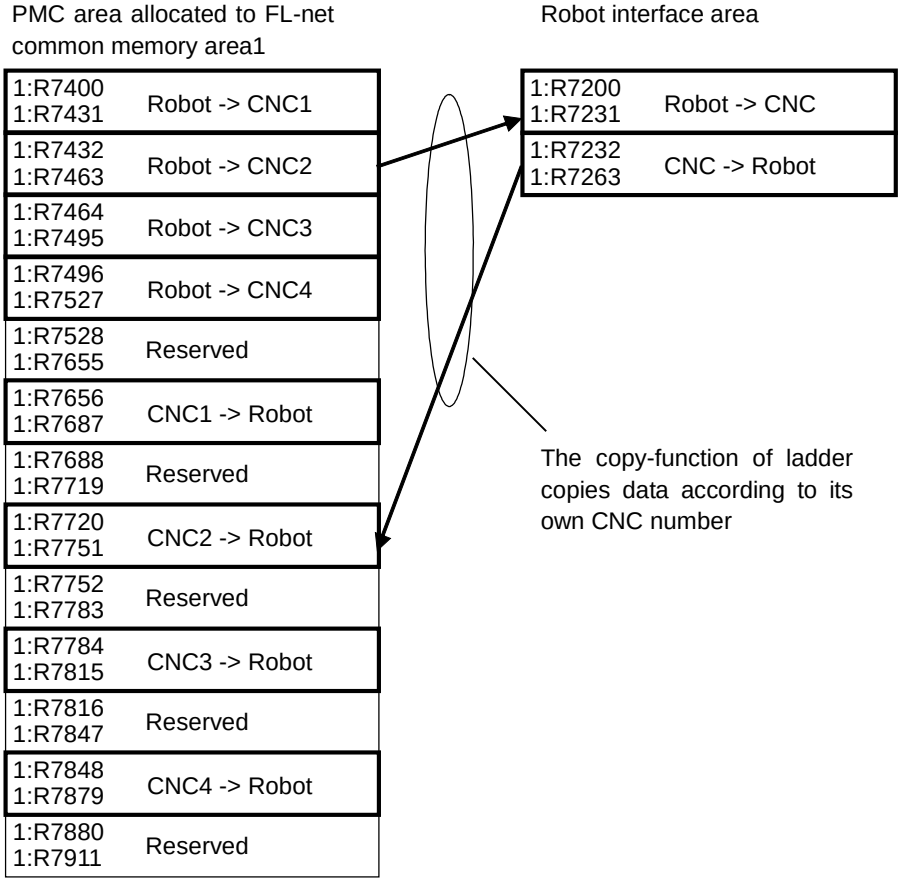


Fig.3.2(b) Robot interface area of CNC2 connected to the robot via FL-net

Connection via I/O Link

The copy-function of ladder program exchanges the data between the X/Y area assigned to I/O Link connection unit and the robot interface area.
It makes ROBOT STATUS screen and the main ladder program removed from the dependence upon communication protocols.

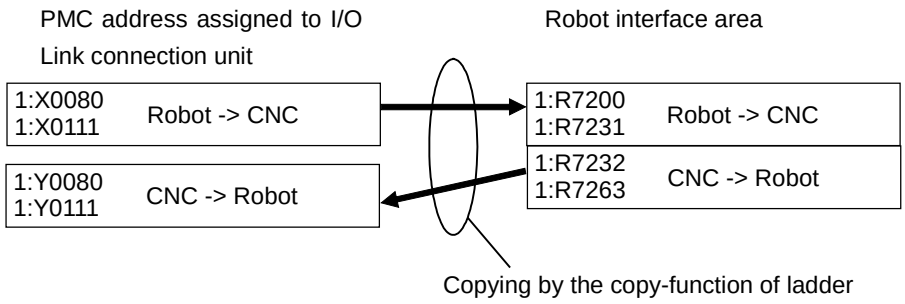


Fig. 3.2(c) Robot interface area of the CNC connected to the robot via I/O Link

3.3 BUTTON ON MACHINE OPERATOR'S PANEL

This function needs the following three buttons on the machine operator's panel

Table 3.3 Buttons necessary for the function

Button, Switch	Explanation
Selection switch of interlock mode and stand-alone mode	The switch with two positions, Stand-alone mode and Interlock mode. It specifies either of the two modes of the machine tools, the stand-alone mode or interlock mode. - Stand-alone mode : The machine tool works without the relationship with the robot. - Interlock mode : The machine tool works in cooperation with the robot.
Robot operation button	It is a button that turns the signal on while pressing. It is used when the operator actually moves the robot with ROBOT REMOTE OPERATION screen.
Cycle stop button	It is a button that turns the signal on while pressing. It is used to direct cycle stop. If cycle stop is directed, automatic system operation is stopped when the machining of current work-piece has finished.

Please machine tool builder prepare these three buttons on the machine operator's panel. And, input the state of these buttons to PMC via I/O Link. In the ladder program, these signals are used to operate the robot.

3.4 ROBOT REMOTE OPERATION SCRREN

Here, a basic specification of ROBOT REMOTE OPERATION screen is explained for the customization of the screen.
Please refer to "5.3 ROBOT REMOTE OPERATION SCREEN" for the way to operate screen.

Outline

The ROBOT REMOTE OPERATION screen is a screen for the remote operation of the robot from the machine tool. Following operations for the robot are provided.

- Jog feed
- Hand operation
- Home position return
- Robot restart
- Override change
- Reset

This is a screen for the maintenance of the robot. It is used on the following situation.

- The robot stopped by some causes while daily operation.
- Recovery without using the robot teach pendant

It is not a screen for a start-up of the system nor for the teaching of the robot.
The ROBOT REMOTE OPERATION screen is offered as not a standard screen of CNC but a sample screen of FANUC PICTURE.

NOTE
1. For details of customizing the sample screen, please refer to the material included in CD "Robot connection function sample program" (A08B-9510-J550).
2. About FANUC PICTURE, please refer to "FANUC PICTURE OPERATOR'S MANUAL".
3. This sample screen doesn't correspond to PANEL *i* with 19" display.

⚠ WARNING
The machine tool builder must customize this sample screen according to the specification of the machine. Moreover, the machine tool builder must verify the safety of the robot operation enough.

⚠ WARNING
1. Please do not make the touch panel operation screen where two points or more are pushed at the same time. When two points or more are pushed at the same time, the touch panel might work as if the center of the points was pushed. In this case, there is a possibility of the accident due to the mis-output and the malfunction.
2. Please do not include the following operations to the touch panel screen.
   - Operation related to safeties of life and significant damage, etc.
   - Operation that requires emergency and real-time action

   There is a possibility of the accident due to the mis-output and the malfunction when the main body, the unit, and the cable, etc. break down.
   Moreover, there is no guarantee of the real time action of the screen.

Remote operation right

In this function, up to four CNCs can be connected to one robot. When two or more CNCs are connected with the robot, the robot cannot be remotely operated from two or more CNCs at the same time. Only one CNC can remotely operate the robot. When a remote operation from one CNC ends, it is possible to operate it from another CNC remotely. The right to operate the robot remotely is called "Remote operation right".

To operate the robot from ROBOT REMOTE OPERATION screen, it is necessary to acquire the remote operation right first. When the remote operation right can be acquired, it is possible to operate the robot remotely. When a remote operation ends, the remote operation right is released.

It is not allowed to acquire the remote operation right when other CNC is remotely operating the robot or the robot is in service of work-piece changing for other CNC.

The operation to reset the robot can be executed from the ROBOT REMOTE OPERATION screen regardless of the presence of the remote operation right.

Button in machine operator’s panel

Two of three buttons of the machine operator's panel are used on the ROBOT REMOTE OPERATION screen.

Table 3.4 Button in machine operator's panel used in ROBOT REMOTE OPERATION screen

Button and switch	Explanation
Selection switch of interlock mode and stand-alone mode	If CNC is in stand-alone mode, the remote operation right can not be acquired. If interlock mode, the remote operation right can be acquired.
Robot operation button	In ROBOT REMOTE OPERATION screen, the robot can be actually moved by pressing this button. - Jog feed The robot executes the operation of Jog feed while this button is being pressed. - Hand operation The robot executes Hand operation when this button is pressed. - Home position return The robot executes the operation of returning to home position while this button is being pressed. - Restart The robot restarts when this button is pressed.
Cycle stop button	This button is not used in ROBOT REMOTE OPERATION screen.

The procedures for executing Jog feed, Hand operation, Home position return and Restart are as follows.
1. Select the type of operation in ROBOT REMOTE OPERATION screen.
2. The robot works when the robot operation button of the machine operator's panel is pressed.

The sample ladder program for the remote operation screen directs the operation to the robot by the operation of both the screen and the button. For details, please refer to the material included in CD "Robot connection function sample program" (A08B-9510-J550).

> ⚠ **WARNING**
> Because of safety reasons, please don't replace the robot operation button of machine operator's panel by the button on the screen made by FANUC PICTURE.

Restart the robot

When the machining ends at CNC, the exchange of work-piece is requested to robot by executing M code in NC program. At this time, the robot might terminate abnormally by some reasons. The operation afterwards can be chosen from the following two.

1. The operator resets the CNC and executes the machining from the beginning.
2. The operator removes the cause of abnormality with the robot. Afterwards, the operator returns the robot to home position, and executes the restart of the robot.

When CNC is reset, both CNC and the robot will be executed from the beginning.
When restart is executed, the CNC keeps FIN waiting status. Only the robot will be executed from the beginning. If the operation of the robot ends normally as a result of restart, CNC continuously machines the next work-piece.

The remote operation right is unnecessary for the restart of the robot.

Hand operation and robot status display

It is a work of machine tool builder to decide the content of the hand operation and the robot status display, and to customize the screen.

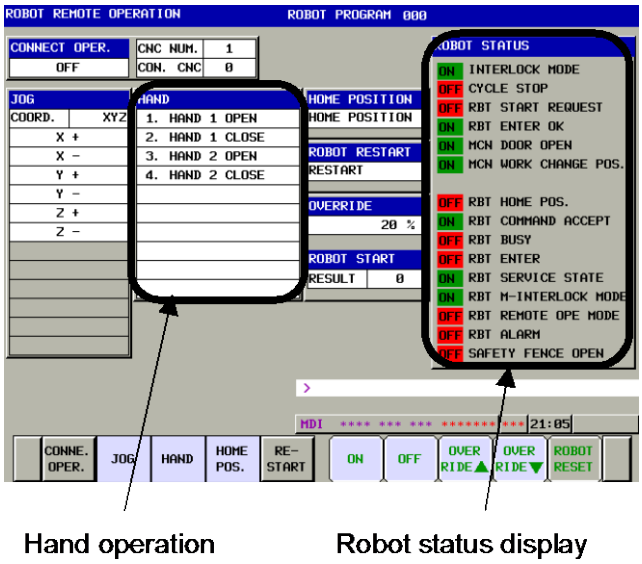


Fig. 3.4 Hand operation and robot status display in ROBOT REMOTE OPERATION screen

Ladder program

The sample ladder for the remote operation screen is offered. This ladder program reads the operator's instruction from ROBOT REMOTE OPERATION screen and the button of the machine operator's panel, and operates the robot through standard interface signal. For details, please refer to the material included in CD "Robot connection function sample program" (A08B-9510-J550).

> ⚠ **WARNING**
> The machine tool builder must customize this sample ladder program according to the specification of the machine. Moreover, the machine tool builder must verify the safety of the robot operation enough.

3.5 SAMPLE LADDER PROGRAM FOR SYSTEM OPERATION

For details about the sample ladder program for system operation, please refer to the material included in CD "Robot connection function sample program" (A08B-9510-J550).

> ⚠ **WARNING**
> The machine tool builder must customize this sample ladder program according to the specification of the machine. Moreover, the machine tool builder must verify the safety of the robot operation enough.

CNC Number

The sample ladder program uses K80.2 and K80.3 of the PMC parameter to acquire own CNC number.

Table 3.5(a) PMC parameter for specifying CNC number

PMC parameter	CNC1	CNC2	CNC3	CNC4
K80.2	0	1	0	1
K80.3	0	0	1	1

Please set the value according to the CNC number.

Button in machine operator's panel

Two of three buttons of the machine operator's panel are used for system operation.

Table 3.5(b) Button in machine operator's panel used for system operation

Button and switch	Explanation
Selection switch of interlock mode and stand-alone mode	If CNC is in stand-alone mode, M code of M60/M61/M62 in NC program is disregarded. If interlock mode, the work-piece exchange is requested to the robot by M code of M60/M61/M62. When the work-piece exchange of the robot ends, the machine tool continuously machines the next work-piece.
Robot operation button	This button is not used by system operation.
Cycle stop button	This button is used to direct cycle stop.

Beginning and end of machining, and cycle stop

The procedure to begin the machining is as follows.

1. Confirm that a correct robot program number has been selected by the ROBOT PROGRAM SELECT screen of CNC.
2. Confirm that the robot can be started.
3. Select the NC program at CNC and start the machine tool.

After the machining is begun, the exchange of work-piece is requested to the robot according to M code added to NC program. As a result, the machine tool continuously machines the work-piece with exchanging it.

System operation ends when there is no work-piece to machine.
The flow of a usual system operation end is as follows.

1. When the machining ends, CNC sends the robot the request to exchange the work-piece.
2. When the robot detects the end of work-piece, the robot ends the program without reporting the end of exchange.
3. CNC keeps the status of waiting FIN. The operator executes either of following procedure.
   - The operator resets CNC and ends the machining.
   - The operator refills the work-piece and returns the robot to the state that can be started if necessary. He operates the ROBOT REMOTE OPERATION screen to restart the robot.

The cycle stop enables the operator to end the system operation at any timing. If the cycle stop button has been pressed, the robot unloads the work-piece after a set of machining is finished. And then the system operation ends automatically.
The flow of the end of system operation with cycle stop is as follows.

1. The operator presses the cycle stop button at any timing.
2. When the machining of the current work-piece ends, CNC requests the robot to unload the work-piece.
3. The robot unloads the work-piece and reports the completion to CNC.
4. If the completion report is arrived from robot, the ladder program sends FIN and reset & rewind to CNC. As a result, the system operation ends.

The operator directs cycle stop by pressing the cycle stop button in the machine operator's panel. Whether the cycle stop is directed or not can be confirmed with the value of cycle stop signal (CNC 1:R7245.6, Robot controller DI[111]).

3.6 SETTINGS IN ALLOCATION SCREEN

The settings about the allocation of PMC data area are executed in the ALLOCATION screen of the robot connection function setting.

Procedure for displaying ALLOCATION screen (10.4 inch display unit)

1. Press the function key SYSTEM .
2. Press the continuous key ▷ some times until the soft key [ROBOT CON.] appears on the screen.
3. Press the soft key [ROBOT CON.].
4. The setting screen of robot connection function is displayed.
5. Press the page key PAGE ↑ or PAGE ↓ to switch the screen between ALLOCATION screen and ROBOT STATUS screen.

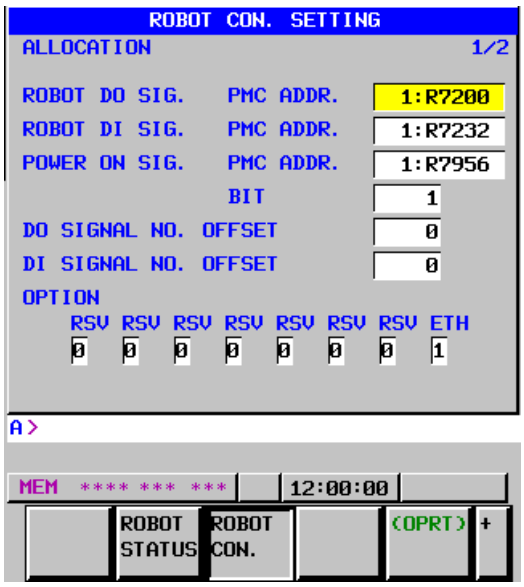


Fig. 3.6(a) ALLOCATION screen (10.4 inch display unit)

Procedure for displaying ALLOCATION screen (7.2/8.4 inch display unit)

1. Press the function key SYSTEM .
2. Press the continuous key ▷ some times until the soft key [RB CON] appears on the screen.
3. Press the soft key [RB CON].
4. The setting screen of robot connection function is displayed.
5. Press the page key PAGE ↑ or PAGE ↓ to switch the screen between ALLOCATION screen and ROBOT STATUS screen.

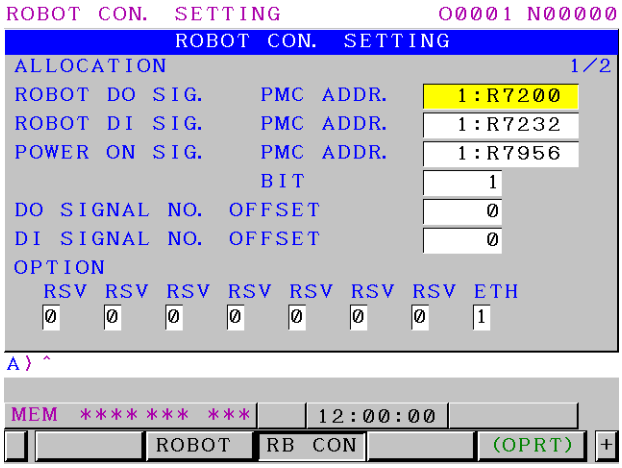


Fig. 3.6(b) ALLOCATION screen (7.2/8.4 inch display unit)

Procedure for displaying ALLOCATION screen (15 inch display unit)

1. Press the function key 

.
2. Press the vertical soft key [NEXT PAGE] some times until the vertical soft key [ROBOT CON.] appears.
3. Press the vertical soft key [ROBOT CON.].
4. The setting screen of robot connection function is displayed.

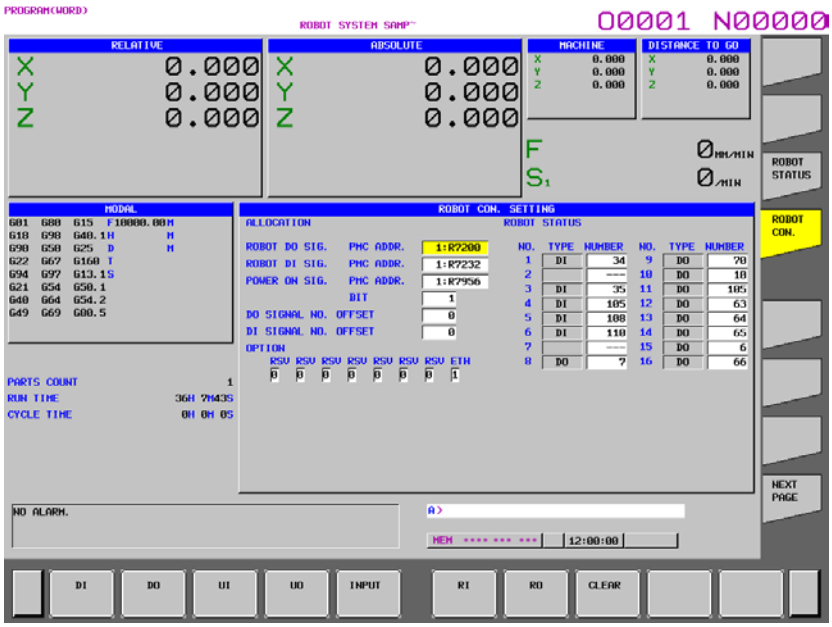


Fig. 3.6(c) Setting screen of robot connection function (15 inch display unit)

Content of settings in ALLOCATION screen

ROBOT DO SIG. PMC ADDR.

Please set the PMC address of the DO signal of the robot (from robot to CNC) in the robot interface area.
The ROBOT STATUS screen reads the value of signals from the address specified by this item and displays it on the screen.
The address character "R", "E" and "X" can be specified. 32 bytes are used for robot DO signal.
The value of a standard setting is 1:R7200. If the PMC data area from 1:R7200 to 1:R7231 is already used, please specify the address of empty 32byte area.

NOTE
If the value of item "ROBOT DO SIG. PMC ADDR." is changed from the standard setting, it is necessary to modify the ladder program. For details, please refer to the material included in CD "Robot connection function sample program" (A08B-9510-J550).

ROBOT DI SIG. PMC ADDR.

Please set the PMC address of the DI signal of the robot (from CNC to Robot) in the robot interface area.
The ROBOT STATUS screen reads the value of signals from the address specified by this item and displays it on the screen.
The address character "R", "E" and "Y" can be specified. 32 bytes are used for robot DI signal.
The value of a standard setting is 1:R7232. If the PMC data area from 1:R7232 to 1:R7263 is already used, please specify the address of empty 32byte area.

NOTE
If the value of item "ROBOT DI SIG. PMC ADDR." is changed from the standard setting, it is necessary to modify the ladder program. For details, please refer to the material included in CD "Robot connection function sample program" (A08B-9510-J550).

POWER ON SIG. PMC ADDR., BIT

Please set the PMC address where the robot power supply ON signal is allocated.
The address character "R", "E", and "X" can be specified.
When FL-net connection is used, please output the list of participating nodes to PMC area. And then, specify the PMC address that includes the robot node.
When I/O Link connection is used, please specify the PMC address of Robot power ON signal (DO[61]) in the interface area.
The item "bit" specifies which bit shows power supply ON of the robot in the specified PMC address. The range is from 0 to 7.
The standard setting is as follows.

Table 3.6(a) Value of POWER ON SIG. PMC ADDR. And BIT

Robot power on signal	FL-net	I/O Link (DO[61])
PMC ADDRESS	1:R7956	1:R7207
BIT	1	4

NOTE
If the value of item “POWER ON SIG. PMC ADDR., BIT” is changed from the standard setting, it is necessary to modify the ladder program. For details, please refer to the material included in CD “Robot connection function sample program”(A08B-9510-J550).

DO SIGNAL NO. OFFSET, DI SIGNAL NO. OFFSET

On the robot side, DI/DO signals for four CNCs are continuously allocated.
Please set the following values according to the CNC number to match the number of the DI/DO signal displayed on the ROBOT STATUS screen of CNC to the number of an actual DI/DO signal of the robot.

Table 3.6(b) Value of DO/DI SIGNAL No. OFFSET

CNC	CNC1	CNC2	CNC3	CNC4
DO SIGNAL NO. OFFSET DI SIGNAL NO. OFFSET	0	256	512	768

OPTION

It is a bit flag for the option setting of the robot connection function.

- Bit 0 : ETH
  Communication by Ethernet is
  0 : not used.
  1 : used.
- Bit 1 to 7 : Reserved (Please set zero.)

Operation in ALLOCATION screen

The method of operating the ALLOCATION screen is as follows.

Setting of numerical value and character string

1. Press the cursor key  ,  ,  , or  to move the cursor to the item to enter the value.
2. Input numerical value or character string and press MDI key 

or soft key [INPUT].
3. Numerical value or character string is set.

NOTE

Please note the following issues when setting the item "ROBOT DO SIG. PMC ADDR.", "ROBOT DI SIG. PMC ADDR." and "POWER ON SIG. PMC ADDR.".

1. R address, E address, X address (ROBOT DO SIG. PMC ADDR. and POWER ON SIG. PMC ADDR. only), and Y address (ROBOT DI SIG. PMC ADDR. only) can be set.
   In case of multi-path PMC, please specify the PMC address like;
   <Path number>:<PMC address>.
   For example, please specify "2:R500" for R0500 of 2nd path PMC. When the PMC address only is input like R500, it is processed as the first path PMC (1:R0500).
   If there is no ":" key, "/" or "EOB" key can be used instead.
2. Please input blank (SP) to delete the entered PMC address.

3.7 SETTING OF ROBOT STATUS

The robot status is displayed at the right side of the screen on the ROBOT STATUS screen and ROBOT PROGRAM SELECT screen.

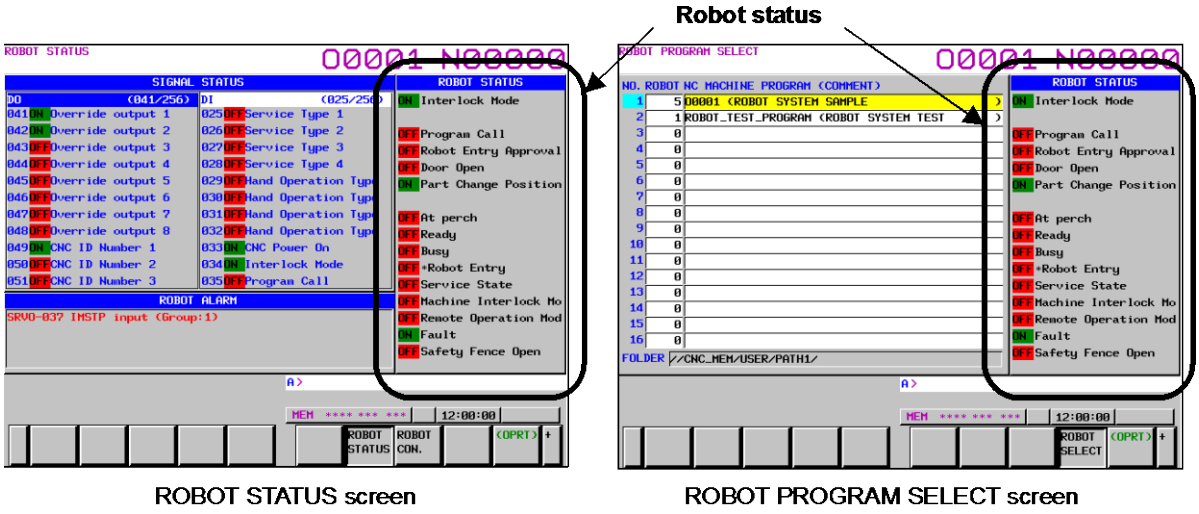


Fig. 3.7(a) Robot status display

The signal name and the value of up to 16 signals are displayed in the robot status.
The signal displayed in this robot status can be changed according to an actual machine.
The procedure to specify the signal type (DI/DO, RI/RO and UI/UO) and number is as follows.

Set-up procedures of the robot status

The setting of the robot status is specified with the ROBOT STATUS screen of the setting screen of robot connection function.

Procedure for displaying ROBOT STATUS screen (10.4 inch display unit)

1. Press the function key [SYSTEM] .
2. Press the continuous key [▷] some times until the soft key [ROBOT CON.] appears on the screen.
3. Press the soft key [ROBOT CON.].
4. The setting screen of robot connection function is displayed.
5. Press the page key [PAGE↑] or [PAGE↓] to switch the screen between ALLOCATION screen and ROBOT STATUS screen.

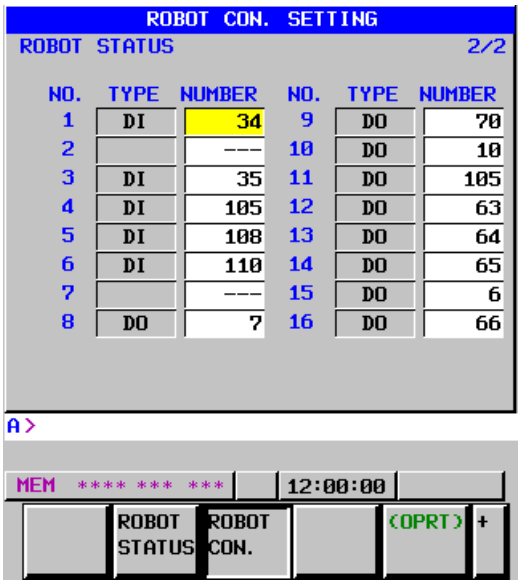


Fig. 3.7(b) ROBOT STATUS screen (10.4 inch display unit)

Procedure for displaying ROBOT STATUS screen (7.2/8.4 inch display unit)

1. Press the function key [SYSTEM] .
2. Press the continuous key [▷] some times until the soft key [RB CON] appears on the screen.
3. Press the soft key [RB CON].
4. The setting screen of robot connection function is displayed.
5. Press the page key [↑ PAGE] or [PAGE ↓] to switch the screen between ALLOCATION screen and ROBOT STATUS screen.

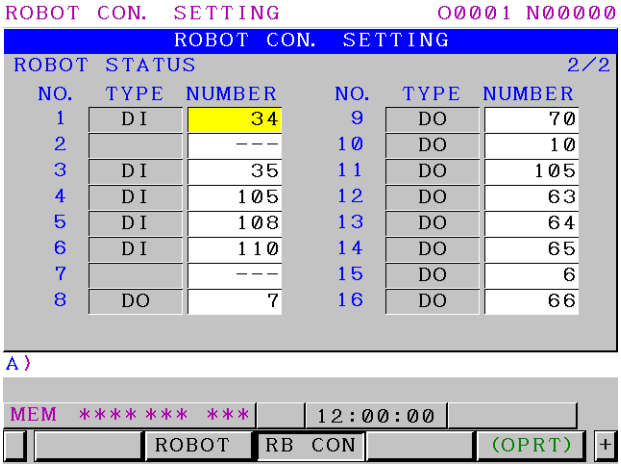


Fig. 3.7(c) ROBOT STATUS screen (7.2/8.4 inch display unit)

Procedure for displaying ROBOT STATUS screen (15 inch display unit)

1. Press the function key [SYSTEM] .
2. Press the vertical soft key [NEXT PAGE] some times until the vertical soft key [ROBOT CON.] appears.
3. Press the vertical soft key [ROBOT CON.].
4. The setting screen of robot connection function is displayed.

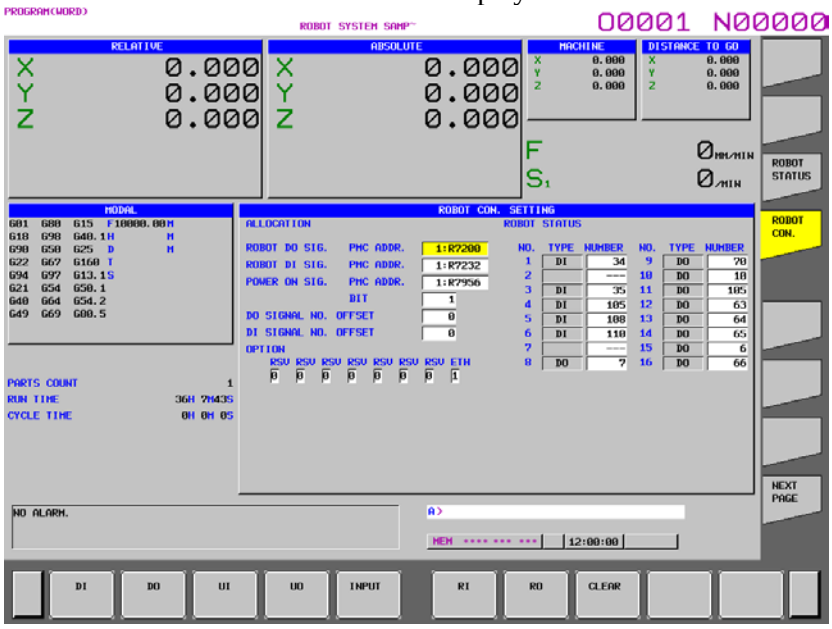


Fig. 3.7(d) ROBOT STATUS screen (15 inch display unit)

Content of settings in ROBOT STATUS screen

TYPE

The type of signal displayed in the robot status area on the ROBOT STATUS screen and the ROBOT PROGRAM SELECT screen can be selected. The type of signal that can be selected is as follows.

Table 3.7(a) Type and its meaning

Type	Meaning	Number of signals
DI	General-purpose signal between robot and CNC	232
DO	General-purpose signal between robot and CNC	216
UI	Signal for the interlock between robot and CNC	24
UO	Signal for the interlock between robot and CNC	24
RI	Signal between robot and hand	8
RO	Signal between robot and hand	8

NUMBER

The number of signal displayed in the robot status area can be specified. The range of the number that can be set according to the selected type is as follows.

Table 3.7(b) Range of number that can be set according to type

Type	Range of number
DI	1 to 256
DO	1 to 256
UI	1 to 24
UO	1 to 24
RI	1 to 8
RO	1 to 8

The following settings mean the same signal.

- [DI 1 to DI 24] = [UI 1 to UI 24]
- [DO 1 to DO 24] = [UO 1 to UO 24]
- [DO 25 to DO 32] = [RI 1 to RI 8]
- [DO 33 to DO 40] = [RO 1 to RO 8]

NOTE

Signal of DI[1] to DI[24] and UI[1] to UI[24] indicate the value of the signal that CNC outputs to the robot controller. When two or more CNCs are connected with the robot controller, the value of these signals might be different from the value of signals in the robot controller because the robot controller exclusively controls these signals. For details, please refer to “7. INTERFACE BETWEEN CNC AND ROBOT”.

Operation of ROBOT STATUS screen

The procedure of operating the ROBOT STATUS screen is as follows.

Selection of Type

1. Press the soft key [(OPRT)]. The following soft key is displayed.

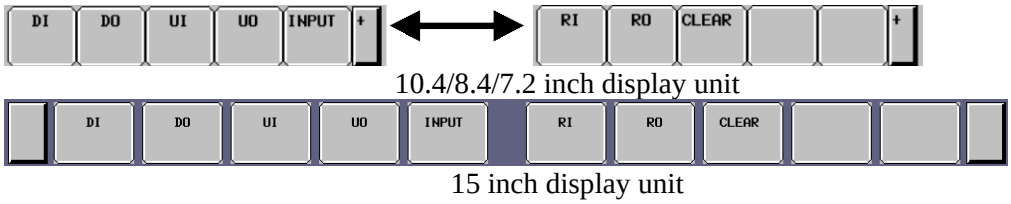


Fig. 3.7(e) Soft key display of ROBOT STATUS screen

2. Select the type of signal with the soft key
   - Soft key [UO/UI] : Interlock signal between robot and CNC
   - Soft key [RO/RI] : Signal between robot and hand
   - Soft key [DO/DI] : General-purpose signal between robot and CNC
3. The selected type is displayed on the screen.

Setting of Number

1. Press the cursor key ← or → to move the cursor to "NUMBER" row.
2. Input the number within the range of selected type, and press MDI key INPUT or the soft key [INPUT].
3. The input number is displayed on the screen.

4 SETTING IN ROBOT

In order to interlock CNC and Robot, the following settings are required in the robot controller.

- Setting reference position
- Setting jog frame
- Transfer of I/O comment
- Setting alarm message transfer *
- Setting step of override change in remote operation *
- Setting Program Number Selection (PNS) *
- Setting interference prevention space
- Setting for CNC Operation screen
- Setting for robot jog feed operation from CNC

About the items attached *, it is not need to change the default setting to use this function. If necessary, change these settings.

4.1 SETTING REFERENCE POSITION

In the ladder program provided by this function, the robot program can be started by CNC only when the robot is in the reference position 1. In order to execute the robot program interlocking with CNC, the reference position 1 for the robot must be set in the robot controller. The position that the robot can move without interference when a robot program is started is required for the reference position of the robot. Because the robot program is started by CNC repeatedly, any robot programs must be taught so that the robot starts to move from the reference position and robot ends to move at the reference position.

NOTE

About the explanation for the reference position, refer to one of the following manuals corresponding to your using robot controller.

- FANUC Robot Series R-30*i*A Controller HANDLING TOOL OPERATOR'S MANUAL
- FANUC Robot Series R-30*i*A Mate CONTROLLER LR HANDLING TOOL OPERATOR'S MANUAL
- FANUC Robot Series R-30*i*B/ R-30*i*B Mate/R-30*i*B Mate Plus/R-30*i*B Mate Plus Controller OPERATOR'S MANUAL (Basic Operation)

If you modify the ladder program in the robot controller, above limitations can be changed. For example, it is possible to start the robot program even if the robot is not the reference position, or it is possible to start the robot program when the robot is the reference position 2 or 3. About how to modify the ladder program in the robot controller, refer to "10. ROBOT LADDER PROGRAM".

Procedure to set the reference position

1 Press MENU key to display the screen menu.
2 Select "SETUP".
3 Press TYPE (F1) key to display the screen change menu.
4 Select "Ref Position". The reference position list screen is displayed as follows.

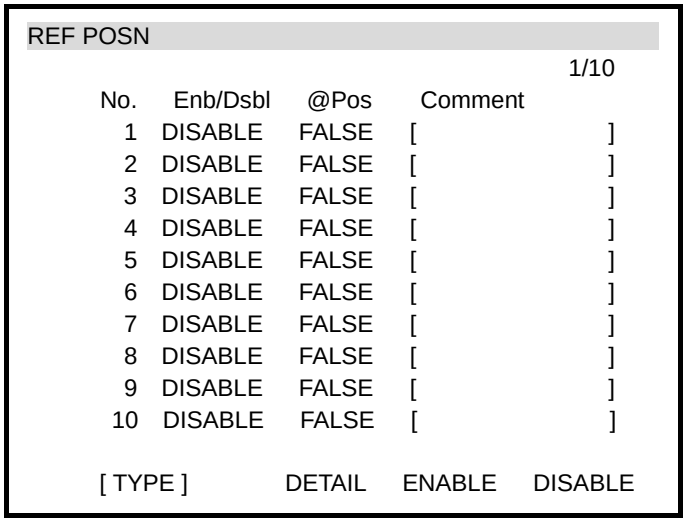


Fig. 4.1(a) Reference position list screen

5 Set the cursor to No.1.
6 Press DETAIL (F3) key. The reference position detail screen is displayed.

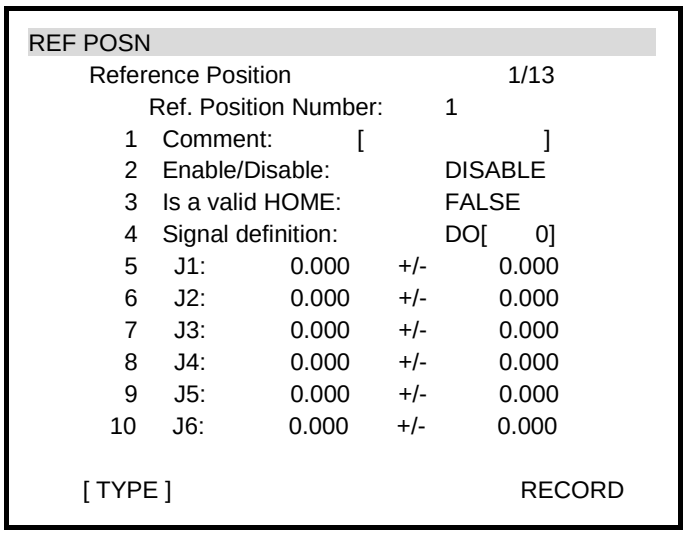


Fig. 4.1(b) Reference position detail screen

7 Input the data for the reference position.
8 Press PREV key. The Reference position list screen is displayed.
9 Set the cursor to the item Enable/Disable, and set ENABLE using function key.
10 Move the robot to the reference position 1. Then, confirm that the peripheral I/O UO[7] (Reference Position) is turned on.

4.2 SETTING JOG FRAME

Jog frame is a Cartesian coordinate frame defined for robot jog feed operation. Set jog frame in accordance with the system in order to move the robot by jog feed efficiently. Usually, the machine frame of the machine tool and the jog frame of the robot do not match. In case that jog frame of the robot does not match the machine frame of the machine tool, it is difficult to understand the direction that the robot moves by jog feed. In Jog feed of the robot by remote operation on CNC, the jog frame corresponding to CNC number is used. For example, the remote jog feed by CNC 2 uses the jog frame 2.
Set the jog frames from jog frame 1 to jog frame 4 so that the jog frame matches the machine frame of the machine tool attached each CNC. The following explains how to set jog frame 1.

NOTE

About the detail of jog frame and how to set jog frame, refer to one of the following manuals corresponding to your using robot controller.

- FANUC Robot Series R-30*i*A Controller HANDLING TOOL OPERATOR'S MANUAL
- FANUC Robot Series R-30*i*A Mate CONTROLLER LR HANDLING TOOL OPERATOR'S MANUAL
- FANUC Robot Series R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/ R-30*i*B Mate Plus Controller OPERATOR'S MANUAL (Basic Operation)

Procedure to set jog frame

1 Press MENU key to display the screen menu.
2 Select "SETUP".
3 Press TYPE (F1) key to display the screen change menu.
4 Select "Frames".
5 Press Other (F3) key.
6 Select "Jog Frame". The jog frame list screen is displayed as follows.

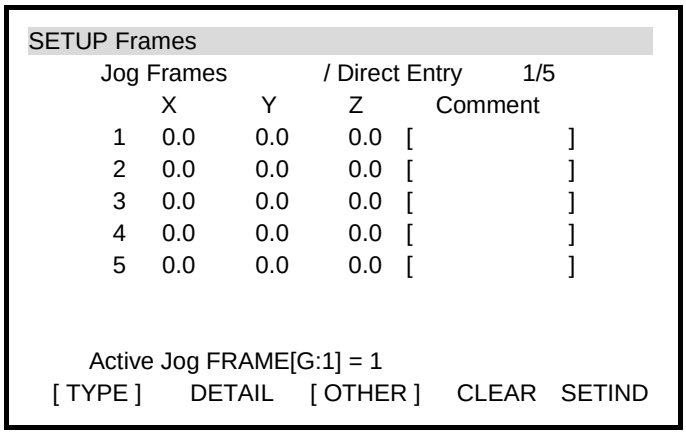


Fig. 4.2(a) Jog frame list screen

7 Set the cursor to the jog frame number that you want to set.
8 Press DETAIL (F2).
9 Press METHOD (F2).
10 Select "Direct Entry" in the displayed menu.

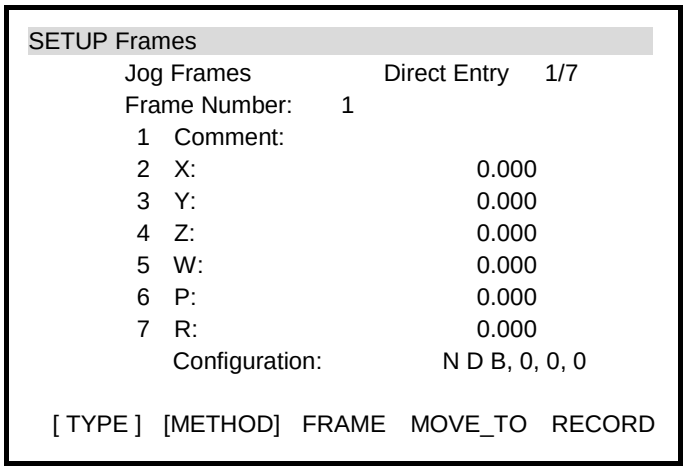


Fig. 4.2(b) Jog frame detail screen

11 Input comment and the data for each axis.
12 Press PREV key to display the jog frame list screen.

4.3 TRANSFER I/O COMMENTS IN ROBOT CONTROLLER

In this function, it is possible to display the I/O status in the robot controller to the screen on CNC. And it is possible to display the I/O comments in the robot controller to the screen on CNC by sending the I/O comments in the robot controller to CNC.
The comments for UI/UO, RI/RO and DI/DO in the robot controller can be sent to CNC by communication. In order to send I/O comments to CNC, data communication between CNC and the robot is required. About setting for the communication between CNC and the robot, refer to "2. CONNECTION OF CNC AND ROBOT ".
In order to send I/O comments to CNC, manual operation in the robot controller is needed. When I/O comment is modified, the modified comment is not sent to CNC without manual operation.
Note that all CNCs connected by Ethernet will get the I/O comment, regardless of the value of "CNC to be connected".

Procedure to transfer I/O comments

1 Press MENU key to display the screen menu.
2 Select "SETUP".
3 Press TYPE (F1) key to display the screen change menu.
4 Select "Machine I/F" in the menu. Machine Interface screen is displayed.

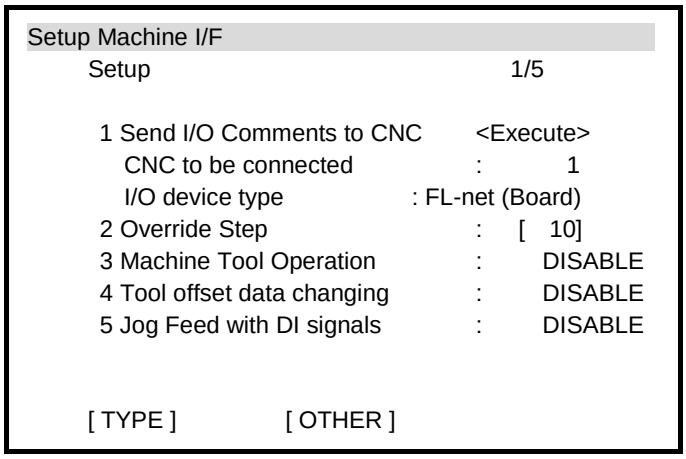


Fig. 4.3 Machine interface screen

5 Set the cursor to < Execute > of the item "Send I/O Comments to CNC", then press ENTER key to send I/O comments. It is possible to cancel to send I/O comments by PREV key.
6 Select ALL or UPDATE by the function key. ALL means that all I/O comments are send to CNC, and UPDATE means that only the I/O comments modified after last sending are send to CNC. It is possible to cancel to send I/O comments by PREV key.

NOTE
Please send ALL comment if comments are modified by means other than editing on teach pendant.

4.4 SETTING ALARM MESSAGE TRANSFER

When the communication between CNC and the robot is available, the message for the alarm occurring in the robot controller can be displayed in the ROBOT STATUS screen on CNC. There are following 2 settings about the alarm message transfer.

Table 4.4(a) Setting for alarm message transfer

Setting	Description
Enable/Disable the alarm message transfer	When the alarm message transfer is enabled, up to 4 alarm messages are displayed on CNC. When the alarm message transfer is disabled, the alarm message for the robot is not displayed on CNC. The default setting is “Enable”.
Selection of the kind of the alarm to transfer.	Select whether the alarm which severity is WARN is displayed on CNC or not, and select whether the cause code of the alarm is displayed on CNC or not. In default setting, both the display of the warning and the display of the cause code are disabled.

Procedure to set alarm message transfer

1 Press MENU key to display the screen menu.
2 Select “SETUP”.
3 Press TYPE (F1) key to display the screen change menu.
4 Select “Machine I/F” in the menu. Machine Interface screen is displayed.
5 Press OTHER (F3) key, then select “MTCOM” in the menu. The following screen is displayed.

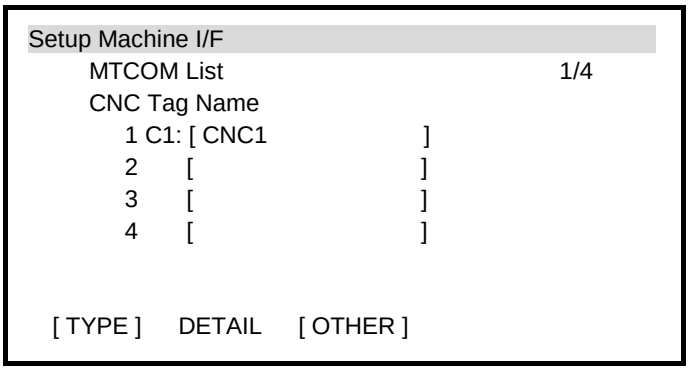


Fig. 4.4(a) Machine interface screen (Communication list screen)

6 Set the cursor to the client tag that you want to set, then press DETAIL (F2) key. The following screen is displayed.

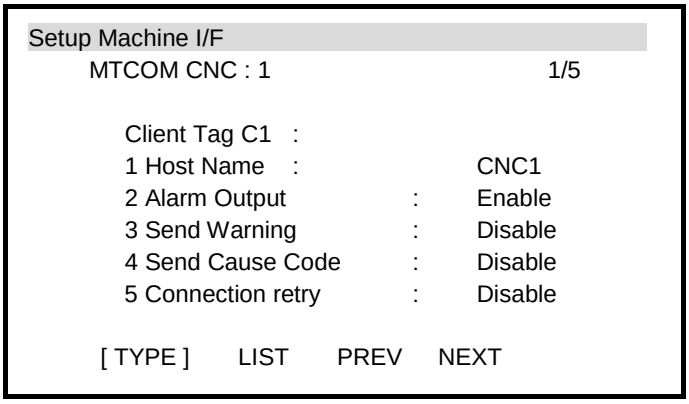


Fig. 4.4(b) Machine interface screen (Communication detail screen)

7 Select Enable or Disable about the item “Alarm Output”, “Send Warning” and “Send Cause Code”. Followings are the description of the setting items.

Table 4.4(b) Setting items and description

Setting item	Description
Alarm Output	If Enable is selected in this item, up to 4 alarm messages are send to CNC when alarm occurs and the alarms are reset in the robot controller. The default setting is “Enable”.
Send Warning	If Enable is selected in this item, the message of the alarm which severity is WARN is send to CNC. The default setting is “Disable”.
Send Cause Code	If Enable is selected in this item, the cause code of the alarm is send to CNC. The default setting is “Disable”.

8 Press LIST (F2) to display the communication list screen.

The operations by the function keys in this screen are as follows.

Table 4.4(c) Key operations in Machine interface screen (Communication detail screen)

Key	Operation
LIST (F2)	Return to the communication list screen.
PREV (F3)	Display the communication detail screen for previous CNC number.
NEXT (F4)	Display the communication detail screen for next CNC number.

4.5 SETTING STEP OF OVERRIDE CHANGE

It is possible to change the speed override to move the robot by the remote operation on CNC. In default setting, the step of override change is 10%. It is possible to change the step of override change.

Procedure to set the step of override change

1 Press MENU key to display the screen menu.
2 Select “SETUP”.
3 Press TYPE (F1) key to display the screen change menu.
4 Select “Machine I/F” in the menu. Machine Interface screen is displayed.

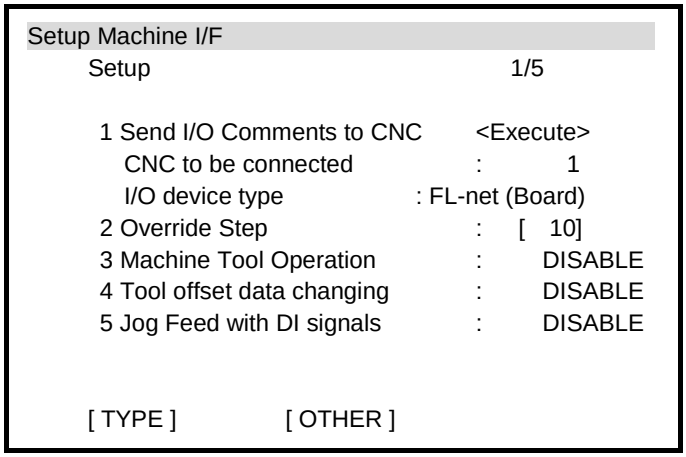


Fig. 4.5 Machine interface screen

5 Set the cursor to “Override Step”.
6 Input the value and press ENTER key. Setting data is available immediately.

4.6 SETTING PROGRAM NUMBER SELECTION (PNS)

In this function, the robot program is started from CNC by Program Number Selection function in the robot controller. In the program number selection function, there are following 3 setting items.

- Job Prefix
- Base Number
- Acknowledge pulse width

Do not change Jog Prefix and Base Number in case that the provided ladder program is used. If Base Number is changed, the robot program selected in CNC is not started correctly. If the Acknowledge pulse width is changed, the robot ladder program does not work correctly. Only Job Prefix can be change. When the Job Prefix is changed, modify the program name using new prefix string.

4.7 SETTING INTERFERENCE PREVENTION SPACE

In case that the machine tool and the robot are interlocked, it is required that the robot cannot enter into the machine tool while the machine tool is working. On the other hand, it is required that the machine tool cannot work while the robot enters into the machine tool. This function realizes this mutual interference prevention by defining the interference prevention signals between CNC and the robot and controlling these signals appropriately.

In the robot controller, some methods to output the signal to prevent the interference are prepared. For example, the robot program can check the signal for the machine tool working and output the signal that indicates that the robot is in the machine tool. And the robot controller can output signal to prevent interference by the interference prevention space function.

This section describes the setting for interference prevention space function. In interference prevention space function, the robot cannot enter into the designated area unless the interference prevention input signal is turned on, and the robot turns off the interference output signal while the robot is in that area.

NOTE

1. About interference prevention space function, refer to one of the following manuals corresponding to your using robot controller.
   - FANUC Robot Series R-30*i*A Controller HANDLING TOOL OPERATOR'S MANUAL
   - FANUC Robot Series R-30*i*A Mate CONTROLLER LR HANDLING TOOL OPERATOR'S MANUAL
   - FANUC Robot Series R-30*i*B/ R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus Controller OPERATOR'S MANUAL (Basic Operation)
2. When North America setting (A05B-2600-R650 : R-30*i*B/R-30*i*B Mate or later, A05B-2500-R650 : R-30*i*A/R-30*i*A Mate) is ordered, this function is an option. It is required to order Space Check (A05B-2600-J609 : R-30*i*B/R-30*i*B Mate or later, A05B-2500-J609 : R-30*i*A/R-30*i*A Mate).

Procedure to set interference prevention space function

1 Press MENU key to display the screen menu.
2 Select "SETUP".
3 Press TYPE (F1) key to display the screen change menu.
4 Select "Space fnct." in the menu. Machine Interface screen is displayed.

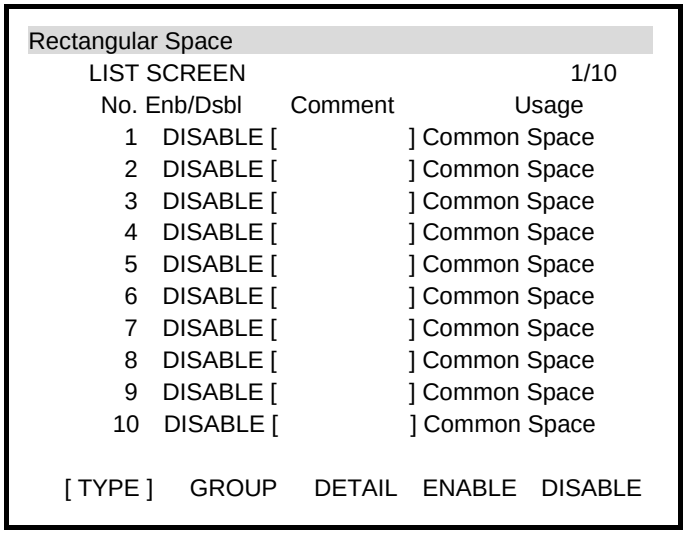


Fig. 4.7(a) Interference prevention space list screen

5 Press DETAIL (F3). The detail screen is displayed.

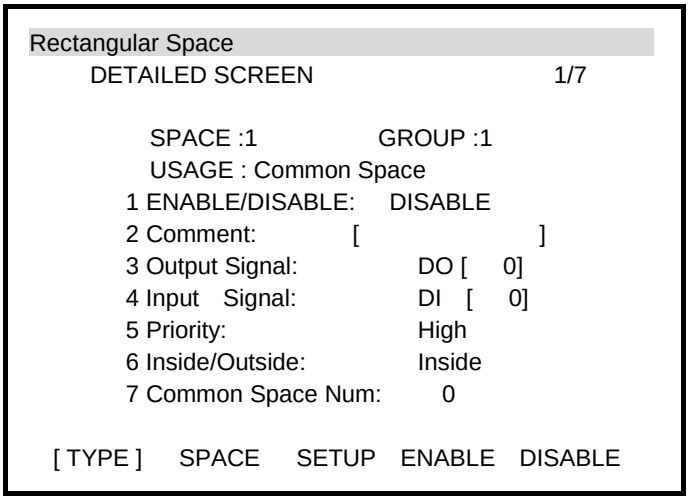


Fig. 4.7(b) Interference prevention space detail screen

6 In case that you want to define the signals in accordance with “7.4 Other interface signals”, set 105 to the item “Output Signal”, then set 105 to the item “Input Signal”.

7 In order to set the space, press SPACE (F2) to display Space Setup screen. In this screen, set the interference prevention space. There are following two methods to set the interference prevention space.
   a. Move the cursor to each item and enter the coordinate value by numeric keys.
   b. Move the robot to the vertex of the rectangular, then, press RECORD (F5) with shift key to record the robot position.

8 After setting the space, press PREV key to return to the Detail screen.

9 Press PREV key again to return to the List screen.

4.8 SETTING FOR CNC OPERATION SCREEN

In CNC operation screen on the robot teach pendant, it is possible to operate jog feed of the machine tool and input tool offset data of CNC. In order to execute these operations, it is need to enable each operation in Machine interface screen beforehand.

Furthermore, in order to execute jog feed of the machine tool on CNC operation screen, it is need to set keep relay K0001.0 in PMC to 1 to enable signal process for the machine tool operation.

Procedure to set

1 Press MENU key to display the screen menu.
2 Select “SETUP”.
3 Press TYPE (F1) key to display the screen change menu.
4 Select “Machine I/F” in the menu. Machine interface screen is displayed.

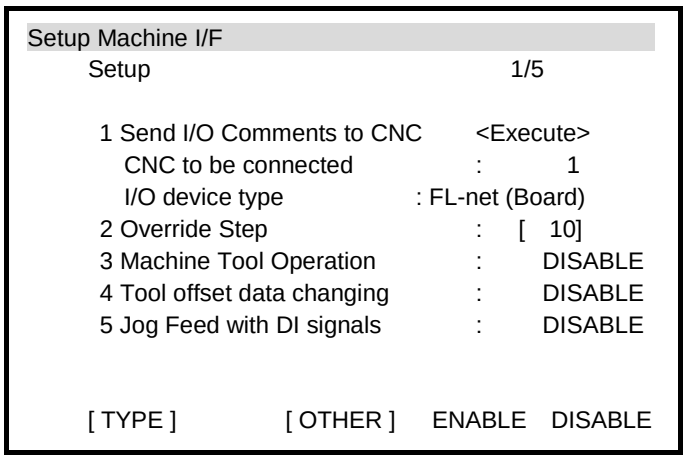


Fig. 4.8(a) Machine interface screen

5 Set the cursor to “Machine Tool Operation”.
6 Select ENABLE to execute machine tool operation in CNC Operation screen.
7 Set the cursor to “Tool offset changing”.
8 Select ENABLE to input tool offset of CNC in CNC Operation screen.

In order to execute machine tool operation, set keep relay in PMC by the following procedure.

9 Press MENU key to display the screen menu.
10 Select “I/O”.
11 Press TYPE (F1) key to display the screen change menu.
12 Select “PMC” in the menu. PMC screen is displayed.

