

# FANUC Robot **series**

**R-30iB/R-30iB Mate/ R-30iB Plus/ R-30iB  
Mate Plus CONTROLLER**

**OPERATOR'S MANUAL (Collaborative Robot Function)**

**MAROBCLBR09151E REV B**

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**FANUC America Corporation  
3900 W. Hamlin Road  
Rochester Hills, Michigan 48309-325**

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5,008,834 5,063,281 5,066,847 5,066,902 5,093,552 5,107,716 5,111,019  
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5,329,469 5,333,242 5,337,148 5,371,452 5,375,480 5,418,441 5,432,316  
5,440,213 5,442,155 5,444,612 5,449,875 5,451,850 5,461,478 5,463,297  
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5,691,615 5,698,121 5,708,342 5,715,375 5,719,479 5,727,132 5,742,138  
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6,324,443 6,328,523 6,330,493 6,340,875 6,356,671 6,377,869 6,382,012  
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7,328,083 7,330,777 7,333,879 7,355,725 7,359,817 7,373,220 7,376,488  
7,386,367 7,464,623 7,447,615 7,445,260 7,474,939 7,486,816 7,495,192  
7,501,778 7,502,504 7,508,155 7,512,459 7,525,273 7,526,121

## Conventions

### **WARNING**

Information appearing under the "WARNING" caption concerns the protection of personnel. It is boxed and bolded to set it apart from the surrounding text.

### **CAUTION**

Information appearing under the "CAUTION" caption concerns the protection of equipment, software, and data. It is boxed and bolded to set it apart from the surrounding text.

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

- **Original Instructions**

Thank you very much for purchasing FANUC Collaborative Robot.

Before using the Collaborative robot, be sure to read MECHANICAL UNIT OPERATOR'S MANUAL and understand the content.

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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

Before using the FANUC collaborative robot, be sure to read MECHANICAL UNIT OPERATOR'S MANUAL to become familiar with those contents.

## DEFINITION OF SAFETY NOTATIONS

To ensure the safety of users and prevent damage to the machine, this manual indicates each precaution on safety with "**WARNING**" or "**CAUTION**" according to its severity. Supplementary information is indicated by "**NOTE**". Please read each "**WARNING**", "**CAUTION**" and "**NOTE**" before using the robots.

Symbol	Definitions
 <b>WARNING</b>	Used if hazard resulting in the death or serious injury of the user will be expected to occur if he or she fails to follow the approved procedure.
 <b>CAUTION</b>	Used if a hazard resulting in the minor or moderate injury of the user, or equipment damage may be expected to occur if he or she fails to follow the approved procedure.
<b>NOTE</b>	Used if a supplementary explanation not related to any of WARNING and CAUTION is to be indicated.

- Check this manual thoroughly, and keep it handy for the future reference.



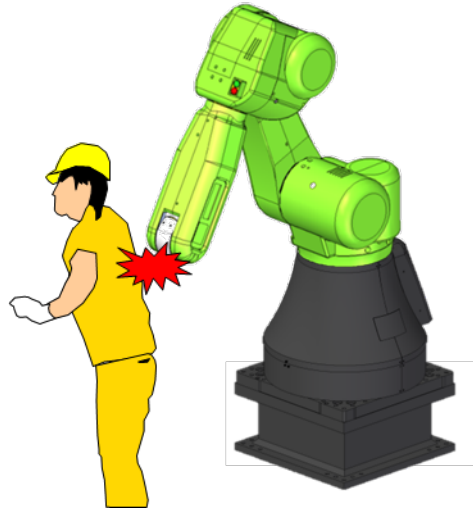


# PREFACE

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The coexistence of human and robot will make a difference in production site from the point of view of productivity, efficiency and so on. However, for coexistence of human and robot, adequate risk assessment for the whole the robot system is necessary to verify the human safety.

Collaborative robot is befitted for this purpose, because the collaborative robot has the contact stop function to stop when the external force exceeds the limit. This function is useful for design of the robot system.



The collaborative robot is certified to meet the requirements of International Standard ISO 10218-1 by a notarized body.

The contact stop function is certified to meet the requirements of International ISO 13849-1 for Category 3, PL (Performance Level) d by a notarized body.

In order to design the collaborative robot system, it is necessary to understand the collaborative robot function. This manual describes the collaborative robot function use.

## RELATED MANUALS

For the FANUC Robot series, the following manuals are available:

R-30iB, R-30iB Mate, R-30iB Plus, R-30iB Mate Plus controller	OPERATOR'S MANUAL Basic Operation <b>B-83284EN</b> Alarm Code List <b>B-83284EN-1</b> Optional Function <b>B-83284EN-2</b> Dual Check Safety Function <b>B-83184EN</b>	Intended readers : Operator, programmer, maintenance engineer, system designer Topics : Robot functions, operations, programming, setup, interfaces, alarms Use : Robot operation, teaching, system design
	MAINTENANCE MANUAL <b>B-83525EN</b>	Intended readers : Maintenance engineer, system designer Topics : Installation, start-up, connection, maintenance Use : Installation, start-up, connection, maintenance
FANUC Robot CR-4iA, CR-7iA, CR-7iA/L Mechanical unit	OPERATOR'S MANUAL <b>B-83774EN</b>	Intended readers: System designer, Maintenance engineer Topics: Installation, connection to controller, maintenance Use: Installation, start-up, connection, maintenance
FANUC Robot CR-35iA Mechanical unit	OPERATOR'S MANUAL <b>B-83734EN</b>	Intended readers: System designer, Maintenance engineer Topics: Installation, connection to controller, maintenance Use: Installation, start-up, connection, maintenance

This manual uses following terms.

Name	Terms in this manual
Robot mechanical unit	Mechanical unit

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# 1 ABSTRACT

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## 1.1 RESTRICTION OF COLLABORATIVE ROBOT

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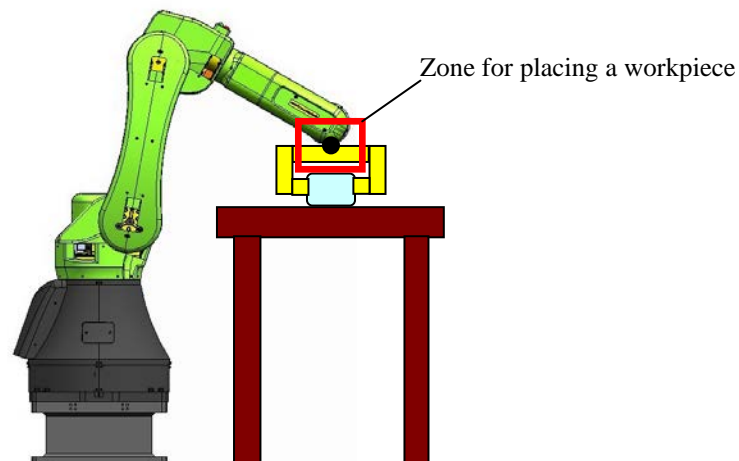
- Constant path function is needed for the collaborative robot function. So you can NOT use any option unsupported by Constant path function.
- Circular motion and Circle arc motion are not supported.
- Payload Identification is not supported.

## 1.2 SOFTWARE OPTION FOR COLLABORATIVE ROBOT

---

Robot library software of Collaborative robot is sufficient for the simple collaborative system. For more advanced system as followings, DCS function is required. Refer to Chapter 5.

- Limit the area for picking or placing a workpiece
- Disable the contact stop function in specified area



### Recommended DCS functions

- |      |                                   |
|------|-----------------------------------|
| J567 | DCS Position/Speed check function |
| J568 | DCS Safe I/O connection function  |

DCS Joint Position Check function is installed as standard.

Refer to Dual Check Safety Function OPERATOR'S MANUAL (B-83184EN) for detail of this function.

---

## 1.3 SETUP STEPS

---

To use the collaborative robot, you must do the followings. You can use the other functions except for the collaborative robot function as same manner as the standard FANUC robot. Refer to each function manual.

- 1 Set up the collaborative robot function. Refer to Chapter 2. For more detail information of the collaborative robot function, refer to Chapter 4.
- 2 Perform the payload confirmation operation after every power on. Refer to Chapter 3.
- 3 Teach production programs. Refer to Chapter 5 of this manual and OPERATOR'S MANUAL (Basic Operation) (B-83284EN), Chapter of PROGRAMMING.
- 4 Make periodical check program of force sensor. Refer to Chapter 6.
- 5 Run production with above programs. Refer to OPERATOR'S MANUAL (Basic Operation) (B-83284EN), Chapter of EXECUTING A PROGRAM.
- 6 Set up the special functions of the collaborative robot. Refer to Chapter 7.

If you have any problem of the collaborative robot, refer to Appendix A.

# 2 SETTING UP

This chapter describes how to set up the collaborative robot. By default, SAFE I/O device is set correctly. Set up after Section 2.2.

## 2.1 SETTING SAFE I/O DEVICE

Collaborative robot has a built-force sensor, and this sensor detects a external force to realize the contact stop function. By default, the four “Force Sensor” devices are assigned to Device 2 to 5. These devices are needed for the collaborative robot function. If the safe I/O device configuration is changed, the following operation is needed.

### Initialize Safe I/O device

- 1 Press [MENU] key.
- 2 Select SYSTEM.
- 3 Press F1, [TYPE].
- 4 Select DCS. If neither DCS top screen nor Safe I/O device screen, press [PREV] key, and select Safe I/O device.
- 5 Press F2, [INIT]. The message “Do you want to change setting?” is displayed.
- 6 Press F4, [YES].
- 7 Press F2, [INIT] again. The message “Initialize device configuration?” is displayed.
- 8 Press F4, [YES].
- 9 Make sure that the types of Device 2 to 5. The following screen will be displayed.

DCS			
Safe I/O device			
1	Safe I/O device: I/O connect	OK	
2	SFDO Pulse check: ENABLE(PL e)	OK	
Configuration		status	
--- Device 1 -----			
3	Type: E-stop board	OK	
4	Robot number: 1	OK	
5	Input: SPI[ 1 - 8](PL e)	OK	
6	Output: SPO[ 1 - 8](PL e)	OK	
--- Device 2 -----			
7	Type: Force Sensor	CHGD	
8	Robot number: 0	OK	
9	Input: SPI[ 0 - 0](PL e)	OK	
10	Output: SPO[ 0 - 0](PL e)	OK	
--- Device 3 -----			
11	Type: Force Sensor	CHGD	
12	Robot number: 0	OK	
13	Input: SPI[ 0 - 0](PL e)	OK	
14	Output: SPO[ 0 - 0](PL e)	OK	
--- Device 4 -----			
15	Type: Force Sensor	CHGD	
16	Robot number: 0	OK	
17	Input: SPI[ 0 - 0](PL e)	OK	
18	Output: SPO[ 0 - 0](PL e)	OK	
--- Device 5 -----			
19	Type: Force Sensor	CHGD	
20	Robot number: 0	OK	
21	Input: SPI[ 0 - 0](PL e)	OK	
22	Output: SPO[ 0 - 0](PL e)	OK	
	[TYPE]	INIT	UNDO

- 10 Apply DCS parameter. Refer to Dual Check Safety Function OPERATOR'S MANUAL (B-83184EN), Chapter of OVERVIEW, Section of APPLY TO DCS PARAMETER.

## 2.2 SETTING COLLABORATIVE ROBOT FUNCTION

This section introduces the setting of the collaborative robot function. In the collaborative robot screen, you can set up the collaborative robot function.

### Collaborative robot screen

- 1 Press the [MENU] key.
- 2 Select SYSTEM.
- 3 Press F1, [TYPE].
- 4 Select DCS.
- 5 If neither DCS top screen nor Collaborative robot screen, press the [PREV] key, and select Collaborative robot. The following screen will be displayed. Some items is not displayed depending on the software version.

DCS			
Collaborative robot			
Contact stop status	STOP		
Enable/Disable	ENABLE		OK
Force sensor			
Serial number:	0		OK
Group:	1		OK
Payload setup:	<DETAIL>		OK
Active Payload number:	No. 1 [*****]		
External force Limit / Disabling input			
Current:	0.0		
Limit 1:	150.00[N] ---[ 0]		OK
Limit 2:	0.00[N] ---[ 0]		OK
Limit 3:	0.00[N] ---[ 0]		OK
Limit 4:	0.00[N] ---[ 0]		OK
Escape:	300.00[N]		OK
[TYPE]	CONFIRM	PEAKCLR	UNDO

You can set up the collaborative function in this screen.

For configurable items, OK/CHGD/PEND is displayed in the right.

OK : Setting parameter and DCS parameter are the same.

CHGD : Setting parameter is changed, but not applied to DCS parameter.

PEND : Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.

When you change DCS parameter setting, “Apply to the DCS parameter” is necessary. Refer to Dual Check Safety Function OPERATOR’S MANUAL (B-83184EN), Chapter of OVERVIEW, Section of APPLY TO DCS PARAMETER.

DCS			
Collaborative robot			
Contact stop status	STOP		
Enable/Disable	ENABLE		OK
Force sensor			
Serial number:	0		OK
Group:	1		OK
Payload setup:	<DETAIL>		OK
Active Payload number:	No. 1 [*****]		
External force Limit / Disabling input			
Current:	0.0		
Limit 1:	150.00[N] ---[ 0]		OK
Limit 2:	0.00[N] ---[ 0]		OK
Limit 3:	0.00[N] ---[ 0]		OK
Limit 4:	0.00[N] ---[ 0]		OK
Escape:	300.00[N]		OK
[TYPE]	CONFIRM	PEAKCLR	UNDO



## Contact stop status

The status of the contact stop function is displayed. Refer to Section 2.3.

## Enable/Disable (configurable)

Enabling or disabling the contact stop function.

### DISABLE

The contact stop function is disabled. In this setting, the robot is same as a standard robot. You can move the robot only in T1 mode. In T2 or AUTO mode, “SYST-343 Enable Contact Stop function” occurs, and you cannot move the robot.

### ENABLE

The contact stop function is enabled.

### ENBL (Shift+Reset)

Contact stop is always enabled in AUTO mode. When you hold down the [SHIFT] key and press the [RESET] key in T1 or T2 mode and the contact stop status is STOP (Refer to Section 2.3), the contact stop function is disabled until the [SHIFT] key is released or the safety is confirmed.

Refer to Subsection 4.1.1 for the detail of the difference between ENABLE and ENBL(Shift+Reset).



### CAUTION

When “ENBL (Shift+Reset)” is selected, the contact stop function might be disabled when you hold down the [SHIFT] key and press the [RESET] key in T1 or T2 mode. If “ENBL (Shift+Reset)” is used, adequate risk assessment for the whole the robot system is necessary to verify that the contact stop can be disabled while Shift+Reset is pressed in T1 or T2 mode.

## Force Sensor Serial number

The serial number of the force sensor is displayed.

## Group (configurable)

Set the group number of the collaborative robot.

## Payload setup

You can see current payload setup. Refer to Subsection 2.2.1.

## Active payload number

Current payload number is displayed and not configurable in this screen. You can select the payload number in “SYSTEM > Motion” screen or by PAYLOAD instruction in program. Refer to OPERATOR'S MANUAL (Basic Operation) (B-83284EN).

## External force (N)

### Current

You can see the current external force. This item moved to Force monitor in the software version 7DC3/30 or later.

**Limit 1 to 4 (configurable)**

Set the external force limit 1 to 4 between 0[N] and 150[N], inclusive. 0[N] means disable and you cannot set the limit 1 to 0[N].

When the contact stop function is enabled, “@” is displayed as following.

Limit 1:	150.00[N]	---[ 0]	OK
@Limit 2:	90.00[N]	---[ 0]	OK
Limit 3:	0.00[N]	---[ 0]	OK
Limit 4:	0.00[N]	---[ 0]	OK

This means the active force limit. The active force limit is minimum limit in available limits. When the external force exceeds the active force limit, the robot will stop. To disable the force limit, set the limit to 0[N] or the corresponding disabling input to ON. You can disable the force limit to change the active force limit dynamically in a program. In the example of this screen, the limit 1 and 2 are enabled, then @ is attached to the minimum limit 2. The limit 3 and 4 is set 0[N], then they are disabled.

**Escape (configurable)**

Set the external force limit for Push To Escape between 0[N] and 300[N], inclusive. In Push To Escape, if the external force exceeds this limit, the robot is stopped. This means that the robot does not escape when you push with a force more than the force limit.

**Disabling input (configurable)**

Set the Safe I/O to disable each force limit. When the disabling input is ON, the corresponding force limit is disabled. When the all limits are disabled, the contact stop function is disabled.

@Limit 1:	150.00[N]	SIR[ 1]	OK
Limit 2:	90.00[N]	SIR[ 2]	OK
Limit 3:	0.00[N]	---[ 0]	OK
Limit 4:	0.00[N]	---[ 0]	OK

In the example of this screen, SIR[2] is ON to disable the limit 2. The limit 1 is only enabled, then @ is attached to the limit 1.

