

DX200 OPTIONS INSTRUCTIONS

FOR FUNCTIONAL SAFETY BOARD OPERATION

Upon receipt of the product and prior to initial operation, read these instructions thoroughly, and retain for future reference.

MOTOMAN INSTRUCTIONS

MOTOMAN-□□□ INSTRUCTIONS
DX200 INSTRUCTIONS
DX200 OPERATOR'S MANUAL (for each purpose)
DX200 MAINTENANCE MANUAL

The DX200 operator's manual above corresponds to specific usage. Be sure to use the appropriate manual.

Part Number: 165988-1CD
Revision: 2

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MANDATORY

- This manual explains the Functional Safety Board operations of the DX200 system and general operations. Read this manual carefully and be sure to understand its contents before handling the DX200.
- General items related to safety are listed in Chapter 1: Safety of the DX200 Instructions. To ensure correct and safe operation, carefully read the DX200 Instructions before reading this manual.



CAUTION

- Some drawings in this manual are shown with the protective covers or shields removed for clarity. Be sure all covers and shields are replaced before operating this product.
- The drawings and photos in this manual are representative examples and differences may exist between them and the delivered product.
- YASKAWA may modify this model without notice when necessary due to product improvements, modifications, or changes in specifications.
- If such modification is made, the manual number will also be revised.
- If your copy of the manual is damaged or lost, contact a YASKAWA representative to order a new copy. The representatives are listed on the back cover. Be sure to tell the representative the manual number listed on the front cover.
- YASKAWA is not responsible for incidents arising from unauthorized modification of its products. Unauthorized modification voids your product's warranty.

We suggest that you obtain and review a copy of the ANSI/RIA National Safety Standard for Industrial Robots and Robot Systems (ANSI/RIA R15.06-2012). You can obtain this document from the Robotic Industries Association (RIA) at the following address:

Robotic Industries Association
900 Victors Way
P.O. Box 3724
Ann Arbor, Michigan 48106
TEL: (734) 994-6088
FAX: (734) 994-3338
www.roboticsonline.com

Ultimately, well-trained personnel are the best safeguard against accidents and damage that can result from improper operation of the equipment. The customer is responsible for providing adequately trained personnel to operate, program, and maintain the equipment. **NEVER ALLOW UNTRAINED PERSONNEL TO OPERATE, PROGRAM, OR REPAIR THE EQUIPMENT!**

We recommend approved Yaskawa training courses for all personnel involved with the operation, programming, or repair of the equipment.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.

Notes for Safe Operation

Read this manual carefully before installation, operation, maintenance, or inspection of the DX200.

In this manual, the Notes for Safe Operation are classified as "WARNING", "CAUTION", "MANDATORY", or "PROHIBITED".



WARNING

Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury to personnel.



CAUTION

Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury to personnel and damage to equipment. It may also be used to alert against unsafe practices.



MANDATORY

Always be sure to follow explicitly the items listed under this heading.



PROHIBITED

Must never be performed.

Even items described as "CAUTION" may result in a serious accident in some situations.

At any rate, be sure to follow these important items



To ensure safe and efficient operation at all times, be sure to follow all instructions, even if not designated as "CAUTION" and "WARNING".



WARNING

- Before operating the manipulator, check that servo power is turned OFF pressing the emergency stop buttons on the front door of the DX200 and the programming pendant. When the servo power is turned OFF, the SERVO ON LED on the programming pendant is turned OFF.

Injury or damage to machinery may result if the emergency stop circuit cannot stop the manipulator during an emergency. The manipulator should not be used if the emergency stop buttons do not function.

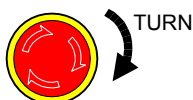
Figure 1: Emergency Stop Button



- Once the emergency stop button is released, clear the cell of all items which could interfere with the operation of the manipulator. Then turn the servo power ON.

Injury may result from unintentional or unexpected manipulator motion.

Figure 2: Release of Emergency Stop



- Observe the following precautions when performing teaching operations within the P-point maximum envelope of the manipulator:
 - View the manipulator from the front whenever possible.
 - Always follow the predetermined operating procedure.
 - Keep in mind the emergency response measures against the manipulator's unexpected motion toward you.
 - Ensure that you have a safe place to retreat in case of emergency.

Improper or unintended manipulator operation may result in injury.

- Confirm that no person is present in the P-point maximum envelope of the manipulator and that you are in a safe location before:
 - Turning ON the power for the DX200.
 - Moving the manipulator with the programming pendant.
 - Running the system in the check mode.
 - Performing automatic operations.

Injury may result if anyone enters the P-point maximum envelope of the manipulator during operation. Always press an emergency stop button immediately if there is a problem.

The emergency stop buttons are located on the right of front door of the DX200 and the programming pendant.



CAUTION

- Perform the following inspection procedures prior to conducting manipulator teaching. If problems are found, repair them immediately, and be sure that all other necessary processing has been performed.
 - Check for problems in manipulator movement.
 - Check for damage to insulation and sheathing of external wires.
- Always return the programming pendant to the hook on the cabinet of the DX200 after use.

The programming pendant can be damaged if it is left in the manipulator's work area, on the floor, or near fixtures.

- Read and understand the Explanation of Warning Labels in the DX200 Instructions before operating the manipulator:

Definition of Terms Used Often in This Manual

The MOTOMAN is the YASKAWA industrial robot product.

The MOTOMAN usually consists of the manipulator, the controller, the programming pendant, and supply cables.

In this manual, the equipment is designated as follows:

Equipment	Manual Designation
DX200 controller	DX200
DX200 programming pendant	Programming pendant
Cable between the manipulator and the controller	Manipulator cable

Descriptions of the programming pendant, buttons, and displays are shown as follows:

Equipment	Manual Designation	
Programming Pendant	Character Keys /Symbol Keys	The keys which have characters or its symbol printed on them are denoted with []. ex. [ENTER]
	Axis Keys /Numeric Keys	[Axis Key] and [Numeric Key] are generic names for the keys for axis operation and number input.
	Keys pressed simultaneously	When two keys are to be pressed simultaneously, the keys are shown with a "+" sign between them, ex. [SHIFT]+[COORD]
	Displays	The menu displayed in the programming pendant is denoted with { }. ex. {JOB}

Description of the Operation Procedure

In the explanation of the operation procedure, the expression "Select •••" means that the cursor is moved to the object item and the SELECT key is pressed, or that the item is directly selected by touching the screen.

Registered Trademark

In this manual, names of companies, corporations, or products are trademarks, registered trademarks, or brand names for each company or corporation. The indications of (R) and TM are omitted.

Customer Support Information

If you need assistance with any aspect of your Safety Board Operation system, please contact Motoman Customer Support at the following 24-hour telephone number:

(937) 847-3200

For **routine** technical inquiries, you can also contact Motoman Customer Support at the following e-mail address:

techsupport@motoman.com

When using e-mail to contact Motoman Customer Support, please provide a detailed description of your issue, along with complete contact information. Please allow approximately 24 to 36 hours for a response to your inquiry.



Please use e-mail for **routine** inquiries only. If you have an urgent or emergency need for service, replacement parts, or information, you must contact Motoman Customer Support at the telephone number shown above.

Please have the following information ready before you call:

- | | |
|----------------------------|--|
| • System | Safety Board Operation |
| • Robots | |
| • Primary Application | |
| • Controller | DX200 |
| • Software Version | Access this information on the Programming Pendant's LCD display screen by selecting {MAIN MENU} - {SYSTEM INFO} - {VERSION} |
| • Robot Serial Number | Located on the robot data plate |
| • Robot Sales Order Number | Located on the DX200 controller data plate |

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1 Overview of the Function

1.1 Outline

Two CPUs installed in the functional safety function independently acquire the manipulator encoder feedback pulse, and, based on this pulse, the functional safety function monitors the manipulator's position, speed and the posture of its tool.

The data such as the result of safety monitoring is compared by each of the two CPUs, and the power supply to the motor is suspended and the manipulator is completely stopped when an error is detected.

With this function, improving of the safety of the manipulator's motion and minimizing of the equipment layouts when manipulators are installed are realized.

1.2 List of Safety Functions

To the functional safety function, following six different functions for monitoring purposes are equipped.

- (1) Axis range limit function
Monitors each axis angle to be equal to or in the designated safety area.
- (2) Axis speed monitor function
Monitors each axis speed to be equal or slower than the designated speed.
- (3) Robot range limit function
Monitors the manipulator arm or its tool to be in the designated safety area.
- (4) Speed limit function
Monitors the speed of manipulator TCP (Tool Center Point) and its FCP (Flange Center Point) when the robot control group is monitored.
If the station control group is monitored, it monitors the axis speed.
- (5) Tool angle monitor function
Monitors the manipulator tool angle to be inside the range of limited angle when the angle is centered on the designated standard posture.
- (6) Tool change monitor function
Monitors the tool file used in the functional safety function to be consistent with the user specified tool file.

1.3 Configuration of Setting Files

There are wide range of setting files for the functional safety function. However, most of them are listed up in {SAFETY FUNC.} menu in the programming pendant top menu.

Followings are the function safety relevant files expanded from {SAFETY FUNC.} menu.

Top menu	Sub menu (1st layer)	Sub menu (2nd layer)
SAFETY FUNC.	List of {AXIS RANGE LIMIT} status window	AXIS RANGE LIMIT condition file (32 files/system)
	List of {AXIS SPEED MONITOR} status window	AXIS SPEED MONITOR condition file (32 files/system)
	List of {ROBOT RANGE LIMIT} status window	ROBOT RANGE LIMIT condition file (32 files/system)
	List of {SPEED LIMIT} status window	SPEED LIMIT condition file (32 files/system) TEACH MODE SPEED LIMIT condition file (32 files/system)
	List of {TOOL ANGLE MONITOR} status window	TOOL ANGLE MONITOR condition file (32 files/system)
	List of {TOOL CHANGE MONITOR} status window	TOOL CHANGE MONITOR condition file (16 files/system)

2 System Configuration

2.1 Outline

To utilize this function in the DX200 system, “functional safety board”, “functional safety I/O logic board”, and “functional safety terminal block board” are added.

2.1.1 Functional Safety Board

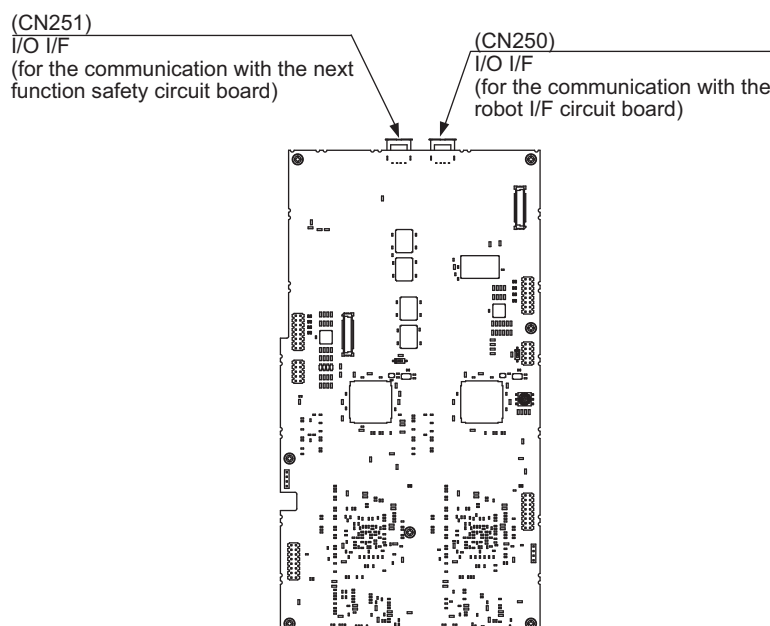
Main specification of “functional safety board” is described as below. It corresponds to one servo board (SRDA-EAXA21) because “functional safety board” is directly mounted to the servo board.

The “functional safety board” monitors motors (up to nine motors) which are connected to the corresponding servo board.

Each servo board and the functional safety board can be connected up to 8 stations (#1 to #8) to a system.

Item	Specification
Unit type	JANCD-YSF25-E
Unit size	W 142.5 x H 264.5 [mm]
Function	(1)Axis range limit function (2)Axis speed monitor function (3)Robot range limit function (4)Speed limit function (5)Tool angle monitor function (6)Tool change monitor function
Settings (Rotary switch S1)	Connect to the 1st station of the servo: 0 Connect to the 2nd to 8th station of the servo: 1 to 7 (set each rotary switch of the functional safety board to the same value rotary switch on the connected servo station)

Fig. 2-1: Functional Safety Board: JANCD-YSF25-E



2.1.2 Functional Safety I/O Logic Board

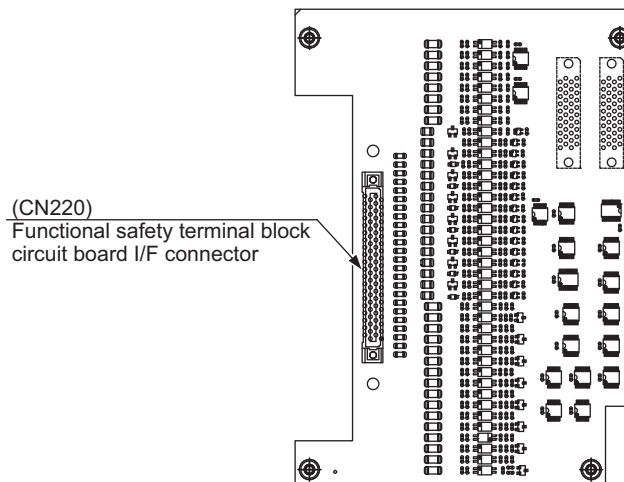
The “functional safety I/O logic board” is a board to receive/transmit the safety I/O signal used in the functional safety function.

Following is the type and main specifications of the “functional safety I/O logic board”.

Item	Specification
Unit type	JANCD-YSF24-E
Unit size	W113 x H165 (mm)
Function	Receive/transmit the functional safety user I/O signal.

Following is the dimension diagram of the “functional safety I/O logic board: JANCD-YSF24-E”.

Fig. 2-2: Functional Safety I/O Logic Board: JANCD-YSF24-E



2.1.3 Functional Safety Terminal Block Board

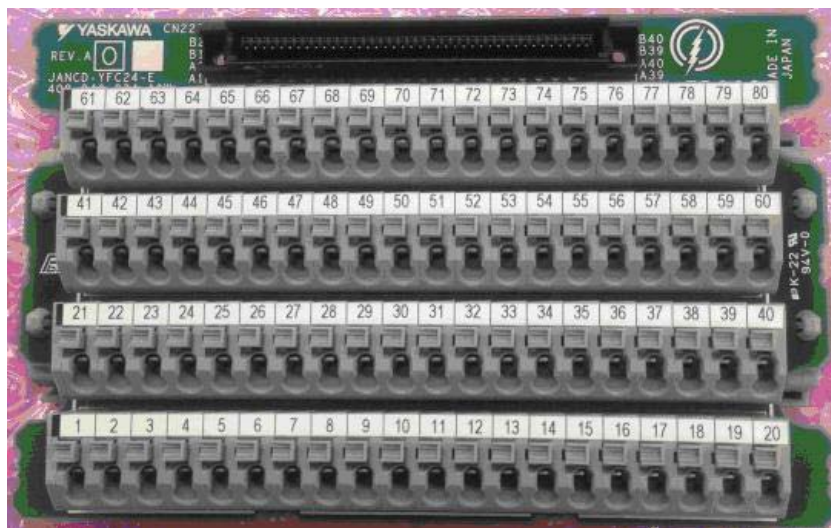
Safety signals are connected to the “functional safety terminal block board”.

Following is the type and main specifications of the “functional safety terminal station board”.

Item	Specification
Unit type	JANCD-YFC24-E
Unit size	W 7.6 x H 12.1[mm]
Function	Connects the functional safety user I/O signal.
Signal points	Input: 8 points/station Output: 8 points/station Output feedback: 8 points/station

Following is the dimension diagram of the “functional safety terminal block board: JANCD-YFC24-E”.

Fig. 2-3: Functional Safety Terminal Block Board



Following table shows details of the connection terminal.

Table 2-1: JANCD-YFC24-E Details for the Connection Terminal (Sheet 1 of 2)

Signal Name	Connection No.	Dual Signal	Function	Factory Setting
XIN1_1+	1	○	Functional Safety Universal Input 1 (Corresponding FSBIN01)	Open
XIN1_1-	2			
XIN1_2+	3	○	Functional Safety Universal Input 2 (Corresponding FSBIN02)	Open
XIN1_2-	4			
XIN2_1+	5	○	Functional Safety Universal Input 2 (Corresponding FSBIN02)	Open
XIN2_1-	6			
XIN2_2+	7	○	Functional Safety Universal Output 1 (Corresponding FSBOUT01)	Open
XIN2_2-	8			
XOUT1_1+	9	○	Functional Safety Universal Output 1 (Corresponding FSBOUT01)	Open
XOUT1_1-	10			
XOUT1_2+	11	○	Functional Safety Universal Output 2 (Corresponding FSBOUT02)	Open
XOUT1_2-	12			
XOUT2_1+	13	○	Functional Safety Universal Output 2 (Corresponding FSBOUT02)	Open
XOUT2_1-	14			
XOUT2_2+	15	-	Functional Safety Universal Output 1 Feedback	Open
XOUT2_2-	16			
XEDM1+	17	-	Functional Safety Universal Output 2 Feedback	Open
XEDM1-	18			
XEDM2+	19	-	Functional Safety Universal Output 2 Feedback	Open
XEDM2-	20			
XIN3_1+	21	○	Functional Safety Universal Input 3 (Corresponding FSBIN03)	Open
XIN3_1-	22			
XIN3_2+	23	○	Functional Safety Universal Input 3 (Corresponding FSBIN03)	Open
XIN3_2-	24			
XIN4_1+	25	○	Functional Safety Universal Input 4 (Corresponding FSBIN04)	Open
XIN4_1-	26			
XIN4_2+	27	○	Functional Safety Universal Output 3 (Corresponding FSBOUT03)	Open
XIN4_2-	28			
XOUT3_1+	29	○	Functional Safety Universal Output 3 (Corresponding FSBOUT03)	Open
XOUT3_1-	30			
XOUT3_2+	31	○	Functional Safety Universal Output 4 (Corresponding FSBOUT04)	Open
XOUT3_2-	32			
XOUT4_1+	33	○	Functional Safety Universal Output 4 (Corresponding FSBOUT04)	Open
XOUT4_1-	34			
XOUT4_2+	35	-	Functional Safety Universal Output 3 Feedback	Open
XOUT4_2-	36			
XEDM3+	37	-	Functional Safety Universal Output 4 Feedback	Open
XEDM3-	38			
XEDM4+	39	-	Functional Safety Universal Output 4 Feedback	Open
XEDM4-	40			

Safety Board Operation 2 System Configuration
 2.1 Outline

Table 2-1: JANCD-YFC24-E Details for the Connection Terminal (Sheet 2 of 2)

Signal Name	Connection No.	Dual Signal	Function	Factory Setting
XIN5_1+ XIN5_1-	41 42	○	Functional Safety Universal Input 5 (Corresponding FSBIN05)	Open
XIN5_2+ XIN5_2-	43 44			
XIN6_1+ XIN6_1-	45 46	○	Functional Safety Universal Input 6 (Corresponding FSBIN06)	Open
XIN6_2+ XIN6_2-	47 48			
XOUT5_1+ XOUT5_1-	49 50	○	Functional Safety Universal Output 5 (Corresponding FSBOU05)	Open
XOUT5_2+ XOUT5_2-	51 52			
XOUT6_1+ XOUT6_1-	53 54	○	Functional Safety Universal Output 6 (Corresponding FSBOU06)	Open
XOUT6_2+ XOUT6_2-	55 56			
XEDM5+ XEDM5-	57 58	—	Functional Safety Universal Output 5 Feedback	Open
XEDM6+ XEDM6-	59 60	—	Functional Safety Universal Output 6 Feedback	Open
XIN7_1+ XIN7_1-	61 62	○	Functional Safety Universal Input 7 (Corresponding FSBIN07)	Open
XIN7_2+ XIN7_2-	63 64			
XIN8_1+ XIN8_1-	65 66	○	Functional Safety Universal Input 8 (Corresponding FSBIN08)	Open
XIN8_2+ XIN8_2-	67 68			
XOUT7_1+ XOUT7_1-	69 70	○	Functional Safety Universal Output 7 (Corresponding FSBOU07)	Open
XOUT7_2+ XOUT7_2-	71 72			
XOUT8_1+ XOUT8_1-	73 74	○	Functional Safety Universal Output 8 (Corresponding FSBOU08)	Open
XOUT8_2+ XOUT8_2-	75 76			
XEDM7+ XEDM7-	77 78	—	Functional Safety Universal Output 7 Feedback	Open
XEDM8+ XEDM8-	79 80	—	Functional Safety Universal Output 8 Feedback	Open

Please refer to the connection diagram for the connection of each signal.

2.1.4 Wiring Procedure of the Terminal Block

For your safety, appropriate work must be done by following the instructions below.

■ **Tool: Screwdriver**

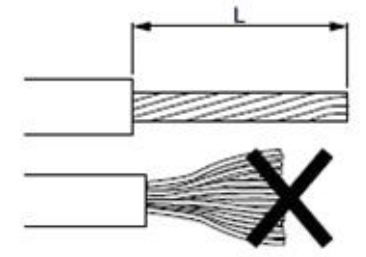
For the connection, be sure to use a screwdriver of an applicable size and configuration.

- WAGO standard screwdriver
WAGO 210-119
WAGO 210-119SB (Short, delivered with the product)



■ **Applicable Wires**

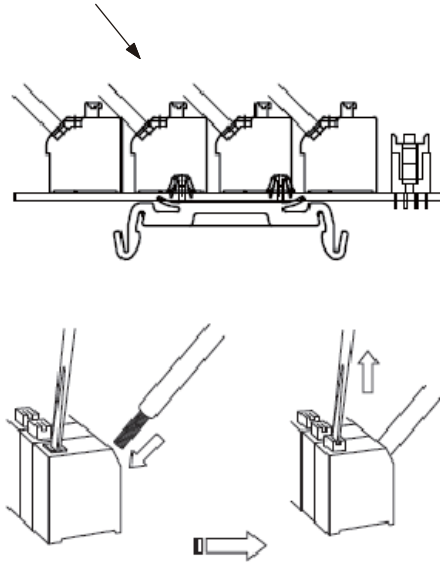
1. The length of the exposed conductor (L) should be as follows:



- The length of the exposed conductor set for the terminal block (L)
WAGO series 250 (with 5.0 mm pitch): 9-10 mm
 - Applicable max cable outside diameter: 3.1 mm dia.
2. In case that the conductor is bent or feazed, make it straight as illustrated in the figure above.

■ Wire Connection

Terminal block: screwless clamp
terminal WAGO series 250



1. Place the screwdriver on the lever upright as shown in the figure above and push it straight down.
2. Insert the wire into the connection hole slowly until its leading end touches the end of the hole.
For thin wires, never insert the wire with force, or the wire jacket may get caught in.
3. Pull out the screwdriver to clamp the conductor with the spring.
4. Check if the wire is connected firmly by pulling the wire softly.

2.1.5 Functional Safety Universal Input Signal 1-8

When opening this connection terminal, corresponding FSBIN turns ON(1).

When short circuiting this connection terminal, corresponding FSBIN turns OFF(0).

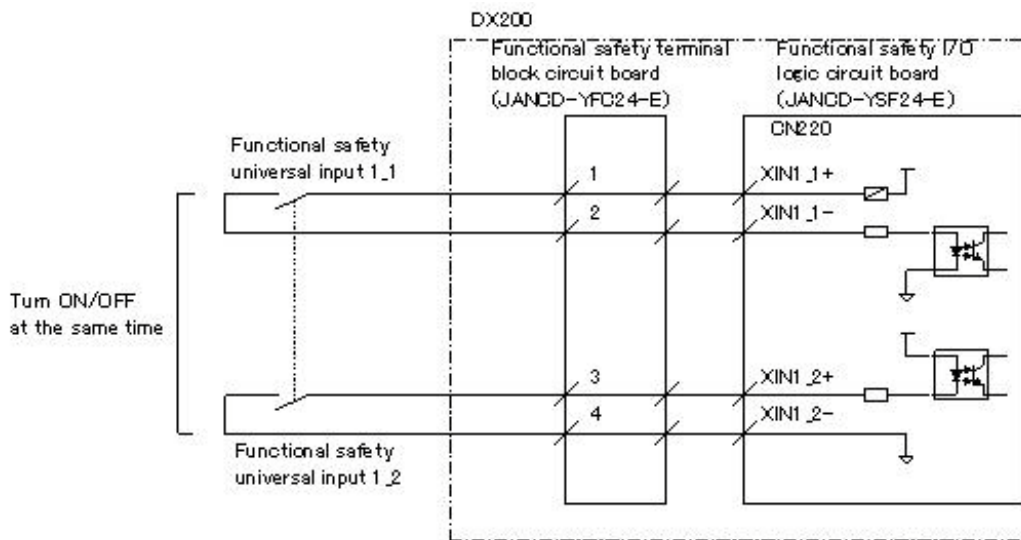


For safety reasons, dual circuits are used for the functional safety universal input signals.

When state of the input mismatch continues for 500ms or more, the following alarm occurs.

Alarm4751 : YSF24 GENERAL INPUT SIG. ERROR

Fig. 2-4: Example of Connecting Functional Safety Universal Input Signal



2.1.6 Functional Safety Universal Output Signal 1-8

Corresponding to the state of FSBOUT, outputs of this connection terminal changes.

When FSBOUT is turned ON(1), corresponding connection terminal outputs DC24V.

When FSBOUT is turned OFF(0), corresponding connection terminal outputs 0V.

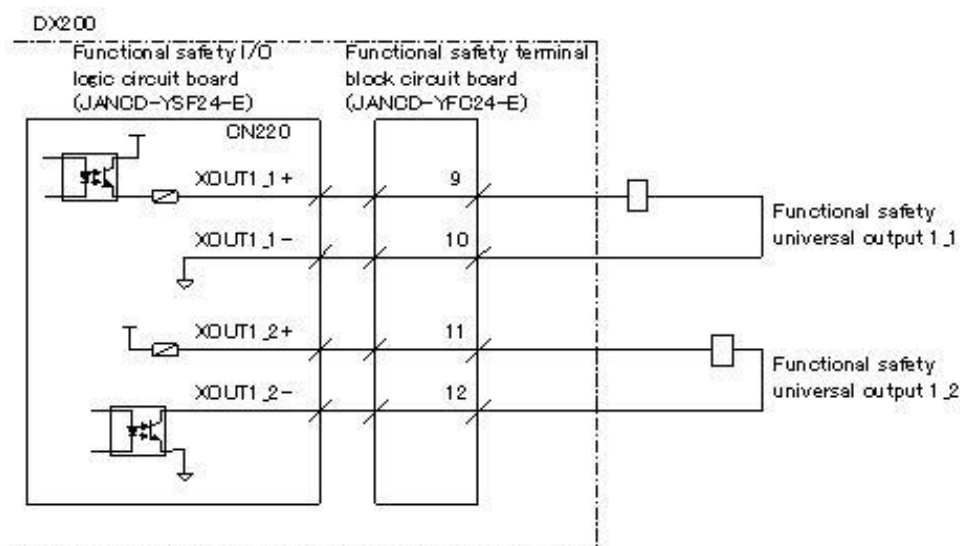


- Rated output value is DC24V and less than 50mA. Avoid connecting excessive load.
- When connecting the inductive load, such as the safety relay, with the output circuit, use of the built-in protective circuit for the surge suppressor or connect the flyback diode in parallel to the inductive load to suppress the surge voltage. It may cause the damage on the output circuit.
- The feedback signal must be input to the DX200 when using the functional safety universal output signal.



The functional safety universal output signal is output as the dual signals.

Fig. 2-5: Example of Connecting Functional Safety Universal Output Signal



2.1.7 Functional Safety Universal Output Feedback Signal 1-8

This connection terminal inputs the status of the driven devices by the functional safety universal output signal as the feedback signal.

When opening this connection terminal, corresponding feedback signal turns ON(1).

When short circuiting this connection terminal, corresponding feedback signal turns OFF(0).

The logic feedback signal to the output signal must be in the state shown in the following table.

Output value of functional safety universal output signal	Input value of functional safety universal output feedback signal	Judge
OFF(0)	OFF(0)	NG
OFF(0)	ON(1)	OK
ON(1)	OFF(0)	OK
ON(1)	ON(1)	NG

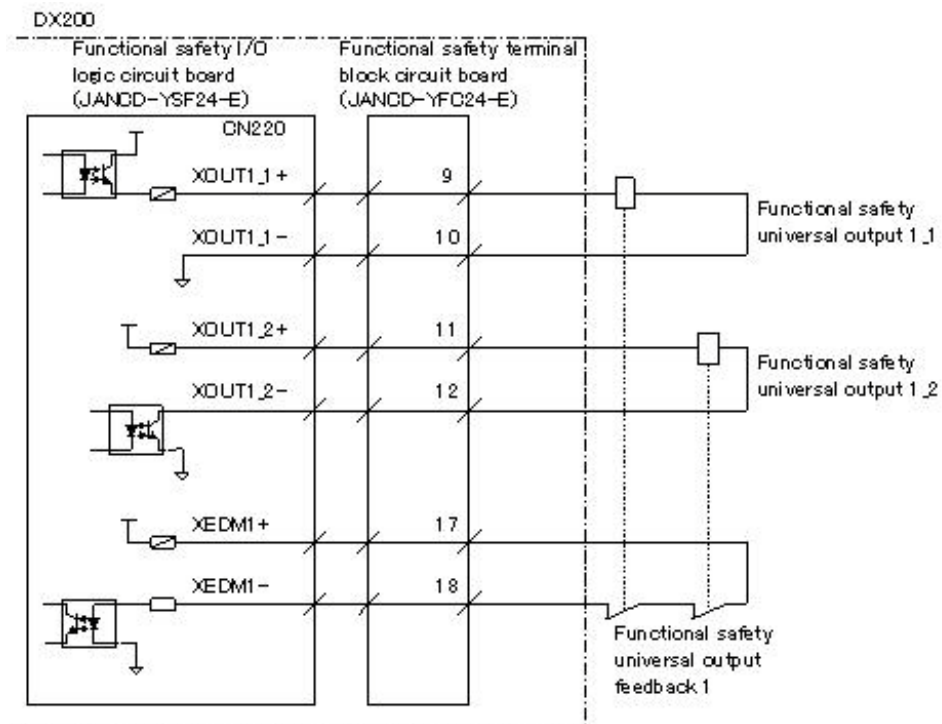


The logic feedback signal to the output signal is judged.

When the NG state continues for 500 ms or more, the following alarm occurs.

Alarm4768 : YSF24 GENERAL OUT FB DIAG. ERROR

Fig. 2-6: Example of Connecting Functional Safety Universal Output Feedback Signal

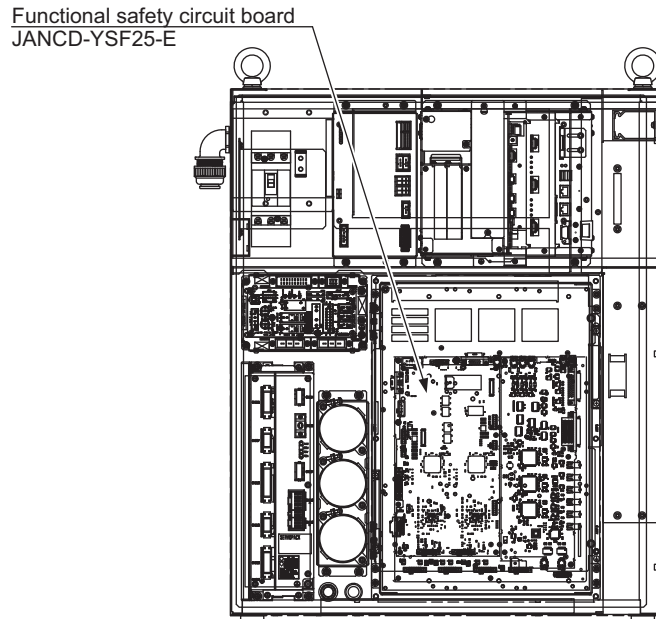


2.2 Board Arrangement

Following figures show the arrangement of each functional safety board, functional safety I/O logic board, and functional safety terminal block board when they are mounted on the DX200.

■ Arrangement of the Functional Safety Board

Fig. 2-7: Arrangement of the Functional Safety Board (DX200 Front View)



■ Arrangement of the Functional Safety I/O Logic board

Fig. 2-8: Arrangement of the Functional Safety I/O Logic board (DX200 Back View)

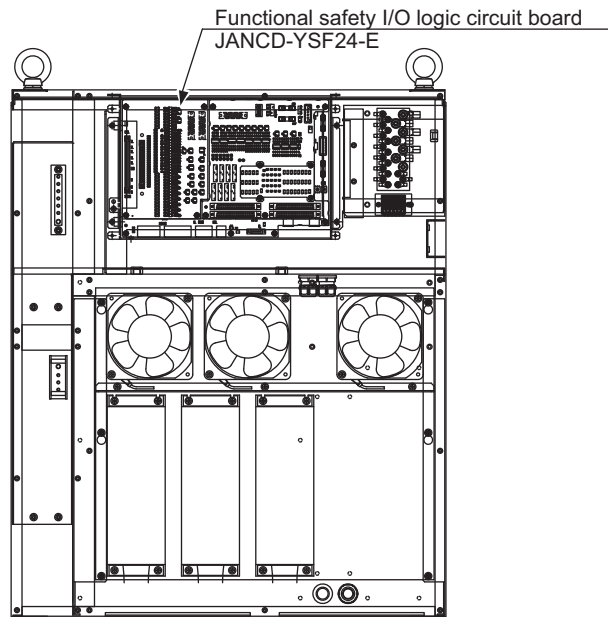
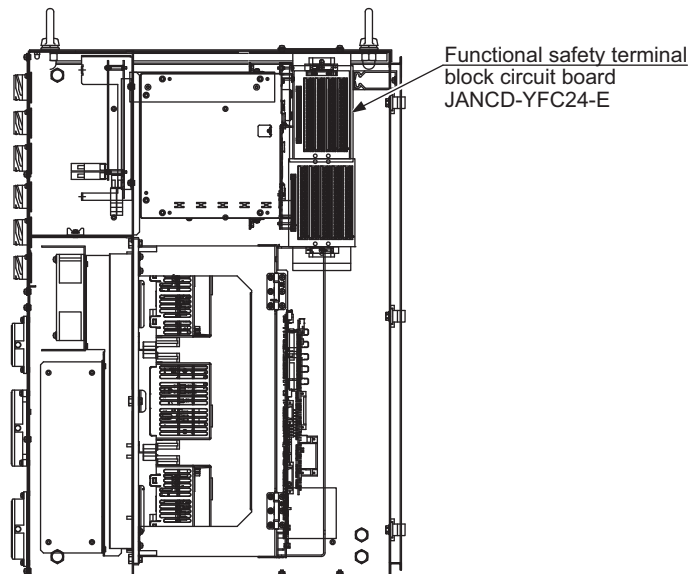
**■ Arrangement of the Functional Safety Terminal Block Board**

Fig. 2-9: Arrangement of the Functional Safety Terminal Block Board (DX200 Right Side View)



2.3 System Configuration for Dual-Arm Manipulator

Like dual-arm manipulator (SDA model) system, a system where the robot group (arm) and the base group (base) exist separately and individually arranged on the different servo board exists.