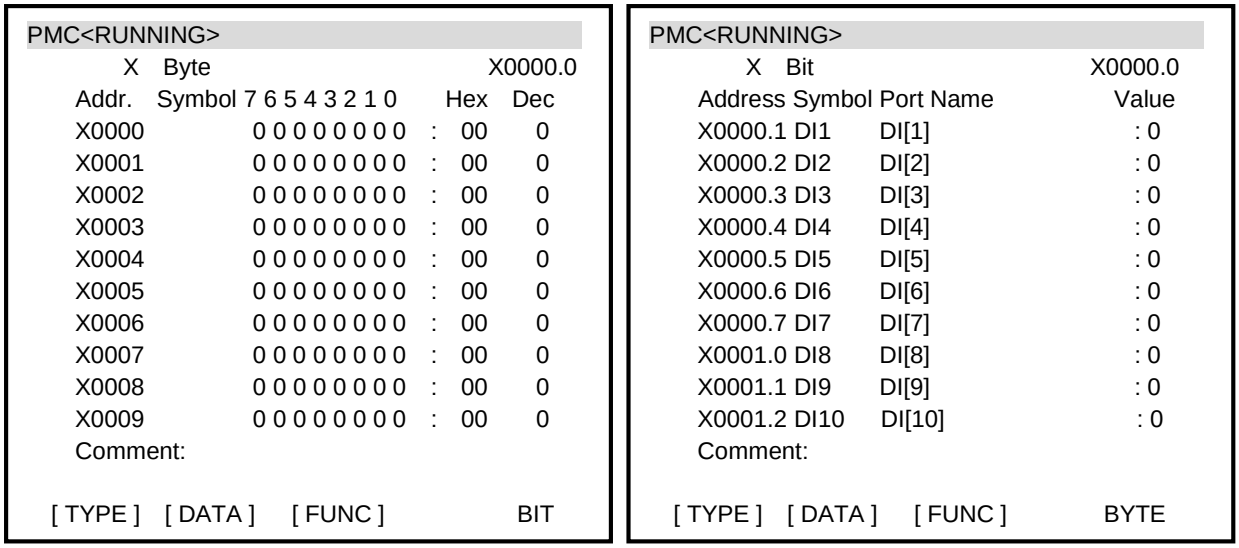


Fig. 4.8(b) PMC screen (Data)

13 Press DATA (F2) key to display the data selection menu.
14 Select “K” in the menu.
15 Set the cursor to the bit “K0001.0” and set K0001.0 to 1.

If the keep relay in PMC cannot be modified and the message “Protected by K17.4” is displayed, enable to modify data by the following procedure, then modify the keep relay.

16 Press DATA (F2) key to display the data selection menu.
17 Select “Parameters” in the menu. The following screen is displayed.

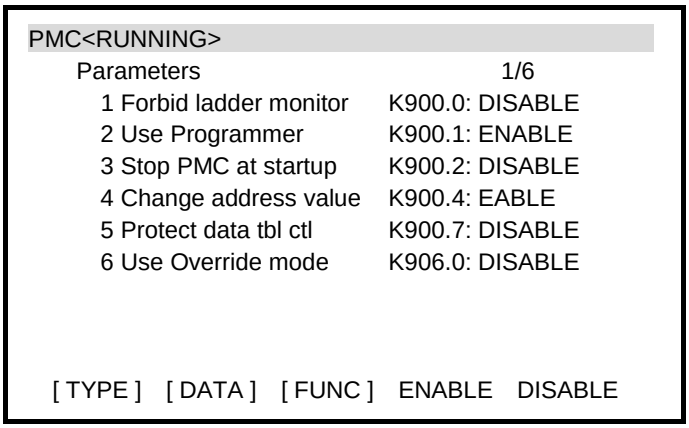


Fig. 4.8(c) PMC screen (Parameters)

18 Set the cursor to “Change address value” and set ENABLE.
19 Set the keep relay according to the procedure 13~15.
20 After change of the keep relay, set “Change address value” to DISABLE if necessary.

4.9 SETTING FOR ROBOT JOG FEED OPERATION FROM CNC

It is possible to operate jog feed of the robot from CNC operation panel. In order to operate jog feed of the robot from CNC operation panel, it is need to enable robot jog feed operation with DI signals in Machine interface screen beforehand.

Procedure to set

1 Press MENU key to display the screen menu.
2 Select “SETUP”.
3 Press TYPE (F1) key to display the screen change menu.
4 Select “Machine I/F” in the menu. Machine interface screen is displayed.

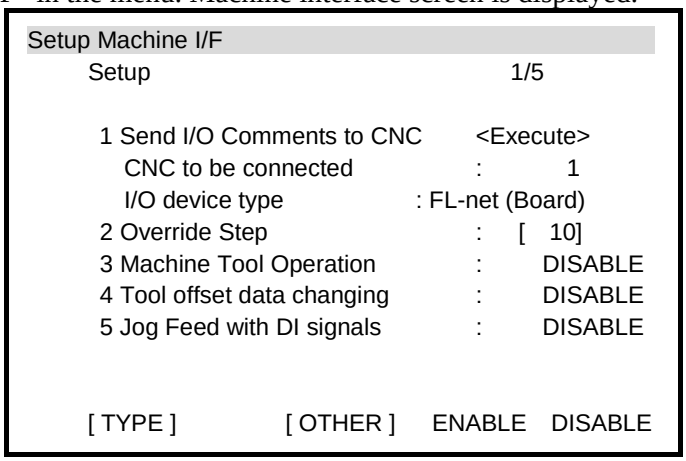


Fig. 4.9 Machine interface screen

5 Set the cursor to “Jog Feed with DI signals”.
6 Select ENABLE to enable the robot jog feed from CNC operation panel. The message “Jog Feed with DI signals is enabled.” is displayed.
When CNC to be connected is 0, even if ENABLE(F4) is selected, the message “ This requires one or more CNC connected.” is displayed and the setting is not changed to ENABLE.
7 In order to enable new setting, please turn of and on the power of the robot controller.

NOTE
In case that the setting for “Jog Feed with DI signals” is changed, the new setting is enabled after the robot controller is restarted.

5 ROBOT SCREEN ON CNC

CNC provides the following robot operation screens.

- ROBOT STATUS screen
- ROBOT PROGRAM SELECT screen
- ROBOT REMOTE OPERATION screen

5.1 ROBOT STATUS SCREEN

The status of Robot signals and alarms are displayed on the ROBOT STATUS screen.

Procedure for displaying the ROBOT STATUS screen

10.4 inch display unit

1. Press the function key 

.
2. Press the continuous key  some times until the soft key [ROBOT STATUS] appears on the screen.
3. Press the soft key [ROBOT STATUS].
4. The ROBOT STATUS screen is displayed.

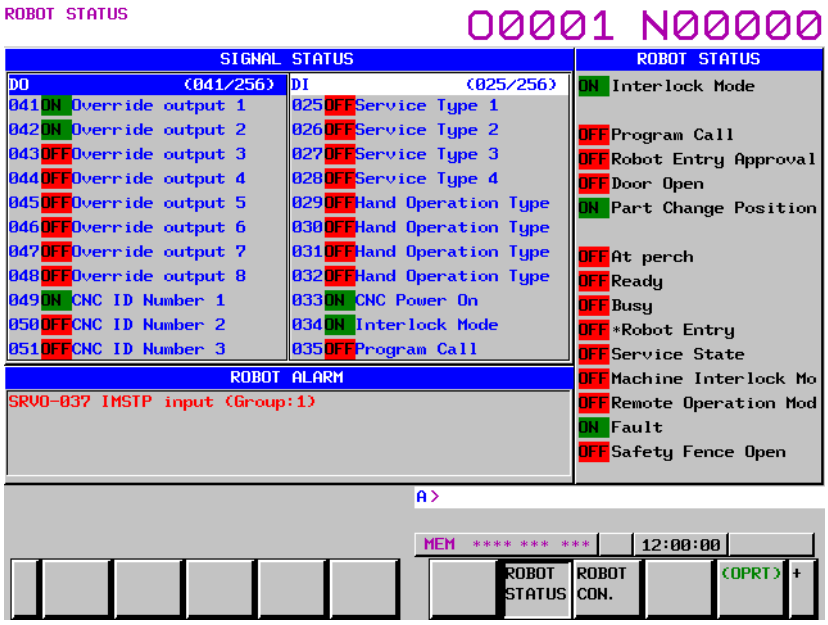


Fig.5.1 (a) ROBOT STATUS screen (10.4inch)

7.2/8.4 inch display unit

1. Press the function key. 

2. Press the continuous key  some times until the soft key [ROBOT STATUS] appears on the screen.
3. Press the soft key [ROBOT STATUS].
4. The ROBOT STATUS screen is displayed.

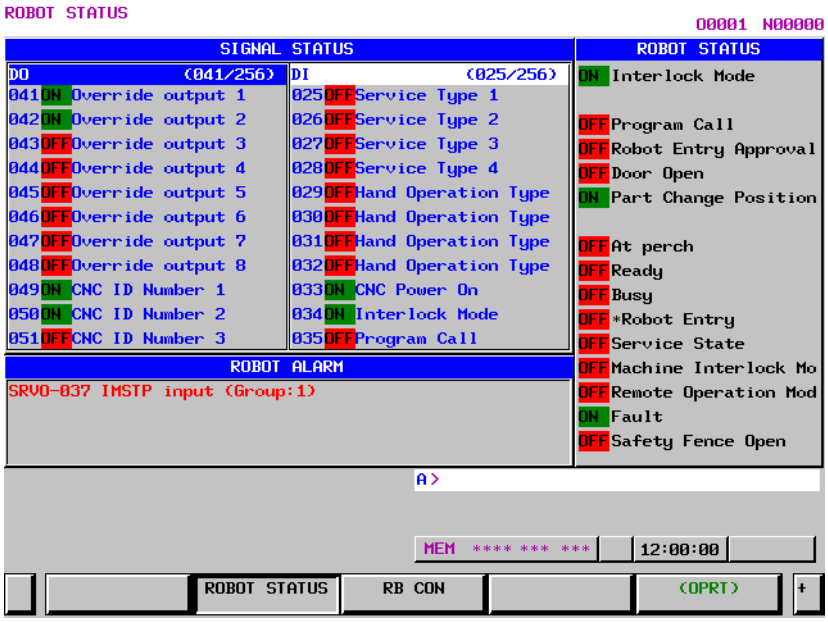


Fig.5.1 (b) ROBOT STATUS screen (8.4inch)

15 inch display unit

1. Press the function key 

.
2. Press the vertical soft key [NEXT PAGE] some times until the soft key [ROBOT STATUS] appears on the screen.
3. Press the vertical soft key [ROBOT STATUS].
4. The ROBOT STATUS screen is displayed.

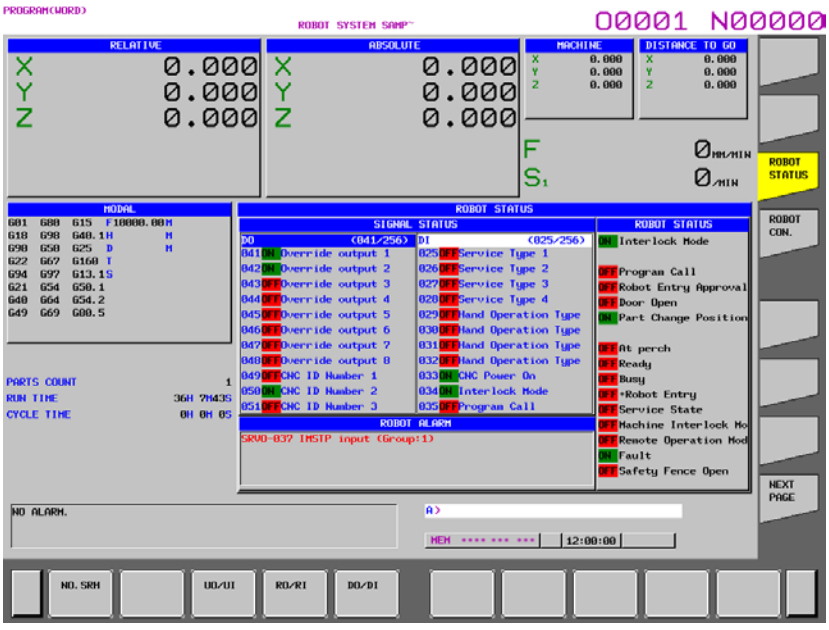


Fig.5.1 (c) ROBOT STATUS screen (15inch)

Explanation of ROBOT STATUS screen

The following items are displayed on the ROBOT STATUS screen.

(1) SIGNAL STATUS (DO: Output signals from Robot)

Item	Description	Num. Of signals
UO	Interlock signals between Robot and CNC	24
RO	Signals between Robot and its hand unit	8
DO	General-purpose signals between Robot and CNC	216

(2) SIGNAL STATUS (DI: Input signals to Robot)

Item	Description	Num. Of Signals
UI	Interlock signals between Robot and CNC	24
RI	Signals between Robot and its hand unit	8
DI	General-purpose signals between Robot and CNC	232

(3) ROBOT STATUS
The signals selected from “SIGNAL STATUS (DI/DO)” are displayed. Up to 16 robot signals are selectable by the setting screen.

(4) ROBOT ALARM
When the alarm occurs in the robot, the alarm messages are displayed.
Up to four messages can be displayed at the same time.

Operation of ROBOT STATUS screen

The following operations are available on the ROBOT STATUS screen.

Display changing of the signal types

1. Press the soft key [(OPRT)]. The following soft keys appear.

2. Press the soft key of the signals which you will display.
   - Soft key [UO/UI]: Interlock signals between Robot and CNC
   - Soft key [RO/RI]: Signals between Robot and its hand unit
   - Soft key [DO/DI]: General-purpose signals between Robot and CNC
3. The selected signals are displayed on the screen.

Scrolling

1. Press the cursor key ← or → to select either SIGNAL STATUS (DI) or (DO). The title of the selected signal is highlighted.
2. Press the cursor key ↑ or ↓ to scroll the selected SIGNAL STATUS list by one line. And press the page key PAGE↑ or PAGE↓ to scroll the list by one page.

Number searching

1. Press the cursor key ← or → to select either SIGNAL STATUS (DI) or (DO).
2. Input the signal number to search, and press the soft key [NO. SRH].
3. The searched signal is displayed at the top of the list.

5.2 ROBOT PROGRAM SELECT SCREEN

The robot program and NC program can be managed on the ROBOT PROGRAM SELECT screen by relating each other.

Procedure for displaying the ROBOT PROGRAM SELECT screen

10.4 inch display unit

1. Press the function key PROG.
2. Press the continuous key ▷ some times until the soft key [ROBOT SELECT] appears on the screen.
3. Press the soft key [ROBOTSELECT].
4. The ROBOT PROGRAM SELECT screen is displayed.

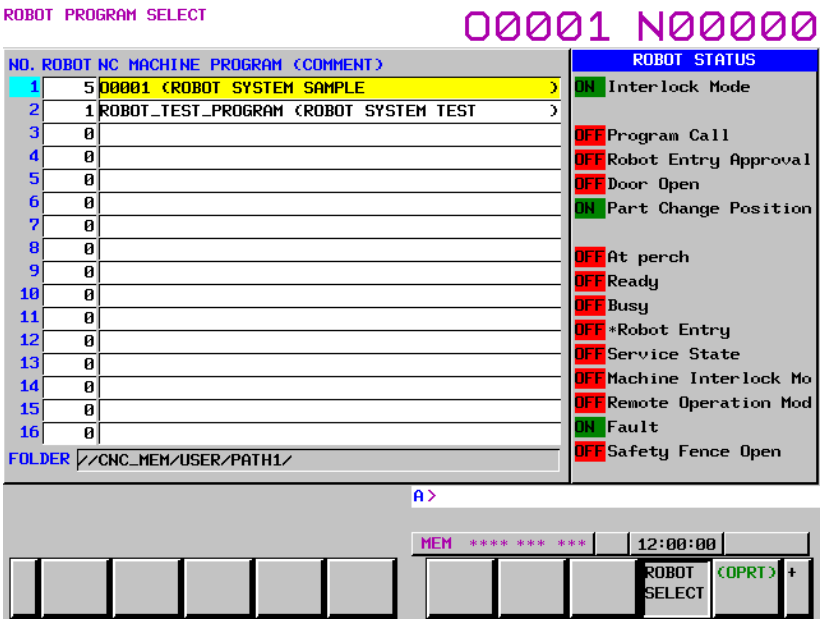


Fig.5.2 (a) ROBOT PROGRAM SELECT screen(10.4 inch)

7.2/8.4 inch display unit

1. Press the soft key PROG.
2. Press the continuous key ▷ some times until the soft key [ROBOT SELECT] appears on the screen.
3. Press the soft key [ROBOT].
4. The ROBOT PROGRAM SELECT screen is displayed.

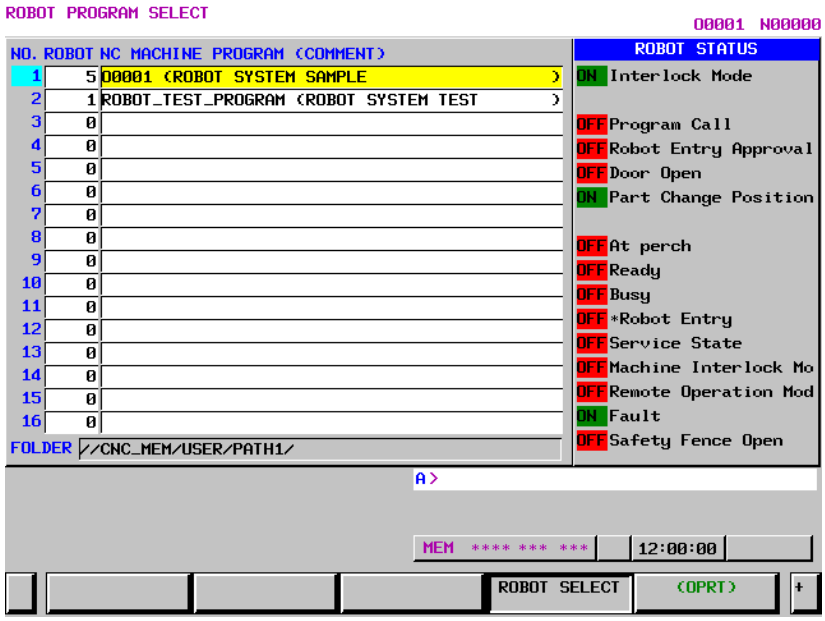


Fig.5.2 (b) ROBOT PROGRAM SELECT screen (8.4 inch)

15 inch display unit

1. Press the function key 

.
2. The vertical soft key [NEXT PAGE] some times until the soft key [ROBOT SELECT] appears on the screen.
3. Press the vertical soft key [ROBOT SELECT].
4. The ROBOT PROGRAM SELECT screen is displayed.

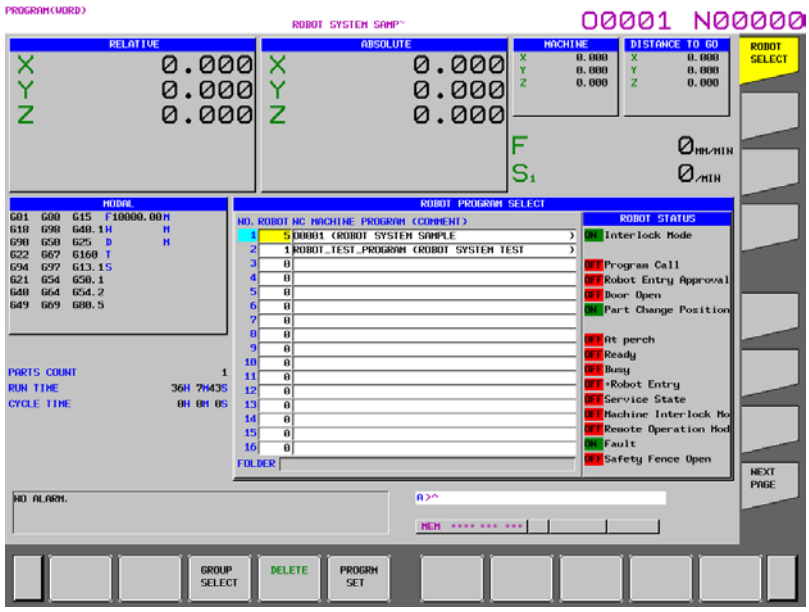


Fig.5.2 (c) ROBOT PROGRAM SELECT screen (15 inch)

Explanation of ROBOT PROGRAM SELECT screen

The following items are displayed on the ROBOT PROGRAM SELECT screen.

(1) Workgroup list
The relation of Robot program, NC program and comments is displayed. Up to 16 groups can be registered.

- NO.
  The selected group number is highlighted with blue.
- ROBOT
  The robot program number is displayed. The robot program is common for all CNC paths.
- NC MACHINE PROGRAM (COMMENT)
  The NC program is displayed by each CNC path.
  When a comment is longer than a display size, a character "~" is put at the end of displayed character string.
- FOLDER
  The folder of the selected NC program is displayed.
  When a folder name is longer than a display size, a part of the folder path is shortened with a character "…". If the cursor points at a Robot program, information is not displayed on this item.

(2) ROBOT STATUS
The signals selected from SIGNAL STATUS(DI) and SIGNAL STATUS(DO) is displayed. Up to 16 robot signals are selectable by the setting screen.

Operating of ROBOT PROGRAM SELECT screen

The following operations are available on the ROBOT PROGRAM SELECT screen.

Selecting of Work group

1. Set the operation mode of all CNC paths to "EDIT" or "MEM".
2. Press the soft key [(OPRT)]. And the following soft keys will appear.

3. Press the cursor key ↑ or ↓ to move the work group you will set.
4. Press the soft key [GROUP SELECT].
5. The Robot program and NC program of the work group are notified to Robot and CNC respectively.

NOTE
When you modify the setting of selected work group, please select the same work group again after the modification is finished. By selecting the work group again, the modified value is notified to CNC and the robot.

Setting of Robot program number

1. Press the cursor key ← or → to move the cursor to the "ROBOT" column.
2. Input a Robot program number, and press the MDI key INPUT.
3. The inputted number is memorized to the corresponding work group list.

NOTE
Some consecutive inputs by EOB are not allowed.

Setting of NC program

There are two methods to select NC program.

- The setting operation in the ROBOT PROGRAM SELECT screen
- The setting operation in the PROGRAM FOLDER screen

・The setting operation in the ROBOT PROGRAM SELECT screen

1. Press the cursor key [↑], [↓], [←], or [→] to move the cursor to the [NC MACHINE PROGRAM] column of the work group you will set.
2. Input a program name, and press the MDI key [INPUT].
3. Then, the program is selected from the foreground folder of the selected CNC path, and memorized to the work group.

・The setting operation in the PROGRAM FOLDER screen

1. Press the cursor key [↑], [↓], [←], or [→] to move the cursor to the [NC MACHINE PROGRAM] column of the work group you will set.
2. Press the soft key [(OPRT)].
3. Press the soft key [PROGRAM SET].

4. The previously-selected current folder and the device will be displayed on the PROGRAM FOLDER screen.
   Please note that the available soft keys depend on the selected device type. And when “CNC_MEM”, “MEMCARD” or “DATA_SV” is chosen as the device type, soft key [MACHIN SELECT] is available.

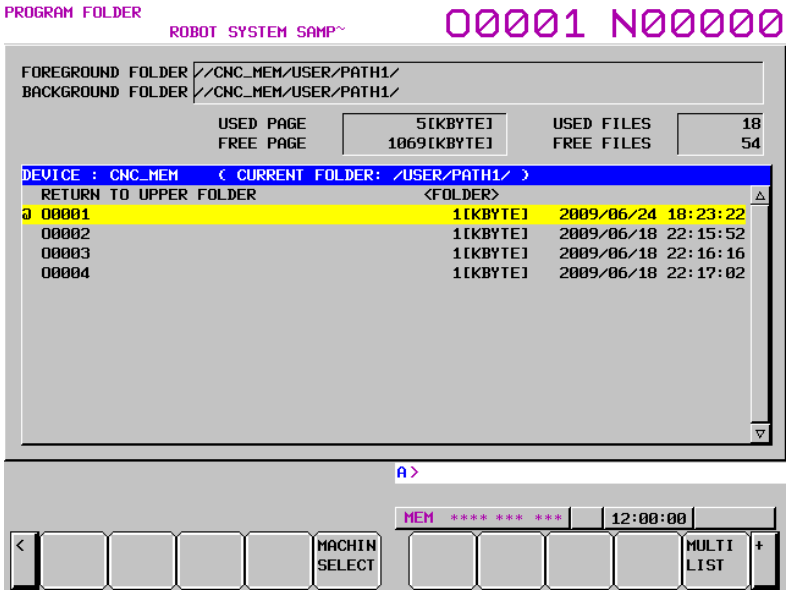


Fig.5.2 (d) PROGRAM FOLDER screen

5. Move the cursor to the program you will select, press the soft key [MACHIN SELECT].

6. The selected NC program will be memorized and displayed on the ROBOT PROGRAM SELECT screen.

NOTE
The soft key [MACHIN SELECT] is displayed on the PROGRAM FOLDER screen only when entering from the ROBOT PROGRAM SELECT screen.

Deleting of the selected data

1. Press the soft key [(OPRT)], and the following soft keys will appear.

2. Press the soft key  ,  ,  , or  to move the cursor to the data you will delete.
3. Press the soft key [DELETE], and the following soft keys will appear.

4. If the soft key [EXEC] is pressed, the highlighted data is deleted. If the soft key [CAN] is pressed, the deletion is canceled.

5.3 ROBOT REMOTE OPERATION SCREEN

The robot can be remotely operated from the ROBOT REMOTE OPERATION screen of CNC.

The ROBOT REMOTE OPERATION screen is provided as a sample program of FANUC PICTURE. This section describes the operation procedure of the sample ROBOT REMOTE OPERATION screen.

Procedure for displaying the ROBOT REMOTE OPERATION screen

10.4 inch display unit

1. Press the function key  .
2. The ROBOT REMOTE OPERATION screen is displayed.

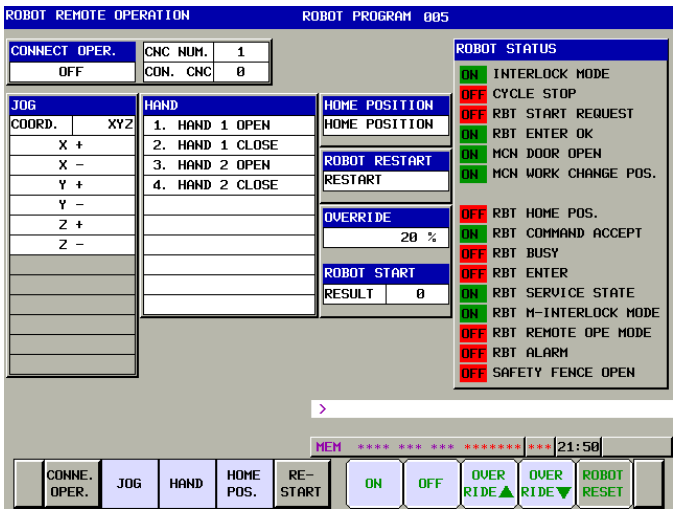


Fig.5.3 (a) ROBOT REMOTE OPERATION screen (10.4 inch)

7.2/8.4inch display unit

1. Press the function key  .
2. The ROBOT REMOTE OPERATION screen is displayed.

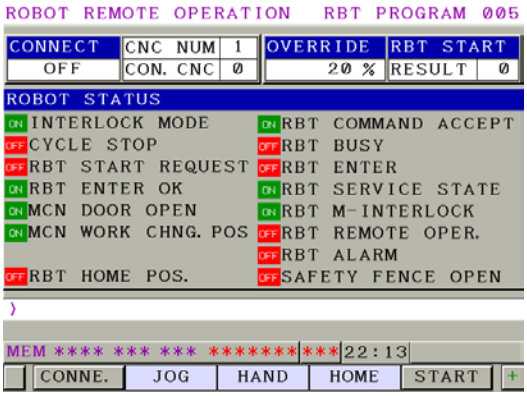


Fig. 5.3 (b) ROBOT REMOTE OPERATION screen (8.4 inch)

The 8.4 inch REMOTE OPERATION screen is composed of the following three sub screens.
When calling the ROBOT REMOTE OPERATION screen from other CNC screen, the ROBOT CONNECTION screen is displayed first. And each sub screen can be changed by the corresponding soft key.

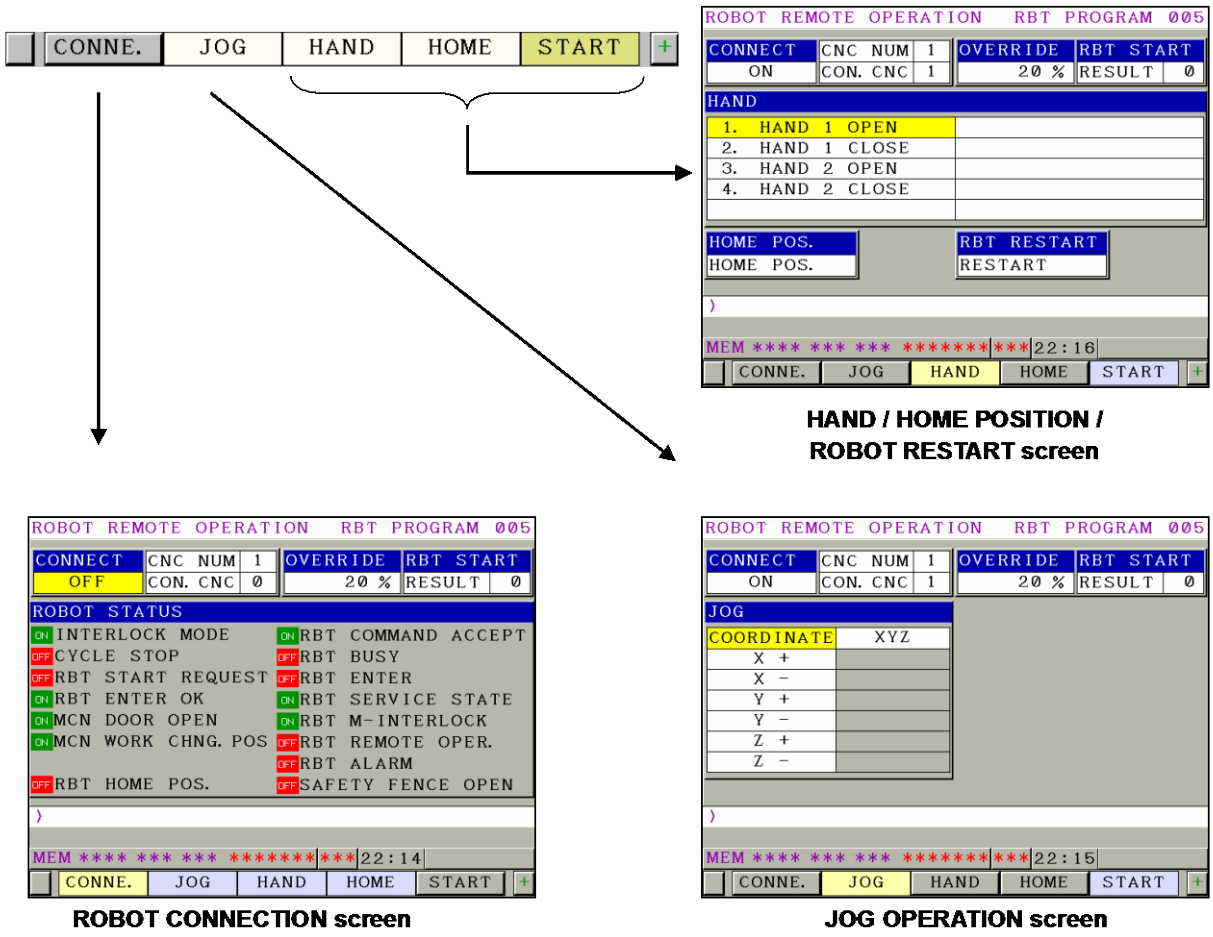


Fig. 5.3 (c) Sub screens of ROBOT REMOTE OPERATION（8.4 inch）

When pressing the soft key [+], the soft keys are changed as follows. The definition of each soft key is same as that of 10.4 inch ROBOT REMOTE OPERATION screen.

- ROBOT CONNECTION screen

- JOG FEED screen

- HAND / HOME POSITION RETURN / ROBOT RESTART screen

And when pressing the soft key ◁, the soft keys are changed back to the ones for selecting the sub screens.

15 inch display unit

1. Press the function key CUSTOM2.
2. The ROBOT REMOTE OPERATION screen is displayed.

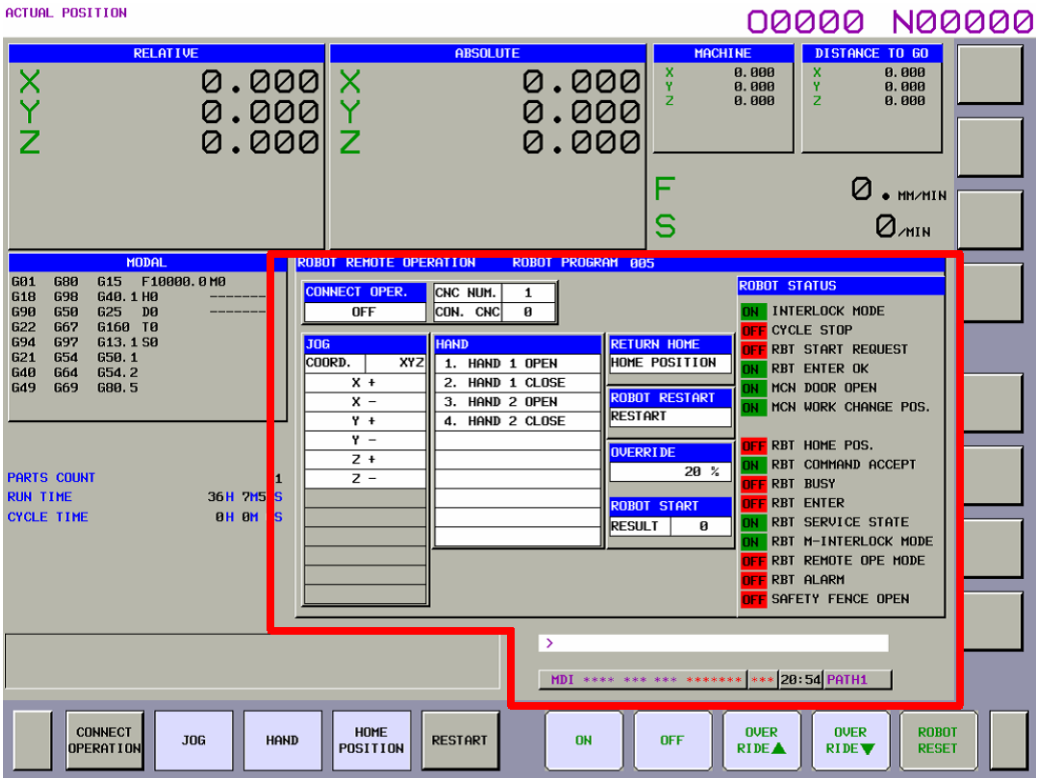


Fig. 5.3 (d) ROBOT REMOTE OPERATION screen (15 inch)

Explanation of ROBOT REMOTE OPERATION screen

The following operations are available from the soft keys of the ROBOT REMOTE OPERATION screen.

(1) CONNECT OPERATION
The robot remote operation right (for Jog feed, Hand operation, Home position return and Override change) can be acquired/released.

(2) JOG FEED
The robot coordinate system can be selected from [XYZ (Cartesian coordinate system)] and [JOINT (Joint coordinate system)], and the robot can be manipulated manually.
The following is the relationship of the coordinate system and each direction of axis.

Coordinate	Direction of axis
XYZ	X+, X-, Y+, Y-, Z+, Z-
JOINT	J1+, J1-, J2+, J2-, J3+, J3-, J4+, J4-, J5+, J5-, J6+, J6-

(3) HAND OPERATION
The hand operation that is selected from up to ten operation patterns can be executed.

(4) HOME POSITION RETURN

The robot can be returned to its home position.

(5) OVERRIDE CHANGE
The override of robot operation speed can be increased/decreased.

(6) RESTART
The robot can be restarted.
If the robot stops the execution by some reason and CNC falls into a waiting state, the system can be restarted by this operation without restarting the CNC side.

(7) ROBOT RESET
The robot alarm can be reset.
The robot alarm is cleared, but its action is not affected.

The following information is indicated on the ROBOT REMOTE OPERATION screen.

(1) CNC NUM.
The CNC number (1-4) configured by the robot is displayed.

(2) CON. CNC
The CNC number that has the robot remote operation right currently is displayed. When any CNC does not have the remote operation right, “0” is displayed.

(3) ROBOT PROGRAM
The robot program number is displayed at the top of the screen (the right side of the title bar).

(4) OVERRIDE
The current override of the robot operation speed is displayed in the range of 1% to 100%. When the override is “low speed” (less than 1%), “---“ is displayed.

(5) RESULT of ROBOT START
When the robot program is finished with a normal state, “0” is displayed. If it is not finished normally, the error code except for “0” is displayed.

(6) ROBOT STATUS
The signals selected from SIGNAL STATUS(DO) and SIGNAL STATUS(DI) is displayed. Up to 16 robot signals can be displayed.

When moving the cursor to the selected item, the cursor is highlighted with yellow.

Operation of ROBOT REMOTE OPERATION screen

The following operations are available on the ROBOT REMOTE OPERATION screen.

Acquiring the remote operation right

1 Press the soft key [CONNE. OPER.] to move the cursor to “OFF” of “CONNECT. OPER”. And the soft keys, “ON” and “OFF” appear.

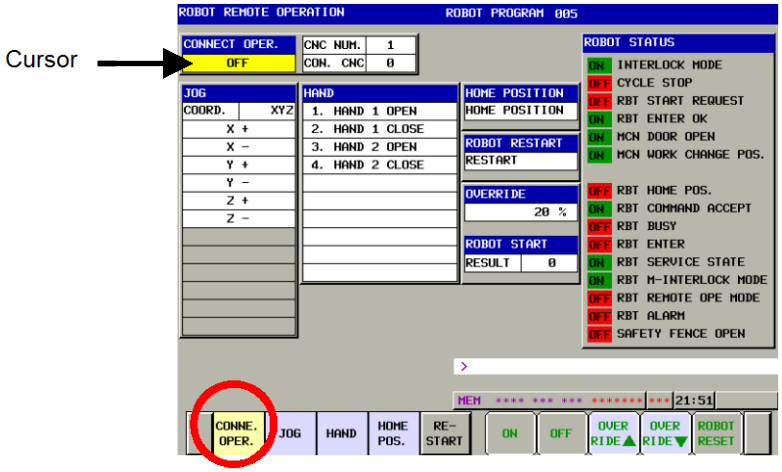


Fig. 5.3 (e) Acquiring the remote operation right(1)

2 Confirm that the robot state is in the INTERLOCK MODE by using the ROBOT STATUS.
3 Press the soft key [ON] to acquire the remote operation right of the robot.
4 When the remote operation right is acquired successfully, the highlighted field is changed to “ON”, and own CNC number is displayed at “CON. CNC”.

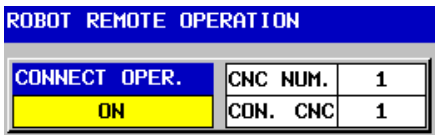


Fig 5.3 (f) Acquiring the remote operation right (2)

NOTE
1. To operate Jog / hand / home position/ override, the remote operation right has to be acquired.
2. The robot can be reset regardless of the remote operation right.
3. If the remote operation right cannot be acquired because the robot is running a program, or the other CNC has already acquired the remote operation right, the message, “Failed to get control right of robot.” is displayed in the message field at the bottom of the screen.
4. When the machine tool is in the stand-alone mode, the remote operation right cannot be acquired. (The message “Interlock mode signal is off” is displayed in the screen.)

Releasing the remote operation right

When selecting the soft key [CONNE. OPER.] and pressing the soft key [OFF], or when closing the ROBOT REMOTE OPERATION screen and returning to other CNC screen, the remote operation right will be released.
If robot operation is necessary again, the remote operation right has to be acquired.

Jog feed

1. Press the soft key [JOG] to move the cursor to “COORD.”.
   And select the coordinate system by pressing the soft keys “XYZ” or “JOINT”.

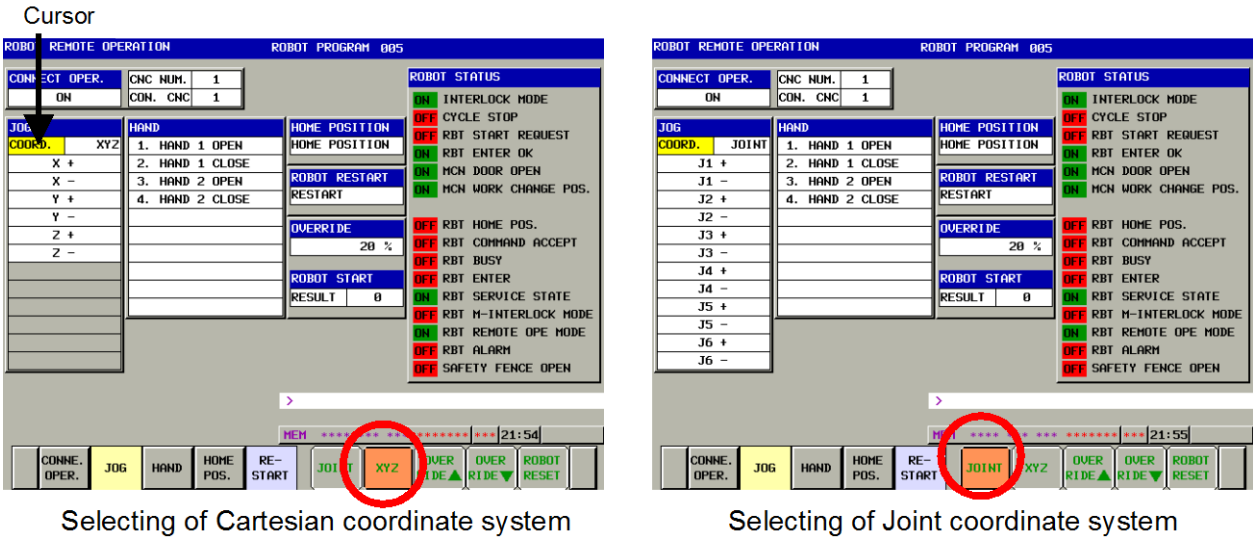


Fig. 5.3 (g) Selecting of the coordinate system for Jog feed

NOTE
The Cartesian coordinate system is selected initially.

2. Select the axis direction by using the Cursor key ↑ or ↓.

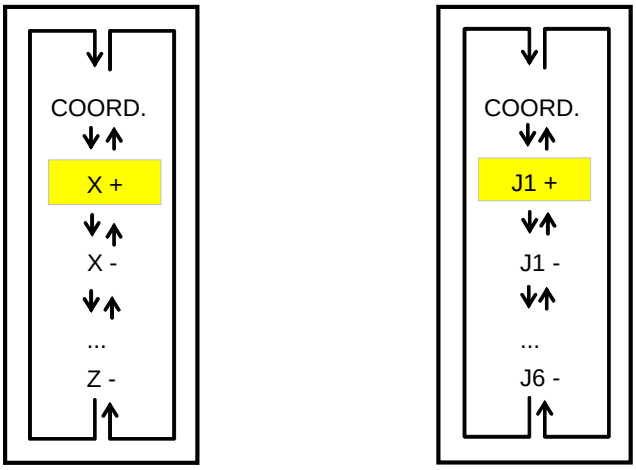


Fig.5.3 (h) Selecting of axis direction for Jog operation

NOTE
Just when the cursor is focusing an axis, the coordinate system cannot be changed.

3. The robot will be moved according to the selected coordinate system and axis direction just while being pushing "Robot operation button" of a machine operator's panel.

NOTE
The soft key is not available while pushing "Robot operation button" of a machine operator's panel.

Hand operation

1. Press the soft key [HAND] to move the cursor to "<Hand operation>" as follows.

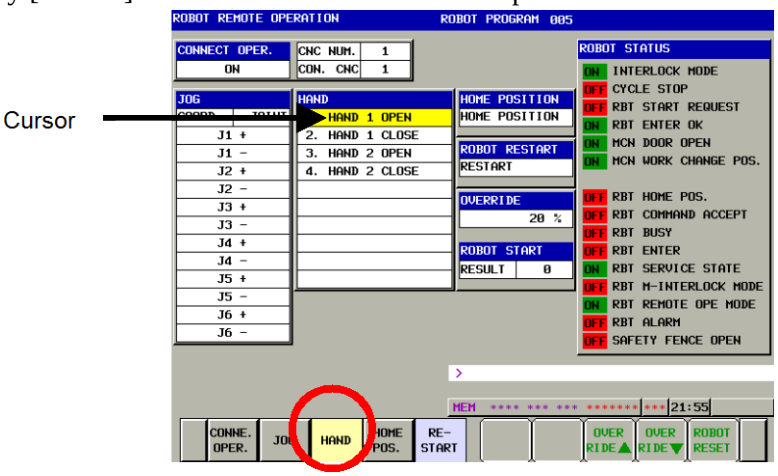


Fig.5.3 (i) Hand operation

2. Select the hand operation by using the Cursor key ↑ or ↓.

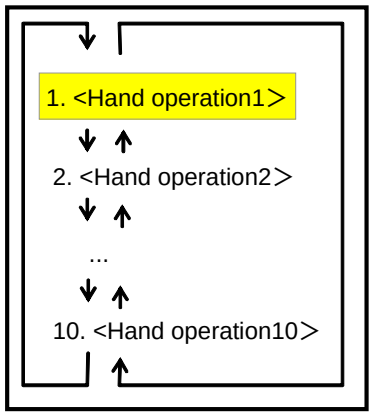


Fig.5.3 (j) Selecting of Hand operation

3. When one of the hand operations is being selected and "Robot operation button" of a machine operator's panel is pushed, the robot will start the corresponding hand operation.

NOTE
The machine tool builder has to customize the contents of the hand operations according to the actual system.

Home position return

1 Press the soft key [HOME POS.] to move the cursor to "HOME POSITION" as follows.

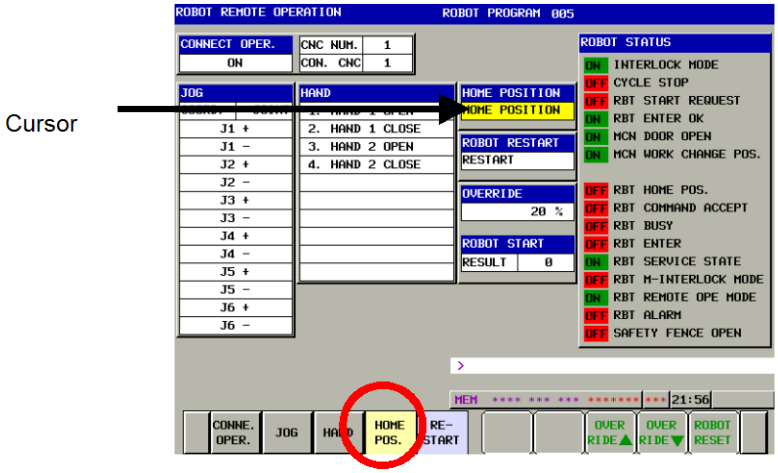


Fig. 5.3 (k) Home position

2 When "HOME POSITION" is being selected and "Robot operation button" of a machine operator's panel is pushed, the robot will start returning to the home position.
The robot just moves only while the button is being pushed. When the robot reaches the home position, "RBT HOME POS." of ROBOT STATUS becomes "ON". So the button has to be kept pushing until reaching the home position (until "RBT HOME POS." is "ON").

NOTE
When the robot already reached its home position, the robot does not move any more even if the button is pushed.

Override change

The override of the robot operation speed can be changed by using the soft key [OVERRIDE].

NOTE
When the soft key is pushed once, its changed width of the override value depends on the setting of the robot controller. Please see “4.5. SETTING STEP OF OVERRIDE CHANGE”.

Robot restart

If the robot stops the execution by some reason and CNC falls into a waiting state, the system can be restarted by restarting the robot program without restarting the CNC side.

Note that the robot controller must be in a state that CNC can call the robot program. It is typically required to reset the robot and return the robot to its home position before restarting the robot program Please refer to "7.1.3 Recovery from Failure of a Robot Program" for detail.

1 Check that “CON.CNC” is “0”. (All CNCs do not have the remote operation right of the robot.)
2 Press the soft key [RE-START], and the cursor will be moved to ”RESTART” as follows.

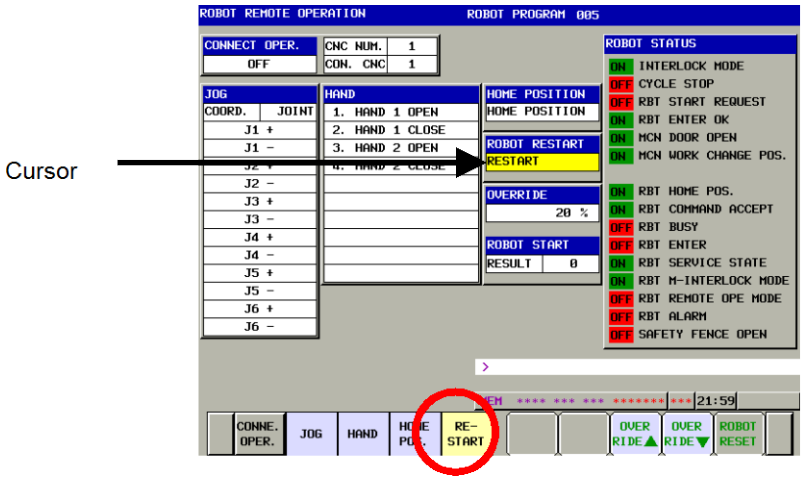


Fig. 5.3 (l) Robot restart

3 When “RESTART” is being selected and "Robot operation button" of a machine operator’s panel is pushed, the robot will start the current robot program.

NOTE
The robot restart operation can be executed only when all CNCs are releasing the robot remote operation right.
If another CNC has acquired the remote operation right when the robot restart operation is executed in this screen, the robot cannot start the robot program.

Robot reset

When the soft key [ROBOT RESET] is pressed, the robot alarms are cleared.

NOTE
The robot reset operation can be executed regardless of the robot remote operation right.

6 CNC SCREEN ON ROBOT

The CNC screens displayed on the robot teach pendant are as follows.

- CNC status display screen: CNC actual position of the tool, occurring alarm in CNC and so on are displayed on the robot teach pendant.
- CNC operation screen: Machine tool operation and input of tool offset in CNC can be executed on the robot teach pendant.

NOTE

- In case that the robot does not communicate with CNC by Ethernet, CNC data cannot be displayed on the robot teach pendant.
- In case that the screen on teach pendant is divided, both CNC status display screens and CNC operation screens can't be displayed in some windows. If you try to display these screens in another window, the alarm occurs and the designated screen can't be displayed.

6.1 CNC STATUS DISPLAY SCREEN

CNC status display screen consists of the following screens.

- CNC actual position screen
- CNC alarm screen
- CNC message screen
- CNC running program screen
- I/O screen

The language for display in these screens is same as the language selected in the robot controller. But, if the language selected in the robot controller is different from the language selected in CNC, these screens may not be displayed correctly.

Procedure to display CNC status display screen

1 Press MENU key to display the screen menu.
2 Select "Browser" in the menu.
3 Press TYPE (F1).
4 Select "CNC" in the displayed menu.
5 CNC actual position screen is displayed.

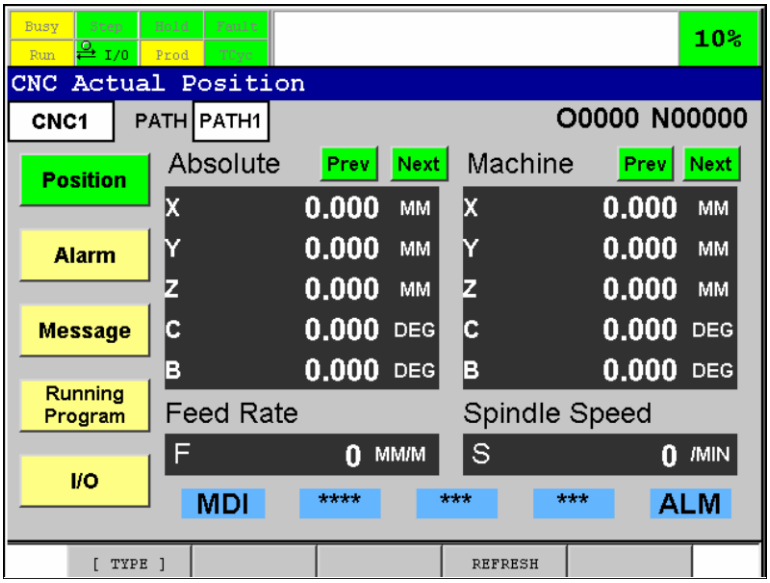


Fig. 6.1(a) CNC actual position screen

Displayed contents in CNC status display screen

The common items displayed in all CNC status display screens are as follows.

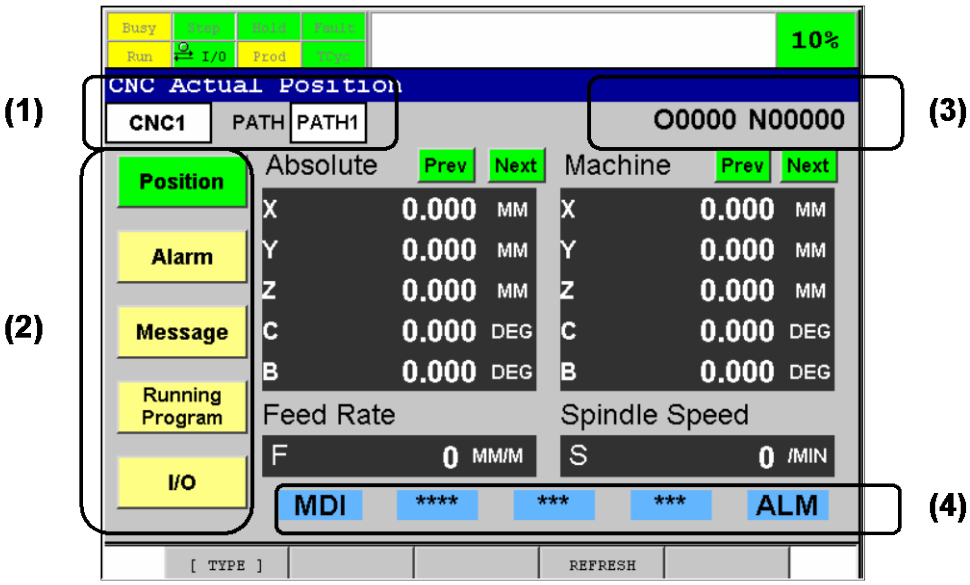


Fig. 6.1(b) Screen format

(1) Host Name, Path Name
- The name of the displayed CNC and path are displayed.
- The name of CNC is displayed by the host name of the client tag. If host name is not defined, IP address is displayed as the name of CNC.
- If you want to change CNC and path to display, press these boxes, then select CNC and path in the displayed menu.

(2) Screen Change Button
- If you want to display other screen in CNC status display screens, press the button corresponding to new screen.
- The button for the current selected screen is displayed green.

(3) CNC Program Name, Sequence Number
- The program name selected in CNC and the sequence number are displayed.

(4) CNC status lamp

- These lamps display CNC status. Followings are explanation for each lamp.

Fig. 6.1(c) CNC status display lamp

(1) This lamp indicates CNC current mode.

Table 6.1(a) Mode list

Display	Description
MDI	Manual data input, MDI operation
MEM	Automatic operation (memory operation)
RMT	Automatic operation (DNC operation) Automatic operation reading the program from external device
EDIT	Memory editing
HND	Manual handle feed
JOG	Jog feed
INC	Manual incremental feed
REF	Manual reference position return The mode to move the designated axis to the reference position by manual operation
TJOG	TEACH IN mode that the manual operation is the jog feed. TEACH IN mode is the mode to create the program with recording the current position of each controlled axis to CNC memory when the tool is moved by the manual operation.
THND	TEACH IN mode that the manual operation is the manual handle feed. TEACH IN mode is the mode to create the program with recording the current position of each controlled axis to CNC memory when the tool is moved by the manual operation.
****	Mode other than the above

(2) This lamp indicates CNC automatic operation status.

Table 6.1(b) Automatic operation status list

Display	Description
****	Reset (When the power is turned on or the state in which program execution has terminated and automatic operation has terminated.)
STOP	Automatic operation stop (The state in which one block has been executed and automatic operation is stopped.)
HOLD	Feed hold (The state in which execution of one block has been interrupted and automatic operation is stopped.)
STRT	Automatic operation start-up (The state in which the system operates automatically.)
MSTR	Manual numerical command start state (The state in which a manual numerical command is being executed.) Alternatively, tool retract and recover operation state (The state in which a recover operation and repositioning operation are being performed.)

(3) This lamp indicates CNC axis moving status, dwell status.

Table 6.1(c) Axis moving status, dwell status list

Display	Description
MTN	Indicates that the axis is moving.
DWL	Indicates the dwell state. (The state in which the transition to the next block is delayed for the designated time.)
***	Indicate a state other than the above.

(4) This lamp indicates CNC auxiliary function execution status.

Table 6.1(d) Auxiliary function execution status list

Display	Description
FIN	Indicates the state in which an auxiliary function is being executed. (Waiting for the complete signal from the PMC)
***	Indicate a state other than the above.

(5) This lamp indicates CNC alarm status.

Table 6.1(e) Alarm status list

Display	Description
ALM	Indicates that an alarm is issued. (Blinks in reversed display.)
BAT	Indicates that the voltage of the lithium battery (the backup battery of the CNC) has decreased. (Blinks in reversed display.)
Space	Indicate a state other than the above.

About each status display, refer to Common to Lathe System/Machining Center System OPERATOR'S MANUAL corresponding to your using CNC.

6.1.1 CNC Actual Position Screen

In CNC actual position screen, current position of the tool in CNC absolute coordinate and position of the tool in CNC machine coordinate are displayed. Feed rate and spindle speed are displayed, too.

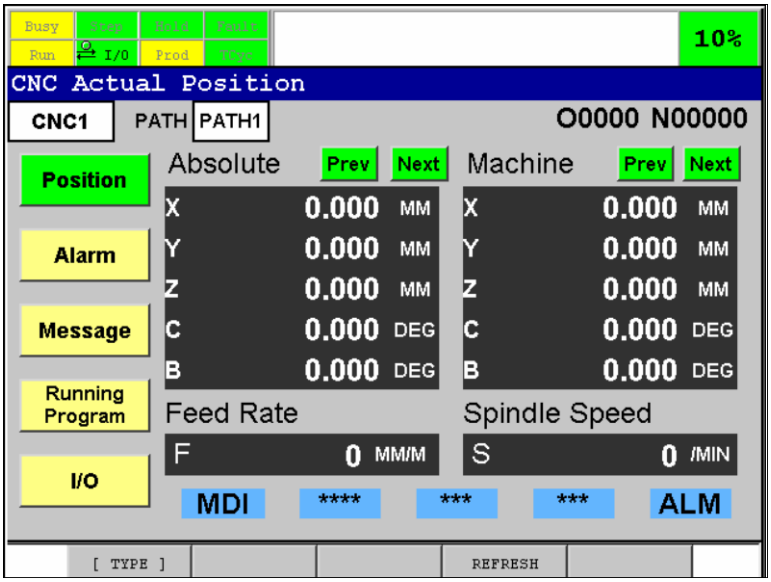


Fig. 6.1.1 CNC actual position screen

Displayed contents in CNC actual position screen

The displayed contents in CNC actual position screen are as follows.