DCS					
Collaborative robot					
Force Monitor:					
	Resultant	X	Y	Z	
Curr:	0.00[N]				
	0%	0%	0%	0%	
Peak:	0%	0%	0%	0%	
Output:					
Curr:	GO[ 0]	GO[ 0]	GO[ 0]	GO[ 0]	
Warning:	0%				
Payload Monitor:					
FORCE	Resultant	X	Y	Z	
Curr:	0%	0%	0%	0%	
Comp:		0%	0%	0%	
Peak:	0%	0%	0%	0%	
Output:					
Curr:	GO[ 0]	GO[ 0]	GO[ 0]	GO[ 0]	
Comp:		GO[ 0]	GO[ 0]	GO[ 0]	
Warning:	50%				
MOMENT	Resultant	X	Y	Z	
Curr:	0%	0%	0%	0%	
Comp:		0%	0%	0%	
Peak:	0%	0%	0%	0%	
Output:					
Curr:	GO[ 0]	GO[ 0]	GO[ 0]	GO[ 0]	
Comp:		GO[ 0]	GO[ 0]	GO[ 0]	
Warning:	50%				
Warning in DSBL: DISABLE					
	[TYPE]	CONFIRM	PEAKCLR		UNDO

## Force Monitor/Payload Monitor

These items are displayed in the software version 7DC3/30 or later. An external force and a load applied to the robot is displayed. You can configure the warning posted when the monitored value exceeds specified value, and output monitored value. Refer to Subsection 4.2.3.

DCS				
Collaborative robot				
Payload change distance (mm)				
	Current	+Limit	-Limit	
X:	0.00	0.00	0.00	OK
Y:	0.00	0.00	0.00	OK
Z:	0.00	0.00	0.00	OK
Rotation:	Current	Limit		
	0.00[deg]	0.20[deg]		OK
Enabling input:	ON	[ 0]		OK
Password for CONFIRM:	ENABLE			OK
CONFIRM by DI:	DISABLE			OK
CONFIRM input:	DI	[ 0]		
Payload No. output:	GO	[ 0]		
Speed limit:	250.00	[mm/s]		OK
Use Payload Comp:	ENABLE			OK
[ TYPE ]	CONFIRM	PEAKCLR		UNDO

## Payload change distance

### Current

You can see the current distance and the rotation angle of the posture from a payload change position. The rotation angle of the posture is displayed in the software version 7DC3/30 or later. When the payload changing output is OFF (Refer to Section 2.3), this value is 0.

### +Limit, -Limit, Rotation Limit (configurable)

When the payload change distance is enabled, the active payload number is changed, then the contact stop function will switch to disable. If the face plate position is changed more than the payload change distance, the contact stop function switches to enable immediately. The payload change distance can be set for each direction individually, +X, -X, +Y, -Y, +Z and -Z of the world coordinate system. Rotation Limit is displayed in the software version 7DC3/30 or later. Rotation Limit is one value without distinction of direction. This is useful for the collaborative robot to pick or place a workpiece. Refer to Chapter 5.

### Enabling input (configurable)

Set the Safe I/O to enable the payload change distance. When the enabling input is ON, the payload change distance is enabled. When the Safe I/O is OFF, the payload change distance is disabled, and STOP state (Refer to Section 2.3) will be initiated immediately when the actual payload number is changed. Default setting is ON[ 0]. It means the payload change distance is always enabled.

## Password for CONFIRM (configurable)

After power on the controller, the payload confirmation operation must be performed to clear the alarm. The collaborative robot does not move until the payload confirmation is performed. When Password for CONFIRM is ENABLE, DCS password is required for the payload confirmation operation. Default setting is ENABLE. Refer to Chapter 3.

## CONFIRM by DI (configurable)

This item is displayed in the software version 7DC3/30 or later. You can perform the payload confirmation operation with some kind of terminal without other than the teach pendant. Refer to Chapter 3.

**Speed limit (configurable)**

This item is displayed in the software version 7DC3/28 or later. When the contact stop is enable, the speed of the collaborative robot exceeds the speed limit, “SYST-323 Collaborative speed limit” will be posted, and the robot will stop.

**WARNING**

If the speed limit is set to inappropriate value, the force at the time of contact increases, and a serious personal injury could result. Risk assessment for the whole robot system is required to determine appropriate speed limit. Refer to followings about the risk according to the speed.

CR-35iA: MECHANICAL UNIT OPERATOR'S MANUAL(B-83734EN), Section 3.6 THE CHARACTERISTIC OF COLLABORATIVE ROBOT AND LIMITATIONS AND USAGE NOTES

CR-4iA, CR-7iA, CR-7iA/L: MECHANICAL UNIT OPERATOR'S MANUAL(B-83774EN), Section 3.6 THE CHARACTERISTIC OF COLLABORATIVE ROBOT AND LIMITATIONS AND USAGE NOTES

**Use Payload Comp(configurable)**

This item is displayed in the software version 7DC3/33 or later. Use when same payload acts on the robot every time during robot move. Refer to Section 7.5.

**F2 [CONFIRM]**

Pressing the F2 [CONFIRM] and the payload confirmation starts. The payload confirmation operation must be performed at least once after power on. The collaborative robot does not move until the payload confirmation is performed. Refer to Chapter 3.

**WARNING**

- 1 If the collaborative robot settings are incorrectly, the safety function will not work, and a serious personal injury could result. When the collaborative robot settings are changed, the values must be verified and the function must be tested again.
- 2 When the contact stop is disabled, the collaborative robot does not stop even though the external force exceeds the limit, and a serious personal injury could result. If the robot system is designed to be able to disable the contact stop, adequate risk assessment for the whole robot system is necessary to verify that the contact stop can be disabled.
- 3 If “Password for CONFIRM” is set to DISABLE, anybody can perform the payload confirmation operation. If the payload confirmation operation is performed incorrectly, the external force is not detected correctly and safety function will not work, and a personal injury could result. When “Password for CONFIRM” is set to DISABLE, everybody who can operate the teach pendant must be authorized to perform the payload confirmation operation.

## 2.2.1 Verify Payload Setup

In the collaborative robot screen, select Payload setup: <DETAIL>, then the payload setup screen is displayed. In this screen, current parameters for the contact stop are displayed as followings. In this screen, you cannot change their parameters.

DCS					
Payload setup					Status
PAYLOAD 1					
PAYLOAD	[kg]	35.00			OK
CENTER X	[cm]	0.00			OK
CENTER Y	[cm]	0.00			OK
CENTER Z	[cm]	0.00			OK
INERTIA X	[kg cm <sup>2</sup> ]	0.00			OK
INERTIA Y	[kg cm <sup>2</sup> ]	0.00			OK
INERTIA Z	[kg cm <sup>2</sup> ]	0.00			OK
PAYLOAD 2					
PAYLOAD	[kg]	35.00			OK
	[TYPE]				

### PAYLOAD 1 to 9

Payload settings are displayed. In “SYSTEM > Motion” screen, you can change the payload settings.

DCS					
Payload setup					Status
ARM LOAD #3					
PAYLOAD	[kg]	0.00			OK
CENTER X	[cm]	-3.50			OK
CENTER Y	[cm]	0.00			OK
CENTER Z	[cm]	8.00			OK
ARM LOAD #0					
PAYLOAD	[kg]	0.00			OK
CENTER X	[cm]	0.00			OK
CENTER Y	[cm]	0.00			OK
CENTER Z	[cm]	0.00			OK
ARM LOAD #0					
	[TYPE]				

## ARM LOAD #axis\_number

Arm load settings are displayed. In “SYSTEM > Motion” screen, you can change the payload settings.

DCS		
Payload setup		Status
Gravity vector		
X [mm/s <sup>2</sup> ]	0.00	OK
Y [mm/s <sup>2</sup> ]	0.00	OK
Z [mm/s <sup>2</sup> ]	9800.00	OK
Speed limit for push to escape		
J1 [deg/s]	9.00	OK
J2 [deg/s]	9.00	OK
Monitor interval(ms):	500	OK
Vibration limit(N):	30.00	OK
Payload error limit(N):	60.00	OK
Status chk err lim(N):	60.00	OK
Status chk time lim(s):	90.00	OK
Vibration tolerance:	32	OK
Payload change distance		
Rotation limit (deg):	0.20	OK
[TYPE]		

### Gravity vector

Gravity vector is displayed. The gravity vector is changed by the mount angle of the robot.

### Speed limit for push to escape

Speed limit in Push To Escape is displayed.

### Monitor interval

Sampling time of the external force monitor is displayed. Refer to the section 4.2.

### Vibration limit

The force limit by vibration is displayed.

### Payload error limit

Payload error limit is displayed. When the error of the payload setting exceeds the payload error limit, the robot can not move. Refer to the subsection 4.2.2.

### Status chk error lim

This is “Status check error limit”, internal parameter for the auto status check.

### Status chk time lim

This is “Status check time limit”, the limit of time interval for the auto status check.

### Vibration tolerance

Tolerance of floor vibration

### Payload change distance Rotation limit (deg)

The orient rotation limit of the payload change distance. This item is displayed in the software version before 7DC3/29.



#### WARNING

If the payload setting is incorrect, the safety function will not work correctly, and a personal injury could result. When payload settings are changed, the values must be verified and the function must be tested again.

## 2.3 OUTPUT SIGNAL OF COLLABORATIVE ROBOT STATUS

The state of the collaborative robot could be output as the digital output (DO, RO, Flag) by set the system variables. This is useful for programming and visual indicator.

### SAFE state output

#### SETTING

\$DCSS\_CLLB[1].\$DOTYP\_SAFE: Set the type of output (DO:2, RO:9, F:35)

\$DCSS\_CLLB[1].\$DOIDX\_SAFE: Set the index of output

#### SPECIFICATION

ON: The contact stop function is enabled and the safety is confirmed. In this case, the robot can move as usual.

### STOP state output

#### SETTING

\$DCSS\_CLLB[1].\$DOTYP\_STOP: Set the type of output (DO:2, RO:9, F:35)

\$DCSS\_CLLB[1].\$DOIDX\_STOP: Set the index of output

#### SPECIFICATION

ON: The contact stop function is enabled and the safety is not confirmed. In this case, the robot cannot move. The signal is ON in the following cases.

- The payload number is changed, but the payload change distance is disabled.
- The intensity of the external force is high.
- The auto status check has not been performed for Status check time limit. Refer to the subsection 4.2.1.

### DSBL state output

#### SETTING

\$DCSS\_CLLB[1].\$DOTYP\_DSBL: Set the type of output (DO:2, RO:9, F:35)

\$DCSS\_CLLB[1].\$DOIDX\_DSBL: Set the index of output

#### SPECIFICATION

ON: The contact stop function is disabled.

This signal is useful for a visual indication when the robot is in collaborative operation.

### ESCP state output

#### SETTING

\$DCSS\_CLLB[1].\$DOTYP\_ESCP: Set the type of output (DO:2, RO:9, F:35)

\$DCSS\_CLLB[1].\$DOIDX\_ESCP: Set the index of output

#### SPECIFICATION

ON: In Push To Escape.

### Payload changing output

#### SETTING

\$DCSS\_CLLB[1].\$DOTYP\_PLCHG: Set the type of output (DO:2, RO:9, F:35)

\$DCSS\_CLLB[1].\$DOIDX\_PLCHG: Set the index of output

#### SPECIFICATION

ON: The contact stop function is disabled and the safety is not confirmed. In this case, if the contact stop is changed to enabling, the state would transition to STOP state, and the robot would stop. The signal is ON in the following cases.

- The payload number is changed when the payload change distance is enabled.
- The intensity of the external force is high.
- The auto status check has not been performed for Status check time limit. Refer to the subsection 4.2.1.

**Auto status check Time Out output****SETTING**

\$DCSS\_CLLB[1].\$DOTYP\_TMOUT: Set the type of output (DO:2, RO:9, F:35)

\$DCSS\_CLLB[1].\$DOIDX\_TMOUT: Set the index of output

**SPECIFICATION**

ON: The auto status check has not been performed for Status check time limit. Refer to the subsection 4.2.1.

**Program Running output****SETTING**

\$DCSS\_CLLB[1].\$DOTYP\_RUN: Set the type of output (DO:2, RO:9, F:35)

\$DCSS\_CLLB[1].\$DOIDX\_RUN: Set the index of output

**SPECIFICATION**

ON: The program is running or the auto resume function is waiting to resume. This keeps ON when the program is resumed by Auto resume function. Refer to Section 7.1.

**Program Paused output****SETTING**

\$DCSS\_CLLB[1].\$DOTYP\_PAUSE: Set the type of output (DO:2, RO:9, F:35)

\$DCSS\_CLLB[1].\$DOIDX\_PAUSE: Set the index of output

**SPECIFICATION**

ON: The program is paused and the auto resume function is not waiting to resume. Refer to Section 7.1.

**WARNING**

Collaborative status output is not a Safe I/O. If you assign it to Safe I/O used by the safety function, the safety function will not work under some fault conditions and serious personal injury could result. Do not use the collaborative status output for safety purposes.



# 3 PAYLOAD CONFIRMATION OPERATION AFTER POWER ON

You must confirm that the payload setting is consistent with the actual payload at least once after power on the controller. This operation is called as Payload confirmation. The robot cannot move before Payload confirmation. In the collaborative robot screen, pressing F2[CONFIRM] and the payload confirmation process starts.



## **WARNING**

If the payload confirmation operation is performed incorrectly, the external force is not detected correctly and the safety function will not work, and a personal injury could result. When the payload confirmation operation is performed, the actual payload of the robot must be confirmed correctly, and anybody must not contact the robot.

## **Payload confirmation Operation**

- 1 If the message “Code number (master)” is displayed, enter the master code number for DCS. If the code number is not correct, the payload confirmation operation is failed.  
If the “Password for CONFIRM” is DISABLE in the collaborative robot screen, it is not necessary to enter code number.
- 2 First question “Actual payload is No. X?” is displayed.  
Confirm the actual payload of the robot hand/tool/workpiece is surely equal to payload No. X.
  - If No. X is correct, press F4 [YES] and next question will be displayed.
  - Else, press F5 [NO] and the payload confirmation operation is failed. Change the payload setting and try again.
- 3 Second question “Nobody contacts with the robot?” is displayed.  
Confirm nobody contacts the robot, no foreign material is on the robot, and there is no external force to the actual robot.
  - If nobody contacts with the robot, press F4 [YES] and the result of the payload confirmation will be displayed.
  - Else, press F5 [NO] and the payload confirmation is failed. Remove the external force to the robot and try again.

## **The result of the payload confirmation**

### **“Payload confirmation success”**

Payload confirmation operation is completed. You can use the collaborative robot after this.

### **“Payload confirmation failed”**

Remove the external force to the robot and try again. For example, a floor vibration may cause the external force.



## **WARNING**

If “Password for CONFIRM” is set to DISABLE, anybody can perform the payload confirmation operation. If the payload confirmation operation is performed incorrectly, the external force is not detected correctly and safety function will not work, and a personal injury could result. When “Password for CONFIRM” is set to DISABLE, everybody who can operate the teach pendant must be authorized to perform the payload confirmation operation.

## 3.1 Payload Confirmation without Teach Pendant

When you would like to perform the payload confirmation operation with some kind of terminal other than the teach pendant, configure “CONFIRM by DI” in the collaborative robot screen. This configuration is displayed in the software version 7DC3/30 or later.

DCS					
Collaborative robot					
CONFIRM by DI:		DISABLE	OK		
CONFIRM input:		DI[ 0 ]			
Payload No. output:		GO[ 0 ]			
[TYPE]	CONFIRM	PEAKCLR		UNDO	

### CONFIRM by DI (configurable)

When this item is set to ENABLE, you can perform the payload confirmation operation with an external signal. If it is ENABLE, you can also perform the payload confirmation operation with the teach pendant.

### CONFIRM input (configurable)

When “CONFIRM by DI” is ENABLE and you change CONFIRM from OFF to ON, the payload confirmation will be performed. When the CONFIRM input changes from OFF to ON, you need to confirm that the actual payload of the robot hand/tool/workpiece is surely equal to current payload setting and nobody contacts with the robot. When CONFIRM input switches over and over in a short time, the payload confirmation may be performed incorrectly. Keep ON state more than 1 second.

### Payload No. output (configurable)

Current payload setting number is output to a group output signal or a register set in this item. When you perform the payload confirmation operation with some kind of terminal other than the teach pendant, you can confirm the actual payload of the robot hand/tool/workpiece is surely equal to current payload setting by display of current payload setting number on the terminal.