In this system, for the safety monitoring, the encoder feedback pulse information of the axis which does not exist in its own station should be acquired from other servo station.

Following restrictions are imposed since transmitting and receipt of the encoder data is performed by way of the servo external axis (SRDA-EAXB21A).



When using dual-arm type configuration manipulators, the maximum number of connecting axis for the servo station at the encoder data receiving side decreases.

Maximum numbers of connecting axis
= (9 axes - the number of axes whose encoder data was acquired from other servo station)

3 Common Operation

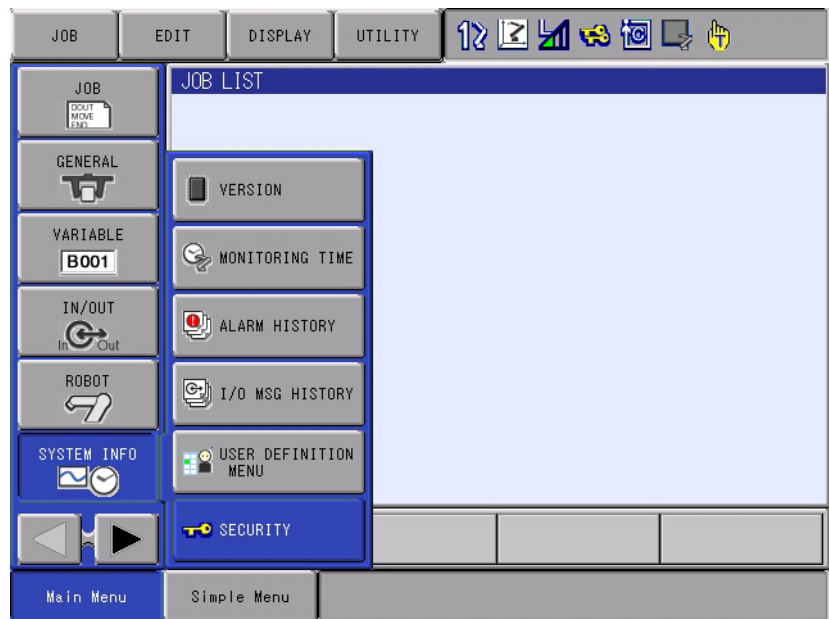
Common operations when using the functional safety function are described in this chapter.

3.1 Security when Using this Function

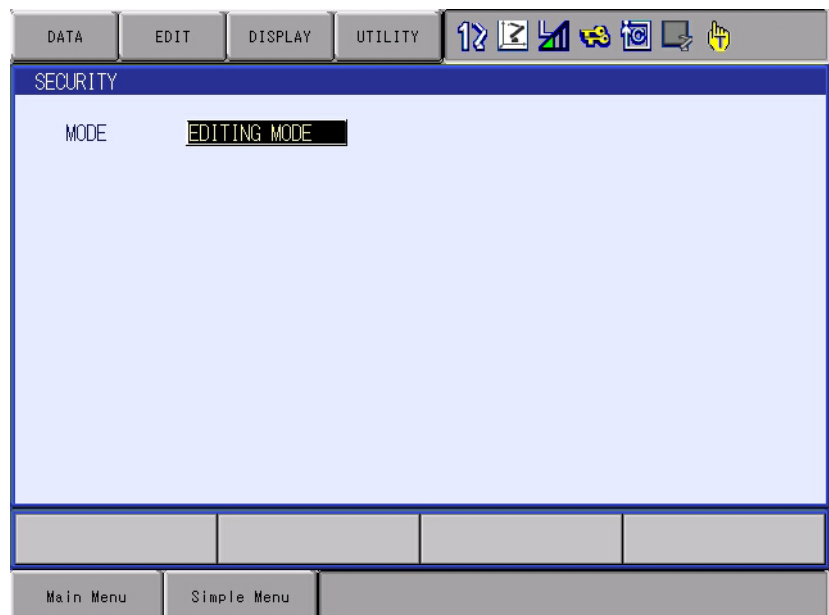
When using the functional safety function, settings of the condition file for this function is necessary. This settings should be executed when the security mode is in the safety mode. For this reason, this file settings is to be performed by the person who has a safety license.

Followings are the procedures for changing the security mode.

1. Press {SYSTEM INFO} under the main menu.



2. Press {SECURITY} in the sub menu.



3. Change the mode from {EDITING MODE} to {SAFETY MODE}.

- Press [SELECT], move the cursor to {SAFETY MODE}, and press [SELECT] again.



4. Input a password for {SAFETY MODE}, and then press [ENTER].

- The security mode is changed to {SAFETY MODE}.



Available operations by the functional safety function vary according to the security levels.

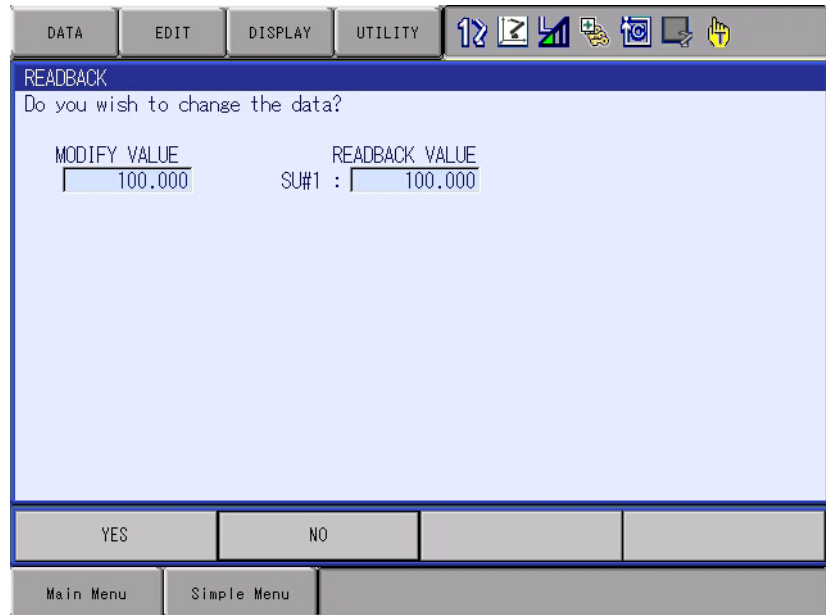
Followings are the available operations limited by the security levels.

Security level	Available operations
Operation, Edit, Management	Only browsing of the data such as functional safety function relevant data is available. Editing is not available.
Safety	Editing or browsing of the functional safety data is available.

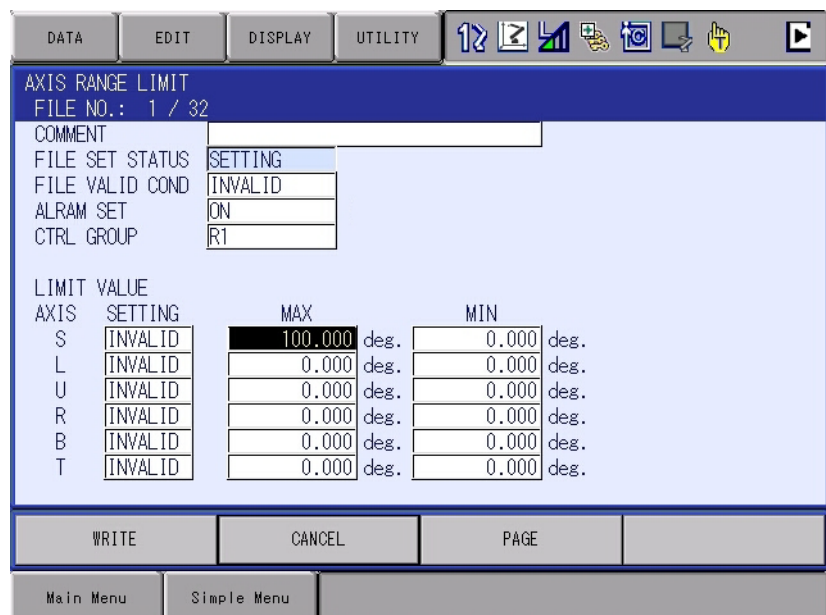
3.2 Read-Back Operation

When the functional safety function is valid, a read-back window as shown below is displayed in case data is modified on the condition file setting window or on the tool file window of the functional safety window.

1. Modify a setting value on the functional safety function-relevant data setting window.
 - READBACK window appears.
 - This window is displayed to confirm whether the input data to the functional safety board is appropriate or not.



- Check both values displayed at {MODIFIED VALUE} and {READ-BACK VALUE}, and then press {YES} on the window. The display of the file to be operated is changed. In case {NO} is selected, the value at the file to be modified returns to the value before modification.
2. {WRITE} and {CANCEL} appear at the bottom of the window when a value is changed on the read-back window.



- {WRITE} : Memorizes the object files specified to the functional safety board.
- {CANCEL} : Deletes the set value specified to the functional safety board and back to the previous settings.

When more than two setting values are changed, the read-back window appears same time as changed times. However, those modified data would not be saved unless {WRITE} is pressed. In the cases below, those data to which {WRITE} is not pressed is deleted.

- When {CANCEL} is pressed.
- When other menu is selected and opened.
- When the page is changed.
- When the mode is changed.
- When an alarm occurred.

Following is the list of setting window where the read-back operation is executed.

Main menu	Sub menu
Manipulator	TOOL
	TOOL INTERFERENCE
Functional safety board	AXIS RANGE LIMIT FUNCTION
	AXIS SPEED MONITOR FUNCTION
	ROBOT RANGE LIMIT FUNCTION
	SPEED LIMIT FUNCTION
	TOOL ANGLE MONITOR FUNCTION
	TOOL CHANGE MONITOR FUNCTION
	COASTING VALUE SETTING
	RANGE COMBINATION

3.3 External Memory Device (Saving/Loading)

The functional safety function-relevant files can be saved/loaded to/from external memory devices.

Saving of the files can be performed in any security modes whereas loading is available only when the security mode is in the safety mode.

File	Security for loading
AXIS RANGE LIMIT DATA	Safety
AXIS SPEED MONITOR DATA	Safety
ROBOT RANGE DATA	Safety
SPEED LIMIT DATA	Safety
TOOL ANGLE MONITOR DATA	Safety
TOOL CHANGE MONITOR DATA	Safety
APPR WARNING BUZZER DATA	Safety



When loading the functional safety function-relevant files, a message “Select “Functional Safety Board FLASH Reset” in the maintenance mode.” appears.

For the details, please refer to *section 7.2 “FLASH Data Reset” on page 7-2.*

4 Details of Functional Safety Function

In this chapter, details of the functional safety function are described.

4.1 Axis Range Limit Function

4.1.1 Outline

Axis range limit function is a function which sets each axis range of motion for the manipulator, base and station group and monitors whether each axis is inside the already-fixed range of motion using a software.

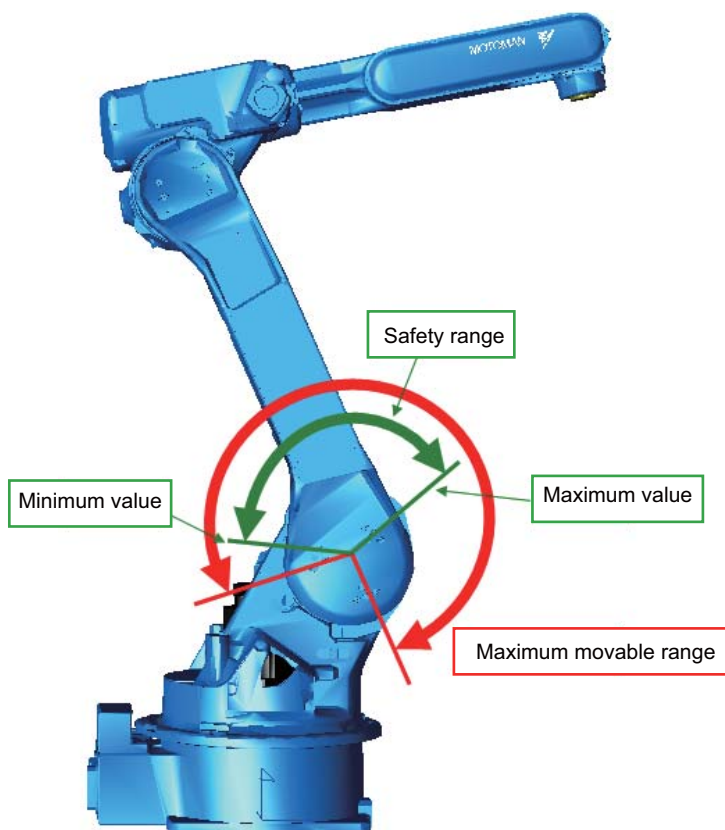
This function specifies the upper limit and the lower limit of the range of motion to those axes and the range inside the limits is defined as the safety range.

While an axes is in operation, based on the axis motion speed, this function calculates the coasting value in case of the immediate stop by the alarm, and then, including this value, it monitors the safety range. With this monitoring operation, the axes would not exceed the safety range even if a motion error is detected.

In case an error is detected, the power supply to the motor is stopped using the machine safety board (JANCD-YSF21-E). And the error is notified using an alarm.

Thirty two files are prepared to this function and all axes motion range of any one control group is set to one file. When a control group is set to several files, the control group can be monitored by switching conditions.

Fig. 4-1: Limit of Motion Range at Each Axis



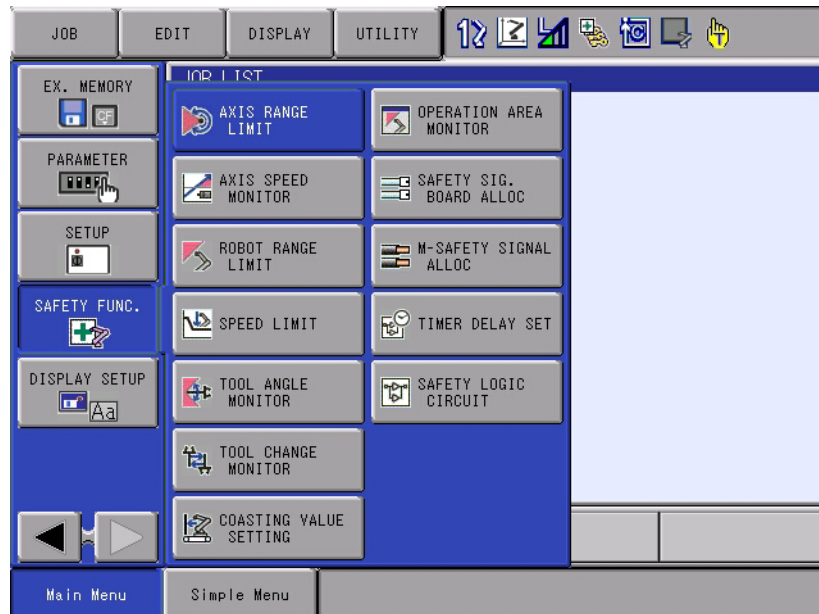
Follow the procedures below when starting the axis range limit function.

1. Set the coasting value.
(Before using this function, set the coasting value by following the procedures described in 6.2 in case the base axis or the station axis exits in the system.)
↓
2. Set the condition file of the axis range limit function.
↓
3. Confirm the safety range.
↓
4. Start the axis range limit function

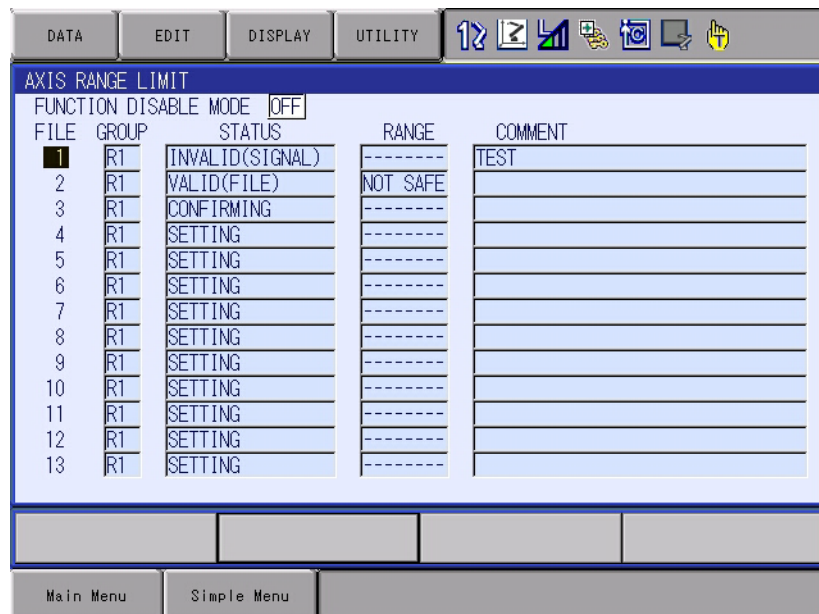
4.1.2 Axis Range Limit Function Window

Followings are the setting procedures for the axis range limit function.

1. Change the mode to the security mode, and then press {SAFETY FUNC.} under the main menu.



2. Press {AXIS RANGE LIMIT} in the sub menu.
 - The list of the axis range limit status appears.



On the status list window, the thirty two setting files for the axis range limit function are arranged so that their status can be confirmed. By scrolling down the window, all the list can be seen.

Followings are the details of the item on the window.

<Details of the Window >**1. {FUNCTION DISABLE MODE}**

Valid/invalid the axis range limit function. When “ON” is selected, this function becomes invalid temporarily.

Value	Meaning
OFF	The axis range limit function is valid.
ON	The axis range limit function is invalid. The play back, test run, forward/backward operation become prohibited.

For the details, please refer to *section 6.1 “Function Disable Mode Function Setting” on page 6-1.*

2. {FILE}

The number of the condition file is displayed.

Move the cursor to any number and press [SELECT]. The individual setting window for the selected condition file appears.

3. {GROUP}

The control group to be monitored specified by the condition file is indicated.

4. {STATUS}

Monitoring status of the present condition file is indicated.

Value	Meaning
SETTING	The condition file is in the initial status or in the data setting status. Monitoring is not performed.
CONFIRMING	Confirming the area after the data is set. The status of the monitoring operation depends on the valid condition of the condition file.
VALID (FILE)	Data setting is completed and monitoring status of the file is in valid status.
INVALID (FILE)	Data setting is completed and monitoring status of the file is in invalid status.
VALID (SIGNAL)	Data setting is completed and monitoring status of the file is in valid status by the establishment of the safety signal condition.
INVALID (SIGNAL)	Data setting is completed and monitoring status of the file is in invalid status by the disestablishment of the safety signal condition.

5. {RANGE}

Result of the present monitoring is displayed

Value	Meaning
SAFE	Result of the object file monitoring is safe (inside the safety range).
NOT SAFE	Result of the object file monitoring is not-safe (outside the safety range)
-	The object file is in monitoring invalid status.

6. {COMMENT}

The comment input is displayed.

4.1.3 AXIS RANGE LIMIT Condition File Setting

On the status list window, select a file number with the cursor, and then press [SELECT].

- A setting window for the selected condition file of the axis range limit function appears.

LIMIT VALUE			
AXIS	SETTING	MAX	MIN
S	VALID	10.000 deg.	-15.000 deg.
L	INVALID	0.000 deg.	0.000 deg.
U	VALID	50.000 deg.	30.000 deg.
R	INVALID	0.000 deg.	0.000 deg.
B	INVALID	0.000 deg.	0.000 deg.
T	INVALID	0.000 deg.	0.000 deg.

INPUT SIGNAL	SET	STATUS
bit0	FSBIN01(#1)	ON <input checked="" type="radio"/>
bit1	FSBIN02(#1)	OFF <input type="radio"/>
bit2	SFBIN01	ON <input type="radio"/>
bit3	-----	*** <input type="radio"/>
bit4	-----	*** <input type="radio"/>

OUTPUT SIGNAL	STATUS
FSBOUT01(#1)	<input type="radio"/>

By scrolling down the window with the cursor, all the items can be seen.

<Details of the Window >

In this section, only the items inherent to the axis range limit function are explained. For the items not mentioned here, please refer to *section 4.7 "Common Setting Item for the Condition File"* on page 4-76.

1.{AXIS}

All the axis existing in a control group selected at {GROUP} item are indicated. (8 axes at maximum)

2.{SETTING}

To one objective axis, validating/invalidating of the monitoring can be set.

This setting is referred when the condition file is valid for monitoring, and is not referred when it is invalid for monitoring.

Followings show the combination of conditions.

File monitoring status	Axis monitoring status	Result
Valid	Valid	Monitoring of the object axis is valid.
Valid	Invalid	Monitoring of the object axis is invalid.
Invalid	Valid	Monitoring of the object axis is invalid.
Invalid	Invalid	Monitoring of the object axis is valid.

3. {MAX}, {MIN}

Values for maximum/minimum range of motion can be input for the object axis.

As their inputting range, with the axis's home position defined as 0, the position value limited by the soft limit switch of the manipulator can be input.

When the axis is a rotating axis, it is measured in [deg], and is [mm] when the axis is a direct acting axis.

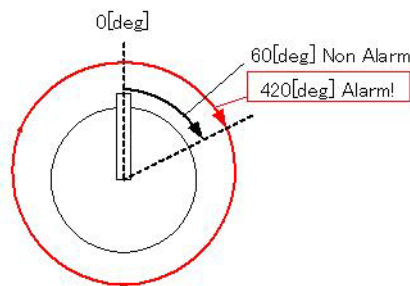
Value	Meaning
Minimum value	Expresses the limited range in which an axis moves in the negative direction. In case the following inequality is true, adding an positive value to the minimum value is possible. The minimum value < The maximum value
Maximum value	Expresses the limited range in which an axis moves in the positive direction. In case the following inequality is true, adding an negative value to the minimum value is possible. The minimum value < The maximum value

To a T-axis or to a positioner to which an mechanical stopper is not equipped, there may be a case where an value which exceeds ± 360 [deg] can be input.

In this case, the maximum/minimum range are limited by the basis of numerical range but not by the basis of visual range.

For example, when 420 [deg] is set as the maximum value, the axis positions at 60 [deg] and 420 [deg] visually look as they are at the same position. However, even if the axis passed through the 60 [deg] position it will not be defined as an error and an error is detected when the axis reaches just before the 420 [deg] position.

Fig. 4-2: When the Axis Limit Value Exceeds ± 360 [deg]

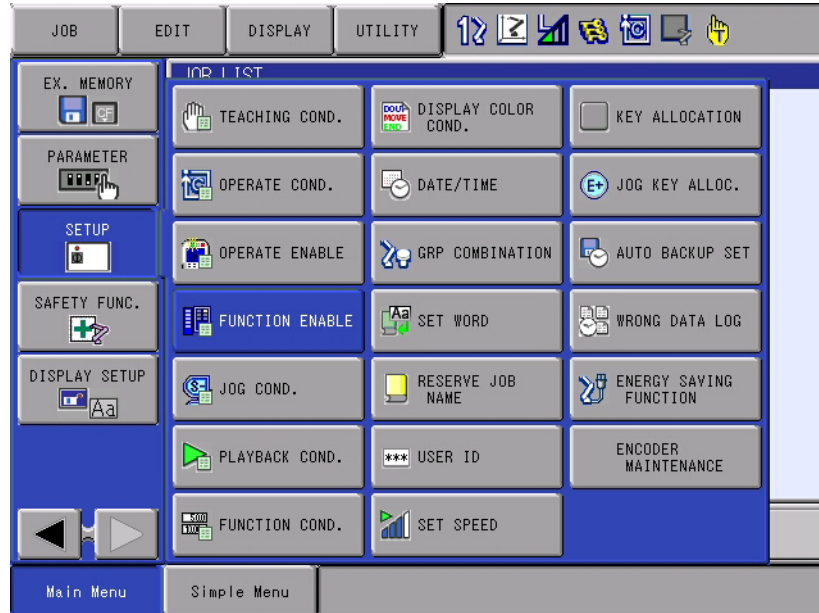


4.1.4 Confirming Method of Each Axis Operating Angle

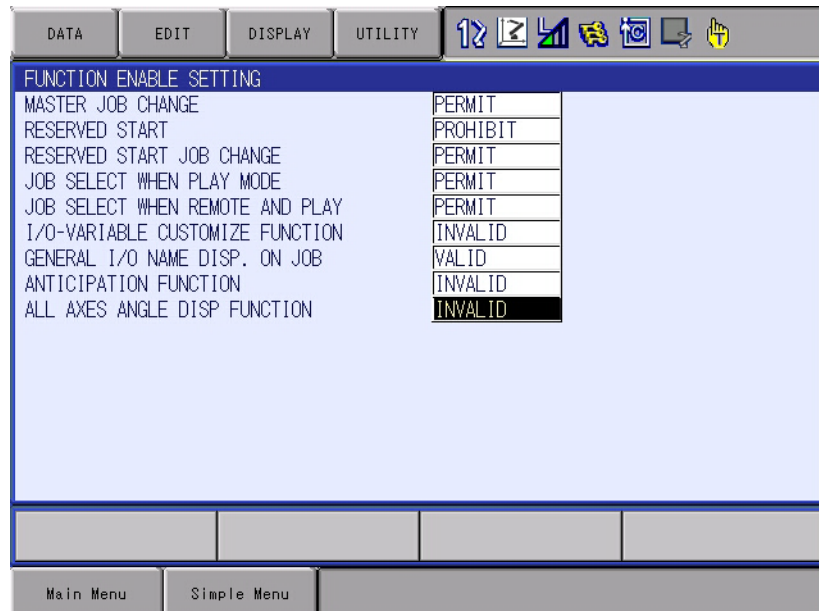
Each axis angle information can be confirmed on the CURRENT POSITION window.

Follow the procedures below when confirming the manipulator's present angle.

1. Change the security mode to the management mode or higher.
Press {SETUP} under the main menu.

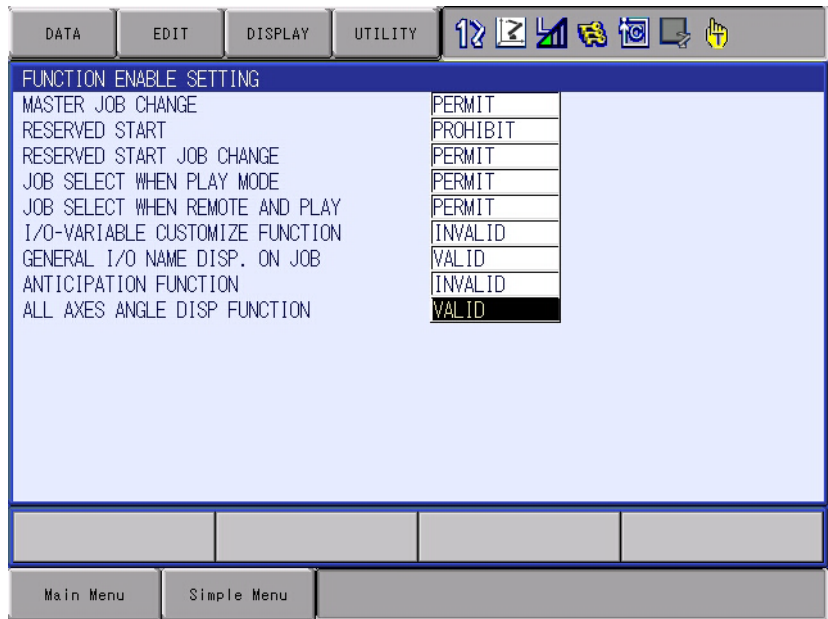


2. Press {FUNCTION ENABLE} in the sub menu.
– FUNCTION ENABLE SETTING window appears.

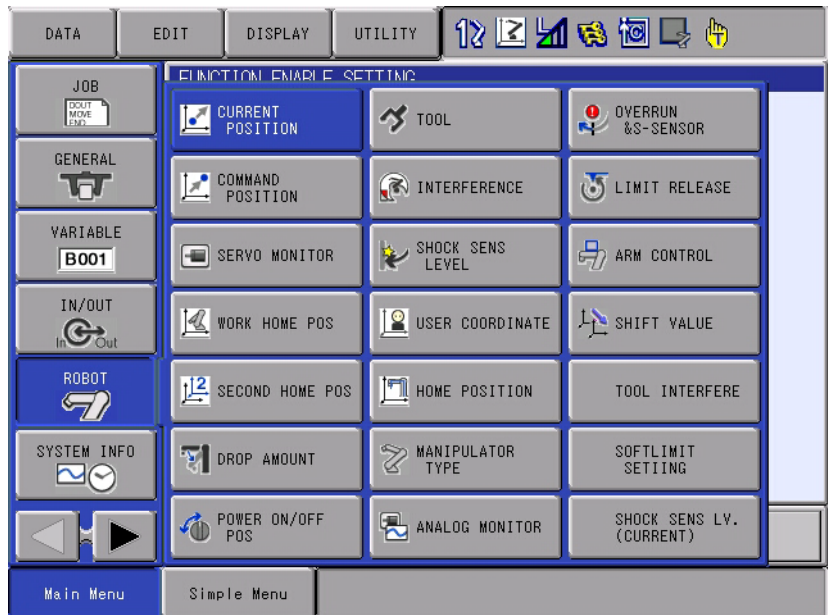


4 Details of Functional Safety Function
 4.1 Axis Range Limit Function

3. Set "VALID" to {ALL AXES ANGLE DISP FUNCTION}.



4. Press {ROBOT} under the main menu.

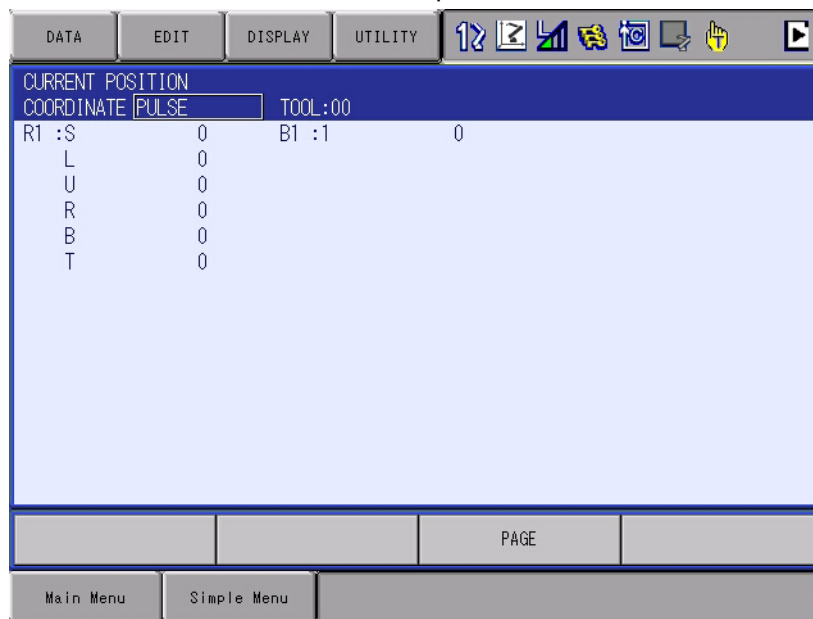


4 Details of Functional Safety Function

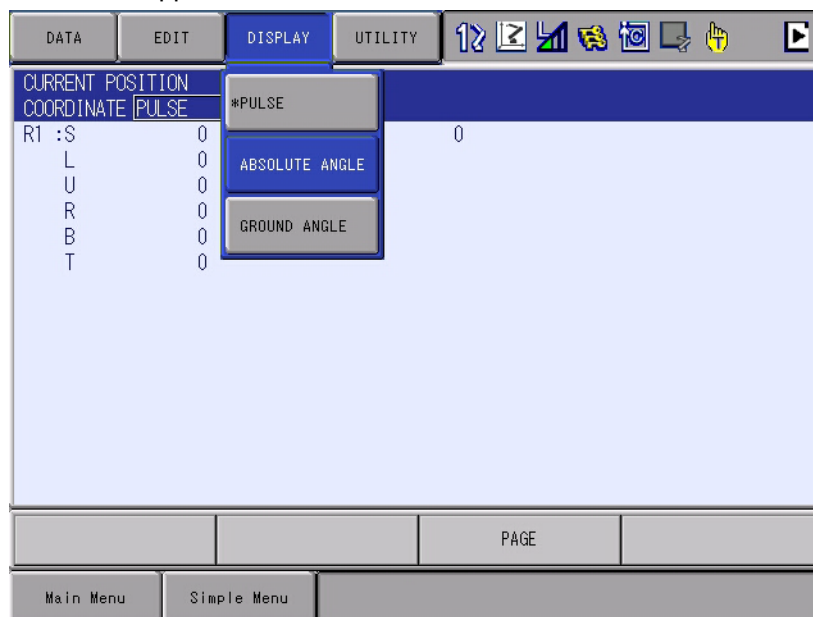
4.1 Axis Range Limit Function

5. Press {CURRENT POSITION} in the sub menu.

– CURRENT POSITION window opens.



6. While CURRENT POSITION window is appeared, press {DISPLAY} tab at the upper left side of the window.



4 Details of Functional Safety Function

4.1 Axis Range Limit Function

7. Press {ABSOLUTE ANGLE} in the list under the {DISPLAY} tab.
- On {CURRENT POSITION} window, absolute angles of the axes which exist in the present system is displayed.



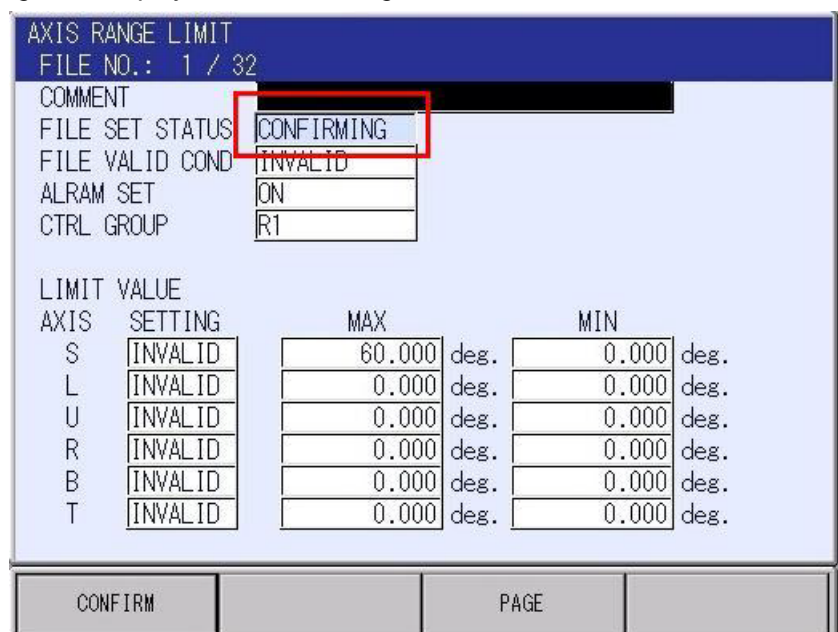
4.1.5 Confirmation of Safety Range

Confirmation of the monitoring operation to be appropriately performed inside the specified safety range is required after values are set to both {MAX} and {MIN} and {WRITE} is executed.