1. Position data in the absolute coordinate
   - Position data in the absolute coordinate are displayed. Unit for the position data is any one of "MM" or "Inch" or "deg" according to the displayed unit in CNC.
   - Position data for 5 axes can be displayed at the same time. Position data up to 24 axes can be displayed.
   - Axis name is same as the axis name displayed in CNC.

2. Position data in machine coordinate
   - Position data in the machine coordinate. Unit for the position data is any one of “MM” or “Inch” or “deg” according to the displayed unit in CNC.
   - Position data for 5 axes can be displayed at the same time. Position data up to 24 axes can be displayed.
   - Axis name is same as the axis name displayed in CNC.
3. Feed rate
   - Feed rate is displayed. Unit for the feed rate is any one of “MM/min” or “Inch/min” according to the displayed unit in CNC.
4. Spindle speed
   - Spindle speed is displayed. Unit for the spindle speed is “/min”.

Operation in CNC actual position screen

In CNC actual position screen, following operations are enabled.

Change of the displayed axis

In case that there are more than 5 axes in CNC, the displayed axes can be changed by “Prev” button and “Next” button.

Update axis name

When the axis name is changed in CNC, it is possible to change axis name in this screen to the axis name in CNC by pressing “REFRESH” (F4) key.

6.1.2 CNC Alarm Screen

In CNC alarm screen, the alarms occurring in CNC are displayed.

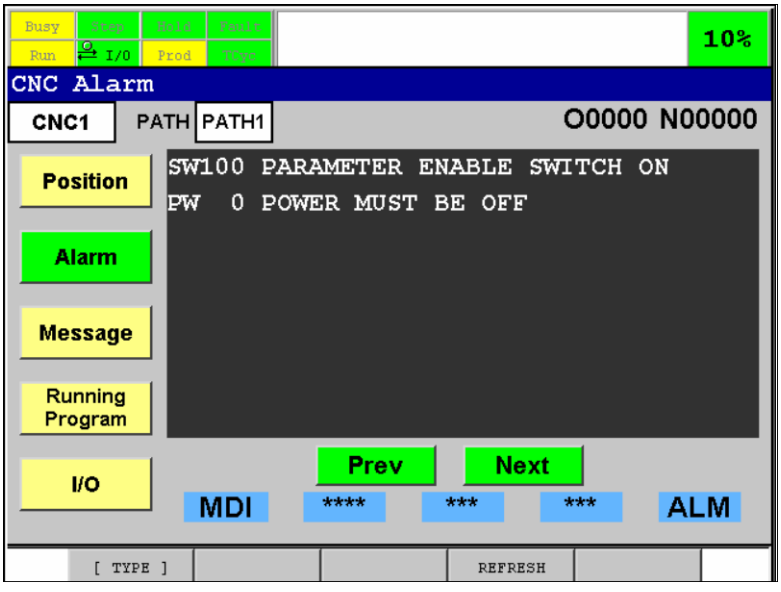


Fig. 6.1.2 CNC alarm screen

Displayed contents in CNC alarm screen

The displayed contents in CNC alarm screen are as follows.

1. Occurring alarm
   - Up to 17 alarms occurring in CNC are displayed in this screen.
   - Up to 8 alarms are displayed at the same time.

Operation in CNC alarm screen

In CNC alarm screen, the following operation is enabled.

Change the page

When more than 8 alarms are occurring in CNC, the displayed page can be changed by “Prev” button and “Next” button.

6.1.3 CNC Message Screen

In CNC message screen, the operator messages displayed in CNC are displayed.

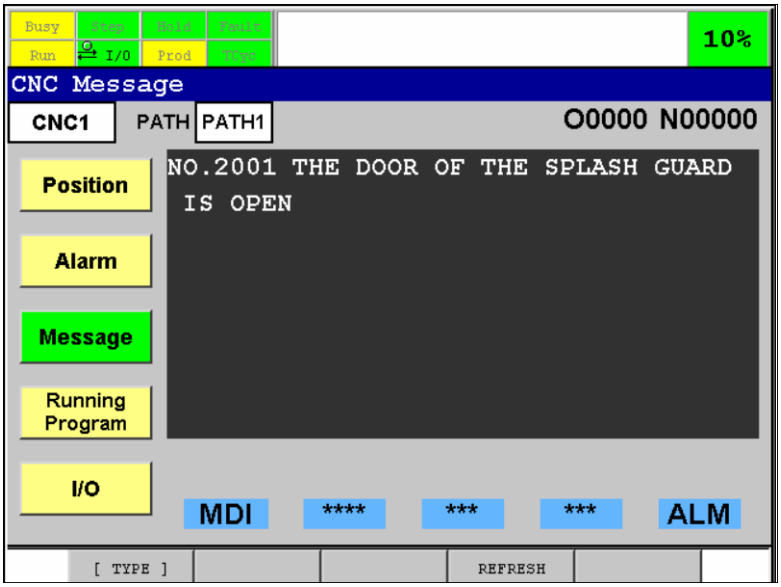


Fig. 6.1.3 CNC message screen

Displayed contents in CNC message screen

The displayed contents in CNC message screen are as follows.

1. Operator message
   - Operator messages displayed in CNC are displayed.
   - In case that CNC is set not to display the operator message, no message is displayed in this screen.
   - In this screen, up to 254 characters can be displayed. The characters after 254th character in the operator message cannot be displayed in this screen.

6.1.4 CNC Running Program Screen

In CNC running program screen, running program in CNC is displayed.

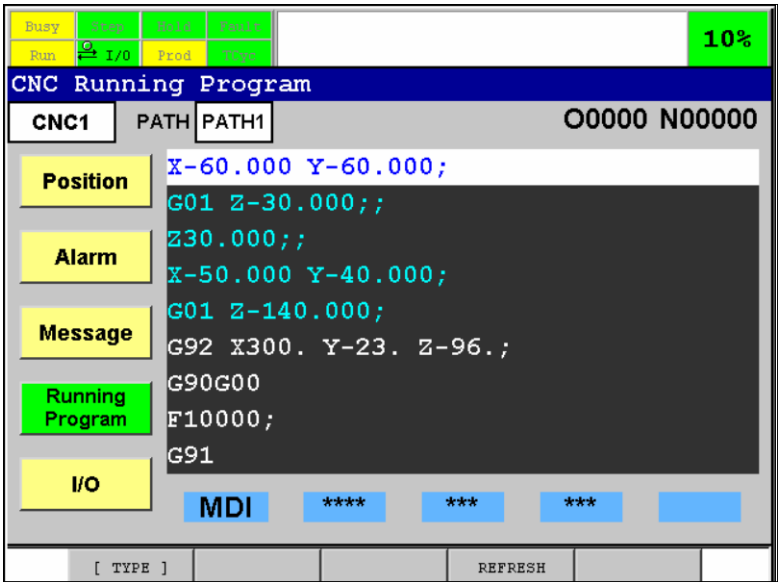


Fig. 6.1.4 CNC running program screen

Displayed contents in CNC running program screen

The displayed contents in CNC running program screen are as follows.

1. Running program
   - The program executed in CNC is displayed in this screen.
   - One block of CNC program is displayed in one line. Up to 37 characters can be displayed in one line.
   - The block executed in CNC is displayed in the first line.
   - The read-ahead block is highlighted with light blue.
   - Up to 9 blocks can be displayed at the same time.

6.1.5 I/O Screen

In I/O screen, the I/O data connected with CNC are displayed.

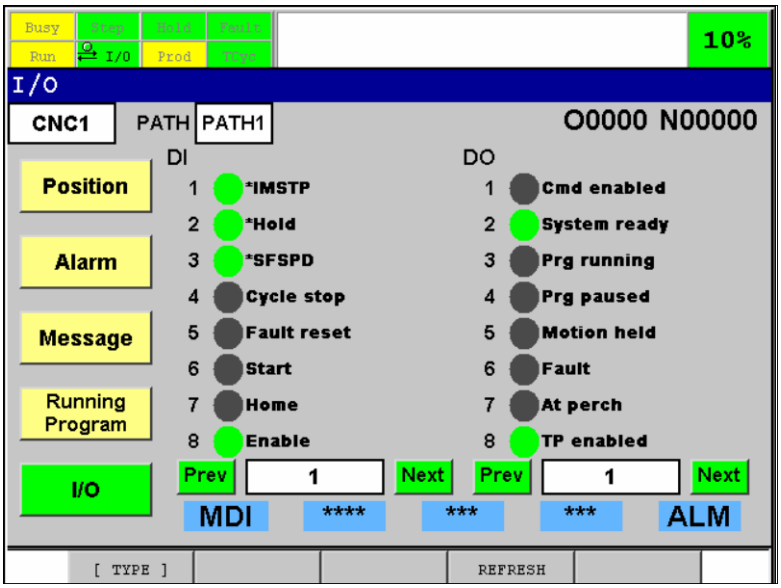


Fig. 6.1.5(a) I/O screen

Displayed contents in I/O screen

The displayed contents in I/O screen are as follows.

1. DI signal
   - Signal status and comments of robot input signal (DI) connected with CNC are displayed.
   - The comments are same as the comments set in I/O screen for the robot controller.
2. DO signal
   - Signal status and comments of robot output signal (DO) connected with CNC are displayed.
   - The comments are same as the comments set in I/O screen for the robot controller.

Operation in I/O screen

In I/O screen, following operation is enabled.

Change screen

The displayed I/O can be changed by pressing arrow buttons and by input of signal number.

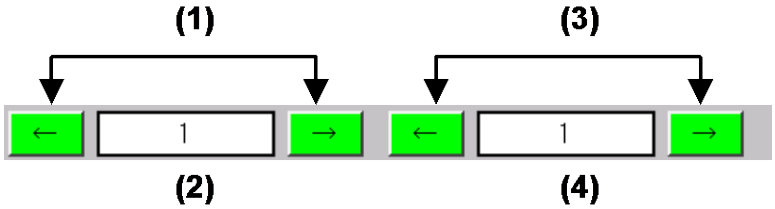


Fig. 6.1.5(b) I/O display change

(1) Arrow buttons to change DI data
   - Next 8 DI data or previous 8 DI data are displayed by pressing these buttons.

(2) DI number input
   - 8 DI data beginning from the input number are displayed.

(3) Arrow buttons to change DO data
   - Next 8 DO data or previous 8 DO data are displayed by pressing these buttons.

(4) DO number input
   - 8 DO data beginning from the input number are displayed.

6.2 CNC OPERATION SCREEN

CNC operation screen consists of the following screens.

- Machine tool operation screen
- Tool offset screen

The language for display in these screens is same as the language selected in the robot controller. But, if the language selected in the robot controller is different from the language selected in CNC, these screens may not be displayed correctly.

Procedure to display CNC operation screen

1 Press MENU key to display the screen menu.
2 Select “Browser” in the menu.
3 Press TYPE (F1).
4 Select “CNC OPERATION” in the displayed menu.
5 Machine tool operation screen is displayed.

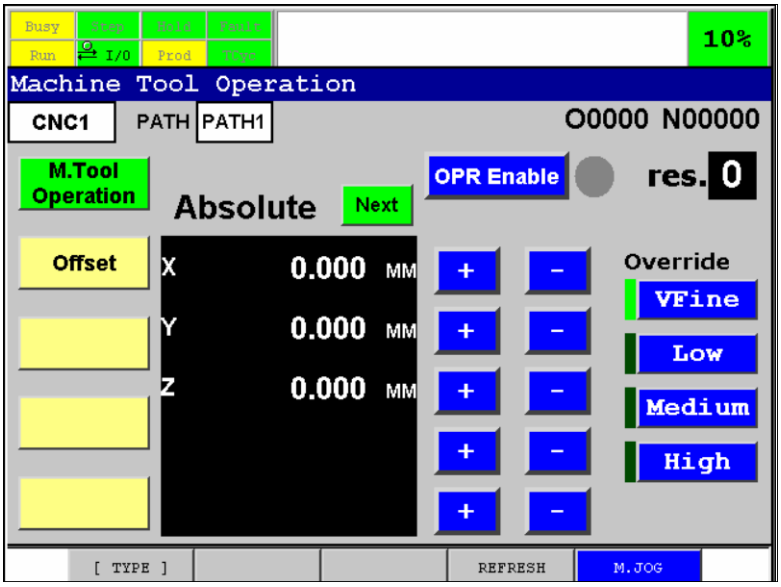


Fig. 6.2(a) Machine tool operation screen

Displayed contents in CNC operation screen

The common items displayed in all CNC operation screens are as follows.

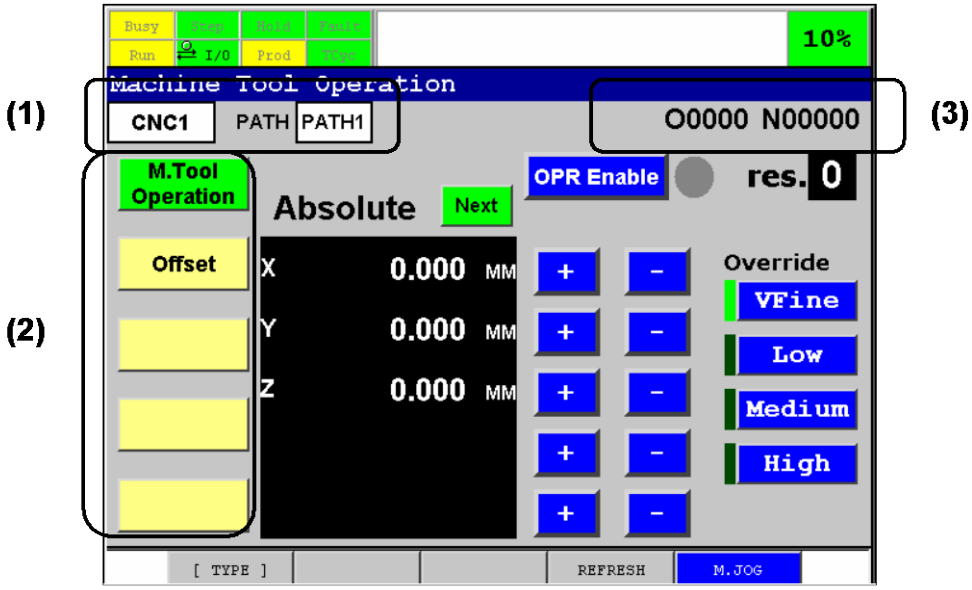


Fig. 6.2(b) Screen format

(1) Host Name, Path Name
- The name of the displayed CNC and path are displayed.
- The name of CNC is displayed by the host name of the client tag. If host name is not defined, IP address is displayed as the name of CNC.
- If you want to change CNC and path to display, press these boxes, then select CNC and path in the displayed menu.

(2) Screen Change Button
- If you want to display other screen in CNC operation screens, press the button corresponding to the screen that you want to display.
- The button for the current selected screen is displayed green.

(3) CNC Program Name, Sequence Number
- The program name selected in CNC and the sequence number are displayed.

6.2.1 Machine Tool Operation Screen

In Machine tool operation screen, jog feed of the machine tool can be executed on the robot teach pendant.

- Up to 8 axes can be operated by jog feed per one path.
- Up to 5 paths can be operated by switching.
- Up to 4 machine tools can be operated by switching.

NOTE
The robot controller only processes the signals to execute jog feed of machine tool according to the operation in this screen. In order to execute jog feed of machine tool actually, it is required to create the ladder program in CNC to move axes in the machine tool according to signals from the robot controller. Please refer to "7.3 MACHINE TOOL OPERATION ON ROBOT TEACH PENDANT" and create the ladder program in CNC.

In order to execute machine tool operation on this screen, the following settings are required.

- Enable machine tool operation in machine interface screen.
- Set the keep relay K0001.0 in PMC to 1.

About setting method of these settings, please refer to "4.8 SETTING FOR CNC OPERATION SCREEN".

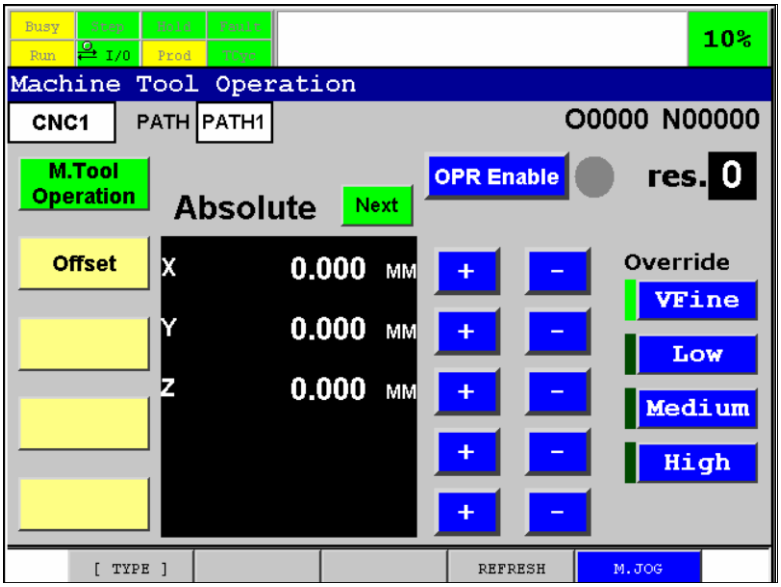


Fig. 6.2.1(a) Machine tool operation screen

Displayed contents in Machine tool operation screen

The displayed contents in machine tool operation screen are as follows.

1. Operation Enable button, Operation Enable lamp, Response code from CNC
   - In case that all conditions to operate the machine tool operation are satisfied, when Operation Enable ("OPR. Enable") button is pressed, Machine Operation Enable Request signal is output to CNC.
   - If Machine Operation Enable Status signal is responded from CNC that has received Machine Operation Enable Request signal, Operation Enable lamp which is in the right side of "OPR. Enable" button is turned on to indicate that the machine tool can be operated on this screen.

- In case that machine tool cannot be operated, Operation Enable lamp is not turned on and the Response code that indicates the reason is displayed in “res.”.

2. CNC Actual Position display
   - Current position of each axis in CNC in absolute coordinate is displayed. Up to 5 axes data are displayed at one screen.
   - In case that the number of axes in the selected path is more than 5, the displayed axes can be changed by “Next” button.
   - In case that there are more than 8 axes in the selected path, the axis data after 8th axis is not displayed.
3. Machine Operation Axis and Direction Select button
   - The axis and direction for jog feed of the machine tool are selected using these buttons. In order to select the axis and the direction, press the “+” or “–“ button which is in the right side of the each axis data that you want to operate.
   - The axis which position data is displayed can be selected. In case that the machine tool has more than 5 axes, change the displayed axes by “Next” button in order to select an axis after 5th axis.
4. Machine Operation Speed Override button
   - The speed override for jog feed of the machine tool can be selected from “VFine”, “Low”, “Medium”, “High”.

Operation in Machine tool operation screen

In machine tool operation screen, following operations are enabled.

Enable machine tool operation

Operation to change override and execute jog feed in machine tool operation screen is enabled by the following procedure.

1. Set CNC to interlock mode.
2. Enable the robot teach pendant. If emergency stop button on the robot teach pendant is pressed, release emergency stop button. In case that the robot controller is R-30*i*A controller or R-30*i*A Mate controller, if the emergency stop button on the operator panel is pressed or the external emergency stop signal is asserted, release the emergency stop status.
3. Press Operation Enable button in machine tool operation screen. When Operation Enable button is pressed, the robot controller outputs Machine Operation Enable Request signal to CNC.
4. In case that Machine Operation Enable Status signal is returned from CNC, the lamp in the right side of Operation Enable button is turned on. Turning on this lamp indicates that the operation in this screen is enabled. In case that the request for operation is rejected by CNC, the reason is displayed by the response code from CNC.
5. While machine tool operation is enabled, if Operation Enable button is pressed again or the following conditions are not satisfied, machine tool operation become disabled and operation enable lamp is turned off.
   - Robot teach pendant is enabled.
   - Emergency stop button on the robot teach pendant is not pressed.
   - Emergency stop button on the operator panel is not pressed. (R-30*i*A/R-30*i*A Mate controller)
   - External emergency stop signal is not asserted. (R-30*i*A/R-30*i*A Mate controller)
   - Interlock Mode signal in CNC is ON.
   - The robot controller communicates with CNC by Ethernet.
   - Machine Tool Operation screen is displayed on the robot teach pendant.

Change override

While machine tool operation is enabled, override to execute jog feed of machine tool can be selected by machine operation speed override button among “VFine”, “Low”, “Medium” and “High”.

- In standard setting, following table indicates the override value for each button.

Table 6.2.1(a) Standard value of override

Button	Override
VFine	1%
Low	25%
Medium	50%
High	100%

- The output value when each button is pressed can be changed by the system variables $MTSERV_CFG.$OV_VAL[1]~[4].

Table 6.2.1(b) System variables to define override value for each button

Button	System variables
VFine	$MTSERV_CFG.$OV_VAL[1]
Low	$MTSERV_CFG.$OV_VAL[2]
Medium	$MTSERV_CFG.$OV_VAL[3]
High	$MTSERV_CFG.$OV_VAL[4]

- When Machine tool operation screen is displayed, or when selected CNC or path is changed, VFine is selected automatically.
- When the selection of override is changed during machine tool operation, machine tool operation is stopped.

Jog feed operation

While machine tool operation is enabled, jog feed of machine tool is executed by the following procedure.

1. Select axis and direction for jog feed of machine tool by pressing “+” or “-“ button in the right side of position data of each axis. Two or more buttons in these buttons cannot be pressed simultaneously.
2. Press “M.JOG” (F5) key while the shift key is pressed on the robot teach pendant.

NOTE
“M.JOG” button in machine tool operation screen is not available. Please press F5 key on the robot teach pendant to operate jog feed.

3. When the jog feed of the machine tool is executed for the first time after machine tool operation screen is displayed or the selected CNC or path is changed, the following pop-up dialog box is displayed to confirm the CNC and Path.

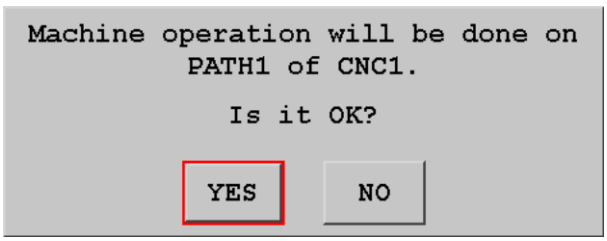


Fig. 6.2.1(b) Pop-up dialog box

4. Confirm CNC and path displayed in pop-up dialog box. If CNC and path that you want to operate is displayed in pop-up dialog box, press “YES” button. Then, press “M.JOG” (F5) key while the shift key is pressed again. If CNC or path is different form CNC or path that you want to operate, press “NO” button and select correct CNC and path.

It is possible not to display this pop-up dialog box by setting the system variable. In case that the system variable $MTSERV_CFG.$JOG_CONFIRM is TRUE, pop-up dialog box is displayed. If the system variable $MTSERV_CFG.$JOG_CONFIRM is FALSE, pop-up dialog box is not displayed and the signals for jog feed of the machine tool are output without confirmation.

5. While the jog feed of machine tool is executed, axis and direction for jog feed cannot be changed. In order to change axis and direction for jog feed, stop the jog feed and then change axis and direction for jog feed.
6. The conditions to stop the machine tool operation are as follows.
   - Shift key or “M.JOG” (F5) key is released.
   - Emergency stop button on the robot teach pendant is pressed.
   - Emergency stop button on the operator panel is pressed. (R-30*i*A/R-30*i*A Mate controller)
   - External emergency stop signal is asserted. (R-30*i*A/R-30*i*A Mate controller)
   - Operation Enable button is pressed again to disable the operation.
   - The robot teach pendant is disabled.
   - Interlock Mode signal in CNC is turned off.
   - The screen on the robot teach pendant is changed to another screen.
   - All Machine Operation Axis and Direction Select buttons are not pressed.
   - Other Operation Axis and Direction Select button or other Machine Operation Speed Override button is pressed.
   - Ethernet communication with the selected CNC is disconnected.
   - Robot program is executed.
   - Robot is moved.

6.2.2 Tool Offset Screen

In tool offset screen, tool offset data used in CNC can be input on the robot teach pendant.

Tool offset data in CNC for machining center system and tool offset data in CNC for lathe system are different. And the required tool offset is different by the option configuration in CNC. In tool offset screen, the required tool offset data are displayed according to type of CNC.

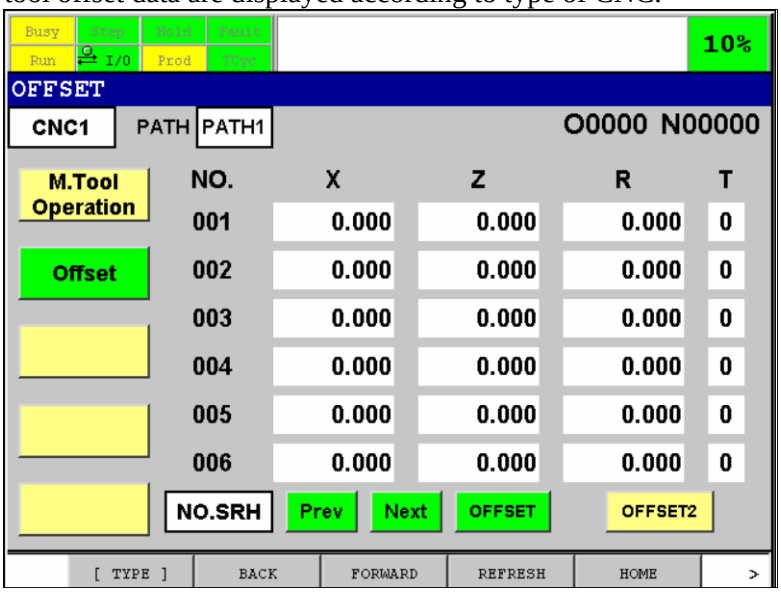


Fig. 6.2.2(a) Tool offset screen

In order to set tool offset data in this screen, it is needed to set “Tool offset data changing” to ENBALE in Machine interface screen in SETUP menu. If “Tool offset data changing” is set to DISABLE, the back surface of tool offset data in this screen is gray. Tool offset data that back surface is gray cannot be set.

Displayed contents in Tool offset screen

The displayed contents in tool offset screen are as follows.

1. Tool offset data
   - Current tool offset value in CNC are displayed.
   - The number of the tool offset data displayed in this screen is decided by the setting of the number of tool offset data per a path in CNC.
   - The unit and decimal place of tool offset data are decided by setting in CNC.

Tool offset data in CNC for machining center system and tool offset data in CNC for lathe system are different. And the required tool offset is different by the option configuration in CNC. Furthermore, the tool offset data that is required when tool offset for milling and turning function is enabled in CNC are different. Tool offset screen corresponding to each CNC type is as follows.

Machining center system

In CNC for machining center system, the tool offset screen is decided by the type of tool offset memory.

Tool offset memory A

In tool offset memory A, the following tool offset data are displayed in tool offset screen.

- Tool offset data
- Direction of imaginary tool nose (T) (When direction of imaginary tool nose is enabled in CNC)

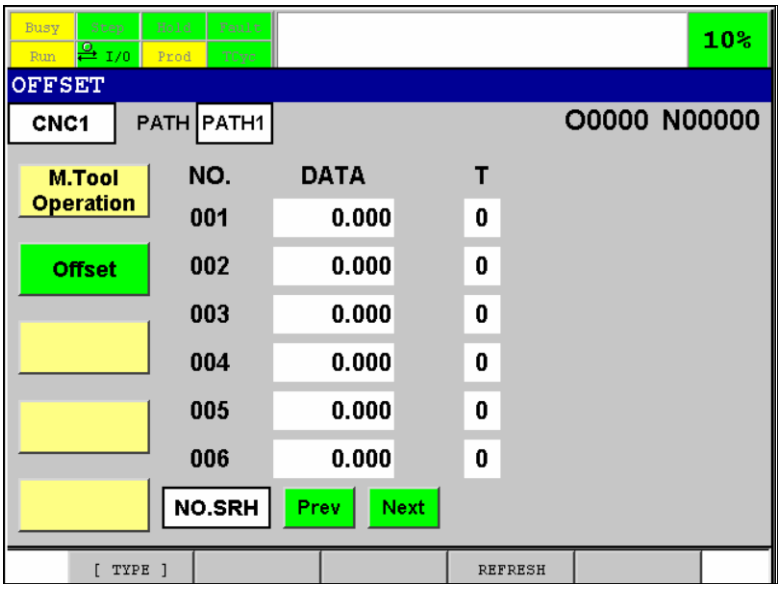


Fig. 6.2.2(b) Tool offset screen (Machining center system / Tool offset memory A)

Tool offset memory B

In tool offset memory B, the following tool offset data are displayed in tool offset screen.

- Tool geometry offset data
- Tool wear offset data
- Direction of imaginary tool nose (T) (When direction of imaginary tool nose is enabled in CNC)

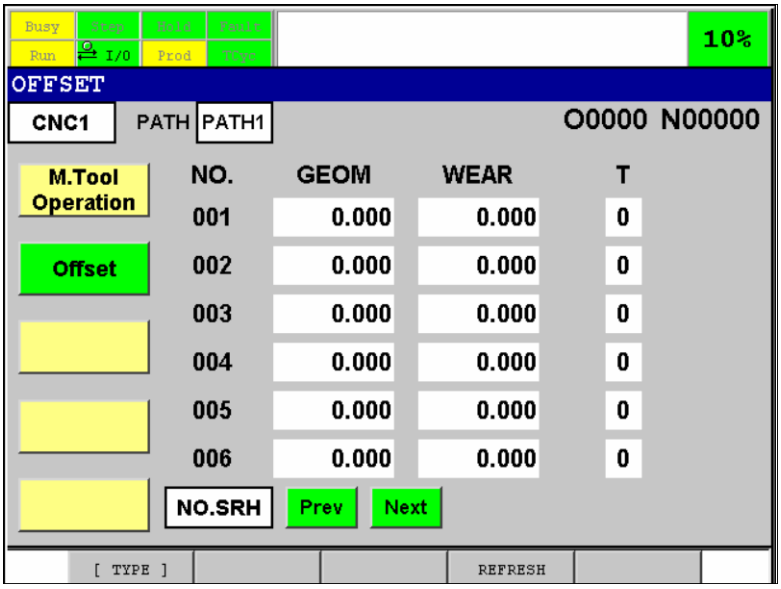


Fig. 6.2.2(c) Tool offset screen (Machining center system / Tool offset memory B)

Tool offset memory C

In tool offset memory C, the following tool offset data are displayed in tool offset screen.

- Tool length geometry offset data
- Tool length wear offset data
- Tool radius geometry offset data
- Tool radius wear offset data
- Direction of imaginary tool nose (T) (When direction of imaginary tool nose is enabled in CNC)

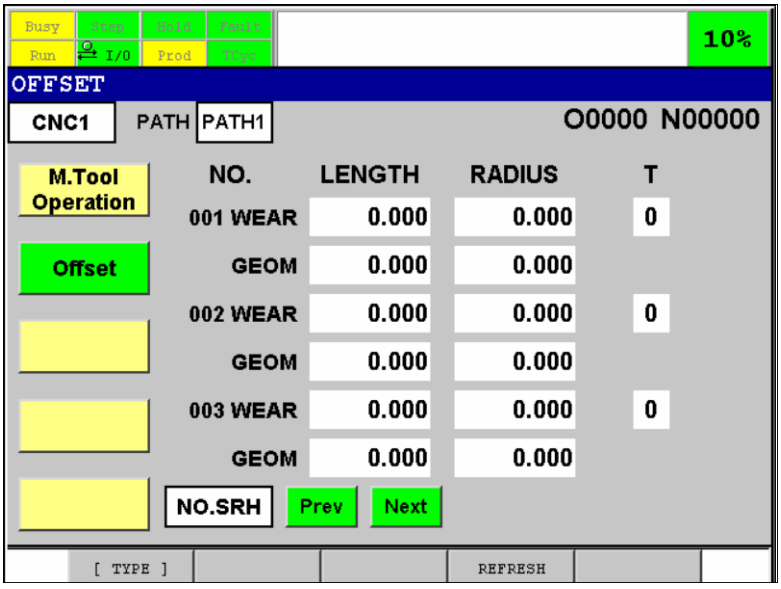


Fig. 6.2.2(d) Tool offset screen (Machining center system / Tool offset memory C)

Lathe system

In CNC for lathe system, the tool offset screen is decided by tool geometry/wear compensation in CNC.

Tool geometry/wear compensation is disabled

In case that tool geometry/wear compensation is disabled in CNC, the following tool offset data are displayed in tool offset screen.

- X-axis offset data

- Y-axis offset data (When Y-axis offset is enabled in CNC)
- Z-axis offset data
- Tool nose radius offset data (When tool nose radius offset is enabled in CNC)
- Direction of imaginary tool nose (T) (When direction of imaginary tool nose is enabled in CNC)

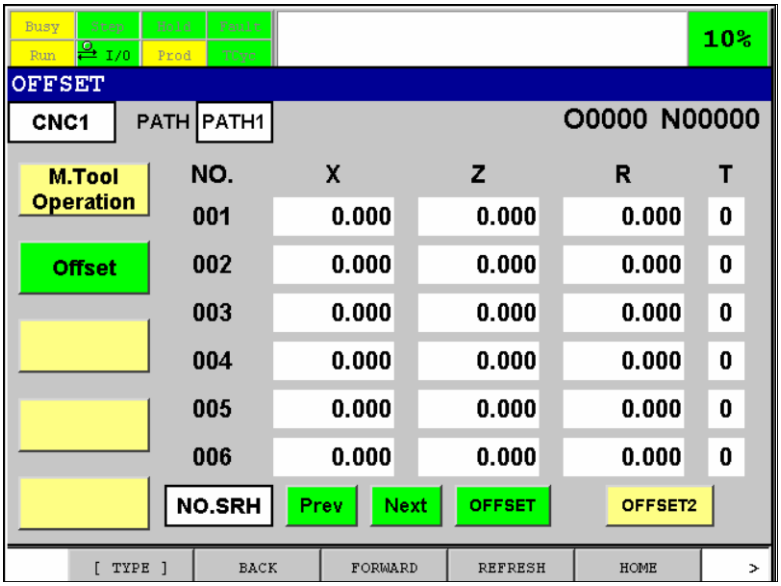


Fig. 6.2.2(e) Tool offset screen (Lathe system / Tool geometry/wear compensation is disabled)

When “OFFSET2” button is pressed, Y-axis offset data are displayed. In case that Y-axis offset is disabled in CNC, “OFFSET2” button is not displayed.

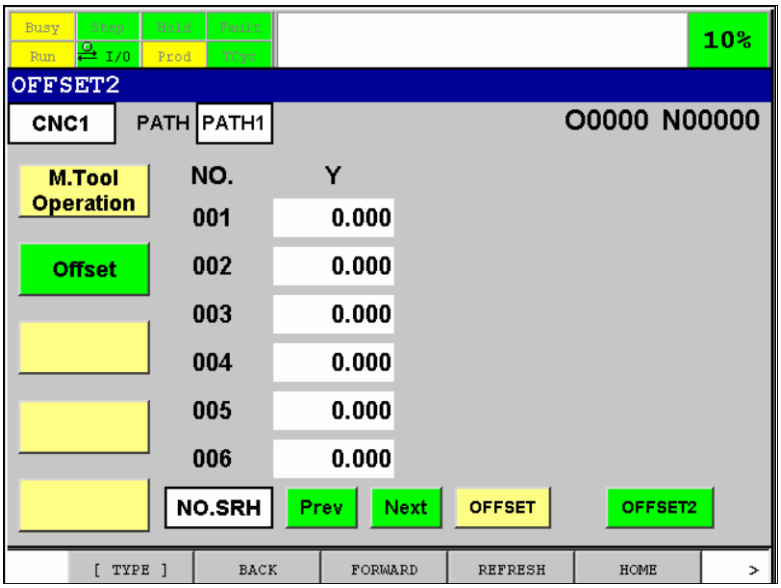


Fig. 6.2.2(f) Tool offset screen (Lathe system / Tool geometry/wear compensation is disabled)

In order to return to previous screen, press “OFFSET” button.

Tool geometry/wear compensation is enabled

In case that tool geometry/wear compensation is enabled in CNC, the following tool offset data are displayed in tool offset screen.

- X-axis wear offset data
- Y-axis wear offset data (When Y-axis offset is enabled in CNC)
- Z-axis wear offset data

- X-axis geometry offset data
- Y-axis geometry offset data (When Y-axis offset is enabled in CNC)
- Z-axis geometry offset data
- X-axis second geometry offset data (When second geometry tool offset is enabled in CNC)
- Y-axis second geometry offset data (When second geometry tool offset is enabled in CNC)
- Z-axis second geometry offset data (When second geometry tool offset is enabled in CNC)
- Tool nose radius wear offset data (When tool nose radius offset is enabled in CNC)
- Tool nose radius geometry offset data (When tool nose radius offset is enabled in CNC)
- Direction of imaginary tool nose (T) (When direction of imaginary tool nose is enabled in CNC)

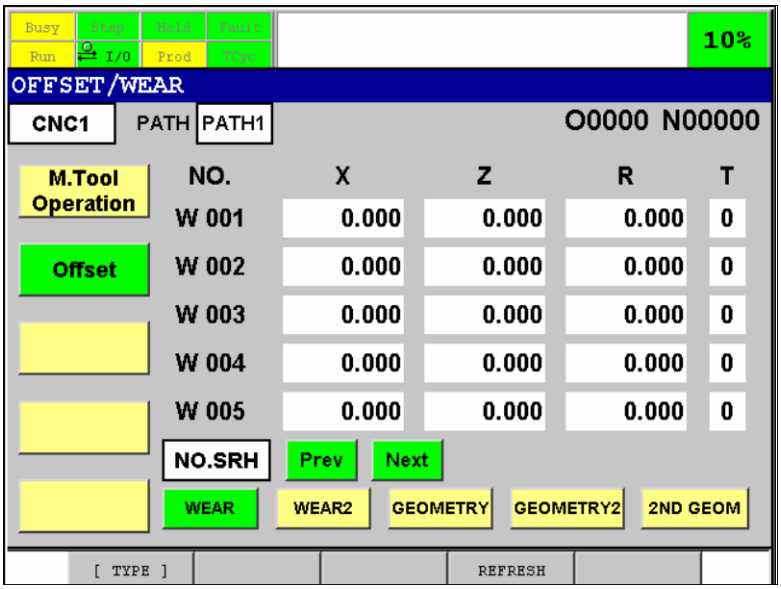


Fig. 6.2.2(g) Tool offset screen (Lathe system / Tool geometry/wear compensation is enabled)

Alphabet “W” in the left of tool offset number represents the wear offset data, and “G” represents the geometry offset data. In case that these alphabets are not displayed in the tool offset data display by setting in CNC, these alphabets are not displayed in this screen, too. When setting for display of “W” and “G” is modified in CNC while tool offset screen is displayed on the robot teach pendant, please press “REFRESH” key on the robot teach pendant to reflect the setting in CNC.

In order to display tool offset data to set, change the screen by the buttons under side of screen. The button corresponding to current screen is green. Table 6.2.2(a) shows the tool offset data displayed by each button.

Table 6.2.2(a) Screen switch buttons

Button	Displayed tool offset data
WEAR	X-axis wear offset, Z-axis wear offset, Tool nose radius wear offset, Direction of imaginary tool nose
WEAR2	Y-axis wear offset When Y-axis offset is disabled in CNC, this button is not displayed.
GEOMETRY	X-axis geometry offset, Z-axis geometry offset, Tool nose radius geometry offset, Direction of imaginary tool nose
GEOMETRY2	Y-axis geometry offset When Y-axis offset is disabled in CNC, this button is not displayed.
2ND GEOM	X-axis second geometry offset, Y-axis second geometry offset, Z-axis second geometry offset When second tool offset is disabled in CNC, this button is not displayed.

- Screen displayed by “WEAR” button

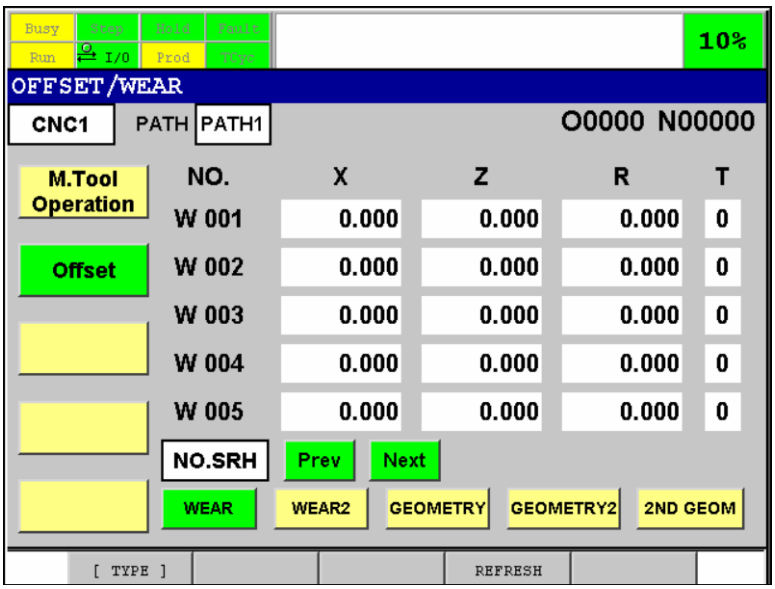


Fig. 6.2.2(h) Tool offset screen (Lathe system / Tool geometry/wear compensation is enabled)

- Screen displayed by “WEAR2” button

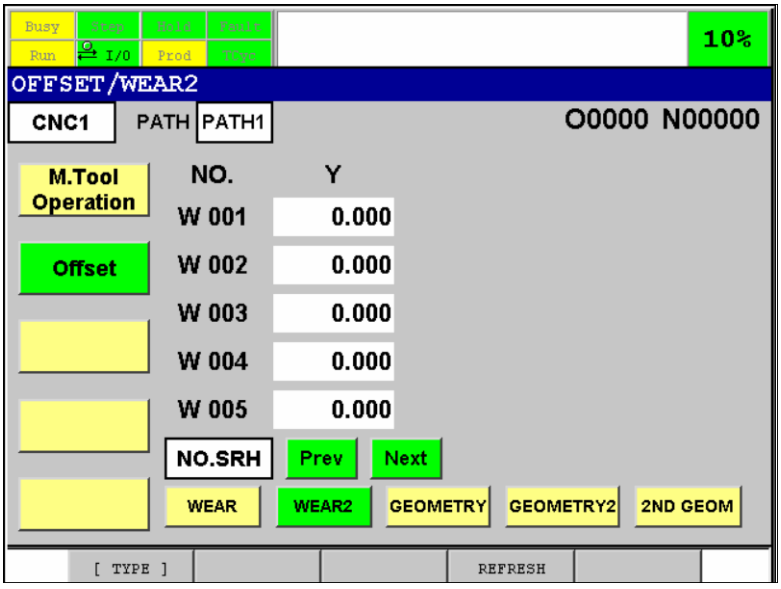


Fig. 6.2.2(i) Tool offset screen (Lathe system / Tool geometry/wear compensation is enabled)

- Screen displayed by “GEOMETRY” button

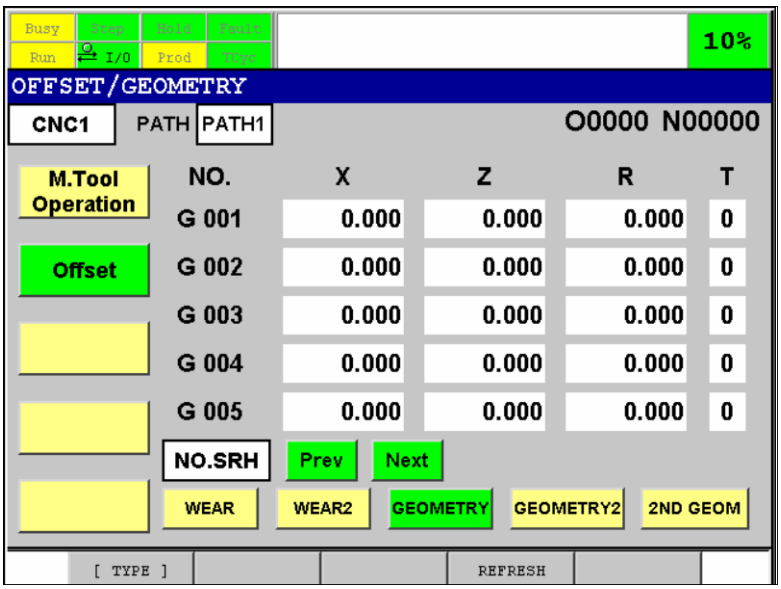


Fig. 6.2.2(j) Tool offset screen (Lathe system / Tool geometry/wear compensation is enabled)

- Screen displayed by “GEOMETRY2” button

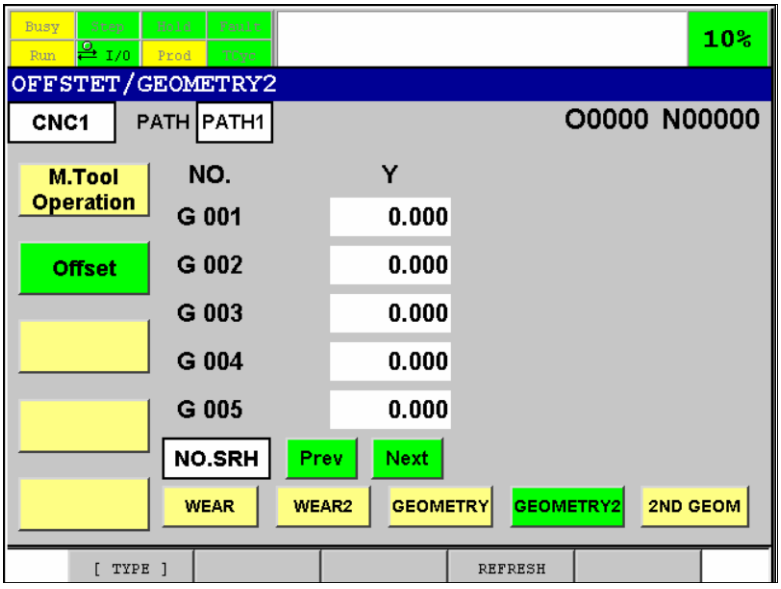


Fig. 6.2.2(k) Tool offset screen (Lathe system / Tool geometry/wear compensation is enabled)

- Screen displayed by “2ND GEOM” button

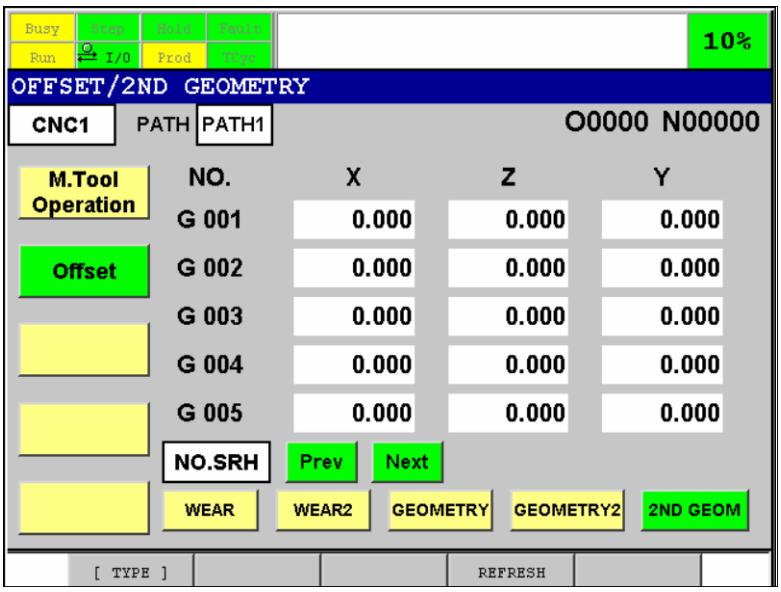


Fig. 6.2.2(l) Tool offset screen (Lathe system / Tool geometry/wear compensation is enabled)

In case that tool offset for milling and turning function is enabled

In case that tool offset for milling and turning function is enabled, the following tool offset data are displayed in tool offset screen.

- X-axis wear offset data
- Y-axis wear offset data
- Z-axis (tool length) wear offset data
- X-axis geometry offset data
- Y-axis geometry offset data
- Z-axis (tool length) geometry offset data
- Tool nose radius (tool radius) wear offset data (When tool nose radius offset is enabled in CNC)
- Tool nose radius (tool radius) geometry offset data (When tool nose radius offset is enabled in CNC)
- Direction of imaginary tool nose (T) (When direction of imaginary tool nose is enabled in CNC)

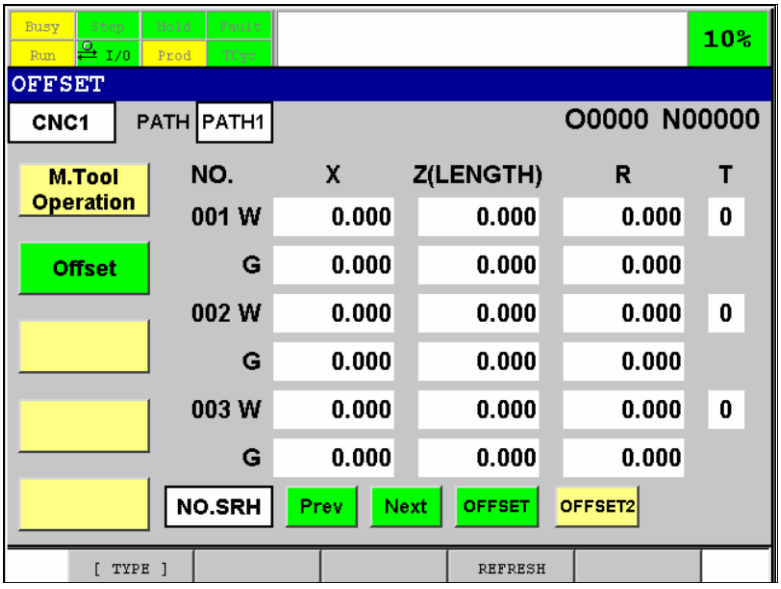


Fig. 6.2.2(m) Tool offset screen (Tool offset for milling and turning function is enabled)

Alphabet “W” in the left of tool offset number represents the wear offset data, and “G” represents the geometry offset data. In case that these alphabets are not displayed in the tool offset data display by setting in CNC, these alphabets are not displayed in this screen, too. When setting for display of “W” and “G” is modified in CNC while tool offset screen is displayed on the robot teach pendant, please press “REFRESH” key on the robot teach pendant to reflect the setting in CNC.

When “OFFSET2” button is pressed, Y-axis wear offset data and Y-axis geometry offset data are displayed.

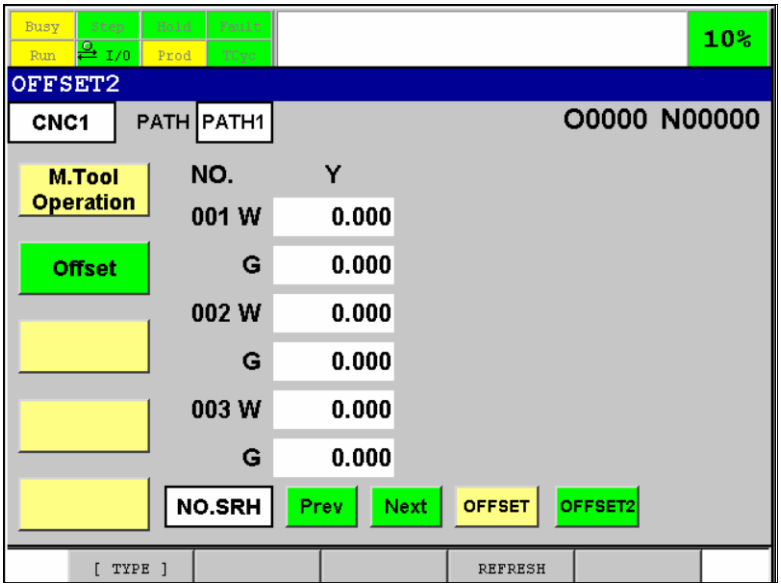


Fig. 6.2.2(n) Tool offset screen (Tool offset for milling and turning function is enabled)

In order to return to previous screen, press “OFFSET” button.

Operation in Tool offset screen

In tool offset screen, following operations are enabled.

Set tool offset data

Set new tool offset data in the “Numeric keyboard” window that is displayed when one of tool offset data in the screen is selected. After new tool offset data is input, when Enter key on the teach pendant is pressed, data is sent to CNC.

- The unit and decimal place of tool offset data in this screen are decided by setting in CNC.
- The setting range corresponding to the unit and decimal place of tool offset data are as follows.

Table 6.2.2(b) Setting range corresponding to decimal place (Metric input)

Decimal place	Setting range		
2 decimal places	-9999.99mm	~	+9999.99mm
3 decimal places	-9999.999mm	~	+9999.999mm
4 decimal places	-9999.9999mm	~	+9999.9999mm
5 decimal places	-9999.99999mm	~	+9999.99999mm
6 decimal places	-999.999999mm	~	+999.999999mm

Table 6.2.2(c) Setting range corresponding to decimal place (Inch input)

Decimal place	Setting range		
3 decimal places	-999.999inch	~	+999.999inch
4 decimal places	-999.9999inch	~	+999.9999inch
5 decimal places	-999.99999inch	~	+999.99999inch
6 decimal places	-999.999999inch	~	+999.999999inch
7 decimal places	-99.9999999inch	~	+99.9999999inch

- In case that the setting “Tool offset data change” in Machine interface screen is set to DISABLE, all tool offset data in tool offset screen cannot be modified. The back surface of all tool offset data is gray.
- Tool offset data restricted to modify by “Setting the tool offset value by MDI key input” in CNC cannot be modified in this screen. The back surface of tool offset data restricted to modify is gray.

NOTE

The back surface of the tool offset data that is restricted to modify is gray. But, in the following cases, the back surface of the tool offset data that is restricted to modify may not be gray. In these cases, please press “REFRESH” (F4) key in the tool offset screen in order to update the screen.

- While tool offset screen is displayed, setting of “Tool offset data changing” is modified in Machine interface screen.
- While tool offset screen is displayed, setting of “Setting the tool offset value by MDI key input” in CNC is modified.

Change the page

- When “NO. SRC” button is pressed and the tool offset number is input, the tool offset that the number is input are displayed at the head of the screen. The maximum number of tool offset number in this screen is same as the maximum number of tool offset number in CNC.
- When “Prev.” button is pressed, previous page is displayed. In case that “Prev.” button is pressed when first page is displayed, the last page is displayed.
- When “Next” button is pressed, next page is displayed. In case that “Next” button is pressed when last page is displayed, the first page is displayed. The maximum number of tool offset number in this screen is same as the maximum number of tool offset number in CNC.

7 INTERFACE BETWEEN CNC AND ROBOT

In this function, the signals used for interaction between CNC and the robot are defined as the standard interface signal.
In CNC, the standard interface signals are assigned into the data area for robot connection function in PMC data area. In the robot, the standard interface signals are assigned into PMC area automatically.
The ladder programs to interlock CNC and the robot through the standard interface signals are provided to both CNC and the robot. The standard interface signals and the ladder programs realize the following functions.

- Interlock between NC Program and the robot program
- Remote operation on machine operation panel
- Machine tool operation on the robot teach pendant

7.1 INTERLOCK BETWEEN NC PROGRAM AND ROBOT PROGRAM

In order to interlock NC Program and the robot program, the robot program is started by the request in NC Program.

1. The robot program designated by CNC is executed by the start request issued in NC Program.
2. After the robot program is started, NC Program waits until the robot program ends.
3. CNC goes forward the step of NC Program after CNC receives the signal that notifies the completion of the robot program.

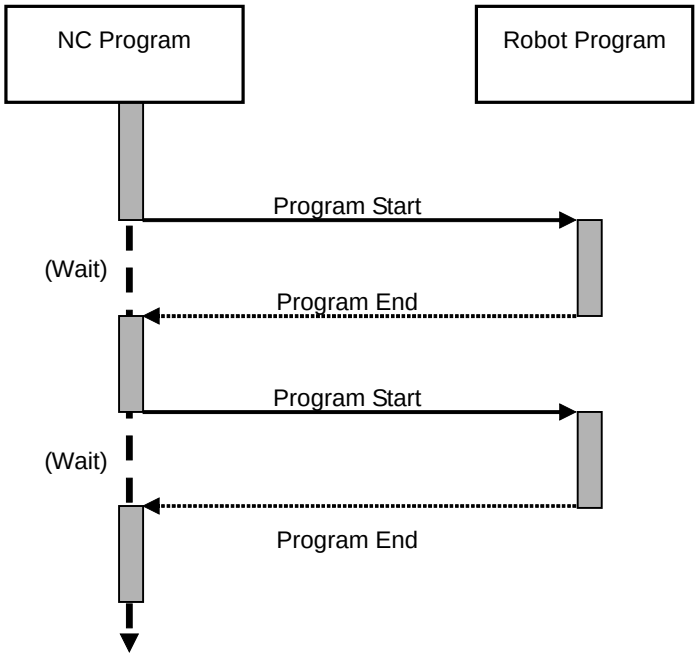


Fig. 7.1 (a) NC Program and robot program

In order to shorten the down time of the machine tool, the starting method that the robot program is started before machining in the machine tool is ended and keeps waiting for the end of machining is used commonly. This starting method is called "Overlap start".

In overlap start, Service Call signal and Service completed signal to interlock between NC Program and the robot program are used in addition to the signals needed for the program start. The robot program for overlap start is divided into three parts, which are pre-service, service and post-service. Sequence of overlap start is shown below.

1 NC Program issue Program Call signal prior to machining process completed. Specified Robot Program is launched.
2 This robot program processes the pre-service task and waits for Service Call signal.
3 NC Program issue Service Call signal when machining process is completed. NC Program waits for Service Completed signal.
4 Robot Program continues and processes the service task and issue Service Completed signal at the end of the service task.
5 NC Program receives Service Completed signal and continues.
6 Robot Program processes the post-service task. In overlap start, Robot Program does not issue Completed signal at the end of the robot program.