#### WARNING

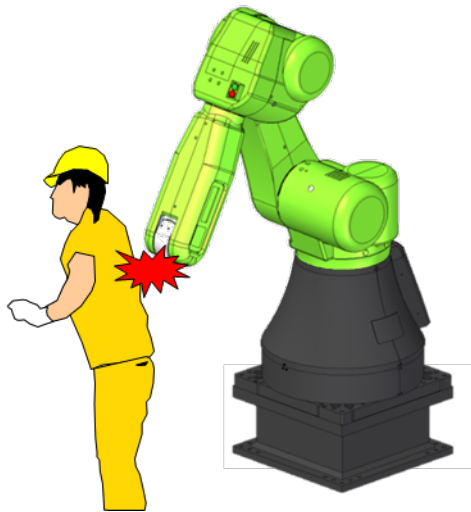
If “CONFIRM by DI” is set to ENABLE, you set CONFIRM input to ON, it is necessary to confirm that the actual payload of the robot matches current payload setting and anybody does not contact the robot. Measure is necessary to prevent putting CONFIRM input by unauthorized person such as locking. If the payload confirmation operation is performed incorrectly, the external force is not detected correctly and safety function will not work, and a personal injury could be result.

# 4 SPECIFICATION OF COLLABORATIVE FUNCTION

This chapter introduces functions of the collaborative robot.

## 4.1 CONTACT STOP FUNCTION

When the external force exceeds the active force limit, the robot will stop.



After a contact stop, the robot cannot move until the intensity of the external force becomes low.

When multiple programs are executed by multitasking function, all programs pause by the contact stop function. If you don't want to stop a program by the contact stop, set Interruption Disable in the program detail screen. Refer to OPERATOR'S MANUAL (Basic Operation) (B-83284EN), Chapter of PROGRAM STRUCTURE.



### **WARNING**

Motion groups other than Collaborative robot are outside of the scope of the contact stop function. If a person comes into contact with the motion group other than Collaborative robot, a serious personal injury could result. If the robot system is designed to include the motion group other than Collaborative robot, adequate risk assessment for the whole robot system is necessary to verify that the motion group other than Collaborative robot are outside of the scope of the contact stop function.

### 4.1.1 Contact Stop in Teach Mode

The contact stop function is also enabled in T1/T2 mode. When the contact stop occurs, you cannot jog the robot in the usual manner until the intensity of the external force becomes low. This section provides the way to escape the robot by jogging in the contact stop situation. If the intensity of the external force does not become low, for example the robot contacts fixed object, you cannot jog in the usual manner. To recover this STOP situation, there are different manners between “ENABLE” and “ENBL(Shift+Reset)” set in the collaborative robot screen.

#### ENABLE

To recover from the STOP situation, you can jog the robot to the direction to go back to before contact. Hold down SHIFT key, press RESET key, and jog the robot without releasing SHIFT key. If the robot moves to the other direction, the robot stops immediately.

#### ENBL(Shift+Reset)

To recover from the STOP situation, hold down SHIFT key and press RESET key, then the contact stop function is disabled, and you can jog the robot. If the SHIFT key is released, or the intensity of the external force becomes low, the contact stop function is enabled again.



#### CAUTION

- 1 In ENBL (Shift+Reset) case, when the contact stop is disabled by holding SHIFT key and pressing RESET key, even if an operator moves the robot to a dangerous direction by jogging, the robot will not stop.
- 2 When “ENBL (Shift+Reset)” is selected, the contact stop might be disabled when you hold down SHIFT key and press RESET key in T1 or T2 mode. If “ENBL (Shift+Reset)” is used, adequate risk assessment for the whole robot system is necessary to verify that the contact stop can be disabled when you hold down SHIFT key and press RESET key in T1 or T2 mode.

## 4.2 COLLABORATIVE ROBOT MONITOR

To verify that the contact stop function works correctly, the status of Collaborative robot is monitored periodically. If the status is possibly-abnormal, the robot stops until the external force data is confirmed normal status.

### 4.2.1 Auto Status Check

For the safety confirmation of Collaborative robot function, Auto Status Check is performed periodically.

- While the robot moving, the auto status check will not be performed. That is, when all motors of the robot stops, the auto status check is performed, even if the program is running.
- When the external force is large, the auto status check is not performed.
- When the elapsed time from a previous auto status check is longer than the reset time limit, the robot stops until the auto status check is performed. About Status check time limit, refer to the subsection 2.2.1.

Collaborative robot cannot move continuously more than Status check time limit. It is necessary to program that the robot stops in a state that does not receive any external force. Or you can use the auto resume function to avoid the program continues to be paused. Refer to Section 7.1.

## 4.2.2 Payload Monitor

If the payload setting is inconsistent with the actual payload, the sensor cannot detect the external force correctly. In this case, the robot stops until the intensity of the external force becomes low. For example, when the robot drops a workpiece unexpectedly, the robot cannot move.

When the robot picks or places a workpiece, an actual payload would be inconsistent with the payload setting temporarily. Then the sensor cannot also detect the external force correctly. In this case, the payload change distance is useful. Please refer to Chapter 5.

## 4.2.3 Collaborative Robot Monitor Screen

“Force Monitor” and “Payload Monitor” are displayed in the collaborative robot screen in the software version 7DC3/30 or later. You can monitor an external force and a load applied to the robot.

DCS					
Collaborative robot					
Force Monitor:		Current	Peak		
		0.00[N] ( 0%)	0%		
Settings :		Warning	Output		
		0%	GO[ 0]		
Payload Monitor:		Current	Peak		
Force :		0%	0%		
Moment :		0%	0%		
Settings :		Warning	Output		
Force :		50%	GO[ 0]		
Moment :		50%	GO[ 0]		
Warning in DSBL:		DISABLE			
[TYPE]	CONFIRM	PEAKCLR		UNDO	

In the software version 7DC3/31 or later, direction components based on the robot world frame is displayed.

DCS					
Collaborative robot					
Force Monitor:					
	Resultant	X	Y	Z	
Curr:	0.00[N]				
	0%	0%	0%	0%	
Peak:	0%	0%	0%	0%	
Output:	GO[ 0]	GO[ 0]	GO[ 0]	GO[ 0]	
Warning:	0%				
Payload Monitor:					
FORCE	Resultant	X	Y	Z	
Curr:	0%	0%	0%	0%	
Peak:	0%	0%	0%	0%	
Output:	GO[ 0]	GO[ 0]	GO[ 0]	GO[ 0]	
Warning:	50%				
MOMENT	Resultant	X	Y	Z	
Curr:	0%	0%	0%	0%	
Peak:	0%	0%	0%	0%	
Output:	GO[ 0]	GO[ 0]	GO[ 0]	GO[ 0]	
Warning:	50%				
Warning in DSBL:		DISABLE			
[TYPE]	CONFIRM	PEAKCLR		UNDO	

In the software version 7DC3/33 or later, the compensation value of Variable Payload Compensation function is also displayed. Refer to Section 7.5.

DCS					
Collaborative robot					
Force Monitor:					
	Resultant	X	Y	Z	
Curr:	0.00[N]				
	0%	0%	0%	0%	
Peak:	0%	0%	0%	0%	
Output:					
Curr:	GO[ 0]	GO[ 0]	GO[ 0]	GO[ 0]	
Warning:	0%				
Payload Monitor:					
FORCE	Resultant	X	Y	Z	
Curr:	0%	0%	0%	0%	
Comp:		0%	0%	0%	
Peak:	0%	0%	0%	0%	
Output:					
Curr:	GO[ 0]	GO[ 0]	GO[ 0]	GO[ 0]	
Comp:		GO[ 0]	GO[ 0]	GO[ 0]	
Warning:	50%				
MOMENT	Resultant	X	Y	Z	
Curr:	0%	0%	0%	0%	
Comp:		0%	0%	0%	
Peak:	0%	0%	0%	0%	
Output:					
Curr:	GO[ 0]	GO[ 0]	GO[ 0]	GO[ 0]	
Comp:		GO[ 0]	GO[ 0]	GO[ 0]	
Warning:	50%				
Warning in DSBL:		DISABLE			
[TYPE]	CONFIRM	PEAKCLR		UNDO	

## Force Monitor

External force applied to the robot is displayed and output to external signals. You can monitor instant force such that a human contact.

### Curr[N]

Current external force applied to the robot is displayed.

### Curr[%]

Current force / Active Force Limit x 100 (When the contact stop function is disabled, the value is 0 %.)  
When the value is 100 %, a contact stop occurs. (SYST-320 “Contact force exceeds limit” is posted.)

## Payload Monitor

Steady load applied to the robot is displayed and output to external signals. When the payload setting does not match the actual payload, this value will be large.

### Force: Curr [%]

Averaged force / tolerance x 100 (During the payload change, the value is 0 %.)

When the value is 100 %, payload error occurs. (SYST-325 “Payload error is detected” is posted.)

### Force: Comp [%]

Force Compensation value during playback of Variable Payload Compensation function. Refer to Section 7.5.

### Moment: Curr [%]

Averaged moment / tolerance x 100 (During the payload change, the value is 0 %.)

When the value is 100 %, payload error occurs. (SYST-325 “Payload error is detected” is posted.)

### Moment: Comp [%]

Moment Compensation value during playback of Variable Payload Compensation function. Refer to Section 7.5.

## Peak

Peak hold value of each item is displayed. Press F3[PEAK CLR] to clear the value.

**Warning**

When the current value[%] exceeds each warning value[%], following warning occurs.

- SYST-350 Force Monitor warning
- SYST-348 Payload Monitor (Force) warning
- SYST-349 Payload Monitor (Moment) warning

Set integer value from 0 to 100. When the value is 0, warning does not occur.

**Warning in DSBL**

DISABLE: No warning occurs when the contact stop function is disabled.

ENABLE: Warnings also occur when the contact stop function is disabled.

**Output**

Each item can be output to signals etc. Following signal types can be set.

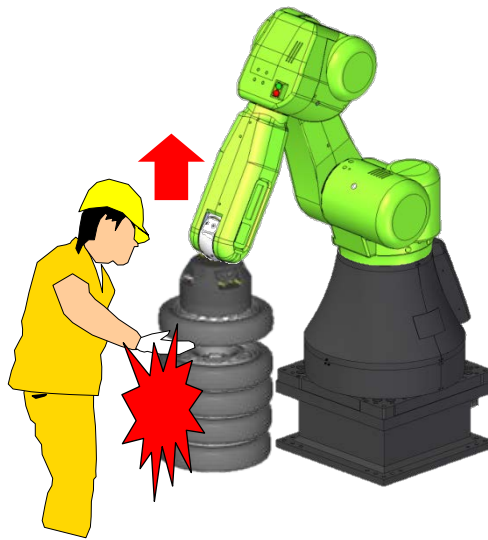
GO: Current value is output to Group output.

R: Current value is output to Numeric Register.

DO/RO: When the current value exceeds the set warning value, signal is set to ON.

## 4.3 RETREAT AFTER CONTACT STOP

When the robot was stopped by the contact stop and if strong force remained, the robot will retreat slightly.

**Condition**

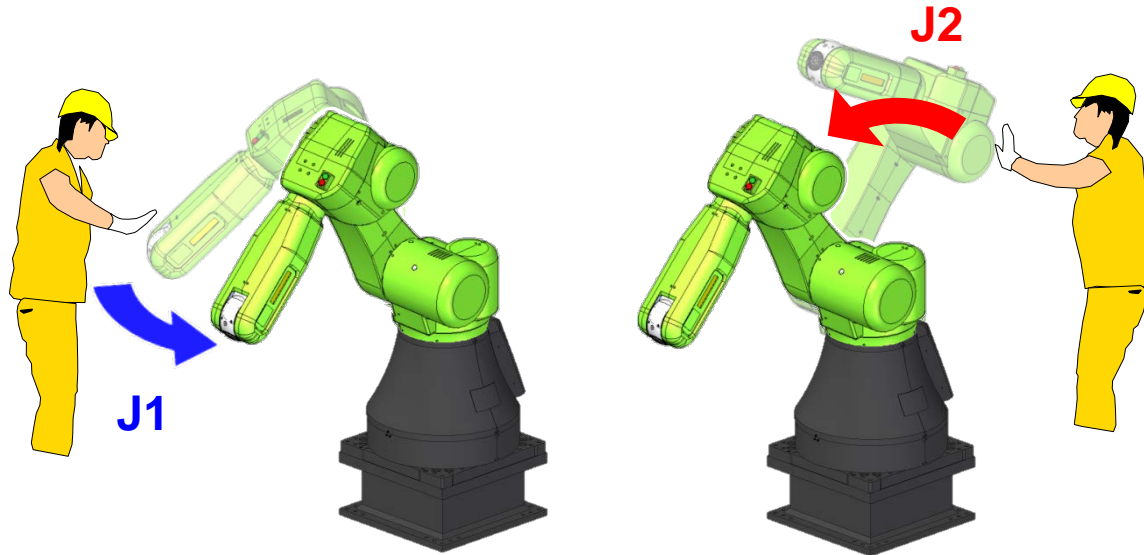
Only at the contact stop in execution of the program (not in jogging)

**How to disable the function**

Set the system variable “\$DCSS\_CLLB[1].\$REV\_ENB” to FALSE.

## 4.4 PUSH TO ESCAPE

When an operator pushes the robot, the robot moves to pushed direction. Only J1 and J2 can respectively escape by pushing. In Push To Escape, TCP orientation is not kept.



### Condition

- AUTO mode
- Any alarm is not posted.
- The robot stops.
- The contact stop function is enabled.
- The external force is less than the force limit for Push To Escape.

### How to disable the function

Set the system variable “\$DCSS\_CLLB[1].\$PTE\_ENABLE” to FALSE.

### Tips for pushing

- When you push the robot too strongly, the robot cannot escape.
- Farther and farther from the rotation axis, it is easy to push.
- If the robot does not escape, release your hand for a moment and try again.



# 5 PROGRAMMING

You can teach a program of the collaborative robot in much the same way as other FANUC robots except for situations such that the collaborative robot is subjected to external force.

For example, while the robot picks or places a workpiece, the robot is subjected to external force. The payload number is changed by PAYLOAD instruction in program. The timing of PAYLOAD instruction execution is not the same as the timing of the actual workpiece picking/placing. Therefore a contact stop may occur by mismatch between the payload setting and the actual payload. To avoid the unnecessary contact stop during the payload change, the contact stop function can be disabled.

In this situation, to prevent a program from being paused by the contact stop, you should set the contact stop function to disable in limited area. There are following ways to disable the contact stop function.

- To set all disabling I/O of force limits to ON
- To change payload number when the payload change distance enabling input

The disabling I/O of force limits and the payload change distance enabling could be assigned with the safety I/O (e.g. Cartesian position check, Joint speed check, etc.). The safety I/O is helpful to teach a safety program.

## WARNING

- 1 When the contact stop is disabled, the collaborative robot does not stop even though the external force exceeds the limit, and serious personal injury could result. If the robot system is designed to be able to disable the contact stop, adequate risk assessment for the whole robot system is necessary to verify that the contact stop can be disabled.
- 2 Opening and closing of a robot hand could do a human serious personal injury. When you design a robot hand, adequate risk assessment for the robot hand is necessary to verify that the robot hand do a human no injury.

This chapter provides some examples of programming the collaborative robot.

## 5.1 PICKING WORKPIECE

### 5.1.1 Simple Picking Program

This section provides a setting to pick a workpiece. In following way, the contact stop is disabled just after payload number change. If the robot moves more than the payload change distance, the contact stop is enabled.

## WARNING

When the contact stop is disabled, the collaborative robot does not stop even though the external force exceeds the limit, and serious personal injury could result. If the robot system is designed to be able to disable the contact stop, adequate risk assessment for the whole robot system is necessary to verify that the contact stop can be disabled.

## SETTING

### Payload change distance

- 1 Press the [MENU] key.
- 2 Select SYSTEM.
- 3 Press F1, [TYPE].
- 4 Select DCS.
- 5 If neither DCS top screen nor Collaborative robot screen, press [PREV] key, and select Collaborative robot.
- 6 Scroll down. You will see a screen similar to the following.