“CONFIRMING” is indicated to the status of the condition file on the axis range limit window. Move the axis in the object group to confirm that it stops inside the specified safety range.

When confirming the safety, valid the monitoring operation by either setting “VALID” to {FILE VALID COND} or inputting a selected safety signal to the condition file.

Fig. 4-3: Display when Confirming





In the functional safety function, the range of motion is monitored by calculating the coasting values of the manipulator or the external axis. (Refer to *section 6.2 “External Axis Coasting Value Setting”* on page 6-7.) For this reason, the manipulator stops just before exceeding the safety range in case it moves to the teaching point near the safety range.

4.1.6 Start AXIS RANGE LIMIT Operation

After confirming that the object axis moves to reach the edge of the specified safety range, press {CONFIRM} button on the window. “COMPLETE” is indicated to {FILE SET STATUS}, and execution of the axis range limit operation becomes valid.

Execute playback operation to confirm the manipulator’s motion. An alarm may occur in case the teaching point or the settings are inappropriate.

When “Alarm 4780: F-SAFE AXIS RANGE LIMIT INTF” or “Alarm 4781: AXIS RANGE LIMIT INTF” appeared.

<Cause>

The position of the axis is out of the safety range or a range of motion error is detected when the axis moved.

In the functional safety function, the axis position is monitored on the basis of the feedback pulse from the motor. In this case, taking the axis speed or coasting value into consideration, calculation of the movement is executed so that the manipulator would not come out from the safety range.

For this reason, in case a teaching point is set close to the edge of the safety range, and when the teaching speed is high, this alarm occurs.

0<Countermeasure>

Confirm the safety range.

Modify the teaching point so that it moves not to close to the safety range border.

Decrease the manipulator’s teaching speed when it passes by the border of the safety range.

4.2 AXIS SPEED MONITOR Function

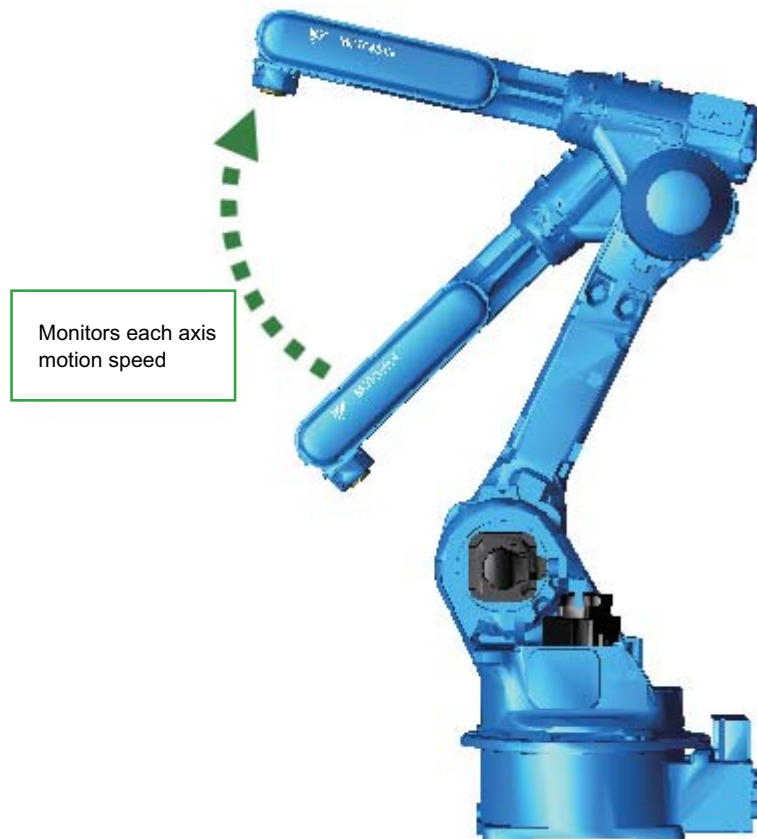
4.2.1 Outline

Axis speed monitor function is a function which sets the upper limit of the speed to each axis motion speed for the manipulator, base and station group, and then monitors whether each axis is inside the already-fixed speed using a software. When "0" is set, it is called stop position monitoring. This monitors the axis whether it does not move to exceed the limit of specified range from the point where the monitoring is started.

In case an error is detected, the power supply to the motor is stopped using the machine safety board (JANCD-YSF21-E). And the error is notified using an alarm.

Thirty two files are prepared to this function and all axes motion range of any one control group is set to a file. When a control group is set to several files, the control group can be monitored by switching conditions.

Fig. 4-4: Monitoring of Motion Speed at Each Axis



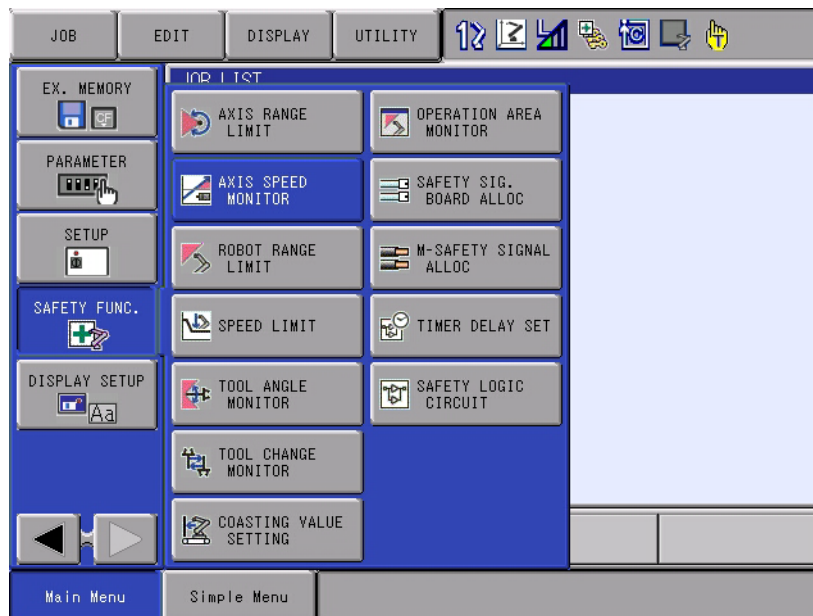
Follow the procedures below when starting the axis speed monitor function.

1. Set the axis speed monitor condition file.
↓
2. Start monitoring the axis speed.

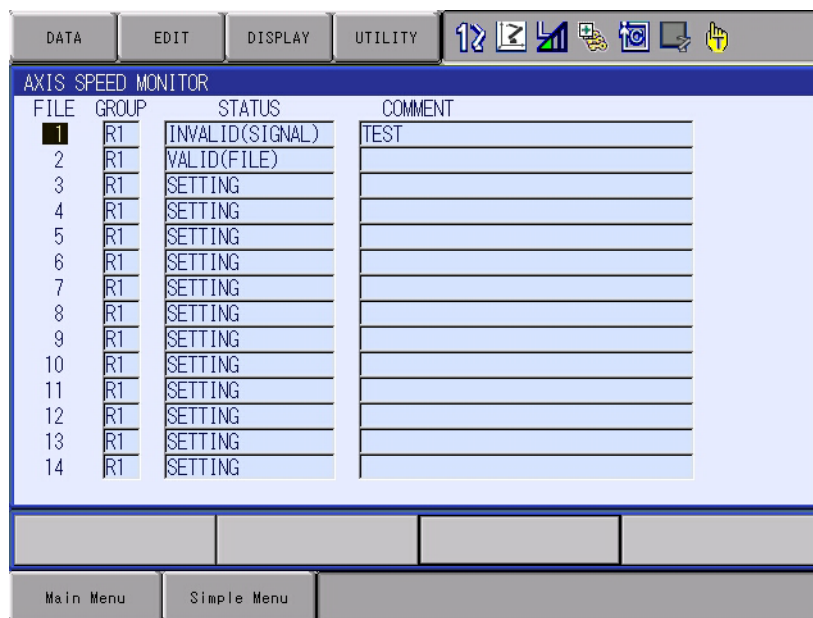
4.2.2 Axis Speed Monitor Function Window

Followings are the setting procedures for the axis speed monitor function.

1. Change the mode to the security mode, and then press {SAFETY FUNC.} under the main menu.



2. Press {AXIS SPEED MONITOR} in the sub menu.
 - The list of the axis speed monitor status appears.



On the status list window, the thirty two setting files for the axis speed limit function are arranged so that their status can be confirmed. By scrolling down the window, all the list can be seen.

Followings are the details of the item on the window.

<Details of the Window >

1.{FILE}

The number of the condition file is displayed.

Move the cursor to any number and press [SELECT]. The individual setting window for the selected condition file appears.

2. {GROUP}

The control group to be monitored set by the condition file

3. {STATUS}

Monitoring status of the present condition file

Value	Meaning
SETTING	The condition file is in the initial status or in the data setting status. Monitoring is not performed.
VALID (FILE)	Data setting is completed and monitoring status of the file is in valid status.
INVALID (FILE)	Data setting is completed and monitoring status of the file is in invalid status.
VALID (SIGNAL)	Data setting is completed and monitoring status of the file is in valid status by the establishment of the safety signal condition.
INVALID (SIGNAL)	Data setting is completed and monitoring status of the file is in invalid status by the disestablishment of the safety signal condition.

4.{COMMENT}

The comment input is displayed.

4.2.3 AXIS SPEED MONITOR Condition File Setting

On the status list window, select a file number with the cursor, and then press [SELECT].

A setting window for the selected condition file of the axis speed monitor function appears.

LIMIT VALUE			
AXIS	SETTING	SPEED	ACCEP. RNG
S	VALID	0.0 deg/s	0.000 deg.
L	VALID	30.0 deg/s	***** deg.
U	INVALID	0.0 deg/s	0.000 deg.
R	INVALID	0.0 deg/s	0.000 deg.
B	INVALID	0.0 deg/s	0.000 deg.
T	INVALID	0.0 deg/s	0.000 deg.

INPUT SIGNAL	SET	STATUS
bit0 FSBIN01(#1)	ON	<input checked="" type="radio"/>
bit1 FSBIN02(#1)	OFF	<input type="radio"/>
bit2 SFBIN01	ON	<input type="radio"/>
bit3 -----	****	<input type="radio"/>
bit4 -----	****	<input type="radio"/>

OUTPUT SIGNAL	FSBOUT02(#1)	<input type="radio"/>
---------------	--------------	-----------------------

By scrolling down the window with the cursor, all the items can be seen.

<Details of the Window >

In this section, only the items inherent to AXIS SPEED MONITOR are explained. For the items not mentioned here, please refer to *section 4.7 "Common Setting Item for the Condition File"* on page 4-76.

1.{AXIS}

All the axis existing in a control group selected at {GROUP} item.

2.{SETTING}

To one objective axis, validating/invalidating of the monitoring can be set.

This setting is referred when the condition file is valid for monitoring, and is not referred when it is invalid for monitoring.

Followings show the combination of conditions.

File monitoring status	Axis monitoring status	Result
Valid	Valid	Monitoring of the object axis is valid.
Valid	Invalid	Monitoring of the object axis is invalid.
Invalid	Valid	Monitoring of the object axis is invalid.
Invalid	Invalid	Monitoring of the object axis is valid.

3. {SPEED}

To each object axis, set the upper limit of motion speed.

When the axis is a rotating axis, it is measured in [deg/sec], and is [mm/sec] when the axis is a direct acting axis.

4. {ACCEP. RNG}

When "0" is set to {SPEED}, setting a value to this item becomes possible.

This item is used when the axis is in the stop position monitoring status.

The stop position monitoring operation judges that the axis is not moving by monitoring the object axis position difference between the stop position monitoring starting position and the present position.

To avoid any alarms from occurring due to tiny motions such as turning ON of the servo during the monitoring, this item is set.

An alarm occurs when {ACCEP.RNG} is set in \pm direction from the stop position monitoring starting position and the axis moves to exceed the position.

When the axis is a rotating axis, it is measured in [deg], and is [mm] when the axis is a direct acting axis.

When "0" is set to {ACCEP.RNG}, as default values, 0.2 [deg] is used for the rotating axis and 20 [mm] is used for the direct acting axis.

4.2.4 Start AXIS SPEED MONITOR Operation

After values are input to {SPEED} and press {WRITE} button on the window, "COMPLETED" appears to {FILE SET STATUS}. The axis speed monitor function becomes possible to execute.

4.3 Robot Range Limit Function

4.3.1 Outline

The robot range limit function is a function which carries out following monitoring using software.

1. Define the manipulator's range of motion with polygonal prism or cuboid, and then monitors the manipulator arm or its tool to be inside the range of motion.
→Inside the range monitoring
2. Define the manipulator's approach-prohibited area with polygonal prism or cuboid, and then monitors whether the manipulator arm or its tool does not move inside the area.
→Outside the range monitoring
3. Limit the manipulator's range of motion with a large enough plane (wall), and then monitors the manipulator arm or its tool so as not to interfere with the plane.
→Planar interference monitoring

<Inside the range monitoring>

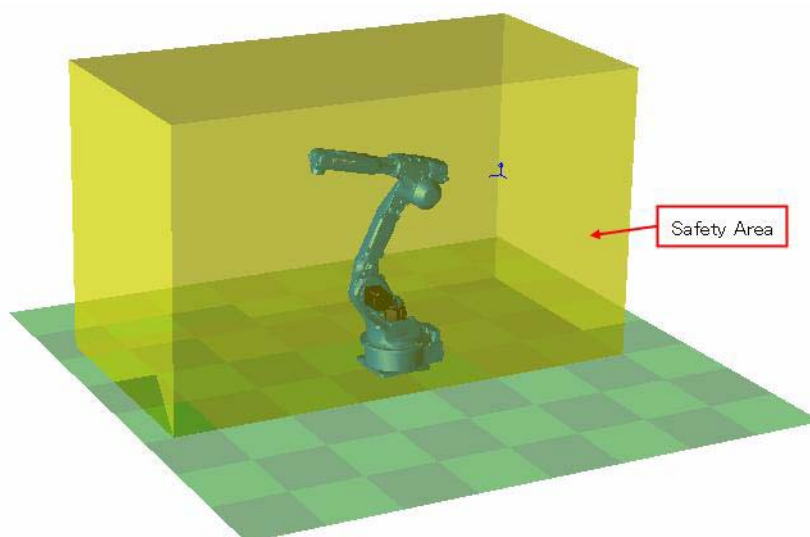
The manipulator's range of motion can be defined using the prism from triangular prism to 16-prisms. The space inside the prism is defined as the safety range.

There are two ways of specifying the prism as follows.

- A polygon on the XY plane with a height in Z-axis direction.
- A cuboid consists of two points on a diagonal line.

When the result of the monitoring is safe, the object arm and the tool of the manipulator are inevitably inside the safety range.

Fig. 4-5: Inside the Range Monitoring



<Outside the range monitoring>

The manipulator's range of motion can be defined using the prism with triangular prism and quadrangular prism. The space outside the prism is defined as the safety range.

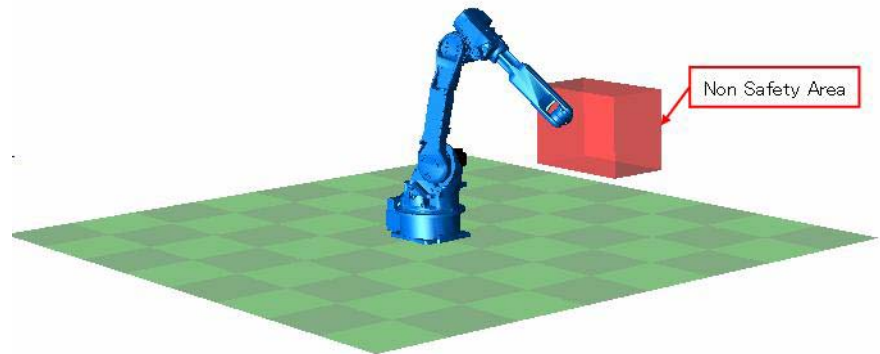
There are two ways of specifying the prism as follows.

-A polygon on the XY plane with a height in Z-axis direction.

-A cuboid consists of two points on a diagonal line.

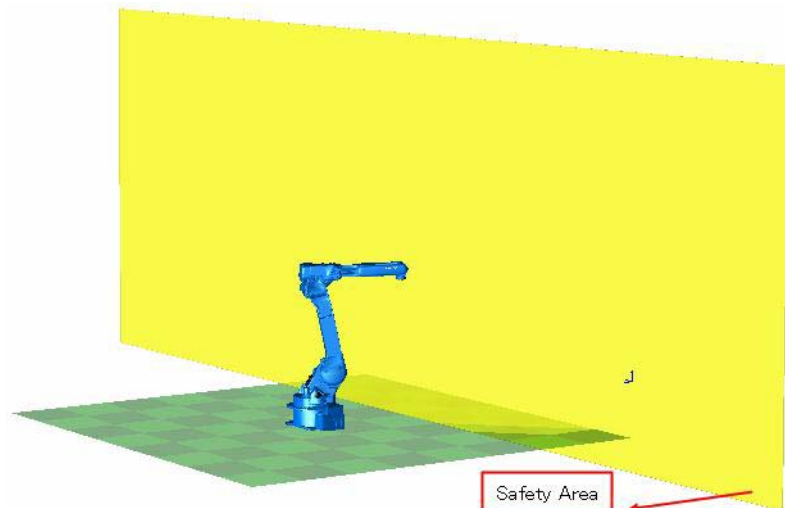
When the result of the monitoring is safe, the object arm and tool of the manipulator are inevitably outside the safety range.

Fig. 4-6: Outside the Range Monitoring

**<Planar interference monitoring>**

Draw a line on either XY, YZ or ZX coordinate plane, and then, along the line, set a plane (wall) in the vertical direction. A plane, which is large enough to the manipulator, is specified. Regarding the plane as a boarder, the area where the manipulator exists is defined as the safety range. The plane is defined by specifying a coordinate plane and two points for drawing a line.

Fig. 4-7: Outside the Range Monitoring



While a manipulator is in operation, based on the manipulator motion speed, this function calculates the coasting value in case of the immediate stop by the alarm, and then, including this value, this function monitors the safety range. With this monitoring operation, the axes would not exceed the safety range even if a motion error is detected.

In case an error is detected, the power supply to the motor is stopped using the machine safety board (JANCD-YSF21-E). And the error is notified using an alarm.

Thirty two files are prepared to this function and any one control group and a safety range is set to a file. When a control group is set to several files, the control group can be monitored by switching conditions.

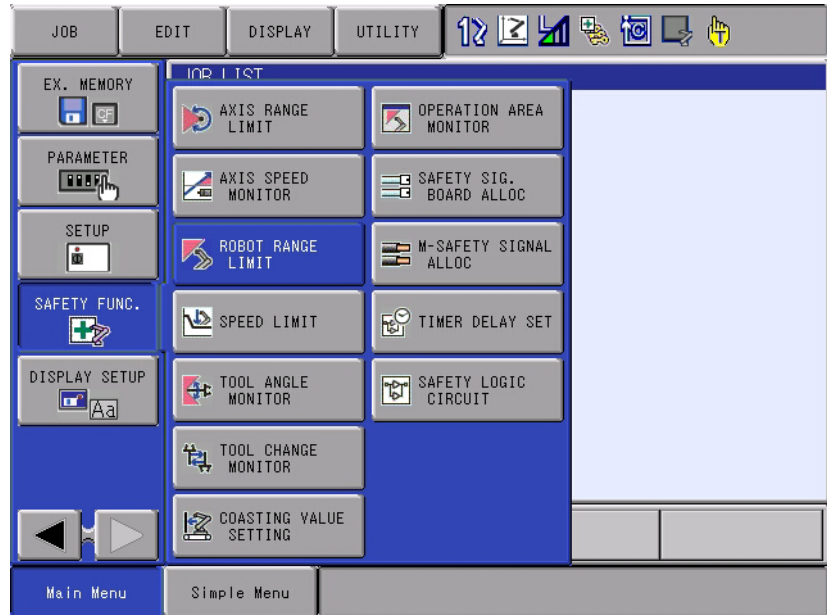
Follow the procedures below when starting the robot range limit function.

1. Set the coasting value.
(Before using this function, set the coasting value by following the procedures described in *section 6.2 "External Axis Coasting Value Setting" on page 6-7* in case the base axis or the station axis exits in the system.)
↓
2. Set the tool file.
(Before using this function, execute tool file setting by referring to *section 6.3 "Tool File Setting" on page 6-10*.)
↓
3. Set the tool interference file.
(Before using this function, execute tool interference file setting by referring to *section 6.4 "Tool Interference File Setting" on page 6-11*.)
↓
4. Set the robot range limit function.
↓
5. Confirm the safety range.
↓
6. Start the robot range limit function.

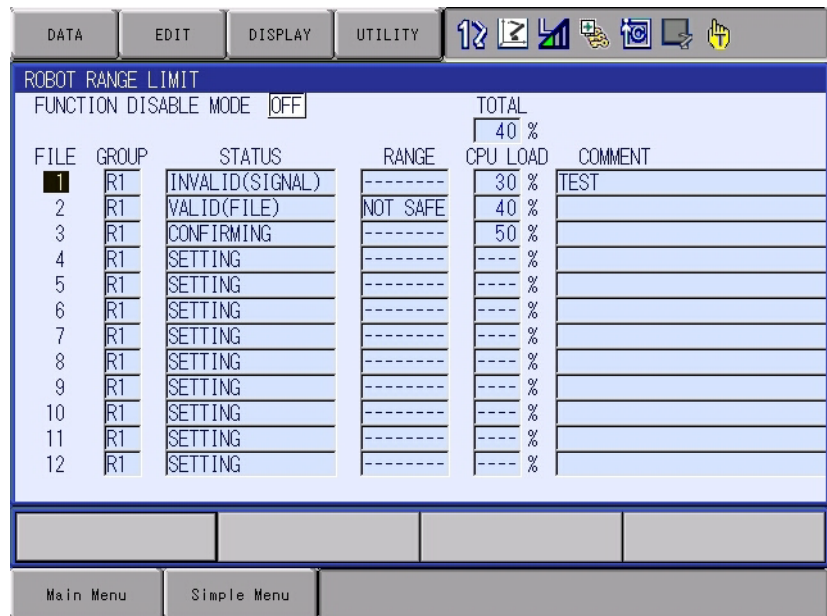
4.3.2 Robot Range Limit Function Window

Followings are the setting procedures for the axis range limit function.

1. Change the mode to the security mode, and then press {SAFETY FUNC.} under the main menu.



2. Press {ROBOT RANGE LIMIT} in the sub menu.
 - The list of the robot range limit status appears.



On the status list window, the thirty two setting files for the axis range limit function are arranged so that their status can be confirmed. By scrolling down the window, all the list can be seen.

Followings are the details of the item on the window.

<Details of the Window >

1. {FUCTION DISABLE MODE}

Valid/invalid the robot range limit function. When "ON" is selected, the condition files of the thirty two files of this function can be set to invalid temporarily.

Value	Meaning
OFF	The robot range limit function is valid.
ON	The robot range limit function is invalid. The play back, test run, forward/backward operation become prohibited.

For the details, please refer to *section 6.1 "Function Disable Mode Function Setting" on page 6-1.*

2. {FILE}

The number of the condition file is displayed.

Move the cursor to any number and press [SELECT]. The individual setting window for the selected condition file appears.

3. {GROUP}

The control group to be monitored specified by the condition file is indicated.

4. {STATUS}

Monitoring status of the present condition file is indicated.

Value	Meaning
SETTING	The condition file is in the initial status or in the data setting status. Monitoring is not performed.
CONFIRMING	Confirming the area after the data is set. The status of the monitoring operation depends on the valid condition of the condition file.
VALID (FILE)	Data setting is completed and monitoring status of the file is in valid status.
INVALID (FILE)	Data setting is completed and monitoring status of the file is in invalid status.
VALID (SIGNAL)	Data setting is completed and monitoring status of the file is in valid status by the establishment of the safety signal condition.
INVALID (SIGNAL)	Data setting is completed and monitoring status of the file is in invalid status by the disestablishment of the safety signal condition.

5. {RANGE}

Result of the present monitoring is displayed

Value	Meaning
Safe	Result of the object file monitoring is safe (inside the safety range) is safe (inside the safety range)
Not-safe	Result of the object file monitoring is not-safe (outside the safety range)
-	The object file is in monitoring invalid status.

6. {CPU LOAD}

The robot range limit function can, to some extent, freely define the shape as its range of motion. However, the time period needed for processing the monitoring varies depending on the shape or the method of monitoring.

Regard the allocated processing time for robot range limit function as 100%, the ratio of necessary processing time for the area created in the object area is indicated to this item.

Followings are processing time for each area created in the object area.

Monitoring method	Numbers of point	Processing time
Inside the area	4	20%
	8	23%
	16	30%
Outside the area	3	18%
	4	20%
	4 (Cuboid)	18%
Plane (X-Y)	-	8%
Plane (Y-Z)	-	8%
Plane (X-Z)	-	8%

7. {TOTAL}

Total {CPU LOAD} of the files to which monitoring is validated.



When executing the robot range limit function even after the total cpu load exceeded over 100%, following alarms may occur due to insufficient processing time.

Alarm 500 SEGMENT PROC NOT READY

Alarm 1899 F-SAFE MONITOR EXECUTE TIMEOVER

When an alarm occurred, reduce the area where the monitoring is simultaneously validated to avoid the cpu load from exceeding 100%.

8. {COMMENT}

The comment input is displayed.

4.3.3 Robot Range Limit Function Condition File Setting Window

On the status list window, select a file number with the cursor, and then press [SELECT].

A setting window for the selected condition file of the ROBOT RANGE LIMIT function appears.

On this window, the indication pattern on the window changes depending on the selection of {MONITOR TARGET} or {SHAPE TYPE}. For the details of the indication, please refer to the table below.

MONITOR TARGET	SHAPE TYPE	Indication
INSIDE, OUTSIDE	PRISM	Pattern A
	CUBOID	Pattern B
Plane (X-Y), (Y-Z), (X-Z)	-	Pattern C

■ **Pattern A**

Following is the pattern A of the indication of condition file setting window.

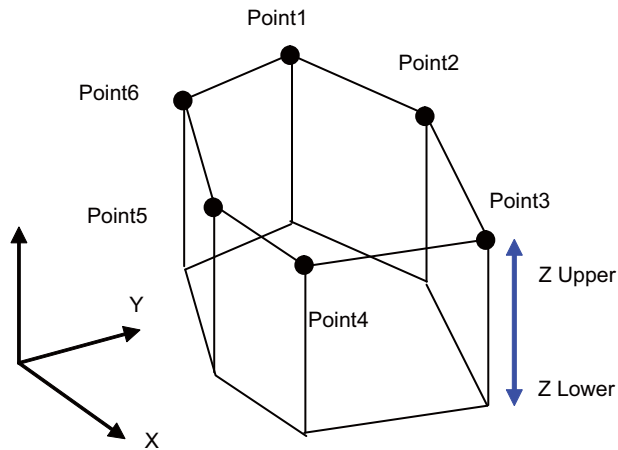
By scrolling down the window with the cursor, all the indication can be seen.

On this window, the polygonal prism is defined with the following two steps.

STEP 1: Define a polygonal prism on the X-Y plane.

STEP 2: Specify 2 points on the Z-axis to define them as the height for the polygonal prism on the X-Y plane.

Fig. 4-8: Image of Robot Limit Range: Pattern A

**<Details of the Window >**

In this section, only the items inherent to robot range limit functions are explained. For the items not mentioned here, please refer to *section 4.7 "Common Setting Item for the Condition File"* on page 4-76.

1. {MONITOR TARGET}

To the area of the object file, set the monitoring method.

Value	Method
INSIDE	Set the inside range monitoring.
OUTSIDE	Set the outside range monitoring.
Plane (X-Y)	Set the planar interference monitoring (X-Y)
Plane (Y-Z)	Set the planar interference monitoring (Y-Z)
Plane (X-Z)	Set the planar interference monitoring (X-Z)

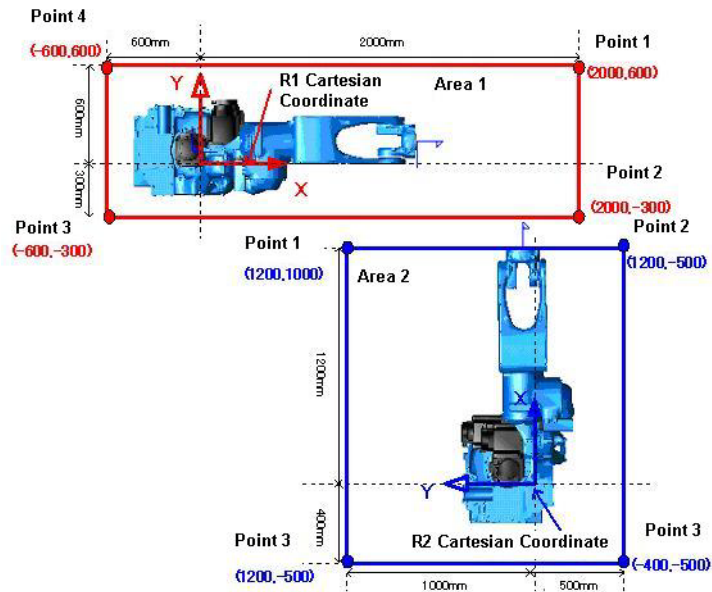
2. {COORD}

Specify the coordinates system to be monitored.

Value	Method
ROBOT	Define the monitoring area on the robot cartesian coordinate system.
BASE	Define the monitoring area on the base cartesian coordinate system.

Setting Example of Coordinate “Robot” : When setting the area shown in Fig. 4-9 “Area Setting (Robot)”.

Fig. 4-9: Area Setting (Robot)



For the area 1, as shown in Fig. 4-10 “Example of Condition File Setting (R1: Robot)”, select R1 to CTRL GROUP and ROBOT to COORD. Also, to each POINT, set positions which are on the R1 cartesian coordinates.

For the area 2, as shown in Fig. 4-11 “Example of Condition File Setting (R2: Robot)”, select R2 to CTRL GROUP and ROBOT to COORD. Also, to each POINT, set each position which are on the R2 cartesian coordinates.

Fig. 4-10: Example of Condition File Setting (R1: Robot)

CTRL GROUP	R1	
MONITOR TARGET	INSIDE	
COORD	ROBOT	
SHAPE TYPE	PRISM	
CPU LOAD	33 %	
USED POINT NUM	4	
	<X> (mm)	<Y> (mm)
POINT1	2000	600
POINT2	2000	-300
POINT3	-600	-300
POINT4	-600	600
<Z UPPER> (mm)	0	
<Z LOWER> (mm)	0	

Fig. 4-11: Example of Condition File Setting (R2: Robot)

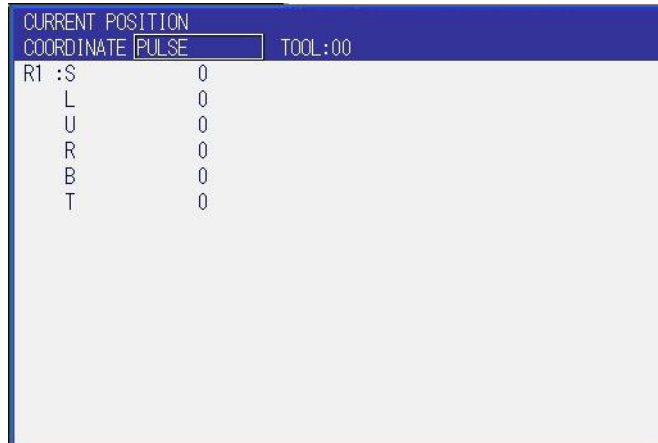
CTRL GROUP	R2	
MONITOR TARGET	INSIDE	
COORD	ROBOT	
SHAPE TYPE	PRISM	
CPU LOAD	33 %	
USED POINT NUM	4	
	<X> (mm)	<Y> (mm)
POINT1	1200	1000
POINT2	1200	-500
POINT3	-400	-500
POINT4	-400	1000
<Z UPPER> (mm)	0	
<Z LOWER> (mm)	0	

4 Details of Functional Safety Function

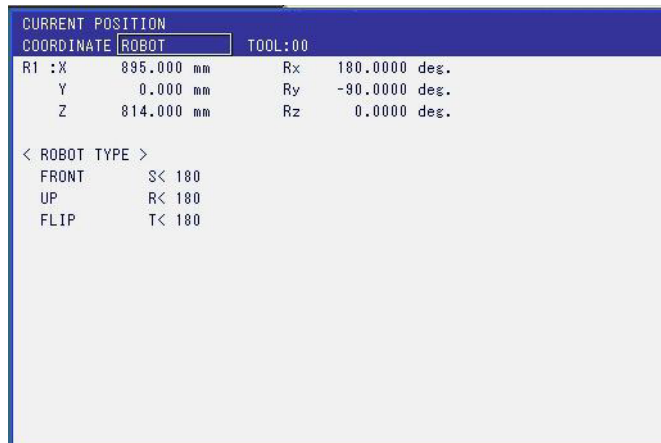
4.3 Robot Range Limit Function

When setting a position to a POINT, confirm the position following the procedures below.

1. Select {ROBOT} → {CURRENT POSITION} under the main menu.
 - The CURRENT POSITION window appears.



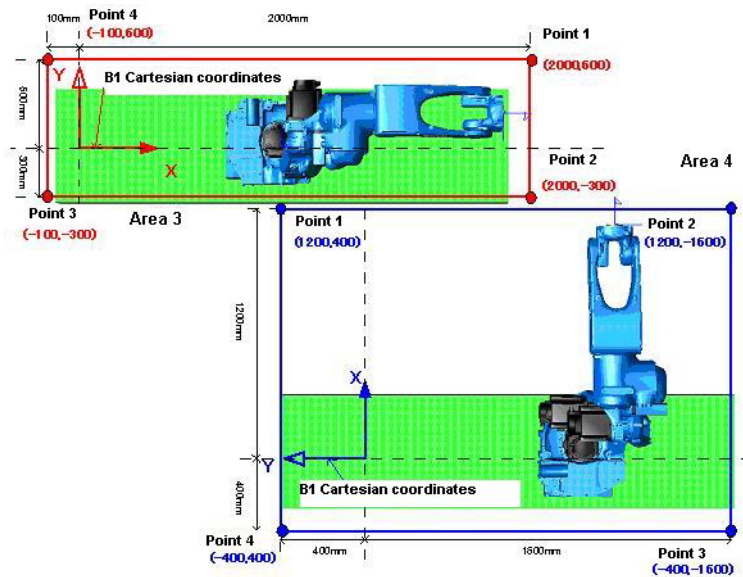
2. Select {ROBOT} at {COORDINATE}.