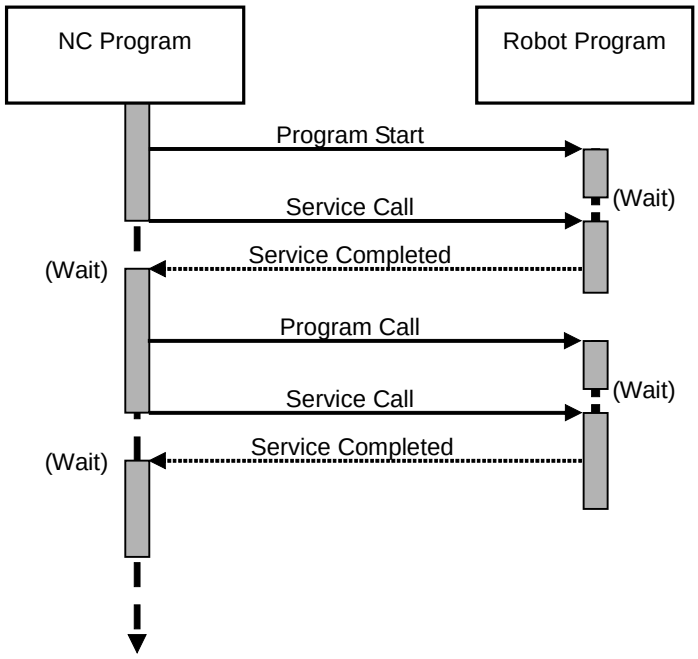


Fig. 7.1 (b) NC Program and robot program (Overlap start)

Create NC Program and the robot program according to above sequence.

- In order to create NC Program, refer to “8. NC PROGRAM”.
- In order to create the robot program, refer to “9. ROBOT PROGRAM”.

7.1.1 Interface Signals to Interlock Program

In order to interlock NC Program and the robot program, the following signals in the standard interface signals are used.
This section describes the interface signals in case that only one CNC is connected to the robot controller. About the interface signals in case that two or more CNCs are connected to the robot controller, refer to “7.1.5 Connection between Multiple CNCs and Robot”.
The “CNC signal address” in the following tables is the address in the robot interface area which is independent on communication protocol and the CNC number, and the address in case that the standard setting value is used without change. About the detail of the robot interface area, refer to “3.2 DATA AREA OF ROBOT CONNECTION FUNCTION”.

Form CNC to the robot controller

CNC Signal address	Robot DI number	Name
R7232.0	1	*IMSTP
R7232.1	2	*Hold
R7232.2	3	*SFSPD
R7232.3	4	Cycle stop
R7232.4	5	Fault reset
R7232.5	6	Start
R7233.0	9	PNS1
R7233.1	10	PNS2
R7233.2	11	PNS3
R7233.3	12	PNS4
R7233.4	13	PNS5
R7233.5	14	PNS6
R7233.6	15	PNS7
R7233.7	16	PNS8
R7235.0	25	Service Type 1
R7235.1	26	Service Type 2
R7235.2	27	Service Type 3
R7235.3	28	Service Type 4
R7236.1	34	Interlock Mode
R7236.2	35	Program Call
R7245.1	106	Service Call
R7245.6	111	Cycle Stop

From the robot controller to CNC

CNC Signal address	Robot DO number	Name
R7200.0	1	Command enabled
R7200.1	2	System ready
R7200.2	3	Program running
R7200.3	4	Program paused
R7200.4	5	Motion held
R7200.5	6	Fault
R7200.6	7	At perch
R7200.7	8	TP enabled
R7201.0	9	Battery alarm
R7201.1	10	Busy
R7201.2	11	SNO1
R7201.3	12	SNO2
R7201.4	13	SNO3
R7201.5	14	SNO4
R7201.6	15	SNO5
R7201.7	16	SNO6
R7202.0	17	SNO7
R7202.1	18	SNO8
R7202.2	19	SNACK
R7207.0	57	Program Reply 1
R7207.1	58	Program Reply 2
R7207.2	59	Program Reply 3
R7207.3	60	Program Reply 4
R7207.5	62	Maintenance State
R7207.6	63	Service State
R7207.7	64	Machine Interlock Mode
R7208.0	65	Remote Operation Mode
R7208.4	69	Not Ready
R7208.5	70	Ready
R7208.6	71	Completed
R7213.1	106	Service Completed

Description of signals (from CNC to the robot controller)

*IMSTP (CNC : R7232.0, Robot Controller : DI[1])

- In CNC sample ladder, this signal is always ON, or the output of this signal is coupled with the emergency stop of CNC. These two specifications are switched by the setting of PMC parameter.
- In the robot ladder program, the status of this signal is input in peripheral I/O UI[1].

*Hold (CNC : R7232.1, Robot Controller : DI[2])

- In CNC sample ladder, this signal is always ON.
- In the robot ladder program, the status of this signal is input in peripheral I/O UI[2].

*SFSPD (CNC : R7232.2, Robot Controller : DI[3])

- In CNC sample ladder, this signal is always ON.
- In the robot ladder program, the status of this signal is input in peripheral I/O UI[3].

Cycle stop (CNC : R7232.3, Robot Controller : DI[4])

- In CNC sample ladder, this signal is always OFF.
- In the robot ladder program, the status of this signal is input in peripheral I/O UI[4].

Fault reset (CNC : R7232.4, Robot Controller : DI[5])

- When reset operation is executed in the ROBOT REMOTE OPERATION screen on CNC, CNC sample ladder turns on this signal for 200ms.
- In the robot ladder program, the status of this signal is input in peripheral I/O UI[5]. In addition, if the following condition is satisfied, the status of this signal is input in peripheral I/O UI[4] at the same time.
  - Service state signal is ON.
  - Keep relay K0000.7 is 0.
  - The robot program is paused.

Enable (CNC : R7232.7, Robot Controller : DI[8])

- In CNC sample ladder, this signal is always ON.
- In the robot ladder program, the status of this signal is input in peripheral I/O UI[8].

PNS1 to 8 (CNC : R7233.0 to R7233.7, Robot Controller : DI[9] to DI[16])

- In CNC ladder program, when the robot program number is selected in the ROBOT PROGRAM SELECT screen on CNC, the robot program number is output by binary code through these signals. The value of output program number is preserved even if the power of CNC is turned off.
- In the robot ladder program, the status of these signals are input in peripheral I/O UI[9] to UI[16].

Service Type 1 to 4 (CNC : R7235.0 to R7235.3, Robot Controller : DI[25] to DI[28])

- CNC sample ladder outputs the service type to request of the robot controller by binary code through these signals before turns on Program Call signal.
- In the robot ladder program, these signals are read by binary code, then set to group I/O GI[1]. It is required to create the robot program so that the service type designated by these signals is executed.

Interlock Mode (CNC : R7236.1, Robot Controller : DI[34])

- In CNC sample ladder, while CNC is interlock mode, this signal is ON.
- The robot ladder program responds to only the request from CNC in which this signal is ON. The request from CNC in which this signal is OFF is ignored.

Program Call (CNC : R7236.2, Robot Controller : DI[35])

- When the robot program number is selected in ROBOT PROGRAM SELECT screen on CNC, the robot program number is output to the signal PNS1 to 8.
- In CNC sample ladder, this signal is turned on after Service Type signals are turned on in order to start the robot program.
- In the robot ladder program, when the conditions to start the robot program are satisfied, this signal is input to peripheral I/O UI[17] and UI[18] in order to start the robot program.

Service Call (CNC : R7245.1, Robot Controller : DI[106])

- In the system that both NC Program and the robot program are executed in parallel, the work exchange motion of robot is interlocked with the machine work by this signal. For detail, refer to “7.1.4 Overlap Start”.

Cycle Stop (CNC : R7245.6, Robot Controller : DI[111])

- In CNC sample ladder, this signal is turned on and off by pressing cycle stop button on machine operator’s panel. If this signal is ON when the work exchange request is output to the robot controller, the program cycle is terminated. When not the work exchange request but the work unload request is output to the robot controller, CNC is reset and rewound, and the process is ended after the robot operation is completed.
- In the robot ladder program, this signal is not used.

Description of signals (from the robot controller to CNC)

Command enabled (CNC : R7200.0, Robot Controller : DO[1])

- In the robot ladder program, the status of peripheral I/O UO[1] is output to this signal.
- In CNC sample ladder, this signal is not used.

System ready (CNC : R7200.1, Robot Controller : DO[2])

- In the robot ladder program, the status of peripheral I/O UO[2] is output to this signal.

- In CNC sample ladder, this signal is not used.

Program running (CNC : R7200.2, Robot Controller : DO[3])

- In the robot ladder program, the status of peripheral I/O UO[3] is output to this signal.
- In CNC sample ladder, this signal is not used.

Program paused (CNC : R7200.3, Robot Controller : DO[4])

- In the robot ladder program, the status of peripheral I/O UO[4] is output to this signal.
- In CNC sample ladder, this signal is not used.

Motion held (CNC : R7200.4, Robot Controller : DO[5])

- In the robot ladder program, the status of peripheral I/O UO[5] is output to this signal.
- In CNC sample ladder, this signal is not used.

Fault (CNC : R7200.5, Robot Controller : DO[6])

- In the robot ladder program, the status of peripheral I/O UO[6] is output to this signal.
- In CNC sample ladder, this signal is not used.

At perch (CNC : R7200.6, Robot Controller : DO[7])

- In the robot ladder program, the status of peripheral I/O UO[7] is output to this signal.
- In CNC sample ladder, this signal is not used.

TP enabled (CNC : R7200.7, Robot Controller : DO[8])

- In the robot ladder program, the status of peripheral I/O UO[8] is output to this signal.
- In CNC sample ladder, this signal is not used.

Battery alarm (CNC : R7201.0, Robot Controller : DO[9])

- In the robot ladder program, the status of peripheral I/O UO[9] is output to this signal.
- In CNC sample ladder, this signal is not used.

Busy (CNC : R7201.1, Robot Controller : DO[10])

- In the robot ladder program, the status of peripheral I/O UO[10] is output to this signal.
- In CNC sample ladder, this signal is not used.

SNO1 to 8 (CNC : R7201.2 to R7202.1, Robot Controller : DO[11] to DO[18])

- In the robot ladder program, the status of peripheral I/O UO[11] to DO[18] are output to these signals.
- CNC reads these signals by binary code, and displays the value to “Robot Program Number” in ROBOT REMOTE OPERATION screen.

SNACK (CNC : R7202.2, Robot Controller : DO[19])

- In the robot ladder program, the status of peripheral I/O UO[19] is output to this signal.
- In CNC sample ladder, this signal is not used.

Program Reply 1 to 4 (CNC : R7207.0 to R7207.3, Robot Controller : DO[57] to DO[60])

- In the robot ladder program, in case that the robot program cannot be started when the program start request is received from CNC, or the robot program is not ended successfully, the binary code to represent the cause of the failure is output through these signals. These signals are turned off when Fault reset signal is input from CNC.
- CNC reads these signals by binary code, and display the value to the item “ROBOT START RESULT” in ROBOT REMOTE OPERATION screen.

Table 7.1.1 Program reply signal

Reply 1	The robot controller cannot accept the request form CNC.
Reply 2	The robot controller is in the alarm or emergency stop state, or safety fence is opened.
Reply 3	In Remote Operation mode.
Reply 4	The last execution program ended abnormally, or the robot controller is in Not Ready.
Reply 5	The program selected in CNC does not exist. The condition for PNS start is not satisfied.
Reply 6	The program executed by PNS start did not end normally.

Maintenance State (CNC : R7207.5, Robot Controller : DO[62])

- In the robot ladder program, this signal is output if the following conditions are satisfied.
  - Mode switch on the robot controller is set to T1 or T2 mode.
  - Teach pendant of the robot controller is enabled.
- In CNC sample ladder, this signal is not used.

Service State (CNC : R7207.6, Robot Controller : DO[63])

- In the robot ladder program, this signal is output if the following conditions are satisfied.
  - Mode switch on the robot controller is set to AUTO mode.
  - Teach pendant of the robot controller is disabled.
- If this signal is turned off while CNC can operate the robot by remote operation, CNC ladder program turns off Remote Operation Request signal to release the right for the remote operation.

Machine Interlock Mode (CNC : R7207.7, Robot Controller : DO[64])

- In the robot ladder program, while the following conditions for machine interlock mode are satisfied, this signal is ON.
  - Service State signal is ON.
  - CNC connected to the robot controller does not perform the remote operation.
- In CNC sample ladder, this signal is not used.

Remote Operation Mode (CNC : R7208.0, Robot Controller : DO[65])

- In the robot ladder program, while the following conditions for remote operation mode are satisfied, this signal is ON.
  - Service State signal is ON.
  - CNC connected to the robot controller performs the remote operation.
- In CNC sample ladder, this signal is not used.

Not Ready (CNC : R7208.4, Robot Controller : DO[69])

- In the robot ladder program, while the following conditions are satisfied and Machine Interlock Mode signal is ON, this signal is ON.
  - Completed signal is OFF.
  - The peripheral I/O UO[1] (Command Enable) in the robot controller is OFF.
  - The peripheral I/O UO[7] (Reference position) in the robot controller is OFF.
  - The peripheral I/O UO[10] (Busy) in the robot controller is OFF.
- In CNC sample ladder, this signal is not used.

Ready (CNC : R7208.5, Robot Controller : DO[70])

- In the robot ladder program, while the following conditions are satisfied and Machine Interlock Mode signal is ON, this signal is ON.
  - Completed signal is OFF.
  - The peripheral I/O UO[1] (Command Enable) in the robot controller is ON.
  - The peripheral I/O UO[7] (Reference position) in the robot controller is ON.
  - The peripheral I/O UO[10] (Busy) in the robot controller is OFF.
- In CNC sample ladder, this signal is not used.

Completed (CNC : R7208.6, Robot Controller : DO[71])

- In the robot ladder program, when the robot program started by the request from CNC is ended successfully, this signal is turned on. If the robot program cannot be started by any reason, or the robot program is ended abnormally, this signal is not turned on. When this signal is turned on, if Program Call signal is ON, this signal is turned off when Program Call signal is turned off. When the robot program is ended normally, if Program Call signal is OFF, this signal is not turned on. This signal is turned off when Program Call signal is input from CNC is turned off.
- Because CNC sample ladder detects the end of the robot program execution by this signal, when this signal is turned on, CNC sample ladder operates the door of machine tool and indicates the performance of FIN to CNC.

Service Completed (CNC : R7213.1, Robot Controller : DO[106])

- In the system that both NC Program and the robot program are executed in parallel, the work exchange motion of robot is interlocked with the machine work by this signal. For detail, refer to “7.1.4 Overlap Start”.

NOTE

About peripheral I/O in the robot controller, refer to one of the following manuals corresponding to your using robot controller.

- FANUC Robot series R-30*i*A CONTROLLER HANDLING TOOL OPERATOR'S MANUAL(B-83124EN)
- FANUC Robot series R-30*i*A Mate CONTROLLER LR HANDLING TOOL OPERATOR'S MANUAL (B-83134EN)
- FANUC Robot series R-30*i*B/R-30*i*B Mate/ R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER OPERATOR'S MANUAL (Basic Operation)(B-83284EN)

7.1.2 Start of Robot Program by CNC

A robot program is started by the command in NC Program.

Process in CNC

- When the robot program number is selected in ROBOT PROGRAM SELECT screen on CNC, the selected program number is output by PNS 1 to 8 signals.
- When M code is executed in NC Program, the request for the robot operation is output by Service Type 1 to 4 signals according to the kind of M code and the state of cycle stop signal.

Table 7.1.2 Service type signal

Request for the robot operation	Service type signal			
	1	2	3	4
Load work piece	1	0	0	0
Unload and load work piece	0	1	0	0
Unload work piece	1	1	0	0

About the request for the robot operation that outputs to the robot controller according to M code and Cycle Stop signal, refer to "8. NC PROGRAM".

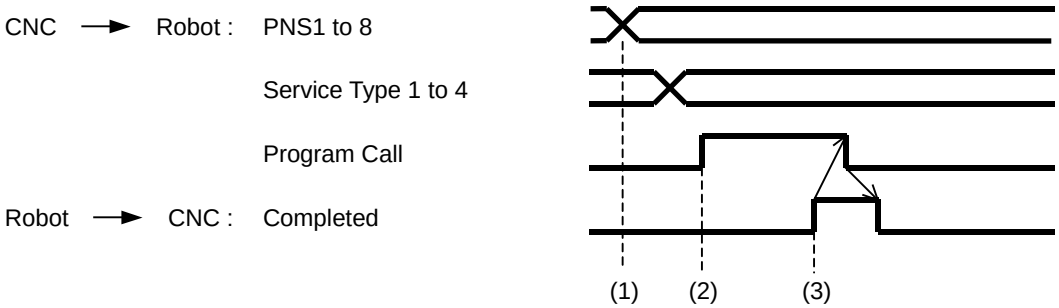
- The Program Call signal is turned on after Service Type signals are output.

Process in the robot controller

- The robot ladder program starts the robot program when the robot controller receives the PNS signals, Service Type 1 to 4 signals, and Program Call signal.
- It is required to create a robot program to execute the requested operation according to Service Type signals.
- When the execution of the robot program is ended normally, Completed signal is turned on.

Signal sequence

The signal sequence to start the robot program by CNC is as follows.



(1) When the robot program number is selected in ROBOT PROGRAM SELECT screen on CNC, the value of the robot program number is set to PNS 1 to 8.
(2) When M code is executed in CNC program, CNC ladder program outputs Service Type signals according to the request to the robot, and turns on Program Call signal. The robot controller reads Service Type signals when robot Program Call signal is turned on, and executes the requested operation.
(3) When the robot completes the requested operation, Completed signal is turned on. When Completed signal is turned on, CNC ladder program is turned off Program Call signal, and input FIN to CNC. In the robot controller, when Program Call signal is turned off, Completed signal is turned off.

End of the robot program execution

In the following case, Completed signal is output from the robot controller.

- When the robot program execution is ended because the last line in the robot program has been executed normally.
- When the robot program execution is ended because the END instruction in the robot program has been executed.

In the following case, Completed signal is not output even if the robot program execution is ended.

- When the robot program execution is aborted by selecting “Abort” in the menu displayed by pressing FCTN key on the robot teach pendant.
- When the robot program execution is aborted because the ABORT instruction in the robot program has been executed.
- When the robot program execution is aborted by input of peripheral signal UI[4] (CSTOPI).
- When the robot program execution is aborted by the alarm which severity is more serious than STOP.L.
- When the paused program is aborted because any other program is selected in case that the multi program selection is disabled.

7.1.3 Recovery from Failure of a Robot Program

If the robot program cannot be started or the execution of the robot program is ended abnormally, Completed signal is not turned on and Program Reply signals are output in order to notify the cause to CNC. This state is that the robot program is aborted and the NC program is waiting for Completed signal.

The system operation can be continued by restarting the robot program without restarting the NC program. If restarted robot program ended successfully, Completed signal will be turned ON and NC program can resume.

Note that in case the robot program is not aborted but is paused, this method cannot be applied. Paused robot program must be aborted by Reset operation (described below) or manual operation using the teach pendant.

Recovery procedure from failure of a robot program is following:
1. Eliminate errors and issue Fault reset signal from CNC.
2. Correct condition so that READY signal is ON.
3. Issue PNS signal, Service Type signal and Program Call signal from CNC.

Reset operation from CNC.

Once the robot program is ended abnormally, following program call from CNC always fails. To reset this status, identify and eliminate the cause for failure of the robot program and issue Fault reset pulse signal from CNC. This signal clear alarms of the robot controller and clear the state of robot program failure.

In addition, when keep relay K0000.7 is 0, the paused robot program can be aborted by input of Fault reset signal from CNC.

Condition for Robot Program Call

The Ready signal must be ON to call a Robot Program from CNC. Correct condition if this signal is OFF. This may include returning the robot to its home position.

Program call from CNC

The robot ladder program starts the robot program when the robot controller receives the PNS signals, Service Type 1 to 4 signals, and Program Call signal while Ready signal is ON.
This is identical to the sequence to start the robot program initially. There are no distinction between starting operation and continuing operation in robot side.

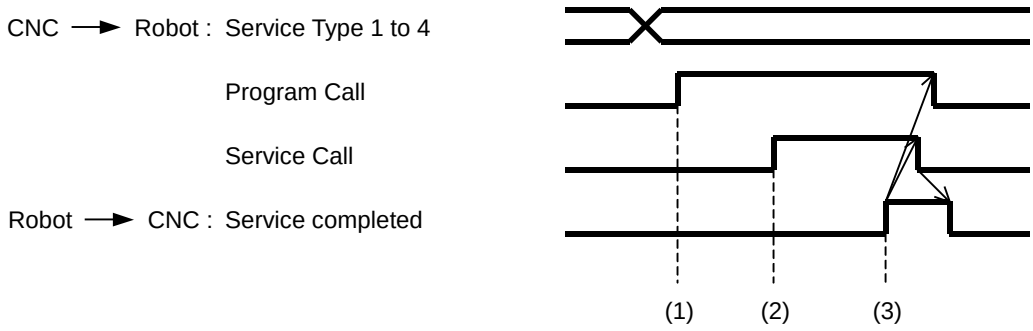
7.1.4 Overlap Start

In order to shorten the down time of the machine tool, the starting method that the robot program is started before machining in the machine tool is ended and keeps waiting for the end of machining is used commonly. This starting method is called “Overlap start”. In overlap start, Service Call signal and Service completed signal to interlock between NC Program and the robot program are used in addition to the signals needed for the program start.

- In NC Program, M code to notify the overlap start is executed before machining is ended.
- In the robot program, robot is moved to the position near the machine tool, and waits for input of Service Call signal from CNC.
- In NC Program, M code to request to exchange the work piece is executed when machining is ended, and Service Call signal is output to the robot controller.
- When the robot program receives Service Call signal, waiting for Service Call signal is released, and the requested operation is executed.
- NC Program waits for input of Service Completed signal from the robot controller.
- When the robot goes outside the machine tool after the operation inside the machine tool, the robot controller output Service Completed signal to CNC in order to release waiting in NC Program.

Signal sequence

In overlap start, the signal sequence to start the robot program by CNC is as follows.



(1) In NC program, when M code (M62) to notify the overlap start is executed, CNC sample ladder output the kind of request operation to Service Type 1 to 4 signals, and turns on Program Call signal, inputs FIN to CNC immediately. The robot controller reads Service Type signals when Program Call signal is turned on, the robot moves to the position near the machine tool.
(2) In NC program, when machining is ended, M code to request the robot of the work exchange is executed, and CNC sample ladder turns on Service Call signal. In the robot program, the requested operation is executed when Service Call signal is turned on.
(3) In the robot program, when the requested operation is ended, Service Completed signal is turned on. In CNC sample ladder, when Service Completed signal is turned on, Program Call signal and Service Call signal is turned off, and input FIN to CNC. In the robot program, when Service Call signal is turned off, Service Completed signal is turned off.

7.1.5 Connection between Multiple CNCs and Robot

Interface signal

In case that the robot is connected with two or more CNCs, the interface signals in the robot controller are extended according to the number of CNC. The signals for each CNC are same as the signals described in "7.1.1 Interface Signal to Interlock Program". Only the signal number in each CNC is different. The signal number in each CNC is as follows.

NOTE
It is need to set the number of the connected CNC with the robot beforehand. Refer to "2. CONNECTION BETWEEN CNC AND ROBOT".

Form CNC to the robot controller

Name of signal	CNC1 Signal number	CNC2 Signal number	CNC3 Signal number	CNC4 Signal number
*IMSTP	DI[1]	DI[257]	DI[513]	DI[769]
*Hold	DI[2]	DI[258]	DI[514]	DI[770]
*SFSPD	DI[3]	DI[259]	DI[515]	DI[771]
Cycle stop	DI[4]	DI[260]	DI[516]	DI[772]
Fault reset	DI[5]	DI[261]	DI[517]	DI[773]
Start	DI[6]	DI[262]	DI[518]	DI[774]
PNS1	DI[9]	DI[265]	DI[521]	DI[784]
PNS2	DI[10]	DI[266]	DI[522]	DI[785]
PNS3	DI[11]	DI[267]	DI[523]	DI[786]
PNS4	DI[12]	DI[268]	DI[524]	DI[787]

Name of signal	CNC1 Signal number	CNC2 Signal number	CNC3 Signal number	CNC4 Signal number
PNS5	DI[13]	DI[269]	DI[525]	DI[788]
PNS6	DI[14]	DI[270]	DI[526]	DI[789]
PNS7	DI[15]	DI[271]	DI[527]	DI[790]
PNS8	DI[16]	DI[272]	DI[528]	DI[791]
Service Type 1	DI[25]	DI[281]	DI[537]	DI[793]
Service Type 2	DI[26]	DI[282]	DI[538]	DI[794]
Service Type 3	DI[27]	DI[283]	DI[539]	DI[795]
Service Type 4	DI[28]	DI[284]	DI[540]	DI[796]
Interlock Mode	DI[34]	DI[290]	DI[546]	DI[802]
Program Call	DI[35]	DI[291]	DI[547]	DI[803]
Service Call	DI[106]	DI[362]	DI[618]	DI[874]

From the robot controller to CNC

Name of signal	CNC1 Signal number	CNC2 Signal number	CNC3 Signal number	CNC4 Signal number
Command enabled	DO[1]	DO[257]	DO[513]	DO[769]
System ready	DO[2]	DO[258]	DO[514]	DO[770]
Program running	DO[3]	DO[259]	DO[515]	DO[771]
Program paused	DO[4]	DO[260]	DO[516]	DO[772]
Motion held	DO[5]	DO[261]	DO[517]	DO[773]
Fault	DO[6]	DO[262]	DO[518]	DO[774]
At perch	DO[7]	DO[263]	DO[519]	DO[775]
TP enabled	DO[8]	DO[264]	DO[520]	DO[776]
Battery alarm	DO[9]	DO[265]	DO[521]	DO[777]
Busy	DO[10]	DO[266]	DO[522]	DO[778]
SNO1	DO[11]	DO[267]	DO[523]	DO[779]
SNO2	DO[12]	DO[268]	DO[524]	DO[780]
SNO3	DO[13]	DO[269]	DO[525]	DO[781]
SNO4	DO[14]	DO[270]	DO[526]	DO[782]
SNO5	DO[15]	DO[271]	DO[527]	DO[783]
SNO6	DO[16]	DO[272]	DO[528]	DO[784]
SNO7	DO[17]	DO[273]	DO[529]	DO[785]
SNO8	DO[18]	DO[274]	DO[530]	DO[786]
SNACK	DO[19]	DO[275]	DO[531]	DO[787]
Program Reply 1	DO[57]	DO[313]	DO[569]	DO[825]
Program Reply 2	DO[58]	DO[314]	DO[570]	DO[826]
Program Reply 3	DO[59]	DO[315]	DO[571]	DO[827]
Program Reply 4	DO[60]	DO[316]	DO[572]	DO[828]
Maintenance State	DO[62]	DO[318]	DO[574]	DO[829]
Service State	DO[63]	DO[319]	DO[575]	DO[830]
Machine Interlock Mode	DO[64]	DO[320]	DO[576]	DO[831]
Remote Operation Mode	DO[65]	DO[321]	DO[577]	DO[832]
Not Ready	DO[69]	DO[325]	DO[578]	DO[837]
Ready	DO[70]	DO[326]	DO[579]	DO[838]
Completed	DO[71]	DO[327]	DO[583]	DO[839]
Service Completed	DO[106]	DO[362]	DO[618]	DO[874]

About following signals, there is the different point between the case that the robot is connected with two or more CNCs and the case that robot is connected with only one CNC.

- *IMSTP signal
  In case that the robot is connected with two or more CNCs, the logical product of *IMSTP signals all CNC which are in interlock mode is input to peripheral I/O UI[1].
- *HOLD signal

In case that the robot is connected with two or more CNCs, the logical product of *HOLD signals in all CNC which are in interlock mode is input to peripheral I/O UI[2].

- *SFSPD signal
  In case that the robot is connected with two or more CNCs, the logical product of *SFSPD signals in all CNC which are in interlock mode is input to peripheral I/O UI[3].
- ENABLE signal
  In case that the robot is connected with two or more CNCs, the logical product of ENABLE signals in all CNC which are in interlock mode is input to peripheral I/O UI[8].

About Service Type 1 to 4 signals, the input signals from each CNC are set to the group I/O in the robot controller as follows.

Table 7.1.5 Service type input signal

	CNC1	CNC2	CNC3	CNC4
Group input signal number for service type signal	GI[1]	GI[2]	GI[3]	GI[4]

Program start by CNC

In case that two or more CNCs output Program Call signals, the robot controller executes the robot program requested by each CNC in the order of the request receipt. Other CNCs that output Program Call signal wait for the execution of the requested program. When the robot controller cannot execute the program, the robot controller output the not 0 value to Program Reply signals. In this case, the requested program is not executed.

7.1.6 Failure to Interlock Program

There are many reasons why the start of the robot program by CNC and the interlocking are failed. This section describes some common cases.

Ready signal in the robot controller is not ON.

When Ready signal in the robot controller is not ON, check the following points.

- Check whether single step is disabled.
- Check whether robot is in the reference position 1.

If above conditions are satisfied, check whether the remote condition is satisfied and peripheral I/O UO[1] in the robot controller is ON. About the remote condition, refer to one of the following manuals corresponding to your using robot controller.

- FANUC Robot Series R-30*i*A CONTROLLER HANDLING TOOL OPERATOR'S MANUAL
- FANUC Robot Series R-30*i*A Mate CONTROLLER LR HANDLING TOOL OPERATOR'S MANUAL
- FANUC Robot Series R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER OPERATOR'S MANUAL (Basic Operation)

In overlap start, CNC does not work after the robot program execution is ended.

In overlap start, Service Completed signal (DO[106]) is turned on/off by the command in the robot program. After the execution of the robot program is ended abnormally, DO[106] remains ON. Because the change of Service Completed signal from OFF to ON is detected in CNC sample ladder, even if NC Program is restarted in this state, the robot program does work correctly. In this case, turn off DO[106] first, then restart NC Program.

7.2 ROBOT REMOTE OPERATION ON CNC

It is possible to execute the robot remote operation on CNC operator's panel. The remote operations executed by the standard interface signals and CNC sample ladder and the robot ladder program are as follows.

- Joint jog feed of the robot
- Cartesian jog feed of the robot
- Hand operation of the robot
- Home position return of the robot
- Check and change of speed override of the robot

In robot remote operation, the robot controller executes the operation requested by CNC according to the input signals from CNC allowed to execute the robot remote operation. Hand operation of the robot, home position return of the robot, and change of speed override of the robot are executed using macro programs in the robot controller. About the detail of these macro programs, refer to "9.2 TEACHING MACRO PROGRAM FOR REMOTE OERATION". Joint jog of the robot and Cartesian jog of the robot are executed without macro program.

NOTE
In order to execute jog feed of the robot by remote operation, it is need to enable the function beforehand. Refer to "4.10 SETTING FOR ROBOT JOG FEED OPERATION FROM CNC".

7.2.1 Interface Signals for Robot Remote Operation

In order to execute the robot remote operation, the following signals in the standard interface signals are used. This section describes the interface signals in case that only one CNC is connected to the robot controller. About the interface signals in case that two or more CNCs are connected to the robot controller, refer to "7.2.5 Connection between Multiple CNCs and Robot".
The "CNC signal address" in the following tables is the address in the robot interface area which is independent on communication protocol and the CNC number, and the address in case that the standard setting value is used without change. About the detail of the robot interface area, refer to "3. SETTING AND CUSTOMIZING IN CNC".

From CNC to the robot controller

CNC Signal address	Robot DI number	Name
R7235.4	29	Hand Operation Type 1
R7235.5	30	Hand Operation Type 2
R7235.6	31	Hand Operation Type 3
R7235.7	32	Hand Operation Type 4
R7236.3	36	Remote Operation Request
R7236.4	37	Remote Operation Run
R7236.5	38	Override Up
R7236.6	39	Override Down
R7236.7	40	Joint Jog Selection
R7237.0	41	Direction for Joint Jog (J1+)
R7237.1	42	Direction for Joint Jog (J1-)
R7237.2	43	Direction for Joint Jog (J2+)
R7237.3	44	Direction for Joint Jog (J2-)
R7237.4	45	Direction for Joint Jog (J3+)

Form the robot controller to CNC

CNC Signal address	Robot DO number	Name
R7205.0	41	Override output 1
R7205.1	42	Override output 2
R7205.2	43	Override output 3
R7205.3	44	Override output 4
R7205.4	45	Override output 5
R7205.5	46	Override output 6
R7205.6	47	Override output 7
R7205.7	48	Override output 8
R7206.0	49	CNC ID Number 1
R7206.1	50	CNC ID Number 2
R7206.2	51	CNC ID Number 3
R7206.3	52	CNC ID Number 4
R7206.4	53	Access Control 1
R7206.5	54	Access Control 2

CNC Signal address	Robot DI number	Name
R7237.5	46	Direction for Joint Jog (J3-)
R7237.6	47	Direction for Joint Jog (J4+)
R7237.7	48	Direction for Joint Jog (J4-)
R7238.0	49	Direction for Joint Jog (J5+)
R7238.1	50	Direction for Joint Jog (J5-)
R7238.2	51	Direction for Joint Jog (J6+)
R7238.3	52	Direction for Joint Jog (J6-)
R7238.4	53	Direction for Coordinate Jog (X+)
R7238.5	54	Direction for Coordinate Jog (X-)
R7238.6	55	Direction for Coordinate Jog (Y+)
R7238.7	56	Direction for Coordinate Jog (Y-)
R7239.0	57	Direction for Coordinate Jog (Z+)
R7239.1	58	Direction for Coordinate Jog (Z-)
R7239.2	59	Home Position Return

CNC Signal address	Robot DO number	Name
R7206.6	55	Access Control 3
R7206.7	56	Access Control 4
R7207.4	61	Robot Power On
R7207.7	64	Machine Interlock Mode
R7208.0	65	Remote Operation Mode
R7208.7	72	Jog Feed Operation State
R7209.0	73	Hand Operation State
R7209.1	74	Home Return Operation State
R7209.2	75	ACK for Remote Operation Request
R7209.3	76	NAK for Remote Operation Request

Description of signals (from CNC to the robot controller)

Hand Operation Type 1 to 4 (CNC : R7235.4 to R7235.7, Robot Controller : DI[29] to DI[32])

- In CNC sample ladder, the type of hand operation selected in ROBOT REMOTE OPERATION screen on CNC is output by binary code. It is possible to designate the type of hand operation from 1 to 10. When the Remote Operation Run siganl is turned on after the type of the hand operation is output, the hand operation correspoing to the requested type is executed in the robot controller.
- In the robot controller, these 4 input signals are assigned to Group I/O GI[5]. While the hand operation is executed, the signals to designate the jog direction and home position return signal must be OFF.

Remote Operation Request (CNC : R7236.3, Robot Controller : DI[36])

- In CNC sample ladder, when the operation to acquire the remote operation right is executed in the ROBOT REMOTE OPERATION screen of CNC by pressing soft key "CONNE.OPR." and then "ON", this signal is turned ON. When the remote operation right is released, this signal is turned off.
- When this signal is turned on, the robot controller changes the mode to remote operation mode and outputs ACK for Remote Operation Request signal to CNC. But, in the following case, the robot controller outputs NAK for Remote Operation Request signal to CNC.
  - While the robot program started by CNC is executing
  - In case that the robot program started by CNC has been ended abnormally
  - In case that the robot controller has already changed the mode to remote operation mode by the request of the other CNC

  When Remote Operation Request signal is turned off, the robot controller changes the mode to machine interlock mode.

Remote Operation Run (CNC : R7236.4, Robot Controller : DI[37])

- In CNC sample ladder, in case that the operation to move the robot is selected in the ROBOT REMOTE OPERATION screen, when the robot operation button on machine operator’s panel is pressed, this signal is turned on.

Selected operation	Signal status
Jog feed Home position return	While the robot operation button is pressed, this signal is ON.
Hand operation	When the robot operation button is pressed, this signal is ON for 200 milliseconds.

- In the robot controller, when this signal is turned on with the signal to select operation, Jog Feed Operation State signal or Hand Operation State signal or Home Return Operation State signal, in remote operation mode, the requested operation is executed. In jog feed operation and home position return operation, when this signal is turned off, the executing operation is stopped. Hand Operation is executed when the robot controller detects the rising edge of this signal.

Override Up (CNC : R7236.5, Robot Controller : DI[38])

- When Override Up key is pressed in the ROBOT REMOTE OPERATION screen on CNC, CNC sample ladder turns on this signal for 200 milliseconds.
- In the robot controller, when this signal is turned on, the speed override is changed. Only when the robot controller is in remote operation mode, it is possible to change speed override by CNC. After speed override is changed by CNC in remote operation mode, even if the mode is changed to machine interlock mode, speed override is not changed.

Override Down (CNC : R7236.6, Robot Controller : DI[39])

- When Override Down key is pressed in the ROBOT REMOTE OPERATION screen on CNC, CNC sample ladder turns on this signal for 200 milliseconds.
- In the robot controller, when this signal is turned on, the speed override is changed. Only when the robot controller is in remote operation mode, it is possible to change speed override by CNC. After speed override is changed by CNC in remote operation mode, even if the mode is changed to machine interlock mode, speed override is not changed.

Joint Jog Selection (CNC : R7236.7, Robot Controller : DI[40])

- This is the signal to select the type of jog feed in case that the jog feed of robot is executed by the remote operation on CNC. In CNC sample ladder, when JOINT is set to JOG COORD in the ROBOT REMOTE OPERATION screen on CNC, this signal is turned on. When XYZ is set to JOG COORD, this signal is turned off.
- In the robot controller, when the jog feed operation is requested by CNC with this signal ON, the designated axis is jogged. When the jog feed operation is requested by CNC with this signal OFF, the jog feed is executed in Cartesian coordinate. If the input signal to designate jog direction is inconsistent with the status of this signal, jog feed by remote operation is not executed.

Direction for Jog Feed (CNC : R7237.0 to R7239.1, Robot Controller : DI[41] to DI[58])

- In CNC sample ladder, when the direction for jog feed is selected in the ROBOT REMOTE OPERATION screen on CNC, one of these signals is output.
- In the robot controller, when Remote Operation Run signal is turned on by CNC after above operation on CNC is executed, the robot is jogged to the designated direction. Do not turn on another signal in these signals while one of these signals is ON. And, do not turn on Hand Operation Type signal and Home Position Return signal while one of jog direction signal is on.

Home Position Return (CNC : R7239.2, Robot Controller : DI[59])

- In CNC sample ladder, when HOME POSITION is selected, this signal is turned on.
- In the robot controller, when Remote Operation Run signal is turned on by CNC in above status, the robot moves to the home position by the execution of macro program. Do not turn ON Direction for Jog Feed signals and Hand Operation Type signals while this signal is ON.

Description of signals (from the robot controller to CNC)

Override output 1 to 8 (CNC : R7205.0 to R7205.7, Robot Controller : DO[41] to DO[48])

- The robot ladder program outputs the speed override value by binary code through these signals. If the speed override is FINE or VFINE in the robot controller, 0 is output.
- CNC reads override value of the robot controller by these signals and displays the value to the item OVERRRIDE in the ROBOT REMOTE OPERATION screen.

CNC ID Number 1 to 4 (CNC : R7206.0 to R7206.3, Robot Controller: DO[49] to DO[52])

- The robot ladder program outputs the number to identify the connected CNC by binary code through these signals. For example, the robot controller outputs 1 to CNC 1 connected to the robot controller by the signals from DO[1] to DO[256], and outputs 2 to CNC 2 connected to the robot controller by the signals from DO[257] to DO[512].
- CNC reads CNC ID number by these signals and display to the item “CNC NUM”. In the ROBOT REMOTE OPERATION screen.

Access Control 1 to 4 (CNC : R7206.4 to R7206.7, Robot Controller : DO[53] to DO[56])

- In case that two or more CNCs are connected to the robot controller, when one of the connected CNCs executes remote operation, or when the robot program is executed by request from one of the connected CNCs, the robot ladder program outputs the ID number for that CNC by binary code.
- CNC reads these signals number and displays the value to the item “CON. CNC” in the ROBOT REMOTE OPERATION screen.

Robot Power ON (CNC : R7207.4, Robot Controller : DO[61])

- While the power of the robot controller is ON, the robot ladder program outputs this signal.
- While this signal is ON, CNC sample ladder controls the signals connected the robot controller.

Machine Interlock Mode (CNC : R7207.7, Robot Controller : DO[64])

- In the robot ladder program, while Service State signal is ON and all CNCs connected with the robot controller do not execute robot remote operation, this signal is output.
- In CNC sample ladder, this signal is not used.

Remote Operation Mode (CNC : R7208.0, Robot Controller : DO[65])

- In the robot ladder program, while Service State signal is ON and CNC connected with the robot controller executes the robot remote operation, this signal is output.
- In CNC sample ladder, this signal is not used.

Jog Feed Operation State (CNC : R7208.7, Robot Controller : DO[72])

- In the robot ladder program, while Remote Operation Mode signal is ON and jog feed operation is selected on CNC, this signal is output. Because jog feed and hand operation and home position return in the ROBOT REMOTE OPERATION screen on CNC are executed exclusively, this signal is not turned on when either Hand Operation State signal or Home Return State signal is ON.
- In CNC sample ladder, this signal is not used.

Hand Operation State (CNC : R7209.0, Robot Controller : DO[73])

- In the robot ladder program, while Remote Operation Mode signal is ON and hand operation is selected on CNC, this signal is output. Because jog feed and hand operation and home position return in the ROBOT REMOTE OPERATION screen on CNC are executed exclusively, this signal is not turned on when either Jog Feed Operation State signal or Home Return State signal is ON.
- In CNC sample ladder, this signal is not used.

Home Return State (CNC : R7209.1, Robot Controller : DO[74])

- In the robot ladder program, while Remote Operation Mode signal is ON and home position return operation is selected on CNC, this signal is output. Because jog feed and hand operation and home position return in the ROBOT REMOTE OPERATION screen on CNC are executed exclusively, this signal is not turned on when either Jog Feed Operation State signal or Hand Operation State signal is ON.

- In CNC sample ladder, this signal is not used.

ACK for Remote Operation Request (CNC : R7209.2, Robot Controller : DO[75])

- When Remote Operation Request signal is turned on by CNC, if the remote operation can be executed in the robot controller, this signal is output by pulse signal. Refer to "7.2.2 Condition for Robot Remote Operation".

NAK for Remote Operation Request (CNC : R7209.3, Robot Controller : DO[76])

- When Remote Operation Request signal is turned on by CNC, if the remote operation cannot be executed in the robot controller, this signal is output by pulse signal. Refer to "7.2.2 Condition for Robot Remote Operation".

7.2.2 Condition for Robot Remote Operation

The robot remote operation by CNC can be executed when the robot controller is in the following state.

- Service State signal is ON.
- Machine Interlock Mode signal is ON.
- Ready or Not Ready signal is ON.

Ready signal and Not Ready signal are turned on when the robot program is not executed in the robot controller. When both Ready signal and Not Ready signal are not ON, the robot remote operation cannot be executed.

7.2.3 Acquire and Release the Right for Remote Operation

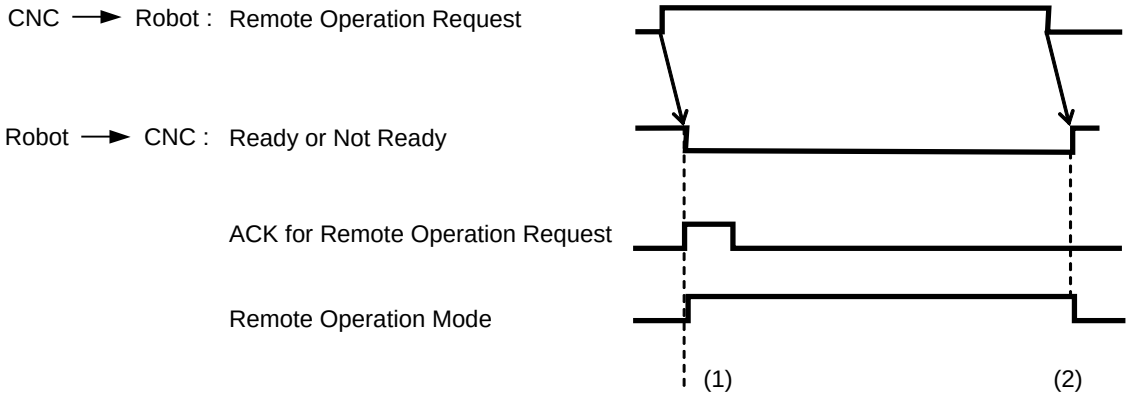
Acquire the right for remote operation

In order to execute the robot remote operation on CNC, CNC must acquire the right for remote operation. When the acquisition for the right of remote operation is ordered in the ROBOT REMOTE OPERATION screen on CNC, CNC sample ladder turns on Remote Operation Request signal. If the robot controller can execute remote operation, the robot ladder program turns on ACK for Remote Operation Request signal. If the robot controller cannot execute remote operation, the robot ladder program turns on NAK for Remote Operation Request signal. If CNC sample ladder receives NAK signal from the robot controller, CNC sample ladder turns off Remote Operation Request signal.

Release the right for remote operation

When the release for the right of remote operation is ordered in the ROBOT REMOTE OPERATION screen on CNC, CNC sample ladder turns off Remote Operation Request signal. If the robot controller detects that Remote Operation Request signal is turned off, the robot controller changes the mode to machine interlock mode.

Signal sequence



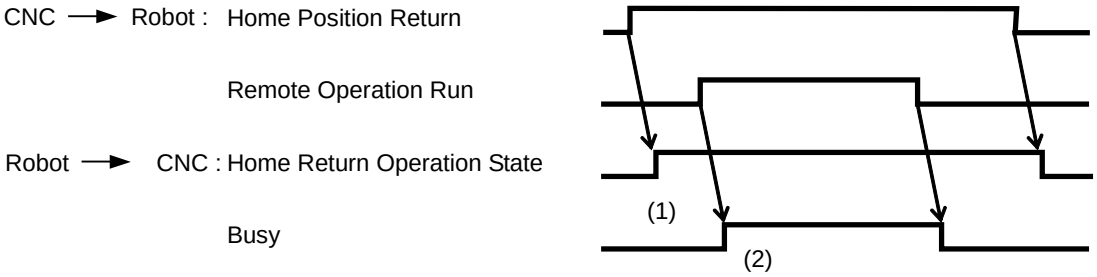
(1) When Ready signal or Not Ready signal is ON in the robot controller, if Remote Operation Request signal is turned on in CNC, ACK for Remote Operation Request signal is turned on in the robot controller, and Remote Operation Mode signal is turned on.
(2) When robot remote operation is ended in CNC, Remote Operation Request signal is turned off, and Remote Operation Mode signal is turned off, then Ready signal or Not Ready signal is turned on.

The robot controller remains in remote operation state until Remote Operation Request signal from CNC is turned off. But, if the robot teach pendant become enabled in the robot controller that is in the remote operation state, the robot remote operation on CNC cannot be executed. In case that the robot ladder program turns on Maintenance State signal or turns off Service State signal, because the robot controller is in the state that the robot controller cannot execute the remote operation, CNC sample ladder turns off Remote Operation Request signal. And, if the power of the robot controller is turned off, the remote operation on CNC cannot be executed. When Robot Power On signal is turned off, CNC sample ladder turns off Remote Operation Request signal.

7.2.4 Detail of Robot Remote Operation

In the robot remote operation on CNC, hand operation and jog feed operation, home position return operation can be executed. In order to execute the remote operation in the robot controller, CNC sample ladder outputs the signal to select the operation after output of Remote Operation Request signal, then outputs Remote Operation Run signal.

Signal sequence



(1) When Home Position Return signal (or one of Hand Operation signals or one of Jog Direction selection signals) is turned on, Home Return Operation State signal (or Hand Operation State signal or Jog Feed Operation State signal) in the robot controller is turned on.
(2) When Remote Operation Run signal in CNC is turned on, the program for home position return (or hand operation or jog feed) is executed in the robot controller. While the program is executed, Busy signal is ON.

While the remote operation is executed, Override Up and Down signal in CNC can change the speed override in the robot controller at any time.

7.2.5 Connection between Multiple CNCs and Robot

Interface signal

In case that the robot is connected with two or more CNCs, the interface signals in the robot controller are extended according to the number of CNC. The signals for each CNC are same as the signals described in "7.2.1 Interface Signals for Robot Remote Operation". Only the signal number in each CNC is different. The signal number in each CNC is as follows.

NOTE
It is need to set the number of the connected CNC with the robot beforehand. Refer to "2. CONNECTION BETWEEN CNC AND ROBOT".

Form CNC to the robot controller

Name of signal	CNC1 Signal number	CNC2 Signal number	CNC3 Signal number	CNC4 Signal number
Hand Operation Type 1	DI[29]	DI[285]	DI[541]	DI[797]
Hand Operation Type 2	DI[30]	DI[286]	DI[542]	DI[798]
Hand Operation Type 3	DI[31]	DI[287]	DI[543]	DI[799]
Hand Operation Type 4	DI[32]	DI[288]	DI[544]	DI[800]
Remote Operation Request	DI[36]	DI[292]	DI[548]	DI[804]
Remote Operation Run	DI[37]	DI[293]	DI[549]	DI[805]
Override Up	DI[38]	DI[294]	DI[550]	DI[806]
Override Down	DI[39]	DI[295]	DI[551]	DI[807]
Joint Jog Selection	DI[40]	DI[296]	DI[552]	DI[808]
Direction for Joint Jog (J1+)	DI[41]	DI[297]	DI[553]	DI[809]
Direction for Joint Jog (J1-)	DI[42]	DI[298]	DI[554]	DI[810]
Direction for Joint Jog (J2+)	DI[43]	DI[299]	DI[555]	DI[811]
Direction for Joint Jog (J2-)	DI[44]	DI[300]	DI[556]	DI[812]
Direction for Joint Jog (J3+)	DI[45]	DI[301]	DI[557]	DI[813]
Direction for Joint Jog (J3-)	DI[46]	DI[302]	DI[558]	DI[814]
Direction for Joint Jog (J4+)	DI[47]	DI[303]	DI[559]	DI[815]
Direction for Joint Jog (J4-)	DI[48]	DI[304]	DI[560]	DI[816]
Direction for Joint Jog (J5+)	DI[49]	DI[305]	DI[561]	DI[817]
Direction for Joint Jog (J5-)	DI[50]	DI[306]	DI[562]	DI[818]
Direction for Joint Jog (J6+)	DI[51]	DI[307]	DI[563]	DI[819]
Direction for Joint Jog (J6-)	DI[52]	DI[308]	DI[564]	DI[820]
Direction for Coordinate Jog (X+)	DI[53]	DI[309]	DI[565]	DI[821]
Direction for Coordinate Jog (X-)	DI[54]	DI[310]	DI[566]	DI[822]
Direction for Coordinate Jog (Y+)	DI[55]	DI[311]	DI[567]	DI[823]
Direction for Coordinate Jog (Y-)	DI[56]	DI[312]	DI[568]	DI[824]
Direction for Coordinate Jog (Z+)	DI[57]	DI[313]	DI[569]	DI[825]
Direction for Coordinate Jog (Z-)	DI[58]	DI[314]	DI[570]	DI[826]
Home Position Return	DI[59]	DI[315]	DI[571]	DI[827]

From the robot controller to CNC

Name of Signal	CNC1 Signal number	CNC2 Signal number	CNC3 Signal number	CNC4 Signal number
Override output 1	DO[41]	DO[297]	DO[553]	DO[809]
Override output 2	DO[42]	DO[298]	DO[554]	DO[810]
Override output 3	DO[43]	DO[289]	DO[555]	DO[811]
Override output 4	DO[44]	DO[300]	DO[556]	DO[812]
Override output 5	DO[45]	DO[301]	DO[557]	DO[813]
Override output 6	DO[46]	DO[302]	DO[558]	DO[814]
Override output 7	DO[47]	DO[303]	DO[559]	DO[815]
Override output 8	DO[48]	DO[304]	DO[560]	DO[816]
CNC ID Number 1	DO[49]	DO[305]	DO[561]	DO[817]
CNC ID Number 2	DO[50]	DO[306]	DO[562]	DO[818]
CNC ID Number 3	DO[51]	DO[307]	DO[563]	DO[819]
CNC ID Number 4	DO[52]	DO[308]	DO[564]	DO[820]
Access Control 1	DO[53]	DO[309]	DO[565]	DO[821]
Access Control 2	DO[54]	DO[310]	DO[566]	DO[822]
Access Control 3	DO[55]	DO[311]	DO[567]	DO[823]
Access Control 4	DO[56]	DO[312]	DO[568]	DO[824]
Robot Power On	DO[61]	DO[317]	DO[573]	DO[829]
Machine Interlock Mode	DO[64]	DO[318]	DO[576]	DO[832]
Remote Operation Mode	DO[65]	DO[319]	DO[577]	DO[833]
Jog Feed Operation State	DO[72]	DO[328]	DO[584]	DO[840]
Hand Operation State	DO[73]	DO[329]	DO[585]	DO[841]
Home Return Operation State	DO[74]	DO[330]	DO[586]	DO[842]
ACK for Remote Operation Request	DO[75]	DO[331]	DO[587]	DO[843]
NAK for Remote Operation Request	DO[76]	DO[332]	DO[588]	DO[844]

In case that Hand Operation Type selection signals are input from two or more CNCs, the input signals from CNC that has the right for the remote operation is set to group I/O GI[5] in the robot controller.

Remote operation on CNC

When Remote Operation Request signal is output in two or more CNCs, the robot controller outputs ACK for Remote Operation Request signal to CNC which output signal is received in the robot controller first, the robot controller outputs NAK for Remote Operation Request signal to other CNC. Only CNC that receives ACK signal from the robot controller can execute remote operation.

7.3 MACHINE TOOL OPERATION ON ROBOT TEACH PENDANT

It is possible to operate machine tool in Machine tool operation screen on the robot teach pendant. The machine tool operations executed by the standard interface signals and the ladder program in CNC and the robot ladder program are as follows.

- Jog feed of the machine tool
- Speed override change for jog feed of the machine tool

While the operation is executed in Machine tool operation screen on the robot teach pendant, the signals that is required for jog feed of the machine tool are output to CNC according to the operation. In order to execute jog feed of machine tool actually, it is required to create the ladder program in CNC to move axes in the machine tool according to signals from the robot controller. Please understand the specification of signals by the following description and create the ladder program in CNC.

7.3.1 Interface Signals for Machine Tool Operation

In order to execute the machine tool operation on the robot teach pendant, the following signals in the standard interface signals are used. This section describes the interface signals in case that only one CNC is connected to the robot controller. About the interface signals in case that two or more CNCs are connected to the robot controller, refer to "7.3.3 Connection between Multiple CNCs and Robot".
The "CNC signal address" in the following tables is the address in the robot interface area which is independent on communication protocol and the CNC number, and the address in case that the standard setting value is used without change. About the detail of the robot interface area, refer to "3.SETTING AND CUSTOMIZING IN CNC".

From CNC to the robot controller

CNC Signal address	Robot DI number	Name
R7247.0	121	Machine Operation Enable Status
R7247.1	122	Machine Operation Request Reject
R7247.2	123	Machine Operation Request Reject code 1
R7247.3	124	Machine Operation Request Reject code 2
R7247.4	125	Machine Operation Request Reject code 3
R7247.5	126	Machine Operation Request Reject code 4

Form the robot controller to CNC

CNC Signal address	Robot DO number	Name
R7215.0	121	Machine Operation Request
R7215.1	122	Machine Operation Path Selection (Path1)
R7215.2	123	Machine Operation Path Selection (Path2)
R7215.3	124	Machine Operation Path Selection (Path3)
R7215.4	125	Machine Operation Path Selection (Path4)
R7215.5	126	Machine Operation Path Selection (Path5)
R7215.6	127	Machine Operation Heart Beat signal
R7215.7	128	(Reserved)
R7216.0	129	Machine Jog Feed Override 0
R7216.1	130	Machine Jog Feed Override 1
R7216.2	131	Machine Jog Feed Override 2
R7216.3	132	Machine Jog Feed Override 3
R7216.4	133	Machine Jog Feed Override 4
R7216.5	134	Machine Jog Feed Override 5
R7216.6	135	Machine Jog Feed Override 6
R7216.7	136	Machine Jog Feed Override 7
R7217.0	137	Machine Jog Feed Override 8

CNC Signal address	Robot DO number	Name
R7217.1	138	Machine Jog Feed Override 9
R7217.2	139	Machine Jog Feed Override 10
R7217.3	140	Machine Jog Feed Override 11
R7217.4	141	Machine Jog Feed Override 12
R7217.5	142	Machine Jog Feed Override 13
R7217.6	143	Machine Jog Feed Override 14
R7217.7	144	Machine Jog Feed Override 15
R7218.0	145	Machine Jog Feed Axis (1ST+)
R7218.1	146	Machine Jog Feed Axis (1ST-)
R7218.2	147	Machine Jog Feed Axis (2ND+)
R7218.3	148	Machine Jog Feed Axis (2ND-)
R7218.4	149	Machine Jog Feed Axis (3RD+)
R7218.5	150	Machine Jog Feed Axis (3RD-)
R7218.6	151	Machine Jog Feed Axis (4TH+)
R7218.7	152	Machine Jog Feed Axis (4TH-)
R7219.0	153	Machine Jog Feed Axis (5TH+)
R7219.1	154	Machine Jog Feed Axis (5TH-)
R7219.2	155	Machine Jog Feed Axis (6TH+)
R7219.3	156	Machine Jog Feed Axis (6TH-)
R7219.4	157	Machine Jog Feed Axis (7TH+)
R7219.5	158	Machine Jog Feed Axis (7TH-)
R7219.6	159	Machine Jog Feed Axis (8TH+)
R7219.7	160	Machine Jog Feed Axis (8TH-)

Description of signals (from CNC to the robot controller)

Machine Operation Enable Status (CNC : R7247.0, Robot Controller : DI[121])

- When CNC receives Machine Operation Request signal that is turned on by pressing Operation Enable button in Machine tool operation screen on the robot teach pendant, if it is possible to be operated the machine tool by the robot teach pendant in CNC, turn on this signal and keep ON status while it is possible to be operated the machine tool by the robot teach pendant in CNC.
- In the robot controller, if this signal becomes OFF, Operation Enable Lamp is turned off and the operation on the robot teach pendant is not available.

Machine Operation Request Reject (CNC : R7247.1, Robot Controller : DI[122])

- When CNC receives Machine Operation Request signal that is turned on by pressing Operation Enable button in Machine tool operation screen on the robot teach pendant, if it is not possible to be operated the machine tool on the robot teach pendant in CNC, output this signal in CNC by pulse output for 200 miliseconds.