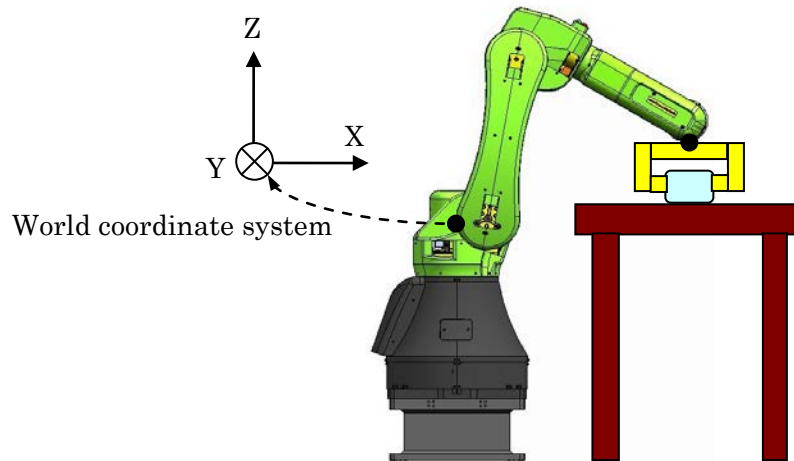
DCS				
Collaborative robot				
Limit 1:	105.00	---	[ 0]	OK
Limit 2:	0.00	---	[ 0]	OK
Limit 3:	0.00	---	[ 0]	OK
Limit 4:	0.00	---	[ 0]	OK
Escape:	300.00			OK
Payload change distance (mm)				
	Current	+Limit	-Limit	
X:	0.00	0.00	0.00	OK
Y:	0.00	0.00	0.00	OK
Z:	0.00	0.00	0.00	OK
Enabling input:	ON	[ 0]		OK
[ TYPE ]	CONFIRM			UNDO

- 7 Set Payload change distance +Limit and -Limit of each direction(X, Y, Z). In this example, +Limit of Z = 3.0mm, and the limit of other directions is 1.0mm.

DCS				
Collaborative robot				
Limit 1:	105.00	---	[ 0]	OK
Limit 2:	0.00	---	[ 0]	OK
Limit 3:	0.00	---	[ 0]	OK
Limit 4:	0.00	---	[ 0]	OK
Escape:	300.00			OK
Payload change distance (mm)				
	Current	+Limit	-Limit	
X:	0.00	1.00	1.00	CHGD
Y:	0.00	1.00	1.00	CHGD
Z:	0.00	3.00	1.00	CHGD
Enabling input:	ON	[ 0]		OK
[ TYPE ]	CONFIRM			UNDO

- 8 Apply to DCS parameter. Refer to Dual Check Safety Function OPERATOR'S MANUAL (B-83184EN), Chapter of OVERVIEW, Section of APPLY TO DCS PARAMETER.

In above setting, when the payload number is changed, the contact stop is disabled. When the flange position of the robot moves to +Z direction of the world coordinate system more than 3mm or other direction more than 1mm from the position the payload number is changed, the contact stop returns to enabled.



If the contact stop returns to enabled before the external force is sufficiently small, the program will be paused. Adjust the setting as followings, and prevent the program from being paused.

- Reduce the speed of the movement the robot lift up a workpiece.
- Wait a little after lifting up a workpiece.
- Set the payload change distance to sufficient distance to the external force is small.



### CAUTION

The payload change distance is 0 by default. If you change the payload change distance, adequate risk assessment for the whole robot system is necessary to verify that the payload change distance does not cause any dangerous situation.



### WARNING

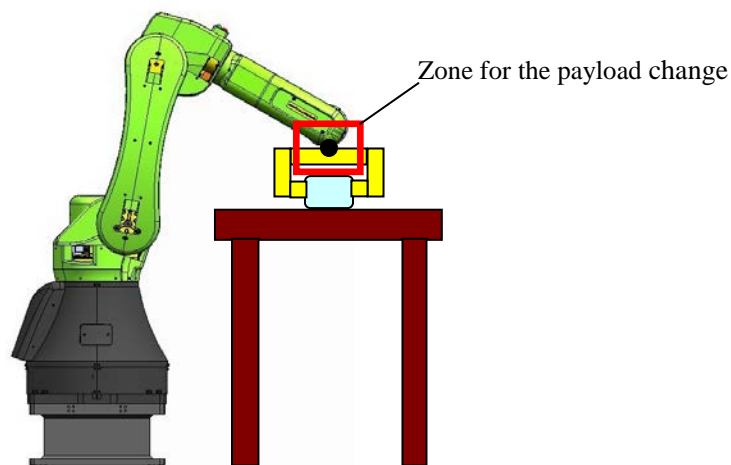
- 1 When the contact stop is disabled, the collaborative robot does not stop even though the external force exceeds the limit, and serious personal injury could result. If the robot system is designed to be able to disable the contact stop, adequate risk assessment for the whole robot system is necessary to verify that the contact stop can be disabled.
- 2 In this setting, when the payload number is changed, the contact stop function is disabled anywhere in the envelope of the robot. This indicates the contact stop function is disabled unexpectedly, if any mistakes.

## 5.1.2 Limiting Picking Area

In previous sample program, when the payload number is changed, the contact stop function is disabled anywhere in the envelope of the robot. This indicates the contact stop function is disabled unexpectedly, if any mistakes. For example, the payload number is changed by a mistake of programming.

This section provides additional setting to specify the area to payload change. In this setting, even if the payload number is changed out of the zone, the contact stop function still is enabled. You can program as below.

- Set the DCS tool model for the payload change.
- Set the zone for the payload change to the DCS Cartesian Position Check.
- Set Safe I/O connect
- Set Safe I/O of the zone as the payload change distance enabling input.



### SOFTWARE OPTION

The following options are necessary for below setting.

J567 DCS Position/Speed check function

J568 DCS Safe I/O connection function

Refer to Dual Check Safety Function OPERATOR'S MANUAL (B-83184EN) for more detail information about these options. Below setting is one example.

## SETTING

### DCS Tool model setting

- 1 Press [MENU] key.
- 2 Select SYSTEM.
- 3 Press F1, [TYPE].
- 4 Select DCS.
- 5 If neither DCS top screen nor User model, press [PREV] key several times, and select User model.
- 6 Select No.1 and press F3, [DETAIL]. You will see a screen similar to the following.

DCS					
User element detail					
No. 1 [*****]					
Element: 1 Status: OK					
1	Enable/Disable:	DISABLE			
2	Link No. (99:FacePlate) :	99			
3	Link type:	NORMAL			
4	Tool frame:	0			
5	Shape:	Point			
6	Size (mm):	0.0			
Pos1					
7	X:	0.000	Y:	0.000	Z: 0.000
Pos2					
8	X:	0.000	Y:	0.000	Z: 0.000
	[TYPE]			UNDO	>

- 7 Set the TCP model as below. Please set the Tool frame position in (X, Y, Z) of Pos1. In this example, size is 50mm.

DCS					
User element detail					
No. 1 [*****]					
Element: 1 Status: CHGD					
1	Enable/Disable:	ENABLE			
2	Link No. (99:FacePlate) :	99			
3	Link type:	NORMAL			
4	Tool frame:	0			
5	Shape:	Point			
6	Size (mm):	50.0			
Pos1					
7	X:	0.000	Y:	0.000	Z: 0.000
Pos2					
8	X:	0.000	Y:	0.000	Z: 0.000
	[TYPE]			UNDO	>

- 8 Apply to DCS parameter. Refer to Dual Check Safety Function OPERATOR'S MANUAL (B-83184EN), Chapter of OVERVIEW, Section of APPLY TO DCS PARAMETER.

## DCS Cartesian Position Check setting

- 1 Press [MENU] key.
- 2 Select SYSTEM.
- 3 Press F1, [TYPE].
- 4 Select DCS.
- 5 If neither DCS top screen nor Cart. position check, press [PREV] key, and select Cart. position check.
- 6 Select No.1 and press F3, [DETAIL]. You will see a screen similar to the following.

DCS			
Cartesian position check			
No. 1	Status:----		
1 Comment:	[*****]		
2 Enable/Disable:	DISABLE		
3 Method(Safe side):	Diagonal(IN)		
4 Group:	1		
5 Target model 1:	-1		
6 Target model 2:	0		
7 Target model 3:	0		
	(0:Disable, -1:Robot, -2:Tool)		
8 User frame:	0		
Position(mm):			
	Current	Point 1	Point 2
9 X	1110.0	0.0	0.0
10 Y	0.0	0.0	0.0
11 Z	940.0	0.0	0.0
12 Stop type:	Power-Off stop		
13 disabling input:	---[ 0: ]		
[TYPE]	PREV	NEXT	RECORD UNDO >

- 7 Set the zone for the payload change such as below.
  - Set target model to TCP model.
  - Set Stop type to Not stop. The robot can move both inside and outside this zone.
  - Set the Position for the payload change. Please note that the contact stop function is disabled when TCP is in this zone.

DCS			
Cartesian position check			
No. 1	Status:CHGD		
1 Comment:	[*****]		
2 Enable/Disable:	ENABLE		
3 Method(Safe side):	Diagonal(IN)		
4 Group:	1		
5 Target model 1:	1		
6 Target model 2:	0		
7 Target model 3:	0		
	(0:Disable, -1:Robot, -2:Tool)		
8 User frame:	0		
Position(mm):			
	Current	Point 1	Point 2
9 X	1110.0	1000.0	800.0
10 Y	0.0	-100.0	100.0
11 Z	940.0	600.0	800.0
12 Stop type:	Not stop		
13 disabling input:	---[ 0: ]		
[TYPE]	PREV	NEXT	RECORD UNDO >

8. Apply to DCS parameter. Refer to Dual Check Safety Function OPERATOR'S MANUAL (B-83184EN), Chapter of OVERVIEW, Section of APPLY TO DCS PARAMETER.

### Safe I/O connect setting

- 1 Press [MENU] key.
- 2 Select SYSTEM.
- 3 Press F1, [TYPE].
- 4 Select DCS.
- 5 If neither DCS top screen nor Safe I/O connect, press [PREV] key several times, and select Safe I/O connect. You will see a screen similar to the following.

DCS					
Safe I/O connect					
	Output	Input1	Input2	Status	
	---[ 0 ]=	---[ 0 ]	---[ 0 ]	OK	
	---[ 0 ]=	---[ 0 ]	---[ 0 ]	OK	
	---[ 0 ]=	---[ 0 ]	---[ 0 ]	OK	
	---[ 0 ]=	---[ 0 ]	---[ 0 ]	OK	
	---[ 0 ]=	---[ 0 ]	---[ 0 ]	OK	
	---[ 0 ]=	---[ 0 ]	---[ 0 ]	OK	
	---[ 0 ]=	---[ 0 ]	---[ 0 ]	OK	
	---[ 0 ]=	---[ 0 ]	---[ 0 ]	OK	
	---[ 0 ]=	---[ 0 ]	---[ 0 ]	OK	
	---[ 0 ]=	---[ 0 ]	---[ 0 ]	OK	
	---	---	---	---	

- 6    Set  $SIR[1] = CPC[1]$  (Cartesian Position Check of the zone for the payload change).

[illegible]

- 7 Apply DCS parameter. Refer to Dual Check Safety Function OPERATOR'S MANUAL (B-83184EN), Chapter of OVERVIEW, Section of APPLY TO DCS PARAMETER.

When you would like to set plural zones for the payload change, you can set such as followings.

[illegible]

**Payload change distance Enabling input**

- 1 Press [MENU] key.
- 2 Select SYSTEM.
- 3 Press F1, [TYPE].
- 4 Select DCS.
- 5 If neither DCS top screen nor Collaborative robot screen, press [PREV] key, and select Collaborative robot.
- 6 Scroll down. You will see a screen similar to the following.

DCS					
Collaborative robot					
Limit 1:	105.00	---	[ 0 ]		OK
Limit 2:	0.00	---	[ 0 ]		OK
Limit 3:	0.00	---	[ 0 ]		OK
Limit 4:	0.00	---	[ 0 ]		OK
Escape:	300.00				OK
Payload change distance (mm)					
	Current	+Limit	-Limit		
X:	0.00	1.00	1.00		OK
Y:	0.00	1.00	1.00		OK
Z:	0.00	3.00	1.00		OK
Enabling input:	ON	[ 0 ]			OK
[ TYPE ]	CONFIRM			UNDO	

- 7 Set Payload change distance Enabling input to SIR[1].

DCS					
Collaborative robot					
Limit 1:	105.00	---	[ 0 ]		OK
Limit 2:	0.00	---	[ 0 ]		OK
Limit 3:	0.00	---	[ 0 ]		OK
Limit 4:	0.00	---	[ 0 ]		OK
Escape:	300.00				OK
Payload change distance (mm)					
	Current	+Limit	-Limit		
X:	0.00	1.00	1.00		OK
Y:	0.00	1.00	1.00		OK
Z:	0.00	3.00	1.00		OK
Enabling input:	SIR	[ 1 ]			CHGD
[ TYPE ]	CONFIRM			UNDO	

- 8 Apply to DCS parameter. Refer to Dual Check Safety Function OPERATOR'S MANUAL (B-83184EN), Chapter of OVERVIEW, Section of APPLY TO DCS PARAMETER.

In above setting, when the robot is out of the safety area, the contact stop is not disabled by the payload number change. To avoid the contact stop disabled in unexpected area, set the area as above.

## 5.2 DISABLING CONTACT STOP IN PROGRAM

This section provides how to disable the contact stop function by program. This is useful in a system such that the robot should stay in movement even though the robot is subjected to external force in specified area.



### WARNING

When the contact stop is disabled, the collaborative robot does not stop even though the external force exceeds the limit, and serious personal injury could result. If the robot system is designed to be able to disable the contact stop, adequate risk assessment for the whole robot system is necessary to verify that the contact stop can be disabled.



## SOFTWARE OPTION

The following options are necessary for below setting.

- J567 DCS Position/Speed check function
- J568 DCS Safe I/O connection function

Refer to Dual Check Safety Function OPERATOR'S MANUAL (B-83184EN) for more detail information about these options. Below setting is one example.

## SETTING

### DCS Tool model setting

- 1 Press [MENU] key.
- 2 Select SYSTEM.
- 3 Press F1, [TYPE].
- 4 Select DCS.
- 5 If neither DCS top screen nor User model, press [PREV] key several times, and select User model.
- 6 Select No.1 and press F3, [DETAIL]. You will see a screen similar to the following.

DCS			
User element detail			
No.	1 [*****]		
Element:	1	Status:	OK
1 Enable/Disable:	DISABLE		
2 Link No. (99:FacePlate) :	99		
3 Link type:	NORMAL		
4 Tool frame:	0		
5 Shape:	Point		
6 Size (mm):	0.0		
Pos1			
7 X:	0.000	Y: 0.000	Z: 0.000
Pos2			
8 X:	0.000	Y: 0.000	Z: 0.000
[TYPE]		DETAIL	ROBOT UNDO >

- 7 Set the TCP model as below. Please set the Tool frame position in (X, Y, Z) of Pos1. In this example, size is 50mm.

DCS			
User element detail			
No.	1 [*****]		
Element:	1	Status:	CHGD
1 Enable/Disable:	ENABLE		
2 Link No. (99:FacePlate) :	99		
3 Link type:	NORMAL		
4 Tool frame:	0		
5 Shape:	Point		
6 Size (mm):	50.0		
Pos1			
7 X:	0.000	Y: 0.000	Z: 0.000
Pos2			
8 X:	0.000	Y: 0.000	Z: 0.000
[TYPE]			UNDO >

- 8 Apply to DCS parameter. Refer to Dual Check Safety Function OPERATOR'S MANUAL (B-83184EN), Chapter of OVERVIEW, Section of APPLY TO DCS PARAMETER.

## DCS Cartesian Position Check setting

- 1 Press [MENU] key.
- 2 Select SYSTEM.
- 3 Press F1, [TYPE].
- 4 Select DCS.
- 5 If neither DCS top screen nor Cart. position check, press [PREV] key, and select Cart. position check.
- 6 Select No.1 and press F3, [DETAIL]. You will see a screen similar to the following.

DCS			
Cartesian position check			
No. 1		Status:----	
1 Comment: [*****]			
2 Enable/Disable:		DISABLE	
3 Method(Safe side):Diagonal(IN)			
4 Group:		1	
5 Target model 1:		-1	
6 Target model 2:		0	
7 Target model 3:		0	
(0:Disable, -1:Robot, -2:Tool)			
8 User frame:		0	
Position(mm):			
	Current	Point 1	Point 2
9 X	1110.0	0.0	0.0
10 Y	0.0	0.0	0.0
11 Z	940.0	0.0	0.0
12 Stop type:		Power-Off stop	
13 disabling input:		---[ 0: ]	
[TYPE]	PREV	NEXT	RECORD UNDO >

- 7 Set the zone for the contact stop disable
  - Set target model to TCP model.
  - Set Stop type to Not stop. The robot can move both inside and outside this zone.
  - Set the Position for the contact stop disable.

DCS			
Cartesian position check			
No. 1		Status:CHGD	
1 Comment: [*****]			
2 Enable/Disable:		ENABLE	
3 Method(Safe side):Diagonal(IN)			
4 Group:		1	
5 Target model 1:		1	
6 Target model 2:		0	
7 Target model 3:		0	
(0:Disable, -1:Robot, -2:Tool)			
8 User frame:		0	
Position(mm):			
	Current	Point 1	Point 2
9 X	1110.0	1000.0	800.0
10 Y	0.0	-100.0	100.0
11 Z	940.0	600.0	800.0
12 Stop type:		Not stop	
13 disabling input:		---[ 0: ]	
[TYPE]	PREV	NEXT	RECORD UNDO >

- 8 Apply to DCS parameter. Refer to Dual Check Safety Function OPERATOR'S MANUAL (B-83184EN), Chapter of OVERVIEW, Section of APPLY TO DCS PARAMETER.