3. Set the cartesian position indicated on the window to each POINT.

Setting Example of Coordinate “Base” : When setting the area shown in Fig. 4-12 “Area Setting (Base)”.

Fig. 4-12: Area Setting (Base)



For the area 3, as shown in Fig. 4-13 “Example of Condition File Setting (R1: Base)”, select R1 to CTRL GROUP and ROBOT to COORD. Also, to each POINT, set positions which are on the R1 cartesian coordinates.

For the area 4, as shown in Fig. 4-14 “Example of Condition File Setting (R2:Base)”, select R2 to CTRL GROUP and ROBOT to COORD. Also, to each POINT, set each position which are on the R2 cartesian coordinates.

Fig. 4-13: Example of Condition File Setting (R1: Base)

CTRL GROUP	R1	
MONITOR TARGET	INSIDE	
COORD	BASE	
SHAPE TYPE	PRISM	
CPU LOAD	33 %	
USED POINT NUM	4	
	<X>(mm)	<Y>(mm)
POINT1	2000	600
POINT2	2000	-300
POINT3	-100	-300
POINT4	-100	600
<Z UPPER>(mm)	0	
<Z LOWER>(mm)	0	

Fig. 4-14: Example of Condition File Setting (R2:Base)

CTRL GROUP	R2	
MONITOR TARGET	INSIDE	
COORD	BASE	
SHAPE TYPE	PRISM	
CPU LOAD	33 %	
USED POINT NUM	4	
	<X>(mm)	<Y>(mm)
POINT1	1200	400
POINT2	1200	-1600
POINT3	-400	-1600
POINT4	-400	400
<Z UPPER>(mm)	0	
<Z LOWER>(mm)	0	

4 Details of Functional Safety Function

4.3 Robot Range Limit Function

When setting a position to a POINT, confirm the position following the procedures below.

1. Select {ROBOT} → {CURRENT POSITION} under the main menu.
 - The CURRENT POSITION window appears.

CURRENT POSITION			
COORDINATE	PULSE	TOOL:00	
R1 :S	0	B1 :1	0
L	0		
U	0		
R	0		
B	0		
T	0		

2. Select {ROBOT} at {COORDINATE}.

CURRENT POSITION			
COORDINATE	ROBOT	TOOL:00	
R1 :X	895.000 mm	Rx	180.0000 deg.
Y	0.000 mm	Ry	-90.0000 deg.
Z	814.000 mm	Rz	0.0000 deg.
< ROBOT TYPE >		< ORIGIN >	
FRONT	S< 180	X0	0.000 mm
UP	R< 180	Y0	0.000 mm
FLIP	T< 180	Z0	0.000 mm

3. Add the cartesian position indicated at <ORIGIN> to the cartesian position indicated on the window, and then set the sum of the position to each POINT.

3. {SHAPE TYPE}

Specify the creating method of the monitoring area.

If either Plane (X-Y), Plane (Y-Z) or Plane (X-Z) is set to {MONITOR TARGET}, this item is invalid.

Value	Method
PRISM	Create lines between the created points to specify the area for the range of motion. For inside the range monitoring, up to 16 points can be specified. For outside the range monitoring, up to 4 points can be specified.
CUBOID	Specify two points, and then create a cuboid whose diagonal line is created by those points. This cuboid is specified as the area for the range of motion.

4. {CPU LOAD}

Please refer to *section 6. {CPU LOAD}*.

5. {USED POINT NUM}

Specify the numbers of points for creating a polygonal prism.

For the inside the range monitoring, from 3 to 16 can be input.

For the outside the range monitoring, from 3 to 4 can be input.

Ex. For triangular prism, input "3".

For 16-prisms, input "16".

6. {POINT} (X,Y)

Specify points on the X-Y plane to define a polygonal prism.

(Point 1 to 6 in *Fig. 4-8 "Image of Robot Limit Range: Pattern A" on page 4-24.*)

The points are connected in ascending order like "POINT 1 → POINT 2 → POINT 3.....". And the line of these points becomes the wall of the range of motion. Take this procedures into consideration before specifying the points.

The numbers of the points is specified by the settings of {USED POINT NUM}. The last number of the point is connected to the first one.

7. {Z UPPER} {Z LOWER}

Specify the height of the polygonal prism. (Z Upper and Z Lower in *Fig. 4-8.*)

When "0 [mm]" is set to both {Z UPPER} and {Z LOWER}, the height in the Z-axis direction is set to infinite (polygonal prism of infinite height).

■ **Pattern B**

Following is the pattern B of the indication of condition file setting window.

By scrolling down the window with the cursor, all the indication can be seen.

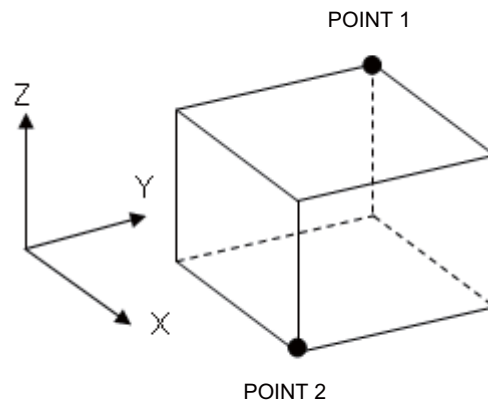
ROBOT RANGE LIMIT			
FILE NO.: 2 / 32			
COMMENT	TEST		
FILE SET STATUS	COMPLETED		
FILE VALID COND	SIGNAL		
ALARM SET	ON		
CTRL GROUP	R1		
MONITOR TARGET	INSIDE		
COORD	ROBOT		
SHAPE TYPE	CUBOID		
CPU LOAD	10 %		
	<X>(mm)	<Y>(mm)	<Z>(mm)
VERTEX1	0	0	2000
VERTEX2	1000	2000	-2000
INPUT SIGNAL		SET	STATUS
bit0	FSBIN01(#1)	ON	●
bit1	FSBIN02(#1)	OFF	○
bit2	SFBIN01	ON	○
bit3	-----	****	○
bit4	-----	****	○
OUTPUT SIGNAL	FSBOUT08(#1)		○
PAGE			

On this window, the cuboid is defined with the following two steps.

STEP 1: Define two points (point 1 and point 2) on the X - Y - Z plane to create a cuboid by regarding the connected line as its diagonal line.

STEP 2: A cuboid area is automatically created based on the specified two points.

Fig. 4-15: Image of Robot Limit Range: Pattern B



<Details of the Window >

Please refer to ■ "Pattern A" on page 4-23 or section 4.7 "Common Setting Item for the Condition File" on page 4-76 for the items not explained here in ■ "Pattern B".

8. {POINT} (X, Y, Z)

Specify two points on a object coordinates system, and then a cuboid is created whose diagonal line is specified by the points.

In case any two point values input in either X, Y or Z are overlapped, the setting is regarded as an error.

■ **Pattern C**

Following is the pattern C of the indication of condition file setting window.

By scrolling down the window with the cursor, all the indication can be seen.

ROBOT RANGE LIMIT			
FILE NO.: 3 / 32			
COMMENT	TEST		
FILE SET STATUS	COMPLETED		
FILE VALID COND	SIGNAL		
ALRAM SET	ON		
CTRL GROUP	R1		
MONITOR TARGET	PLANE(X-Y)		
COORD	ROBOT		
CPU LOAD	20 %		
	<X> (mm)	<Y> (mm)	
POINT1	0	1500	
POINT2	-500	1000	
INPUT SIGNAL		SET	STATUS
bit0	FSBIN01(#1)	OFF	●
bit1	FSBIN02(#1)	ON	○
bit2	SFBIN01	OFF	○
bit3	-----	****	○
bit4	-----	****	○
OUTPUT SIGNAL	FSBOUT01(#1)		○
PAGE			

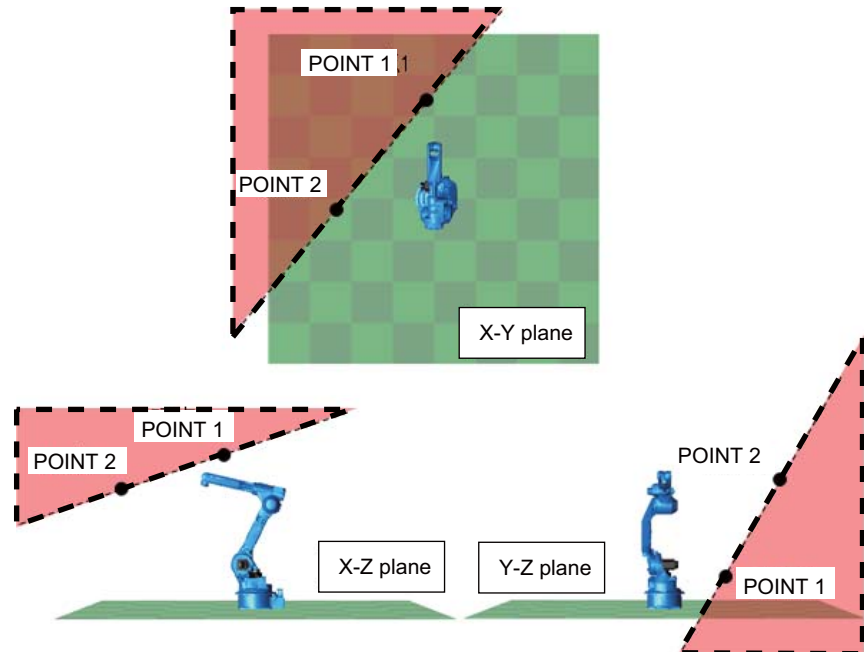
On this window, a plane is defined with the following two steps.

STEP 1: Define a straight line with two points (point 1 and point 2) on any of the selected X-Y, Y-Z or X-Z plane.

STEP 2: In a vertical direction, a plane (wall) is specified along the straight line which was defined in the STEP 1.

A plane, which is large enough to the manipulator, is specified.

Fig. 4-16: Image of Robot Limit Range: Pattern C (Area inside dotted line is non-safety area)



<Details of the Window >

Please refer to ■ "Pattern A" on page 4-23 or section 4.7 "Common Setting Item for the Condition File" on page 4-76.

9. {POINT} (X,Y), (Y, Z) or (X,Z)

Specify two points to draw a straight line on a coordinate plane selected at {MONITOR TARGET}.

In case the coordinates of these two points overlapped, the setting is regarded as an error.

4.3.4 Confirmation of the Safety Range

After the safety range is specified and {READ} is pressed, it is necessary to confirm whether the monitoring is appropriately performed inside the range.

"CONFIRM" is indicated at {FILE SETSTATUS} on the robot range limit window. Set "VALID" to the object file by the file setting or signal condition.

Move the object manipulator or external axis to confirm whether it steps inside the specified safety range.

Fig. 4-17: CONFIRMING Window

ROBOT RANGE LIMIT			
FILE NO.: 1 / 32			
COMMENT			
FILE SET STATUS	CONFIRMING		
FILE VALID COND	SIGNAL		
ALRAM SET	ON		
CTRL GROUP	R1		
MONITOR TARGET	INSIDE		
COORD	ROBOT		
SHAPE TYPE	CUBOID		
CPU LOAD	30 %		
	<X>(mm)	<Y>(mm)	<Z>(mm)
POINT1	1000	1000	2000
POINT2	500	-1000	-2000
CONFIRM		PAGE	

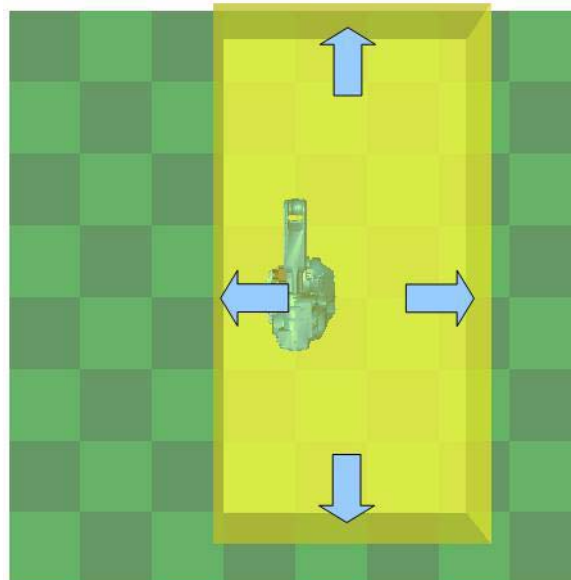
<Confirm Safety Range with Jog Operation>

With the jog operation, confirm whether the specified safety range is appropriate.

○ Inside the range monitoring

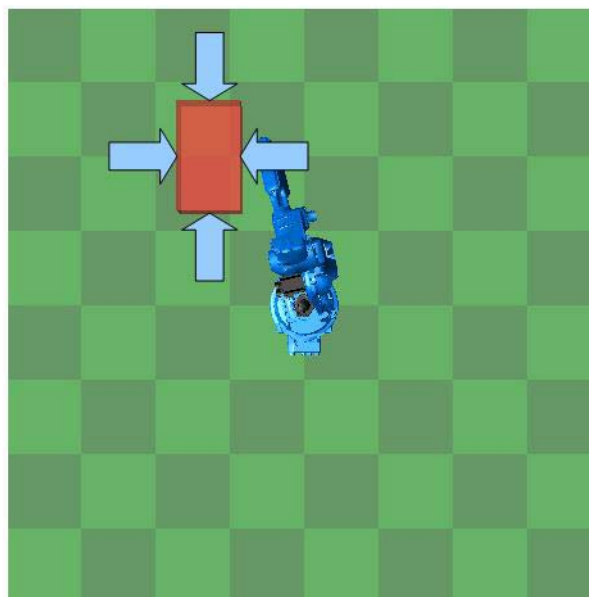
Move the manipulator inside the specified four walls and check that it stops just in front of the wall. In case the area is not a cuboid, check that it stops just in front of all walls.

Fig. 4-18: Inside the Range Monitoring

**○ Outside the range monitoring**

To the walls, move the manipulator toward all the direction where it can make approach and check that it stops just in front of all each wall.

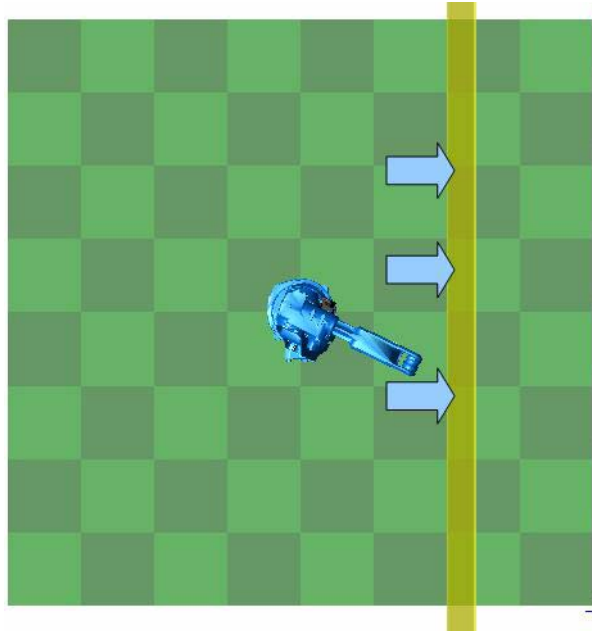
Fig. 4-19: Outside the Range Monitoring



○ Planar interference monitoring

To the specified plane, make the manipulator approach to it. Confirm that the manipulator stops at any three points on the plane.

Fig. 4-20: Planar Interference Monitoring



In the functional safety function, the range of motion is monitored by calculating the coasting values of the manipulator or the external axis. (Refer to *section 6.2 "External Axis Coasting Value Setting" on page 6-7.*) For this reason, the manipulator stops just short of the safety range in case it moves to the teaching point near the safety range.

4.3.5 Starting the ROBOT RANGE LIMIT

After the manipulator is confirmed that it moves to its robot range limit, press {CONFIRMED} on the window. The robot range limit function becomes valid.

Execute the play back operation of the practical movement. An alarms may occur due to inappropriate settings or teaching point setting.

In case “Alarm 4783: F-SAFE ROBOT RANGE LIMIT INTF” or “Alarm 4784: ROBOT RANGE LIMIT INTF” appeared

<Cause>

The positions of the robot and the tool are out of its safety area, or an axis range limit error is detected when the manipulator started moving. Inside the robot range limit, taking the feedback speed or the coasting value which were detected by the functional safety function, into consideration, calculation of the movement is executed so that the manipulator would not come out from the safety range. For this reason, when a manipulator moves close to the border of the range, this alarm occurs because the higher its teaching speed becomes, the more its coasting value increases .

<Countermeasure>

Check that the safety range is appropriately set.

Execute the teaching operation so that the manipulator dose not approach close to the border of the range.

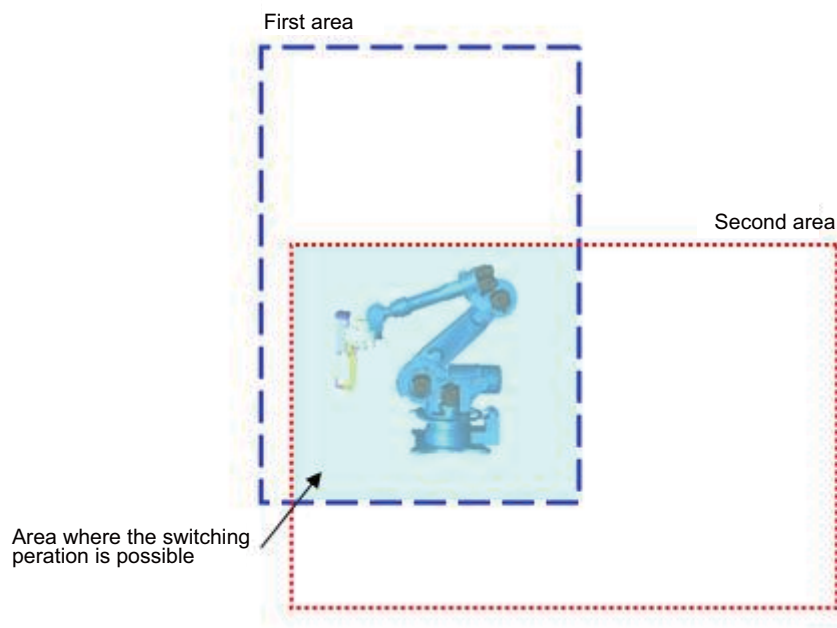
Decrease the teaching speed near the border of the range.

4.3.6 Switch the Monitoring Area

When switching the monitoring area using the safety signal input, execute the switching operation after moving the manipulator to be inside the next monitoring area and stopping it completely.

When executing inside the range monitoring at multiple ranges, set the overlapped range and execute the switching only when the manipulator is inside the overlapped area.

Fig. 4-21: When Switching the Monitoring Area



When monitoring operation is validated to multiple areas at a time, the overlapped area is regarded as the safety range.

Inside the monitoring area + Inside the monitoring area

Fig. 4-22: Simultaneous Monitoring: Multiple Areas (Inside the Monitoring Area + Inside the Monitoring Area)

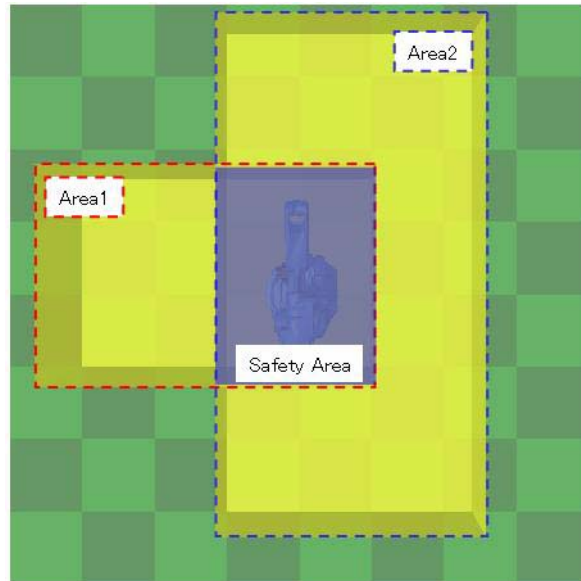
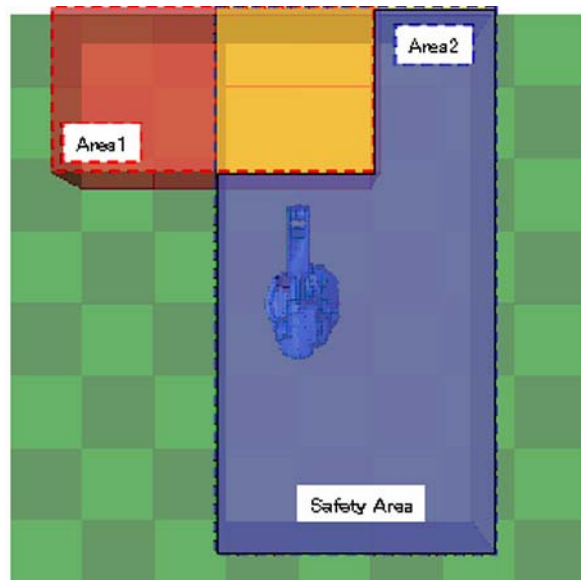
**Inside the monitoring area + Outside the monitoring area**

Fig. 4-23: Simultaneous Monitoring: Multiple Areas (Inside the Monitoring Area + Outside the Monitoring Area)



4.3.7 Safety Range and Manipulator Position

On the operation area monitor window, the specified safety range and the manipulator's present position can be roughly depicted on the programming pendant screen so that their position relation can be confirmed.

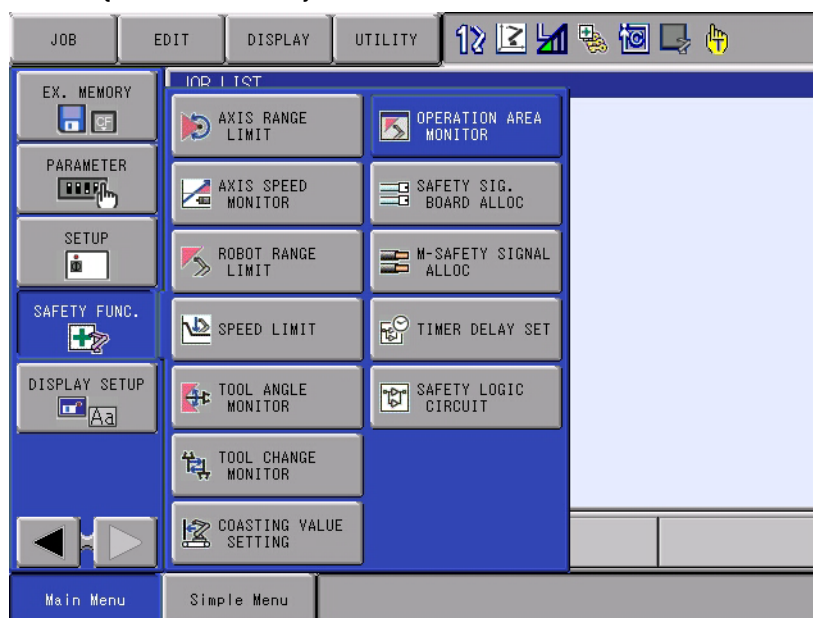
Follow the procedures below to open the operation area monitor window.



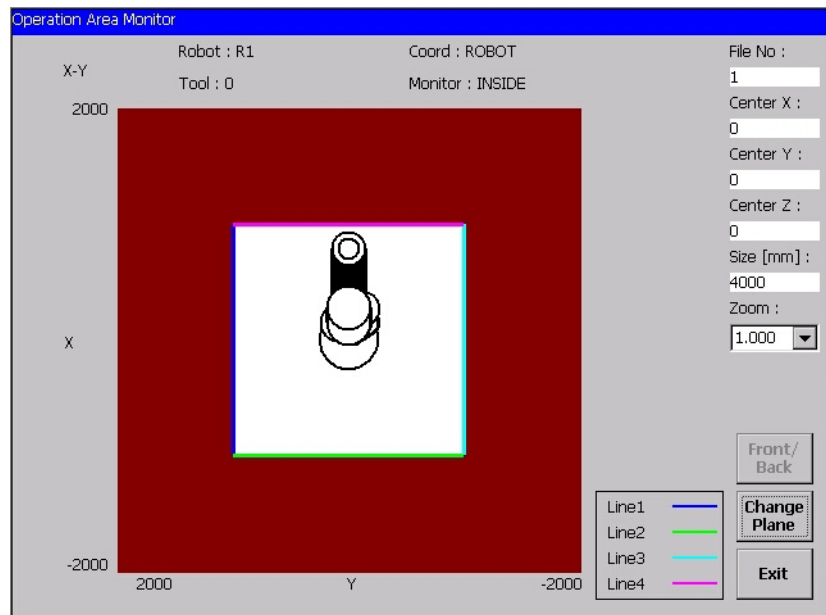
The data to which {WRITE} button is not yet pressed would not be reflected on the {OPERATION AREA MONITOR} window in case this window is opened while the robot range limit condition file is being edited.

Be sure to complete the editing operation before opening the window.

1. Press {SAFETY FUNC.} under the main menu.



2. Press {OPERATION AREA MONITOR} in the sub menu.
 - OPERATION AREA MONITOR window appears.



<Details of the Window >

A. Plane {X-Y}, {Y-Z}, {X-Z}

The plane shown on the window now.

The manipulator and its tool are depicted in the approximate model shape specified set to the robot parameter and to the tool interference file.

When the manipulator is floor-mounted type, each figure indicates as follows;

{X-Y}: top view of the manipulator

{Y-Z}: back side view of the manipulator

{X-Z}: left side view of the manipulator

B. {ROBOT}

The number of the manipulator is indicated.

C. {TOOL}

The tool number specified to the manipulator shown on the window is indicated.

D. {COORDINATES}

The coordinates of the safety area shown on the window is indicated.

Value	Meaning
Base	Base coordinates
Tool	Tool coordinates

E. {Monitor}

Monitoring method for the safety range shown on the window is indicated..

Value	Meaning
Inside	Perform the inside range monitoring
Outside	Perform the outside range monitoring
Plane (X-Y)	Perform the plane interference monitoring
Plane (Y-Z)	
Plane (X-Z)	

F. {FILE No.}

The number of condition file of the robot range limit function. Inputting value from 1 to 32 can switch the condition file.

G. {Center X}, {Center Y}, {Center Z}

Specifies the center point coordinates in the depictable range on the plane. When the plane X-Y is shown on the window, the manipulator is depicted on the plane with the center of the plane (X,Y) coordinates at its center. Unit: [mm].

H. {Size}

Length of one side of the depicting area is specified. Unit: [mm].

I. {Zoom}

Scale the indicated plane. Magnification can be selected among 0.125, 0.25, 0.5, 1, 2, 4 and 8.

When 2 is selected as its magnification, the scale of the apparent size of the plane becomes double and becomes half when 0.5 is selected.

In case the value of {CENTER} or {SIZE} is modified, the magnification at {ZOOM} returns to 1.

J. {Front/Back} button

It is indicated only when Y-X plane indication is set. The view of the plane changes from manipulator front view to back view each time this button is pressed.

K. {Left/Right} button

It is indicated only when Y-X plane indication is set. The view of the plane changes from manipulator right side view to left side view each time this button is pressed.

L. {CHANGE PLANE} button

The plane on the window alternates every time this button is pressed. (X-Y → Y-Z → X-Z → X-Y)

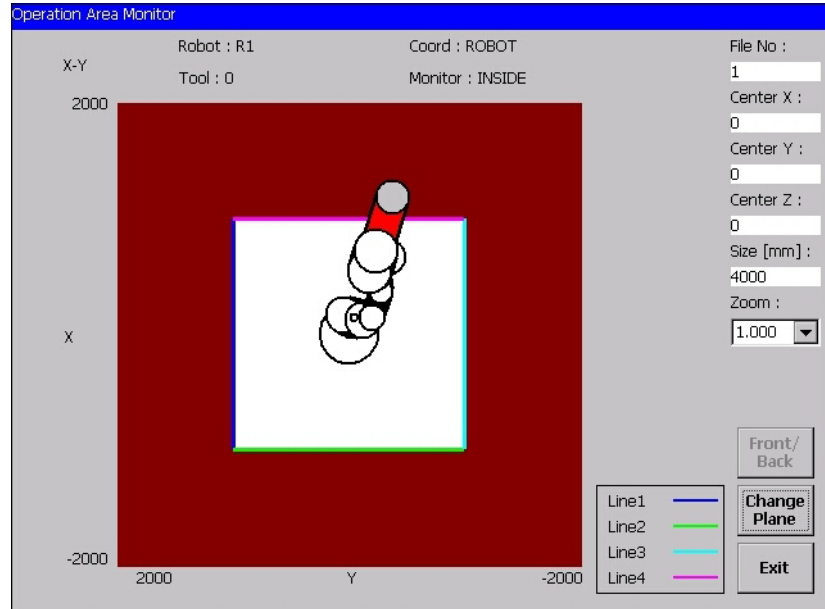
However, this button is invalid when "Plane *-*" is specified to {Monitor} because the plane view is fixed.

M. {Exit} button

Closes the operation area monitor window.

<Details of the Plane on the Window >

- Example of X-Y plane (Indication of Y-Z and X-Z are also the same when monitoring the plane.)

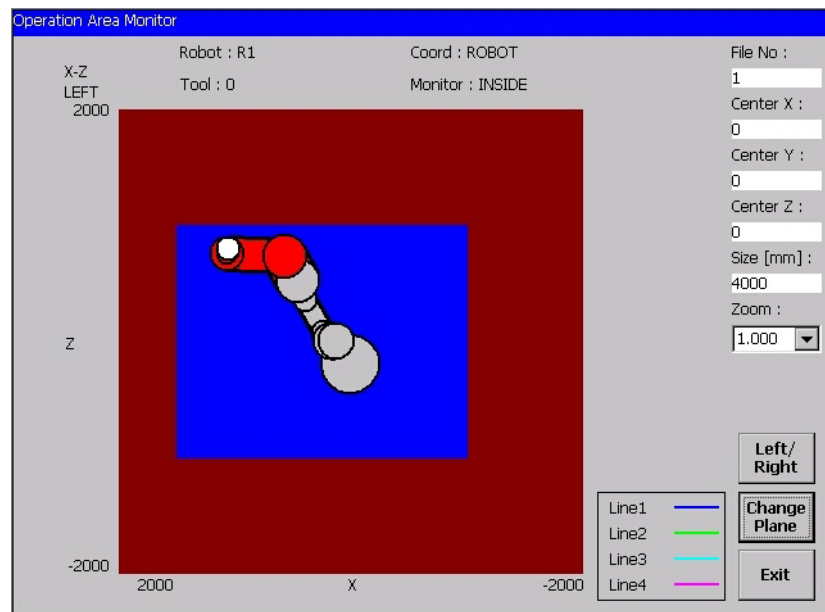


On the X-Y plane, the safety range is shown as the white area and not safety area is shown as brown area. The borders between the areas are indicated in colored lines and this lines are regarded as the wall. The manipulator model and the tool model :

- contacting with the wall are indicated in red.
- inside the safety area are indicated in white.
- inside the not safety area are indicated in gray color.

The plane defined as Z upper or Z lower on the X-Y plane are not indicated.

- Example of Y-Z and X-Z planes



Each Y-Z and X-Z plane indicates the side of the safety area. On the Y-Z and X-Z planes, only the “wall” looked in the short from the view point is indicated.

The manipulator model and the tool model :

- seen opposite side of the “wall” are indicated in gray color.
- seen in front of the “wall” are indicated in white.
- contacting to the “wall” are indicated in red.

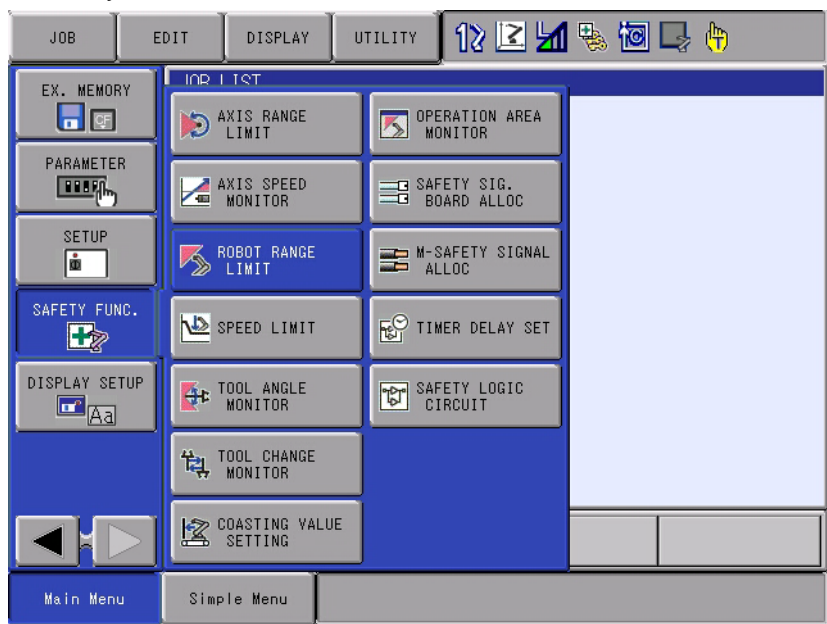
4.3.8 Proximity Warning Buzzer Setting

A warning buzzer sounds and a message “Approaching the non safety area” when the manipulator approaches a certain distance to the boundary of the non safety area. The distance object of detection can be modified on the approach warning buzzer window. The default distance is set to 50 [mm].

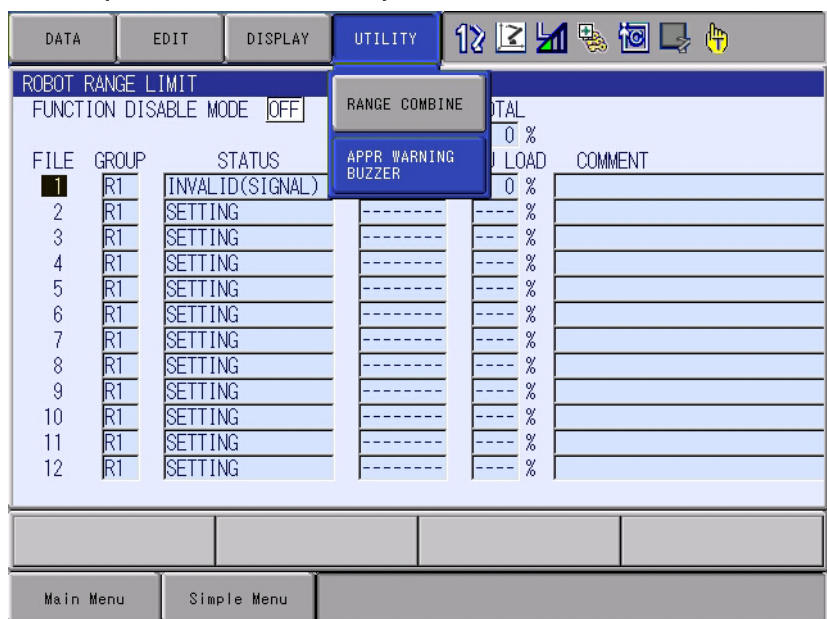
Also, the approaching status can be output as a user output signal. (The signal is turned ON when the manipulator is detected to be in the specified distance.) This output can be also specified on the approach warning buzzer window. This is not set in the default settings (signal is not output).