Machine Operation Request Reject Code1 to 4 (CNC : R7247.2 to R7247.5, Robot Controller : DI[123] to DI[126])

- Before CNC outputs Machine Operation Request Reject signal, output the reason for the reject in these signals by binary code.
- The robot controller reads these signals and displays the code number in Machine tool operation screen.
- If CNC outputs Machine Operation Enable Status signal in response to Machine Operation Request signal, turn off all of these signals.
- Keep On status until CNC responds to Machine Operation Request next time.

Description of signals (from the robot controller to CNC)

Machine Operation Request (CNC : R7215.0, Robot Controller : DO[121])

- When Operation Enable button is pressed in Machine tool operation screen, if all of following conditions are satisfied, this signal is turned on.
  - Interlock Mode signal is ON in CNC.
  - Robot teach pendant is enabled.
  - Emergency stop button on the robot teach pendant is not pressed.
  - Emergency stop button on the operator panel is not pressed. (R-30*i*A/R-30*i*A Mate controller)
  - External emergency stop signal is not asserted.(R-30*i*A/R-30*i*A Mate controller)
  - Robot controller communication with the selected CNC by Ethernet.

Machine Operation Path Selection (Path1 to 5) (CNC : R7215.1 to R7125.5, Robot Controller : DO[122] to DO[126])

- The signal corresponding to the operated path in Machine tool operation screen is output. In case that Machine Operation Enable Status signal is turned on and the robot teach pendant is enabled, while “M.jog“ (F5) key is pressed with shift key, this signal is output.
- While the pop-up dialog box to confirm CNC and path is displayed, this signal is not output.

Machine Operation Heart Beat (CNC : R7215.6, Robot Controller : DO[127])

- While Machine Operation Enable Status signal is ON, this signal repeats ON and OFF status at 128 miliseconds interval.

Machine Jog Feed Override 0 to 15 (CNC : R7216.0 to R7217.7, Robot Controller : DO[129] to DO[144])

- The override value corresponding to the jog feed speed override selected in the Machine tool operation screen is output by these signal by binary code. In case that Machine Operation Enable Status signal is turned on and the robot teach pendant is enabled, while “M.jog“ (F5) key is pressed with shift key, these signals are output.
- While the pop-up dialog box to confirm CNC and path is displayed, this signal is not output.
- The conditions to turned off these signals are as follows.
  - Emergency stop button on the robot teach pendant is pressed.
  - Emergency stop button on the operator panel is pressed. (R-30*i*A/R-30*i*A Mate controller)
  - External emergency stop signal is asserted.(R-30*i*A/R-30*i*A Mate controller)
  - Interlock Mode signal is turned off in CNC.
  - Machine Tool Operation Enable Stautus signal is turned off.
  - The disaplayed screen is changed on the robot teach pendant.
  - The robot teach pendant is disabled.
  - Other axis and direction select button is pressed in the Machine tool operation screen.
  - All axis and direction select button are not pressed in the Machine tool operation screen.
  - Operation Enable button is pressed to disable the operation in Machine tool operation screen.
  - Ethernet communication with the selected CNC is disconnected.
  - The robot program is executed in th robot controller.
  - Robot is moved by jog feed or program execution.

Machine Jog Feed Axis (CNC : R7218.0 to R7219.7, Robot Controller : DO[145] to DO[160])

- The signal corresponding to the axis and direction for jog feed selected in the Machine tool operation screen is output.
- Two or more signals in these signals are not ON at the same time.
- In case that Machine Operation Enable Status signal is turned on and the robot teach pendant is enabled, while “M.jog“ (F5) key is pressed with shift key, these signals are output.
- While the pop-up dialog box to confirm CNC and path is displayed, this signal is not output.
- The conditions to turned off these signals are as follows.
  - Emergency stop button on the robot teach pendant is pressed.
  - Emergency stop button on the operator panel is pressed. (R-30*i*A/R-30*i*A Mate controller)

- External emergency stop signal is asserted.(R-30*i*A/R-30*i*A Mate controller)
- Interlock Mode signal is turned off in CNC.
- Machine Tool Operation Enable Stautus signal is turned off.
- The disaplayed screen is changed on the robot teach pendant.
- The robot teach pendant is disabled.
- Other axis and direction select button is pressed in the Machine tool operation screen.
- All axis and direction select button are not pressed in the Machine tool operation screen.
- Operation Enable button is pressed to disable the operation in Machine tool operation screen.
- Ethernet communication with the selected CNC is disconnected.
- The robot program is executed in th robot controller.
- Robot is moved by jog feed or program execution.

7.3.2 Create Ladder Program in CNC

In order to execute the machine tool operation on the robot teach pendant, create the ladder program in CNC to realize the following signal process.

Enable machine tool operation

- Keep ON Machine Operation Enable Status signal while Machine Operation Request signal is ON, if the machine operation by the robot teach pendant is available in CNC. In the robot controller, the operation in Machine tool operation screen is available while Machine Operation Enable Status signal is ON.
- After CNC turns on Machine Operation Enable Status signal, if CNC wants to disable the machine operation by the robot teach pendant, turn off Machine Operation Enable Status signal. If Machine Operation Enable Status signal is turned off, all signals for machine operation that have been turned on by the robot controller are turned off.
- When Machine Operation Request signal is turned on by the robot controller, if CNC cannot accept the request for jog feed of the machine tool by the robot teach pendant, output the reason for reject to Machine Operation Request Reject Code signals 1 to 4 by binary code and output Machine Operation Enable Request Reject signal by pulse signal for 200 milliseconds. The response code output to Machine Operation Request Reject Code signals is displayed in Machine tool operation screen on the robot teach pendant.
- After Machine Tool Operation Request is turned on by the robot controller, if neither Machine Operation Enable Status signal nor Machine Operation Enable Request Reject signal is not turned on within one second, the robot controller do the same process as the case that Machine Operation Request Reject signal is turned on and Machine Operation Request Reject Code is 0.

Execute jog feed of machine tool

- In CNC, execute jog feed of the machine tool according to the instruction from the robot controller while Machine Operation Enable Status signal is ON.
- Before CNC executes jog feed of the machine tool, set override value to the designated value by Machine Jog Feed Override signals in the designated path by Machine Operation Path Select signals.
- If one of Machine Jog Feed Axis Select signals is input, move the axis selected by Machine Jog Feed Axis Select signals to the direction selected by Machine Jog Feed Axis Select signals in the designated path by Machine Operation Path Select signal. Two or more signals in Machine Jog Feed Axis Select signals are not turned on at the same time.
- Confirm whether the robot controller works correctly by Machine Operation Heart Beat signal while CNC executes jog feed of the machine tool according to the instruction from the robot controller. While Machine Operation Enable Status signal is ON, Machine Operation Heart Beat signal repeats ON and OFF at 128 milliseconds interval. When Machine Operation Heart Beat signal remains ON or OFF for a while, stop jog feed of the machine tool immediately because the robot controller may become abnormal status.

7.3.3 Connection between Multiple CNCs and Robot

Interface signal

In case that the robot is connected with two or more CNCs, the interface signals in the robot controller are extended according to the number of CNC. The signals for each CNC are same as the signals described in "7.3.1 Interface Signals for Machine Tool Operation". Only the signal number in each CNC is different. The signal number in each CNC is as follows.

NOTE
It is need to set the number of the connected CNC with the robot beforehand. Refer to "2. CONNECTION BETWEEN CNC AND ROBOT".

Form CNC to the robot controller

Name of signal	CNC1 Signal number	CNC2 Signal number	CNC3 Signal number	CNC4 Signal number
Machine Operation Enable Status	DI[121]	DI[377]	DI[633]	DI[889]
Machine Operation Request Reject	DI[122]	DI[378]	DI[634]	DI[890]
Machine Operation Request Reject code 1	DI[123]	DI[379]	DI[635]	DI[891]
Machine Operation Request Reject code 2	DI[124]	DI[380]	DI[636]	DI[892]
Machine Operation Request Reject code 3	DI[125]	DI[381]	DI[637]	DI[893]
Machine Operation Request Reject code 4	DI[126]	DI[382]	DI[638]	DI[894]

From the robot controller to CNC

Name of Signal	CNC1 Signal number	CNC2 Signal number	CNC3 Signal number	CNC4 Signal number
Machine Operation Request	DO[121]	DO[377]	DO[633]	DO[889]
Machine Operation Path Selection (Path1)	DO[122]	DO[378]	DO[634]	DO[890]
Machine Operation Path Selection (Path2)	DO[123]	DO[379]	DO[635]	DO[891]
Machine Operation Path Selection (Path3)	DO[124]	DO[380]	DO[636]	DO[892]
Machine Operation Path Selection (Path4)	DO[125]	DO[381]	DO[637]	DO[893]
Machine Operation Path Selection (Path5)	DO[126]	DO[382]	DO[638]	DO[894]
Machine Operation Heart Beat signal	DO[127]	DO[383]	DO[639]	DO[895]
(Reserved)	DO[128]	DO[384]	DO[640]	DO[896]
Machine Jog Feed Override 0	DO[129]	DO[385]	DO[641]	DO[897]
Machine Jog Feed Override 1	DO[130]	DO[386]	DO[642]	DO[898]
Machine Jog Feed Override 2	DO[131]	DO[387]	DO[643]	DO[899]
Machine Jog Feed Override 3	DO[132]	DO[388]	DO[644]	DO[900]
Machine Jog Feed Override 4	DO[133]	DO[389]	DO[645]	DO[901]
Machine Jog Feed Override 5	DO[134]	DO[390]	DO[646]	DO[902]
Machine Jog Feed Override 6	DO[135]	DO[391]	DO[647]	DO[903]
Machine Jog Feed Override 7	DO[136]	DO[392]	DO[648]	DO[904]
Machine Jog Feed Override 8	DO[137]	DO[393]	DO[649]	DO[905]
Machine Jog Feed Override 9	DO[138]	DO[394]	DO[650]	DO[906]
Machine Jog Feed Override 10	DO[139]	DO[395]	DO[651]	DO[907]
Machine Jog Feed Override 11	DO[140]	DO[396]	DO[652]	DO[908]
Machine Jog Feed Override 12	DO[141]	DO[397]	DO[653]	DO[909]
Machine Jog Feed Override 13	DO[142]	DO[398]	DO[654]	DO[910]
Machine Jog Feed Override 14	DO[143]	DO[399]	DO[655]	DO[911]
Machine Jog Feed Override 15	DO[144]	DO[400]	DO[656]	DO[912]
Machine Jog Feed Axis (1ST+)	DO[145]	DO[401]	DO[657]	DO[913]
Machine Jog Feed Axis (1ST-)	DO[146]	DO[402]	DO[658]	DO[914]
Machine Jog Feed Axis (2ND+)	DO[147]	DO[403]	DO[659]	DO[915]

Name of Signal	CNC1 Signal number	CNC2 Signal number	CNC3 Signal number	CNC4 Signal number
Machine Jog Feed Axis (2ND-)	DO[148]	DO[404]	DO[660]	DO[916]
Machine Jog Feed Axis (3RD+)	DO[149]	DO[405]	DO[661]	DO[917]
Machine Jog Feed Axis (3RD-)	DO[150]	DO[406]	DO[662]	DO[918]
Machine Jog Feed Axis (4TH+)	DO[151]	DO[407]	DO[663]	DO[919]
Machine Jog Feed Axis (4TH-)	DO[152]	DO[408]	DO[664]	DO[920]
Machine Jog Feed Axis (5TH+)	DO[153]	DO[409]	DO[665]	DO[921]
Machine Jog Feed Axis (5TH-)	DO[154]	DO[410]	DO[666]	DO[922]
Machine Jog Feed Axis (6TH+)	DO[155]	DO[411]	DO[667]	DO[923]
Machine Jog Feed Axis (6TH-)	DO[156]	DO[412]	DO[668]	DO[924]
Machine Jog Feed Axis (7TH+)	DO[157]	DO[413]	DO[669]	DO[925]
Machine Jog Feed Axis (7TH-)	DO[158]	DO[414]	DO[670]	DO[926]
Machine Jog Feed Axis (8TH+)	DO[159]	DO[415]	DO[671]	DO[927]
Machine Jog Feed Axis (8TH-)	DO[160]	DO[416]	DO[672]	DO[928]

7.4 OTHER INTERFACE SIGNALS

In addition to the above-mentioned interface signals, following signals are prepared as the interface signal between CNC and the robot. Use these signals in NC Program and the robot program according to need.

From CNC to the robot controller

CNC Signal address	Robot DI number	Name
R7236.0	33	CNC Power On
R7242.0	81	Response of Peripheral Device 1
R7242.1	82	Response of Peripheral Device 2
R7242.2	83	Response of Peripheral Device 3
R7242.3	84	Response of Peripheral Device 4
R7242.4	85	Response of Peripheral Device 5
R7242.5	86	Response of Peripheral Device 6
R7242.6	87	Response of Peripheral Device 7
R7242.7	88	Response of Peripheral Device 8
R7243.0	89	Response of Peripheral Device 9
R7243.1	90	Response of Peripheral Device 10
R7243.2	91	Response of Peripheral Device 11
R7243.3	92	Response of Peripheral Device 12
R7243.4	93	Response of Peripheral Device 13

From the robot controller to CNC

CNC Signal address	Robot DO number	Name
R7203.0	25	RI[1]
R7203.1	26	RI[2]
R7203.2	27	RI[3]
R7203.3	28	RI[4]
R7203.4	29	RI[5]
R7203.5	30	RI[6]
R7203.6	31	RI[7]
R7203.7	32	RI[8]
R7204.0	33	RO[1]
R7204.1	34	RO[2]
R7204.2	35	RO[3]
R7204.3	36	RO[4]
R7204.4	37	RO[5]
R7204.5	38	RO[6]

CNC Signal address	Robot DI number	Name
R7243.5	94	Response of Peripheral Device 14
R7243.6	95	Response of Peripheral Device 15
R7243.7	96	Response of Peripheral Device 16
R7244.0	97	Production System Response 1
R7244.1	98	Production System Response 2
R7244.2	99	Production System Response 3
R7244.3	100	Production System Response 4
R7244.4	101	Input of Production System Operation 1
R7244.5	102	Input of Production System Operation 2
R7244.6	103	Input of Production System Operation 3
R7244.7	104	Input of Production System Operation 4
R7245.0	105	Robot Entry Approval
R7245.2	107	Machine Alarm
R7245.3	108	Door Open
R7245.4	109	Door Close
R7245.5	110	Part Change Position

CNC Signal address	Robot DO number	Name
R7204.6	39	RO[7]
R7204.7	40	RO[8]
R7208.1	66	Safety Fence Open
R7208.2	67	Safety Fence Close
R7208.3	68	In E.Stop state
R7210.0	81	Command to Peripheral Device 1
R7210.1	82	Command to Peripheral Device 2
R7210.2	83	Command to Peripheral Device 3
R7210.3	84	Command to Peripheral Device 4
R7210.4	85	Command to Peripheral Device 5
R7210.5	86	Command to Peripheral Device 6
R7210.6	87	Command to Peripheral Device 7
R7210.7	88	Command to Peripheral Device 8
R7211.0	89	Command to Peripheral Device 9
R7211.1	90	Command to Peripheral Device 10
R7211.2	91	Command to Peripheral Device 11
R7211.3	92	Command to Peripheral Device 12
R7211.4	93	Command to Peripheral Device 13
R7211.5	94	Command to Peripheral Device 14
R7211.6	95	Command to Peripheral Device 15
R7211.7	96	Command to Peripheral Device 16
R7212.0	97	Production Operation 1
R7212.1	98	Production Operation 2
R7212.2	99	Production Operation 3
R7212.3	100	Production Operation 4
R7212.4	101	Output of Production System Response 1
R7212.5	102	Output of Production System Response 2

CNC Signal address	Robot DO number	Name
R7212.6	103	Output of Production System Response 3
R7212.7	104	Output of Production System Response 4
R7213.0	105	*Robot Entry

Description of signals (from CNC to the robot controller)

CNC Power On (CNC : R7236.0, Robot Controller : DI[33])

- In CNC sample ladder, this signal is ON while the power of CNC is ON.
- If this signal is changed to OFF from ON, MTCOM connection will be disconnected, so don't use this signal for other purpose. By the way, if this signal is changed to ON from OFF, MTCOM communication will start.
- The index of this signal can be changed by $MTSERV_CFG.$CNC_POW_IO[CNC number].

Response of Peripheral Device 1 to 16 (CNC : R7242.0 to R7243.7, Robot Controller : DI[81] to DI[96])

- The robot controller uses these signals to monitor the peripheral device connected to CNC. In CNC sample ladder, this signal is not used. In order to use these signals, it is required to create ladder program in both CNC and the robot controller.

Production System Response 1 to 4 (CNC : R7244.0 to R7244.3, Robot Controller : DI[97] to DI[100])

- These signals are used to notify all CNCs connected to the robot controller that the specified signal is turned on in all CNCs. These signals are used coupled with Output of Production System Response signals that are output by the robot controller to CNC. In CNC ladder program, turn on these signals if necessary. The robot ladder program calculates the logical product for Production System Response n (n= 1 to 4) signals input from all CNCs that are connected to the robot controller and in interlock mode, and outputs the result of logical product to Output of Production System Response n signals. For example, Production System Response 3 in all CNCs connected to the robot controller are turned on, Output of Production System Response 3 signals in all CNCs are turned on. If one of CNC connected to the robot controller turns off Production System Response 3 signal, Output of Production System Response 3 signals in all CNCs are turned off.
- In order to use these signals, it is required to set the keep relay in the robot ladder program. For detail, refer to "10 ROBOT LADDER PROGRAM".

Input of Production System Operation 1 to 4 (CNC : R7244.4 to R7244.7, Robot Controller : DI[101] to DI[104])

- These signals are used to notify the status of the specified signal in one of CNCs connected to the robot controller. These signals are used coupled with Production Operation signals that are output by the robot controller to CNC. In CNC ladder program, turn on these signals if necessary. The robot ladder program calculates the logical addition for Input of Production System Operation n (n= 1 to 4) signals input from all CNCs that are connected to the robot controller and in interlock mode, and outputs the result of logical addition to Production Operation n signals. For example, Input of Production System Operation 2 signal in CNC 1 is turned on, Production Operation 2 signals in all CNCs are turned on. If CNC 3 turns on Input of Production System Operation 2 signal, Production Operations 2 signals in all CNCs are turned on, too.
- In order to use these signals, it is required to set the keep relay in the robot ladder program. For detail, refer to "10 ROBOT LADDER PROGRAM".

Robot Entry Approval (CNC : R7245.0, Robot Controller : DI[105])

- This signal is used to prevent the interference between the machine tool and the robot. In CNC sample ladder, this signal is ON while machine is in the part exchange position and the door of the machine tool is opened. If additional interlock between the machine tool and the robot is needed, use this signal.

Machine Alarm (CNC : R7245.2, Robot Controller : DI[107])

- In CNC sample ladder, this signal is ON while alarm occurs in CNC.

Door Open (CNC : R7245.3, Robot Controller : DI[108])

- In CNC sample ladder, while the door that prevents the robot from entering into the machine tool is opened, this signal is ON.

Door Close (CNC : R7245.4, Robot Controller : DI[109])

- In CNC sample ladder, while the door that prevents the robot from entering into the machine tool is closed, this signal is ON.

Part Change Position (CNC : R7245.5, Robot Controller : DI[110])

- In CNC sample ladder, while the part is in the position to be loaded and unloaded by the robot in the machine tool, this signal is ON.

Description of signals (from the robot controller to CNC)

RI[1] to RI[8] (CNC : R7203.0 to R7203.7, Robot Controller : DO[25] to DO[32])

- In the robot ladder program, the status of robot I/O from RI[1] to RI[8] in the robot controller is output to these signals. In case that the two or more CNCs are connected to the robot controller, same signals are output to each CNC. The status of these signals is displayed in the ROBOT STATUS screen on CNC.

RO[1] to RO[8] (CNC : R7204.0 to R7204.7, Robot Controller : DO[33] to DO[40])

- In the robot ladder program, the status of robot I/O from RO[1] to RO[8] in the robot controller is output to these signals. In case that the two or more CNCs are connected to the robot controller, same signals are output to each CNC. The status of these signals is displayed in the ROBOT STATUS screen on CNC.

Safety Fence Open (CNC : R7208.1, Robot Controller : DO[66])

- The robot ladder program outputs the status of FENCE signal of the robot controller. This signal is ON while the safety fence is opened. The status of these signals is displayed in the ROBOT STATUS screen on CNC.

Safety Fence Close (CNC : R7208.2, Robot Controller : DO[67])

- The robot ladder program outputs the status of FENCE signal of the robot controller. This signal is ON while the safety fence is closed. The status of these signals is displayed in the ROBOT STATUS screen on CNC.

In E Stop State (CNC : R7208.3, Robot Controller : DO[68])

- The robot ladder program outputs the status of emergency stop. This signal is ON while the emergency stop button (on the teach pendant or on the operator panel) is pressed, or external emergency stop signal is open. The status of these signals is displayed in the ROBOT STATUS screen on CNC.

Command to Perepheral Device 1 to 16 (CNC : R7210.0 to R7211.7, Robot Controller : DO[81] to DO[96])

- These signals are used to control the peripheral device connected to CNC by the robot controller. In CNC sample ladder, these signals are not used. If necessary, create the ladder program in CNC to output these signals to the peripheral device.

Production Operation 1 to 4 (CNC : R7212.0 to R7212.3, Robot Controller : DO[97] to DO[100])

- In the robot ladder program, the status of Input of Production System Operation signals are output to the Product Operation signals in CNC connected to the robot controller and is in interlock mode. Refer to the description for Input of Production System Operation signals additionally.

Output of Production System Response 1 to 4 (CNC : R7212.4 to R7212.7, Robot Controller : DO[101] to DO[104])

- In the robot ladder program, the result of the logical product for Production System Response signals is output to CNC as Output of Production System Response signal. Refer to the description for Production System Response signals additionally.

*Robot Entry (CNC : XR7213.0, Robot Controller : DO[105])

- This signal is used to prevent the interference between the machine tool and the robot. In the robot controller, this signal is OFF while the robot enters into the machine tool. In order to use this signal, some settings are needed. Refer to "4.7 SETTING INTERFERENCE PREVENTION SPACE".

Connection between multiple CNCs and the robot

In case that the robot is connected with two or more CNCs, the interface signals in the robot controller are extended according to the number of CNC. The signals for each CNC are same as the signals described in above. Only the signal number in each CNC is different. The signal number in each CNC is as follows.

NOTE
It is need to set the number of the connected CNC with the robot beforehand. Refer to "2. CONNECTION BETWEEN CNC AND ROBOT".

From CNC to the robot controller

Name of signal	CNC1 Signal number	CNC2 Signal number	CNC3 Signal number	CNC4 Signal number
CNC Power On	DI[33]	DI[289]	DI[545]	DI[801]
Response of Peripheral Device 1	DI[81]	DI[337]	DI[593]	DI[849]
Response of Peripheral Device 2	DI[82]	DI[338]	DI[594]	DI[850]
Response of Peripheral Device 3	DI[83]	DI[339]	DI[595]	DI[851]
Response of Peripheral Device 4	DI[84]	DI[340]	DI[596]	DI[852]
Response of Peripheral Device 5	DI[85]	DI[341]	DI[597]	DI[853]
Response of Peripheral Device 6	DI[86]	DI[342]	DI[598]	DI[854]
Response of Peripheral Device 7	DI[87]	DI[343]	DI[599]	DI[855]
Response of Peripheral Device 8	DI[88]	DI[344]	DI[600]	DI[856]
Response of Peripheral Device 9	DI[89]	DI[345]	DI[601]	DI[857]
Response of Peripheral Device 10	DI[90]	DI[346]	DI[602]	DI[858]
Response of Peripheral Device 11	DI[91]	DI[347]	DI[603]	DI[859]
Response of Peripheral Device 12	DI[92]	DI[348]	DI[604]	DI[860]
Response of Peripheral Device 13	DI[93]	DI[349]	DI[605]	DI[861]
Response of Peripheral Device 14	DI[94]	DI[350]	DI[606]	DI[862]
Response of Peripheral Device 15	DI[95]	DI[351]	DI[607]	DI[863]
Response of Peripheral Device 16	DI[96]	DI[352]	DI[608]	DI[864]
Production System Response 1	DI[97]	DI[353]	DI[609]	DI[865]
Production System Response 2	DI[98]	DI[354]	DI[610]	DI[866]
Production System Response 3	DI[99]	DI[355]	DI[611]	DI[867]
Production System Response 4	DI[100]	DI[356]	DI[612]	DI[868]
Input of Production System Operation 1	DI[101]	DI[357]	DI[613]	DI[869]
Input of Production System Operation 2	DI[102]	DI[358]	DI[614]	DI[870]
Input of Production System Operation 3	DI[103]	DI[359]	DI[615]	DI[871]
Input of Production System Operation 4	DI[104]	DI[360]	DI[616]	DI[872]
Robot Entry Approval	DI[105]	DI[361]	DI[617]	DI[873]
Machine Alarm	DI[107]	DI[363]	DI[619]	DI[875]
Door Open	DI[108]	DI[364]	DI[620]	DI[876]
Door Close	DI[109]	DI[365]	DI[621]	DI[877]
Part Change Position	DI[110]	DI[366]	DI[622]	DI[878]

From the robot controller to CNC

Name of Signal	CNC1 Signal number	CNC2 Signal number	CNC3 Signal number	CNC4 Signal number
RI[1]	DO[25]	DO[281]	DO[537]	DO[793]
RI[2]	DO[26]	DO[282]	DO[538]	DO[794]
RI[3]	DO[27]	DO[283]	DO[539]	DO[795]
RI[4]	DO[28]	DO[284]	DO[540]	DO[796]
RI[5]	DO[29]	DO[285]	DO[541]	DO[797]
RI[6]	DO[30]	DO[286]	DO[542]	DO[798]
RI[7]	DO[31]	DO[287]	DO[543]	DO[799]
RI[8]	DO[32]	DO[288]	DO[544]	DO[800]
RO[1]	DO[33]	DO[289]	DO[545]	DO[801]
RO[2]	DO[34]	DO[290]	DO[546]	DO[802]
RO[3]	DO[35]	DO[291]	DO[547]	DO[803]
RO[4]	DO[36]	DO[292]	DO[548]	DO[804]
RO[5]	DO[37]	DO[293]	DO[549]	DO[805]
RO[6]	DO[38]	DO[294]	DO[550]	DO[806]
RO[7]	DO[39]	DO[295]	DO[551]	DO[807]
RO[8]	DO[40]	DO[296]	DO[552]	DO[808]
Safety Fence Open	DO[66]	DO[322]	DO[578]	DO[834]
Safety Fence Close	DO[67]	DO[323]	DO[579]	DO[835]
In E.Stop state	DO[68]	DO[324]	DO[580]	DO[836]
Command to Peripheral Device 1	DO[81]	DO[337]	DO[593]	DO[849]
Command to Peripheral Device 2	DO[82]	DO[338]	DO[594]	DO[850]
Command to Peripheral Device 3	DO[83]	DO[339]	DO[595]	DO[851]
Command to Peripheral Device 4	DO[84]	DO[340]	DO[596]	DO[852]
Command to Peripheral Device 5	DO[85]	DO[341]	DO[597]	DO[853]
Command to Peripheral Device 6	DO[86]	DO[342]	DO[598]	DO[854]
Command to Peripheral Device 7	DO[87]	DO[343]	DO[599]	DO[855]
Command to Peripheral Device 8	DO[88]	DO[344]	DO[600]	DO[856]
Command to Peripheral Device 9	DO[89]	DO[345]	DO[601]	DO[857]
Command to Peripheral Device 10	DO[90]	DO[346]	DO[602]	DO[858]
Command to Peripheral Device 11	DO[91]	DO[347]	DO[603]	DO[859]
Command to Peripheral Device 12	DO[92]	DO[348]	DO[604]	DO[860]
Command to Peripheral Device 13	DO[93]	DO[349]	DO[605]	DO[861]
Command to Peripheral Device 14	DO[94]	DO[350]	DO[606]	DO[862]
Command to Peripheral Device 15	DO[95]	DO[351]	DO[607]	DO[863]
Command to Peripheral Device 16	DO[96]	DO[352]	DO[608]	DO[864]
Production Operation 1	DO[97]	DO[353]	DO[609]	DO[865]
Production Operation 2	DO[98]	DO[354]	DO[610]	DO[866]
Production Operation 3	DO[99]	DO[355]	DO[611]	DO[867]
Production Operation 4	DO[100]	DO[356]	DO[612]	DO[868]
Output of Production System Response 1	DO[101]	DO[357]	DO[613]	DO[869]
Output of Production System Response 2	DO[102]	DO[358]	DO[614]	DO[870]
Output of Production System Response 3	DO[103]	DO[359]	DO[615]	DO[871]
Output of Production System Response 4	DO[104]	DO[360]	DO[616]	DO[872]
*Robot Entry	DO[105]	DO[361]	DO[617]	DO[873]

8 NC PROGRAM

In this function, by calling M code in NC program, CNC requests the operation of work-piece exchange to the robot. Please create the NC program according to the explanation of this chapter.

8.1 OUTLINE OF CNC OPERATION

M code is called from NC program to specify the type and the timing of the operation requested to the robot. When the ladder program detects the execution of M code, the operation request is sent to the robot. When the ladder program receives the operation completion, FIN is sent to CNC, and as a result, the machining is continued.

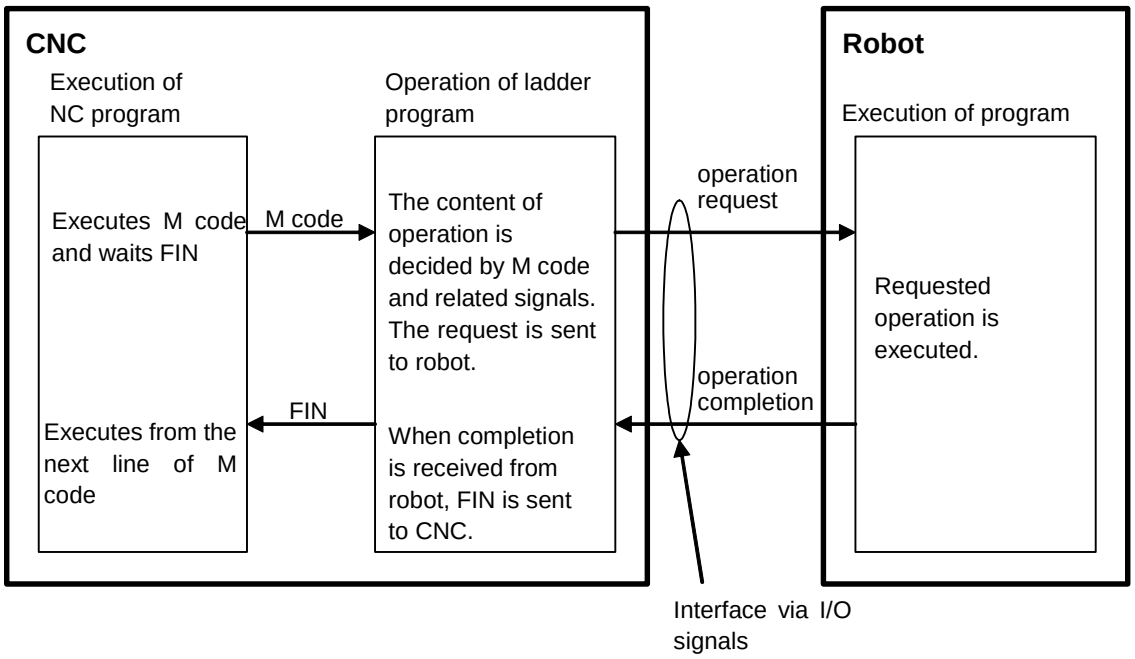


Fig.8.1 NC program and robot program

About the detail of I/O signal interface between the robot and CNC, please refer to chapter "7. INTERFACE BETWEEN CNC AND ROBOT". About the detail of robot program, please refer to chapter "9. ROBOT PROGRAM".

This chapter explains about M code, operation of the ladder program and robot program when the sample ladder program is used.

> ⚠ **CAUTION**
> 1 For details of the ladder program of the sample, please refer to the material included in CD "Robot connection function sample program" (A08B-9510-J550).
> 2 It is necessary to customize the sample ladder program according to the specification of the machine tool. Moreover, please verify coordinated operation with the robot enough.

8.2 M CODE IN NC PROGRAM

When M60-M62 is executed, the sample ladder program requests the operation of unloading and loading the work-piece to the robot. The operation request sent to robot is as follows.

Table 8.2(a) M code

M code	Signal condition	Operation request sent to robot
M60	Interlock Mode signal is ON AND Cycle stop signal is OFF	Unloading and loading work-piece
	Interlock Mode signal is ON AND Cycle stop signal is ON	Unloading work-piece When the robot completes the operation of unloading the work-piece, reset and rewind operation is executed on CNC to finish the machining.
M61	Interlock Mode signal is ON	Loading work-piece The operation request of loading the work-piece is sent to robot on the first time M61 is executed after the status of Interlock Mode signal is switched from OFF to ON. Since the second times, nothing is executed.

Even if M60 or M61 is executed, nothing is executed when Interlock Mode signal is OFF. The NC program automatically advances to the following line of M code.
For details of cycle stop, please refer to the chapter "3.5 SAMPLE LADDER PROGRAM FOR SYSTEM OPERATION".

The example of NC program using these M codes is as follows.

Example 1

O0001	Operator sets work-piece in the machine tool by the hand and begins machining.
(Machining)	Machining continues.
M60	The work-piece is exchanged by M60.
M99	NC program returns to the top by M99.

Example 2

O0001	Operator sets Interlock Mode signal from OFF to ON and begins machining with the status that there is no work-piece in machine tool.
M61	The work-piece is loaded by M61.
(Machining)	Machining continues.
M60	The work-piece is exchanged by M60.
M99	NC program returns to the top by M99.
	In the M61 since the second times, nothing is executed. The next work-piece is machined continuously.

Example 3 (cycle stop)

O0001	The operator can turn Cycle Stop signal on at any timing of machining.
M61	
(Machining)	
M60	The work-piece is unloaded by M60.
M99	When the robot completes to unload the work-piece, reset and rewind is executed on CNC to finish machining.

The content of operation request is finally notified to the robot by the value of Service Type 1-4 signal. The relation between the content of operation request and the value of Service Type 1-4 signals is as follows.

Table 8.2(b) Service type 1-4 signals

Operation request to robot	Service type 1-4 signals			
	1	2	3	4
Loading work-piece	1	0	0	0
Unloading and loading work-piece	0	1	0	0
Unloading work-piece	1	1	0	0

The meaning of service type 1-4 signals is the same for the function "overlap start" described below.
For the details of service type 1-4 signals, please refer to the chapter "7. INTERFACE BETWEEN CNC AND ROBOT".

In case of Overlap Start

The operation request sent to robot is as follows.

Table 8.2(c) M code (Overlap Start)

M code	Signal condition	Operation request sent to robot
M60	Interlock Mode signal is ON	Actual work-piece exchange (Service Call signal is ON)
M61	Interlock Mode signal is ON	Loading work-piece The operation request of loading the work-piece is sent to robot on the first time M61 is executed after the status of Interlock Mode signal is switched from OFF to ON. Since the second times, nothing is executed.
M62	Interlock Mode signal is ON AND Cycle stop signal is OFF	Beginning of overlap start Unloading and loading work-piece
	Interlock Mode signal is ON AND Cycle stop signal is ON	Beginning of overlap start Unloading work-piece

> ⚠ **CAUTION**
> When M62 is executed, the robot moves near the machine tool. Neither work-piece unloading nor loading is executed. When M60 is executed, an actual work-piece unloading and loading are executed.

Example 1

O0001	Operator sets Interlock Mode signal from OFF to ON and begins the machining with the status that there is no work-piece in machine tool.
M61	The work-piece is loaded by M61.
(Machining)	Machining continues.
M62	The overlap start is notified by M62 on the way of machining. The robot moves near the machine tool.
(Machining)	Machining continues.
M60	The work-piece is exchanged by M60.
M99	NC program returns to the top by M99.
	In the M61 since the second times, nothing is executed. The next work-piece is machined continuously.

9 ROBOT PROGRAM

It is need to teach the robot program to load and unload a work piece interlocking with machine tool and the macro program for robot remote operation on CNC. According to the description in this chapter, teach the necessary programs.

9.1 THEACHING ROBOT PROGRAM TO INTERLOCK WITH MACHINE

This section describes how to teach the robot program that interlocks with CNC program.

9.1.1 Name of Program

In this function, the robot programs are started by Program Number Selection (PNS) function. The robot program name must be “PNS” + “Four digit number”. The string “PNS” can be changed to other string. Refer to “4.6 SETTING PROGRAM NUMBER SELECTION (PNS)”.

9.1.2 Basic Structure of Robot Program

In the robot program, check the service type input from CNC at the beginning and branch to each process according to the service type. The service type is input to the following group input signals.

Table 9.1.2 Service type input signal

	CNC1	CNC2	CNC3	CNC4
Group input signal number for service type	GI[1]	GI[2]	GI[3]	GI[4]

In the program started by CNC1, branch to the process according to the value of GI[1] as follows.

```
1:   IF GI[1]=1,JMP LBL[110] ;
2:   IF GI[1]=2,JMP LBL[120] ;
3:   JMP LBL[900] ;
4:   ;
5:   LBL[110:Service Type 1] ;
6:   !!!! Process for Service Type 1
7:   END ;
8:   ;
9:   LBL[110: Service Type 2] ;
10:  !!!! Process for Service Type 2
11:  END ;
12:  ;
13:  LBL[900:Incorrect Service type] ;
14:  UALM[1] ;
15:  END ;
```

Branch according to group input G[1].

Teach the process for service type 1.

Teach the process for service type 2.

9.1.3 Example of Robot Program

Following is the example of the robot program. About the process for each service type in this program is described in Table 9.1.3.

Table 9.1.3 Process for each service type

Service type 1	The robot picks up a work piece from the pallet and loads a work piece to machine tool at cycle start. In this case, the robot executes only the load of a work piece because a processed work piece is not in the machine tool.
Service type 2	The robot moves into the machine tool with holding an unprocessed work piece, then unloads a processed work piece at first, and loads an unprocessed work piece.
Service type 3	The robot unloads a processed work piece from the machine tool at cycle end.

Example of the robot program

```
 1:  IF GI[1]=1,JMP LBL[110] ;                  Branch according to service type.
 2:  IF GI[1]=2,JMP LBL[120] ;
 3:  IF GI[1]=3,JMP LBL[130] ;
 4:  JMP LBL[900] ;
 5:  ;
 6:  LBL[110:Load a work piece] ;               < Loading work piece (Service type 1) >
 7:  ! Pick up a work piece ;
 8:  CALL PICK_1     ;                          Teach the motion to pick up an unprocessed work
 9:  ! Move in front of the machine ;           piece from the pallet.
10:  CALL MOVETO1     ;                        Teach the motion to move in front of the machine.
11:  ! Condition to enter ;
12:  WAIT DI[105:Robot Entry Approval]=ON
     TIMEOUT,LBL[910] ;
13:  WAIT DI[108:Door Open]=ON
     TIMEOUT,LBL[910] ;
14:  WAIT DI[110:Part Change Position]=ON
     TIMEOUT,LBL[910] ;
15:  ! Move into the machine ;
16:  CALL MOVEIN1     ;                        Teach the motion to move to the position to load a
17:  ! Load work piece ;                       work piece.
18:  CALL LOAD     ;                           Teach the motion to load a work piece to the machine.
19:  ! Move out of the machine ;
20:  CALL MOVEOUT1     ;                      Teach the motion to move out of the machine.
21:  ! Move to the home position ;
22:  CALL HOME1 ;                              Teach the motion to move to home position.
23:  END ;
24:  ;
25:  LBL[120:Exchange the work piece] ;         < Unloading and loading work piece (Service type 2) >
26:  ! Pick up a work piece ;
27:  CALL PICK     ;                           Teach the motion to pick up an unprocessed work
28:  ! Move in front of the machine ;           piece from the pallet.
29:  CALL MOVETO2     ;                        Teach the motion to move in front of the machine.
30:  ! Condition to enter
31:  WAIT DI[105:Robot Entry Approval]=ON
     TIMEOUT,LBL[910] ;
32:  WAIT DI[108:Door Open]=ON
     TIMEOUT,LBL[910] ;
33:  WAIT DI[110:Part Change Position]=ON
     TIMEOUT,LBL[910] ;
34:  ! Move into the machine ;
35:  CALL MOVEIN2     ;                        Teach the motion to move to the position to unload a
36:  ! Unload the work piece ;                 work piece.
```

```
37:  CALL UNLOAD      ;
38:  ! Load the work piece ;
39:  CALL LOAD      ;
40:  ! Move out of the machine ;
41:  CALL MOVEOUT2      ;
42:  ! Place the work piece ;
43:  CALL PLACE      ;
44:  ! Move to the home position ;
45:  CALL HOME2;
46:  END ;
47:  ;
48:  LBL[130:Unload the work piece] ;
49:  ! Move in front of the machine ;
50:  CALL MOVETO2      ;
51:  ! Condition to enter ;
52:  WAIT DI[105:Robot Entry Approval]=ON
     TIMEOUT,LBL[910] ;
53:  WAIT DI[108:Door Open]=ON
     TIMEOUT,LBL[910] ;
54:  WAIT DI[110:Part Change Position]=ON
     TIMEOUT,LBL[910] ;
55:  ! Move into the machine ;
56:  CALL MOVEIN3      ;
57:  ! Unload the work piece ;
58:  CALL UNLOAD      ;
59:  ! Move out of the machine ;
60:  CALL MOVEOUT3      ;
61:  ! Place the work piece ;
62:  CALL PLACE      ;
63:  ! Move to the home position ;
64:  CALL HOME3      ;
65:  END ;
66:  ;
67:  LBL[900:Incorrect Service Type] ;
68:  UALM[1] ;
69:  END ;
70:  ;
71:  LBL[910:Time out] ;
72:  UALM[2] ;
73:  END ;
```

Teach the motion to unload a work piece to the machine.

Teach the motion to load a work piece to the machine.

Teach the motion to move out of the machine.

Teach the motion to place a processed work piece to the pallet.

Teach the motion to move to home position.

< Unloading work piece (Service type 3) >

Teach the motion to move in front of the machine.

Teach the motion to move to the position to unload a work piece.

Teach the motion to unload a work piece to the machine.

Teach the motion to move out of the machine.

Teach the motion to place a processed work piece to the pallet.

Teach the motion to move to home position.

Example of the robot program for overlap start

Following is example of the robot program to use overlap start. In case that both loading and unloading a work piece are executed in the same cycle and only unloading a work piece is executed at ending cycle, the robot moves to the position in front of the machine tool and waits until Service Call signal is turned on. When Service Call signal is turned on, the robot moves into the machine tool and the designated process is executed. After the process executed into the machine tool is ended, when the robot moves to the position out of the machine tool, the robot turns off Service Completed signal to release waiting in CNC program. Service completed signal is turned off when Service Call Signal is turned off.

Example of the robot program (Overlap start)

```
1:  IF GI[1]=1,JMP LBL[110] ;
2:  IF GI[1]=2,JMP LBL[120] ;
3:  IF GI[1]=3,JMP LBL[130] ;
4:  JMP LBL[900] ;
5:  ;
```

Branch according to service type.

```
 6:  LBL[110:Load a work piece] ;
 7:  ! Pick up a work piece ;
 8:  CALL PICK_1     ;
 9:  ! Move in front of the machine ;
10:  CALL MOVETO1     ;
11:  ! Condition to enter ;
12:  WAIT DI[105:Robot Entry Approval]=ON
     TIMEOUT,LBL[910] ;
13:  WAIT DI[108:Door Open]=ON
     TIMEOUT,LBL[910] ;
14:  WAIT DI[110:Work Change Position]=ON
     TIMEOUT,LBL[910] ;
15:  ! Move into the machine ;
16:  CALL MOVEIN1     ;
17:  ! Load a work piece ;
18:  CALL LOAD     ;
19:  ! Move out of the machine ;
20:  CALL MOVEOUT1     ;
21:  ! Move to the home position ;
22:  CALL HOME1 ;
23:  END ;
24:  ;
25:  LBL[120:Exchange the work piece] ;
26:  ! Pick up a work piece ;
27:  CALL PICK     ;
28:  ! Move in front of the machine ;
29:  CALL MOVETO2     ;
30:  ! Wait for Service Call signal input ;
31:  WAIT DI[106:Service Call]=ON     ;
32:  ! Condition to enter
33:  WAIT DI[105:Robot Entry Approval]=ON
     TIMEOUT,LBL[910] ;
34:  WAIT DI[83:Door Open]=ON
     TIMEOUT,LBL[910] ;
35:  WAIT DI[110:Part Change Position]=ON
     TIMEOUT,LBL[910] ;
36:  ! Move into the machine ;
37:  CALL MOVEIN2     ;
38:  ! Unload the work piece ;
39:  CALL UNLOAD     ;
40:  ! Load a work piece ;
41:  CALL LOAD     ;
42:  ! Move out of the machine ;
43:  CALL MOVEOUT2     ;
44:  ! Service complete ;
45:  DO[106:Service Completed]=ON ;
46:  WAIT DI[106:Service Call]=OFF
     TIMEOUT,LBL[910] ;
47:  DO[106:Service Competed]=OFF ;
48:  ! Start the machine process   ;
49:  ! Place the work piece ;
50:  CALL PLACE     ;
51:  ! Move to the home position ;
52:  CALL HOME2;
53:  END ;
54:  ;
55:  LBL[130:Unload the work piece] ;
56:  ! Move in front of the machine ;
```

< Loading work piece (Service type 1) >

Teach the motion to pick up an unprocessed work piece from the pallet.

Teach the motion to move in front of the machine.

Teach the motion to move to the position to load a work piece.

Teach the motion to load a work piece to the machine.

Teach the motion to move out of the machine.

Teach the motion to move to home position.

< Unloading and loading work piece (Service type 2) >

Teach the motion to pick up an unprocessed work piece from the pallet.

Teach the motion to move in front of the machine.

Wait until Service Call signal is turned on.

Teach the motion to move to the position to unload a work piece.

Teach the motion to unload a work piece to the machine.

Teach the motion to load a work piece to the machine.

Teach the motion to move out of the machine.

Turn on Service Completed signal.

Wait until Service Call signal is turned off.

Turn off Service Completed signal.

Teach the motion to place a processed work piece to the pallet.

Teach the motion to move to home position.

< Unloading work piece (Service type 3) >

```
57:  CALL MOVETO2      ;
58:  ! Wait for Service Call signal input ;
59:  WAIT DI[106]=ON    ;
60:  ! Condition to enter ;
61:  WAIT DI[105:Robot Entry Approval]=ON
     TIMEOUT,LBL[910] ;
62:  WAIT DI[108:Door Open]=ON
     TIMEOUT,LBL[910] ;
63:  WAIT DI[110:Part Change Position]=ON
     TIMEOUT,LBL[910] ;
64:  ! Move into the machine ;
65:  CALL MOVEIN3     ;
66:  ! Unload the work piece ;
67:  CALL UNLOAD      ;
68:  ! Move out of the machine ;
69:  CALL MOVEOUT3    ;
70:  ! Service complete ;
71:  DO[106:Service Completed]=ON ;
72:  WAIT DI[106:Service Call]=OFF
     TIMEOUT,LBL[910] ;
73:  DO[106:Service Completed]=OFF ;
74:  ! Place the work ;
75:  CALL PLACE       ;
76:  ! Move to the home position ;
77:  CALL HOME3       ;
78:  END ;
79:  ;
80:  LBL[900:Incorrect Service Type] ;
81:  UALM[1] ;
82:  END ;
83:  ;
84:  LBL[910:Time out] ;
85:  UALM[2] ;
86:  END ;
```

Teach the motion to move in front of the machine.

Wait until Service Call signal is turned on.

Teach the motion to move to the position to unload a work piece.

Teach the motion to unload a work piece to the machine.

Teach the motion to move out of the machine.

Turn on Service Completed signal.

Wait until Service Call signal is turned off.

Turn off Service Completed signal.

Teach the motion to place a processed work piece to the pallet.

Teach the motion to move to home position.

9.1.4 Attention to Teach Program

Because the robot ladder program aborts the robot program when the robot program is paused, PAUSE instruction in the robot program has no effect in this function.

9.2 TEACHING MACRO PROGRAM FOR REMOTE OPERATION

Robot hand operation and robot home position return, robot speed override change in the remote operation are executed using macro program in the robot controller. The macro programs for these operations are installed in the robot controller beforehand. But, the macro programs for hand operation and home position return are untaught. It is required to teach the macro programs for hand operation and home position return before the remote operation is executed. The macro program for override change can be used as it is. About the robot jog feed operation, the macro program is not used.

9.2.1 Macro Program for Remote Operation

Following macro programs for the remote operation are loaded to the robot controller beforehand. And these programs have been registered as the macro instruction. Do not change settings of the macro instructions for these macro programs.

Table 9.2.1 Macro programs for remote operation

Program name	Description
HANDOP_M	This program receives the request for hand operation and calls sub program for the requested hand operation.
HANDOP01	This program executes the hand operation 1. (Untaught)
HANDOP02	This program executes the hand operation 2. (Untaught)
HANDOP03	This program executes the hand operation 3. (Untaught)
HANDOP04	This program executes the hand operation 4. (Untaught)
HANDOP05	This program executes the hand operation 5. (Untaught)
HANDOP06	This program executes the hand operation 6. (Untaught)
HANDOP07	This program executes the hand operation 7. (Untaught)
HANDOP08	This program executes the hand operation 8. (Untaught)
HANDOP09	This program executes the hand operation 9. (Untaught)
HANDOP10	This program executes the hand operation 10. (Untaught)
MTSHOME	This is the program for home position return. (Untaught)
REM_ENT	This program is executed when the remote operation is started. This program changes the speed override to 5%.
REM_EXT	In case that the keep relay K0000.5 is 1, this program is executed when the remote operation is ended. This program restores the value of speed override.
OVRUP	This program raises the speed override value.
OVRDOWN	This program lowers the speed override value.
OVRSET	OVRUP and OVRDOWN call this program.

9.2.2 Teaching Program for Hand Operation

When hand operation is executed in the remote operation on CNC, the program HANDOP_M that receives the request for hand operation is executed in the robot controller. The type of hand operation designated in CNC is input to group I/O GI[5]. The program HANDOP_M is taught to execute the sub program for each hand operation according to the value of GI[5]. The program HANDOP_M can be executed without change.

HANDOP_M

```
1:   IF GI[5]=1,JMP LBL[10] ;
2:   IF GI[5]=2,JMP LBL[20] ;
3:   IF GI[5]=3,JMP LBL[30] ;
4:   IF GI[5]=4,JMP LBL[40] ;
5:   IF GI[5]=5,JMP LBL[50] ;
6:   IF GI[5]=6,JMP LBL[60] ;
7:   IF GI[5]=7,JMP LBL[70] ;
8:   IF GI[5]=8,JMP LBL[80] ;
9:   IF GI[5]=9,JMP LBL[90] ;
10:  IF GI[5]=10,JMP LBL[100] ;
11:  END ;
12:  ;
13:  LBL[10] ;
14:  CALL HANDOP01      ;
15:  END ;
16:  ;
```

Branch according to the type of hand operation(GI[5]).

< Process for hand operation 1 >
Call sub program for the hand operation 1.

```
17:  LBL[20] ;                    < Process for hand operation 2 >
18:  CALL HANDOP02      ;         Call sub program for the hand operation 2.
19:  END ;
20:  ;
21:  LBL[30] ;                    < Process for hand operation 3 >
22:  CALL HANDOP03      ;         Call sub program for the hand operation 3.
23:  END ;
24:  ;
25:  LBL[40] ;                    < Process for hand operation 4 >
26:  CALL HANDOP04      ;         Call sub program for the hand operation 4.
27:  END ;
28:  ;
29:  LBL[50] ;                    < Process for hand operation 5 >
30:  CALL HANDOP05      ;         Call sub program for the hand operation 5.
31:  END ;
32:  ;
33:  LBL[60] ;                    < Process for hand operation 6 >
34:  CALL HANDOP06      ;         Call sub program for the hand operation 6.
35:  END ;
36:  ;
37:  LBL[70] ;                    < Process for hand operation 7 >
38:  CALL HANDOP07      ;         Call sub program for the hand operation 7.
39:  END ;
40:  ;
41:  LBL[80] ;                    < Process for hand operation 8 >
42:  CALL HANDOP08      ;         Call sub program for the hand operation 8.
43:  END ;
44:  ;
45:  LBL[90] ;                    < Process for hand operation 9 >
46:  CALL HANDOP09      ;         Call sub program for the hand operation 9.
47:  END ;
48:  ;
49:  LBL[100] ;                   < Process for hand operation 10 >
50:  CALL HANDOP10      ;         Call sub program for the hand operation 10.
51:  END ;
```

The sub programs for hand operation from HANDOP01 to HANDOP10 are untaught. Teach these sub programs before hand operation in the remote operation is executed. Teach sub programs for hand operation not to wait infinitely. Because the status of waiting infinitely is not notified to CNC, the operator of CNC may not be able to find the abnormal state in the robot controller.

Example for the sub program HANDOP01

```
1:   RO[1]=OFF ;
2:   RO[2]=ON ;
3:   END ;
```

9.2.3 Teaching Program for Home Position Return

When home position return is executed in the remote operation on CNC, the program MTSHOME is executed in the robot controller. Because this program is untaught, teach this program before home position return operation in the remote operation is executed.

> ⚠ **CAUTION**
> Teach the program for home position return with careful attention paid to the path of robot motion in order to prevent interference with peripheral devices.

Example for the program MTSHOME

```
1:    UFRAME_NUM=1 ;
2:    UTOOL_NUM=1 ;
3:  J  P[1:HOME] 25% FINE    ;
4:    END ;
```

10 ROBOT LADDER PROGRAM

This function provides a factory-installed sequence program, which responds to the program call or remote operation request from CNC. This sequence program is hereinafter called "Robot Ladder Program". Standard interlock with CNC is implemented in the Robot Ladder Program and it can be used "as is".
If necessary, you can modify Robot Ladder Program. In this case, understandings of the structure of Robot Ladder Program and usage of internal relays are required. Please refer to " FANUC Robot Series R-30*i*A CONTROLLER Integrated PMC OPERARTOR'S MANUAL(B-82614EN)" or " FANUC Robot Series R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER Integrated PMC OPERARTOR'S MANUAL(B-83254EN)" for details.
You can use "FANUC LADDER-III for Robot" (A08B-9410-J574) as the programming tool to edit the PMC program.

10.1 OVERVIEW

Robot Ladder Program interconnects DI/DO signals, which is connected to CNC, and the internal relays (Fig. 10.1). Internal relays are assigned to the UI/UO signals or DI signals that issue macro commands. Robot Ladder Program outputs specific internal relays to issues macro commands for remote operation or call a robot program requested from CNC.

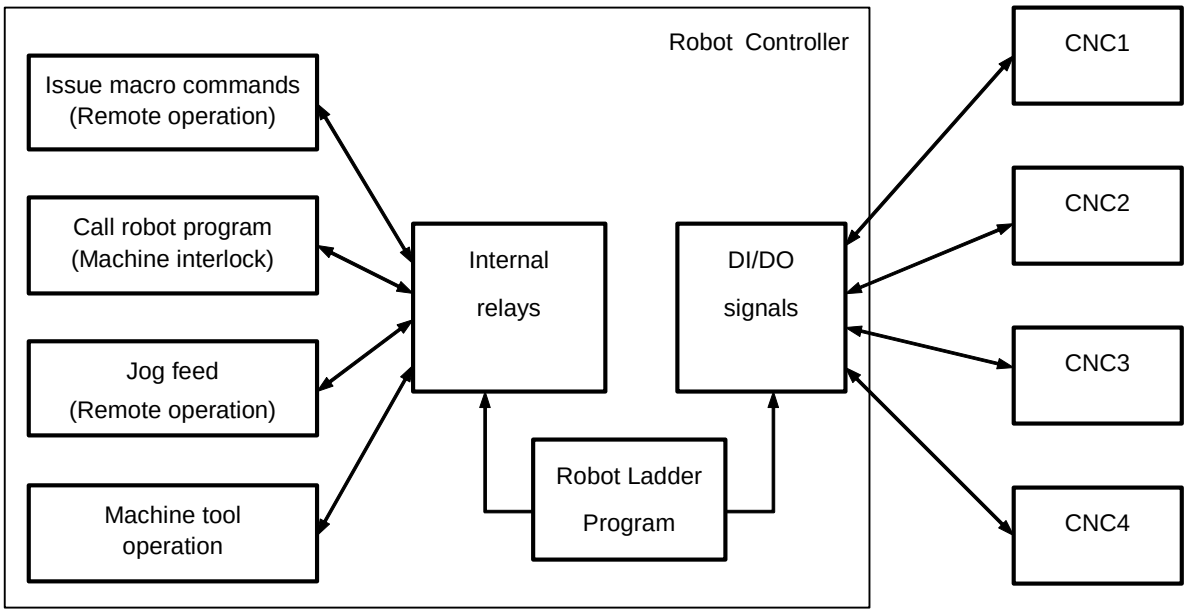


Fig. 10.1 Concept of Robot Ladder Program

10.2 STATE AND TRANSITION OF ROBOT CONTROLLER

This function enables robot remote operation and machine interlock operation from CNC. To do that, it is required to distinguish whether the robot controller is in the state that the robot controller can accept requests from CNC or not. For example, the operation mode T1 or T2 is selected using mode switch, the robot controller cannot accept any requests from CNC. To distinguish whether the robot controller can or cannot accept requests, the state of the robot controller is divided into the following two states.

- Service State: the robot controller is configured to accept requests form CNC.

- Maintenance State: the robot controller is not in service state.

Furthermore, the internal state “Service State” is divided into 3 states from the CNC viewpoint as following.

- Idle: the robot is not working.
- Remote operation: a CNC uses the robot remote operation.
- Machine interlock operation: the robot program is running with the request from CNC.

Behavior of the robot controller to signals from CNC depends on the state. When the robot controller is in "idle" state, the request of remote operation from CNC will be accepted, however, when the robot controller is in "machine interlock operation" or the other CNC already uses the robot remote operation, the remote operation cannot be accepted. To implement such behavior in the sequence program, Robot Ladder Program is based on the state. First, Robot Ladder Program determines which state the robot controller is currently in based on the input signals, and then outputs the appropriate signals based on states. With this design, the sequence program will be structured with states.