## DCS NSI setting

- 1 Press [MENU] key.
- 2 Select I/O.
- 3 Press F1, [TYPE].
- 4 Select Digital.
- 5 Press F2, [CONFIG], and press F3, [IN/OUT]. You will see a screen similar to the following.

I/O Digital Out						
#	RANGE			RACK	SLOT	START STAT.
1	DO[	1-	64]	89	1	1 ACTIV
2	DO[	65-	512]	0	0	0 UNASG

	[TYPE]	MONITOR	IN/OUT	DELETE	HELP	>
--	--------	---------	--------	--------	------	---

- 6 Set unassigned DO to NSI. In this example, DO[70] = NSI[1]. NSI is RACK 36, SLOT 0.

I/O Digital Out						
#	RANGE			RACK	SLOT	START STAT.
1	DO[	1-	64]	89	1	1 ACTIV
2	DO[	65-	69]	0	0	0 UNASG
3	DO[	70-	70]	36	0	1 PEND
4	DO[	71-	512]	0	0	0 UNASG

	[TYPE]	MONITOR	IN/OUT	DELETE	HELP	>
--	--------	---------	--------	--------	------	---

**Safe I/O connect setting**

- 1 Press [MENU] key.
- 2 Select SYSTEM.
- 3 Press F1, [TYPE].
- 4 Select DCS.
- 5 If neither DCS top screen nor Safe I/O connect, press [PREV] key several times, and select Safe I/O connect. You will see a screen similar to the following.

DCS					
Safe I/O connect					
Output	Input1	Input2	Status		
SIR[ 1]=	---[ 0]	---[ 0]	OK		
SIR[ 2]=	---[ 0]	---[ 0]	OK		
SIR[ 3]=	---[ 0]	---[ 0]	OK		
SIR[ 4]=	---[ 0]	---[ 0]	OK		
SIR[ 5]=	---[ 0]	---[ 0]	OK		
SIR[ 6]=	---[ 0]	---[ 0]	OK		
SIR[ 7]=	---[ 0]	---[ 0]	OK		
SIR[ 8]=	---[ 0]	---[ 0]	OK		
SIR[ 9]=	---[ 0]	---[ 0]	OK		
SIR[ 10]=	---[ 0]	---[ 0]	OK		
[TYPE]		CLEAR		UNDO	

- 6 Set SIR[1] = NSI[1] AND CPC[1] (Cartesian Position Check of the zone for the contact stop disable).

DCS					
Safe I/O connect					
Output	Input1	Input2	Status		
SIR[ 1]=	NSI[ 1] AND	CPC[ 1]	CHGD		
SIR[ 2]=	---[ 0]	---[ 0]	OK		
SIR[ 3]=	---[ 0]	---[ 0]	OK		
SIR[ 4]=	---[ 0]	---[ 0]	OK		
SIR[ 5]=	---[ 0]	---[ 0]	OK		
SIR[ 6]=	---[ 0]	---[ 0]	OK		
SIR[ 7]=	---[ 0]	---[ 0]	OK		
SIR[ 8]=	---[ 0]	---[ 0]	OK		
SIR[ 9]=	---[ 0]	---[ 0]	OK		
SIR[ 10]=	---[ 0]	---[ 0]	OK		
[TYPE]		CLEAR		UNDO	

- 7 Apply DCS parameter. Refer to Dual Check Safety Function OPERATOR'S MANUAL (B-83184EN), Chapter of OVERVIEW, Section of APPLY TO DCS PARAMETER.

## Force limit disabling input setting

- 1 Press [MENU] key.
- 2 Select SYSTEM.
- 3 Press F1, [TYPE].
- 4 Select DCS.
- 5 If neither DCS top screen nor Collaborative robot screen, press [PREV] key, and select Collaborative robot. You will see a screen similar to the following.

DCS			
Collaborative robot			
			Status
Contact stop status:	SAFE		
Enable/Disable:	ENABLE		OK
Force sensor			
Serial number:	XXXXXXXX		OK
Group:	1		OK
Payload setup:	<DETAIL>		OK
Active Payload: No. 1 [*****]			
External force (N) / Disabling input			
Limit 1:	105.00	---[ 0]	OK
Limit 2:	100.00	---[ 0]	OK
Limit 3:	0.00	---[ 0]	OK
Limit 4:	0.00	---[ 0]	OK
Escape:	300.00		OK
[TYPE]	CONFIRM		UNDO

- 6 Set the all set limits of disabling input to SIR[1].

DCS			
Collaborative robot			
			Status
Contact stop status:	SAFE		
Enable/Disable:	ENABLE		OK
Force sensor			
Serial number:	XXXXXXXX		OK
Group:	1		OK
Payload setup:	<DETAIL>		OK
Active Payload: No. 1 [*****]			
External force (N) / Disabling input			
LIMIT 1:	105.00	SIR[ 1]	CHGD
LIMIT 2:	100.00	SIR[ 1]	CHGD
LIMIT 3:	0.00	---[ 0]	OK
LIMIT 4:	0.00	---[ 0]	OK
Escape:	300.00		OK
[TYPE]	CONFIRM		UNDO

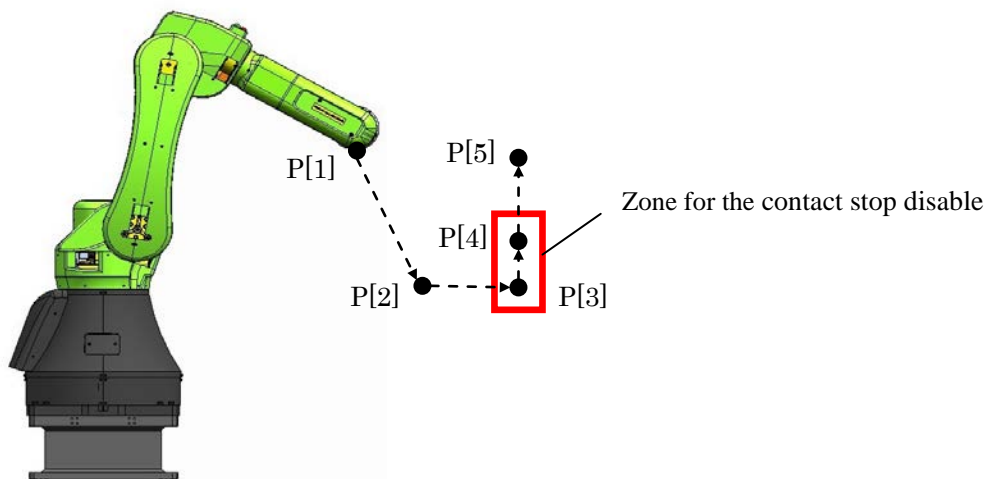
- 7 Apply DCS parameter. Refer to Dual Check Safety Function OPERATOR'S MANUAL (B-83184EN), Chapter of OVERVIEW, Section of APPLY TO DCS PARAMETER.

**SAMPLE PROGRAM**

```
1: L P[1] 200mm/s CNT100  
2: L P[2] 200mm/s CNT100  
3: DO[70] = ON  
4: L P[3] 50mm/s CNT100  
5: L P[4] 50mm/s CNT100  
6: DO[70] = OFF  
7: L P[5] 200mm/s CNT100
```

In the above settings, the contact stop function is disabled when the robot is in the zone for the contact stop disable and DO[70] = ON. Therefore, in line 4 of the sample program, the contact stop function is disabled just after the robot enters into the zone. When the robot leaves the zone after that, the contact stop function is enabled.

If the external force is large and the contact stop function is enabled, the program will be paused. To avoid the situation, set the zone for the contact stop disable appropriately.



# 6 PERIODICAL CHECK

To check the force sensor accuracy, the periodical function check operation should be performed in proper interval. FANUC recommends once a month.

## HOW TO CHECK

- Execute checking program according to the following.
- The robot program can be executed with the robot hand.

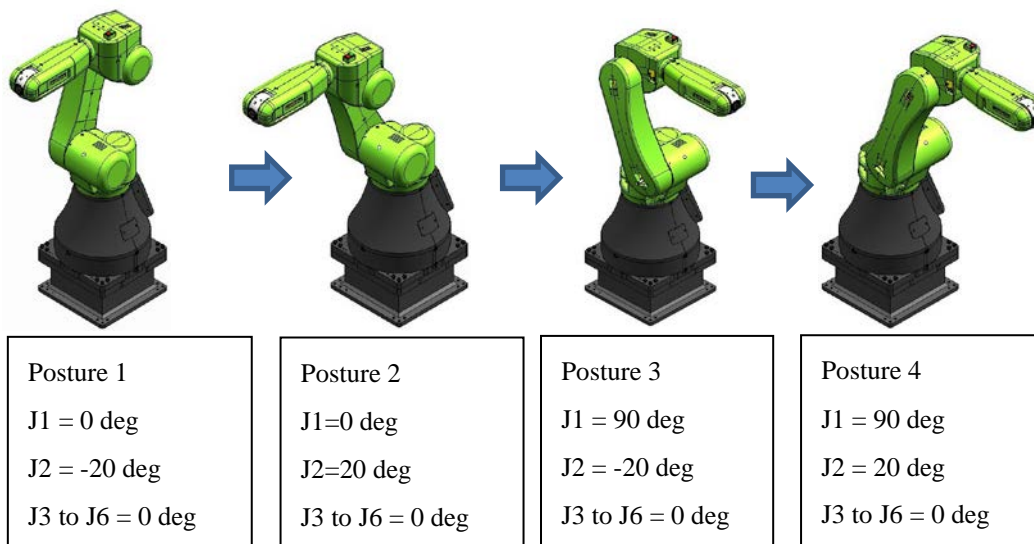
## How to make the checking program

- 1 Make a program that the robot moves to some positions.
  - Term type of motion instruction is FINE.
  - Each postures of the robot in the checking program must have a distance from each other. This is for checking the output of all direction of the force sensor.
  - The maximum number of the position in the checking program is 30.
  - All operating time of the program must be less than 90 sec.
- 2 Insert CALL instruction to call FORCETST(parameter). FORCETST is KAREL program loaded by default.
  - In the first position, call FORCETST(1).
  - In the second position onward, call FORCETST(2).
  - In the last position, call FORCETST(3).

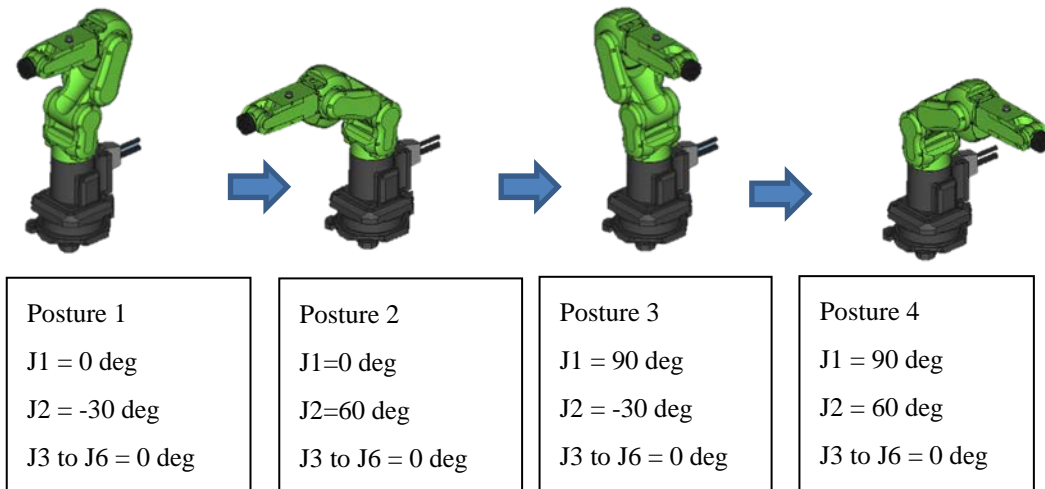
## SAMPLE PROGRAM

The following is the example of the proper position data for the periodical function check.

### CR-35iA



## CR-4iA, CR-7iA, CR-7iA/L



The following is an example checking program.

```

1: J P[1] 30% FINE
2: CALL FORCETST(1)
3: J P[2] 30% FINE
4: CALL FORCETST(2)
5: J P[3] 30% FINE
6: CALL FORCETST(2)
7: J P[4] 30% FINE
8: CALL FORCETST(3)

```

**RESULT OF CHECK**

- If the execution of the checking program is completed without any alarms, the force sensor accuracy is good.
- If “SYST-325 Payload error is detected” occurs, check the payload setting at first. If the payload setting is correct, the force sensor may have problems.
- If “SYST-327 Inappropriate regular test program” occurs, the checking program has a problem. Please refer to above explanation.
  - Verify that each postures of the robot in the checking program must have a distance from each other.
  - Verify that the number of the positions of the checking program is less than 30.



# 7 UTILITY

This chapter explains special functions of the collaborative robot.

## 7.1 AUTO RESUME FUNCTION

Auto resume function automatically resumes the robot program paused by the contact stop function.

### Condition

- In AUTO mode
- Teach Pendant is OFF.
- The program is paused by the contact stop function.
- Any alarm is not posted.

In following cases, the auto resume is canceled.

- The contact stop occurs continuously.
- An operator pushes the robot for a certain time.
- It has a certain time after the contact stop.
- The program was aborted.
- Push To Escape is performed.
- Retreat after the contact stop is performed.
- The paused program's group mask is not same as collaborative robot group.
- HOLD key was pressed after contact stop.



### CAUTION

- 1 The auto resume function is disabled by default. If you enable this function, adequate risk assessment for the whole robot system is necessary to verify that the auto resume function does not cause any dangerous situation.
- 2 If the auto resume function is enable, the situation that the robot program is possible to be resumed automatically should be indicated clearly that the operator can notice from anywhere in the operation area.  
The program running output can be used to the indication; it is ON when the robot program is possible to be resumed automatically. Refer to Section 2.3.

### Setting up

You can set up the auto resume function with below system variables.

#### **\$DCSS\_CLLB[1].\$AUTO\_RESUME**

If it is set to 1, the auto resume function is enabled. If it is set to 0, the auto resume function is disabled.

### Limitation

- Multi task program is not supported, because the auto resume can resume only one task. When multiple programs is executed by multitasking function, all programs pause by the contact stop function. If you don't want to stop a program by the contact stop, set Interruption Disable in the program detail screen. Refer to OPERATOR'S MANUAL (Basic Operation) (B-83284EN), Chapter of PROGRAM STRUCTURE.
- Auto resume function will not resume when the program group mask is not same as collaborative robot group setting. Therefore, CALL instruction may cause unintended resuming. For example, if using following two programs, the program will not be resumed when the cursor is in the PRG\_A.TP but the program will be resumed when the cursor is in the PRG\_B.TP. In this case, set Group mask of collaborative robot group to 1 in PRG\_A detail screen, then the auto resume function will resumes PRG\_A.

PRG\_A.TP(Group Mask \*,\*,...)

1:CALL PRG_B
2:DO[1] = ON
3:WAIT DI[1] = ON
4:CALL PRG_B

PRG\_B.TP(Group Mask 1,\*,...)

1:J P[1] 10% CNT 100
2:J P[2] 10% CNT 10

## 7.2 HIGH SPEED MODE

By default, the speed of the collaborative robot is limited by limited speed value (CR-35iA: 250mm/s, CR-4iA, CR-7iA, CR-7iA/L: 750mm/s)

To use the collaborative robot as High Speed Mode, set the system variable \$CF\_LIM\_GRP[group number of collaborative robot].\$SPEEDLIM to the value less than the maximum speed of the robot . Then the speed of the collaborative robot is limited by the set speed. About the maximum speed of the robot, refer to the manual of each robot.

When the robot is CR-35iA and the software version is 7DC3/23 or later, you can switch on and off of the speed limit without override change. Use in accordance with the following configuration.