Follow the procedures below for opening the approach warning buzzer window.

1. Change the security mode to safety mode and then, press {SAFETY FUNC.} under the main menu.

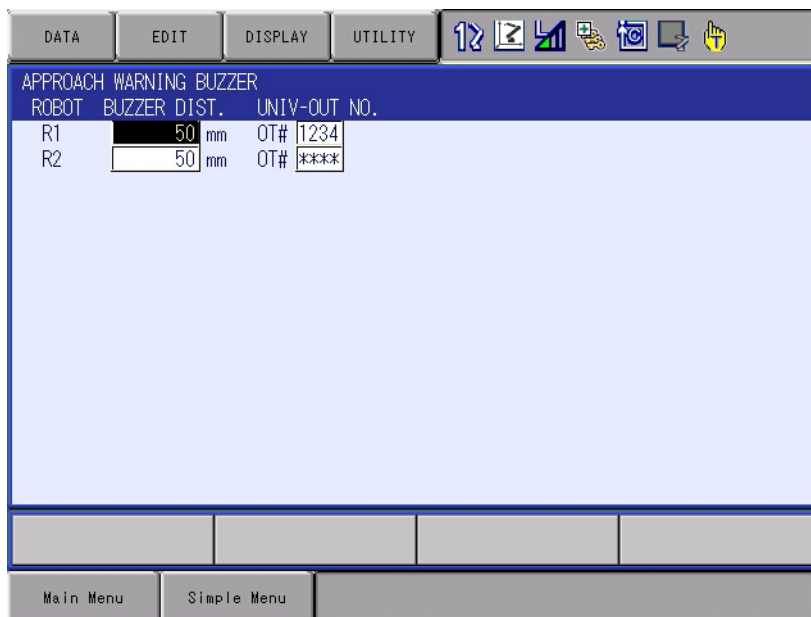


2. Press {ROBOT RANGE LIMIT} in the sub menu.



3. Press {UTILITY} → {APPR WARNING BUZZER}.

– APPROACH WARNING BUZZER window appears.



<Details of the Window >

1. {BUZZER DIST.}

Specify a manipulator approaching distance to sound a buzzer.

Unit: [mm]

2. {UNIV-OUT NO.}

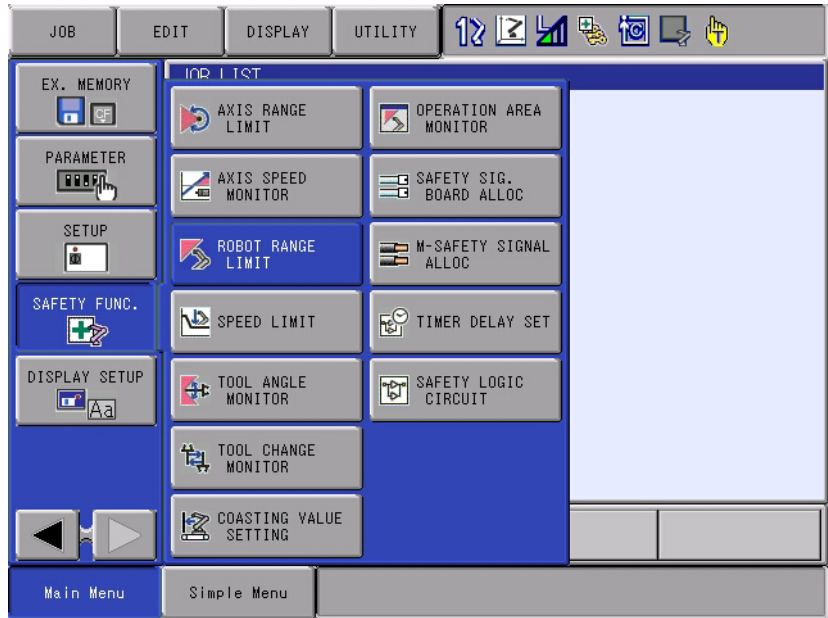
Specify an user output signal number for outputting the status of detecting the approach. When "0" is set, "****" is displayed and no signal is output.

4.3.9 Combining Function of Multiple Monitoring Areas

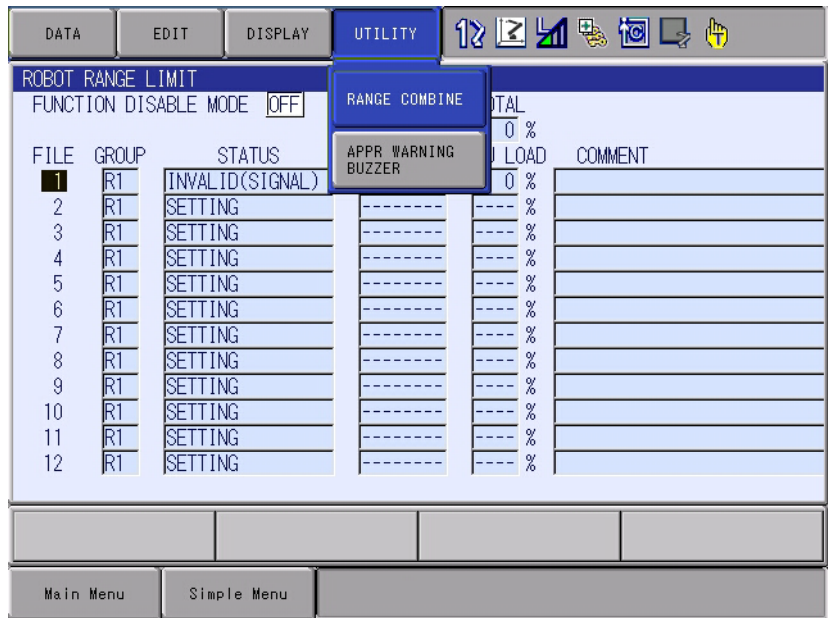
This function creates a new monitoring areas by combining two already-specified monitoring areas.

Follow the procedures below for this operation.

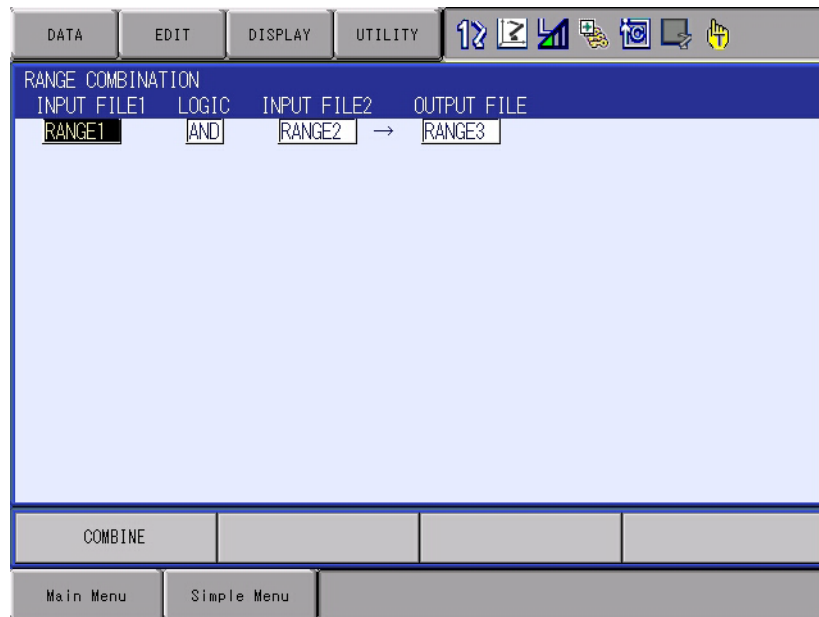
1. Change the security mode to safety mode and then, press {SAFETY FUNC.} under the main menu.



2. Press {ROBOT RANGE LIMIT} in the sub menu.



3. Press {UTILITY} → {RANGE COMBINATION}.
- RANGE COMBINATION window appears.



<Details of the Window >

1. {INPUT FILE1}, {INPUT FILE2}

Specify the file number of the range to combine.

Value	Content
Range 1 to 32	Select the number of the range to be input from 1 to 32.

2. {LOGIC}

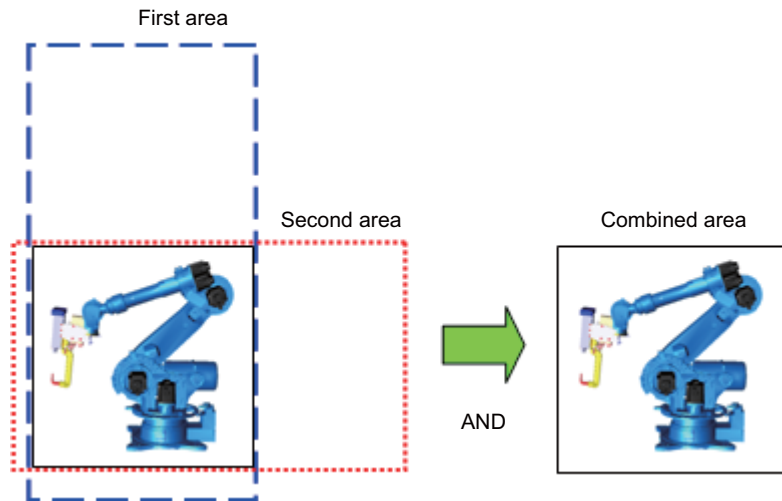
Logic for combining the areas.

Value	Content
AND	Combine the selected two areas with the logic of "AND".
OR	Combine the selected two areas with the logic of "OR".

○ Combination with “AND”

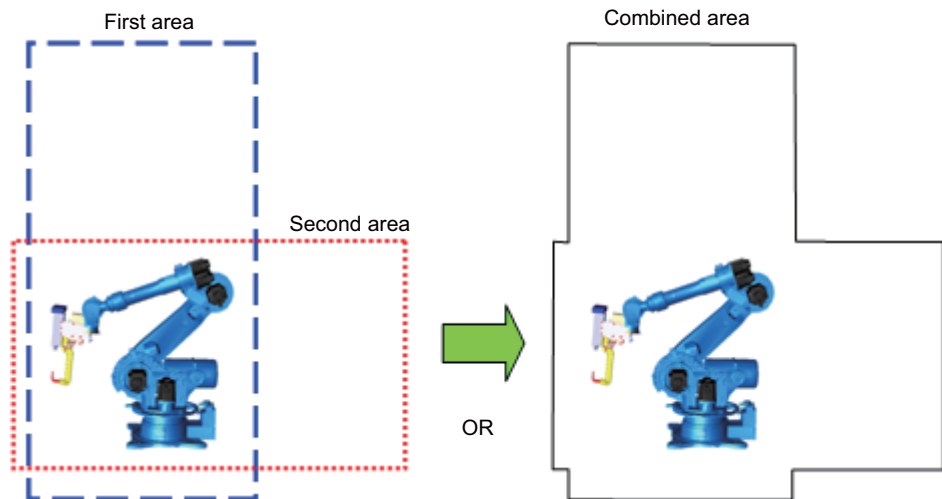
The overlapped area by the combination of two safety areas is created as a new monitoring area.

Fig. 4-24: Image: Combined Area with “AND”

**○ Combination with “OR”**

The whole area consists of two safety areas is created as a new monitoring area.

Fig. 4-25: Image: Combined Area with “OR”



3. {OUTPUT FILE}

Specify the file number of the combined area.

For the file number to be output, choose a file to which the monitoring operation is set invalid because the file number is overwritten.

In case choosing a file to which the monitoring operation is set valid, an error occurs.

Value	Content
Range 1 to 32	Select the number of the range to be output from 1 to 32.

<Combining restrictions >

Combination of the areas are not executed when:

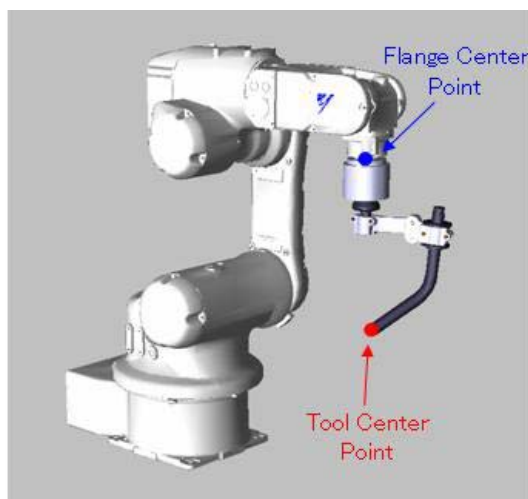
- The two areas are not connected
- Inside the range monitoring and the outside the range monitoring are selected.
- The robot coordinates and the base coordinates are selected.
- The height of each area is different and "OR" is selected as their logic.
- Same file number is specified at {INPUT FILE} and {OUTPUT FILE}
- The shape of the range specified to the input file is not convex.

4.4 Speed Limit Function

4.4.1 Outline

Speed limit function is a function which sets the upper limit of the robot group control point (TCP: Tool Center Point) speed and flange center point (FCP) speed, and then monitors whether the speed at each point does not exceed the already-fixed speed using a software.

Fig. 4-26: TCP (Tool Center Point) and FCP (Flange Center Point)



When “0” is set to speed limit, it is called stop position monitoring. The manipulator or the station group can be monitored by stop position monitoring.

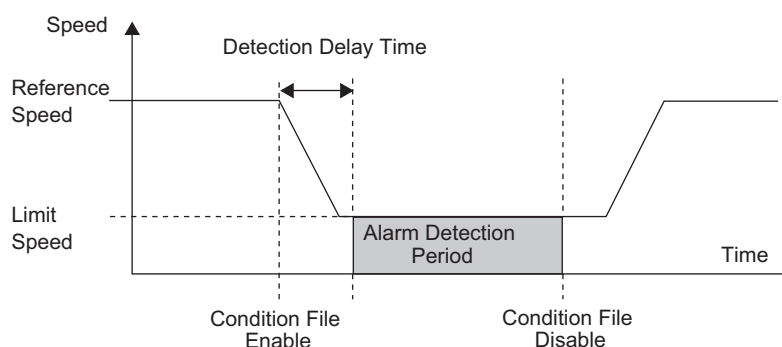
For the manipulator group, the stop position monitoring is performed to TCP or FCP to confirm each point does not move.

For the station group, the stop position monitoring is performed to each axis position to confirm each axis does not move.

When the function file of the speed limit function is validated and in case the taught speed is faster than the limited speed, the speed is decreased to the limited speed, and the monitoring starts.

The time for decreasing the speed varies depending on the manipulator type or teaching conditions. For this reason, in the functional safety function, the period of time from validating the condition file to complete decreasing is regarded as the detection delay time and this can be set to the condition file.

Fig. 4-27: Outline of Speed Limit Function



Thirty two files are prepared to this function and all axes motion range of any one control group is set to a file. When a control group is set to several files, the control group can be monitored by switching conditions.

In case an error is detected, the power supply to the motor is stopped using the machine safety board (JANCD-YSF21-E). And the error is notified using an alarm.

Along with the above mentioned monitoring, when it is in the teaching mode, the speed is always monitored to be 250 mm/sec as the teach mode safety speed.

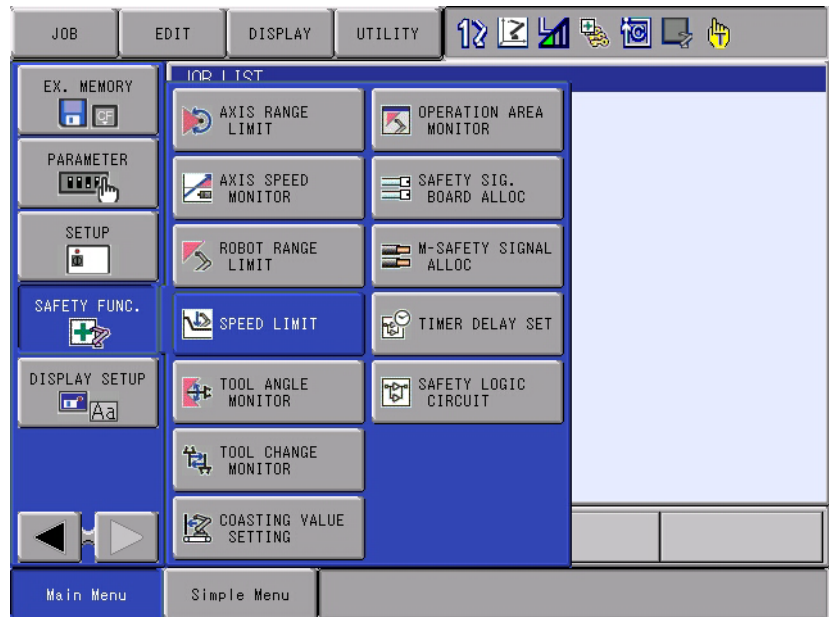
Follow the procedures below when starting the speed limit function.

1. Set the tool file.
(Before using this function, execute tool file setting by referring to section 6.3 "Tool File Setting" on page 6-10.)
↓
2. Set the speed limit condition file.
↓
3. Start the speed limit function.

4.4.2 Speed Limit Function Window

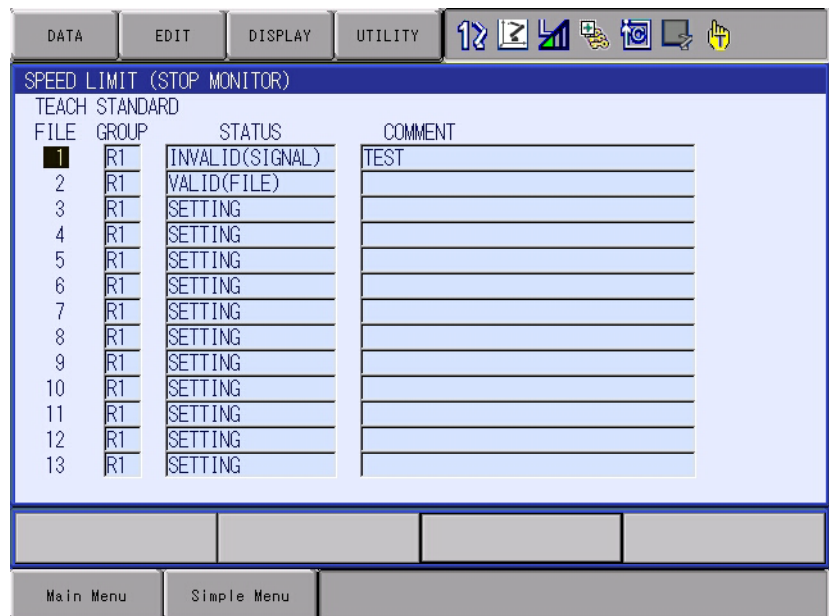
Followings are the setting procedures for the axis range limit function.

1. Change the mode to the security mode, and then press {SAFETY FUNC.} under the main menu.



2. Press {SPEED LIMIT} in the sub menu.

– The list of the speed limit status appears.



On the status list window, the thirty two setting files for the axis range limit function are arranged so that their status can be confirmed. By scrolling down the window, all the list can be seen.

<Details of the Window >**1. {TEACH STANDARD}**

Move the cursor to this item and press {SELECT} to display the list of speed limit for the teach mode.

2. {FILE}

Display the file number for each condition.

3. {GROUP}

Display the object group for the monitoring for the present condition file.

Value	Meaning
SETTING	The condition file is in the initial status or in the data setting status. Not monitoring yet.
VALID (FILE)	Data setting is completed and monitoring status of the file is in valid status.
INVALID (FILE)	Data setting is completed and monitoring status of the file is in invalid status.
VALID (SIGNAL)	Data setting is completed and monitoring status of the file is in valid status by the establishment of the safety signal condition.
INVALID (SIGNAL)	Data setting is completed and monitoring status of the file is in invalid status by the disestablishment of the safety signal condition.

4.{COMMENT}

The comment input is displayed.

4.4.3 Speed Limit Function Condition File Setting Window

1. On the status list window, select a file number with the cursor, and then press [SELECT].

- The individual setting window for the speed limit function opens.

The display on the window varies which group is to be monitored; robot group or station group.

<When the robot group is monitored>

SPEED LIMIT (STOP MONITOR)			
FILE NO.: 1 / 32			
COMMENT	TEST		
FILE SET STATUS	COMPLETED		
FILE VALID COND	SIGNAL		
CTRL GROUP	R1		
LIMIT SPEED	300.0	mm/sec	
DETECTION DELAY TIME	1.00	sec	
ACCEPTABLE RANGE	*****	mm	
INPUT SIGNAL		SET	STATUS
bit0	FSBIN01(#1)	ON	<input type="radio"/>
bit1	FSBIN02(#1)	OFF	<input type="radio"/>
bit2	SFBIN01	ON	<input type="radio"/>
bit3	-----	****	<input type="radio"/>
bit4	-----	****	<input type="radio"/>
OUTPUT SIGNAL	FSBOUT04(#1)		<input type="radio"/>
		PAGE	

<When the station group is monitored>

SPEED LIMIT (STOP MONITOR)			
FILE NO.: 1 / 32			
COMMENT	TEST		
FILE SET STATUS	COMPLETED		
FILE VALID COND	SIGNAL		
CTRL GROUP	S2		
LIMIT SPEED	0.0	mm/sec	
DETECTION DELAY TIME	1.00	sec	
ACCEPTABLE RANGE	1	2.000	mm
INPUT SIGNAL		SET	STATUS
bit0	FSBIN01(#1)	ON	<input type="radio"/>
bit1	FSBIN02(#1)	OFF	<input type="radio"/>
bit2	SFBIN01	ON	<input type="radio"/>
bit3	-----	****	<input type="radio"/>
bit4	-----	****	<input type="radio"/>
OUTPUT SIGNAL	FSBOUT04(#1)		<input type="radio"/>
		PAGE	

By scrolling down the window with the cursor, all the indication can be seen.

<Details of the Window >

In this section, only the items to the axis range limit are explained. For the items not mentioned here, please refer to *section 4.7 "Common Setting Item for the Condition File"* on page 4-76.

1. {LIMIT SPEED}

Specify the speed limit to the motion speed in the object group.

When the robot group is monitored, the limit speed is specified with the unit [mm/sec].

However, "0" (= stop position monitoring) is fixed when the station group is monitored and it is not possible to specify a value to this item.

2. {DETECTION DELAY TIME}

Specify a time frame from validating the condition file to start the alarm detection.

Even if the setting value is "0", 1 [sec] is detected as the detection delay time since the default value is set to this item.

For this reason, when a value is specified to this item, 1 [sec] + the specified value is regarded as the detection delay time.

3. {ACCEPTABLE RANGE}

This item can be specified when "0" is set to {SPEED LIMIT}. Also, this item is used when the stop position monitoring is performed. Although the stop position monitoring monitors the difference between the stop position monitoring start position and the present position, to avoid any alarms from occurring due to tiny motions such as turning ON of the servo during the monitoring, {ACCEPTABLE RANGE} is specified.

An alarm occurs when the axis moves to exceed the position where the acceptable range is added to the stop position monitoring start position. When the robot group is monitored, it is measured in [mm].

and when the station group is monitored and the axis is a rotating axis, it is measured in [deg], and is [mm] when the axis is a direct acting axis.

When "0" is set to {ACCEPTABLE RANGE}, as default values, 20 [mm] is used for the robot group, and for the station group, 0.2 [deg] is used for the rotation axis and 20 [mm] is used for the direct acting axis.

4.4.4 Starting the SPEED LIMIT

Specify the speed limit function and press {WRITE} button, the speed limit function becomes valid.

4.4.5 SPEED LIMIT in Teach Mode

While the teach mode is selected, to strictly observe the safety speed, the speed monitoring of 250 [mm/sec] is performed in the functional safety function. Unlike other speed limit function, this monitoring function cannot be set invalid by the condition file setting.

However, only when the full speed test is input by the external signal and when the manual brake is released, this monitoring function can be set invalid and the speed can be increased faster than 250 [mm/sec] even during the teach mode.

For the full speed test, refer to section 14.6.4 “Full-Speed Test” in the “DX200 INSTRUCTIONS” (165292-1CD).

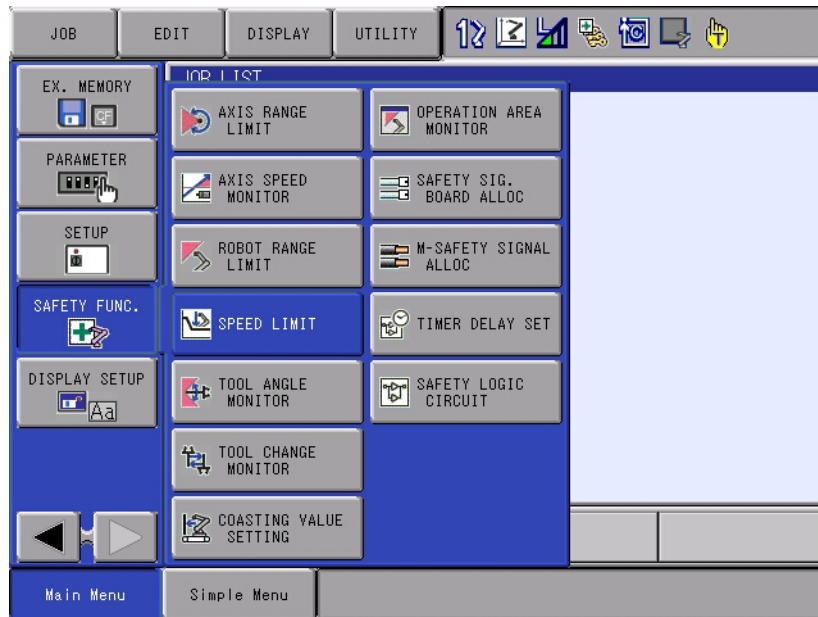
For releasing the manual brake function, refer to “DX200 OPTIONS INSTRUCTIONS FOR MANUAL BRAKE RELEASE FUNCTION” (165310-1CD).



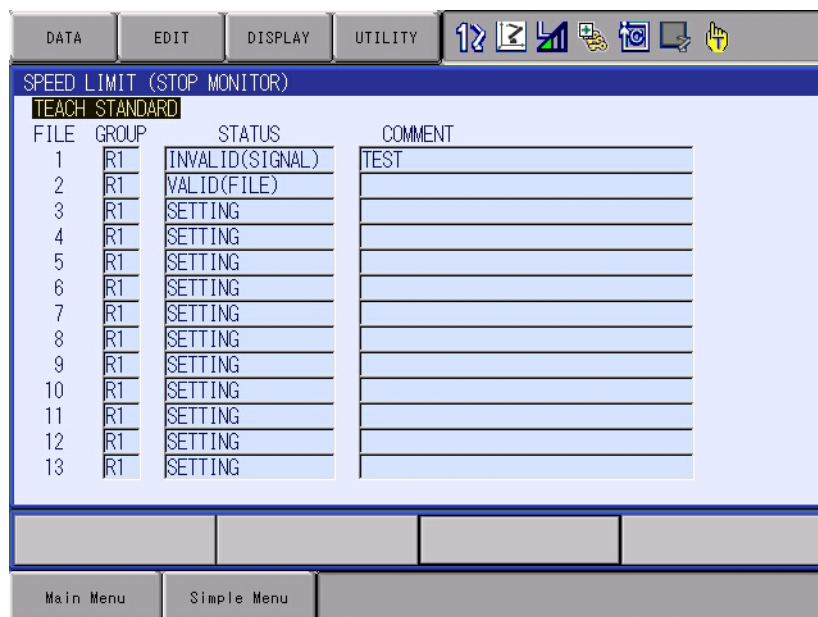
When using the full speed test or manual brake release functions, possible risks attributed to the speed limit release should be sufficiently considered (risk assessment) before operating the manipulator.

The condition file setting window for the speed limit function in the teaching mode opens by the following procedures.

1. Change the security mode to safety mode and then, press {SAFETY FUNC.} under the main menu.



2. Press {SPEEDLIMIT} in the sub menu.



3. Press {TEACH STANDARD}

– A list of condition file of the teach mode speed limit appears..

TEACH MODE SPEED LIMIT	
LIMIT SPEED	250.0 mm/sec
DETECTION DELAY TIME	1.00 sec
OUTPUT SIGNAL	F5BOUT05(#1) <input type="radio"/>

<Details of the Window >**1. {LIMIT SPEED}**

It is fixed to 250 [mm/sec] and not modified.

2. {DETECTION DELAY TIME}

Specify a time frame from validating the condition file to start the alarm detection. It is set as the time for decreasing the speed slower than 250 [mm/sec] when the full speed test function is released. Even if the setting value is "0", 1 [sec] is detected as the detection delay time since the default value is set to this item. For this reason, when a value is specified to this item, 1 [sec] + the specified value is regarded as the detection delay time.

4.5 TOOL ANGLE MONITOR Function

4.5.1 Outline

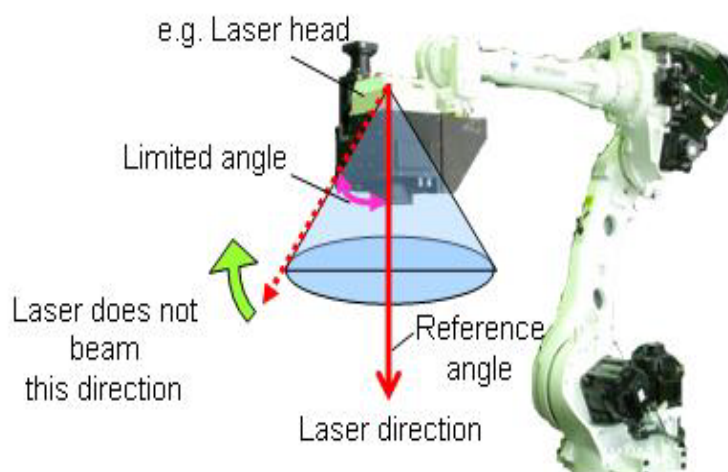
The tool angle monitor function is a function that monitors the angle of the tool by specifying the standard value of manipulator tool tilting angle and the limit of the tool angle, and then, using the software, monitors whether the standard value-centered tool angle does not exceed the specified limit angle. In case the tool file is not specified, it monitors the tilting angle of the flange.

To the object manipulator group, the tool tilting angle which is regarded as the reference for the monitoring is defined as "REF. ANGLE". At this time the tool posture is calculated on the basis of the base coordinates as its standard. While the condition file is validated, this function monitors whether the "REF. ANGLE"-centered angle of the tool does not exceed the specified limit of the tool angle.

In case an error is detected, the power supply to the motor is stopped using the machine safety board (JANCD-YSF21-E).

Thirty two files are prepared to this function and all axes motion range of any one control group is set to a file. When a control group is set to several files, the control group can be monitored by switching conditions.

Fig. 4-28: TOOL ANGLE MONITOR (EX: Laser Welding Application)



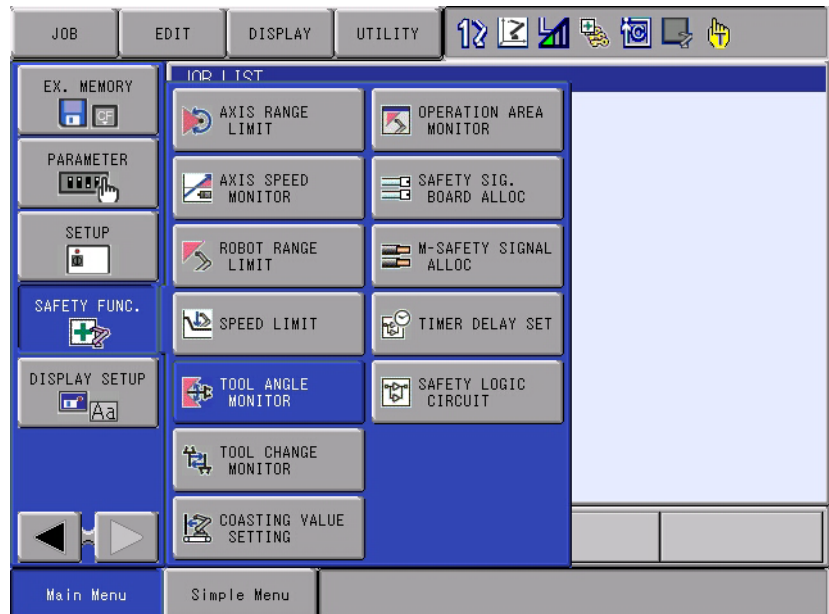
Follow the procedures below when starting the tool angle monitor function.

1. Set the tool file.
(Before using this function, execute tool file setting by referring to section 6.3 "Tool File Setting" on page 6-10.)
↓
2. Set values to {REF. ANGLE} and {LIMIT ANGLE}.
↓
3. Confirm the safety range.
↓
4. Start the tool angle monitor function.

4.5.2 Tool Angle Monitor Function Window

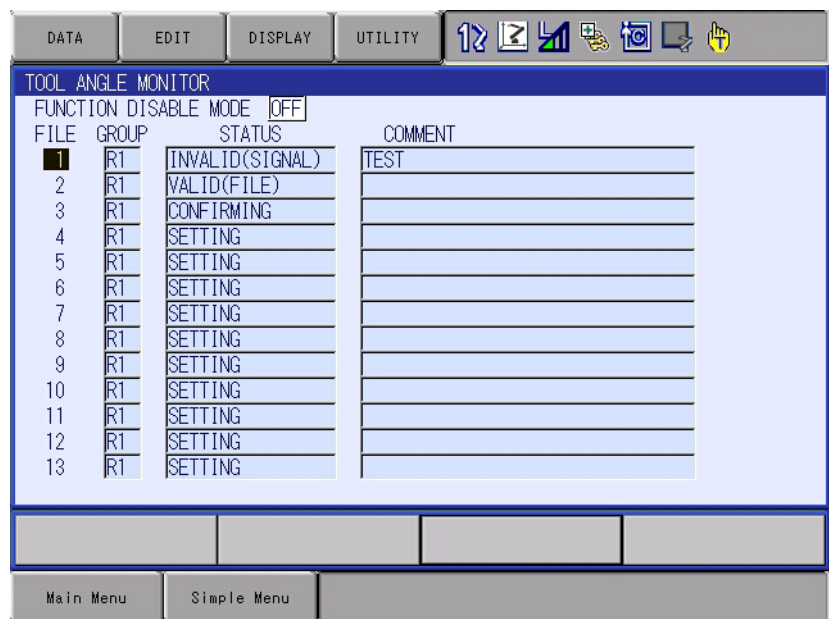
Followings are the setting procedures for the tool angle monitor function.