10.2.1 Implementation of Robot Behavior Based on State Chart

The robot controller is expected to be in the one of the pre-defined states. The robot controller is in state "idle" when no request comes from CNC. The robot controller is defined to be in state "remote operation" when one CNC uses the robot remote operation and to be in state "machine interlock operation" when the robot program is running

The states are changed by transitions. The event that a CNC successfully requests remote operation is interpreted as the transition from state "idle" to "remote operation" is caused. The transition from state "remote operation" to state "idle" is caused vice versa when the use of robot remote operation from CNC ends.

Fig. 10.2.1 shows the concept of the state charts which is implemented on the Robot Ladder program.

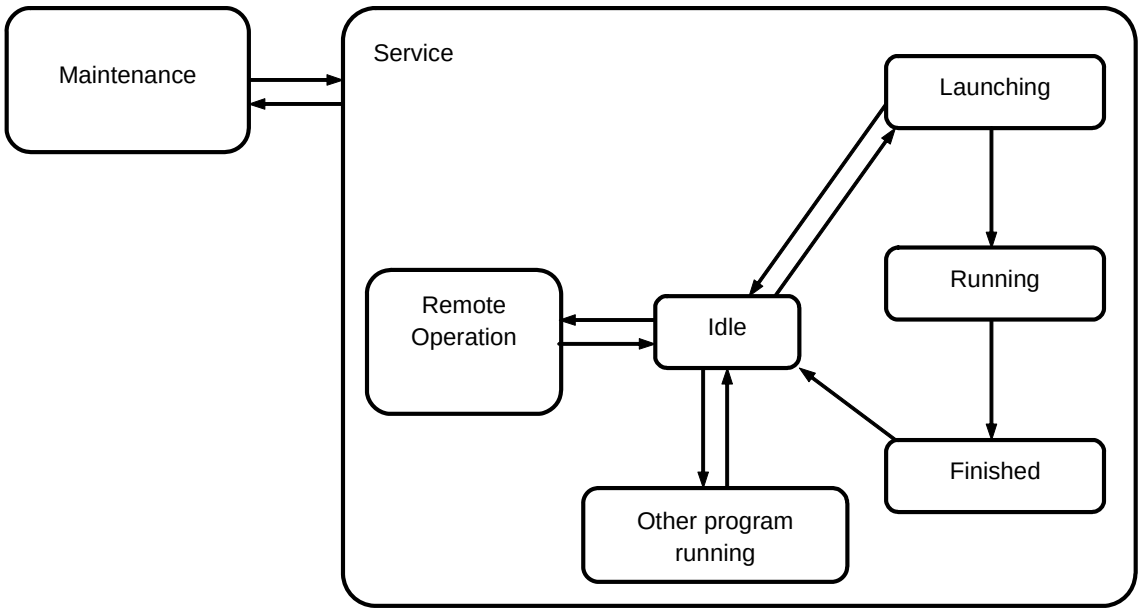


Fig. 10.2.1 Concept of the State chart

This state chart has a hierarchy. The state "maintenance" is defined that the robot controller is not configured to provide services for CNC and the state "service" is defined the opposite state. Three states (idle, remote operation, machine interlock operation) are defined inside the state "service". Detail of these states will be described later.

10.2.2 Implementation of State Transition Using the Sequence Program

Robot Ladder Program relates the states to internal relays. When the robot controller is in a specific state, a corresponding internal relay has the value "1". Internal relays corresponding to the states has a prefix "S". Similarly, Robot Ladder Program relates transitions to internal relays. When a specific transition is caused, then a corresponding internal relay has the value "1". Internal relays corresponding to the transitions has a prefix "T". Such an internal relay is hereinafter called "transition pulse".
Though state transition occurs instantly and no interruption occurs during transition theoretically, representation of transitions with internal relays inescapably allows interruptions during the transition. To avoid interruptions during transition, Robot Ladder Program should not cause other transitions when any "transition pulse" has a value "1". In addition, Robot Ladder Program should make the value of "transition pulse" become 1 during only one scan.
Robot Ladder Program uses additional internal relay to divide the generation of a transition and the reference of the transition. This internal relay, which means the generation of transition, will be called "making transition pulse". In Robot Ladder Program, any sequence that cause a transition sets the value of "making transition pulse" instead of "transition pulse". At the top of the Robot Ladder Program, the value of "transition pulse" are generated from the value of "making transition pulse". This assures the value of "transition pulse" remains unchanged during one scan. The symbols of "making transition pulse" has the suffix "M".
Following is a sample sequence program which implements the state transition described here. This sequence represents state transition that has two states and two transitions.

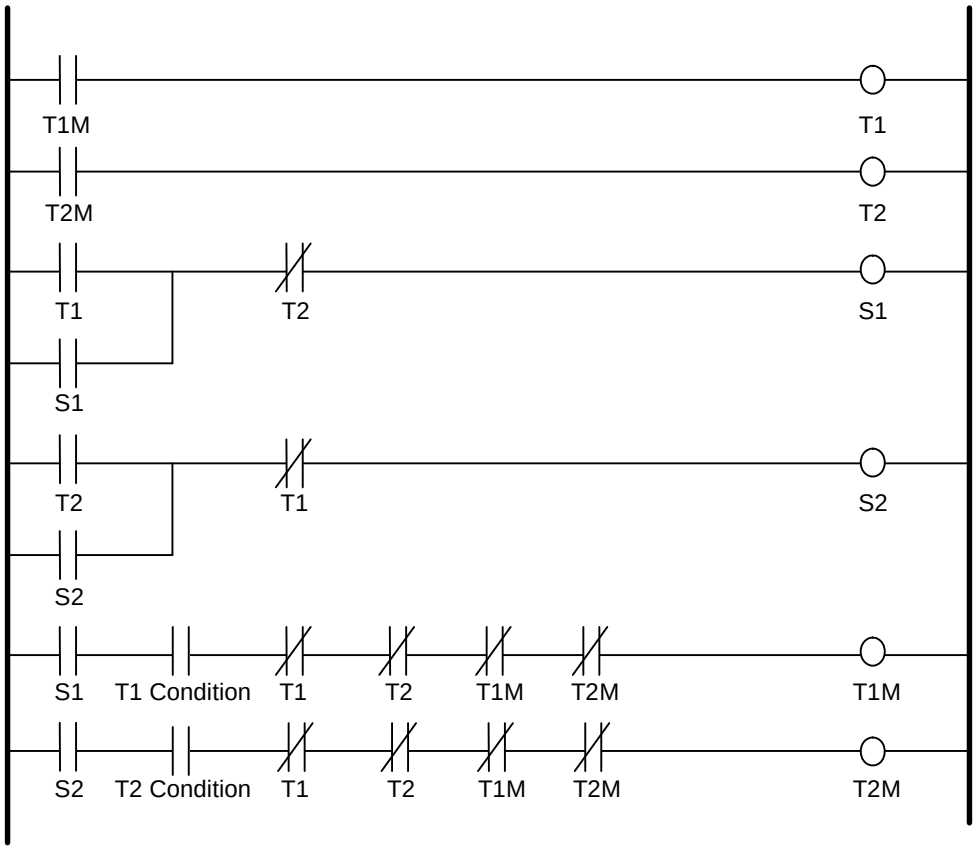


Fig. 10.2.2 Sample sequence which implements state transitions

This sequence implements two states "S1", "S2" and the transitions "T1","T2" between them. T1M and T2M are “making transition pulse” of T1, T2 respectively. This value becomes 1 when the condition is right and no transition occurs. T1M, T2M will make T1, T2 and consequently transition from state "S1" to "S2" or transition from state "S2" to state "S1" will be caused. However, the current scan is considered as during transition because T1 or T2 has the value 1. On this scan, any sequence, which relates the

transition, must be skipped. T1M, T2M will become 0 during this scan. In the next scan, this transition is completed and the robot controller is in state "S1" or state "S2".
Robot Ladder Program is based on this sample structure. In addition, this sequence assures "transition pulse" has the value 1 during only one scan.

10.2.3 Structure of Robot Ladder Program

The structure of Robot Ladder Program is shown as follows:

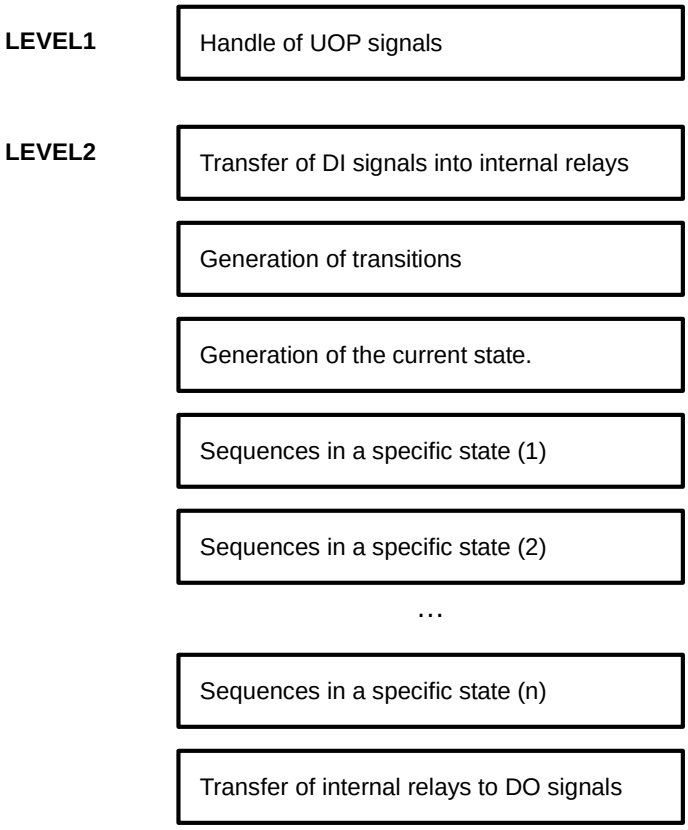


Fig. 10.2.3 Structure of Robot Ladder Program

10.3 RESOURCE

Robot Ladder Program uses the following resources exclusively. These resources should not be shared.

- Data table D0001
- Internal Relay R0000.0~R0294.7
- Keep relay K0000.0~K0001.7

10.3.1 Usage of Internal Relays

Robot Ladder Program does not read DI signals connected to CNC but read the value of internal relays, to which the value of DI signals are transferred. This is to avoid referenced value to be changed during one scan. Similarly, Robot Ladder Program outputs the value to internal relays and then transfers them to DO signals.
Internal relays are not only used for buffer of DI/DO signals but are used for remote operation and machine interlock operation. Usage of internal relays is shown below.

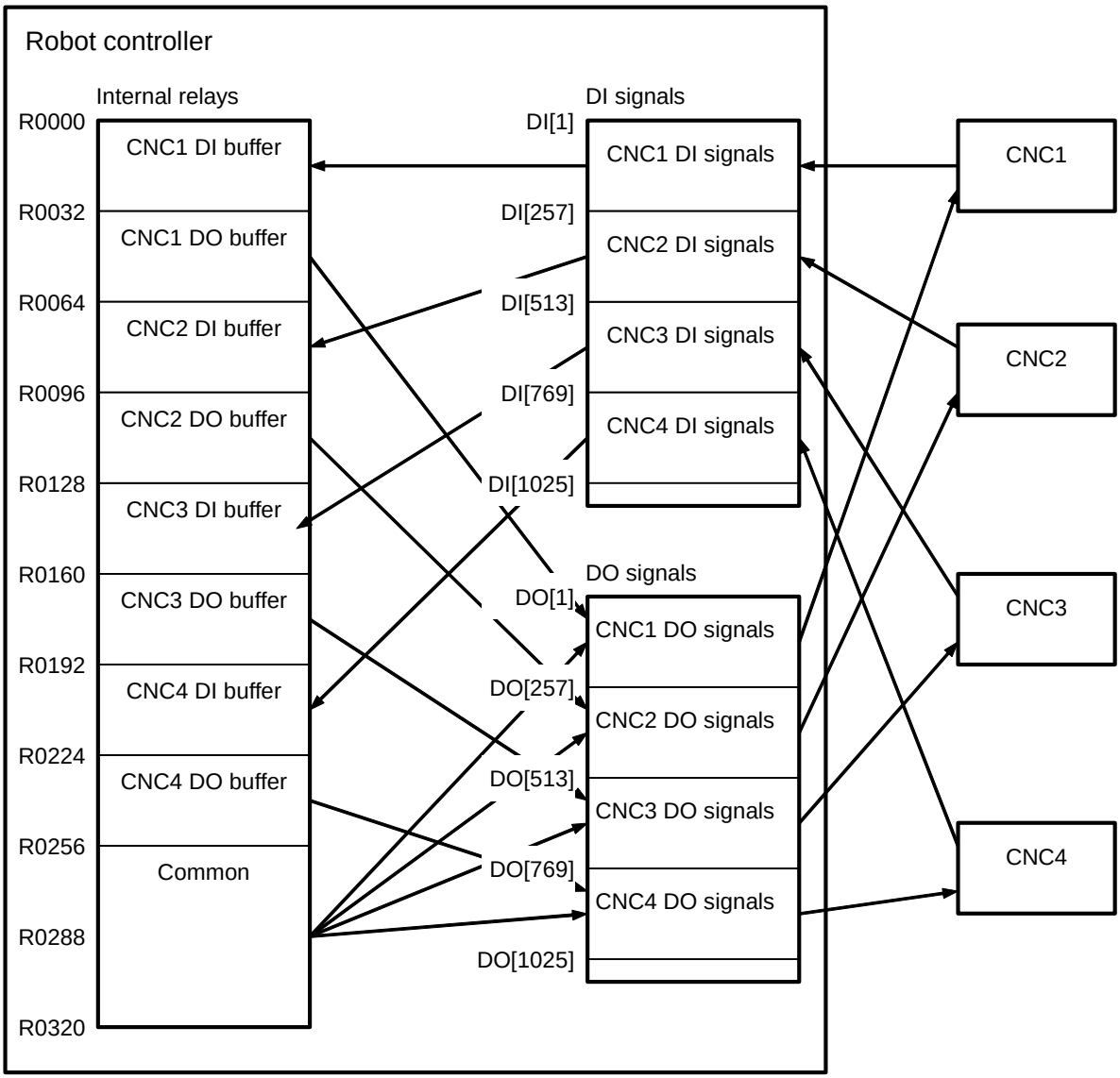


Fig. 10.3.1 Usage of internal relays

Internal relays used by Robot Ladder Program are divided into buffers of DI/DO for individual CNC and commonly used relays. These relays will be called "CNC buffer relays" and "common relays" respectively.
The values of DI signals are transferred into "CNC buffer relays" as shown. Robot Ladder Program does not read the DI signals directly.
DO signals to CNC are transferred from CNC buffer relays and common relays. Many of DO signals are transferred from common relays because these are common for all CNC. Therefore, the most of CNC DO buffer relays are not used.
Please refer to 10.10 for the list of internal relays.

Table 10.3.1 Internal relays

Address	Points	Name	Purpose
R0000 — R0031	256 points	CNC1 DI buffer relays	Buffer for DI signals for CNC1
R0032 — R0063	256 points	CNC1 DO buffer relays	Buffer for DO signals for CNC1
R0064 — R0095	256 points	CNC2 DI buffer relays	Buffer for DI signals for CNC2
R0096 — R0127	256 points	CNC2 DO buffer relays	Buffer for DO signals for CNC2
R0128 — R0159	256 points	CNC3 DI buffer relays	Buffer for DI signals for CNC3
R0160 — R0191	256 points	CNC3 DO buffer relays	Buffer for DO signals for CNC3

Address	Points	Name	Purpose
R0192 — R0223	256 points	CNC4 DI buffer relays	Buffer for DI signals for CNC4
R0224 — R0255	256 points	CNC4 DO buffer relays	Buffer for DO signals for CNC4
R0256 — R0294	312 points	Common relays	For remote operation and machine interlock operation.

10.3.2 Timer

Robot Ladder Program uses following fixed-timers. No settable timers are used.

Table 10.3.2 Used fixed-timers

Timer number	Purpose
1	Pulse width of "ACK/NAK for Remote Operation Request" (Refer to 10.5.1)
2	Pulse width of "ACK/NAK for Remote Operation Request" (Refer to 10.5.1)
3	Pulse width of "ACK/NAK for Remote Operation Request" (Refer to 10.5.1)
4	Pulse width of "ACK/NAK for Remote Operation Request" (Refer to 10.5.1)
5	Pulse width of HOLD signals in Home position return operation (Refer to 10.5.4)
6	Timeout for SNACK
7	Pulse width of PROD_RUN (Refer to 10.6.9)
8	Pulse width of CSTOPI (Refer to 10.5.4)
9	Timeout for BUSY (Refer to 10.6.9)
10	Pulse width of macro commands issue for remote operation entry and remote operation exit. (Refer to 10.5.1)
11	Fixed waiting time just after entry of state "finished" (Refer to 10.6.3)
12	Timeout for heart beat signal for machine operation screen (Refer to 10.9.14)

10.3.3 Keep relay

Robot Ladder Program uses the following keep relays.

Table 10.3.3 Keep relays

Address	Purpose
K0000.0	0: DI signals from CNC1 are ignored. (Default) 1: DI signals from CNC1 are transferred to internal relays.
K0000.1	0: DI signals from CNC2 are ignored. (Default) 1: DI signals from CNC2 are transferred to internal relays.
K0000.2	0: DI signals from CNC3 are ignored. (Default) 1: DI signals from CNC3 are transferred to internal relays.
K0000.3	0: DI signals from CNC4 are ignored. (Default) 1: DI signals from CNC4 are transferred to internal relays.
K0000.4	(Reserved) This value should be 0.
K0000.5	0: Override value is not restored on the exit of remote operation. (Default) 1: Override value is restored on the exit of remote operation.
K0000.6	0: Multiple CNC control (sample) is not used. (Default) 1: Multiple CNC control (sample) is used.
K0000.7	0: Robot programs are aborted with CSTOPI when the program is paused. (Default) 1: Do nothing when the robot program is paused.
K0001.0	0: DO signals are not output for Machine Tool Operation. (Default) 1: DO signals are output for Machine Tool Operation.
K0001.1~K0001.7	Not used

K0000.0~K0000.3 are switches to accept DI signals from CNC1, CNC2, CNC3, and CNC4. These keep relays are modified when the number of CNC are changed with "Machine Tool I/F" screen. You can detach specific CNC by setting the value 0 manually.

K0000.4 is reserved. This value should be 0.
When K0000.5=1, the override value of the robot controller will be restored on the exit of remote operation. The default value is 0.
With K0000.6=1, subprogram "P0002" for multiple CNC control is called. The default value is 0.
With K0000.7=0, Robot Ladder Program sends CSTOPI signal to abort the paused robot programs.
With K0000.7=1, the paused robot programs remain paused. No method is provided to abort the paused robot programs from CNC. In this case, operation from the robot teach pendant is required.

10.4 DETAIL OF STATE TRANSITION

10.4.1 State "Maintenance" and State "Service"

Robot Ladder Program always outputs the value 1 to the internal relays corresponding to state "maintenance" or state "service" exclusively.

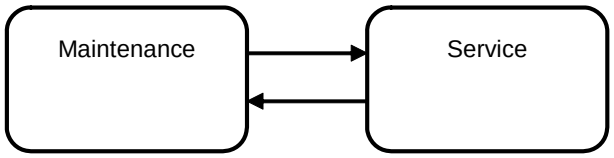


Fig. 10.4.1 State transition (1)

The state "maintenance" is a state in which the robot controller cannot accept remote operation or program call from CNC. The state "service" is the opposite state.
The state "service" requires following conditions. When any of these conditions breaks, the robot controller will settle in state "maintenance".

- The operation mode is "AUTO".
- EMERGENCY STOP error does not occur in the robot controller.
- "Enable UI signals" in system configuration menu is TRUE.

These conditions are not related to neither the behavior of Robot Ladder Program nor the status of the robot controller software, but related to the setting of the robot controller. Therefore, these conditions are determined by the operation or setting by the operator.
The sequence related to state "maintenance" and state "service" is described in sequence program "LEVEL2" (Refer to 10.9.2). These states are transferred to CNC as Service State signal (DO[63], etc.) and Maintenance State signal (DO[62], etc.) (Refer to 10.9.7).
Robot remote operation and machine interlock operation from CNC is allowed when the robot controller is in state "Service".

10.4.2 States Inside "Service"

States inside "Service" consists of the following states.

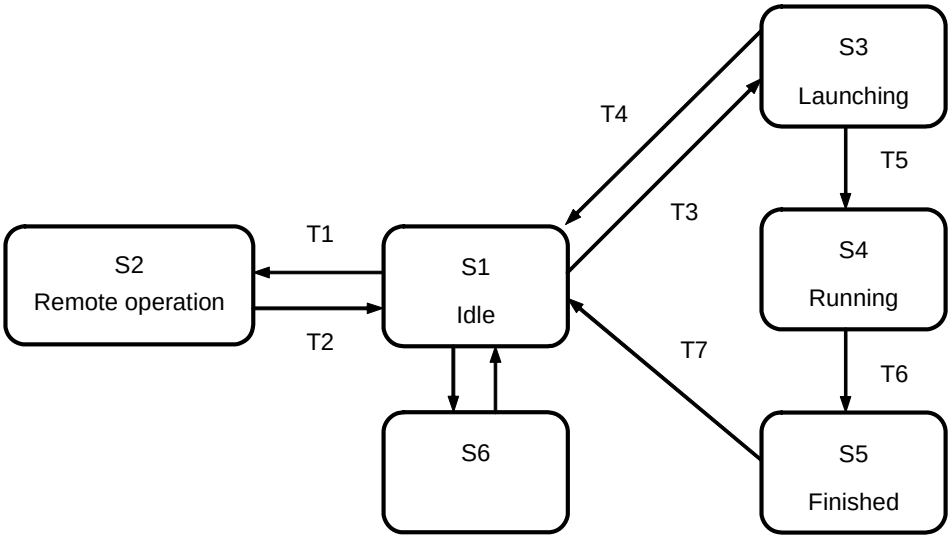


Fig. 10.4.2 State transition inside state "Service"

Table 10.4.2(a) Internal State of Service state

State	Description
State "idle" (S1)	State "idle" (S1) means the robot controller is in state "service" and no robot program is running and not in any state of S2~S5. State S2 means remote operation from CNC and S3~S5 mean the robot controller is running a robot program requested from CNC.
State "remote operation" (S2)	One CNC uses the robot remote operation.
State "launching" (S3)	Robot Ladder Program is launching a robot program using PNS.
State "running" (S4)	A robot program is running.
State "finished" (S5)	A robot program ended.
S6	S6 is defined as not in state "remote operation" and not in state S3, S4, S5 but any robot program is running. It means any robot program, which is invoked without Robot Ladder Program, is running.

Robot Ladder Program defines the following seven transitions.

Table 10.4.2(b) Internal state transition of Service state

Transition	Description
T1	Transition from state "idle" (S1) to state "remote operation" (S2).
T2	Transition from state "remote operation" (S2) to state "idle" (S1).
T3	Transition to state "launching" (S3). This transition requires in state "idle" (S1) and READY signal is ON.
T4	Transition from state "launching" (S3) to state "idle" (S1) in case the requested robot program fails to be launched.
T5	Transition from state "launching" (S3) to state "running" (S4) when the requested robot program is successfully launched.
T6	Transition caused when the robot program ends.
T7	Transition caused when CNC accepts the robot program ends.

State S2, S3, S4 and S5 can be reached from state S1 and these transitions are caused by the operation from CNC or the internal process or Robot Ladder Program. On the other hand, without any external operation to the robot controller, the state of robot controller settles in state S1 or state S6.

10.4.3 State "Maintenance" and State S1~S6

When the robot controller in state "service", the robot controller is also in one of the state of S1~S6. Once the robot controller is forced to transit from state "service" to state "maintenance " and then back from state "maintenance" to state "service", the state of the robot controller becomes as follows:

- When the robot controller is in state "idle" (S1), after the round-trip to state "maintenance" state, the state settles in state S6 if any other program is running and if no program is running the state settles in state "idle" S1.
- If the robot controller is in state "remote operation" (S2) and the transition to "maintenance" state is caused, Robot Ladder Program keeps the state S2. In other words, Remote Operation Mode signal is ON in spite of Maintenance Mode signal is ON. However, in state "maintenance" any operation from CNC is prohibited. Operations from CNC are allowed when the robot controller comes back in state "service" and in state "remote operation" (S2).
- State "launching" (S3) is a state that the robot controller is launching a robot program using PNS. Robot Ladder Program will cause a transition to state "idle" (S1) unless SNACK signal is ON with 288ms after the entry of state "launching" (S3). If transition to "maintenance" is caused in the state "launching" (S3), SNACK remains OFF and consequently the state settles in "S1".
- The state "running" (S4) is when a robot program is running. Transition to state "maintenance" is caused when an operator presses the EMERGENCY STOP button or enables the teach pendant on the state "running" (S4). With K0000.7=1, a robot program will be paused. This situation means the state "running" (S4) will be reserved on the state "maintenance". When back to state "service ", the state "running" (S4) will appear. With the setting of K0000.7=0, a running program will be terminated by Robot Ladder Program. Thus, the state will become state "finished" (S5).
- The state "finished" (S5) will be reserved during round-trip to state "maintenance".

10.4.4 Access Control

In the state "remote operation" (S2), "launching" (S3), "running" (S4), and "finished" (S5) one of connected CNC has the lock to control the robot controller and a corresponding internal relay (AC1 ~ AC4) has the value 1. On the other hand, in the state "idle" (S1) or S6, no CNC has the lock.
A CNC gets lock on the transition to the state "remote operation" (S2) and on the transition to the state "launching" (S3). The lock will be released on the transition from the state "remote operation" (S2) and on the transition from the state "finished" (S5) or from the state "launching" (S3) to the state "idle" (S1).

10.5 DETAILS OF THE STATE “REMOTE OPERATION”

Remote operation relates to the transition from S1 to S2 and the reverse transition. In addition, inside the state "remote operation" (S2), states corresponding to the type of the remote operation are defined.

10.5.1 Transition T1 (Remote Operation Request and the Transition to the State "Remote Operation")

Transition T1 will be caused by the rising edge of Remote Operation Request signal from one of CNC in the state "idle" (S1). Following conditions are also required.

- No CNC sends Remote Operation Request.
- No transition is caused.

On the transition T1, Robot Ladder Program issues the macro command to decrease the override value. Please refer to T1T2 (Refer to 10.9.17) for details.

10.5.2 Transition T2 (End of Remote Operation and the Transition to the State "Idle" (S1))

Transition T2 will be caused when Remote Operation Request signal is off in the state "remote operation" (S2). This sequence is written in the subprogram T1T2 (Refer to 10.9.17).

10.5.3 Inside of the State “Remote Operation”

There are four states defined inside the state "remote operation" (S2).

Table 10.5.3 Internal State of remote operation

State	Description
S21	Not in S22 nor S23 nor S24
S22	A CNC selects hand operation. CNC, which locks the robot controller, outputs signals related to hand operation.
S23	A CNC selects JOG FEED operation. Not in S22 and CNC, which lock the robot controller, outputs signals related to JOG FEED operation.
S24	A CNC selects HOME POSITION RETURN operation. Not in S22 nor S23 and CNC that locks the robot controller outputs signals related to HOME POSITION RETURN operation.

These states are uniquely determined based on the signals from CNC. Sequences to make transitions are not required in Robot Ladder Program.

10.5.4 State "HAND operation" (S22)

Signals to specify the type of HAND operation are independently prepared for each CNC. In the state "remote operation" (S2), Robot Ladder Program will transfer "Hand Operation Type" signals from a CNC, which locks the robot controller, to the common internal relays (R0271.0~R0271.3). These internal relays are assigned as the signal of GI[5]. This means all CNCs use identical macro programs for HAND operation.
HAND operation from CNC is to issue a macro commands. Robot Ladder Program will transfer "Remote Operation Run" signal into a signal assigned to issues a macro command in the state S22 (Refer to 10.5.9). These sequences are written in the subprogram NC_HND (Refer to 10.9.8).

10.5.5 State "JOG FEED operation" (S23)

In the state S23, Robot Ladder Program transfers the signals related to JOG FEED operation into common internal relays. Robot Ladder Program is responsible to transfer signals into corresponding internal relays. These internal relays are assigned as the signal of DI[1025]~DI[1056] and the software of the robot controller moves the robot according to this signals (Refer to 10.9.16).

NOTE
In order to execute jog feed of the robot by remote operation, it is need to enable the function beforehand. Refer to “4.10 SETTING FOR ROBOT JOG FEED OPERATION FROM CNC”.

10.5.6 State "HOME POSITION RETURN" (S24)

"HOME POSITION RETURN" operation from CNC is to issue a macro command, which moves the robot to a specific position. However, a macro program will be launched on the rising edge of a signal and will continue running even if the signal becomes OFF. Robot Ladder Program will turn UI[2:Hold] signal OFF when Remote Operation Run signal becomes OFF during the macro running. This enables to

stop the running macro by the Remote Operation Run signal. Signal of UI[2:Hold] will be turned ON after a while.
Subprogram MVHOME (Refer to 10.9.10) and LEVEL1 (Refer to 10.9.1) implements this behavior. The macro program for "HOME POSITION RETURN" operation will be launched by an internal relay assigned to DI signal.

10.5.7 Override Change

Override change is implemented with issuing macros by signals from CNC. In the state "remote operation" (S2), the change of override value will be accepted anytime.

10.5.8 Macros Launched on the Entry and Exit of Remote Operation

To decrease the override value on the entry of remote operation, Robot Ladder Program issues a macro command. Similarly, Robot Ladder Program issues a macro command to restore the override value on the exit of remote operation. Robot Ladder Program outputs pulse signals to DI signals on the transition of T1 and on the transition of T2. The robot controller should be configured to launch macro programs with these DI signals.
Please refer to T1T2 (Refer to 10.9.17) for details.

10.5.9 Remote Operation Run

Remote Operation Run signals are assigned as the signals of DI[37] (DI[293], DI[549], DI[805]) from CNC1, (CNC2, CNC3, CNC4) respectively. Robot Ladder Program outputs corresponding internal relays (R0004.4, R0068.4, R0132.4, R0196.4) on the rising edge of these signals. These corresponding internal relays will become OFF when DI signals is turned OFF.
This assures that remote operation will not continue after power cycle. If Robot Ladder Program reads Remote Operation Run signal directly and transfer it to the internal relay, the robot may move after power cycle during JOG FEED operation. Since this is not a preferable behavior, Robot Ladder Program sets the internal relays for remote operation on the rising edge of Remote Operation Run signal.
These sequences are written in the subprograms P0005, P0007, P0009 and P0011 (Refer to 10.9.6).
Internal relays to detect the rising edge of Remote Operation Run signal are not shared with other purposes. Any other sequence programs do not reference these internal relays.

10.6 DETAILS OF THE STATE “MACHINE INTERLOCK OPERATION”

Four states of "idle"(S1), "launching" (S3), "running" (S4) and "finished" (S5) relate to machine interlock operation. In addition, Robot Ladder Program defines each CNC has an independent state transition structure.

10.6.1 State Transition of CNC

In machine interlock operation, not only the state-transition of the robot controller but also the state-transition of CNC will be considered. Robot Ladder Program defines each CNC has three states in machine interlock operation.

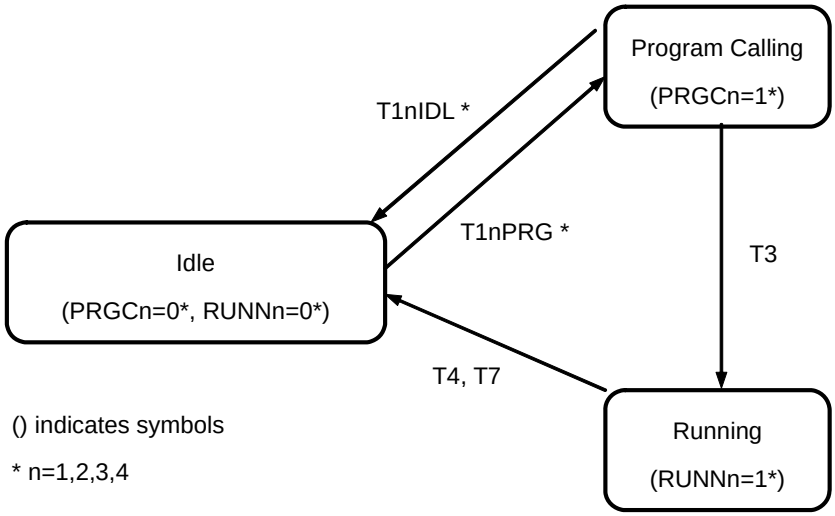


Fig.10.6.1 State transition of CNC in machine interlock operation

Table 10.6.1 State of CNC

State	Description
Idle	Program Call signal is OFF.
Program Calling	Program Call signal is ON but the requested robot program is not running. This state starts on the moment that CNC outputs Program Call signal and ends on the moment that the robot controller launches the requested robot program.
Running	The requested robot program is launched and the robot controller is in the state "running" (S4) or in the state "finished" (S5).

This state transition, which has three states, is considered to belong each CNC independently. For example, such a situation that CNC1 is in the state "idle", CNC2 and CNC3 are in the state "Program Calling" and CNC4 is in the state "running" can happen. However, Only one CNC must be in the state "running".
These three state has relation to the state of the robot controller, S1~S6. All CNC must be in the state "idle" or in the state "Program Calling" when the robot controller is in the state "idle" (S1). When one CNC is in the state "running", the robot controller is in the state-transition process from S3 via S4 to S5. The transition from S5 to S1 of the robot controller will cause the transition from "running" to "idle" of CNC.
Transition from "idle" to "Program Calling" is caused by the rising edge of Program Call signal from CNC. In the state "running", an internal relay (whose symbol is PRGCn, where n indicates CNC number) has the value 1.
From the state "running", a transition back to "idle" and a transition to "running" are defined. On the transition to "running", the requested robot program is launched. In case that Program Call signal is turned OFF or the robot controller cannot launch a robot program from any cause, the transition back to "idle" will be caused.
The transition from idle to running and the transition from Program Calling to idle are called "T1nPRG" and "T1nIDL" respectively, where n indicates CNC number. These states use internal relays of R0288.0~R0289.7.
In the state "running", corresponding internal relay (symbol: RUNN1~RUNN4) has the value 1. Once CNC enters in this state, it will never transit to the state "Program Calling" even if Program Call signal is cycled.
Transitions between the state "idle" and the state "Program Calling" are written in the subprogram PRGC (Refer to 10.9.12).

10.6.2 Keeping of Program Call from CNC

Robot Ladder Program outputs "Completed" signal when the requested robot program ends normally. It is only valid when CNC keeps Program Call signal ON throughout running of robot program. If CNC turns Program Call signal OFF during robot program execution, Robot Ladder Program will remain "Completed" signal OFF when the robot programs ends normally.
To enable this behavior, Robot Ladder Program uses internal relays RTNRQn (where n indicates CNC number) to manage history of Program Call signal. The value of this internal relay is turned 1 on the transition of T3 and is turned 0 on the transition of T4 or T7 or when Program Call signal from CNC becomes OFF.
In overlap start, a robot program and a CNC program will run simultaneously. In case that the robot program requires more long time to be completed than the CNC program does, at the moment the robot program ends, the CNC program may be in the next loop and waiting for the end of the robot program. On such situation if the robot controller outputs "Completed" signal at the end of the robot program, the CNC program will receive this signal as the end of the robot program in the current loop and continue, which actually means the end of the robot program in the previous loop. To avoid this Robot Ladder Program handles Program Call signal from CNC with respect to each loop.

10.6.3 Program Call and Queue

Program Calls from any CNC will be pushed into a queue, which is composed of matrix of internal relays. Robot Ladder Program will pop the Program Call from the queue one by one and launch the requested program.
Please refer to subprogram CUE (Refer to 10.9.13) for details.

10.6.4 Discard of Program Call Request in the Queue

Program Call request in the queue will be reserved in condition that the robot controller is in the state that robot programs can be launched. However, when the robot controller is in the state that robot programs cannot be launched for any cause, any request in the queue will be discarded and then Robot Ladder Program sends NAK to CNC (Refer to 10.9.15).

10.6.5 Transition T3 (Program Call Request from the Queue)

Sequence for launching robot program will be invoked when one of internal relays QUEUE4 has the value 1. More than one internal relay in QUEUE4 may have the value 1. Robot Ladder Programs uses a ring counter which is composed of internal relays, RING1 ~ RING4, to select one.
Transition T3 will be caused on the condition that:

- Program Call request exists in the queue.
- READY signal is ON (Refer to 10.7.1).

This sequence is written in the subprogram LEVEL2.

10.6.6 State "launching" (S3)

State “launching" (S3) is a state that Robot Ladder Program outputs PNSTROBE signal then waits for SNACK signal. Robot Ladder Program will cause a transition to state "idle" (S1) unless SNACK signal is ON within a fixed time after the entry of state "launching" (S3). Robot Ladder Program will cause a transition to state "running" (S4) if it receives SNACK signals. This sequence uses a fixed timer.

10.6.7 Transition T4 (Failure to Launch)

This transition will be caused when SNACK signals remains OFF after PNStrobe and the state settles in "idle" (S1). FAILED signal (Refer to 10.7.2) and Program Reply signal (Refer to 10.7.11) will be set in conjunction with this transition.

10.6.8 Transition T5 (Successful Program Launching)

Robot Ladder Program saves the PNS program number requested from CNC into data table 1 (D0001) in conjunction with the transition of T5.

10.6.9 State "running" (S4)

Robot Ladder Program sends a pulse signal to UI[18:PROD_RUN] on the entry of the state "running". After a while, Robot Ladder Program will cause the transition T6 unless PGRUNC signal (Refer to 10.8.2) is turned ON or PGABTC signal is turned ON (Refer to 10.8.2), where PGRUNC signal indicates the requested program is launched and PGABTC signal indicates the requested program ends.

10.6.10 Transition T6 (Program end)

There is no action in conjunction with the transition T6.

10.6.11 State "finished" (S5)

The state "finished" (S5) is a state that the requested robot program ends but CNC locks the robot controller. Typical situation is the program ends successfully and "Completed" signal is ON. Robot Ladder Program will cause transition to the state "idle" (S1) when Program Call signal is turned OFF.
In case that Program Call signal is OFF prior to the entry of S5, Robot Ladder Program will not output "Completed" signal and immediately cause the transition to the state "idle" (S1) (Refer to 10.6.2). Robot Ladder Program will cause the transition to the state "idle" (S1). In case that the requested robot program is terminated abnormally, FAILED signal (Refer to 10.7.2) and Program Reply (Refer to 10.7.11) signal will be set.

10.6.12 Transition T7

There is no action in conjunction with the transition T7.

10.7 BEHAVIOR OF OTHER SIGNALS

10.7.1 READY Signal and Not READY Signal.

READY signal is ON when the robot controller is in the state "idle" (S1) and the signal UO[1] is ON and the internal relay CREADY is ON. Subprogram P0001 outputs CREADY when the signal UO[7] is ON (default).
Not READY signal is turned on when the state is S1 but READY signal is OFF.

10.7.2 FAILED Signal

This signal keeps the event that the last robot program failed. This value will be turned 0 by RESET signal from any CNC. Program launching process from any CNC will fail when FAILED signal is ON.

10.7.3 UO Signals

UO signals of the robot controller are assigned to the internal relays R0278.0~R0280.7. The system software of the robot controller outputs signals into these internal relays. Robot Ladder Program transfers these values to DO signals for each CNC.

10.7.4 UI Signals

UI signals of the robot controller are assigned to the internal relays R0272.0~R0274.7. Robot Ladder Program sends signals to these internal relays and launches the robot program in machine interlock operation.

10.7.5 HOLD Signal

HOLD signal is differently used in the state "HOME POSITION RETURN" (S24) and other states. In the state "HOME POSITION RETURN", HOLD signal will be cycled when Remote Operation Run signal becomes OFF. In other states, Robot Ladder Program does not change the HOLD signal.

10.7.6 CSTOPI Signal

Robot Ladder Program sends a pulse signal to CSTOPI when the program is paused with K0000.7=0. This will abort the paused robot programs.

10.7.7 Resume

Robot Ladder Program does not send a pulse signal to CSTOPI with K0000.7=1. This setting is for testing the system. With this setting, CNC cannot resume the paused robot program, though, the paused robot program will resume with the robot teach pendant by turning the internal relay assigned to UI[7] ON.
It is more convenient to assign a macro program to be launched by SU, which sends pulse signal to DO[13182]. DO[13182] is an internal relay assigned to UI[7] in this function. It is necessary to set the system variable $MACRTPDSBEX TRUE to run a macro command by SU with the teach pendant disabled.

10.7.8 Reset from CNC

Reset signal from CNC is used in three cases.

- Reset signal will be transferred to UI[5] and resets alarms of the robot controller.
- The FAILED signal will be reset.
- When a robot program is paused for any cause, Robot Ladder Program aborts this program when K0000.7=0.

Robot Ladder Program aborts the paused robot programs when K0000.7=0. Therefore, the situation that a robot program remains paused will not occur. However, the running robot program will be paused after power cycle. In such situation, Robot Ladder Program transfers RESET signal from CNC to UI[4] to abort the paused robot program.

10.7.9 Override Output

This function always outputs the override value of the robot controller to the signal GO[1]. Internal relays are assigned to the signal GO[1]. Robot Ladder Program transfers these values to DO signals for each CNC.

10.7.10 Robot Power On

Robot Power On signal is always ON.

10.7.11 Program Reply

Eight points of signals Program Reply are prepared for each CNC independently. Robot Ladder Program sets value for these signals in case that the robot controller cannot launch the requested robot program. These signals will be set 0 with RESET signal from CNC or the rising edge of Program Call signal.

10.8 USAGE OF BUILT-IN FUNCTIONS OF THE ROBOT CONTROLLER

This section describes how Robot Ladder Program uses the build-in functions of the robot controller.

10.8.1 Macro Commands

Remote operation from CNC uses macro commands. In R-30*i*A/R-30*i*A Mate controller, the internal relays are assigned to DI signals to execute macro command, and the internal relay is turned on to execute macro command. In R-30*i*B/R-30*i*B Mate controller or later, the G addresses in PMC are assigned to DI signals to execute macro command. In order to execute macro command by the internal relay, the values of internal relay are transferred to the G addresses which are assigned to DI signals for macro execution. The internal relays which are relevant to macro execution are as follows.

Table 10.8.1(a) Assignment of macro commands (R-30*i*A/ R-30*i*A Mate controller)

Internal relay	Signal	Symbol	Purpose
R0267.0	DI[19]	MCRREN	To decrease the override value on the entry of remote operation.
R0267.1	DI[20]	MCRREX	To restore the override value on the exit of remote operation.
R0267.2	DI[21]	MCRH	To launch a macro for HAND operation.
R0267.3	DI[22]	MCROVU	To increase the override value.
R0267.4	DI[23]	MCROVD	To decrease the override value.
R0267.5	DI[24]	MCRHOM	To move the robot to Home Position.

Table 10.8.1(b) Assignment of macro commands (R-30*i*B/ R-30*i*B Mate controller or later)

Internal relay	Signal	Symbol	Purpose
R0267.0	DI[1025] (G0008.0)	MCRREN	To decrease the override value on the entry of remote operation.
R0267.1	DI[1026] (G0008.1)	MCRREX	To restore the override value on the exit of remote operation.
R0267.2	DI[1027] (G0008.2)	MCRH	To launch a macro for HAND operation.
R0267.3	DI[1028] (G0008.3)	MCROVU	To increase the override value.
R0267.4	DI[1029] (G0008.4)	MCROVD	To decrease the override value.
R0267.5	DI[1030] (G0008.5)	MCRHOM	To move the robot to Home Position.

10.8.2 Robot Program Status (D0001, PGRUNC, PGABTC, PGENDC)

This function outputs the status of the robot program launched by Robot Ladder Program into the following DO signals. In order to refer to the status of these DO signals in Robot Ladder Program, in R-30*i*A/R-30*i*A Mate controller, the internal relays are assigned to DO signals directly. In R-30*i*B/R-30*i*B Mate controller or later, the values of F addresses which are assigned to DO signals are transferred to the internal relays.

Table 10.8.2(a) DO signals for robot program status. (R-30*i*A/ R-30*i*A Mate controller)

Signal	Address	Symbol	Purpose
DO[1028]	R0261.3	PGRUNC	This signal indicates the requested robot program was launched.
DO[1029]	R0261.4	PGENDC	This signal indicates the requested robot program ended normally.
DO[1030]	R0261.5	PGABTC	This signal indicates a robot program ended (normally or abnormally).

Table 10.8.2(b) DO signals for robot program status. (R-30*i*B/ R-30*i*B Mate controller or later)

Signal	Address	Symbol	Purpose
DO[1028] (F0008.3)	R0261.3	PGRUNC	This signal indicates the requested robot program was launched.
DO[1029] (F0008.4)	R0261.4	PGENDC	This signal indicates the requested robot program ended normally.
DO[1030] (F0008.5)	R0261.5	PGABTC	This signal indicates a robot program ended (normally or abnormally).

This function outputs only the status of a robot program that has the same number of D0001. Therefore, Robot Ladder Program sets the number of the robot program into D0001 prior to launching.

10.8.3 Robot JOG FEED Operation from CNC

Robot Ladder Program transfers signals for JOG FEED operation from CNC into signals from DI[1025] to DI[1056]. This function watches these signals and moves the robot.

NOTE
In order to execute jog feed of the robot by remote operation, it is need to enable the function beforehand. Refer to “4.10 SETTING FOR ROBOT JOG FEED OPERATION FROM CNC”.

10.8.4 Heart Beat Signal of Machine Tool Operation Screen

Machine tool operation screen enables jog feed of the machine tool from the robot teach pendant in the system that the machine tool and the robot are connected by both I/O and communication.
Robot Ladder Program outputs signals for this operation in condition that a heart beat signal of Machine tool operation screen continues. While Machine tool operation screen is activated on the robot teach pendant, this screen outputs the heart beat signal to an internal relay MTOSHB. Robot Ladder Program detects this heart beat signals and set an internal relay MTOSAL ON and sends signals for jog feed operation of the machine tool while MTOSAL is ON.
This behavior is described in subprogram CNCJOG and NCnJOG (where n indicates CNC number) (Refer to 10.9.14, 10.9.19).

10.8.5 FENCE OPEN Signal and I/O Interconnect

The status of FENCE OPEN signal is retrieved into an internal relay using I/O interconnect. Robot Ladder Program transfers the value of this internal relay to DO signals for each CNC.

10.8.6 EMERGENCY STOP

The status of EMERGENCY STOP is set to signal DO[1025] with the settings of System Configuration. In R-30*i*A/R-30*i*A Mate controller, the signal DO[1025] is assigned to a corresponding internal relay. In R-30*i*B/R-30*i*B Mate controller or later, DO[1025] is assigned to F address in PMC, and the value is transferred to a corresponding internal relay.
Robot ladder program transfer the value of the internal relay corresponding to EMERGENCY STOP signal to the connected CNCs.

10.9 DETAILS OF SEQUENCE PROGRAMS

Robot Ladder Program is composed of following subprograms. Subprograms P0001~P0004 are expected to be customized. Understandings of the structure and the behavior of Robot Ladder Program are required to modify other subprograms.

Table 10.9 Structure of Robot Ladder Program

Name	Description
LEVEL1	This program handles UOP signals.
LEVEL2	This program has responsibility to remote operation and machine interlock operation.
P0001 (USER1)	This defines READY signal. This program is expected to be customized.
P0002 (USER2)	This is a sample program to control multiple CNC from one CNC. This is used for a specific CNC to send signals to multiple CNC and to receive signals from multiple CNC. This program is expected to be customized.
P0003 (USER3)	This is an empty subprogram. This program is expected to be customized.
P0004 (USER4)	This is an empty subprogram. This program is expected to be customized.
P0005 (NC1IN)	This program handles input signals from CNC1.
P0006 (NC1OUT)	This program handles output signals to CNC1.
P0007 (NC2IN)	This program handles input signals from CNC2.
P0008 (NC2OUT)	This program handles output signals to CNC2.
P0009 (NC3IN)	This program handles input signals from CNC3.
P0010 (NC3OUT)	This program handles output signals to CNC3.
P0011 (NC4IN)	This program handles input signals from CNC4.
P0012 (NC4OUT)	This program handles output signals to CNC4.
P0013 (NC_HND)	This program reads Hand Type signal from each CNC.
P0014 (NC_PNS)	This program reads PNS signal from each CNC.
P0015 (MVHOME)	This is for HOME POSITION RETURN operation.
P0016 (OVRUD)	This is to change the override value.
P0017 (PRGC)	This program handles Program Call from CNC.
P0018 (CUE)	This program handles queue.
P0021 ~ P0024	These programs check Program Call from CNC can be accepted or not.
P0025, P0026	This is for robot JOG FEED operation from CNC.
P0027	This program checks Remote Operation Request can be accepted or not.
P0028	In remote operation, this program determines which operation is selected.
P0029~ P0032	These programs send signals for machine tool operation from the robot controller.

Name	Description
P0044, P0045	(R-30*i*B/R-30*i*B Mate controller or later) These programs take charge of the transfer from F addresses to the internal relays and the transfer from the internal relays to G addresses.

10.9.1 LEVEL1

The program "LEVEL1" handles internal relays corresponding to UOP signal. Note that sequences related to UI[9]~UI[16], UI[17] and UI[18] are written in LEVEL2.
Sequences in LEVEL1 processes followings:

1. Transfer UI corresponding signals from CNC into UI signals.
2. Transfer UI signals into system interface inputs.
3. Transfer system interface outputs into UO signals. (LEVEL2 transfers UO signals to DO signals for each CNC.)

10.9.2 LEVEL2

LEVEL2 handles remote operation and machine interlock operation. This program processes followings:

1. This part transfers DI signals from CNC1~CNC4 into internal relays (Refer to 10.9.6).
2. This part makes "transition pulse".
3. This part calls subprograms P0001~P0004.
4. This part determines the current state (S1~S6).
5. This part implements behaviors in the state S1.
6. This part makes transition to S1 and transition to S2 if possible (inside subprogram T1T2). (Refer to 10.9.17)
7. This part implements behaviors in remote operation (Refer to 10.9.18).
8. This part pushes Program Call into the queue (Refer to 10.9.12).
9. This part determines transition T3 can be caused or not (Refer to 10.9.15). When Program Calls exist in the queue, this part determines transition T3 can be caused or not.
10. This part makes transition T3 if possible. Using a ring counter, this selects one of Program Calls in the queue and then give locks to one of CNC and handles Program Call signal.
11. This part implements behaviors in state "launching" (S3).
12. This part implements behaviors in state "running" (S4). On the entry of state "running" (S4), Robot Ladder Program sends a pulse signal to PROD_RUN. After a while, Robot Ladder Program makes transition T6 if PGRUNC signal remains OFF or PGRUNC signal and PGABTC signal are both turned ON. Even if PGRUNC signal remains OFF, Robot Ladder Program considers the requested program was once launched but failed immediately.
13. This part implements behaviors in the state "finished" (S5). In this state, Robot Ladder Program outputs "Completed" signal until Program Call from CNC signal is turned OFF. When Program Call signal is turned OFF, Robot Ladder Program will cause transition T7. Robot Ladder Program waits a while to receive "Completed" signal successfully.
14. This part calls subprograms for machine tool operation.
15. This part outputs DO signals for each CNC (Refer to 10.9.7).

10.9.3 P0001 (USER1) ~ Customized READY Signal

This subprogram is to customize READY signal. UO[7] and UO[1] are required for READY signal (default).
READY signal is created in LEVEL2 and subprogram P0001. LEVEL2 defines READY signal as follows.

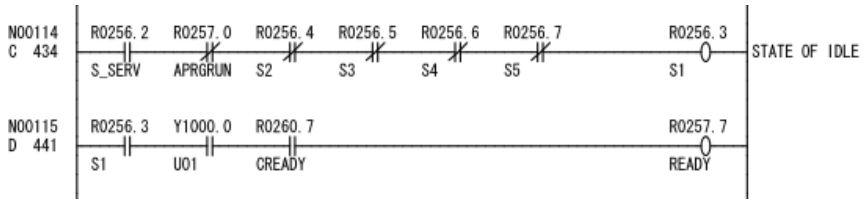


Fig. 10.9.3(a) Sequences to output READY signal

CREADY is created inside P0001. CREADY becomes ON in condition that UO[7] is ON (defaults). If other signal is required for READY signal, please edit subprogram P0001.

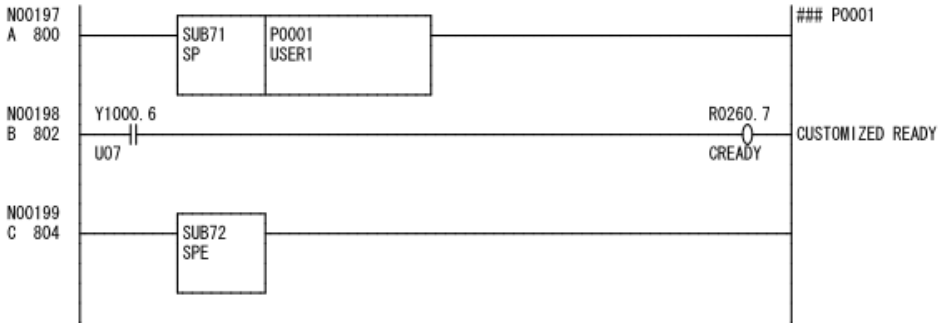


Fig 10.9.3(b) Sequences to customize READY signal

10.9.4 P0002 (USER2) ~ Multiple CNC Control

Sequences in this subprogram behave as a hub between multiple CNC. Internal relays for DI and DO for each CNC are used.
This program is a sample. This program is expected to be customized.
LEVEL2 calls this subprogram when K0000.6 = 1.

10.9.5 P0003 and P0004

These subprograms are empty. These are to be customized. LEVEL2 calls these subprograms.

10.9.6 P0005, P0007, P0009, P0011 (NCnIN)

These subprograms transfer DI signals (DI[1]~DI[18],DI[25]~DI[59]) into internal relays for DI/DO buffer. Signals DI[1], DI[2], DI[3], DI[8] and DI[34] are ignored because they are transferred in LEVEL1. An internal relay corresponding to DI[37] is set on the rising edge of DI[37].

10.9.7 P0006, P0008, P0010, P0012 (NCnOUT)

These subprograms transfer the value of internal relays into DO signals (from No.1 to No.76 for each CNC).

10.9.8 P0013 (NC_HND)

In the state S22 the values of Hand Type signals from CNC, which locks the robot controller, are transferred into internal relays corresponding to GI[5]. This subprogram also transfers Remote Operation Run signal into an internal relay corresponding to DI signal to issue macro command for HAND operation.

10.9.9 P0014 (NC_PNS)

The values of PNS signals from CNC, which locks the robot controller, are transferred into internal relays corresponding to UI[9]~UI[16].

10.9.10 P0015 (MVHOME)

This subprogram handles HOME POSITION RETURN operation, which includes launching a macro command and sending a pulse signal to HOLD to stop the macro.
This program defines three states and four transitions as follows.

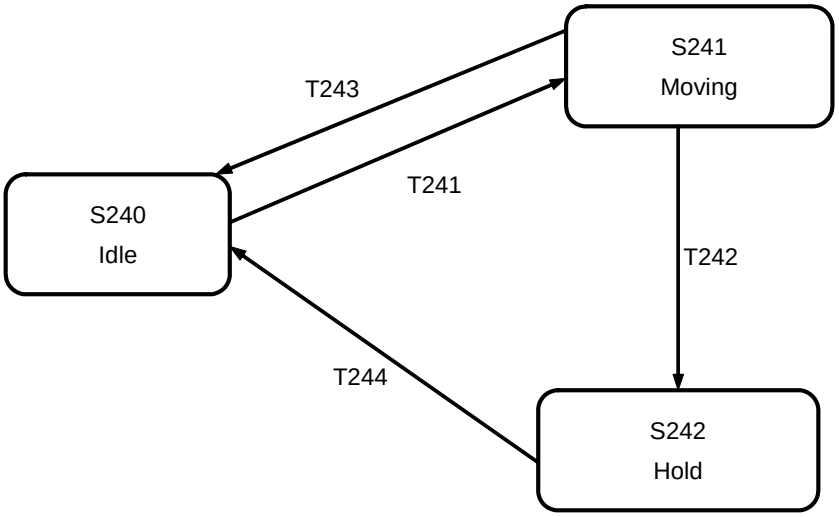


Fig. 10.9.10 State transition inside HOME POSITION RETURN

Table 10.9.10(a) State about HOME POSITION RETURN

State	Description
S240	CNC selects HOME POSITION RETURN but the corresponding macro command is not launched (R0257.5=0, R0257.6=0).
S241	The macro command is running. (R0257.5=1, R0257.6=0).
S242	UI[2:Hold] is turned OFF. (R0257.5=0, R0257.6=1).

Table 10.9.10(b) Transition about HOME POSITION RETURN

Transition	Description
T241	T241 issues the macro command.
T242	T242 turns UI[2:HOLD] signal OFF.
T243	T243 is caused when UI[10:BUSY] is OFF.
T244	T244 turns UI[2:HOLD] signal ON.

10.9.11 P0016 (OVRUD)

In the state "remote operation" (S2), this subprogram transfers Override Up signal and Override Down signal to internal relays corresponding to DI signals to issue macro commands.

10.9.12 P0017 (PRGC)

This program reserves Program Call signal from CNC into the internal relay PRGCn, where n indicates CNC number. This internal relay means such situation that CNC requests a program but the program is

not yet launched. This internal relay will be set 0 when the requested program is launched or the robot controller for any cause falls into the state that cannot launch the program.

10.9.13 P0018 (CUE)

This program handles the queue for Program Call signal.
This queue is composed of internal relays. In case that four CNCs are connected, 16 internal relays must be used as a matrix shown in Fig. 10.9.13.

	Queue 1	Queue 2	Queue 3	Queue 4	Running
CNC1	0	0	0	0	
CNC2	0	0	0	0	
CNC3	0	0	0	0	
CNC4	0	0	0	0	

Fig. 10.9.13 Queue composed of internal relays

In this figure, the right side column "Running" is not a part of the queue but attached here for ease of understandings. The column "Running" indicates corresponding CNC is inside the state "running".
Robot Ladder Program implements four methods to this queue.

Table 10.9.13 Operation for queue

Operation	Description
Shift 4	Shift the values in queue 1 ~ queue 3 to the right and overwrite the value of queue 4. This method will be called when all internal relays in queue 4 are 0.
Shift 3	Shift the values in queue 1 ~ queue 2 to the right and overwrite the value of queue 3. This method will be called when all internal relays in queue 3 are 0 and there is at least one internal relay has the value 1 in queue 4.
Shift 2	Shift the values in queue 1 to the right and overwrite the value of queue 2. This method will be called when all internal relays in queue 2 are 0 and at least one internal relay in queue 4 has the value 1 and this is same in queue 3.
Shift 1	This method fetches Program Call signal into queue 1. This method will be called when all internal relays in queue 1 are 0 and at least one internal relay in queue 4 has the value 1 and this is same in queue 3 and in queue 2.