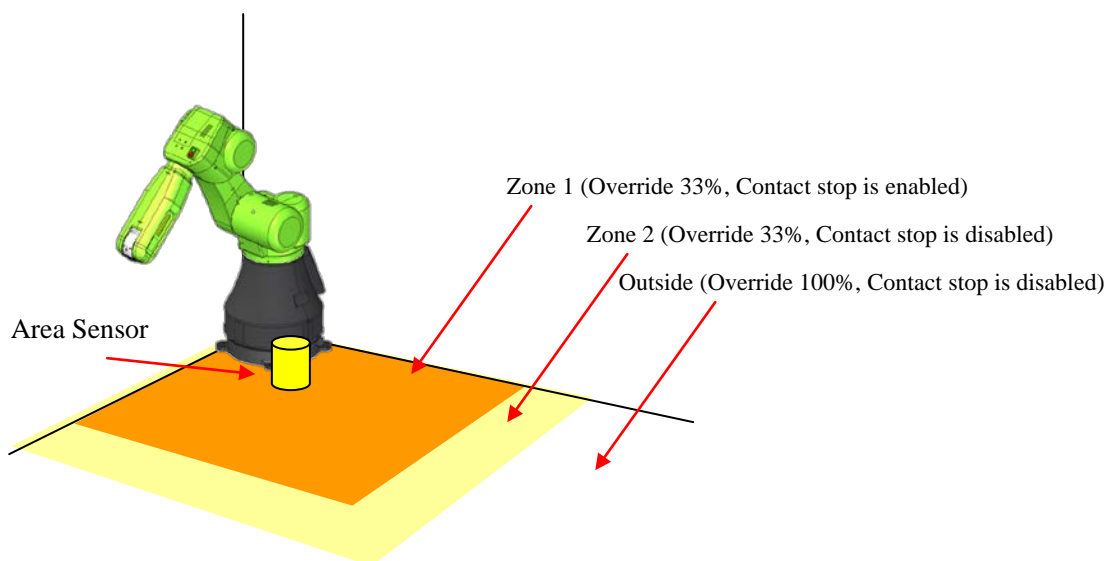
### SAMPLE CONFIGURATION

#### (CR-35iA before 7DC3/22, CR-4iA, CR-7iA, CR-7iA/L)

When the contact stop function is enable, TCP speed is checked regardless of the value of \$CF\_LIM\_GRP[group number of collaborative robot].\$SPEEDLIM. If the TCP speed exceeds the limit, the robot stops. For example, on CR-35iA, to avoid the stop, please set the override to a integer value less than “25000/\$CF\_LIM\_GRP[group number of collaborative robot].\$SPEEDLIM” when the contact stop function is enabled. For example, when \$CF\_LIM\_GRP[group number of collaborative robot].\$SPEEDLIM =750, set the override less than 33% (25000/750=33.333).

The following is the example of the robot system with high speed mode with the area sensor.

- When a human is in the Zone 1, the contact stop is enabled.
- When a human is in the Zone 2 (including Zone 1), the override is set to 33 % by Override Select function.
- When a human is not in Zone 2 (including Zone 1), the override is set to 100 % by Override Select function.



- Area sensor has 1 safety output and 1 non-safety output.
- The safety output of the area sensor is connected to SFDI1 of the robot controller. This signal is accessed as SPI[1] in DCS function. When a human is in Zone 1, the SPI[1] becomes OFF.
- The non-safety output of the area sensor is connected to digital input signal that is assigned to DI[20]. When a human is in the Zone 2, DI[20] becomes OFF.
- Set the disabling input of the force limit to SPI[1]. Refer to Section 2.2.

@Limit 1:	105.00	SPI[ 1]	OK
Limit 2:	0.00	---[ 0]	OK
Limit 3:	0.00	---[ 0]	OK
Limit 4:	0.00	---[ 0]	OK

- Set the Override select as below. By this setting, the override is set to 100% when DI[20] is ON, and the override is set to 33% when DI[20] is OFF. (DI[21] is not used.)

OVERRIDE SELECT			
1 Function Enable :ENABLE			
2 Signal 1 : DI[ 20][OFF]			
3 Signal 2 : DI[ 21][OFF]			
	Signal 1	Signal 2	Override
4	OFF	OFF	33 %
5	OFF	ON	33 %
6	ON	OFF	100 %
7	ON	ON	100 %
	[TYPE]		



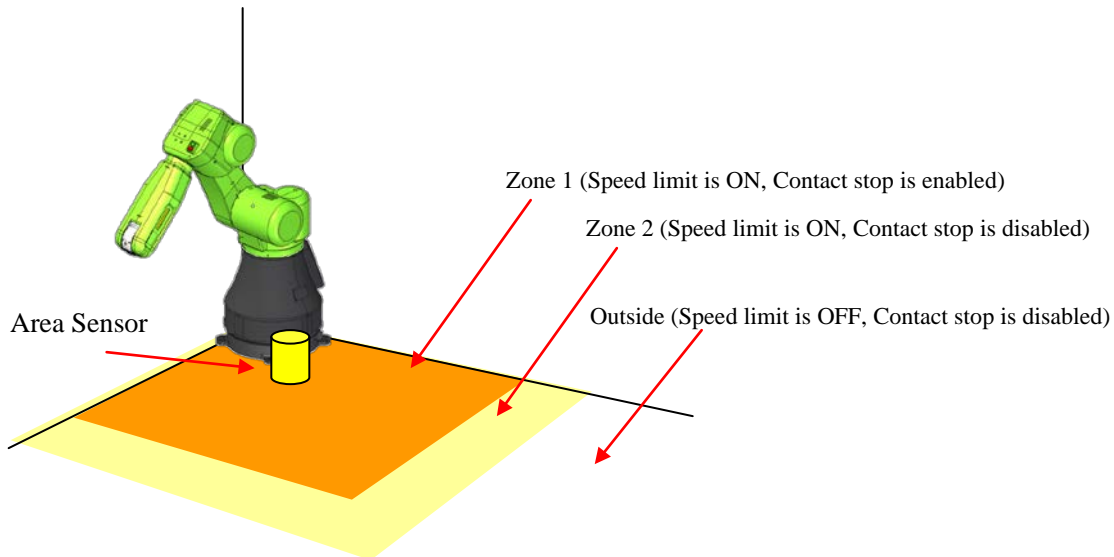
### WARNING

When the contact stop is disabled, the collaborative robot does not stop even though the external force exceeds the limit, and a serious personal injury could result. If the robot system is designed to be able to disable the contact stop, adequate risk assessment for the whole robot system is necessary to verify that the contact stop can be disabled.

**SAMPLE CONFIGURATION (CR-35iA after 7DC3/23)**

The following is the example of the robot system with high speed mode with the area sensor.

- When a human is in the Zone 1, the contact stop is enabled.
- When a human is in the Zone 2 (including Zone 1), the speed limit is ON by turning OFF the disabling input of the speed limit.
- When a human is not in Zone 2 (including Zone 1), the speed limit is OFF by turning ON the disabling input of the speed limit.



- Area sensor has 1 safety output and 1 non-safety output.
- The safety output of the area sensor is connected to SFDI1 of the robot controller. This signal is accessed as SPI[1] in DCS function. When a human is in Zone 1, the SPI[1] becomes OFF.
- The non-safety output of the area sensor is connected to digital input signal that is assigned to DI[20]. When a human is in the Zone 2, DI[20] becomes OFF.
- Set the disabling input of the force limit to SPI[1]. Refer to Section 2.2.

@Limit 1:	105.00	SPI[ 1]	OK
Limit 2:	0.00	---[ 0]	OK
Limit 3:	0.00	---[ 0]	OK
Limit 4:	0.00	---[ 0]	OK

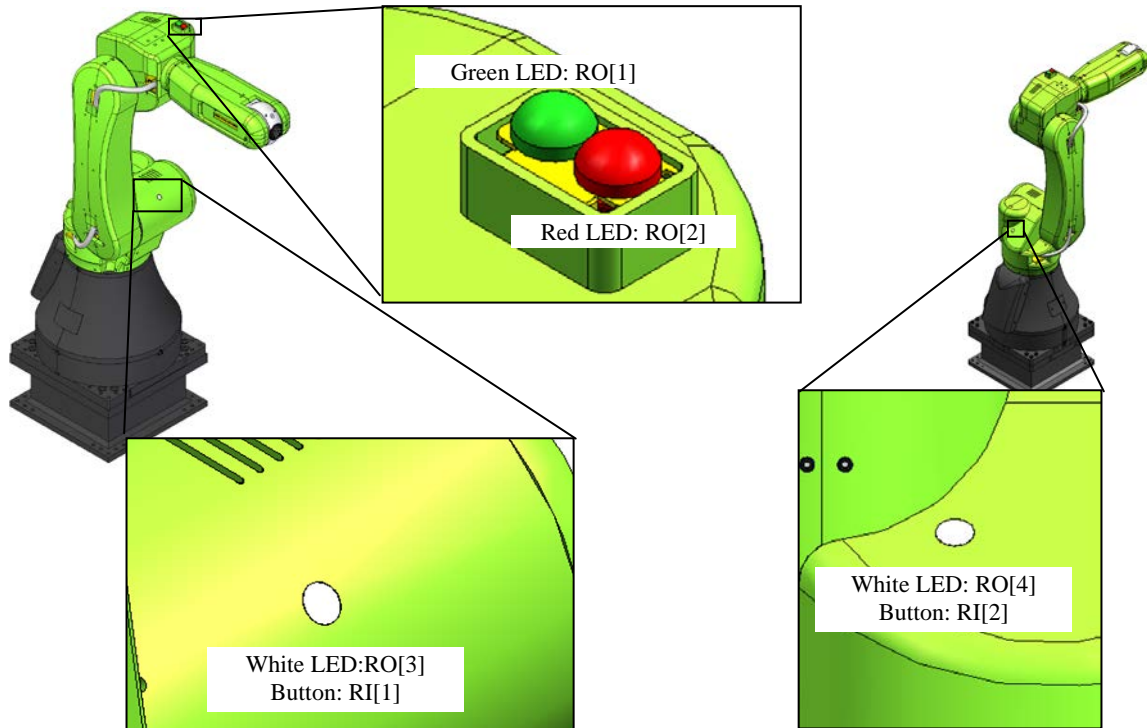
- Assign the disabling input of the speed limit to DI[20]. Set following system variables.  
\$DCSS\_CLLB[1].\$DITYP\_HISPD = 1 (Type of input DI:1, F:35)  
\$DCSS\_CLLB[1].\$DIIDX\_HISPD = 20 (Index of input)

**WARNING**

When the contact stop is disabled, the collaborative robot does not stop even though the external force exceeds the limit, and a serious personal injury could result. If the robot system is designed to be able to disable the contact stop, adequate risk assessment for the whole robot system is necessary to verify that the contact stop can be disabled.

## 7.3 LED AND BUTTON ON ROBOT ARM

The collaborative robot has the following LED and button connected to RO and RI.



By default, these LED and button are not assigned to any function. You can use these LED and Button for general purpose. The following is the example to set up the LED and Button.

### SAMPLE CONFIGURATION SPECIFICATION

- Green LED turns ON when program is running. (It keeps ON when a program is resumed by the auto resume function.)
- Red LED turns ON when an alarm occurs.
- White LED turns ON when the robot can move by pressing the button.  
(Remote, Program is not running, Alarm does not occur and the status of the contact stop is SAFE)

#### Setting

Flag and the back ground logic is used for this setting. For more detail procedure to set Flag and the back ground logic, refer to OPERATOR'S MANUAL (Basic Operation) (B-83284), Chapter of UTILITY, Section of BACKGROUND LOGIC.

- Set F[101-118] are assigned to UI[1-18]. So F[106] is assigned to UI[6:Start]
- Assign F[120] to SAFE state output. Refer to Section 2.3.
- Assign F[121] to Program running output. Refer to Section 2.3.
- Execute the following program as the background logic.

```

1: RO[1]= F[121]
2: RO[2]=(SO[3:Fault LED])
3: RO[3]=(SO[0:Remote LED] AND !RO[1] AND !RO[2] AND F[120])
4: RO[4]=(RO[3])
5: F[106]=(RO[3] AND (RI[1] OR RI[2]))
  
```

**CAUTION**

If the button on the robot arm is used to start robot program, emergency stop button must be prepared near the robot. The emergency stop button on the operator panel of the robot controller can be used for this purpose depending to the position of the robot controller.

## 7.4 OPERATION LOG BOOK

Collaborative robot state, event of payload change and so on can be recorded in the Log Book by operation log book function.

To use function, Operation Log Book option (J695) is required.

Refer to Chapter 12 of Optional Function OPERATOR'S MANUAL (B-83284EN-2) for detail of this function.

The System variable of collaborative robot operation logbook number is \$LOGBOOK.\$LOG\_CLLB. Default value is 4. Logbook is started to record after first payload confirmation.

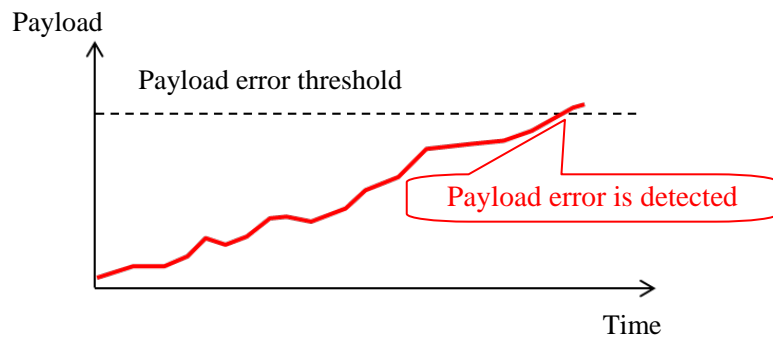
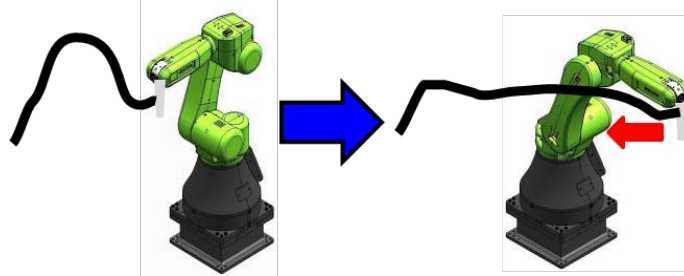
Following events are recorded to Log Book.

Message	Event	Reference
Collaborative state %d (Ch:%d)	This event is recorded when the collaborative robot state is changed.	Refer to Section 2.3 OUTPUT SIGNAL OF COLLABORATIVE ROBOT STATUS for detail.
Force limit is changed to %d	This event is recorded when the force limit is changed.	Refer to Section 2.2 SETTING COLLABORATIVE ROBOT FUNCTION for detail.
Contact stop is disabled	This event is recorded when all of force limit is disabled.	Refer to Section 2.2 SETTING COLLABORATIVE ROBOT FUNCTION for detail.
Payload number is changed to %d	This event is recorded when payload number is changed.	Refer to Section 2.2 SETTING COLLABORATIVE ROBOT FUNCTION for detail.
Contact stop(%s,%d)	This event is recorded when the robot is stopped by contact stop function.	Refer to Section 4.1 CONTACT STOP FUNCTION for detail.
Auto-resume done	This event is recorded when the program is resumed by auto resume function.	Refer to Section 7.1 AUTO RESUME FUNCTION for detail.
Auto resume canceled (%d)	This event is recorded when the program could not resumed by auto resume function. %d is the factor of this event. The factor is recorded in 2nd lines in message.	Refer to Section 7.1 AUTO RESUME FUNCTION for detail.
Reverse motion	This event is recorded when the reverse motion is executed after contact stop.	Refer to Section 4.3 RETREAT AFTER CONTACT STOP for detail.
Contact force is not released	This event is recorded when resumed or started in spite of exceeded the force limit and the collaborative state is stop.	

## 7.5 Variable Payload Compensation function

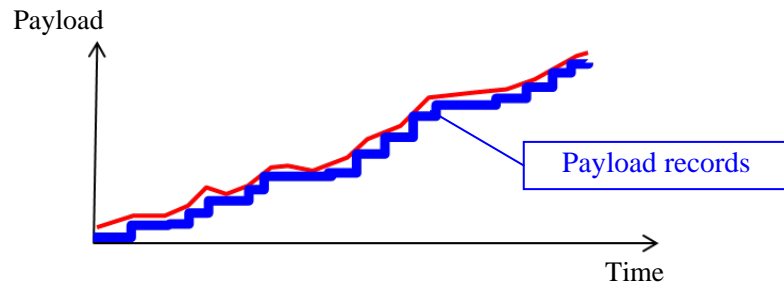
This function is available on the software version 7DC3/33 or after.

When a payload acts on Collaborative Robot, “SYST-325 Payload error is detected” is posted, and the robot stops. For example, in case of that a cable is attached to the robot, when the robot moves and the attitude changes, tension by cable might be detected as payload, and the robot stops.

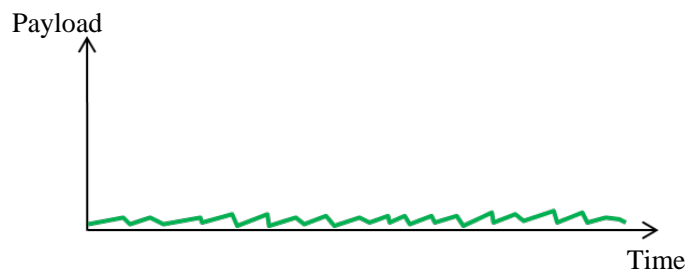


This function cancels an external payload as such system.

Firstly, move the robot in RECORD mode, and Payload is recorded at constant intervals.



During normal operation, recorded payload is canceled from payload detected by sensor.