1. Change the mode to the security mode, and then press {SAFETY FUNC.} under the main menu.



2. Press {TOOL ANGLE MONITOR} in the sub menu.

– The list of the tool angle monitor status appears.



On the status list window, the thirty two setting files for the axis range limit function are arranged so that their status can be confirmed. By scrolling down the window, all the list can be seen.

<Details of the Window >**1. {FUNCTION DISABLE MODE}**

Specify ON/OFF of the tool angle monitor function. When ON is set to this item, this function can be temporarily invalidated.

Value	Meaning
OFF	The tool angle monitor function is valid.
ON	The tool angle monitor function is invalid. At the same time, playback, test-run, forward/backward operations are prohibited.

For the details, refer to section 6.1 "Function Disable Mode Function Setting" on page 6-1.

2. {FILE}

The number of the condition file is displayed.

Move the cursor to any number and press [SELECT]. The individual setting window for the selected condition file appears.

3. {GROUP}

The control group to be monitored specified by the condition file

4. {STATUS}

Monitoring status of the present condition file

Value	Meaning
SETTING	The condition file is in the initial status or in the data setting status. Not monitoring yet.
CONFIRMING	Confirming the area after the data is set. The status of the monitoring operation depends on the valid condition of the condition file.
VALID (FILE)	Data setting is completed and monitoring status of the file is in valid status.
INVALID (FILE)	Data setting is completed and monitoring status of the file is in invalid status.
VALID (SIGNAL)	Data setting is completed and monitoring status of the file is in valid status by the establishment of the safety input signal condition.
INVALID (SIGNAL)	Data setting is completed and monitoring status of the file is in invalid status by the disestablishment of the safety input signal condition.

5. {COMMENT}

The comment input is displayed.

4.5.3 TOOL ANGLE MONITOR Condition File Setting

1. On the status list window, select a file number with the cursor, and then press [SELECT].
 - A setting window for the selected condition file of the axis range monitor function appears.

TOOL ANGLE MONITOR			
FILE NO.: 1 / 32			
COMMENT	TEST		
FILE SET STATUS	COMPLETED		
FILE VALID COND	SIGNAL		
CTRL GROUP	R1		
REF. ANGLE Rx	10.000	deg.	
Ry	20.000	deg.	
Rz	30.000	deg.	
LIMIT ANGLE Ra	5.000	deg.	
INPUT SIGNAL		SET	STATUS
bit0	FSBIN01(#1)	ON	<input checked="" type="radio"/>
bit1	FSBIN02(#1)	OFF	<input type="radio"/>
bit2	SFBIN01	ON	<input type="radio"/>
bit3	-----	****	<input type="radio"/>
bit4	-----	****	<input type="radio"/>
OUTPUT SIGNAL	FSBOUT06(#1)		<input type="radio"/>
PAGE			

By scrolling down the window with the cursor, all the items can be seen.

<Details of the Window >

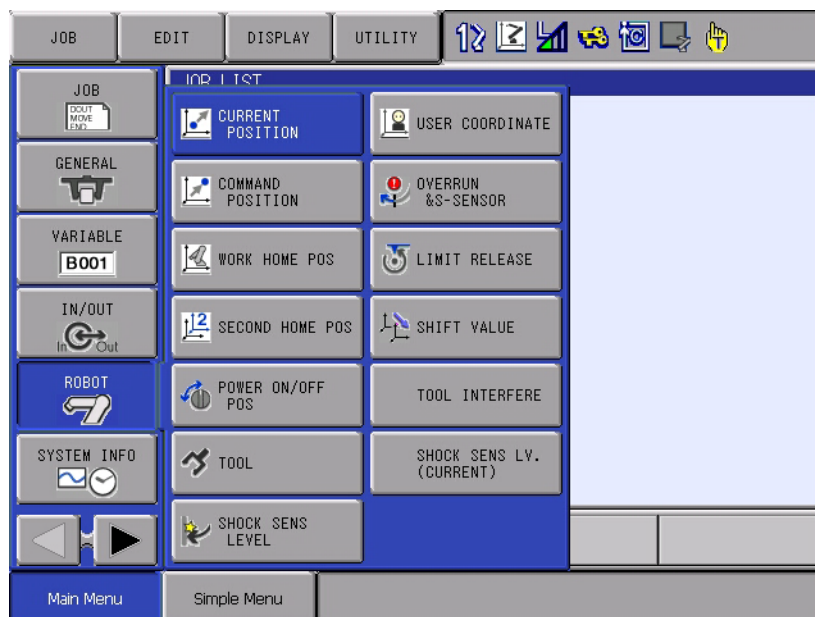
In this section, only the items inherent to the tool angle monitor function are explained. For the items not mentioned here, please refer to section 4.7 "Common Setting Item for the Condition File" on page 4-76.

1. {REF. ANGLE}

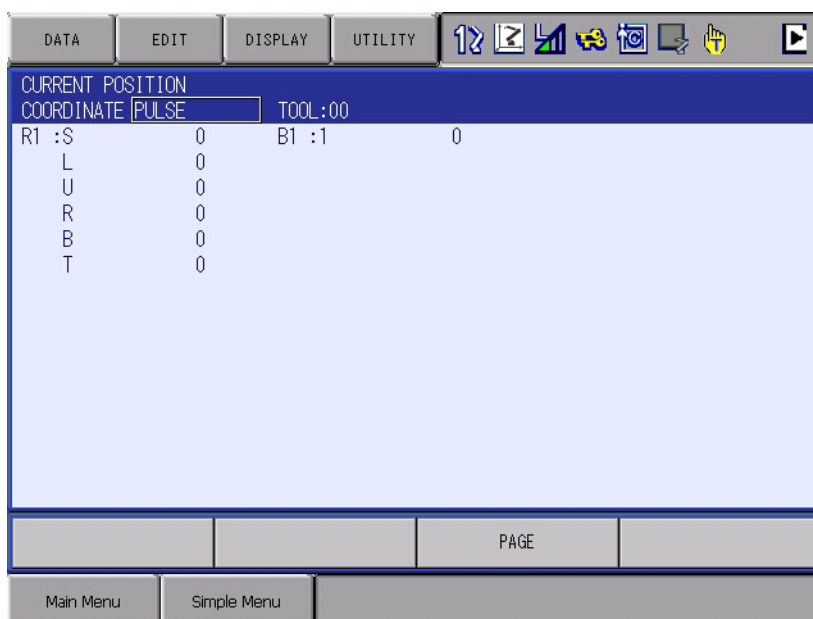
Input a tool angle as a reference value for the tool angle monitor function.

Follow the procedures below to confirm the present tool tilting angle.

1. Press {ROBOT} under the main menu.



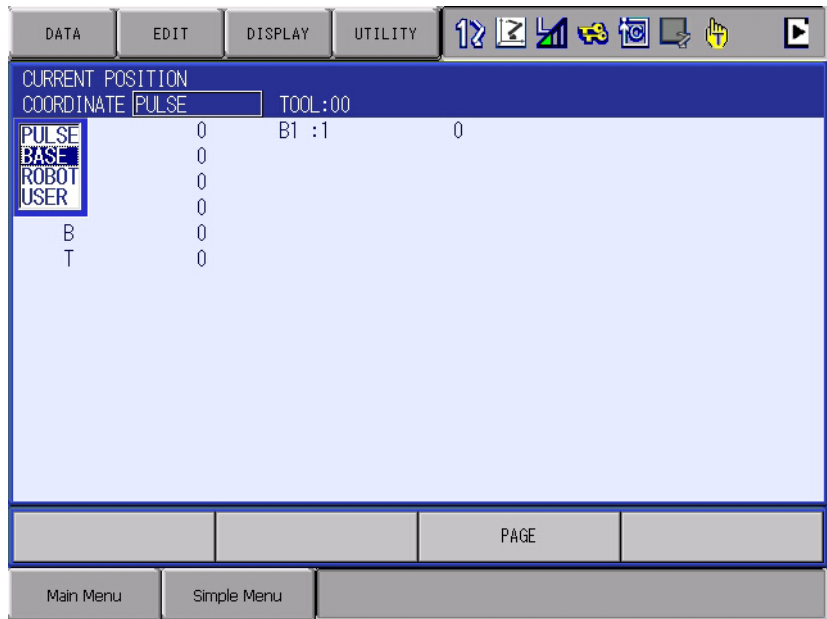
2. Press {CURRENT POSITION} in the sub menu.
– CURRENT POSITION window appears.



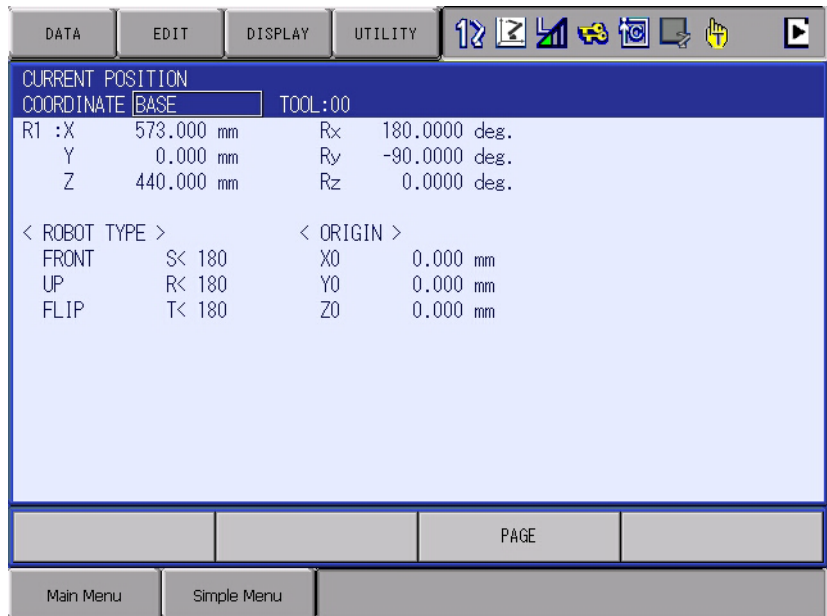
4 Details of Functional Safety Function

4.5 TOOL ANGLE MONITOR Function

3. Select "BASE" in the selection box under {COORDINATE}.



4. In the system where more than two tools are used, select tools when the monitoring is performed.
(For the details, refer to section 2.3.4.1 in the "DX200 OPERATOR'S MANUAL".
5. Move the manipulator to be in the reference posture.
6. Record Rx, Ry and Rz values.



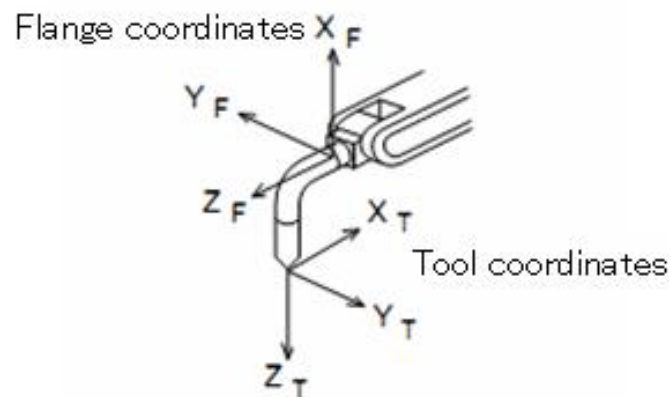
7. Set the recorded Rx, Ry and Rz values to {REF. ANGLE} on the tool angle monitoring condition file window.

2. {LIMIT ANGLE}

Regard the REF.ANGLE-centered tool angle, which is the object of monitoring, comprises of an appraising vector of the reference angle and the present tool angle. The approaching vector is indicated in the following ways.

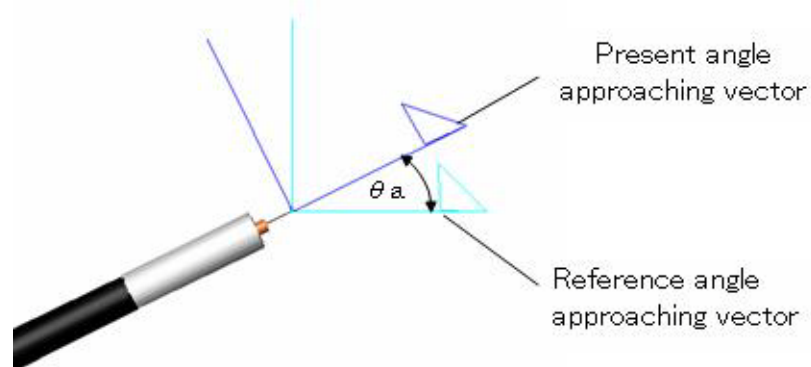
- When the tool file is specified:
The vector of Z_T direction in the tool coordinates.
- When the tool file is not specified:
The vector of Z_F direction in the flange coordinates.

Fig. 4-29: Approaching Vector



Input the upper limit of the angle θ_a which consists of the approaching vector of the reference angle over the approaching vector of the present position as the limit angle. The value from 0° to 90° can be input.

Fig. 4-30: Limit Angle of the Approaching Vector

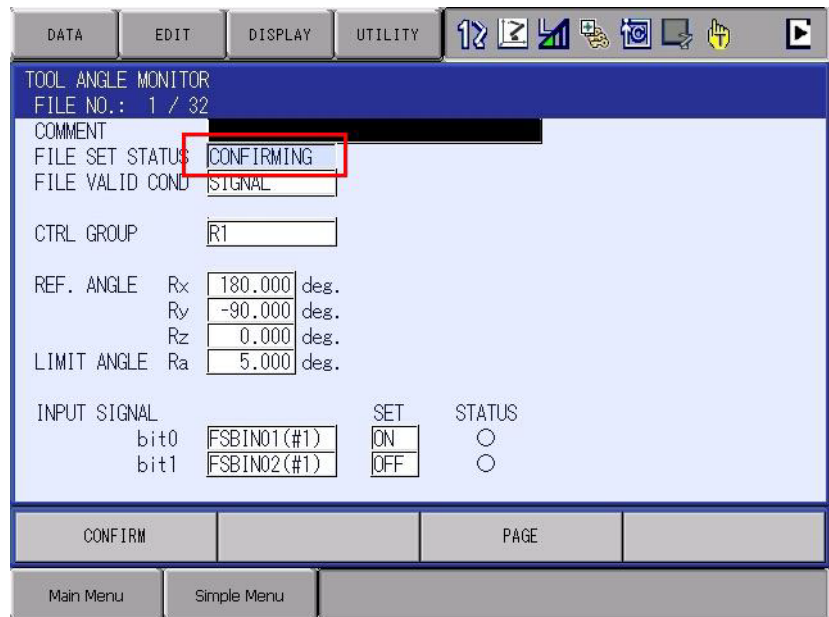


4.5.4 Confirmation of TOOL ANGLE LIMIT MONITOR

After the tool angle monitor is specified and {READ} is pressed, it is necessary to confirm whether the monitoring is appropriately performed inside the specified angle.

“CONFIRM” is indicated at {FILE SET STATUS} on the tool angle monitor window. Move the object manipulator to confirm whether it stops inside the specified angle.

Fig. 4-31: Window for in CONFIRMING Status

**4.5.5 Starting the TOOL ANGLE MONITOR**

After the manipulator is confirmed that it moves to its angle limit, press {CONFIRMED} on the window. The robot range limit function becomes valid.

Execute the practical job movement to confirm the followings.

1. Confirmation of the limit angle in the play mode

There may be following causes, in case an alarm occurred during the play back operation of the operating job.

- Specified REF. ANGLE is not appropriate
- Specified LIMIT ANGLE is not appropriate
- Teaching operation is not appropriate

Re-set REF. ANGLE or LIMIT ANGLE, or correct the teaching operation.

In case “Alarm4792: F-SAFE TOOL ANGL MONITOR ERR” or “Alarm4793: TOOL ANGL MONITOR ERR” appeared

<Cause>

The manipulator’s present posture exceeds the limit angle.

<Countermeasure>

Confirm the reference angle or the limit angle.

Modify the teaching point so that it moves inside the specified limited angle.

4.6 Tool Change Monitor Function

4.6.1 Outline

When performing monitoring functions of the safety such as the robot range limit function or the speed limit function in the functional safety function, appropriate tool information is required to be selected. In the system where the tool change is required, the function safety function changes the tool number in accordance with the specified value from the master CPU.

This tool change monitor function monitors whether the tool is appropriately changed. The monitoring is performed comparing the master CPU-specified tool number and the tool number which is specified to a safety signal -specified condition file. It is judged as an error when a manipulator operates when these numbers are not consistent.

Sixteen files are prepared to this function and one tool number is set to one file. This means that, for a robot group, up to sixteen files can be set to monitor the tool change.

In case an error is detected, the power supply to the motor is stopped using the machine safety board (JANCD-YSF21-E). And the error is notified using an alarm.

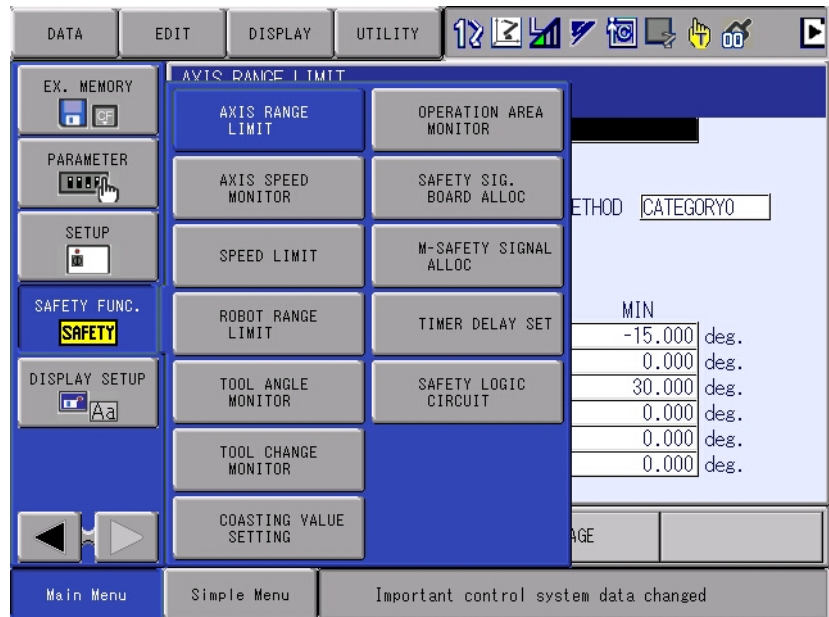
Follow the procedures below when starting the tool change monitor function.

1. Set the tool file.
(Before using this function, execute tool file setting by referring to *section 6.3 "Tool File Setting" on page 6-10.*)
↓
2. Set the tool interference file.
(Before using this function, execute tool interference file setting by referring to *section 6.4 "Tool Interference File Setting" on page 6-11.*)
↓
3. Set the tool change monitor function.
↓
4. Confirm the tool change.
↓
5. Start the tool change monitor function.

4.6.2 Tool Change Monitor Function Window

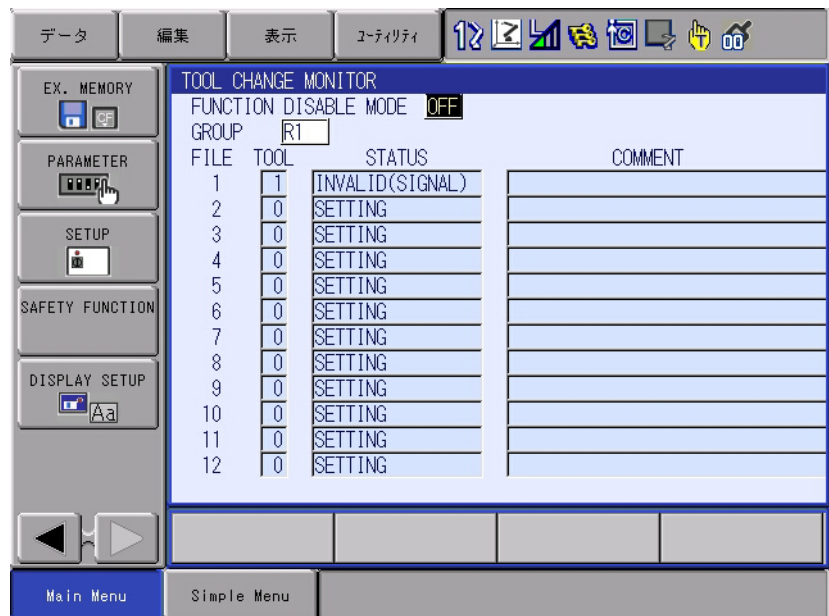
Followings are the setting procedures for the tool angle monitor function.

1. Change mode to security mode, and then press {SAFETY FUNC.} under the main menu.



2. Press {TOOL CHANGE MONITOR} in the sub menu.

– The list of the tool change monitor status appears.



On the status list window, the sixteen setting files for the axis tool change monitor function are arranged so that their status can be confirmed. By scrolling down the window, all the list can be seen.

1. {FUNCTION DISABLE MODE}

Specify ON/OFF of the tool change monitor function. When ON is set to this item, this function can be temporarily invalidated.

Value	Meaning
OFF	The tool change monitor function is valid.
ON	The tool change monitor function is invalid. At the same time, playback, test-run, forward/backward operations are prohibited.

For the details, refer to section 6.1 "Function Disable Mode Function Setting" on page 6-1.

2. {GROUP}

The robot group to be specified by the condition file is selected from R1 to R8 (however, only the groups set to the DX200).

3. {FILE}

The number of the individual condition file is displayed.

A robot group object file selected at {GROUP} is displayed.

Move the cursor to any number and press [SELECT]. The individual setting window for the selected condition file appears.

4. {STATUS}

Monitoring status of the present condition file

Value	Meaning
SETTING	The condition file is in the initial status or in the data setting status. Not monitoring yet.
CONFIRMING	Confirming the area after the data is set. The status of the monitoring operation depends on the valid condition of the condition file.
VALID (FILE)	Data setting is completed and monitoring status of the file is in valid status.
INVALID (FILE)	Data setting is completed and monitoring status of the file is in invalid status.
VALID (SIGNAL)	Data setting is completed and monitoring status of the file is in valid status by the establishment of the safety input signal condition.
INVALID (SIGNAL)	Data setting is completed and monitoring status of the file is in invalid status by the disestablishment of the safety input signal condition.

5. {COMMENT}

The comment input is displayed.

4.6.3 TOOL CHANGE MONITOR Condition File Setting

On the status list window, select a file number with the cursor, and then press [SELECT].

A setting window for the selected condition file of the AXIS CHANGE MONITOR function appears.

By scrolling down the window with the cursor, all the items can be seen.

<Details of the Window >

In this section, only the items inherent to tool change monitor function are explained. For the items not mentioned here, refer to *section 4.7 "Common Setting Item for the Condition File"* on page 4-76.

1. {TOOL NO.}

For confirming the tool number, specify a tool number which is specified to the functional safety function, when this file is selected.

2. {DETECTION DELAY TIME}

Specify a time frame from validating the condition file to start the alarm detection. It is detected as an error in case a tool change monitor condition file is selected and one of the following conditions are met after the time specified in {DETECTION DELAY TIME} is passed.

Error judging standard in the tool change monitoring function

Error judging condition	Stop methods
All the condition files for one robot group is invalidated	The manipulator stops by category "0".
Two or more condition files for one robot group are simultaneously validated	The manipulator stops by the stopping method with the highest priority of the two validated files' stopping method.
The manipulator is in operation while a tool number specifying value and the tool number specifying value of the validated condition files are not consistent.	The manipulator stops by the stopping method of the validated file stopping method.

4.6.4 Confirmation of Tool Change Monitor

After the setting of the condition file and {READ} is pressed, it is necessary to confirm whether the monitoring is appropriately performed by the specified tool.

“CONFIRM” is indicated on the tool change window. “VALID” the file and change the tool, and then move the object manipulator to confirm whether a alarm occurs.



An alarm for the tool change monitor function occurs only when the manipulator is in motion. (If it is in stop status, monitoring is still performed but the alarm does not occur.)

However, once an alarm occurs, it keeps sounding unless the problem is solved even the manipulator stops.



Perform changing the tool file while the manipulator is stop status or there may following dangers when it is performed while the manipulator is in operating status.

- Wrong tool may be selected.
- The manipulator motion speed exceeds the speed limit in case the tool before the change and after the change differs widely.

4.6.5 Starting the Tool Change Monitor

After the tool change is confirmed, press {CONFIRMED} on the window. The tool change monitor function becomes valid.

**CAUTION**

By a tool change, an monitoring error may be detected in the robot range limit function due to the change of tool model or TCP. For this reason, when changing a tool, specify appropriate range of motions for the object tool.

4.6.6 When Using the Tool Change Monitor Function

When using the tool change monitor function, this function should be validated in the maintenance mode.

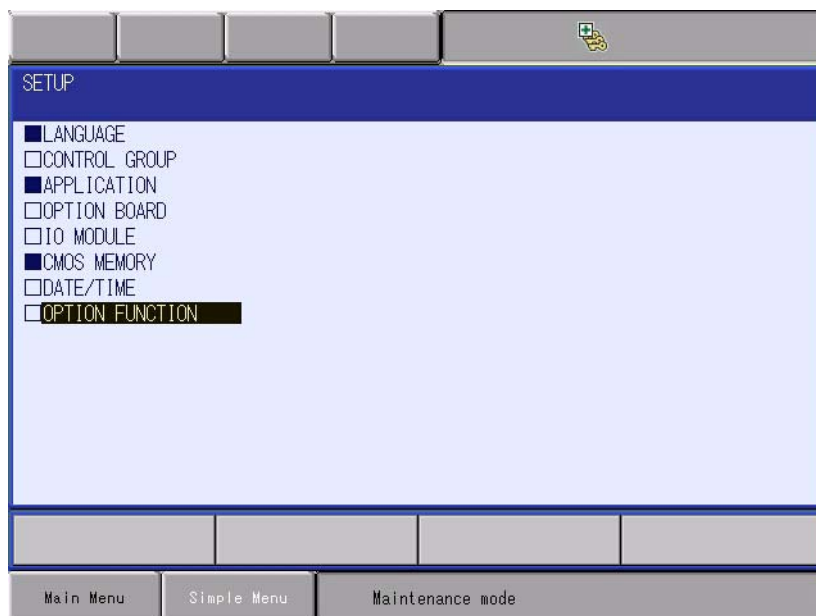
Follow the procedures below.

1. Press {SYSTEM} under the main menu, and then press {SECURITY} to change the mode to the security mode.



2. Press {SYSTEM} under the main menu. And then, press {SET} in the sub menu.

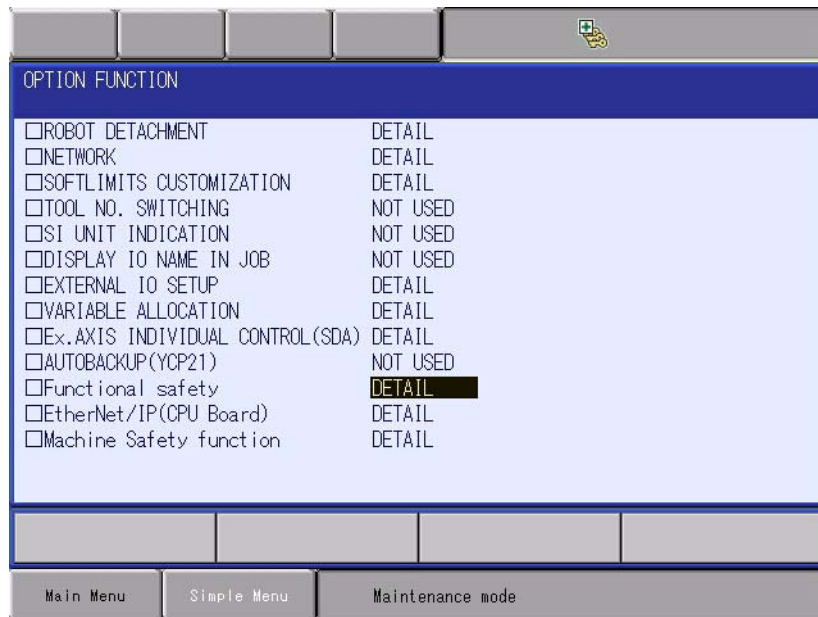
– SETUP window appears.



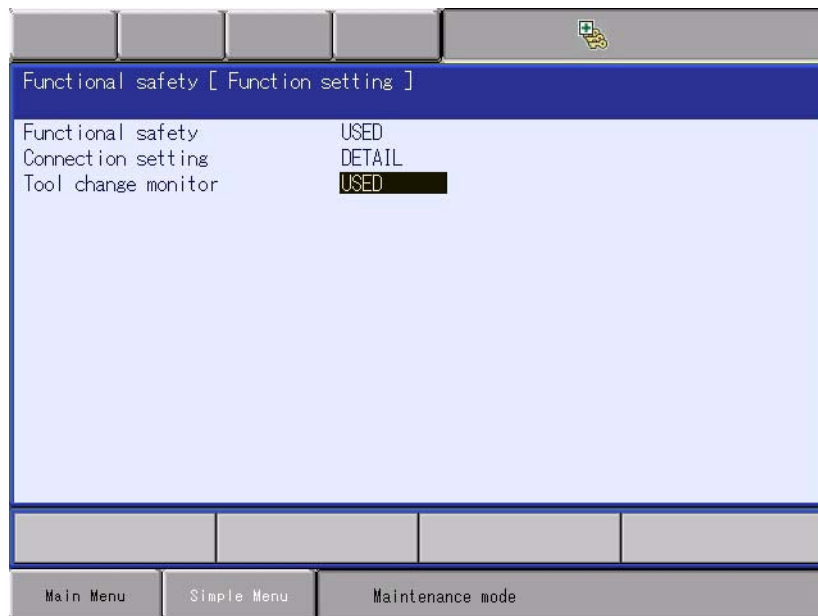
4 Details of Functional Safety Function

4.6 Tool Change Monitor Function

3. Select {OPTION FUNCTION}, {Functional Safety} and “DETAIL”.
 - SAFETY FUNCTION window appears.



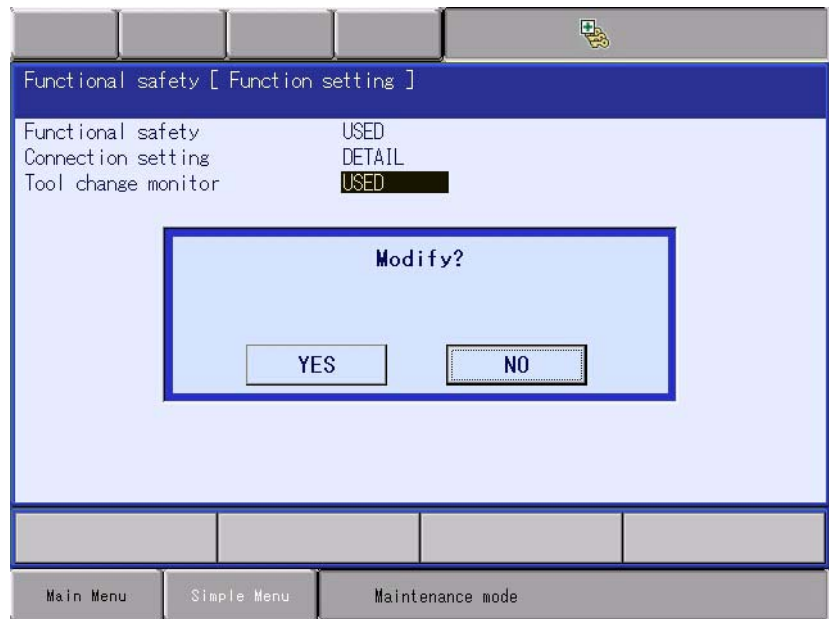
4. Change to set “USED” for the item at {Tool Change Monitor}.



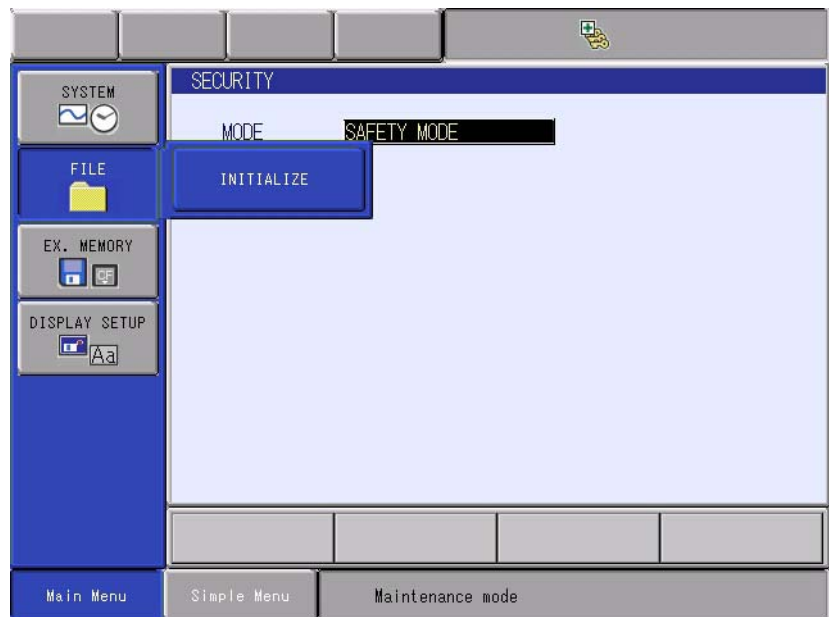
4 Details of Functional Safety Function

4.6 Tool Change Monitor Function

5. Press [ENTER], and a dialog box asking "Modify?" appears.
 - Select "YES".



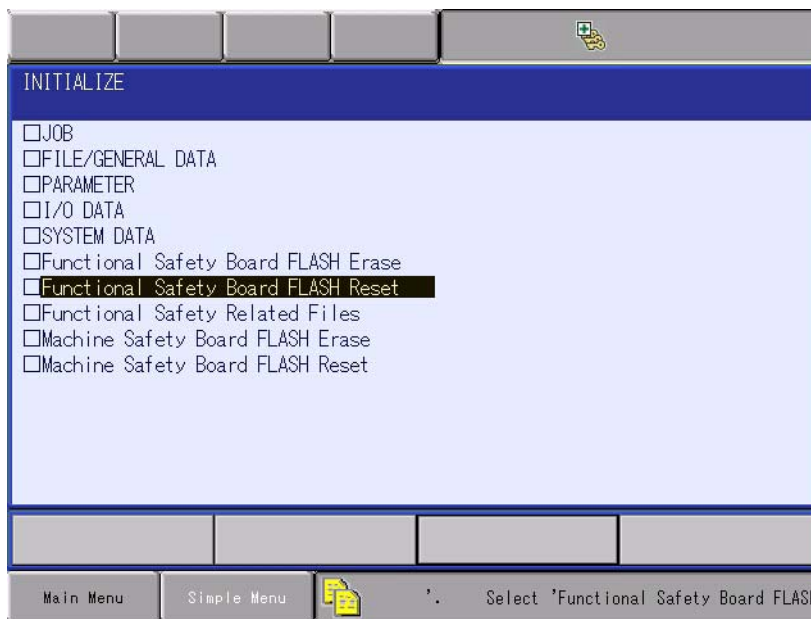
6. Press {FILE} under the main menu. And then, press {INITIALIZE} in the sub menu.
 - A window for initialization appears.