When CNC is in state "Program Calling", a Program Call request will be shifted from queue 1, queue 2, queue 3 to queue 4. When queue 4 has the value 1 and the requested program is launched, the state of CNC transits to state "running" and the value of queue 4 will be set 0. This structure and methods are implemented in subprogram CUE.
In addition, it is possible to push a Program Call into this queue when a requested program from the same CNC is running.

10.9.14 P0019 (CNCJOG) ~ Heart beat of Machine Tool Operation Screen

This subprogram checks the heart beat signal from Machine tool operation screen. Robot Ladder Program resets a timer on the rising and falling edge of this heart beat signal. If this timer is not reset until a fixed time, Robot Ladder Program considers heart beat stops.

10.9.15 P0021~ P0024 (NCnT3G)

These programs check whether Program Call from a specific CNC can be accepted or not when this CNC is in the state "Program Calling". If the Program Call cannot be accepted, Robot Ladder Program sets the value of internal relay TCnIDL and outputs Program Reply signal which indicates the reason. These programs do nothing if Program Call can be accepted.
When the internal relay TCnIDL is turned on, internal relay PRGCn will be turned OFF by subprogram PRGC.

10.9.16 P0025 and P0026 (JOG FEED Operation of Robot from CNC)

In the state S23 (JOG FEED operation of the robot from CNC), these subprograms transfer signals from CNC into internal relays corresponding to DI[1025]~DI[1056]. The signal to enable JOG FEED operation from CNC is always turned ON in state S23. The signal to move a specific robot axis will not be transferred until Remote Operation Run signal is turned ON. Robot Ladder Program only transfers these signals. This function actually moves the robot according to this signal (Refer to 10.8.3). Please set K0000.4=0 to use 18 signals from CNC as 12 signals for Joint Jog and 6 signals for Coordinate Jog. Other configurations are not currently supported.

NOTE
In order to execute jog feed of the robot by remote operation, it is need to enable the function beforehand. Refer to “4.10 SETTING FOR ROBOT JOG FEED OPERATION FROM CNC”.

10.9.17 P0027 (T1T2)

This program handles remote operation. The process of this subprogram is described below:
1. Making a pulse from Remote Operation Request signal (with internal relays R0264.0~R0265.3).
2. Remote Operation Request will be accepted in the state "idle" (S1) unless other CNC send Remote Operation Request signal. If this is not right, Remote Operation Request cannot be accepted (R0265.4~R0265.7).
3. Setting Access Control signal and making transition pulse T1.
4. Sending ACK or NAK to Remote Operation Request. This uses R0287.0~R0287.7 and fixed-timer 1~4.
5. Terminating remote operation.

Remote Operation ends when one of following conditions is satisfied.

- All CNCs turned Remote Operation signals OFF.
- In state "remote operation" (S2) and CNC that locks the robot controller turned Remote Operation signal OFF.

These sequences use internal relays R0266.4~R0266.6 to make a pulse from Remote Operation signal and make transition pulse T2.

10.9.18 P0028 (S2STAT)

These subprograms determine which type of remote operation is selected based on signals from CNC in state "remote operation" (S2).

10.9.19 P0029, P0030, P0031, P0032 Signals for Machine Tool Operation Screen

These subprograms output signals for machine tool operation in the condition that heart beat signal from Machine tool operation screen continues.
Machine tool operation screen sets the value of specific internal relays according to the operation selected on the screen. Robot Ladder Program transfers these internal relays to DO signals.
These subprograms are called when K0001.0=1.

10.9.20 P0044, P0045 Transfer between Internal Relays and F Addresses/ G Addresses (R-30*i*B/ R-30*i*B Mate Controller or Later)

In R-30*i*B/R-30*i*B Mate controller or later, UI/UO signals, DI/DO signals and GI/GO signals are assigned to F addresses/G addresses in PMC. This subprograms take charge of the transfer between F addresses/G addresses and the internal relays.

10.10 LIST OF INTERNAL RELAYS

Usages of internal relays are shown in Table 10.10(a) for common internal relays and Table 10.10(b) for CNC buffer internal relays.

Table 10.10(a) Usage of internal relays (common)

Address	Related signal R-30*i*A R-30*i*A Mate	Related signal R-30*i*B / R-30*i*B Mate or later	Symbol	Description
R0256.0			RCPWON	Robot Power On
R0256.1			S_MNT	Maintenance Mode
R0256.2			S_SERV	Service Mode
R0256.3			S1	State "idle" (S1)
R0256.4			S2	Remote Operation Mode
R0256.5			S3	State "launching"
R0256.6			S4	State "running"
R0256.7			S5	State "finished"
R0257.0			APRGRUN	Any program is running.
R0257.1			S21	S21 remote idle
R0257.2			S22	S22 hand operation selected
R0257.3			S23	S23 jog operation selected
R0257.4			S24	S24 home return operation selected
R0257.5			S241	S241 home running
R0257.6			S242	S242 home run hold
R0257.7			READY	State READY
R0258.0			PRGC1	CNC1 sends Program Call.
R0258.1			PRGC2	CNC2 sends Program Call.
R0258.2			PRGC3	CNC3 sends Program Call.
R0258.3			PRGC4	CNC4 sends Program Call.
R0258.4			SUCCES	Successfully completed
R0258.5			FAILED	The last program ended abnormally.
R0258.6			ABORT1	Aborted
R0258.7			NREADY	State Not READY

Address	Related signal R-30*i*A R-30*i*A Mate	Related signal R-30*i*B / R-30*i*B Mate or later	Symbol	Description
R0259.0			AC1	CNC1 Locks the robot controller.
R0259.1			AC2	CNC2 Locks the robot controller.
R0259.2			AC3	CNC3 Locks the robot controller.
R0259.3			AC4	CNC4 Locks the robot controller.
R0259.4				
R0259.5				
R0259.6				
R0259.7				
R0260.0			T1	Transition to state remote operation
R0260.1			T2	Transition to idle from state remote operation
R0260.2			T3	Transition to state S3
R0260.3			T4	Transition from S3 to S1
R0260.4			T5	Transition to S4
R0260.5			T6	Transition to state S5
R0260.6			T7	Transition to state S1
R0260.7			CREADY	Customized READY
R0261.0	DO[1025]	DO[1025]	ESTOP	In Emergency STOP state
R0261.1	DO[1026]	DO[1026]	FENCE	Fence is open.
R0261.2	DO[1027]	DO[1027]		
R0261.3	DO[1028]	DO[1028]	PGRUNC	Robot Program was launched.
R0261.4	DO[1029]	DO[1029]	PGENDC	Robot Program ended normally.
R0261.5	DO[1030]	DO[1030]	PGABTC	Robot Program ended (normally or abnormally).
R0261.6	DO[1031]	DO[1031]	INTRNS	In transition
R0261.7	DO[1032]	DO[1032]	INTM	A transition will be caused.
R0262.0				Rising edge of Remote Operation Run from CNC1
R0262.1				Rising edge of Remote Operation Run from CNC1
R0262.2				Rising edge of Remote Operation Run from CNC1
R0262.3				Rising edge of Remote Operation Run from CNC1
R0262.4				Rising edge of Remote Operation Run from CNC2
R0262.5				Rising edge of Remote Operation Run from CNC2
R0262.6				Rising edge of Remote Operation Run from CNC2
R0262.7				Rising edge of Remote Operation Run from CNC2
R0263.0				Rising edge of Remote Operation Run from CNC3
R0263.1				Rising edge of Remote Operation Run from CNC3
R0263.2				Rising edge of Remote Operation Run from CNC3
R0263.3				Rising edge of Remote Operation Run from CNC3
R0263.4				Rising edge of Remote Operation Run from CNC4
R0263.5				Rising edge of Remote Operation Run from CNC4
R0263.6				Rising edge of Remote Operation Run from CNC4
R0263.7				Rising edge of Remote Operation Run from CNC4
R0264.0				Making a pulse from Remote Operation Request from CNC1
R0264.1			TC1RRQ	Making a pulse from Remote Operation Request from CNC1
R0264.2				Making a pulse from Remote Operation Request from CNC1
R0264.3				Making a pulse from Remote Operation Request from CNC2
R0264.4			TC2RRQ	Making a pulse from Remote Operation Request from CNC2

Address	Related signal R-30*i*A R-30*i*A Mate	Related signal R-30*i*B / R-30*i*B Mate or later	Symbol	Description
R0264.5				Making a pulse from Remote Operation Request from CNC2
R0264.6				Making a pulse from Remote Operation Request from CNC3
R0264.7			TC3RRQ	Making a pulse from Remote Operation Request from CNC3
R0265.0				Making a pulse from Remote Operation Request from CNC3
R0265.1				Making a pulse from Remote Operation Request from CNC4
R0265.2			TC4RRQ	Making a pulse from Remote Operation Request from CNC4
R0265.3				Making a pulse from Remote Operation Request from CNC4
R0265.4				CNC1 has acquired the lock of remote operation.
R0265.5				CNC2 has acquired the lock of remote operation.
R0265.6				CNC3 has acquired the lock of remote operation.
R0265.7				CNC4 has acquired the lock of remote operation.
R0266.0				Remote Operation ACK/NAK off delay for CNC1
R0266.1				Remote Operation ACK/NAK off delay for CNC2
R0266.2				Remote Operation ACK/NAK off delay for CNC3
R0266.3				Remote Operation ACK/NAK off delay for CNC4
R0266.4				Making a pulse for the end of Remote Operation
R0266.5				Making a pulse for the end of Remote Operation
R0266.6				Making a pulse for the end of Remote Operation
R0266.7				Making a pulse for a macro command on the entry/exit of remote operation
R0267.0	DI[19]	DI[1025]	MCRREN	Macro command on the entry of remote operation.
R0267.1	DI[20]	DI[1026]	MCRREX	Macro command on the exit of remote operation.
R0267.2	DI[21]	DI[1027]	MCRH	Macro command for HAND operation
R0267.3	DI[22]	DI[1028]	MCROVU	Macro to increase the override value.
R0267.4	DI[23]	DI[1029]	MCROVD	Macro to decrease the override value.
R0267.5	DI[24]	DI[1030]	MCRHOM	Macro command for HOME POSITION RETURN
R0267.6	DI[1031]	DI[1031]		
R0267.7	DI[1032]	DI[1032]	DIJOG	JOG Enable
R0268.0	DI[1033]	DI[1033]	J1_X_P	Jog Direction Signal 1+
R0268.1	DI[1034]	DI[1034]	J1_X_M	Jog Direction Signal 1-
R0268.2	DI[1035]	DI[1035]	J2_Y_P	Jog Direction Signal 2+
R0268.3	DI[1036]	DI[1036]	J2/Y_M	Jog Direction Signal 2-
R0268.4	DI[1037]	DI[1037]	J3/Z_P	Jog Direction Signal 3+
R0268.5	DI[1038]	DI[1038]	J3/Z_M	Jog Direction Signal 3-
R0268.6	DI[1039]	DI[1039]	J4/W_P	Jog Direction Signal 4+
R0268.7	DI[1040]	DI[1040]	J4/W_M	Jog Direction Signal 4-
R0269.0	DI[1041]	DI[1041]	J5/P_P	Jog Direction Signal 5+
R0269.1	DI[1042]	DI[1042]	J5/P_M	Jog Direction Signal 5-
R0269.2	DI[1043]	DI[1043]	J6/R_P	Jog Direction Signal 6+
R0269.3	DI[1044]	DI[1044]	J6/R_M	Jog Direction Signal 6-
R0269.4	DI[1045]	DI[1045]	7_P	Jog Direction Signal 7+
R0269.5	DI[1046]	DI[1046]	7_M	Jog Direction Signal 7-
R0269.6	DI[1047]	DI[1047]	8_P	Jog Direction Signal 8+

Address	Related signal R-30*i*A R-30*i*A Mate	Related signal R-30*i*B / R-30*i*B Mate or later	Symbol	Description
R0269.7	DI[1048]	DI[1048]	8_M	Jog Direction Signal 8-
R0270.0	DI[1049]	DI[1049]	9_P	Jog Direction Signal 9+
R0270.1	DI[1050]	DI[1050]	9_M	Jog Direction Signal 9-
R0270.2	DI[1051]	DI[1051]	DIJOGJ	Jog Type: Joint
R0270.3	DI[1052]	DI[1052]	DIJOGX	Jog Type: Coordinate
R0270.4	DI[1053]	DI[1053]		Jog Frame Number 1
R0270.5	DI[1054]	DI[1054]		Jog Frame Number 2
R0270.6	DI[1055]	DI[1055]		Jog Frame Number 3
R0270.7	DI[1056]	DI[1056]		Jog Frame Number 4
R0271.0	GI[5]	GI[5]	HAND1	Hand Operation Type
R0271.1	GI[5]	GI[5]	HAND2	Hand Operation Type
R0271.2	GI[5]	GI[5]	HAND3	Hand Operation Type
R0271.3	GI[5]	GI[5]	HAND4	Hand Operation Type
R0271.4				Ring Counter 1
R0271.5				Ring Counter 2
R0271.6				Ring Counter 3
R0271.7				Ring Counter 4
R0272.0	UI[1]	UI[1]	CIMSTP	UI signal
R0272.1	UI[2]	UI[2]	CHOLD	UI signal
R0272.2	UI[3]	UI[3]	CSFSPD	UI signal
R0272.3	UI[4]	UI[4]	CCSTOP	UI signal
R0272.4	UI[5]	UI[5]	CRESET	UI signal
R0272.5	UI[6]	UI[6]	CSTART	UI signal
R0272.6	UI[7]	UI[7]	CHOME	UI signal
R0272.7	UI[8]	UI[8]	CENABL	UI signal
R0273.0	UI[9]	UI[9]	CPNS1	UI signal
R0273.1	UI[10]	UI[10]	CPNS2	UI signal
R0273.2	UI[11]	UI[11]	CPNS3	UI signal
R0273.3	UI[12]	UI[12]	CPNS4	UI signal
R0273.4	UI[13]	UI[13]	CPNS5	UI signal
R0273.5	UI[14]	UI[14]	CPNS6	UI signal
R0273.6	UI[15]	UI[15]	CPNS7	UI signal
R0273.7	UI[16]	UI[16]	CPNS8	UI signal
R0274.0	UI[17]	UI[17]	CPNSTR	UI signal
R0274.1	UI[18]	UI[18]	CPRDRN	UI signal
R0274.2	UI[19]	UI[19]		UI signal
R0274.3	UI[20]	UI[20]		UI signal
R0274.4	UI[21]	UI[21]		UI signal
R0274.5	UI[22]	UI[22]		UI signal
R0274.6	UI[23]	UI[23]		UI signal
R0274.7	UI[24]	UI[24]		UI signal
R0275.0				Queue 1.1
R0275.1				Queue 1.2
R0275.2				Queue 1.3
R0275.3				Queue 1.4
R0275.4				Queue 2.1
R0275.5				Queue 2.2
R0275.6				Queue 2.3
R0275.7				Queue 2.4

Address	Related signal R-30*i*A R-30*i*A Mate	Related signal R-30*i*B / R-30*i*B Mate or later	Symbol	Description
R0276.0				Queue 3.1
R0276.1				Queue 3.2
R0276.2				Queue 3.3
R0276.3				Queue 3.4
R0276.4				Queue 4.1
R0276.5				Queue 4.2
R0276.6				Queue 4.3
R0276.7				Queue 4.4
R0277.0				Requested program from CNC1 is running.
R0277.1				Requested program from CNC2 is running.
R0277.2				Requested program from CNC3 is running.
R0277.3				Requested program from CNC4 is running.
R0277.4				Shift 1
R0277.5				Shift 2
R0277.6				Shift 3
R0277.7				Shift 4
R0278.0	UO[1]	UO[1]		UO signal
R0278.1	UO[2]	UO[2]		UO signal
R0278.2	UO[3]	UO[3]		UO signal
R0278.3	UO[4]	UO[4]		UO signal
R0278.4	UO[5]	UO[5]		UO signal
R0278.5	UO[6]	UO[6]		UO signal
R0278.6	UO[7]	UO[7]		UO signal
R0278.7	UO[8]	UO[8]		UO signal
R0279.0	UO[9]	UO[9]		UO signal
R0279.1	UO[10]	UO[10]		UO signal
R0279.2	UO[11]	UO[11]		UO signal
R0279.3	UO[12]	UO[12]		UO signal
R0279.4	UO[13]	UO[13]		UO signal
R0279.5	UO[14]	UO[14]		UO signal
R0279.6	UO[15]	UO[15]		UO signal
R0279.7	UO[16]	UO[16]		UO signal
R0280.0	UO[17]	UO[17]		UO signal
R0280.1	UO[18]	UO[18]		UO signal
R0280.2	UO[19]	UO[19]		UO signal
R0280.3	UO[20]	UO[20]		UO signal
R0280.4				UO signal
R0280.5				UO signal
R0280.6				UO signal
R0280.7				UO signal
R0281.0			MTOSHB	Heart Beat signal Input
R0281.1				This relay is internally used to detect Heart Beat.
R0281.2			MTOSPL	This relay is internally used to detect Heart Beat.
R0281.3				This relay is internally used to detect Heart Beat.
R0281.4				This relay is internally used to detect Heart Beat.
R0281.5			MTOSTO	This relay is internally used to detect Heart Beat.
R0281.6				This relay is internally used to detect Heart Beat.
R0281.7			MTOSAL	Heart Beat Alive
R0282.0				PNS number

Address	Related signal R-30*i*A R-30*i*A Mate	Related signal R-30*i*B / R-30*i*B Mate or later	Symbol	Description
R0282.1				PNS number
R0282.2				PNS number
R0282.3				PNS number
R0282.4				PNS number
R0282.5				PNS number
R0282.6				PNS number
R0282.7				PNS number
R0283.0			TM1	Generation of T1
R0283.1			TM2	Generation of T2
R0283.2			TM3	Generation of T3
R0283.3			TM4	Generation of T4
R0283.4			TM5	Generation of T5
R0283.5			TM6	Generation of T6
R0283.6			TM7	Generation of T7
R0283.7				
R0284.0				Internal state of HOME POSITION RETURN operation
R0284.1			T241	Internal state of HOME POSITION RETURN operation
R0284.2				Internal state of HOME POSITION RETURN operation
R0284.3				Internal state of HOME POSITION RETURN operation
R0284.4			T242	Internal state of HOME POSITION RETURN operation
R0284.5				Internal state of HOME POSITION RETURN operation
R0284.6				Internal state of HOME POSITION RETURN operation
R0284.7			T244	Internal state of HOME POSITION RETURN operation
R0285.0				Internal state of HOME POSITION RETURN operation
R0285.1				Internal state of HOME POSITION RETURN operation
R0285.2			T243	Internal state of HOME POSITION RETURN operation
R0285.3				Internal state of HOME POSITION RETURN operation
R0285.4			S6	Other Program running (S6)
R0285.5				Delay after entry of S5
R0285.6				
R0285.7				
R0286.0			OVR1	GO1 (Override)
R0286.1			OVR2	GO1 (Override)
R0286.2			OVR3	GO1 (Override)
R0286.3			OVR4	GO1 (Override)
R0286.4			OVR5	GO1 (Override)
R0286.5			OVR6	GO1 (Override)
R0286.6			OVR7	GO1 (Override)
R0286.7			OVR8	GO1 (Override)
R0287.0			C1ACK	CNC1 ACK
R0287.1			C1NAK	CNC1 NAK
R0287.2			C2ACK	CNC2 ACK
R0287.3			C2NAK	CNC2 NAK
R0287.4			C3ACK	CNC3 ACK
R0287.5			C3NAK	CNC3 NAK
R0287.6			C4ACK	CNC4 ACK
R0287.7			C4NAK	CNC4 NAK
R0288.0				Making a pulse from Program Call from CNC1
R0288.1			TC1PRG	Making a pulse from Program Call from CNC1

Address	Related signal R-30*i*A R-30*i*A Mate	Related signal R-30*i*B / R-30*i*B Mate or later	Symbol	Description
R0288.2				Making a pulse from Program Call from CNC1
R0288.3			TC1IDL	Transition to turn PRGC1 OFF
R0288.4				Making a pulse from Program Call from CNC2
R0288.5			TC2PRG	Making a pulse from Program Call from CNC2
R0288.6				Making a pulse from Program Call from CNC2
R0288.7			TC2IDL	Transition to turn PRGC2 OFF
R0289.0				Making a pulse from Program Call from CNC3
R0289.1			TC3PRG	Making a pulse from Program Call from CNC3
R0289.2				Making a pulse from Program Call from CNC3
R0289.3			TC3IDL	Transition to turn PRGC3 OFF
R0289.4				Making a pulse from Program Call from CNC4
R0289.5			TC4PRG	Making a pulse from Program Call from CNC4
R0289.6				Making a pulse from Program Call from CNC4
R0289.7			TC4IDL	Transition to turn PRGC4 OFF
R0290.0			INVKTO	Timer for SNACK
R0290.1				A pulse to PROD_RUN.
R0290.2			CSTPOF	A pulse to CSTOPI.
R0290.3				Timer for PGRUNC
R0290.4			RTNRQ1	Program Running State 1
R0290.5			RTNRQ2	Program Running State 2
R0290.6			RTNRQ3	Program Running State 3
R0290.7			RTNRQ4	Program Running State 4
R0291.0			C1RTN1	Program Reply 1
R0291.1			C1RTN2	Program Reply 1
R0291.2			C1RTN3	Program Reply 1
R0291.3			C1RTN4	Program Reply 1
R0291.4			C1RTN5	Program Reply 1
R0291.5			C1RTN6	Program Reply 1
R0291.6			C1RTN7	Program Reply 1
R0291.7			C1RTN8	Program Reply 1
R0292.0			C2RTN1	Program Reply 2
R0292.1			C2RTN2	Program Reply 2
R0292.2			C2RTN3	Program Reply 2
R0292.3			C2RTN4	Program Reply 2
R0292.4			C2RTN5	Program Reply 2
R0292.5			C2RTN6	Program Reply 2
R0292.6			C2RTN7	Program Reply 2
R0292.7			C2RTN8	Program Reply 2
R0293.0			C3RTN1	Program Reply 3
R0293.1			C3RTN2	Program Reply 3
R0293.2			C3RTN3	Program Reply 3
R0293.3			C3RTN4	Program Reply 3
R0293.4			C3RTN5	Program Reply 3
R0293.5			C3RTN6	Program Reply 3
R0293.6			C3RTN7	Program Reply 3
R0293.7			C3RTN8	Program Reply 3
R0294.0			C4RTN1	Program Reply 4
R0294.1			C4RTN2	Program Reply 4
R0294.2			C4RTN3	Program Reply 4

Address	Related signal R-30*i*A R-30*i*A Mate	Related signal R-30*i*B / R-30*i*B Mate or later	Symbol	Description
R0294.3			C4RTN4	Program Reply 4
R0294.4			C4RTN5	Program Reply 4
R0294.5			C4RTN6	Program Reply 4
R0294.6			C4RTN7	Program Reply 4
R0294.7			C4RTN8	Program Reply 4

Table 10.10(b) shows the list of internal relays used for DI and DO signals. Left side of this table shows addresses of internal relays for CNC1 and DI/DO signals and description. Internal relays and DI/DO signals for CNC2~CNC4 are shown on the right side.

Table 10.10(b) Usage of internal relays (DI/DO buffer)

Address	Signal	Description	CNC2		CNC3		CNC4	
R0000.0	DI[1]	*IMSTP	R0064.0	DI[257]	R0128.0	DI[513]	R0192.0	DI[769]
R0000.1	DI[2]	*Hold	R0064.1	DI[258]	R0128.1	DI[514]	R0192.1	DI[770]
R0000.2	DI[3]	*SFSPD	R0064.2	DI[259]	R0128.2	DI[515]	R0192.2	DI[771]
R0000.3	DI[4]	Cycle stop	R0064.3	DI[260]	R0128.3	DI[516]	R0192.3	DI[772]
R0000.4	DI[5]	Fault reset	R0065.4	DI[261]	R0129.4	DI[517]	R0193.4	DI[773]
R0000.5	DI[6]	Start	R0065.5	DI[262]	R0129.5	DI[518]	R0193.5	DI[774]
R0000.6	DI[7]	Home	R0065.6	DI[263]	R0129.6	DI[519]	R0193.6	DI[775]
R0000.7	DI[8]	Enable	R0065.7	DI[264]	R0129.7	DI[520]	R0193.7	DI[776]
R0001.0	DI[9]	PNS1	R0065.0	DI[265]	R0129.0	DI[521]	R0193.0	DI[777]
R0001.1	DI[10]	PNS2	R0065.1	DI[266]	R0129.1	DI[522]	R0193.1	DI[778]
R0001.2	DI[11]	PNS3	R0065.2	DI[267]	R0129.2	DI[523]	R0193.2	DI[779]
R0001.3	DI[12]	PNS4	R0065.3	DI[268]	R0129.3	DI[524]	R0193.3	DI[780]
R0001.4	DI[13]	PNS5	R0066.4	DI[269]	R0130.4	DI[525]	R0194.4	DI[781]
R0001.5	DI[14]	PNS6	R0066.5	DI[270]	R0130.5	DI[526]	R0194.5	DI[782]
R0001.6	DI[15]	PNS7	R0066.6	DI[271]	R0130.6	DI[527]	R0194.6	DI[783]
R0001.7	DI[16]	PNS8	R0066.7	DI[272]	R0130.7	DI[528]	R0194.7	DI[784]
R0002.0	DI[17]	PNS strobe	R0066.0	DI[273]	R0130.0	DI[529]	R0194.0	DI[785]
R0002.1	DI[18]	Prod start	R0066.1	DI[274]	R0130.1	DI[530]	R0194.1	DI[786]
R0002.2			R0066.2		R0130.2		R0194.2	
R0002.3			R0066.3		R0130.3		R0194.3	
R0002.4			R0067.4		R0131.4		R0195.4	
R0002.5			R0067.5		R0131.5		R0195.5	
R0002.6			R0067.6		R0131.6		R0195.6	
R0002.7			R0067.7		R0131.7		R0195.7	
R0003.0	DI[25]	Service Type 1	R0067.0	DI[281]	R0131.0	DI[537]	R0195.0	DI[793]
R0003.1	DI[26]	Service Type 2	R0067.1	DI[282]	R0131.1	DI[538]	R0195.1	DI[794]
R0003.2	DI[27]	Service Type 3	R0067.2	DI[283]	R0131.2	DI[539]	R0195.2	DI[795]
R0003.3	DI[28]	Service Type 4	R0067.3	DI[284]	R0131.3	DI[540]	R0195.3	DI[796]
R0003.4	DI[29]	Hand Operation Type 1	R0068.4	DI[285]	R0132.4	DI[541]	R0196.4	DI[797]
R0003.5	DI[30]	Hand Operation Type 2	R0068.5	DI[286]	R0132.5	DI[542]	R0196.5	DI[798]
R0003.6	DI[31]	Hand Operation Type 3	R0068.6	DI[287]	R0132.6	DI[543]	R0196.6	DI[799]
R0003.7	DI[32]	Hand Operation Type 4	R0068.7	DI[288]	R0132.7	DI[544]	R0196.7	DI[800]
R0004.0	DI[33]	CNC Power ON	R0068.0	DI[289]	R0132.0	DI[545]	R0196.0	DI[801]
R0004.1	DI[34]	Interlock Mode	R0068.1	DI[290]	R0132.1	DI[546]	R0196.1	DI[802]
R0004.2	DI[35]	Program Call	R0068.2	DI[291]	R0132.2	DI[547]	R0196.2	DI[803]
R0004.3	DI[36]	Remote Operation Request	R0068.3	DI[292]	R0132.3	DI[548]	R0196.3	DI[804]

Address	Signal	Description	CNC2		CNC3		CNC4	
R0004.4	DI[37]	Remote Operation Run	R0069.4	DI[293]	R0133.4	DI[549]	R0197.4	DI[805]
R0004.5	DI[38]	Override Up	R0069.5	DI[294]	R0133.5	DI[550]	R0197.5	DI[806]
R0004.6	DI[39]	Override Down	R0069.6	DI[295]	R0133.6	DI[551]	R0197.6	DI[807]
R0004.7	DI[40]	Joint Jog Selection	R0069.7	DI[296]	R0133.7	DI[552]	R0197.7	DI[808]
R0005.0	DI[41]	Direction for Joint Jog (J1+)	R0069.0	DI[297]	R0133.0	DI[553]	R0197.0	DI[809]
R0005.1	DI[42]	Direction for Joint Jog (J1-)	R0069.1	DI[298]	R0133.1	DI[554]	R0197.1	DI[810]
R0005.2	DI[43]	Direction for Joint Jog (J2+)	R0069.2	DI[299]	R0133.2	DI[555]	R0197.2	DI[811]
R0005.3	DI[44]	Direction for Joint Jog (J2-)	R0069.3	DI[300]	R0133.3	DI[556]	R0197.3	DI[812]
R0005.4	DI[45]	Direction for Joint Jog (J3+)	R0070.4	DI[301]	R0134.4	DI[557]	R0198.4	DI[813]
R0005.5	DI[46]	Direction for Joint Jog (J3-)	R0070.5	DI[302]	R0134.5	DI[558]	R0198.5	DI[814]
R0005.6	DI[47]	Direction for Joint Jog (J4+)	R0070.6	DI[303]	R0134.6	DI[559]	R0198.6	DI[815]
R0005.7	DI[48]	Direction for Joint Jog (J4-)	R0070.7	DI[304]	R0134.7	DI[560]	R0198.7	DI[816]
R0006.0	DI[49]	Direction for Joint Jog (J5+)	R0070.0	DI[305]	R0134.0	DI[561]	R0198.0	DI[817]
R0006.1	DI[50]	Direction for Joint Jog (J5-)	R0070.1	DI[306]	R0134.1	DI[562]	R0198.1	DI[818]
R0006.2	DI[51]	Direction for Joint Jog (J6+)	R0070.2	DI[307]	R0134.2	DI[563]	R0198.2	DI[819]
R0006.3	DI[52]	Direction for Joint Jog (J6-)	R0070.3	DI[308]	R0134.3	DI[564]	R0198.3	DI[820]
R0006.4	DI[53]	Direction for Coordinate Jog (X+)	R0071.4	DI[309]	R0135.4	DI[565]	R0199.4	DI[821]
R0006.5	DI[54]	Direction for Coordinate Jog (X-)	R0071.5	DI[310]	R0135.5	DI[566]	R0199.5	DI[822]
R0006.6	DI[55]	Direction for Coordinate Jog (Y+)	R0071.6	DI[311]	R0135.6	DI[567]	R0199.6	DI[823]
R0006.7	DI[56]	Direction for Coordinate Jog (Y-)	R0071.7	DI[312]	R0135.7	DI[568]	R0199.7	DI[824]
R0007.0	DI[57]	Direction for Coordinate Jog (Z+)	R0071.0	DI[313]	R0135.0	DI[569]	R0199.0	DI[825]
R0007.1	DI[58]	Direction for Coordinate Jog (Z-)	R0071.1	DI[314]	R0135.1	DI[570]	R0199.1	DI[826]
R0007.2	DI[59]	Home Position Return	R0071.2	DI[315]	R0135.2	DI[571]	R0199.2	DI[827]
R0007.3	DI[60]		R0071.3	DI[316]	R0135.3	DI[572]	R0199.3	DI[828]
R0007.4	DI[61]		R0072.4	DI[317]	R0136.4	DI[573]	R0200.4	DI[829]
R0007.5	DI[62]		R0072.5	DI[318]	R0136.5	DI[574]	R0200.5	DI[830]
R0007.6	DI[63]		R0072.6	DI[319]	R0136.6	DI[575]	R0200.6	DI[831]
R0007.7	DI[64]		R0072.7	DI[320]	R0136.7	DI[576]	R0200.7	DI[832]
R0008.0	DI[65]		R0072.0	DI[321]	R0136.0	DI[577]	R0200.0	DI[833]
R0008.1	DI[66]		R0072.1	DI[322]	R0136.1	DI[578]	R0200.1	DI[834]
R0008.2	DI[67]		R0072.2	DI[323]	R0136.2	DI[579]	R0200.2	DI[835]
R0008.3	DI[68]		R0072.3	DI[324]	R0136.3	DI[580]	R0200.3	DI[836]
R0008.4	DI[69]		R0073.4	DI[325]	R0137.4	DI[581]	R0201.4	DI[837]
R0008.5	DI[70]		R0073.5	DI[326]	R0137.5	DI[582]	R0201.5	DI[838]
R0008.6	DI[71]		R0073.6	DI[327]	R0137.6	DI[583]	R0201.6	DI[839]
R0008.7	DI[72]		R0073.7	DI[328]	R0137.7	DI[584]	R0201.7	DI[840]

Address	Signal	Description	CNC2		CNC3		CNC4	
R0009.0	DI[73]		R0073.0	DI[329]	R0137.0	DI[585]	R0201.0	DI[841]
R0009.1	DI[74]		R0073.1	DI[330]	R0137.1	DI[586]	R0201.1	DI[842]
R0009.2	DI[75]		R0073.2	DI[331]	R0137.2	DI[587]	R0201.2	DI[843]
R0009.3	DI[76]		R0073.3	DI[332]	R0137.3	DI[588]	R0201.3	DI[844]
R0009.4	DI[77]		R0074.4	DI[333]	R0138.4	DI[589]	R0202.4	DI[845]
R0009.5	DI[78]		R0074.5	DI[334]	R0138.5	DI[590]	R0202.5	DI[846]
R0009.6	DI[79]		R0074.6	DI[335]	R0138.6	DI[591]	R0202.6	DI[847]
R0009.7	DI[80]		R0074.7	DI[336]	R0138.7	DI[592]	R0202.7	DI[848]
R0010.0	DI[81]	Response of Peripheral Device 1	R0074.0	DI[337]	R0138.0	DI[593]	R0202.0	DI[849]
R0010.1	DI[82]	Response of Peripheral Device 2	R0074.1	DI[338]	R0138.1	DI[594]	R0202.1	DI[850]
R0010.2	DI[83]	Response of Peripheral Device 3	R0074.2	DI[339]	R0138.2	DI[595]	R0202.2	DI[851]
R0010.3	DI[84]	Response of Peripheral Device 4	R0074.3	DI[340]	R0138.3	DI[596]	R0202.3	DI[852]
R0010.4	DI[85]	Response of Peripheral Device 5	R0075.4	DI[341]	R0139.4	DI[597]	R0203.4	DI[853]
R0010.5	DI[86]	Response of Peripheral Device 6	R0075.5	DI[342]	R0139.5	DI[598]	R0203.5	DI[854]
R0010.6	DI[87]	Response of Peripheral Device 7	R0075.6	DI[343]	R0139.6	DI[599]	R0203.6	DI[855]
R0010.7	DI[88]	Response of Peripheral Device 8	R0075.7	DI[344]	R0139.7	DI[600]	R0203.7	DI[856]
R0011.0	DI[89]	Response of Peripheral Device 9	R0075.0	DI[345]	R0139.0	DI[601]	R0203.0	DI[857]
R0011.1	DI[90]	Response of Peripheral Device 10	R0075.1	DI[346]	R0139.1	DI[602]	R0203.1	DI[858]
R0011.2	DI[91]	Response of Peripheral Device 11	R0075.2	DI[347]	R0139.2	DI[603]	R0203.2	DI[859]
R0011.3	DI[92]	Response of Peripheral Device 12	R0075.3	DI[348]	R0139.3	DI[604]	R0203.3	DI[860]
R0011.4	DI[93]	Response of Peripheral Device 13	R0076.4	DI[349]	R0140.4	DI[605]	R0204.4	DI[861]
R0011.5	DI[94]	Response of Peripheral Device 14	R0076.5	DI[350]	R0140.5	DI[606]	R0204.5	DI[862]
R0011.6	DI[95]	Response of Peripheral Device 15	R0076.6	DI[351]	R0140.6	DI[607]	R0204.6	DI[863]
R0011.7	DI[96]	Response of Peripheral Device 16	R0076.7	DI[352]	R0140.7	DI[608]	R0204.7	DI[864]
R0012.0	DI[97]	Production System Response 1	R0076.0	DI[353]	R0140.0	DI[609]	R0204.0	DI[865]
R0012.1	DI[98]	Production System Response 2	R0076.1	DI[354]	R0140.1	DI[610]	R0204.1	DI[866]
R0012.2	DI[99]	Production System Response 3	R0076.2	DI[355]	R0140.2	DI[611]	R0204.2	DI[867]
R0012.3	DI[100]	Production System Response 4	R0076.3	DI[356]	R0140.3	DI[612]	R0204.3	DI[868]
R0012.4	DI[101]	Input of Production System Operation 1	R0077.4	DI[357]	R0141.4	DI[613]	R0205.4	DI[869]
R0012.5	DI[102]	Input of Production System Operation 2	R0077.5	DI[358]	R0141.5	DI[614]	R0205.5	DI[870]
R0012.6	DI[103]	Input of Production System Operation 3	R0077.6	DI[359]	R0141.6	DI[615]	R0205.6	DI[871]

Address	Signal	Description	CNC2		CNC3		CNC4	
R0012.7	DI[104]	Input of Production System Operation 4	R0077.7	DI[360]	R0141.7	DI[616]	R0205.7	DI[872]
R0013.0	DI[105]	Robot Entry Approval	R0077.0	DI[361]	R0141.0	DI[617]	R0205.0	DI[873]
R0013.1	DI[106]	Service Call	R0077.1	DI[362]	R0141.1	DI[618]	R0205.1	DI[874]
R0013.2	DI[107]	Machine Alarm	R0077.2	DI[363]	R0141.2	DI[619]	R0205.2	DI[875]
R0013.3	DI[108]	Door Open	R0077.3	DI[364]	R0141.3	DI[620]	R0205.3	DI[876]
R0013.4	DI[109]	Door Close	R0078.4	DI[365]	R0142.4	DI[621]	R0206.4	DI[877]
R0013.5	DI[110]	Part Change Position	R0078.5	DI[366]	R0142.5	DI[622]	R0206.5	DI[878]
R0013.6	DI[111]		R0078.6	DI[367]	R0142.6	DI[623]	R0206.6	DI[879]
R0013.7	DI[112]		R0078.7	DI[368]	R0142.7	DI[624]	R0206.7	DI[880]
R0014.0	DI[113]		R0078.0	DI[369]	R0142.0	DI[625]	R0206.0	DI[881]
R0014.1	DI[114]		R0078.1	DI[370]	R0142.1	DI[626]	R0206.1	DI[882]
R0014.2	DI[115]		R0078.2	DI[371]	R0142.2	DI[627]	R0206.2	DI[883]
R0014.3	DI[116]		R0078.3	DI[372]	R0142.3	DI[628]	R0206.3	DI[884]
R0014.4	DI[117]		R0079.4	DI[373]	R0143.4	DI[629]	R0207.4	DI[885]
R0014.5	DI[118]		R0079.5	DI[374]	R0143.5	DI[630]	R0207.5	DI[886]
R0014.6	DI[119]		R0079.6	DI[375]	R0143.6	DI[631]	R0207.6	DI[887]
R0014.7	DI[120]		R0079.7	DI[376]	R0143.7	DI[632]	R0207.7	DI[888]
R0015.0	DI[121]	Machine Operation Enable Status	R0079.0	DI[377]	R0143.0	DI[633]	R0207.0	DI[889]
R0015.1	DI[122]	Machine Operation Enable Request Reject	R0079.1	DI[378]	R0143.1	DI[634]	R0207.1	DI[890]
R0015.2	DI[123]	Machine Operation Request Reject Code 0	R0079.2	DI[379]	R0143.2	DI[635]	R0207.2	DI[891]
R0015.3	DI[124]	Machine Operation Request Reject Code 1	R0079.3	DI[380]	R0143.3	DI[636]	R0207.3	DI[892]
R0015.4	DI[125]	Machine Operation Request Reject Code 2	R0080.4	DI[381]	R0144.4	DI[637]	R0208.4	DI[893]
R0015.5	DI[126]	Machine Operation Request Reject Code 3	R0080.5	DI[382]	R0144.5	DI[638]	R0208.5	DI[894]
R0015.6	DI[127]		R0080.6	DI[383]	R0144.6	DI[639]	R0208.6	DI[895]
R0015.7	DI[128]		R0080.7	DI[384]	R0144.7	DI[640]	R0208.7	DI[896]
R0016.0	DI[129]		R0080.0	DI[385]	R0144.0	DI[641]	R0208.0	DI[897]
R0016.1	DI[130]		R0080.1	DI[386]	R0144.1	DI[642]	R0208.1	DI[898]
R0016.2	DI[131]		R0080.2	DI[387]	R0144.2	DI[643]	R0208.2	DI[899]
R0016.3	DI[132]		R0080.3	DI[388]	R0144.3	DI[644]	R0208.3	DI[900]
R0016.4	DI[133]		R0081.4	DI[389]	R0145.4	DI[645]	R0209.4	DI[901]
R0016.5	DI[134]		R0081.5	DI[390]	R0145.5	DI[646]	R0209.5	DI[902]
R0016.6	DI[135]		R0081.6	DI[391]	R0145.6	DI[647]	R0209.6	DI[903]
R0016.7	DI[136]		R0081.7	DI[392]	R0145.7	DI[648]	R0209.7	DI[904]
R0017.0	DI[137]		R0081.0	DI[393]	R0145.0	DI[649]	R0209.0	DI[905]
R0017.1	DI[138]		R0081.1	DI[394]	R0145.1	DI[650]	R0209.1	DI[906]
R0017.2	DI[139]		R0081.2	DI[395]	R0145.2	DI[651]	R0209.2	DI[907]
R0017.3	DI[140]		R0081.3	DI[396]	R0145.3	DI[652]	R0209.3	DI[908]
R0017.4	DI[141]		R0082.4	DI[397]	R0146.4	DI[653]	R0210.4	DI[909]
R0017.5	DI[142]		R0082.5	DI[398]	R0146.5	DI[654]	R0210.5	DI[910]
R0017.6	DI[143]		R0082.6	DI[399]	R0146.6	DI[655]	R0210.6	DI[911]
R0017.7	DI[144]		R0082.7	DI[400]	R0146.7	DI[656]	R0210.7	DI[912]
R0018.0	DI[145]		R0082.0	DI[401]	R0146.0	DI[657]	R0210.0	DI[913]
R0018.1	DI[146]		R0082.1	DI[402]	R0146.1	DI[658]	R0210.1	DI[914]
R0018.2	DI[147]		R0082.2	DI[403]	R0146.2	DI[659]	R0210.2	DI[915]
R0018.3	DI[148]		R0082.3	DI[404]	R0146.3	DI[660]	R0210.3	DI[916]
R0018.4	DI[149]		R0083.4	DI[405]	R0147.4	DI[661]	R0211.4	DI[917]
R0018.5	DI[150]		R0083.5	DI[406]	R0147.5	DI[662]	R0211.5	DI[918]

Address	Signal	Description	CNC2		CNC3		CNC4	
R0018.6	DI[151]		R0083.6	DI[407]	R0147.6	DI[663]	R0211.6	DI[919]
R0018.7	DI[152]		R0083.7	DI[408]	R0147.7	DI[664]	R0211.7	DI[920]
R0019.0	DI[153]		R0083.0	DI[409]	R0147.0	DI[665]	R0211.0	DI[921]
R0019.1	DI[154]		R0083.1	DI[410]	R0147.1	DI[666]	R0211.1	DI[922]
R0019.2	DI[155]		R0083.2	DI[411]	R0147.2	DI[667]	R0211.2	DI[923]
R0019.3	DI[156]		R0083.3	DI[412]	R0147.3	DI[668]	R0211.3	DI[924]
R0019.4	DI[157]		R0084.4	DI[413]	R0148.4	DI[669]	R0212.4	DI[925]
R0019.5	DI[158]		R0084.5	DI[414]	R0148.5	DI[670]	R0212.5	DI[926]
R0019.6	DI[159]		R0084.6	DI[415]	R0148.6	DI[671]	R0212.6	DI[927]
R0019.7	DI[160]		R0084.7	DI[416]	R0148.7	DI[672]	R0212.7	DI[928]
R0020.0	DI[161]		R0084.0	DI[417]	R0148.0	DI[673]	R0212.0	DI[929]
R0020.1	DI[162]		R0084.1	DI[418]	R0148.1	DI[674]	R0212.1	DI[930]
R0020.2	DI[163]		R0084.2	DI[419]	R0148.2	DI[675]	R0212.2	DI[931]
R0020.3	DI[164]		R0084.3	DI[420]	R0148.3	DI[676]	R0212.3	DI[932]
R0020.4	DI[165]		R0085.4	DI[421]	R0149.4	DI[677]	R0213.4	DI[933]
R0020.5	DI[166]		R0085.5	DI[422]	R0149.5	DI[678]	R0213.5	DI[934]
R0020.6	DI[167]		R0085.6	DI[423]	R0149.6	DI[679]	R0213.6	DI[935]
R0020.7	DI[168]		R0085.7	DI[424]	R0149.7	DI[680]	R0213.7	DI[936]
R0021.0	DI[169]		R0085.0	DI[425]	R0149.0	DI[681]	R0213.0	DI[937]
R0021.1	DI[170]		R0085.1	DI[426]	R0149.1	DI[682]	R0213.1	DI[938]
R0021.2	DI[171]		R0085.2	DI[427]	R0149.2	DI[683]	R0213.2	DI[939]
R0021.3	DI[172]		R0085.3	DI[428]	R0149.3	DI[684]	R0213.3	DI[940]
R0021.4	DI[173]		R0086.4	DI[429]	R0150.4	DI[685]	R0214.4	DI[941]
R0021.5	DI[174]		R0086.5	DI[430]	R0150.5	DI[686]	R0214.5	DI[942]
R0021.6	DI[175]		R0086.6	DI[431]	R0150.6	DI[687]	R0214.6	DI[943]
R0021.7	DI[176]		R0086.7	DI[432]	R0150.7	DI[688]	R0214.7	DI[944]
R0022.0	DI[177]		R0086.0	DI[433]	R0150.0	DI[689]	R0214.0	DI[945]
R0022.1	DI[178]		R0086.1	DI[434]	R0150.1	DI[690]	R0214.1	DI[946]
R0022.2	DI[179]		R0086.2	DI[435]	R0150.2	DI[691]	R0214.2	DI[947]
R0022.3	DI[180]		R0086.3	DI[436]	R0150.3	DI[692]	R0214.3	DI[948]
R0022.4	DI[181]		R0087.4	DI[437]	R0151.4	DI[693]	R0215.4	DI[949]
R0022.5	DI[182]		R0087.5	DI[438]	R0151.5	DI[694]	R0215.5	DI[950]
R0022.6	DI[183]		R0087.6	DI[439]	R0151.6	DI[695]	R0215.6	DI[951]
R0022.7	DI[184]		R0087.7	DI[440]	R0151.7	DI[696]	R0215.7	DI[952]
R0023.0	DI[185]		R0087.0	DI[441]	R0151.0	DI[697]	R0215.0	DI[953]
R0023.1	DI[186]		R0087.1	DI[442]	R0151.1	DI[698]	R0215.1	DI[954]
R0023.2	DI[187]		R0087.2	DI[443]	R0151.2	DI[699]	R0215.2	DI[955]
R0023.3	DI[188]		R0087.3	DI[444]	R0151.3	DI[700]	R0215.3	DI[956]
R0023.4	DI[189]		R0088.4	DI[445]	R0152.4	DI[701]	R0216.4	DI[957]
R0023.5	DI[190]		R0088.5	DI[446]	R0152.5	DI[702]	R0216.5	DI[958]
R0023.6	DI[191]		R0088.6	DI[447]	R0152.6	DI[703]	R0216.6	DI[959]
R0023.7	DI[192]		R0088.7	DI[448]	R0152.7	DI[704]	R0216.7	DI[960]
R0024.0	DI[193]		R0088.0	DI[449]	R0152.0	DI[705]	R0216.0	DI[961]
R0024.1	DI[194]		R0088.1	DI[450]	R0152.1	DI[706]	R0216.1	DI[962]
R0024.2	DI[195]		R0088.2	DI[451]	R0152.2	DI[707]	R0216.2	DI[963]
R0024.3	DI[196]		R0088.3	DI[452]	R0152.3	DI[708]	R0216.3	DI[964]
R0024.4	DI[197]		R0089.4	DI[453]	R0153.4	DI[709]	R0217.4	DI[965]
R0024.5	DI[198]		R0089.5	DI[454]	R0153.5	DI[710]	R0217.5	DI[966]
R0024.6	DI[199]		R0089.6	DI[455]	R0153.6	DI[711]	R0217.6	DI[967]
R0024.7	DI[200]		R0089.7	DI[456]	R0153.7	DI[712]	R0217.7	DI[968]
R0025.0	DI[201]		R0089.0	DI[457]	R0153.0	DI[713]	R0217.0	DI[969]
R0025.1	DI[202]		R0089.1	DI[458]	R0153.1	DI[714]	R0217.1	DI[970]
R0025.2	DI[203]		R0089.2	DI[459]	R0153.2	DI[715]	R0217.2	DI[971]

Address	Signal	Description	CNC2		CNC3		CNC4	
R0025.3	DI[204]		R0089.3	DI[460]	R0153.3	DI[716]	R0217.3	DI[972]
R0025.4	DI[205]		R0090.4	DI[461]	R0154.4	DI[717]	R0218.4	DI[973]
R0025.5	DI[206]		R0090.5	DI[462]	R0154.5	DI[718]	R0218.5	DI[974]
R0025.6	DI[207]		R0090.6	DI[463]	R0154.6	DI[719]	R0218.6	DI[975]
R0025.7	DI[208]		R0090.7	DI[464]	R0154.7	DI[720]	R0218.7	DI[976]
R0026.0	DI[209]		R0090.0	DI[465]	R0154.0	DI[721]	R0218.0	DI[977]
R0026.1	DI[210]		R0090.1	DI[466]	R0154.1	DI[722]	R0218.1	DI[978]
R0026.2	DI[211]		R0090.2	DI[467]	R0154.2	DI[723]	R0218.2	DI[979]
R0026.3	DI[212]		R0090.3	DI[468]	R0154.3	DI[724]	R0218.3	DI[980]
R0026.4	DI[213]		R0091.4	DI[469]	R0155.4	DI[725]	R0219.4	DI[981]
R0026.5	DI[214]		R0091.5	DI[470]	R0155.5	DI[726]	R0219.5	DI[982]
R0026.6	DI[215]		R0091.6	DI[471]	R0155.6	DI[727]	R0219.6	DI[983]
R0026.7	DI[216]		R0091.7	DI[472]	R0155.7	DI[728]	R0219.7	DI[984]
R0027.0	DI[217]		R0091.0	DI[473]	R0155.0	DI[729]	R0219.0	DI[985]
R0027.1	DI[218]		R0091.1	DI[474]	R0155.1	DI[730]	R0219.1	DI[986]
R0027.2	DI[219]		R0091.2	DI[475]	R0155.2	DI[731]	R0219.2	DI[987]
R0027.3	DI[220]		R0091.3	DI[476]	R0155.3	DI[732]	R0219.3	DI[988]
R0027.4	DI[221]		R0092.4	DI[477]	R0156.4	DI[733]	R0220.4	DI[989]
R0027.5	DI[222]		R0092.5	DI[478]	R0156.5	DI[734]	R0220.5	DI[990]
R0027.6	DI[223]		R0092.6	DI[479]	R0156.6	DI[735]	R0220.6	DI[991]
R0027.7	DI[224]		R0092.7	DI[480]	R0156.7	DI[736]	R0220.7	DI[992]
R0028.0	DI[225]		R0092.0	DI[481]	R0156.0	DI[737]	R0220.0	DI[993]
R0028.1	DI[226]		R0092.1	DI[482]	R0156.1	DI[738]	R0220.1	DI[994]
R0028.2	DI[227]		R0092.2	DI[483]	R0156.2	DI[739]	R0220.2	DI[995]
R0028.3	DI[228]		R0092.3	DI[484]	R0156.3	DI[740]	R0220.3	DI[996]
R0028.4	DI[229]		R0093.4	DI[485]	R0157.4	DI[741]	R0221.4	DI[997]
R0028.5	DI[230]		R0093.5	DI[486]	R0157.5	DI[742]	R0221.5	DI[998]
R0028.6	DI[231]		R0093.6	DI[487]	R0157.6	DI[743]	R0221.6	DI[999]
R0028.7	DI[232]		R0093.7	DI[488]	R0157.7	DI[744]	R0221.7	DI[1000]
R0029.0	DI[233]		R0093.0	DI[489]	R0157.0	DI[745]	R0221.0	DI[1001]
R0029.1	DI[234]		R0093.1	DI[490]	R0157.1	DI[746]	R0221.1	DI[1002]
R0029.2	DI[235]		R0093.2	DI[491]	R0157.2	DI[747]	R0221.2	DI[1003]
R0029.3	DI[236]		R0093.3	DI[492]	R0157.3	DI[748]	R0221.3	DI[1004]
R0029.4	DI[237]		R0094.4	DI[493]	R0158.4	DI[749]	R0222.4	DI[1005]
R0029.5	DI[238]		R0094.5	DI[494]	R0158.5	DI[750]	R0222.5	DI[1006]
R0029.6	DI[239]		R0094.6	DI[495]	R0158.6	DI[751]	R0222.6	DI[1007]
R0029.7	DI[240]		R0094.7	DI[496]	R0158.7	DI[752]	R0222.7	DI[1008]
R0030.0	DI[241]		R0094.0	DI[497]	R0158.0	DI[753]	R0222.0	DI[1009]
R0030.1	DI[242]		R0094.1	DI[498]	R0158.1	DI[754]	R0222.1	DI[1010]
R0030.2	DI[243]		R0094.2	DI[499]	R0158.2	DI[755]	R0222.2	DI[1011]
R0030.3	DI[244]		R0094.3	DI[500]	R0158.3	DI[756]	R0222.3	DI[1012]
R0030.4	DI[245]		R0095.4	DI[501]	R0159.4	DI[757]	R0223.4	DI[1013]
R0030.5	DI[246]		R0095.5	DI[502]	R0159.5	DI[758]	R0223.5	DI[1014]
R0030.6	DI[247]		R0095.6	DI[503]	R0159.6	DI[759]	R0223.6	DI[1015]
R0030.7	DI[248]		R0095.7	DI[504]	R0159.7	DI[760]	R0223.7	DI[1016]
R0031.0	DI[249]		R0095.0	DI[505]	R0159.0	DI[761]	R0223.0	DI[1017]
R0031.1	DI[250]		R0095.1	DI[506]	R0159.1	DI[762]	R0223.1	DI[1018]
R0031.2	DI[251]		R0095.2	DI[507]	R0159.2	DI[763]	R0223.2	DI[1019]
R0031.3	DI[252]		R0095.3	DI[508]	R0159.3	DI[764]	R0223.3	DI[1020]
R0031.4	DI[253]		R0096.4	DI[509]	R0160.4	DI[765]	R0224.4	DI[1021]
R0031.5	DI[254]		R0096.5	DI[510]	R0160.5	DI[766]	R0224.5	DI[1022]
R0031.6	DI[255]		R0096.6	DI[511]	R0160.6	DI[767]	R0224.6	DI[1023]
R0031.7	DI[256]		R0096.7	DI[512]	R0160.7	DI[768]	R0224.7	DI[1024]