## 7.5.1 How to use Variable Payload Compensation Function

### Enable the function

In the collaborative robot screen, you can enable this function by “Use Payload Comp”.

- After change, you need to apply DCS parameters.
- When it is “ENABLE”, you can record or playback the payload.
- When you change from “ENABLE” to “DISABLE”, the recorded data is not deleted.

DCS					
Collaborative robot					
Payload change distance (mm)					
	Current	+Limit	-Limit		
X:	0.00	0.00	0.00		OK
Y:	0.00	0.00	0.00		OK
Z:	0.00	0.00	0.00		OK
Rotation:	Current	Limit			
	0.00[deg]	0.20[deg]			OK
Enabling input:	ON	[ 0]			OK
Password for CONFIRM:	ENABLE				OK
CONFIRM by DI:	DISABLE				OK
CONFIRM input:	DI	[ 0]			
Payload No. output:	GO	[ 0]			
Speed limit:	250.00	[mm/s]			OK
Use Payload Comp:	ENABLE				OK
[ TYPE ]	CONFIRM	PEAKCLR		UNDO	

### Procedure for use

- 1 Call Karel program “FCMPSTRT” at the start position of compensation.
  - 1st parameter : 1 = RECORD mode, 2 = RECORD mode (RECORD clear), 0 = PLAY mode
  - 2nd parameter : Schedule number
  - 3rd parameter : Interval for compensation (ms) Recordable time is “Interval x 1000”. Minimum of interval is 8(ms).
- 2 Call Karel program “FCMPEND” at the end position of compensation.

```

1: J P[1] 100% FINE
2:   CALL FCMPSTRT(0, 20, 100)
3: J P[2] 100% FINE
4: L P[3] 250mm/sec FINE
5: L P[4] 250mm/sec FINE
6:   CALL FCMPEND
7: J P[5] 30% FINE

```

- 3 Execute with RECORD mode (1st parameter is 1)
  - Payload is recorded at set intervals.
  - When the recording starts, “SYST-352 Payload Record Start” warning is posted.
  - When the recording ends, “SYST-353 Payload Record Finish” warning is posted. It may take time for save recorded data to the memory. If the controller power is off during saving data, recorded data is gone.
  - When the recording fails, “SYST-354 Payload Record Failed” warning is posted. The program execution does not stop. For the cause of fail, refer to Subsection 7.5.2.
  - When you execute again with the schedule already recorded, average of payload is recorded. When you record 10 times, average value of 10 times is recorded. If you want to delete records, execute with RECORD CLEAR (1st parameter is 2).



- 4 When you execute with PLAY mode (1st parameter is 0)
  - Payload is compensated with the recorded payload.
  - When you specify unrecorded schedule, the warning “SYST-355 Payload is NOT recorded” will be posted.
  - When the compensation is failed, the warning “SYST-356 Payload Compensation is stopped” will be posted, and compensation will be zero. For the cause of fail, refer to Subsection 7.5.2.
  - In PLAY mode, specification of 3rd parameter (interval) for compensation has no meaning. Compensation works at interval at the time of recording.

## Compensation Data

- The compensation data is saved below FR:¥CLLB¥
- FR:¥CLLB is saved as CLLB.ZIP in backup of “all of above”.

## Compensation value monitoring

Each elements of the compensation value is displayed in payload monitor screen. And you can set and output the values to GO or Register.

DCS					
Collaborative robot					
Payload Monitor:					
FORCE	Resultant	X	Y	Z	
Curr:	0%	0%	0%	0%	
Comp:		0%	0%	0%	
Peak:	0%	0%	0%	0%	
Output:					
Curr:	GO[ 0]	GO[ 0]	GO[ 0]	GO[ 0]	
Comp:		GO[ 0]	GO[ 0]	GO[ 0]	
Warning:	50%				
MOMENT	Resultant	X	Y	Z	
Curr:	0%	0%	0%	0%	
Comp:		0%	0%	0%	
Peak:	0%	0%	0%	0%	
Output:					
Curr:	GO[ 0]	GO[ 0]	GO[ 0]	GO[ 0]	
Comp:		GO[ 0]	GO[ 0]	GO[ 0]	
Warning:	50%				
Warning in DSBL: DISABLE					
	[TYPE]	CONFIRM	PEAKCLR		UNDO

## 7.5.2 Restrictions of Variable Payload Compensation Function

### General

- This function works well in the case of that the same payload acts every time.
- When this function is enabled, Push to escape function is disabled.
- Payload is recorded in association with the point of motion path of the robot. There is no problem if the override is changed or the robot stops with WAIT statement in both RECORD mode and PLAY mode.
- In below situation, the difference between the recorded payload and actual payload, and the robot might stop by “SYST-325 Payload error is detected” alarm.
  - In the system that the payload changes every time
  - In the case of that the motion path or motion line is changed, the followings are examples
    - The program includes branches with IF and so on.
    - Execution with STEP mode
    - Addition of motion lines after recording
    - Re-teaching after recording
  - When the speed is changed, the payload is also changed.
- In the system that the external force is detected by floor vibration, vibration is changed between recording and playback, and this function will not compensates well.
- The shorter the interval for compensation, the higher the accuracy and the shorter the recording time. Recommended interval is the value obtained by dividing the operating time by 1000.

**RECORD mode**

- During recording, the compensation does not work. In the case of that the contact stop occurs on the way, recording fails. Set disabling input of force limit to ON, record with the contact stop disable.

**WARNING**

When the contact stop is disabled, the collaborative robot does not stop even though the external force exceeds the limit, and a serious personal injury could result. If the robot system is designed to be able to disable the contact stop, adequate risk assessment for the whole robot system is necessary to verify that the contact stop can be disabled.

- In following cases, the warning “SYST-354 Payload Record Failed (No.X, Y)” occurs. During first recording, it becomes an unrecorded state. During after second recording, it becomes the last recorded state. X of warning message means the schedule number, and Y means the error code. Refer below causes and remedies.

Error Code	Cause	Remedy
1	Hold occurs.	Don't hold during recording.
2	Hold occurs during after second recording.	Don't hold during recording.
3	The program is aborted.	Don't abort the program during recording.
4	The program is aborted during after second recording.	Don't abort the program during recording.
5	Backward execution occurs.	Don't execute backward during recording.
6	Backward execution occurs during after second recording.	Don't execute backward during recording.
7	FCMPSTRT is called.	Don't call other FCMPSTRT between FCMPSTRT and FCMPEND.
8	FCMPSTRT is called during after second recording.	Don't call other FCMPSTRT between FCMPSTRT and FCMPEND.
9	The recording data is abnormal.	Repower the controller. If the problem is not cleared, save the diagnostic log just after failure and send the files to FANUC sales person.
10	The recoding data is abnormal.	Repower the controller. If the problem is not cleared, save the diagnostic log just after failure and send the files to FANUC sales person.
11	Payload is Unrecorded during after second recording	Execute with 1 <sup>st</sup> parameter 2 (RECORD(RECORD CLEAR))
12	The recording data is abnormal during after second recording.	Repower the controller. If the problem is not cleared, save the diagnostic log just after failure and send the files to FANUC sales person.
13	Cause Recording time exceeds.	Recording time limit is “Interval x 1000”. Set the interval to longer value.

- When the controller power off occurs during recording, the recorded date does not remain.

## PLAY mode

- When the program is paused, the compensation remains the value at stop.
- When the program is restarted with original path resume enable, the compensation remains the value at stop until the robot returns stop position.
- In following cases, “SYST-355 Payload Compensation is stopped (No. X, Y)” warning occurs, and the compensation is finished. The compensation value is to zero. X of warning message means the schedule number, and Y means the error code. Refer below causes and remedies.

Error Code	Cause	Remedy
1	The program is aborted.	Don't abort the program during compensation.
2	Backward execution occurs.	Don't execute backward during compensation.
3	FCMPSTRT is called.	Don't call other FCMPSTRT between FCMPSTRT and FCMPEND.
4	The robot restarts on different motion path.	When the motion path is changed after resume, the compensation is stopped. If the original resume function is disabled, enable it. Don't change the program line
5	The recording data is abnormal.	Repower the controller. If the problem is not cleared, save the diagnostic log just after failure and send the files to FANUC sales person.

- When the controller power off occurs during playback, the compensation is finished.

## 7.6 DOUBLE TAP FUNCTION

When you push the parts shown in the figure below twice, the digital signal is output. For example, you set that the start signal is raised when the double tap signal is output, and then you can restart the robot with double tap after the contact stop.



### CAUTION

The double tap function is disabled by default. If you set this function, adequate risk assessment for the whole robot system is necessary to verify that the double tap function does not cause any dangerous situation.

### Condition

Only support for CR-4*i*A, CR-7*i*A and CR-7*i*A/L.  
CR-35*i*A is not supported.

### Setting up

You can set up the double tap function with below system variables.

\$DCSS\_CLLB[1].\$DOTYP\_TAP: Set the type of output (DO:2, RO:9, F:35)

\$DCSS\_CLLB[1].\$DOIDX\_TAP: Set the index of output



# 8 iHMI FOR COLLABORATIVE ROBOT

iHMI is a user interface with a design that even who have never used FANUC product can start up easily. Refer to OPERATOR'S MANUAL (Basic Operation) (B-83284EN), Chapter of iHMI. This chapter introduces functions and operation of iHMI for Collaborative robot.

Contents of this chapter

- 8.1 OVERVIEW OF THE HOME SCREEN
- 8.2 OPERATIONS RELATED TO SETUP
- 8.3 OPERATIONS RELATED TO TEACH
- 8.4 COLLABORATIVE ROBOT MONITOR

iHMI can only be used with R-30iB Plus/R-30iB Mate Plus controller.

## 8.1 OVERVIEW OF THE HOME SCREEN

This section explains the overview of the home screen.

For iHMI for collaborative robot, added functions for collaborative robots to groups of "SETUP", "TEACH", and "RUN".

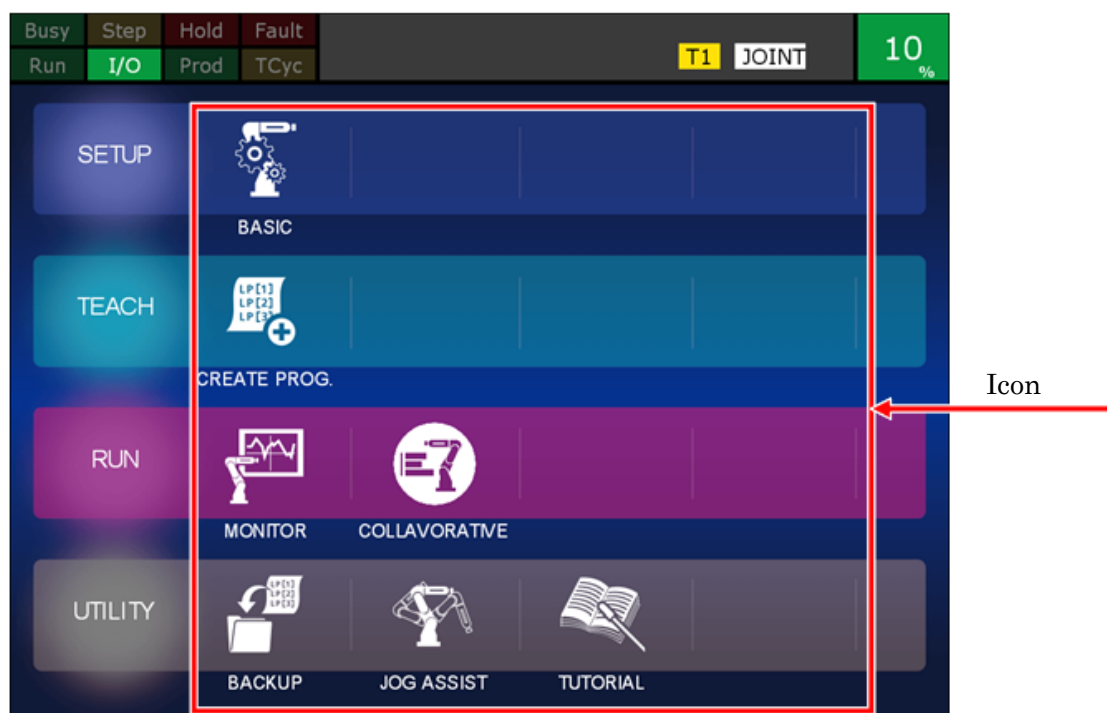





Fig. 8.1 Home screen

Table 8.1 Icons on the home screen

Type	Icon	Description
Setup	 BASIC	Display the Basic Setup Selection screen. On the selection screen, you select the Initial Setup screen and End of Arm Tool Setup Screen, Collaborative Setup screen. The collaborative setting guide will guide settings that make simple pick & place programs executable and settings that enable to switch between fast modes.
Teach	 CREATE PROGRAM	Display the Create a Program screen. On the Create a Program screen, you create programs using template programs (sample programs) for achieving certain objectives. You can also select a "Blank Template" for creating a program from scratch.
Run	 COLLABORATIVE	Display the Collaborative Monitor screen. Graphically displays the external force applied to the robot.

## 8.2 OPERATIONS RELATED TO SETUP

Tap the [BASIC] icons on the home screen and display the Basic Setup Selection screen.

On the Basic Setup Selection screen, select either the Initial Setup screen or the End of Arm Tool Setup screen, Collaborative Setup screen.

The screen display flow for setup is shown below.

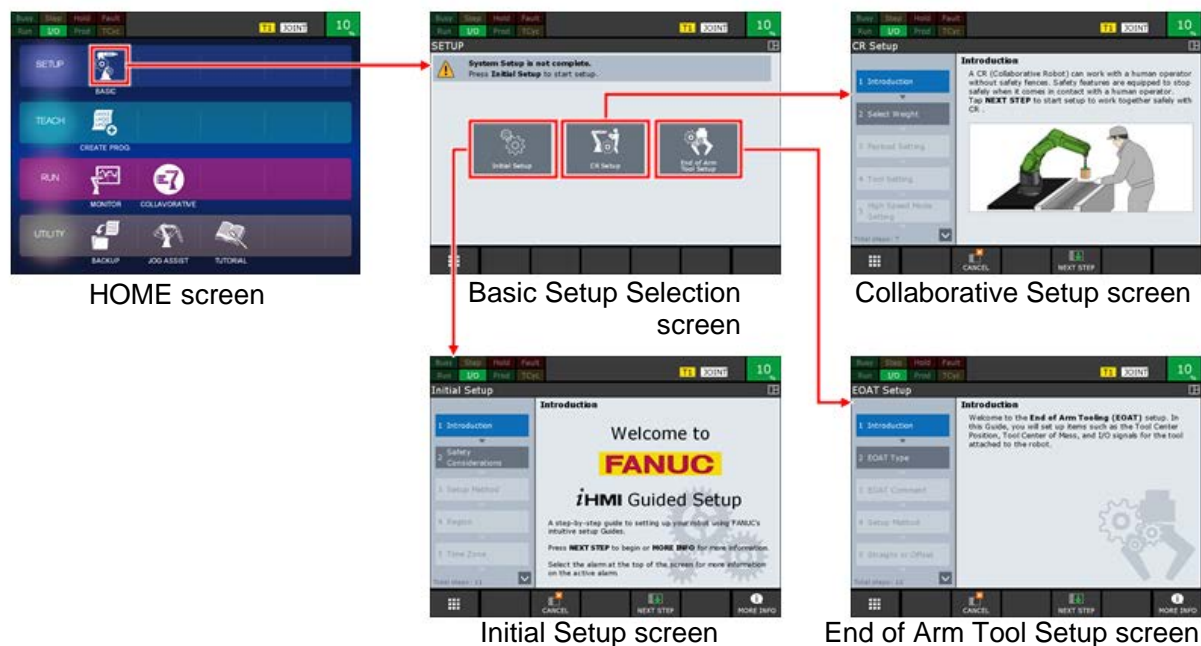


Fig. 8.2 Screen display flow (Setup)

For Initial Setup Guide and End of Arm Tool Setup Guide, refer to OPERATOR'S MANUAL (Basic Operation) (B-83284EN), Section of Operations related to Setup.

## 8.2.1 Collaborative Setup Guide

The collaborative setup guide will guide settings that make simple pick & place programs executable and settings that enable to switch between fast modes. The collaborative setup guide screen is shown below.