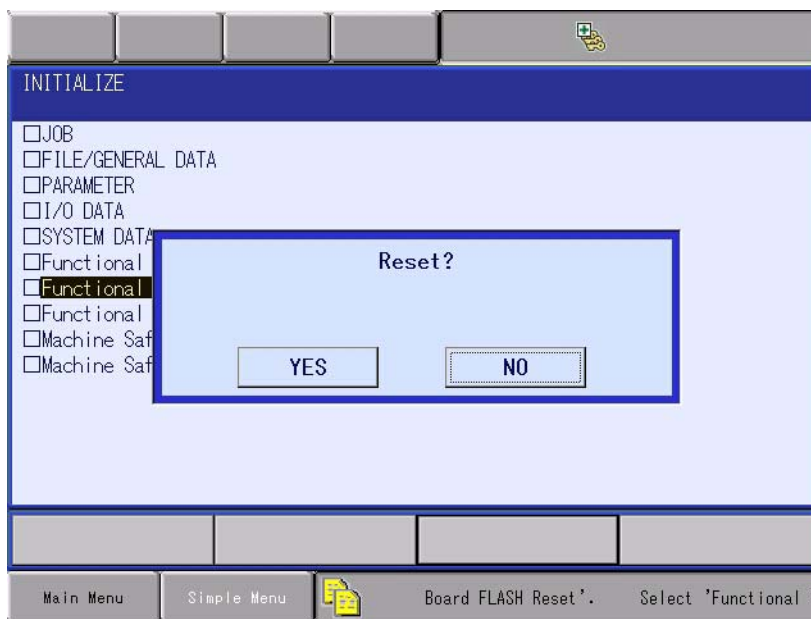
4 Details of Functional Safety Function

4.6 Tool Change Monitor Function

7. Move the cursor and select “Functional Safety Board FLASH Reset” on the window.



8. Select “YES” when a window shown appears.
- Data of the functional safety board is reset. When resetting is completed, a buzzer sounds in a few seconds.



9. Turn ON the controller power supply.

Following alarm occurs at the first start-up and operation of the manipulator after validating the tool change function because all the tool change condition files are not specified yet.

“Alarm 4789: F-SAFE TOOL CHANGE MONITOR ERR”

Perform the tool change condition file settings, validate the tool change monitoring function and reset the alarm.



CAUTION

The tool change monitoring function is set to invalid at the default status.

For the appropriate safety monitoring, be sure to validate the function and perform the monitoring.

This monitoring should be set valid to monitor that the tool is not changed even if the tool file is not changed.

4.7 Common Setting Item for the Condition File

Although the condition files of the functional safety function exist by functions, there are common setting items to many files such as VALID/INVALID of the file.

Here, in this chapter, details of the common items are explained. For the safety signal settings, refer to *chapter 5 “Safety Signal”*.

{AXIS RANGE LIMIT} window is used as an example.

AXIS RANGE LIMIT	
FILE NO.:	1 / 32
COMMENT	TEST
FILE SET STATUS	COMPLETED
FILE VALID COND	SIGNAL
ALRAM SET	ON
CTRL GROUP	R1

<Details of the Window >**1. {COMMENT}**

The comment input is displayed.

2. {FILE SET STATUS}

Status of the present condition file

Value	Meaning
SETTING	The condition file is in the initial status or in the updating status. When the data is changed by the read back operation, press {WRITE} button, the data writing to the functional safety function is completed, and then this changes to "CONFIRMING" or "COMPLETED".
CONFIRMING	The data is appropriately set and the limit area can be confirmed after the file validating conditions are met. Press {COMFIRM} button on the window after the area is confirmed. "COMPLETE" is indicated when the data setting process are completed. In case the data is changed at this timing, the indication changes to "CONFIRMING". Only the files mentioned below exist while "CONFIRMING" is indicated. <ul style="list-style-type: none"> • Axis range limit function • Robot range limit function • Tool angle monitor function • Tool change monitor function
COMPLETED	The condition file setting is completed. The safety monitoring can be performed after the file validating conditions are met. In case the data is changed at this timing, the indication changes to "CONFIRMING".

{FILE SET STATUS} can be specified on all the condition file window.

3. {FILE VALID COND}

Specify the conditions for validating the monitoring of the object files. However, to validate the monitoring, condition file data should be appropriately specified. The settings at this item might be ignored in case "SETTING" is indicated at {FILE SET STATUS}.

Value	Meaning
INVALID	Always invalidate the object file.
VALID	Always validate the object file.
SIGNAL	Judge valid/invalid by referring the safety input signal. For the details of the safety signal usage, refer to <i>chapter 5 "Safety Signal"</i> .

{FILE VALID COND} can be specified on all the condition file window.

4. {ALARM}

Select alarm or not alarm to the monitoring result of the object file.

Value	Meaning
ON (MOVE STOP)	Servo is turned OFF with an alarm when an error occurs under the object file monitoring condition.
OFF (CONT MOVE)	Although monitoring is performed under the object file condition, alarm does not occur and the servo is not turned OFF even if a monitoring error occurred. The monitoring result can be obtained by the safety output signal.

{ALARM} can be specified only to the axis range limit function and the robot range limit function.



CAUTION

When "OFF" is set to {ALARM}, the functional safety function does not stop the manipulator operation even if a monitoring error is detected in the object file. In this regard, before operating the manipulator, sufficiently consider possible risks attributed to the alarmless operation (risk assessment) and take necessary measures to them.

5. {GROUP}

Specify the control group to be monitored specified by the condition file.

Selectable control groups vary depending on the function.

Function	Selectable control group
Axis range limit function	Robot, Base, Station group
Axis speed monitor function	Robot, Base, Station group
Robot range limit function	Robot group
Speed limit function	Robot, Station group
Tool angle monitor function	Robot group
Tool change monitor function	The group is fixed by files. When modifying the object group, change it on the list of tool angle monitor function window.

5 Safety Signal

For the functional safety function, the safety monitoring condition files can be switched by the safety input signal.

Also, this function corresponds the outputting of the monitoring result by the safety output signal.

Followings are the safety signal available for the functional safety function.

Safety sign

Signal	Signal point	Remarks
Functional safety general signal	Input: 8 points/station Output: 8 points/station	This signal is connected per functional safety board.
Safety fieldbus signal	Input: 64 points/system Output: 64 points/system	One safety fieldbus signal is connected to one system. Depending on the settings, up to 64 points can be used from one safety board. The safety fieldbus function is not a functional safety function but an optional function.

If the safety fieldbus signal is included, up to 72 points can be used from one safety board.

To condition files, as many functional safety signals as desired can be allocated within the possible signal points, in this consequence signals are flexibly used even if the board has small numbers of signal points.

Follow the procedures below when using the safety signals.

1. Safety fieldbus signal allocation (it is not necessarily use only the functional safety user signal)
↓
2. Set the condition file.

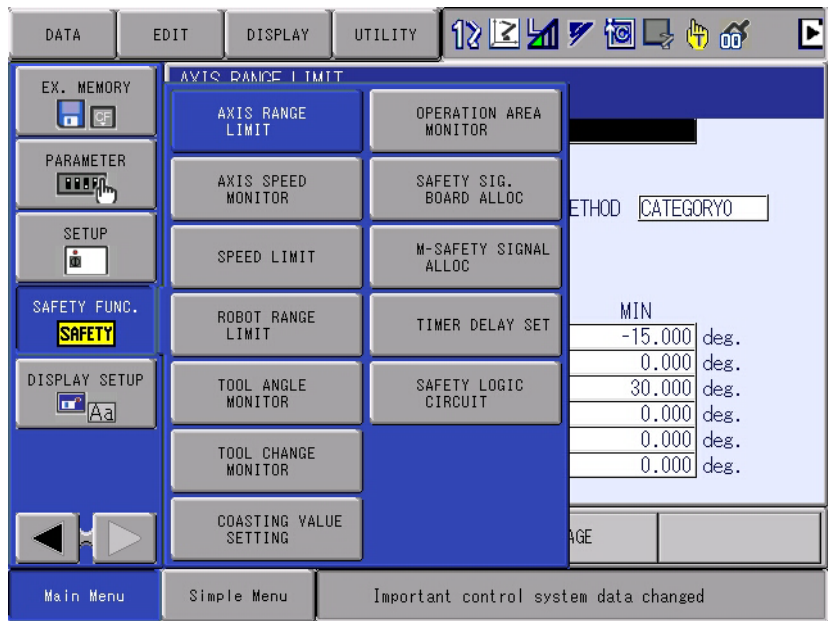
5.1 Safety Fieldbus Signal Allocation

The safety fieldbus function is not a functional safety function but an optional function. When it is valid, the safety fieldbus signal can be used in the functional safety function.

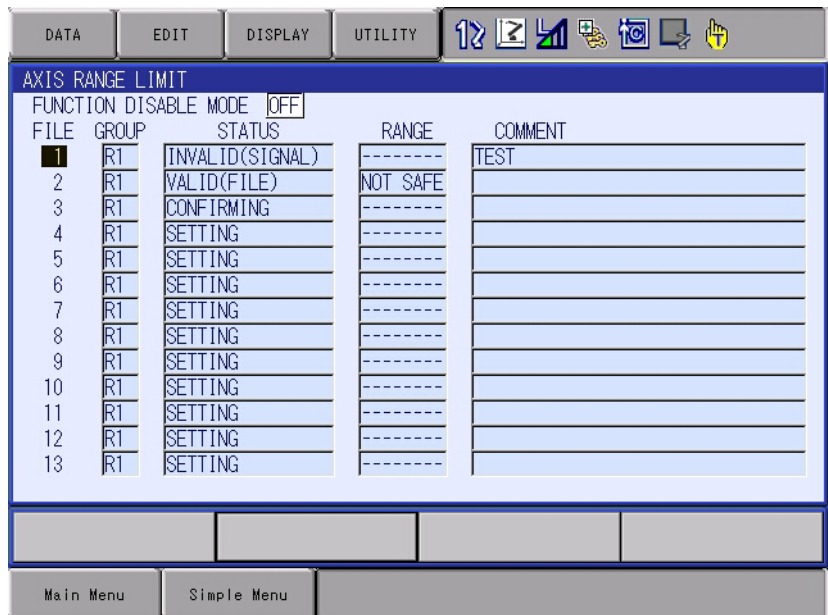
Safety fieldbus signal transmits/receives the safety-guaranteed “safety data” through the fieldbus communication path. It has 64 input signal points and 64 output signal points.

These signals are commonly used in the whole system and thus they can be referred from both machine safety board and functional safety board. In this consequence, “SAFETY SIG. BOARD ALLOC” function is prepared to define which signal is to be used in which board.

1. Change the mode to the security mode, and then press {SAFETY FUNC.} under the main menu.



2. Press {SAFETY SIG. BOARD ALLOC} in the sub menu.
 - The list of the safety signal board allocation status appears.



○ Allocation of input signal

DATA EDIT DISPLAY UTILITY			
SAFETY SIG. BOARD ALLOC			STS : DONE
INPUT	UNIT	COMMENT	
SFBIN 00	YSF21-E		
SFBIN 01	YSF25-E #1		
SFBIN 02	YSF25-E ALL USE		
SFBIN 03	NOT USED		
SFBIN 04	NOT USED		
SFBIN 05	NOT USED		
SFBIN 06	NOT USED		
SFBIN 07	NOT USED		
SFBIN 08	NOT USED		
SFBIN 09	NOT USED		
SFBIN 10	NOT USED		
SFBIN 11	NOT USED		
SFBIN 12	NOT USED		
SFBIN 13	NOT USED		

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Main Menu Simple Menu

○ Allocation of output signal

DATA EDIT DISPLAY UTILITY			
SAFETY SIG. BOARD ALLOC			STS : DONE
INPUT	UNIT	COMMENT	
SFBIN 00	YSF21-E		
SFBIN 01	YSF25-E #1		
SFBIN 02	YSF25-E ALL USE		
SFBIN 03	NOT USED		
SFBIN 04	NOT USED		
SFBIN 05	NOT USED		
SFBIN 06	NOT USED		
SFBIN 07	NOT USED		
SFBIN 08	NOT USED		
SFBIN 09	NOT USED		
SFBIN 10	NOT USED		
SFBIN 11	NOT USED		
SFBIN 12	NOT USED		
SFBIN 13	NOT USED		

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Main Menu Simple Menu

<Details of the Window >**1. {INPUT SIGNAL}, {INPUT SIGNAL}**

Indicates the input or output signal.

2. {UNIT}

The board where the safety fieldbus input signal is to be used are selected from the following (a) to (d), and that of output signal is selected from the following (a) to (c).

- a) The signal is not used
- b) YSF21-1E (machine safety board)
- c) YSF25 #1 to YSF25 #8
(lone functional safety board)
- d) YSF25-1E ALL (whole of functional safety board)

Basically, to avoid duplicated use of one signal, one safety signal is allocated to one board. However, confined to the input signal, when one signal is referred by several terminals, it can be redundantly referred by selecting "whole of functional safety board".

Item	Meanings
The signal is not used	The object signal is not used
YSF21-1E (machine safety board)	The object signal can be used on the machine safety board.
YSF25 #1 to YSF25 #8 (lone functional safety board)	The object signal is used on the functional safety board (one terminal from terminal 1 to terminal 8)
YSF25-1E ALL (whole functional safety board)	The object signal is used on the whole functional safety board existing in the system.

5.2 Safety Function Condition File Setting

A window for setting signals are prepared to all the condition files.

Axis range limit function window is shown below as an example of signal setting window.

INPUT SIGNAL		SET	STATUS
bit0	FSBIN01(#1)	ON	<input checked="" type="radio"/>
bit1	FSBIN02(#1)	OFF	<input type="radio"/>
bit2	SFBIN01	ON	<input type="radio"/>
bit3	-----	****	<input type="radio"/>
bit4	-----	****	<input type="radio"/>
OUTPUT SIGNAL	FSBOUT01(#1)		<input type="radio"/>

<Details of the Window >

1. {INPUT SIGNAL}

To validate an object condition file, specify a safety input signal for reference.

Same input signal cannot be specified in the same condition file. The already-specified signal does not appear in the selection list in the same condition file.

However, only the safety fieldbus input signals to which available allocation is specified on the functional safety board is indicated in the selection list.

Value	Meanings
NO CONFIG	Signal is not specified
FSBIN01 to FSBIN08	Specify the functional safety user input signal (signal 1 to 8) (# n): station number of the functional safety board
SFBIN01 to SFBIN64	Specify the safety fieldbus input signal (signal 1 to 64)

{INPUT SIGNAL} is indicated on all the condition file window. "SIGNAL" should be set to {FILE VALID COND} when inputting values to this item.

2. {SET}

To the input value of the signal selected at {INPUT SIGNAL}, specify either ON or OFF for satisfying the condition to set valid.

Value	Meanings
OFF	The valid condition is satisfied when the value set at {INPUT SIGNAL} becomes OFF.
ON	The valid condition is satisfied when the value set at {INPUT SIGNAL} becomes ON.

{INPUT SIGNAL} can be specified on all the condition file window. "SIGNAL" should be set to {FILE VALID COND} when inputting values to this item.

3. {STATUS}

The present input value of the signal input at {INPUT SIGNAL}.

Value	Meanings
○	The present input value of the signal set at {INPUT SIGNAL} is OFF.
●	The present input value of the signal set at {INPUT SIGNAL} is ON.

{INPUT SIGNAL} can be specified on all the condition file window. "SIGNAL" should be set to {FILE VALID COND} when inputting values to this item.

4. {OUTPUT SIGNAL}

Specify a signal to output the object condition file monitoring result.

To avoid a redundant output result, two of the same output signal cannot be specified in one system. The already-specified signal does not appear in the selection list in the same condition file.

However, only the safety fieldbus input signals to which available allocation is specified on the functional safety board is indicated in the selection list.

Value	Meanings
NO CONFIG	Signal is not specified
FSBIN01 to FSBIN08	Specify the functional safety user input signal (signal 1 to 8) (# n): terminal number of the safety functional board
SFBIN01 to SFBIN64	Specify the safety fieldbus input signal (signal 1 to 64)

{OUTPUT SIGNAL} can not be specified on all the condition file window.

5.3 File Switching to Valid/Invalid by the Safety Signal

Judging method for switching the condition file using the safety input signal is explained here.

Fig. 5-1: Signal Setting Window

INPUT SIGNAL		SET	STATUS
bit0	FSBIN01(#1)	ON	●
bit1	FSBIN02(#1)	OFF	○
bit2	SFBIN01	ON	○
bit3	-----	****	○
bit4	-----	****	○
OUTPUT SIGNAL	FSBOUT01(#1)		○

The input signal is judged line-by-line.

As shown in Fig. 5-1 "Signal Setting Window" on page 5-7, when performing a setting as marked with the red square, the condition of bit 0 line is defined as satisfied because "ON" is set to {SET} at the input signal {FSBIN01}, and ● (=ON) is set to {STATUS}.

Up to 5 signals can be set to a condition file (up to 4 for the tool change monitor function).

Conditions of the lines from bit0 line to bit4 line are judged by the safety input signal respectively, the object condition file is validated only when all the conditions are satisfied.

For the line "****" (undefined) is indicated at {SET} is disregarded for this judgement.

Fig. 5-2: When the Conditions for File Validation is Satisfied

INPUT SIGNAL		SET	STATUS
bit0	FSBIN01(#1)	OFF	○
bit1	FSBIN02(#1)	ON	●
bit2	SFBIN01	ON	○
bit3	SFBIN02	OFF	○
bit4	-----	****	○
OUTPUT SIGNAL	FSBOUT01(#1)		○

All the conditions are satisfied

Disregarded

Fig. 5-3: When the Condition for File Validation is Not Satisfied

INPUT SIGNAL		SET	STATUS
bit0	FSBIN01(#1)	OFF	○
bit1	FSBIN02(#1)	ON	●
bit2	SFBIN01	ON	○
bit3	SFBIN02	OFF	○
bit4	-----	****	○
OUTPUT SIGNAL	FSBOUT01(#1)		○

Conditions is not satisfied

Disregarded

There can be a time difference after the first signal and before the last signal. In the functional safety function, an interval of 32 [ms] is equipped to the system to be totally switched to internally settled after the last signal change.



For this reason, please take this into consideration when performing the following operations.

- When switching several signals, do not take more than 32 [ms].
→The signals may be settled with half-specified values.
- Do not use signals that continue shifting ON/OFF within the interval of less than 32 [ms].
→Signals will not be settled.

On the basis of above mentioned judging methods, following patterns can be conceived when switching files using three signals.

Pattern 1: When switching one file using one signal

Operate more than two files respectively.

Simultaneous monitoring is available.

The number of the object file: 3

Condition file	Signal and setting	Setting	Conditions for validating the file
File 1	Signal A	ON	● (Signal A)
File 2	Signal B	OFF	○ (Signal B)
File 3	Signal C	ON	● (Signal C)

Pattern 2: When switching one file using more than two signals

Select one file out of several files.

Many files can be managed with less signals. This pattern is effective when simultaneous monitoring is not necessary.

The number of the object file: 8

Condition file	Signal and setting	Setting	Conditions for validating the file
File 1	Signal A	OFF	<input type="radio"/> (Signal A)
	Signal B	OFF	<input type="radio"/> (Signal B)
	Signal C	OFF	<input type="radio"/> (Signal C)
File 2	Signal A	ON	<input checked="" type="radio"/> (Signal A)
	Signal B	OFF	<input type="radio"/> (Signal B)
	Signal C	OFF	<input type="radio"/> (Signal C)
File 3	Signal A	OFF	<input type="radio"/> (Signal A)
	Signal B	ON	<input checked="" type="radio"/> (Signal B)
	Signal C	OFF	<input type="radio"/> (Signal C)
File4	Signal A	ON	<input checked="" type="radio"/> (Signal A)
	Signal B	ON	<input checked="" type="radio"/> (Signal B)
	Signal C	OFF	<input type="radio"/> (Signal C)
File 5	Signal A	OFF	<input type="radio"/> (Signal A)
	Signal B	OFF	<input type="radio"/> (Signal B)
	Signal C	ON	<input checked="" type="radio"/> (Signal C)
File 6	Signal A	ON	<input checked="" type="radio"/> (Signal A)
	Signal B	OFF	<input type="radio"/> (Signal B)
	Signal C	ON	<input checked="" type="radio"/> (Signal C)
File 7	Signal A	OFF	<input type="radio"/> (Signal A)
	Signal B	ON	<input checked="" type="radio"/> (Signal B)
	Signal C	ON	<input checked="" type="radio"/> (Signal C)
File 8	Signal A	ON	<input checked="" type="radio"/> (Signal A)
	Signal B	ON	<input checked="" type="radio"/> (Signal B)
	Signal C	ON	<input checked="" type="radio"/> (Signal C)

5.4 Safety Signal Output Value

The output signal outputs the status of safety or not safety over the monitoring conditions when the object condition file is validated.

Followings show the meanings of output result for each safety function.

Basically, output signal ON is defined as safety side and OFF is defined as not safety side in preparation for the disconnection of the hard signals, etc.

In case the status becomes not safety and OFF is output during the monitoring, the OFF signal is kept outputting unless the error alarm is reset.

If the alarm is set to be out of occurring by a condition file, the signal keeps outputting OFF while in not safety status and becomes ON when it returns to the safety status.



CAUTION

In case a major alarm occurred in the functional safety function, all the output signals are turned OFF.

Axis range limit function

Object file status	Monitoring result	Output value
Invalid	-	OFF
Valid	All the axes monitoring is validated are inside the safety range.	ON
	Some of the axes monitoring are validated are detected to be outside the safety range	OFF
	For some of the axes monitoring are validated, the stop position to which coasting value is included are detected to be in error status when moving close to the border of the safety range.	OFF

Axis speed monitor function

Object file status	Monitoring result	Output value
Invalid	-	OFF
Valid	All the axes monitoring is validated are inside the safety range.	ON
	Some of the axes monitoring are validated are detected to be outside the safety range	OFF

Robot range limit function

Object file status	Monitoring result	Output value
Invalid	-	OFF
Valid	Object manipulator or tool is inside the safety range.	ON
	Object manipulator or tool is detected to be outside the safety range	OFF
	For the object manipulator or tool, the stop position to which coasting value is included are detected to be in error status when moving close to the border of the safety.	OFF

Speed limit function

Object file status	Monitoring result	Output value
Invalid	-	OFF
Valid	Object groups for monitoring are inside the limited speed.	ON
	Object groups for monitoring detected the limited speed error.	OFF

Tool angle monitor function

Object file status	Monitoring result	Output value
Invalid	-	OFF
Valid	The tool angle of the object group for monitoring is inside the limited angle.	ON
	An error is detected to the tool angle of the object group for monitoring.	OFF

Tool change monitor function

Object file status	Monitoring result	Output value
Invalid	There is no valid file	OFF
Valid	One condition file is specified as valid and the value is inconsistent with the master CPU.	ON
	One condition file is specified as valid but the value is not consistent with the master CPU.	OFF the valid file signal
	Several condition files are specified as valid	OFF all the valid file signal

6 Common Settings

6.1 Function Disable Mode Function Setting

When this function is used, all the object condition files of the safety monitoring function (32 files) can be set invalid.

This function is used in the following functions marked with ○.

Function	Availability
Axis range limit function	○
Axis speed monitor function	X
Robot range limit function	○
Speed limit function	X
Tool angle monitor function	○
Tool change monitor function	○

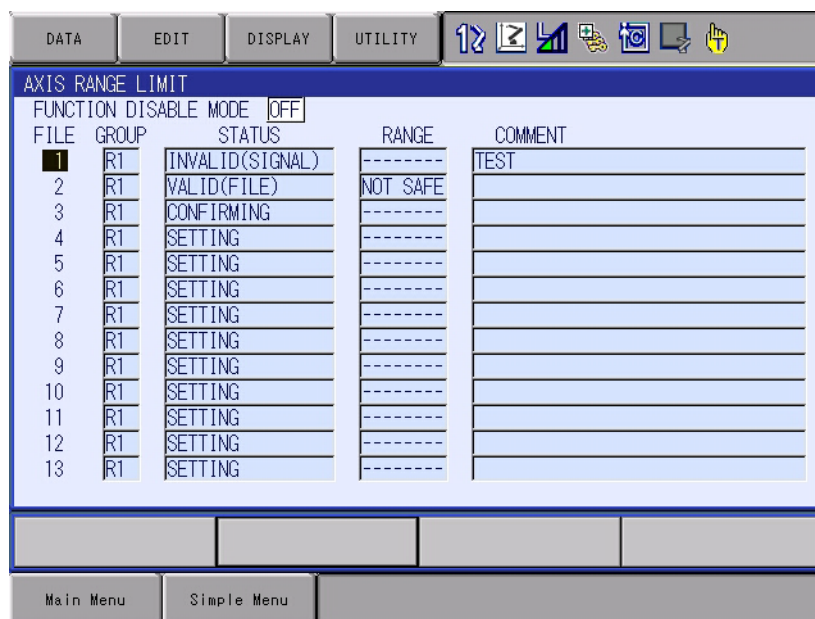
This temporal disabling function is mainly used to recover from the alarming status activated by exceeding the safety range for the range of motion limiting function.

Although the alarm activated by the safety monitoring is a re-settable alarm, it alarms again even if it is re-set when the manipulator or the external axis is exceeding the safety range.

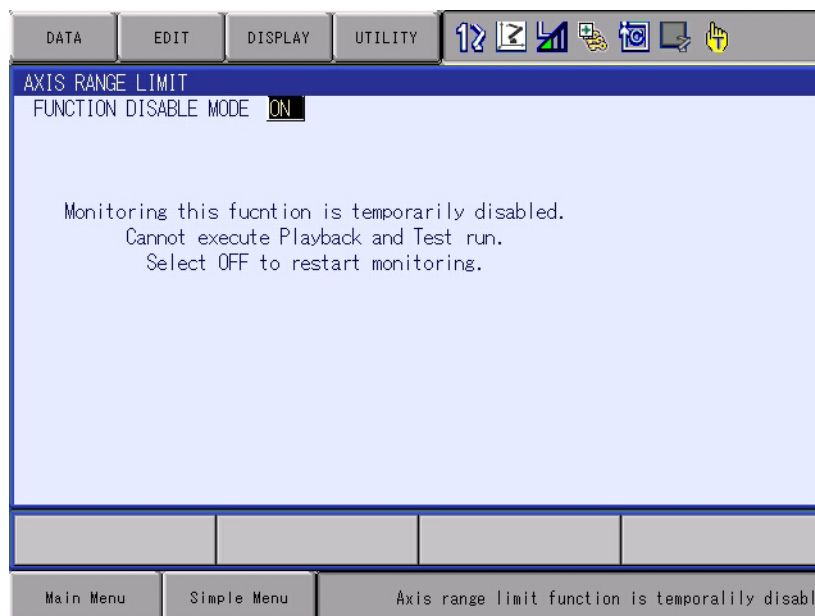
Follow the procedures below when recovering from the alarm.

1. Temporarily disable the safety function that an alarm is detected.
↓
2. Reset the alarm
↓
3. Jog operate to move the manipulator or the external axis inside the safety range.
↓
4. Release the temporal disable.

The function disable mode function can be specified on the list of status window. The axis range limit function window is used as an example of settings.



Set "ON" to {FUNCTION DISABLE MODE}. The window changes as below to show that the function is temporarily disabled.



Also, in the message area at the lower right of the window, a message showing that the object function is being temporarily disabled appears.

<Message>

“Axis range limit function is temporarily disable”

“Robot range limit function is temporarily disable”

“Tool angle monitor function is temporarily disable”

“Tool change monitor function is temporarily disable”

To an specific output signal, a signal for the disabled function is output.

<Specific output signal>

-Axis range limit is temporarily disabled

-Robot range limit is temporarily disabled

-Tool angle monitor is temporarily disabled

-Tool change monitor is temporarily disabled

6.1.1 Restrictions while Function Disable Mode Function is Valid

Restrictions are set to the following operations while the function disable mode function is validated because this function also invalids monitoring operations.

When moving the manipulator or the external axis while the restrictions are set, only the jog operation using the programming pendant is available. And an error occurs when trying to execute those operations.

- Play back operation
- Forward and Backward operations
- Test-run operation
- I/O Jog operation
- Execution of motor gun auto tuning

<Error Message>

Error 1191: Axis range limit function is temporarily disable

Error 1192: Robot range limit function is temporarily disable

Error 1193: Tool angle monitor function is temporarily disable

Error 1194: Tool change monitor function is temporarily disable

Following error codes are returned when executing the data transmission or start commands of the high-speed Ethernet server, or when executing jobs of Motoplus or Pendant customization functions.

<Error Message>

3061: "Axis range limit function is temporarily disable"

3062: "Robot range limit function is temporarily disable"

3063: "Tool angle monitor function is temporarily disable"

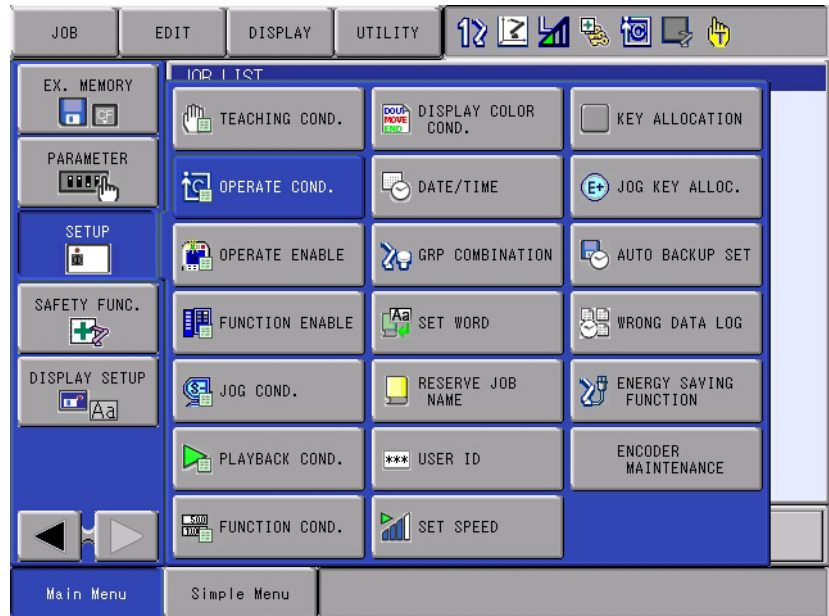
3064: "Tool change monitor function is temporarily disable"

6.1.2 Security Level Setting for Function Disable Mode

For the functions in which the function disable mode exists, the security level to use this mode can be selected.

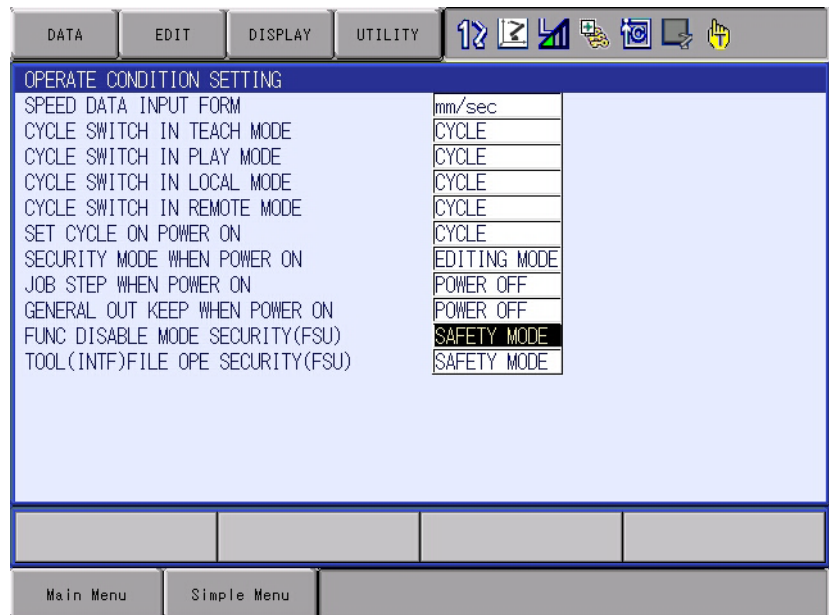
Open the function disable mode setting window by the following procedures.

1. Change the mode to safety mode, and then press {SETUP} under the main menu.



2. Press {OPERATE COND.} in the sub menu.

- OPERATE CONDITION SETTING window appears.
- When the security level is higher than the safety mode and the functional safety function is validated, {FUNC DISABLE MODE SECURITY(FSU)} item appears on this window.



<Details of the Window >**{FUNC DISABLE MODE SECURITY (FSU)}**

Value	Meaning
EDITING MODE	Switching of {FUNCTION DISABLE MODE} is permitted in the editing or higher mode.
MANAGEMENT MODE	Switching of {FUNCTION DISABLE MODE} is permitted in the management or higher mode.
SAFETY MODE	Switching of {FUNCTION DISABLE MODE} is permitted in the safety mode. (Default)

6.2 External Axis Coasting Value Setting

This setting can be referred by the following safety functions. When using the safety function marked with ○ in the following table, an advanced setting is required.

Function	Reference
Axis range limit function	○
Axis speed monitor function	X
Robot range limit function	○
Speed limit function	X
Tool angle monitor function	X
Tool change monitor function	X

In case the power supply to the servo is turned OFF while the manipulator is in operation, it may move a little bit before completely stopping because of the force of inertia. The functional safety function functions by estimating the moving value (coasting value) of the manipulator from the servo OFF position to the completely stopped position in accordance with each axis speed.

By setting the manipulator to stop just before it exceeds the safety range including its coasting distance on the basis of the estimated coasting value, the stop position of the manipulator does not exceed the safety range.

For example, when the manipulator is operating with 100% of operating speed, the functional safety function starts instructing the manipulator to stop “the coasting value when the manipulator is operating with 100% of operating speed” before the border of its limited area.

Also, when the manipulator is operating with 50% of operating speed, the functional safety function starts instructing the manipulator to stop “the coasting value when the manipulator is operating with 50% of operating speed” before the border of its limited area.

For the coasting value of the manipulator, it is already set before shipment. However, for an external axis, it should be set by the customer.

When the monitoring operations in the axis range limit function or the robot range limit function is valid but its coasting value is not set, an error may occur and following operations will be restricted.

- Play back operation
- Forward and Backward operations
- Test-run operation
- I/O Jog operation
- Execution of motor gun at tuning



The coasting value is difficult to obtain by calculation. Do not use values using in other systems because the value varies largely depending on the structure or shape of the external axis.