Address	Signal	Description	CNC2		CNC3		CNC4	
R0032.0	DO[1]	Cmd enabled	R0096.0	DO[257]	R0160.0	DO[513]	R0224.0	DO[769]
R0032.1	DO[2]	System ready	R0096.1	DO[258]	R0160.1	DO[514]	R0224.1	DO[770]
R0032.2	DO[3]	Prg running	R0096.2	DO[259]	R0160.2	DO[515]	R0224.2	DO[771]
R0032.3	DO[4]	Prg paused	R0096.3	DO[260]	R0160.3	DO[516]	R0224.3	DO[772]
R0032.4	DO[5]	Motion held	R0097.4	DO[261]	R0161.4	DO[517]	R0225.4	DO[773]
R0032.5	DO[6]	Fault	R0097.5	DO[262]	R0161.5	DO[518]	R0225.5	DO[774]
R0032.6	DO[7]	At perch	R0097.6	DO[263]	R0161.6	DO[519]	R0225.6	DO[775]
R0032.7	DO[8]	TP enabled	R0097.7	DO[264]	R0161.7	DO[520]	R0225.7	DO[776]
R0033.0	DO[9]	Batt alarm	R0097.0	DO[265]	R0161.0	DO[521]	R0225.0	DO[777]
R0033.1	DO[10]	Busy	R0097.1	DO[266]	R0161.1	DO[522]	R0225.1	DO[778]
R0033.2	DO[11]	SNO1	R0097.2	DO[267]	R0161.2	DO[523]	R0225.2	DO[779]
R0033.3	DO[12]	SNO2	R0097.3	DO[268]	R0161.3	DO[524]	R0225.3	DO[780]
R0033.4	DO[13]	SNO3	R0098.4	DO[269]	R0162.4	DO[525]	R0226.4	DO[781]
R0033.5	DO[14]	SNO4	R0098.5	DO[270]	R0162.5	DO[526]	R0226.5	DO[782]
R0033.6	DO[15]	SNO5	R0098.6	DO[271]	R0162.6	DO[527]	R0226.6	DO[783]
R0033.7	DO[16]	SNO6	R0098.7	DO[272]	R0162.7	DO[528]	R0226.7	DO[784]
R0034.0	DO[17]	SNO7	R0098.0	DO[273]	R0162.0	DO[529]	R0226.0	DO[785]
R0034.1	DO[18]	SNO8	R0098.1	DO[274]	R0162.1	DO[530]	R0226.1	DO[786]
R0034.2	DO[19]	SNACK	R0098.2	DO[275]	R0162.2	DO[531]	R0226.2	DO[787]
R0034.3	DO[20]	Reserved	R0098.3	DO[276]	R0162.3	DO[532]	R0226.3	DO[788]
R0034.4	DO[21]		R0099.4	DO[277]	R0163.4	DO[533]	R0227.4	DO[789]
R0034.5	DO[22]		R0099.5	DO[278]	R0163.5	DO[534]	R0227.5	DO[790]
R0034.6	DO[23]		R0099.6	DO[279]	R0163.6	DO[535]	R0227.6	DO[791]
R0034.7	DO[24]		R0099.7	DO[280]	R0163.7	DO[536]	R0227.7	DO[792]
R0035.0	DO[25]	RI[1]	R0099.0	DO[281]	R0163.0	DO[537]	R0227.0	DO[793]
R0035.1	DO[26]	RI[2]	R0099.1	DO[282]	R0163.1	DO[538]	R0227.1	DO[794]
R0035.2	DO[27]	RI[3]	R0099.2	DO[283]	R0163.2	DO[539]	R0227.2	DO[795]
R0035.3	DO[28]	RI[4]	R0099.3	DO[284]	R0163.3	DO[540]	R0227.3	DO[796]
R0035.4	DO[29]	RI[5]	R0100.4	DO[285]	R0164.4	DO[541]	R0228.4	DO[797]
R0035.5	DO[30]	RI[6]	R0100.5	DO[286]	R0164.5	DO[542]	R0228.5	DO[798]
R0035.6	DO[31]	RI[7]	R0100.6	DO[287]	R0164.6	DO[543]	R0228.6	DO[799]
R0035.7	DO[32]	RI[8]	R0100.7	DO[288]	R0164.7	DO[544]	R0228.7	DO[800]
R0036.0	DO[33]	RO[1]	R0100.0	DO[289]	R0164.0	DO[545]	R0228.0	DO[801]
R0036.1	DO[34]	RO[2]	R0100.1	DO[290]	R0164.1	DO[546]	R0228.1	DO[802]
R0036.2	DO[35]	RO[3]	R0100.2	DO[291]	R0164.2	DO[547]	R0228.2	DO[803]
R0036.3	DO[36]	RO[4]	R0100.3	DO[292]	R0164.3	DO[548]	R0228.3	DO[804]
R0036.4	DO[37]	RO[5]	R0101.4	DO[293]	R0165.4	DO[549]	R0229.4	DO[805]
R0036.5	DO[38]	RO[6]	R0101.5	DO[294]	R0165.5	DO[550]	R0229.5	DO[806]
R0036.6	DO[39]	RO[7]	R0101.6	DO[295]	R0165.6	DO[551]	R0229.6	DO[807]
R0036.7	DO[40]	RO[8]	R0101.7	DO[296]	R0165.7	DO[552]	R0229.7	DO[808]
R0037.0	DO[41]	Override Output 1	R0101.0	DO[297]	R0165.0	DO[553]	R0229.0	DO[809]
R0037.1	DO[42]	Override Output 2	R0101.1	DO[298]	R0165.1	DO[554]	R0229.1	DO[810]
R0037.2	DO[43]	Override Output 3	R0101.2	DO[299]	R0165.2	DO[555]	R0229.2	DO[811]
R0037.3	DO[44]	Override Output 4	R0101.3	DO[300]	R0165.3	DO[556]	R0229.3	DO[812]
R0037.4	DO[45]	Override Output 5	R0102.4	DO[301]	R0166.4	DO[557]	R0230.4	DO[813]
R0037.5	DO[46]	Override Output 6	R0102.5	DO[302]	R0166.5	DO[558]	R0230.5	DO[814]
R0037.6	DO[47]	Override Output 7	R0102.6	DO[303]	R0166.6	DO[559]	R0230.6	DO[815]
R0037.7	DO[48]	Override Output 8	R0102.7	DO[304]	R0166.7	DO[560]	R0230.7	DO[816]
R0038.0	DO[49]	CNC ID Number 1	R0102.0	DO[305]	R0166.0	DO[561]	R0230.0	DO[817]
R0038.1	DO[50]	CNC ID Number 2	R0102.1	DO[306]	R0166.1	DO[562]	R0230.1	DO[818]
R0038.2	DO[51]	CNC ID Number 3	R0102.2	DO[307]	R0166.2	DO[563]	R0230.2	DO[819]
R0038.3	DO[52]	CNC ID Number 4	R0102.3	DO[308]	R0166.3	DO[564]	R0230.3	DO[820]
R0038.4	DO[53]	Access Control 1	R0103.4	DO[309]	R0167.4	DO[565]	R0231.4	DO[821]

Address	Signal	Description	CNC2		CNC3		CNC4	
R0038.5	DO[54]	Access Control 2	R0103.5	DO[310]	R0167.5	DO[566]	R0231.5	DO[822]
R0038.6	DO[55]	Access Control 3	R0103.6	DO[311]	R0167.6	DO[567]	R0231.6	DO[823]
R0038.7	DO[56]	Access Control 4	R0103.7	DO[312]	R0167.7	DO[568]	R0231.7	DO[824]
R0039.0	DO[57]	Program Reply 1	R0103.0	DO[313]	R0167.0	DO[569]	R0231.0	DO[825]
R0039.1	DO[58]	Program Reply 2	R0103.1	DO[314]	R0167.1	DO[570]	R0231.1	DO[826]
R0039.2	DO[59]	Program Reply 3	R0103.2	DO[315]	R0167.2	DO[571]	R0231.2	DO[827]
R0039.3	DO[60]	Program Reply 4	R0103.3	DO[316]	R0167.3	DO[572]	R0231.3	DO[828]
R0039.4	DO[61]	Robot Power On	R0104.4	DO[317]	R0168.4	DO[573]	R0232.4	DO[829]
R0039.5	DO[62]	Maintenance State	R0104.5	DO[318]	R0168.5	DO[574]	R0232.5	DO[830]
R0039.6	DO[63]	Service State	R0104.6	DO[319]	R0168.6	DO[575]	R0232.6	DO[831]
R0039.7	DO[64]	Machine Interlock Mode	R0104.7	DO[320]	R0168.7	DO[576]	R0232.7	DO[832]
R0040.0	DO[65]	Remote Operation Mode	R0104.0	DO[321]	R0168.0	DO[577]	R0232.0	DO[833]
R0040.1	DO[66]	Safety Fence Open	R0104.1	DO[322]	R0168.1	DO[578]	R0232.1	DO[834]
R0040.2	DO[67]	Safety Fence Close	R0104.2	DO[323]	R0168.2	DO[579]	R0232.2	DO[835]
R0040.3	DO[68]	In E.STOP state	R0104.3	DO[324]	R0168.3	DO[580]	R0232.3	DO[836]
R0040.4	DO[69]	Not Ready	R0105.4	DO[325]	R0169.4	DO[581]	R0233.4	DO[837]
R0040.5	DO[70]	Ready	R0105.5	DO[326]	R0169.5	DO[582]	R0233.5	DO[838]
R0040.6	DO[71]	Completed	R0105.6	DO[327]	R0169.6	DO[583]	R0233.6	DO[839]
R0040.7	DO[72]	Jog Feed Operation State	R0105.7	DO[328]	R0169.7	DO[584]	R0233.7	DO[840]
R0041.0	DO[73]	Hand Operation State	R0105.0	DO[329]	R0169.0	DO[585]	R0233.0	DO[841]
R0041.1	DO[74]	Home Position Return state	R0105.1	DO[330]	R0169.1	DO[586]	R0233.1	DO[842]
R0041.2	DO[75]	ACK for Remote Operation Request	R0105.2	DO[331]	R0169.2	DO[587]	R0233.2	DO[843]
R0041.3	DO[76]	NAK for Remote Operation Request	R0105.3	DO[332]	R0169.3	DO[588]	R0233.3	DO[844]
R0041.4	DO[77]		R0106.4	DO[333]	R0170.4	DO[589]	R0234.4	DO[845]
R0041.5	DO[78]		R0106.5	DO[334]	R0170.5	DO[590]	R0234.5	DO[846]
R0041.6	DO[79]		R0106.6	DO[335]	R0170.6	DO[591]	R0234.6	DO[847]
R0041.7	DO[80]		R0106.7	DO[336]	R0170.7	DO[592]	R0234.7	DO[848]
R0042.0	DO[81]	Command to Peripheral Device 1	R0106.0	DO[337]	R0170.0	DO[593]	R0234.0	DO[849]
R0042.1	DO[82]	Command to Peripheral Device 2	R0106.1	DO[338]	R0170.1	DO[594]	R0234.1	DO[850]
R0042.2	DO[83]	Command to Peripheral Device 3	R0106.2	DO[339]	R0170.2	DO[595]	R0234.2	DO[851]
R0042.3	DO[84]	Command to Peripheral Device 4	R0106.3	DO[340]	R0170.3	DO[596]	R0234.3	DO[852]
R0042.4	DO[85]	Command to Peripheral Device 5	R0107.4	DO[341]	R0171.4	DO[597]	R0235.4	DO[853]
R0042.5	DO[86]	Command to Peripheral Device 6	R0107.5	DO[342]	R0171.5	DO[598]	R0235.5	DO[854]
R0042.6	DO[87]	Command to Peripheral Device 7	R0107.6	DO[343]	R0171.6	DO[599]	R0235.6	DO[855]
R0042.7	DO[88]	Command to Peripheral Device 8	R0107.7	DO[344]	R0171.7	DO[600]	R0235.7	DO[856]
R0043.0	DO[89]	Command to Peripheral Device 9	R0107.0	DO[345]	R0171.0	DO[601]	R0235.0	DO[857]
R0043.1	DO[90]	Command to Peripheral Device 10	R0107.1	DO[346]	R0171.1	DO[602]	R0235.1	DO[858]
R0043.2	DO[91]	Command to Peripheral Device 11	R0107.2	DO[347]	R0171.2	DO[603]	R0235.2	DO[859]

Address	Signal	Description	CNC2		CNC3		CNC4	
R0043.3	DO[92]	Command to Peripheral Device 12	R0107.3	DO[348]	R0171.3	DO[604]	R0235.3	DO[860]
R0043.4	DO[93]	Command to Peripheral Device 13	R0108.4	DO[349]	R0172.4	DO[605]	R0236.4	DO[861]
R0043.5	DO[94]	Command to Peripheral Device 14	R0108.5	DO[350]	R0172.5	DO[606]	R0236.5	DO[862]
R0043.6	DO[95]	Command to Peripheral Device 15	R0108.6	DO[351]	R0172.6	DO[607]	R0236.6	DO[863]
R0043.7	DO[96]	Command to Peripheral Device 16	R0108.7	DO[352]	R0172.7	DO[608]	R0236.7	DO[864]
R0044.0	DO[97]	Production Operation 1	R0108.0	DO[353]	R0172.0	DO[609]	R0236.0	DO[865]
R0044.1	DO[98]	Production Operation 2	R0108.1	DO[354]	R0172.1	DO[610]	R0236.1	DO[866]
R0044.2	DO[99]	Production Operation 3	R0108.2	DO[355]	R0172.2	DO[611]	R0236.2	DO[867]
R0044.3	DO[100]	Production Operation 4	R0108.3	DO[356]	R0172.3	DO[612]	R0236.3	DO[868]
R0044.4	DO[101]	Output of Production System Response 1	R0109.4	DO[357]	R0173.4	DO[613]	R0237.4	DO[869]
R0044.5	DO[102]	Output of Production System Response 2	R0109.5	DO[358]	R0173.5	DO[614]	R0237.5	DO[870]
R0044.6	DO[103]	Output of Production System Response 3	R0109.6	DO[359]	R0173.6	DO[615]	R0237.6	DO[871]
R0044.7	DO[104]	Output of Production System Response 4	R0109.7	DO[360]	R0173.7	DO[616]	R0237.7	DO[872]
R0045.0	DO[105]	*Robot Entry	R0109.0	DO[361]	R0173.0	DO[617]	R0237.0	DO[873]
R0045.1	DO[106]	Service Completed	R0109.1	DO[362]	R0173.1	DO[618]	R0237.1	DO[874]
R0045.2	DO[107]		R0109.2	DO[363]	R0173.2	DO[619]	R0237.2	DO[875]
R0045.3	DO[108]		R0109.3	DO[364]	R0173.3	DO[620]	R0237.3	DO[876]
R0045.4	DO[109]		R0110.4	DO[365]	R0174.4	DO[621]	R0238.4	DO[877]
R0045.5	DO[110]		R0110.5	DO[366]	R0174.5	DO[622]	R0238.5	DO[878]
R0045.6	DO[111]		R0110.6	DO[367]	R0174.6	DO[623]	R0238.6	DO[879]
R0045.7	DO[112]		R0110.7	DO[368]	R0174.7	DO[624]	R0238.7	DO[880]
R0046.0	DO[113]		R0110.0	DO[369]	R0174.0	DO[625]	R0238.0	DO[881]
R0046.1	DO[114]		R0110.1	DO[370]	R0174.1	DO[626]	R0238.1	DO[882]
R0046.2	DO[115]		R0110.2	DO[371]	R0174.2	DO[627]	R0238.2	DO[883]
R0046.3	DO[116]		R0110.3	DO[372]	R0174.3	DO[628]	R0238.3	DO[884]
R0046.4	DO[117]		R0111.4	DO[373]	R0175.4	DO[629]	R0239.4	DO[885]
R0046.5	DO[118]		R0111.5	DO[374]	R0175.5	DO[630]	R0239.5	DO[886]
R0046.6	DO[119]		R0111.6	DO[375]	R0175.6	DO[631]	R0239.6	DO[887]
R0046.7	DO[120]		R0111.7	DO[376]	R0175.7	DO[632]	R0239.7	DO[888]
R0047.0	DO[121]	Machine Operation Enable Request	R0111.0	DO[377]	R0175.0	DO[633]	R0239.0	DO[889]
R0047.1	DO[122]	Machine Operation Path Select (Path1)	R0111.1	DO[378]	R0175.1	DO[634]	R0239.1	DO[890]
R0047.2	DO[123]	Machine Operation Path Select (Path2)	R0111.2	DO[379]	R0175.2	DO[635]	R0239.2	DO[891]
R0047.3	DO[124]	Machine Operation Path Select (Path3)	R0111.3	DO[380]	R0175.3	DO[636]	R0239.3	DO[892]
R0047.4	DO[125]	Machine Operation Path Select (Path4)	R0112.4	DO[381]	R0176.4	DO[637]	R0240.4	DO[893]
R0047.5	DO[126]	Machine Operation Path Select (Path5)	R0112.5	DO[382]	R0176.5	DO[638]	R0240.5	DO[894]
R0047.6	DO[127]	Machine Operation Heart Beat Signal	R0112.6	DO[383]	R0176.6	DO[639]	R0240.6	DO[895]
R0047.7	DO[128]	Reserve	R0112.7	DO[384]	R0176.7	DO[640]	R0240.7	DO[896]

Address	Signal	Description	CNC2		CNC3		CNC4	
R0048.0	DO[129]	Machine Jog Feed Override 0	R0112.0	DO[385]	R0176.0	DO[641]	R0240.0	DO[897]
R0048.1	DO[130]	Machine Jog Feed Override 1	R0112.1	DO[386]	R0176.1	DO[642]	R0240.1	DO[898]
R0048.2	DO[131]	Machine Jog Feed Override 2	R0112.2	DO[387]	R0176.2	DO[643]	R0240.2	DO[899]
R0048.3	DO[132]	Machine Jog Feed Override 3	R0112.3	DO[388]	R0176.3	DO[644]	R0240.3	DO[900]
R0048.4	DO[133]	Machine Jog Feed Override 4	R0113.4	DO[389]	R0177.4	DO[645]	R0241.4	DO[901]
R0048.5	DO[134]	Machine Jog Feed Override 5	R0113.5	DO[390]	R0177.5	DO[646]	R0241.5	DO[902]
R0048.6	DO[135]	Machine Jog Feed Override 6	R0113.6	DO[391]	R0177.6	DO[647]	R0241.6	DO[903]
R0048.7	DO[136]	Machine Jog Feed Override 7	R0113.7	DO[392]	R0177.7	DO[648]	R0241.7	DO[904]
R0049.0	DO[137]	Machine Jog Feed Override 8	R0113.0	DO[393]	R0177.0	DO[649]	R0241.0	DO[905]
R0049.1	DO[138]	Machine Jog Feed Override 9	R0113.1	DO[394]	R0177.1	DO[650]	R0241.1	DO[906]
R0049.2	DO[139]	Machine Jog Feed Override 10	R0113.2	DO[395]	R0177.2	DO[651]	R0241.2	DO[907]
R0049.3	DO[140]	Machine Jog Feed Override 11	R0113.3	DO[396]	R0177.3	DO[652]	R0241.3	DO[908]
R0049.4	DO[141]	Machine Jog Feed Override 12	R0114.4	DO[397]	R0178.4	DO[653]	R0242.4	DO[909]
R0049.5	DO[142]	Machine Jog Feed Override 13	R0114.5	DO[398]	R0178.5	DO[654]	R0242.5	DO[910]
R0049.6	DO[143]	Machine Jog Feed Override 14	R0114.6	DO[399]	R0178.6	DO[655]	R0242.6	DO[911]
R0049.7	DO[144]	Machine Jog Feed Override 15	R0114.7	DO[400]	R0178.7	DO[656]	R0242.7	DO[912]
R0050.0	DO[145]	Machine Jog Feed Axis (1st Axis+)	R0114.0	DO[401]	R0178.0	DO[657]	R0242.0	DO[913]
R0050.1	DO[146]	Machine Jog Feed Axis (1st Axis-)	R0114.1	DO[402]	R0178.1	DO[658]	R0242.1	DO[914]
R0050.2	DO[147]	Machine Jog Feed Axis (2nd Axis+)	R0114.2	DO[403]	R0178.2	DO[659]	R0242.2	DO[915]
R0050.3	DO[148]	Machine Jog Feed Axis (2nd Axis-)	R0114.3	DO[404]	R0178.3	DO[660]	R0242.3	DO[916]
R0050.4	DO[149]	Machine Jog Feed Axis (3rd Axis+)	R0115.4	DO[405]	R0179.4	DO[661]	R0243.4	DO[917]
R0050.5	DO[150]	Machine Jog Feed Axis (3rd Axis-)	R0115.5	DO[406]	R0179.5	DO[662]	R0243.5	DO[918]
R0050.6	DO[151]	Machine Jog Feed Axis (4th Axis+)	R0115.6	DO[407]	R0179.6	DO[663]	R0243.6	DO[919]
R0050.7	DO[152]	Machine Jog Feed Axis (4th Axis-)	R0115.7	DO[408]	R0179.7	DO[664]	R0243.7	DO[920]
R0051.0	DO[153]	Machine Jog Feed Axis (5th Axis+)	R0115.0	DO[409]	R0179.0	DO[665]	R0243.0	DO[921]
R0051.1	DO[154]	Machine Jog Feed Axis (5th Axis-)	R0115.1	DO[410]	R0179.1	DO[666]	R0243.1	DO[922]
R0051.2	DO[155]	Machine Jog Feed Axis (6th Axis+)	R0115.2	DO[411]	R0179.2	DO[667]	R0243.2	DO[923]

Address	Signal	Description	CNC2		CNC3		CNC4	
R0051.3	DO[156]	Machine Jog Feed Axis (6th Axis-)	R0115.3	DO[412]	R0179.3	DO[668]	R0243.3	DO[924]
R0051.4	DO[157]	Machine Jog Feed Axis (7th Axis+)	R0116.4	DO[413]	R0180.4	DO[669]	R0244.4	DO[925]
R0051.5	DO[158]	Machine Jog Feed Axis (7th Axis-)	R0116.5	DO[414]	R0180.5	DO[670]	R0244.5	DO[926]
R0051.6	DO[159]	Machine Jog Feed Axis (8th Axis+)	R0116.6	DO[415]	R0180.6	DO[671]	R0244.6	DO[927]
R0051.7	DO[160]	Machine Jog Feed Axis (8th Axis-)	R0116.7	DO[416]	R0180.7	DO[672]	R0244.7	DO[928]
R0052.0	DO[161]		R0116.0	DO[417]	R0180.0	DO[673]	R0244.0	DO[929]
R0052.1	DO[162]		R0116.1	DO[418]	R0180.1	DO[674]	R0244.1	DO[930]
R0052.2	DO[163]		R0116.2	DO[419]	R0180.2	DO[675]	R0244.2	DO[931]
R0052.3	DO[164]		R0116.3	DO[420]	R0180.3	DO[676]	R0244.3	DO[932]
R0052.4	DO[165]		R0117.4	DO[421]	R0181.4	DO[677]	R0245.4	DO[933]
R0052.5	DO[166]		R0117.5	DO[422]	R0181.5	DO[678]	R0245.5	DO[934]
R0052.6	DO[167]		R0117.6	DO[423]	R0181.6	DO[679]	R0245.6	DO[935]
R0052.7	DO[168]		R0117.7	DO[424]	R0181.7	DO[680]	R0245.7	DO[936]
R0053.0	DO[169]		R0117.0	DO[425]	R0181.0	DO[681]	R0245.0	DO[937]
R0053.1	DO[170]		R0117.1	DO[426]	R0181.1	DO[682]	R0245.1	DO[938]
R0053.2	DO[171]		R0117.2	DO[427]	R0181.2	DO[683]	R0245.2	DO[939]
R0053.3	DO[172]		R0117.3	DO[428]	R0181.3	DO[684]	R0245.3	DO[940]
R0053.4	DO[173]		R0118.4	DO[429]	R0182.4	DO[685]	R0246.4	DO[941]
R0053.5	DO[174]		R0118.5	DO[430]	R0182.5	DO[686]	R0246.5	DO[942]
R0053.6	DO[175]		R0118.6	DO[431]	R0182.6	DO[687]	R0246.6	DO[943]
R0053.7	DO[176]		R0118.7	DO[432]	R0182.7	DO[688]	R0246.7	DO[944]
R0054.0	DO[177]		R0118.0	DO[433]	R0182.0	DO[689]	R0246.0	DO[945]
R0054.1	DO[178]		R0118.1	DO[434]	R0182.1	DO[690]	R0246.1	DO[946]
R0054.2	DO[179]		R0118.2	DO[435]	R0182.2	DO[691]	R0246.2	DO[947]
R0054.3	DO[180]		R0118.3	DO[436]	R0182.3	DO[692]	R0246.3	DO[948]
R0054.4	DO[181]		R0119.4	DO[437]	R0183.4	DO[693]	R0247.4	DO[949]
R0054.5	DO[182]		R0119.5	DO[438]	R0183.5	DO[694]	R0247.5	DO[950]
R0054.6	DO[183]		R0119.6	DO[439]	R0183.6	DO[695]	R0247.6	DO[951]
R0054.7	DO[184]		R0119.7	DO[440]	R0183.7	DO[696]	R0247.7	DO[952]
R0055.0	DO[185]		R0119.0	DO[441]	R0183.0	DO[697]	R0247.0	DO[953]
R0055.1	DO[186]		R0119.1	DO[442]	R0183.1	DO[698]	R0247.1	DO[954]
R0055.2	DO[187]		R0119.2	DO[443]	R0183.2	DO[699]	R0247.2	DO[955]
R0055.3	DO[188]		R0119.3	DO[444]	R0183.3	DO[700]	R0247.3	DO[956]
R0055.4	DO[189]		R0120.4	DO[445]	R0184.4	DO[701]	R0248.4	DO[957]
R0055.5	DO[190]		R0120.5	DO[446]	R0184.5	DO[702]	R0248.5	DO[958]
R0055.6	DO[191]		R0120.6	DO[447]	R0184.6	DO[703]	R0248.6	DO[959]
R0055.7	DO[192]		R0120.7	DO[448]	R0184.7	DO[704]	R0248.7	DO[960]
R0056.0	DO[193]		R0120.0	DO[449]	R0184.0	DO[705]	R0248.0	DO[961]
R0056.1	DO[194]		R0120.1	DO[450]	R0184.1	DO[706]	R0248.1	DO[962]
R0056.2	DO[195]		R0120.2	DO[451]	R0184.2	DO[707]	R0248.2	DO[963]
R0056.3	DO[196]		R0120.3	DO[452]	R0184.3	DO[708]	R0248.3	DO[964]
R0056.4	DO[197]		R0121.4	DO[453]	R0185.4	DO[709]	R0249.4	DO[965]
R0056.5	DO[198]		R0121.5	DO[454]	R0185.5	DO[710]	R0249.5	DO[966]
R0056.6	DO[199]		R0121.6	DO[455]	R0185.6	DO[711]	R0249.6	DO[967]
R0056.7	DO[200]		R0121.7	DO[456]	R0185.7	DO[712]	R0249.7	DO[968]
R0057.0	DO[201]		R0121.0	DO[457]	R0185.0	DO[713]	R0249.0	DO[969]
R0057.1	DO[202]		R0121.1	DO[458]	R0185.1	DO[714]	R0249.1	DO[970]
R0057.2	DO[203]		R0121.2	DO[459]	R0185.2	DO[715]	R0249.2	DO[971]
R0057.3	DO[204]		R0121.3	DO[460]	R0185.3	DO[716]	R0249.3	DO[972]

Address	Signal	Description	CNC2		CNC3		CNC4	
R0057.4	DO[205]		R0122.4	DO[461]	R0186.4	DO[717]	R0250.4	DO[973]
R0057.5	DO[206]		R0122.5	DO[462]	R0186.5	DO[718]	R0250.5	DO[974]
R0057.6	DO[207]		R0122.6	DO[463]	R0186.6	DO[719]	R0250.6	DO[975]
R0057.7	DO[208]		R0122.7	DO[464]	R0186.7	DO[720]	R0250.7	DO[976]
R0058.0	DO[209]		R0122.0	DO[465]	R0186.0	DO[721]	R0250.0	DO[977]
R0058.1	DO[210]		R0122.1	DO[466]	R0186.1	DO[722]	R0250.1	DO[978]
R0058.2	DO[211]		R0122.2	DO[467]	R0186.2	DO[723]	R0250.2	DO[979]
R0058.3	DO[212]		R0122.3	DO[468]	R0186.3	DO[724]	R0250.3	DO[980]
R0058.4	DO[213]		R0123.4	DO[469]	R0187.4	DO[725]	R0251.4	DO[981]
R0058.5	DO[214]		R0123.5	DO[470]	R0187.5	DO[726]	R0251.5	DO[982]
R0058.6	DO[215]		R0123.6	DO[471]	R0187.6	DO[727]	R0251.6	DO[983]
R0058.7	DO[216]		R0123.7	DO[472]	R0187.7	DO[728]	R0251.7	DO[984]
R0059.0	DO[217]		R0123.0	DO[473]	R0187.0	DO[729]	R0251.0	DO[985]
R0059.1	DO[218]		R0123.1	DO[474]	R0187.1	DO[730]	R0251.1	DO[986]
R0059.2	DO[219]		R0123.2	DO[475]	R0187.2	DO[731]	R0251.2	DO[987]
R0059.3	DO[220]		R0123.3	DO[476]	R0187.3	DO[732]	R0251.3	DO[988]
R0059.4	DO[221]		R0124.4	DO[477]	R0188.4	DO[733]	R0252.4	DO[989]
R0059.5	DO[222]		R0124.5	DO[478]	R0188.5	DO[734]	R0252.5	DO[990]
R0059.6	DO[223]		R0124.6	DO[479]	R0188.6	DO[735]	R0252.6	DO[991]
R0059.7	DO[224]		R0124.7	DO[480]	R0188.7	DO[736]	R0252.7	DO[992]
R0060.0	DO[225]		R0124.0	DO[481]	R0188.0	DO[737]	R0252.0	DO[993]
R0060.1	DO[226]		R0124.1	DO[482]	R0188.1	DO[738]	R0252.1	DO[994]
R0060.2	DO[227]		R0124.2	DO[483]	R0188.2	DO[739]	R0252.2	DO[995]
R0060.3	DO[228]		R0124.3	DO[484]	R0188.3	DO[740]	R0252.3	DO[996]
R0060.4	DO[229]		R0125.4	DO[485]	R0189.4	DO[741]	R0253.4	DO[997]
R0060.5	DO[230]		R0125.5	DO[486]	R0189.5	DO[742]	R0253.5	DO[998]
R0060.6	DO[231]		R0125.6	DO[487]	R0189.6	DO[743]	R0253.6	DO[999]
R0060.7	DO[232]		R0125.7	DO[488]	R0189.7	DO[744]	R0253.7	DO[1000]
R0061.0	DO[233]		R0125.0	DO[489]	R0189.0	DO[745]	R0253.0	DO[1001]
R0061.1	DO[234]		R0125.1	DO[490]	R0189.1	DO[746]	R0253.1	DO[1002]
R0061.2	DO[235]		R0125.2	DO[491]	R0189.2	DO[747]	R0253.2	DO[1003]
R0061.3	DO[236]		R0125.3	DO[492]	R0189.3	DO[748]	R0253.3	DO[1004]
R0061.4	DO[237]		R0126.4	DO[493]	R0190.4	DO[749]	R0254.4	DO[1005]
R0061.5	DO[238]		R0126.5	DO[494]	R0190.5	DO[750]	R0254.5	DO[1006]
R0061.6	DO[239]		R0126.6	DO[495]	R0190.6	DO[751]	R0254.6	DO[1007]
R0061.7	DO[240]		R0126.7	DO[496]	R0190.7	DO[752]	R0254.7	DO[1008]
R0062.0	DO[241]		R0126.0	DO[497]	R0190.0	DO[753]	R0254.0	DO[1009]
R0062.1	DO[242]		R0126.1	DO[498]	R0190.1	DO[754]	R0254.1	DO[1010]
R0062.2	DO[243]		R0126.2	DO[499]	R0190.2	DO[755]	R0254.2	DO[1011]
R0062.3	DO[244]		R0126.3	DO[500]	R0190.3	DO[756]	R0254.3	DO[1012]
R0062.4	DO[245]		R0127.4	DO[501]	R0191.4	DO[757]	R0255.4	DO[1013]
R0062.5	DO[246]		R0127.5	DO[502]	R0191.5	DO[758]	R0255.5	DO[1014]
R0062.6	DO[247]		R0127.6	DO[503]	R0191.6	DO[759]	R0255.6	DO[1015]
R0062.7	DO[248]		R0127.7	DO[504]	R0191.7	DO[760]	R0255.7	DO[1016]
R0063.0	DO[249]		R0127.0	DO[505]	R0191.0	DO[761]	R0255.0	DO[1017]
R0063.1	DO[250]		R0127.1	DO[506]	R0191.1	DO[762]	R0255.1	DO[1018]
R0063.2	DO[251]		R0127.2	DO[507]	R0191.2	DO[763]	R0255.2	DO[1019]
R0063.3	DO[252]		R0127.3	DO[508]	R0191.3	DO[764]	R0255.3	DO[1020]
R0063.4	DO[253]		R0128.4	DO[509]	R0192.4	DO[765]	R0256.4	DO[1021]
R0063.5	DO[254]		R0128.5	DO[510]	R0192.5	DO[766]	R0256.5	DO[1022]
R0063.6	DO[255]		R0128.6	DO[511]	R0192.6	DO[767]	R0256.6	DO[1023]
R0063.7	DO[256]		R0128.7	DO[512]	R0192.7	DO[768]	R0256.7	DO[1024]

10.11 NOTES

10.11.1 Unused Subprogram

Subprogram P0020 is unused.

10.11.2 Unused Internal Relays

Internal relay R0258.6 (ABORT1) is unused.

APPENDIX

A STANDARD SETTING

A.1 SETTING VALUE IN CNC

In this section, the value of standard setting for the setting of robot connection function and PMC parameter is described.

The description of remarks in all tables are as follows.

Remarks	Description
Fixed value	The value is fixed. Set the value in the table without change.
Depend on PMC address	The value depends on PMC address in the data area of the robot connection function. In case that the address from 1:R7000 to 1:R7999 can be used, set the value in the table without change. If other address is used, set the modified PMC address.
Depend on CNC number	The value depends on CNC number. Set the corresponding value from CNC1 to CNC4.
Need not to set	It is not need to set the value.

A.1.1 Setting for Robot Connection Function

In the robot connection function, there are 2 screens, “Allocation” and “Robot Status”. The standard setting value set in these screens are as follows.

Allocation

Item	CNC1	CNC2	CNC3	CNC4	Remarks
Allocation					
Robot DO signal PMC Address	1:R7200	Same as in the left	Same as in the left	Same as in the left	Depend on PMC address
Robot DI signal PMC Address	1:R7232	Same as in the left	Same as in the left	Same as in the left	Depend on PMC address
Robot Power On signal PMC Address	1:R7956 (FL-net) 1:R7207 (I/O Link)	Same as in the left	Same as in the left	Same as in the left	Depend on PMC address
Robot Power ON signal Bit	1 (FL-net) 4 (I/O Link)	Same as in the left	Same as in the left	Same as in the left	Fixed value
DO signal number offset	0	256	512	768	Depend on CNC number
DI signal number offset	0	256	512	768	Depend on CNC number
Option	0000 0001	Same as in the left	Same as in the left	Same as in the left	Fixed value

Robot Status

The robot status setting specifies the signal displayed to monitor in the screen. Setting is optional.

Item	Type	Number	Remarks
1	DI	34	
2	DI	111	
3	DI	35	

Item	Type	Number	Remarks
4	DI	105	
5	DI	108	
6	DI	110	
7		---	
8	DO	7	
9	DO	70	
10	DO	10	
11	DO	105	
12	DO	63	
13	DO	64	
14	DO	65	
15	DO	6	
16	DO	66	

The robot status setting is common to all CNC.

A.1.2 Setting PMC Parameter

In case that FL-net is used to transfer I/O, the sample ladder gets CNC number by following PMC parameter.

Item	CNC1	CNC2	CNC3	CNC4	Remarks
K80.2	0	1	0	1	Depend on CNC number
K80.3	0	0	1	1	Depend on CNC number

A.2 SETTING VALUE IN ROBOT CONTROLLER

In the robot controller, the following items are set automatically according to the number of CNC connected to the robot controller.

- I/O assignment and I/O comment
- Robot ladder program
- Keep relay
- Macro registration

A.2.1 Type of Setting Value and Applicable Condition

Setting value in case that this function is not used

If this function is installed in the robot controller, the following settings are done after initial start.

- The macro program for the remote operation and the KAREL programs are loaded.
- The system variable $MACROMAXDRI is set 15 (Refer to A.2.2).
- The number of CNC connected to the robot controller is set 0.

Common setting when one or more CNCs are connected to the robot controller

In case that one or more CNCs are connected to the robot controller, the following settings are done independent of the number of the connected CNC.

- The total number of DI/DO is 1080 (R-30*i*A/R-30*i*A Mate controller) or 1056 (R-30*i*B/R-30*i*B Mate controller or later).
- The robot ladder program for this function is installed.

- UI/UO signals are assigned to the internal relays (R-30*i*A/R-30*i*A Mate controller) or F, G addresses in PMC (R-30*i*B/R-30*i*B Mate controller or later).
- Signals from DI[1025] to DI[1080] (R-30*i*A/R-30*i*A Mate controller) or signals from DI[1025] to DI[1056] (R-30*i*B/R-30*i*B Mate controller or later) are assigned to the internal relays.
- Signals from DO[1025] to DO[1032] are assigned to the internal relays.
- GI[5] signal to designate hand operation is assigned to the internal relay.
- GO[1] is assigned to output override.
- Emergency stop signal is output to DO[1025].
- FENCE signal is output to DO[1026].
- Macro commands are registered (Refer to A.2.2).
- PNS function is enabled.
- The item “CSTOPI for ABORT” in system configuration menu is set to TRUE.
- The item “START for CONTINUE only” in system configuration menu is set to TRUE.
- TCP/IP parameters are set when I/O device type is FL-net by internal Ethernet port.

Setting for each CNC

Settings for each CNC are as follows. The following settings are set for each CNC. For example, if the number of CNC connected to the robot controller is 1, 256 DI/DO signals and GI[1] are assigned, and DI/DO signals after that and group I/O after G[2] are not used. And only K0000.0 is set 1, keep relay after K0000.1 is 0.

- Assignment of group signals from G[1] to G[4] to designate service type
- Assignment of 256 DI/DO points per one CNC and comment input
- Setting 1 to keep relay from K0000.0 to K0000.3

A.2.2 Standard Setting Value List in Robot Controller

Macro Program

In order to execute hand operation, override change, and home position return by remote operation, the following macro programs are used.

Setting for R-30*i*A/R-30*i*A Mate controller is as follows.

Index	Program name	Macro Name	Start method
120	HANDOP_M	HANDOP_M	DI[21]
121	HANDOP01	HANDOP01	Manual operation
122	HANDOP02	HANDOP02	Manual operation
123	HANDOP03	HANDOP03	Manual operation
124	HANDOP04	HANDOP04	Manual operation
125	HANDOP05	HANDOP05	Manual operation
126	HANDOP06	HANDOP06	Manual operation
127	HANDOP07	HANDOP07	Manual operation
128	HANDOP08	HANDOP08	Manual operation
129	HANDOP09	HANDOP09	Manual operation
130	HANDOP10	HANDOP10	Manual operation
136	OVRUP	OVRUP	DI[22]
137	OVRDOWN	OVRDOWN	DI[23]
138	MTSHOME	MTSHOME	DI[24]
139	REM_ENT	REM_ENT	DI[19]
140	REM_EXT	REM_EXT	DI[20]

Setting for R-30*i*B/R-30*i*B Mate controller or later is as follows.

Index	Program name	Macro Name	Start method
120	HANDOP_M	HANDOP_M	DI[1027]
121	HANDOP01	HANDOP01	Manual operation
122	HANDOP02	HANDOP02	Manual operation
123	HANDOP03	HANDOP03	Manual operation
124	HANDOP04	HANDOP04	Manual operation
125	HANDOP05	HANDOP05	Manual operation
126	HANDOP06	HANDOP06	Manual operation
127	HANDOP07	HANDOP07	Manual operation
128	HANDOP08	HANDOP08	Manual operation
129	HANDOP09	HANDOP09	Manual operation
130	HANDOP10	HANDOP10	Manual operation
136	OVRUP	OVRUP	DI[1028]
137	OVRDOWN	OVRDOWN	DI[1029]
138	MTSHOME	MTSHOME	DI[1030]
139	REM_ENT	REM_ENT	DI[1025]
140	REM_EXT	REM_EXT	DI[1026]

Note that a program "OVRSET" is also loaded. OVRUP and OVRDOWN call OVRSET.

System variable

The following system variable is set.

- $MACROMAXDRI=15

Assignment of I/O (R-30*i*A/ R-30*i*A Mate controller)

I/O in the robot controller is assigned as follows.

In case that FL-net is used to transfer I/O

Signal Type	Start Number	End Number	Rack	Slot	Start point	Number of points	Type
UI	1	18	33	2	2177	-	Common
UO	1	20	33	2	2225	-	Common
DI	1	18	68	2	1	18	CNC1
DI	19	24	33	2	2137	6	CNC1
DI	25	256	68	2	25	232	CNC1
DI	256	274	68	3	1	18	CNC2
DI	275	280	33	2	2137	6	CNC2
DI	281	512	68	3	25	232	CNC2
DI	513	530	68	4	1	18	CNC3
DI	531	536	33	2	2137	6	CNC3
DI	537	768	68	4	25	232	CNC3
DI	769	786	68	5	1	18	CNC4
DI	787	792	33	2	2137	6	CNC4
DI	793	1024	68	5	25	232	CNC4
DI	1025	1056	33	2	2137	32	Common
DI	1057	1062	68	2	19	6	CNC1
DI	1063	1068	68	3	19	6	CNC2
DI	1069	1074	68	4	19	6	CNC3
DI	1075	1080	68	5	19	6	CNC4
DO	1	256	68	1	1	256	CNC1

Signal Type	Start Number	End Number	Rack	Slot	Start point	Number of points	Type
DO	257	512	68	1	257	256	CNC2
DO	513	768	68	1	513	256	CNC3
DO	769	1024	68	1	769	256	CNC4
DO	1025	1032	33	2	2089	8	Common
DO	1033	1056	0	0	0	24	Common
GI	1	-	33	2	25	4	CNC1
GI	2	-	33	2	537	4	CNC2
GI	3	-	33	2	1049	4	CNC3
GI	4	-	33	2	1561	4	CNC4
GI	5	-	33	2	2169	4	Common
GO	1	-	33	2	2289	8	Common

In case that I/O Link is used to transfer I/O

Signal Type	Start Number	End Number	Rack	Slot	Start point	Number of points	Type
UI	1	18	33	2	2177	18	Common
UO	1	20	33	2	2225	20	Common
DI	1	18	0	1	1	18	CNC1
DI	19	24	33	2	2137	6	CNC1
DI	25	256	0	1	25	232	CNC1
DI	256	274	0	2	1	18	CNC2
DI	275	280	33	2	2137	6	CNC2
DI	281	512	0	2	25	232	CNC2
DI	513	530	0	3	1	18	CNC3
DI	531	536	33	2	2137	6	CNC3
DI	537	768	0	3	25	232	CNC3
DI	769	786	0	4	1	18	CNC4
DI	787	792	33	2	2137	6	CNC4
DI	793	1024	0	4	25	232	CNC4
DI	1025	1056	33	2	2137	32	Common
DI	1057	1062	0	1	19	6	CNC1
DI	1063	1068	0	2	19	6	CNC2
DI	1069	1074	0	3	19	6	CNC3
DI	1075	1080	0	4	19	6	CNC4
DO	1	256	0	1	1	256	CNC1
DO	257	512	0	2	1	256	CNC2
DO	513	768	0	3	1	256	CNC3
DO	769	1024	0	4	1	256	CNC4
DO	1025	1032	33	2	2089	8	Common
DO	1033	1056	0	0	0	24	Common
GI	1		33	2	25	4	CNC1
GI	2		33	2	537	4	CNC2
GI	3		33	2	1049	4	CNC3
GI	4		33	2	1561	4	CNC4
GI	5		33	2	2169	4	Common
GO	1		33	2	2289	8	Common

Assignment of I/O (R-30*i*B/ R-30*i*B Mate controller or later)

X/Y(PMC external I/O assignment)

External signals are assigned to X addresses and Y addresses in PMC. PMC external I/O assignment is set as follows according to the connected I/O device.

In case that FL-net is used to transfer I/O

Signal Type	Rack	Slot	Size	Address	Type
DI	68	2	32	1:X00000	CNC1
DI	68	3	32	1:X00032	CNC2
DI	68	4	32	1:X00064	CNC3
DI	68	5	32	1:X00096	CNC4

Signal Type	Rack	Slot	Size	Address	Type
DO	68	2	32	1:Y00000	CNC1
DO	68	3	32	1:Y00032	CNC2
DO	68	4	32	1:Y00064	CNC3
DO	68	5	32	1:Y00096	CNC4

In case that I/O Link is used to transfer I/O

Signal Type	Rack	Slot	Size	Signal Type	Type
DI	0	1	32	1:X00000	CNC1
DI	0	2	32	1:X00032	CNC2
DI	0	3	32	1:X00064	CNC3
DI	0	4	32	1:X00096	CNC4

Signal Type	Rack	Slot	Size	Signal Type	Type
DO	0	1	32	1:Y00000	CNC1
DO	0	2	32	1:Y00032	CNC2
DO	0	3	32	1:Y00064	CNC3
DO	0	4	32	1:Y00096	CNC4

UI/UO(PMC internal I/O assignment)

UI/UO signals are assigned to PMC addresses. PMC internal I/O assignment is set as follows regardless of the connected I/O device.

Signal Type	Start Number	End Number	Size	Address	Type
UI	1	32	4	1:G01000	Common

Signal Type	Start Number	End Number	Size	Address	Type
UO	1	32	4	1:F01000	Common

The comments for UI/UO are the comments of the default setting.

GI/GO(PMC internal I/O assignment)

GI/GO signals are assigned to PMC addresses. PMC internal I/O assignment is set as follows regardless of the connected I/O device.

Signal Type	Start Number	End Number	Size	Address	Type	Comment
GI	1	-	2	1:G00260	CNC1	Service Type 1
GI	2	-	2	1:G00262	CNC2	Service Type 2
GI	3	-	2	1:G00264	CNC3	Service Type 3
GI	4	-	2	1:G00266	CNC4	Service Type 4
GI	5	-	2	1:G00268	Common	Hand operation Type

Signal Type	Start Number	End Number	Size	Address	Type	Comment
GO	1	-	2	1:F00260	Common	override output
GO	10001	11500	3000	1:D00000	Common	Only D00000 is used.

DI/DO(Robot I/O assignment)

DI/DO signals are assigned as follows according to the connected I/O device.

In case that FL-net is used to transfer I/O

Signal Type	Start Number	End Number	Rack	Slot	Start point	Number of points	Type
DI	1	256	68	2	1	256	CNC1
DI	257	512	68	3	1	256	CNC2
DI	513	768	68	4	1	256	CNC3
DI	769	1024	68	5	1	256	CNC4

Signal Type	Start Number	End Number	Rack	Slot	Start point	Number of points	Type
DO	1	256	68	1	1	256	CNC1
DO	257	512	68	1	257	256	CNC2
DO	513	768	68	1	513	256	CNC3
DO	769	1024	68	1	769	256	CNC4

In case that I/O Link is used to transfer I/O

Signal Type	Start Number	End Number	Rack	Slot	Start point	Number of points	Type
DI	1	256	0	1	1	256	CNC1
DI	257	512	0	2	1	256	CNC2
DI	513	768	0	3	1	256	CNC3
DI	767	1024	0	4	1	256	CNC4

Signal Type	Start Number	End Number	Rack	Slot	Start point	Number of points	Type
DO	1	256	0	1	1	256	CNC1
DO	257	512	0	2	1	256	CNC2
DO	513	768	0	3	1	256	CNC3
DO	769	1024	0	4	1	256	CNC4

DI/DO(PMC internal I/O assignment)

Some of DI/DO signals are set to PMC addresses. PMC internal I/O assignment is set as follows regardless of the connected I/O device.

Signal Type	Start Number	End Number	Size	Address	Type
DI	1025	1056	4	1:G00256	Common

Signal Type	Start Number	End Number	Size	Address	Type
DO	1025	1056	4	1:F00256	Common
DO	10001	10136	17	1:K00000	Common
DO	11001	23000	1500	1:R00000	Common

A.3 FL-net PARAMETER

This section explains standard settings when FL-net is used to transfer I/O. In this section, the case, that the number of CNC connected to the robot controller is 4 and only the robot and CNC are connected to the network, is described.

A.3.1 Common Item

Node Number, IP Address

Standard setting of Node number and IP Address are as follows.

Device	Node number	IP Address
Robot Controller	1	192.168.250.1
CNC1	2	192.168.250.2
CNC2	3	192.168.250.3
CNC3	4	192.168.250.4
CNC4	5	192.168.250.5

Common memory area 1 (Bit data)

This function uses 256 words from offset 0, the half of common memory area 1.

Type	Offset (Word)	Size (Word)	Points
Robot > CNC	0	64	1024
Reserved	64	64	1024
CNC1 > Robot	128	16	256
Reserved	144	16	256
CNC2 > Robot	160	16	256
Reserved	176	16	256
CNC3 > Robot	192	16	256
Reserved	208	16	256
CNC4 > Robot	224	16	256
Reserved	240	16	256

Common memory area 2 (Word data)

Common memory area 2 is not used.

Network parameter

- TOKEN WATCH TIME 30ms (Robot and CNC standard setting)
- FRAME INTERVAL (MINIMUM FRAME TIME) 0. (It is recommended that MINIMUM FRAME TIME in CNC is equal or more than 10 in case that FL-net/ETHERNET coexisting function is used in CNC.

NOTE
FRAME INTERVAL (MINIMUM FRAME TIME) in all node should be equal or more than 20 if FL-net uses internal port of robot. FRAME INTERVAL, which is maximum in all FL-net attending node, is applied for all node behavior. If no node whose FRAME INTERVAL is 20 or more, attends to network, FRAME INTERVAL becomes less than 20. If robot try to attend this network, FL-net load becomes too high and robot can't attend the network and may can't ramp-up and i-Pendant may become slow. So FRAME INTERVAL in all node should be 20 or more.

A.3.2 FL-net Parameters in CNC

Item	CNC1	CNC2	CNC3	CNC4	Remarks
IP address	192.168.250.2	192.168.250.3	192.168.250.4	192.168.250.5	Depend on CNC number
Node Name	(Optional)	Same as in the left	Same as in the left	Same as in the left	
Area 1 address	128	160	192	224	Depend on CNC number
Area 1 size (word)	16	Same as in the left	Same as in the left	Same as in the left	Fixed value
Area 2 address	0	Same as in the left	Same as in the left	Same as in the left	Need not to set
Area 2 size	0	Same as in the left	Same as in the left	Same as in the left	Need not to set
Token watchdog time (ms)	30	Same as in the left	Same as in the left	Same as in the left	Fixed value
Minimum frame time (100µs)	0	Same as in the left	Same as in the left	Same as in the left	Fixed value (Note)
Own status	---	Same as in the left	Same as in the left	Same as in the left	Need not to set
Entry node	1:R7956	Same as in the left	Same as in the left	Same as in the left	Depend on PMC address
Parameter 1	0000 0001	Same as in the left	Same as in the left	Same as in the left	Fixed value
Parameter 2	0000 0000	Same as in the left	Same as in the left	Same as in the left	Fixed value
Area 1 DI/DO					
PMC address	1:R7400	Same as in the left	Same as in the left	Same as in the left	Depend on PMC address
Area 1 address	0	Same as in the left	Same as in the left	Same as in the left	Fixed value
Allocated size (word)	256	Same as in the left	Same as in the left	Same as in the left	Fixed value
Area 2 DI/DO					
PMC address	---	Same as in the left	Same as in the left	Same as in the left	Need not to set
Area 2 address	0	Same as in the left	Same as in the left	Same as in the left	Need not to set
Allocated size (word)	0	Same as in the left	Same as in the left	Same as in the left	Need not to set

Item	CNC1	CNC2	CNC3	CNC4	Remarks
Message					
Client I/F	---	Same as in the left	Same as in the left	Same as in the left	Need not to set
I/F size	0	Same as in the left	Same as in the left	Same as in the left	Need not to set
Server I/F	---	Same as in the left	Same as in the left	Same as in the left	Need not to set
I/F size	0	Same as in the left	Same as in the left	Same as in the left	Need not to set

NOTE
Note that Minimum frame time should be equal or more than 10 in case that FL-net/ETHERNET coexisting function is used to connect CNC and robot.

The descriptions of remarks in all tables are as follows.

Remarks	Description
Fixed value	The value is fixed. Set the value in the table without change.
Depend on PMC address	The value depends on PMC address in the data area for the robot connection function. In case that the address 1:R7000~1:R7999 can be used, set the value in the table without change. If other address is used, set the PMC address after change.
Depend on CNC number	The value depends on CNC number. Set the corresponding value from CNC1 to CNC4.
Need not to set	It is not need to set the value.

A.3.3 FL-net Parameters in Robot Controller

After doing "Procedure to read the standard setting in robot controller" in "2.2.3.2 Setting in robot controller", following settings are loaded to robot. In this section, the case, that 4 CNC is connected, is described.

NODE NAME in OWN NODE is set to "ROBOT", and Comment in each node is set as follows.

Node number	Comment
1	ROBOT
2	CNC1
3	CNC2
4	CNC3
5	CNC4

Settings to connect 4 CNCs are done, and the reference methods for common memory (DI/DO) are set.

	Node Number	Common memory area 1 offset (Word)	Common memory area 1 size (Word)	Reference (DI/DO assign)	Rack Number	Slot Number
Robot	1	0	64	DO[1 to 1024]	68	1
CNC1	2	128	16	DI[1 to 256]	68	2
CNC2	3	160	16	DI[257 to 512]	68	3
CNC3	4	192	16	DI[513 to 768]	68	4
CNC4	5	224	16	DI[769 to 1024]	68	5

In case that I/O device type is FL-net which uses FL-net board (FL-net or FL-net(Board)), IP address of FL-net is set to 192.168.250.1.

In case that I/O device type is FL-net which uses internal port (FL-net(Port#1) or FL-net(Port#2)), Ethernet IP address and subnet mask in the designated port are set as follows, and router IP address is initialized.

Parameter	Setting value
IP address	192.168.250.1
subnet mask	255.255.255.0

TOKEN WATCH TIME is set to 30ms (Robot standard setting).
FRAME INTERVAL is set to 0. If FL-net uses internal port, FRAME INTERVAL is changed to 20 at cold start etc.

B ALARM

B.1 ALARM IN CNC

About the detail of the alarm in CNC, refer to Common to Lathe System/Machining Center System OPERATOR'S MANUAL corresponding to your using CNC. There is not the alarm specific to this function.

B.2 ALARM IN ROBOT CONTROLLER

About the detail of the alarm in the robot controller, refer to one of the following manuals corresponding to your using robot controller.

- FANUC Robot Series R-30*i*A CONTROLLER HANDLING TOOL OPERATOR'S MANUAL (B-83124EN)
- FANUC Robot Series R-30*i*A Mate CONTROLLER LR HANDLING TOOL OPERATOR'S MANUAL(B-83134EN)
- FANUC Robot Series R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus CONTROLLER OPERATOR'S MANUAL (Alarm Code List)(B-83284EN-1)

In this section, the alarms concerning with this function are described.

Alarm display

In the robot controller, the alarm is displayed as follows.

INTP-653 PAUSE.L J983: System variables not found

(1) (2) (3)

(1) Alarm code : Alarm ID to represent the type of alarm and Alarm Number are displayed.
(2) Alarm severity : The seriousness of the cause of the alarm is displayed. Refer to table B.2.
(3) Alarm message : Description of the alarm

Table B.2 Alarm severity

Severity	Description
WARN	A WARN alarm warns the operator of a comparatively minor or unimportant failure. The WARN alarm does not affect the operation of the robot. When the WARN alarm occurs, no corresponding LED on the teach pendant or the machine operator's panel lights. To prevent a possible failure, appropriate action should be taken.
PAUSE.L PAUSE.G	When a PAUSE alarm occurs, the execution of the program is halted, and the operation of the robot is stopped after the operation in progress is completed. Appropriate action must be taken for the alarm before the program is restarted. The difference between PAUSE.L and PAUSE.G is the range in which the alarm is applied. PAUSE.L is applied in the program that the alarm occurs, and PAUSE.G is applied in all programs.
STOP.L STOP.G	When a STOP alarm occurs, the execution of the program is halted, and the robot is decelerated until it is stopped. Appropriate action must be taken for the alarm before the program is restarted. The difference between STOP.L and STOP.G is the range in which the alarm is applied. STOP.L is applied in the program that the alarm occurs, and STOP.G is applied in all programs.
SERVO	When a SERVO alarm occurs, the power to the servo system is turned off to halt the execution of the program and to stop the robot immediately. A SERVO alarm is issued for safety's sake or when a failure occurs during robot operation.

Severity	Description
ABORT.L ABORT.G	When an ABORT alarm occurs, the execution of the program is forcibly terminated, and the robot is decelerated until it is stopped. The difference between ABORT.L and ABORT.G is the range in which the alarm is applied. ABORT.L is applied in the program that the alarm occurs, and ABORT.G is applied in all programs.
SERVO2	When a SERVO 2 alarm occurs, the power to the servo system is turned off to forcibly terminate the program and to stop the robot immediately. A SERVO2 alarm is issued for safety's sake or when a failure occurs during robot operation.
SYSTEM	A SYSTEM alarm is issued when a major system failure occurs. When the SYSTEM alarm is issued, every robot in the system is disabled. After taking appropriate action for the alarm, turn the power off, the turn it on again.

Alarms in this function

HOST Alarm Code (ID67)

HOST-300 WARN Can't connect to CNC(%s)

[Cause] Robot cannot communicate with CNC.
[Remedy] Check the communication setup.

HOST-301 WARN Not Connected(Tag=%s)

[Cause] CNC is not connected to robot.
[Remedy] Connect the CNC to robot.

HOST-302 WARN CNC isn't Connected

[Cause] CNC is not connected to robot.
[Remedy] Connect CNC to robot.

HOST-303 WARN Not supported CNC

[Cause] The designated CNC is not supported.
[Remedy] Use the supported CNC.

HOST-304 WARN Cycle power to change CNC No.

[Cause] You change the CNC number.
[Remedy] Please cycle power.

HOST-305 WARN Start Comm. with CNC No.%d

[Cause] Communication with CNC is started.
[Remedy] This is for information only. No action is required.

HOST-306 WARN Input I/O number for CNC No.

[Cause] You set the I/O number that is not used in the selected CNC.
[Remedy] Set the I/O number that is used in the selected CNC.

HOST-307 WARN CNC No. is duplicated

[Cause] You input the duplicated CNC number.
[Remedy] Input the CNC number which is not duplicated.

HOST-308 WARN Add CNC to be connected

[Cause] CNC number exceeds the number of the connected CNC.
[Remedy] Controlled Start and increase the number of CNC.

HOST-309 WARN Please set CNC No.%d

[Cause] CNC number is not set.
[Remedy] Please set CNC number.

HOST-310 WARN TP disable

[Cause] You press the OPR enable button but TP is disabled.
[Remedy] Set TP enable.

HOST-311 WARN Interlock Mode signal is off

[Cause] You press the OPR enable button but interlock signal is off.
[Remedy] Set the interlock signal on.

HOST-312 WARN Operation isn't available

[Cause] You try to jog machine tool but operation isn't available.
[Remedy] Set the operation available.

HOST-313 WARN Do M.Tool Operation enable

[Cause] You try to jog machine tool but Machine Tool Operation in Setup Machine I/F isn't available.
[Remedy] Set the Machine Tool Operation available.

INTP Alarm Code (ID12)

INTP-653 PAUSE.L J983: System variables not found

[Cause] The system variable for this function does not exist.
[Remedy] Contact our service center serving your locality.

INTP-654 PAUSE.L J983: DO for program run is invalid

[Cause] In this function, when the robot program is started by the request from CNC, DO designated in system variable is turned on. In case that the designated DO does not exist or the designated DO cannot be turned on, this alarm occurs.
[Remedy] Assign DO designated in the system variable $MTSERV_CFG.$PGRUNDO correctly.

INTP-655 ABORT.L J983: DO for program end is invalid

[Cause] In this function, when the robot program started by the request from CNC is ended normally, DO designated in system variable is turned on. In case that the designated DO does not exist or the designated DO cannot be turned on, this alarm occurs.
[Remedy] Assign DO designated in the system variable $MTSERV_CFG.$PGENDDO correctly.

INTP-656 ABORT.L J983: DO for program abort is invalid

[Cause] In this function, when the robot program started by the request from CNC is ended regardless of whether the program is ended normally or abnormally, DO designated in system variable is turned on. In case that the designated DO does not exist or the designated DO cannot be turned on, this alarm occurs.
[Remedy] Assign DO designated in the system variable $MTSERV_CFG.$PGABOTDO correctly.

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REVISION RECORD

Edition	Date	Contents
04	Aug., 2017	• Addition of Detail for CNC power ON signal • Addition of Attention for FRAME INTERVAL • Support R-30*i*B Plus, R-30*i*B Mate Plus
03	Jul., 2013	• FANUC Series 30*i* /31*i* /32*i* -MODEL B are supported. • FANUC Series 35*i* -MODEL B is supported. • FANUC Power Motion *i* -MODEL A is supported. • FANUC Robot series R-30*i*B/R-30*i*B Mate controller are supported.
02	Feb., 2010	• FANUC Series 0*i*-MODELD is supported. • CNC operation screen is added in the robot controller. • Chapter 10 ROBOT LADDER PROGRAM is revised.
01	Aug., 2009	

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