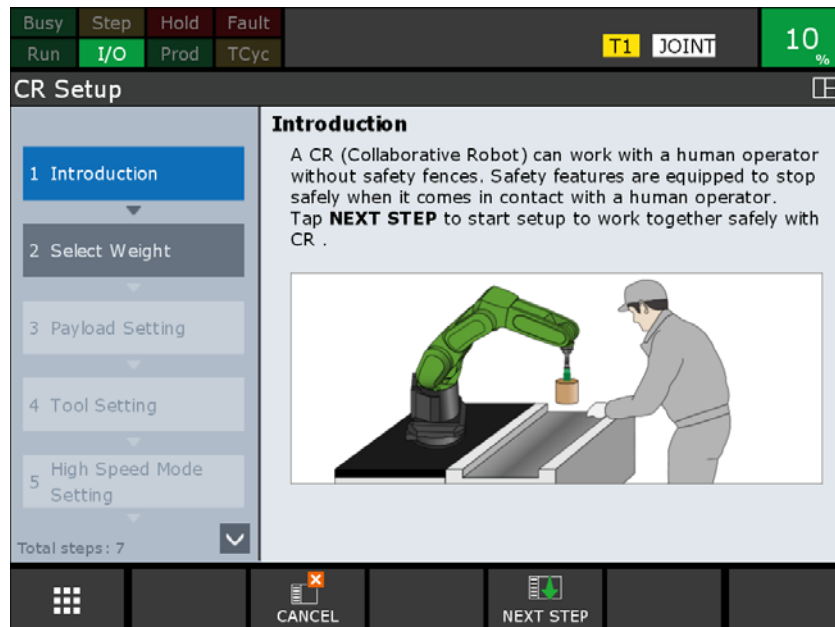


Fig.8.2.1 Collaborative Setup Guide screen

The main setup items on the Collaborative Setup Guide are as follows:

- Payload Setup
- Contact-Stop Invalid Area (Payload change distance)
- Tool Setup
- High Speed Mode

### NOTE

- 1 When the Collaborative Setup guide is completed, the tool setting guide is also automatically set to the completion state.
- 2 When the Collaborative Setup guide is completed, go to DCS screen.

## 8.3 OPERATIONS RELATED TO TEACH

Tap the [Create Program] icon on the home screen and display the Create a Program screen.

The screen display flow when there are no programs is shown below.



Fig.8.3 Screen display flow (when there are no programs)

Refer to OPERATOR'S MANUAL (Basic Operation) (B-83284EN), Section of Operations related to teach.

### 8.3.1 Create Program

On the Create a Program screen, you create programs using template programs (sample programs) for achieving certain objectives. You can also select a "Blank Template" for creating a program from scratch. The Create Program guide screen is shown below.

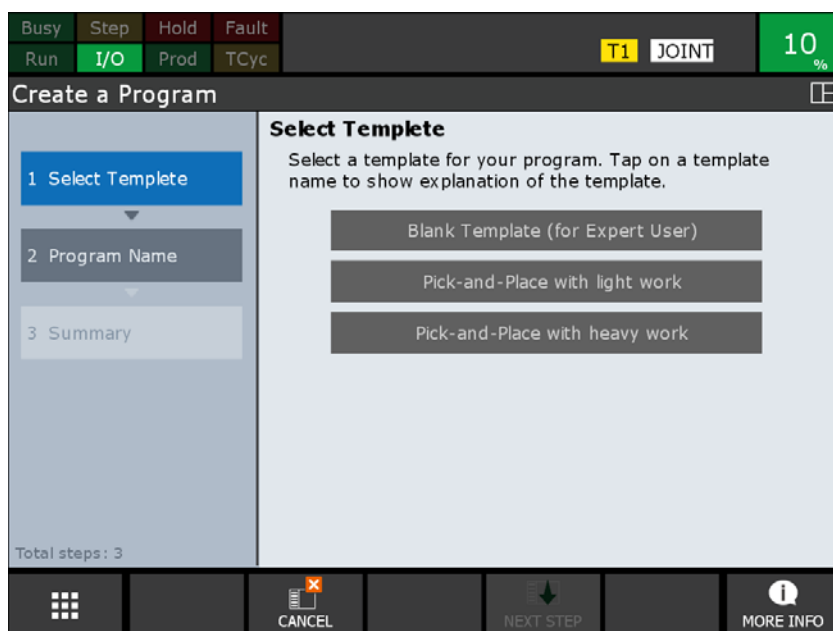


Fig.8.3.1 Create a Program Screen

The templates that can be selected on the Create Program Guide screen are as follows:

- Blank Template
- Pick & Place with light work
- Pick & Place with heavy work



### 8.3.2 Pick & Place with Light Work

This is a template for creating pick & place program with workpiece weight less than 1 kg. You can create a pick & place program with only three teachings.

Teaching points that require teaching by Operator are 1st, 2nd, and 5th point. Other teaching points are taught automatically from 1st and 5th point.

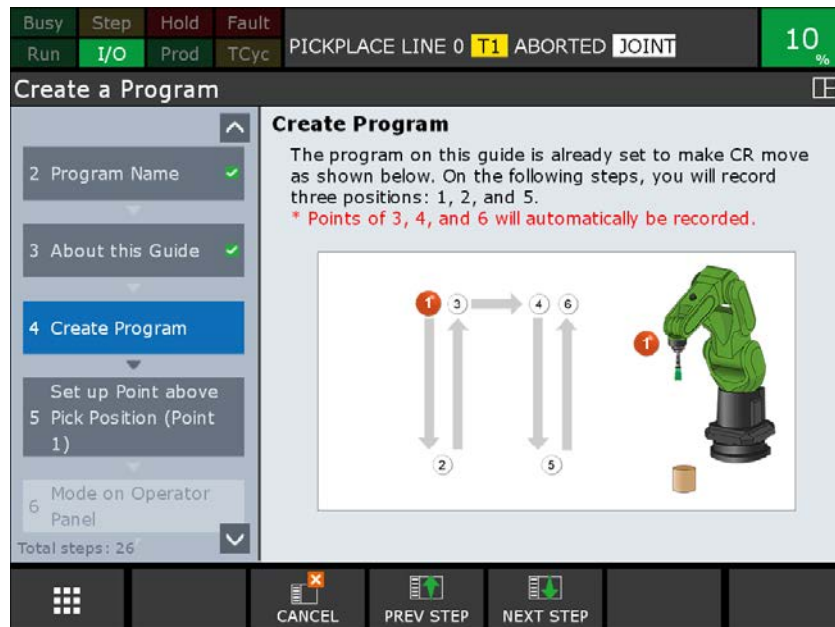


Fig. 8.3.2 Create a Pick & Place with light work screen

If the workpiece is less than 1 kg, you can usually operate without stopping the robot without switching payload.

#### NOTE

If the workpiece is less than 1 kg, the robot may stop. In that case, please use Pick & Place with heavy work template.

### 8.3.3 Pick & Place with Heavy Work

This is a template for creating a pick & place program with a workpiece weight of 1 kg or more. You can create a pick & place program with only 5 teachings.

Teaching points that require teaching by Operator are 1st, 2nd, 3rd, 4th and 7th point. Other teaching points are taught automatically from 1st and 7th point.

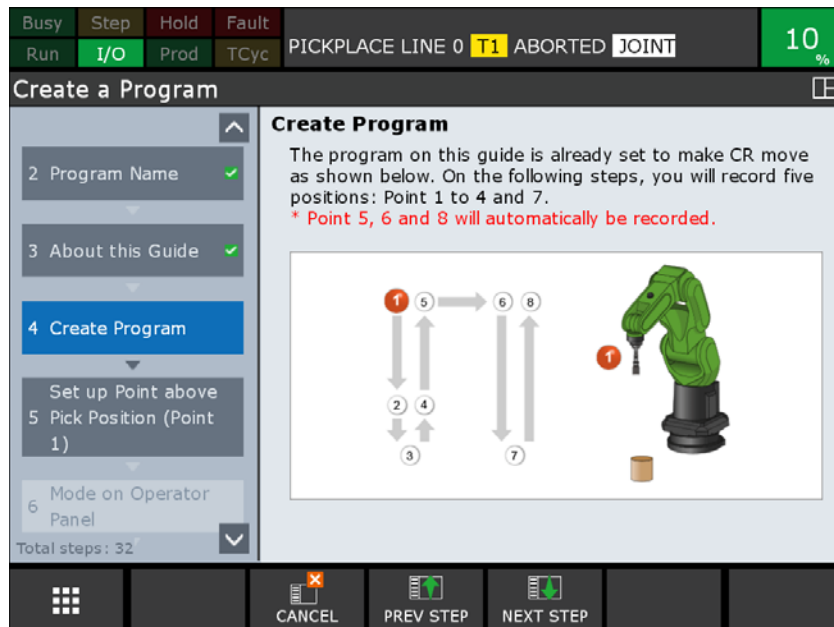


Fig. 8.3.3 Create a Pick & Place with heavy work screen

If the workpiece weight is 1 kg or more, the robot stops unless the payload switching is properly performed. Please make appropriate settings before operating.



#### WARNING

If switch payload, Contact Stop function is disabled In Contact-Stop Invalid Area. The robot does not stop, if an operator contacts. If switch payload, adequate risk assessment for the whole robot system is necessary to verify that the contact stop function becomes invalid within the Contact-Stop Invalid Area.

## 8.4 Collaborative Monitor

Collaborative Robot Monitor provides the screen that can be graphically monitored external forces on cooperating robots.

Tap the "COLLABORATIVE" icon on the home screen to display the Collaborative Robot Monitor screen.



Fig. 8.4 Screen display flow (Collaborative Robot Monitor)

### 8.4.1 Collaborative Robot Monitor Screen

Collaborative Robot Monitor Screen shows the following information.

- (1) Collaborative Robot
- (2) Contact Stop status
- (3) The value of External Force, Payload and Moment
- (4) Active Payload Number
- (5) Direction and magnitude of the Force

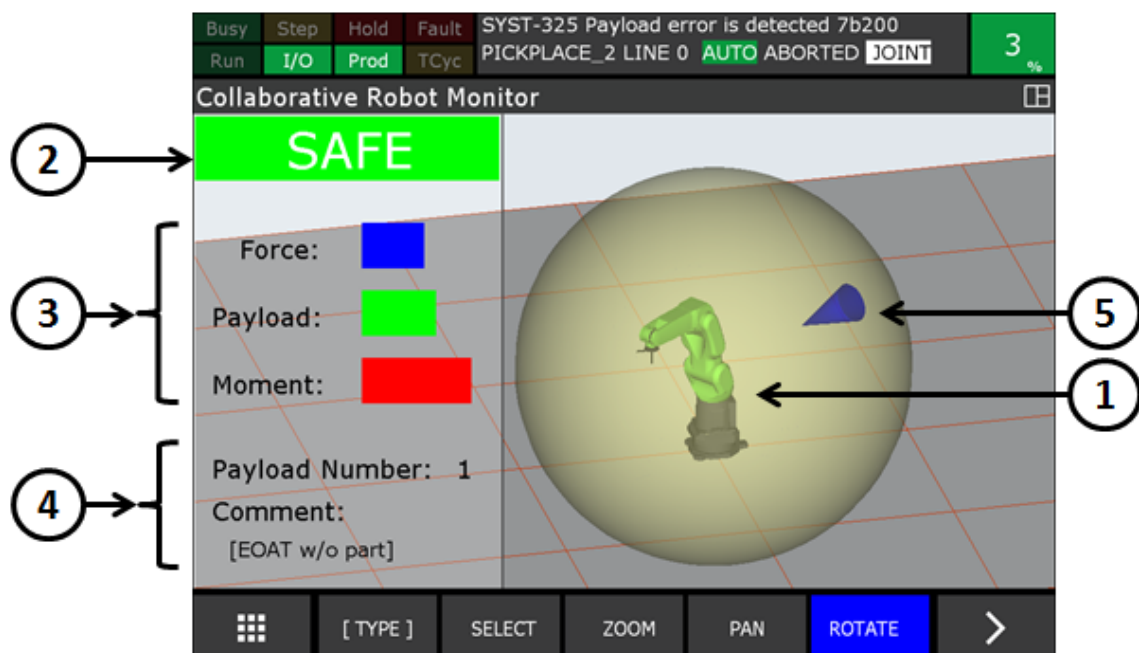


Fig. 8.4.1 Information on Collaborative Robot Monitor screen

Followings are explanation of the information on the screen.

### **Collaborative Robot (1)**

Collaborative robot graphic is shown. The robot model is the same posture as the actual robot.

### **Contact Stop status (2)**

This parameter is the status of contact stop status of the collaborative robot. The contact stop status has the following four statuses. Depending on each state, the background color of the status also changes. Please refer to “2.3 OUTPUT SIGNAL OF COLLABORATIVE ROBOT STATUS” for details of the parameter.

SAFE (green) : The contact stop function is enabled and the safety is confirmed.

STOP (red) : The contact stop function is enabled and the safety is not confirmed.

DSBL (yellow) : The contact stop function is disabled.

ESCP (yellow) : In Push To Escape.

### **The value of Force, Payload and Moment (3)**

The magnitude of the force applied to the robot is displayed. Please refer to “4.2.3 Collaborative Robot Monitor Screen” for details of the parameter.

#### **Force[%]**

External force applied to the robot is displayed by a blue bar. The maximum value is assumed to be 100%, and when it exceeds 80% the color of the bar changes to red.

#### **Payload[%]**

Steady load applied to the robot is displayed by a green bar. The maximum value is assumed to be 100%, and when it exceeds 80% the color of the bar changes to red.

#### **Moment[%]**

Moment applied to the robot is displayed by a green bar. The maximum value is assumed to be 100%, and when it exceeds 80% the color of the bar changes to red.

### **Active Payload Number (4)**

The selected payload number is displayed. If a comment is set for the selected payload, that comment is also displayed.

### **Direction and magnitude of the Force (5)**

The direction and magnitude of the external force applied to the robot is displayed. From the inner surface of the sphere drawn to enclose the robot, a blue cone is displayed towards the direction of force applied to the robot. The length of the cone changes depending on the magnitude of the external force. When the magnitude of force applied to the robot exceeds 80 %, the color of the cone changes to red. If the magnitude of force applied to the robot is less than 20%, the cone is not displayed. Please refer to “4.2.3 Collaborative Robot Monitor Screen” for details of external force.

# APPENDIX



# A TROUBLESHOOTING

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## A.1 INDELIBLE ALARM

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### **“SRVO-358 DCS INVPRM alarm” occurs.**

Verify followings.

- The group number setting of the collaborative robot is correct.
- The force limit settings are between 0 and 150, inclusive.

### **“SRVO-473 DCS CLLB CC\_EXTF alarm” occurs.**

Verify followings.

- Refer to A.2 “SYST-320 Program paused by contact stop” or “SYST-325 Payload error is detected” occurs, even though nobody contacts the robot.”
- Replace the force sensor.

### **“SRVO-477 Calibration data error” occurs.**

Verify if backup files were loaded after initial start. If not, execute one of the following items. After executing, check that “Force Sensor Serial number on the manufacturing plate” corresponds to that of “Force Sensor Serial number on TP”. Refer to PREFACE of each MECHANICAL UNIT OPERATOR’S MANUAL (B-83734EN, B-83774EN).

- Restore appropriate backup files. If necessary, perform “APPLY TO DCS PARAMETER”. Refer to section 1.3 of Dual Check Safety Function OPERATOR’S MANUAL (B-83184EN).
- Copy "CLLB.CM" file from the CD-R which is appendix of the collaborative robot to a memory card or USB memory. Perform the same file with a teach pendant, set the sensor calibration parameter. After this change, perform “APPLY TO DCS PARAMETER”. Refer to section 1.3 of Dual Check Safety Function OPERATOR’S MANUAL (B-83184EN).

### **“SRVO-481 Invalid payload number” occurs.**

Set correct payload number except for 0.

### **“SYST-326 Need to confirm payload” occurs.**

Payload confirmation operation is necessary after power on. Refer to Chapter 3.

## A.2 STOP DURING MOVE

---

**“SYST-320 Program paused by contact stop” or “SYST-325 Payload error is detected” occurs, even though nobody contacts the robot.**

Verify followings.

- The robot does not touch any object.
- Current payload setting is consistent with the actual payload.
- Robot installation plate is fixed.
- Robot installation plate is not warped. When Robot installation plate is warped, correct warped installation surface using spacer etc.
- Vibration of the floor or the hand is not applied to the robot. If a vibration is applied to the robot, deal so that the vibration is not applied to the robot. Reducing the speed or extending the acceleration time with Acceleration override instruction may reduce the vibration of the hand.
- “Force Sensor Serial number on the manufacturing plate” corresponds to that of “Force Sensor Serial number on TP”. Refer to PREFACE of each MECHANICAL UNIT OPERATOR’S MANUAL (B-83734EN, B-83774EN).

**“SYST-322 Auto status check time out” occurs.**

External force reset must be performed periodically. Refer to the subsection 4.2.1.

## A.3 STOP DURING PERIODICAL CHECK

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Refer to Chapter 6.



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# REVISION RECORD

Edition	Date	Contents
02	Oct., 2017	Support small collaborative robot, Add monitor function, Add Variable Payload Compensation function, Add Double Tap function, Add <i>i</i> HMI
01	Sep., 2015	

**B-83744EN/02**



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