When inputting a temporary value, set a large value enough to avoid the risk.

<Error message>

“Error 0384: Coasting value setting of Ex-axis is not completed”

Following error code is returned when executing the data transmission, the starting system command by the high-speed Ethernet server or the play back operations from the programming pendant customization function or Motoplus before setting of the coasting value is not completed.

<Error codes>

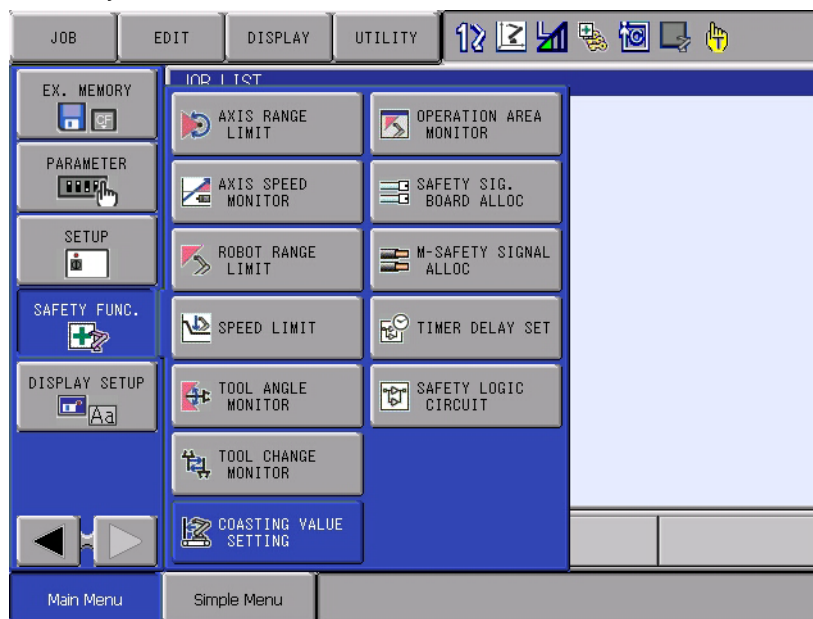
3065 “Coasting value setting of Ex-axis is not completed”



Setting of the coasting value is not necessary for the system to which the external axis does not exist. Also, following sub menu is not displayed.

Open the external axis coasting value setting window by the following procedures.

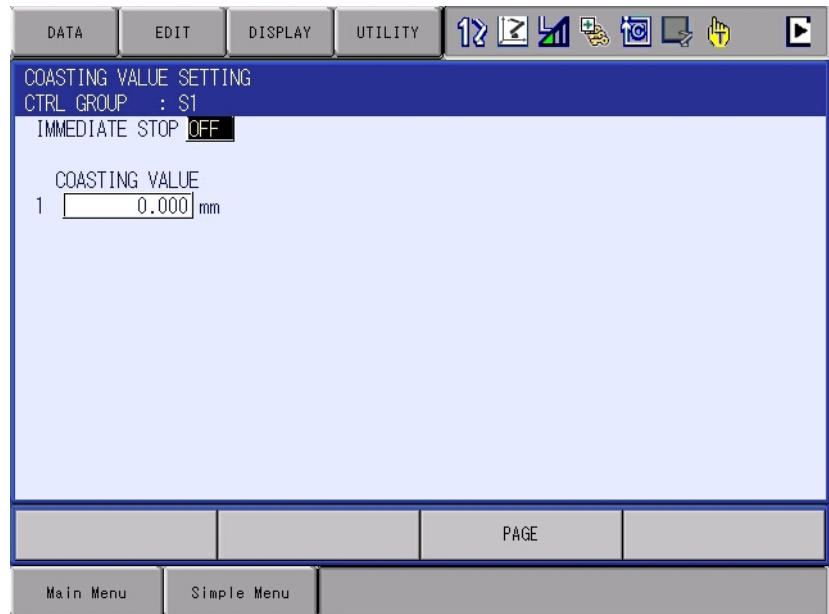
1. Change the mode to the safety mode, and then press {SAFETY FUNC.} under the main menu.



6 Common Settings

6.2 External Axis Coasting Value Setting

2. Press {COASTING VALUE SETTING} in the sub menu.
 - COASTING VALUE SETTING window appears.
 - When several external axes exist, press [PAGE] to alternate the external axes.



<Details of the Window >

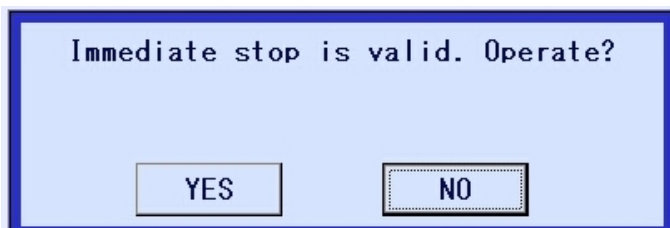
1. {IMMEDIATE STOP}

The value input to {COASTING VALUE} should be measured in the category 0 status. For the coasting value measurement, the category can be modified.

Value	Meaning
OFF	Category 1 is set for the stop of the robot and the external axis (Default)
ON	Category 0 is set for the stop of the robot and the external axis



- “OFF” should be set to {IMMEDIATE STOP} again after the coasting value measurement.
- When the starting operation is executed while “ON” is set, a dialog box notifying that “Immediate stop” is already set appears.
If performing the coasting value measurement, the play back operation can be executed after selecting “YES” and re-start the starting operation.



2. {COASTING VALUE}

Set the coasting value to a object axis. The inputting range is from 0.000 to 999.999.



A message “Select “Functional Safety Board FLSH Reset” in the maintenance mode.” appears when the coasting value is edited.

Re-set the data by following the procedures in *section 7.2 “FLASH Data Reset” on page 7-2.*



While modifying the coasting value, the power supply to the servo is stopped and the operation of the manipulator or the axis is disabled. However the modification is continuously available. For this reason, it is recommended to turn ON the power supply to the controller after finish modifying all the coasting value.

6.3 Tool File Setting

This setting can be referred by the following safety functions. When using the safety function marked with ○ in the following table, an advanced setting is required.

Function	Reference
Axis range limit function	X
Axis speed monitor function	X
Robot range limit function	○
Speed limit function	○
Tool angle monitor function	○
Tool change monitor function	X

The tool file should be appropriately specified for the precise monitoring of the safety function.

Refer to section 8.3 “Tool Data Setting” in the “DX200 INSTRUCTIONS (165292-1CD) for the firm settings.

6.4 Tool Interference File Setting

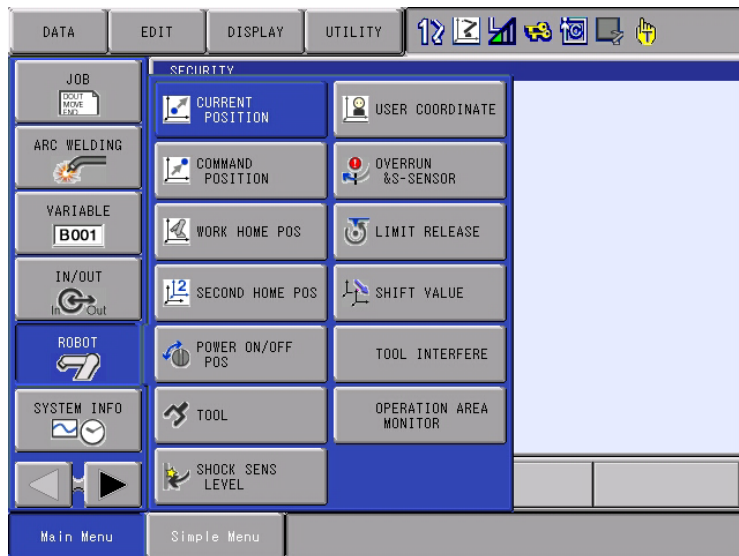
This setting can be referred by the following safety functions. When using the safety function marked with ○ in the following table, an advanced setting is required.

Function	Reference
Axis range limit function	X
Axis speed monitor function	X
Robot range limit function	○
Speed limit function	X
Tool angle monitor function	X
Tool change monitor function	X

In the robot range limit function, monitoring of the manipulator as well as its tool is executed. In this case, register the tool shape to the tool interference file as an approximate model.

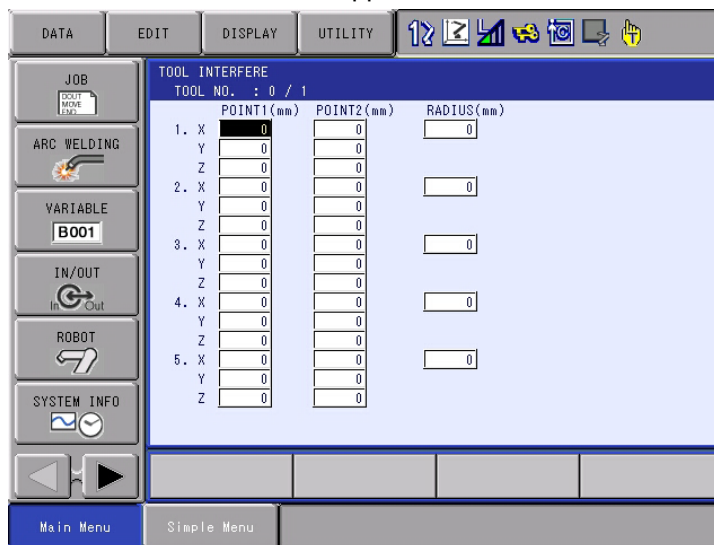
Set a tool interference file as instructed below.

1. Change the mode to the safety mode, and then press {ROBOT} under the main menu.



2. Select {TOOL INTERFERE} under the sub menu.

– TOOL INTERFERE window appears.



<Details of the Window >

1. {1} to {5}

Cylinders and spheres for up to 5 positions can be set.

2. {POINT1} to {POINT5}

Input the coordinate value of XYZ, and set both ends of a cylinder.

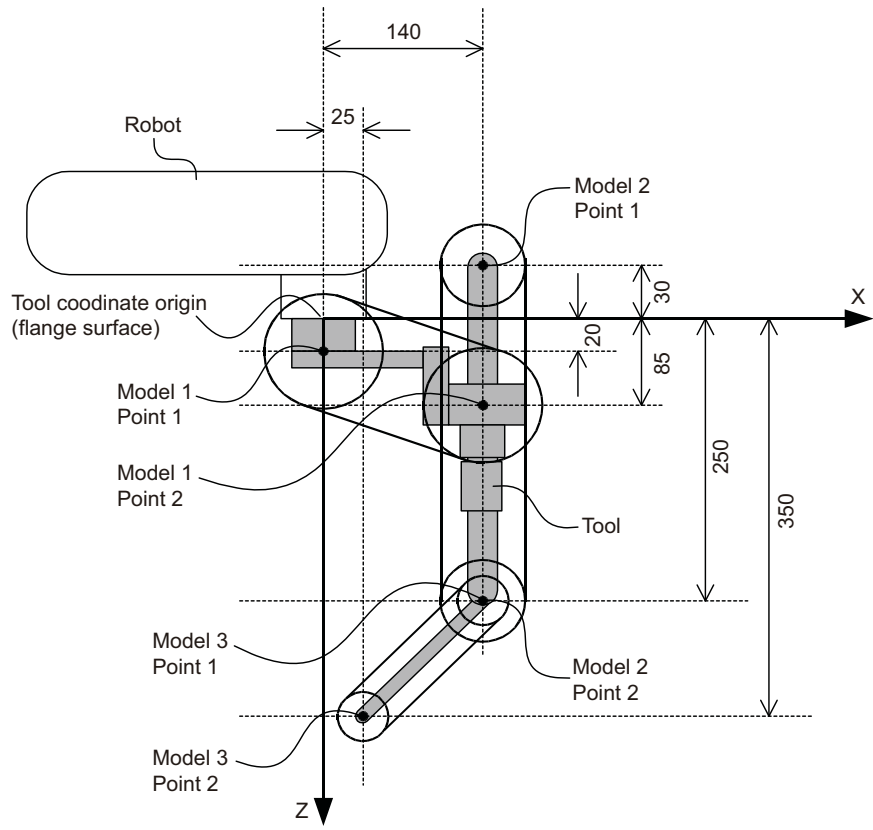
The distance from the center of T axis flange should be set like tool dimension setting.

3. {RADIUS}

The radius of the spheres and cylinder between POINT1 and POINT2 is set. The spheres are set to POINT1 and POINT2.

It is measured in [mm]

The specified radius must have a margin of at least 10 mm compared with the actual tool.

<Tool interference file setting example>*Fig. 6-1: Tool Interference File Setting Example*

6 Common Settings

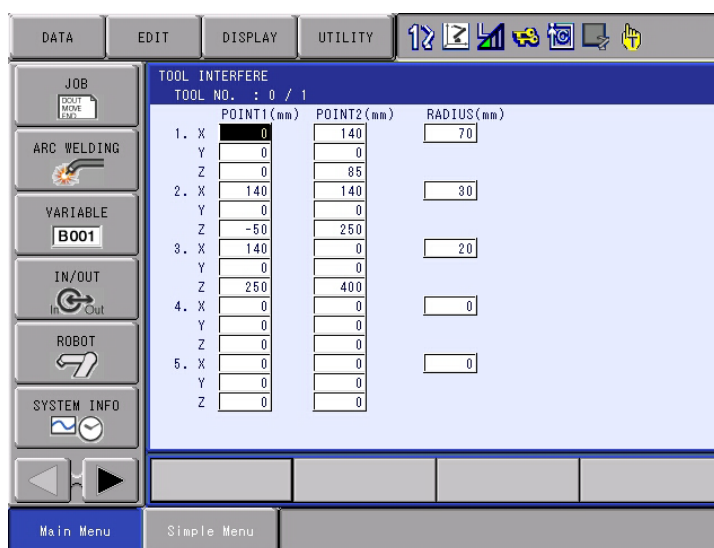
6.4 Tool Interference File Setting

Model 1: Set the flange surface to Point 1, and (X=140, Z=85) to Point 2.

Model 2: Set (X=140, Z=-30) to Point 1, and (X=140, Z=250) to Point 2.
This setting defines a model that is parallel to the Z direction of the tool coordinates.

Model 3: Set (X=140, Z=250) to Point 1, and (X=25, Z=350) to Point 2.
By setting the point 2 of model 2 and the point 1 of model 3 at the same position, model 2 and 3 are defined at consecutive positions.

Following window shows the result of the setting model shown in Fig. 6-1 "Tool Interference File Setting Example".



CAUTION

When setting a radius to a tool model, in accordance to the distance from the flange face, set it a little bit longer one.

Distance from the flange	Recommended radius
0 mm	55 mm
100 mm	58 mm
200 mm	60 mm

6.5 Security Level Setting for Tool File and Tool Interference Files

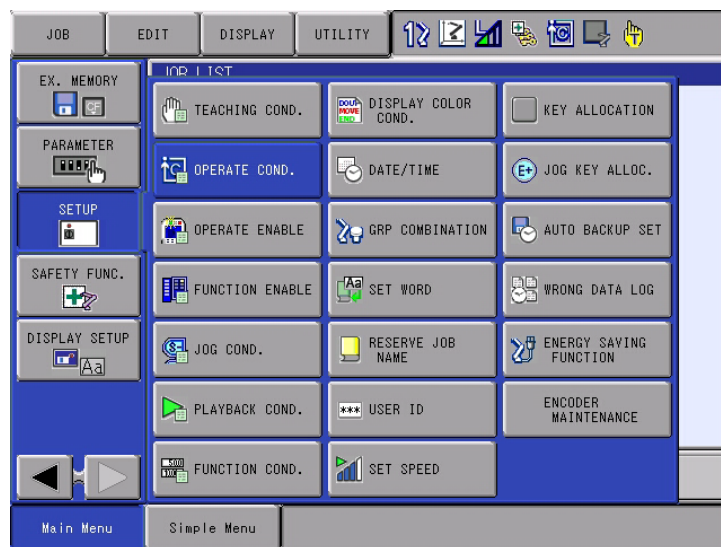
In the system where the functional safety function is not used, both tool file and tool interference files can be operated in the edit or higher mode.

On the other hand, in the system where the function is used, in the default setting, they can be operated only in the safety mode because these files influence the safety monitoring operation.

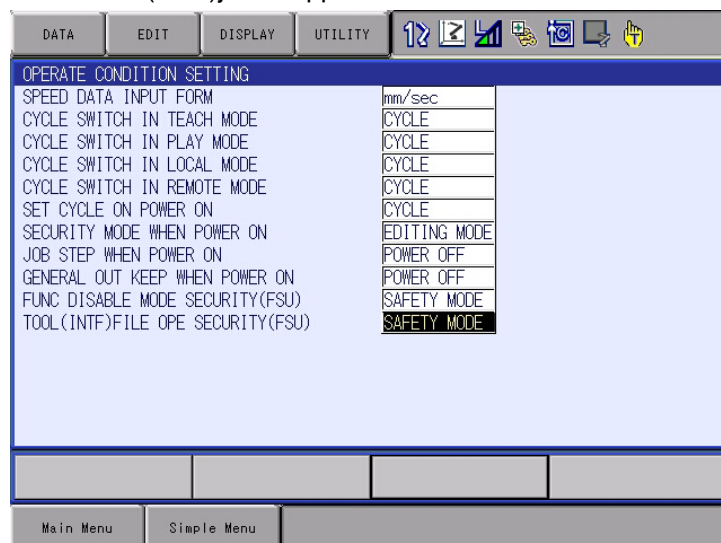
The person who has a safety license can select one out of three security level for operating the tool file or tool interference file.

The setting window opens by the following procedures.

1. Change the mode to the safety mode, and then press {SETUP} under the main menu.



2. Select {OPERATE CONDITION SETTING} under the sub menu.
 - OPERATE CONDITION SETTING window appears.
 - When the security level is higher than the safety mode and the functional safety function is validated, {TOOL (INTIF)FILE OPE SECURITY (FSU)} item appears on this window



<Details of the Window >**{TOOL (INTF)FILE OPE SECURITY (FSU)}**

Value	Meaning
EDITING MODE	Operation of the tool file and tool interference file is permitted in the editing or higher mode.
MANAGEMENT MODE	Operation of the tool file and tool interference file is permitted in the management or higher mode.
SAFETY MODE	Operation of the tool file and tool interference file is permitted in the safety mode. (Default)

7 Data Protection

7.1 Saving Dual Data

The data related to the functional safety function is saved in the function safety board memory in a duplicated manner for safety.

When the control power is turned ON, check is performed to see that dual data sets are the same.

If they are different when the control power is turned ON, the following alarm occurs.

Alarm 0300: "VERIFY ERROR(SYSTEM CONFIG-DATA)[10]"

In the system with the functional safety function, a message "Select 'Functional Safety Board FLASH Reset' in the maintenance mode" is displayed after the following operations.

Turning ON or OFF causes error in verification.

- The data related to the functional safety function is loaded from an external storage.
- The home position calibration or the home position change operation is performed.
- The tool calibration operation is performed.
- The zeroing function is performed.
- Encoder is reset
- Tool weight and tool center settings are performed in the load estimating function

In case one of the above mentioned operations is performed, re-set the data following the procedures shown in *section 7.2 "FLASH Data Reset"*.

In the maintenance mode, there are cases when parameters relevant to the functional safety function are rewritten by several setting operations. For this reason, perform functional safety board FLASH reset operation by following the procedures shown in *section 7.2 "FLASH Data Reset"*.

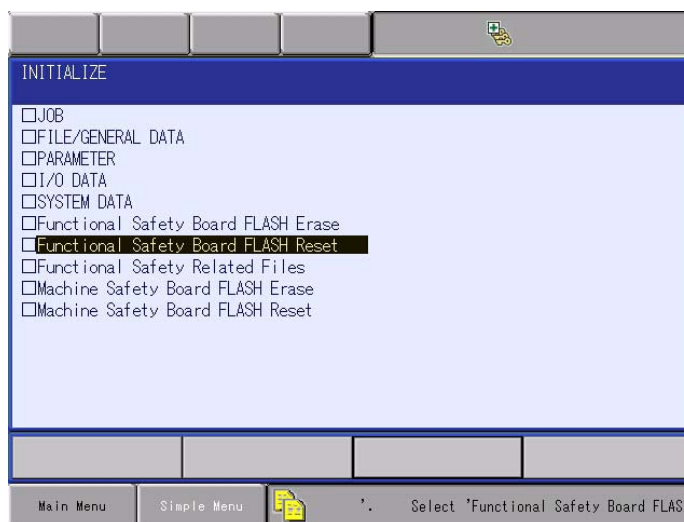
7.2 FLASH Data Reset

If the following alarm occurs when the control power supply is turned ON,

Alarm 0300: "VERIFY ERROR(SYSTEM CONFIG-DATA)[10]"

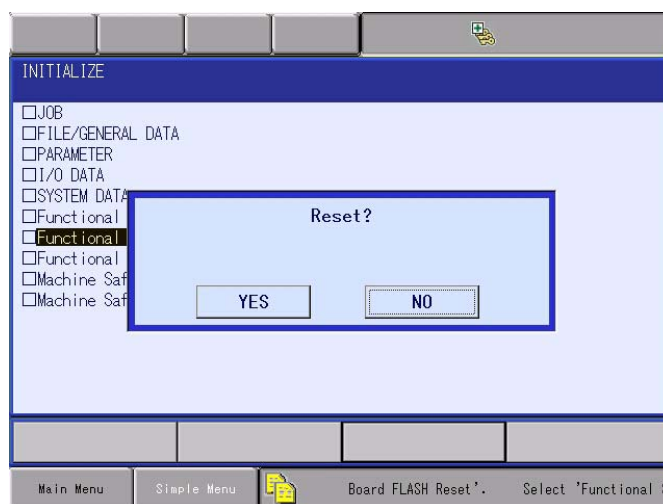
perform the following operations to re-set the data of the function safety board.

1. When the controller power is turned ON, Alarm 0300: "VERIFY ERROR(SYSTEM CONFIG-DATA)[10]" occurs and the maintenance mode is started up.
2. Select {SYSTEM} under the main menu. Then, press {SECURITY} to change the security mode to the safety mode.



3. Select {FILE} under the main menu. Then, select {INITIALIZE} under the sub menu.

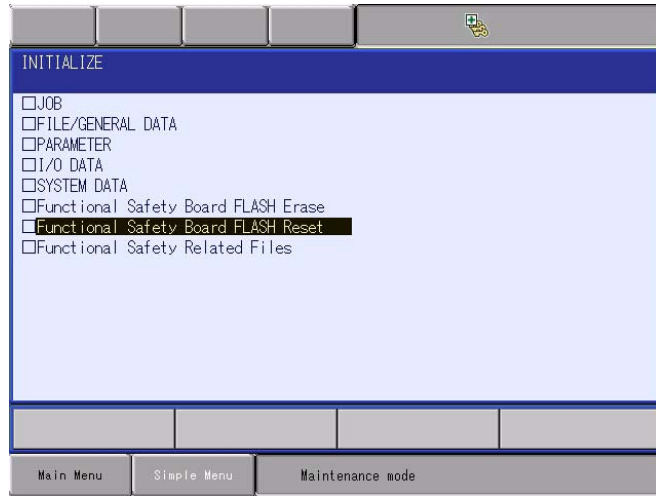
– INITIALIZE window appears.



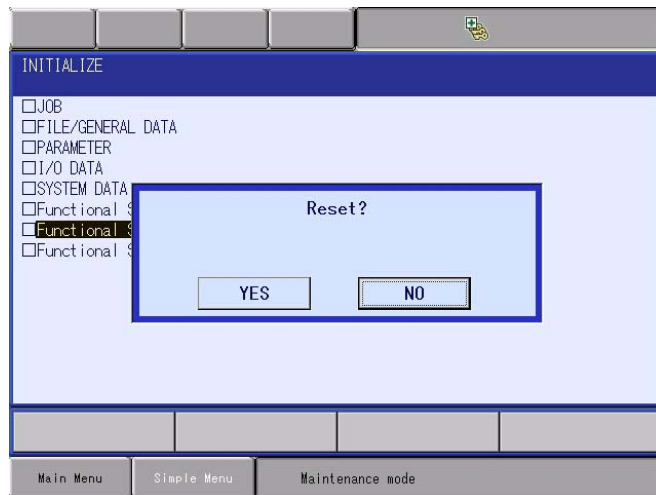
7 Data Protection

7.2 FLASH Data Reset

4. Move the cursor to {Functional Safety Board FLASH Reset} and press [ENTER].



5. The dialog box "Reset?" is displayed. Select [YES].
 - The data of the safety function board is re-set. A few seconds later, the buzzer sounds and the data setting is completed.

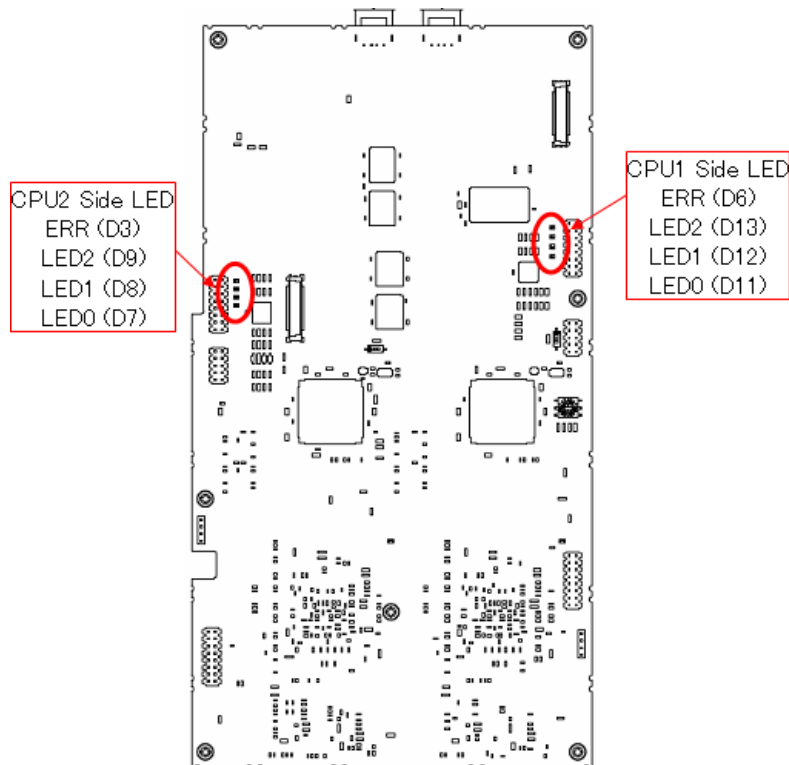


6. When the data reset is completed, turn the control power OFF and then turn the power ON again.

8 LED Indication

As shown in the figure below, 4 LEDs are equipped to each of the 2 CPUs on the functional safety board. The LEDs show the operating statuses.

Fig. 8-1: LED Arrangement























System statuses and LED indications are shown below.

Status	LED indication
Right after applying the power	All light up
During the start-up process	Green LED flights up in a specified pattern (Refer to section 8.1 "LED Indication during Start-up Process".)
After starting up normally	"LED0" (D11, D7) blinks in 1-sec cycle
Function disable mode is set to a function after starting up normally	"LED2" (D13, D9) lights up while the function disable mode is ON
Exception occurrence	"ERR" (D6, D3) at the alarm occurring CPU side lights up
Alarm occurrence	"ERR" (D12 or D8) at the alarm occurring CPU side lights up

8.1 LED Indication during Start-up Process

Followings show the LED indication while start-up operation is processed.

LED indication	Meanings
ERR:D6, D3  Light up LED2:D13, D9  Light up LED1:D12, D8  Light up LED0:D11, D7  Light up	Power supply is turned ON
ERR:D6, D3  <input type="checkbox"/> LED2:D13, D9  <input type="checkbox"/> LED1:D12, D8  <input type="checkbox"/> LED0:D11, D7  Light up	Boot program is started up
ERR:D6, D3  <input type="checkbox"/> LED2:D13, D9  <input type="checkbox"/> LED1:D12, D8  Light up LED0:D11, D7  Light up	Hardware initialization is completed
ERR:D6, D3  <input type="checkbox"/> LED2:D13, D9  Blink LED1:D12, D8  Light up LED0:D11, D7  Light up	OFF-line command waiting (LED2 blinks in 1-sec cycle)
ERR:D6, D3  <input type="checkbox"/> LED2:D13, D9  <input type="checkbox"/> LED1:D12, D8  <input type="checkbox"/> LED0:D11, D7  Blink	System program is started up (off-line) (LED0 blinks in 0.5-sec cycle)

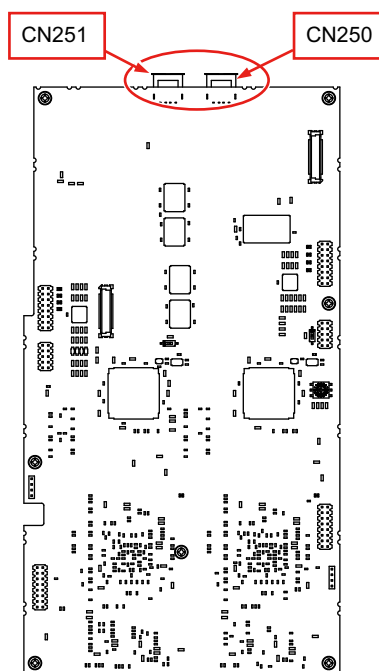
LED indication	Meanings
ERR:D6, D3 <input type="checkbox"/> <input type="checkbox"/> LED2:D13, D9 <input type="checkbox"/> <input type="checkbox"/> LED1:D12, D8 <input checked="" type="checkbox"/> Light up LED0:D11, D7 <input type="checkbox"/> <input type="checkbox"/>	Main program of functional safety function program is started up (pre on-line)
ERR:D6, D3 <input type="checkbox"/> <input type="checkbox"/> LED2:D13, D9 <input checked="" type="checkbox"/> Light up LED1:D12, D8 <input type="checkbox"/> <input type="checkbox"/> LED0:D11, D7 <input checked="" type="checkbox"/> Blink	Synchronization with the main CPU is completed (LED0 blinks in 0.5-sec cycle)
ERR:D6, D3 <input type="checkbox"/> <input type="checkbox"/> LED2:D13, D9 <input type="checkbox"/> <input type="checkbox"/> LED1:D12, D8 <input type="checkbox"/> <input type="checkbox"/> LED0:D11, D7 <input checked="" type="checkbox"/> Blink	Functional safety function start-up process completed (on-line) (LED0 blinks in 1-sec cycle)

9 Functional Safety Board Replacing Procedure

Replace the functional safety function board following the procedures below.

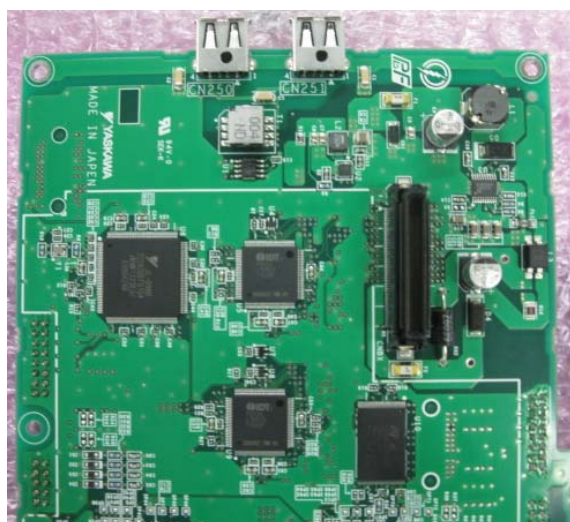
1. Turn OFF the power supply to the DX200.
2. Disconnect cables from the CN250 and CN251 connectors on the functional safety board. (CN251 can be a terminate connector.)

Fig. 9-1: CN250 and CN251 Connectors



3. Replace the functional safety board. A connector CNBX which is connected to a servo board (SRDA-EAXA21A) is mounted at the backside of this board. For this reason, replace the functional safety board with caution so that the CNBX is appropriately connected to the servo board.

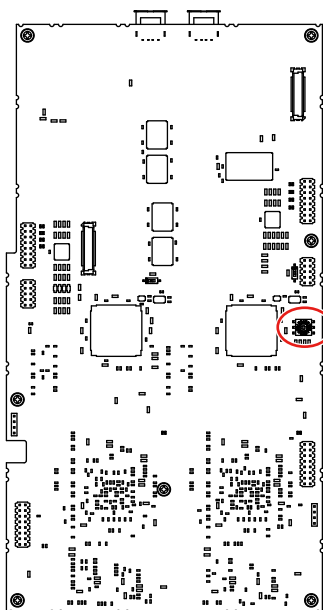
Fig. 9-2: CNBX Connector



4. Connect cables to CN250 and CN251 as they were.
5. Perform the setting of the rotary switch S3 on the functional safety function board. The number of the switch is specified by the terminal number of the board. The terminal number of the functional safety board is same as that of connected servo board. Follow the numbers in the table below when setting the rotary switches.

Terminal number on functional safety board	Rotary switch number
1	0
2	1
3	2
4	3
5	4
6	5
7	6
8	7

Fig. 9-3: Rotary Switch



6. Turn ON the power supply to the DX200.
7. In case the following alarm occurred when the power supply is turned ON, re-set the data following the procedures shown in *section 7.2 "FLASH Data Reset"*
Alarm 0300: "VERIFY ERROR(SYSTEM CONFIG-DATA)[10]".

10 Specific Output Signal

There are following signals output to the concurrent I/O while functional safety function is used.



Signals output to the concurrent I/O is just an auxiliary signals to confirm the functional safety function status.

To realize the safety monitoring, use the safety output signal. (Refer to *chapter 5 "Safety Signal"*.)

- 52010 to 52047

Output the monitoring valid /invalid status of the axis range limit function.

ON: the monitoring is valid

OFF: the monitoring is invalid

52017	52016	52015	52014	52013	52012	52011	52010
SOUT#1608	SOUT#1607	SOUT#1606	SOUT#1605	SOUT#1604	SOUT#1603	SOUT#1602	SOUT#1601
Axis range limit Condition file 8 Valid/Invalid	Axis range limit Condition file 7 Valid/Invalid	Axis range limit Condition file 6 Valid/Invalid	Axis range limit Condition file 5 Valid/Invalid	Axis range limit Condition file 4 Valid/Invalid	Axis range limit Condition file 3 Valid/Invalid	Axis range limit Condition file 2 Valid/Invalid	Axis range limit Condition file 1 Valid/Invalid

52027	52026	52025	52024	52023	52022	52021	52020
SOUT#1616	SOUT#1615	SOUT#1614	SOUT#1613	SOUT#1612	SOUT#1611	SOUT#1610	SOUT#1609
Axis range limit Condition file 16 Valid/Invalid	Axis range limit Condition file 15 Valid/Invalid	Axis range limit Condition file 14 Valid/Invalid	Axis range limit Condition file 13 Valid/Invalid	Axis range limit Condition file 12 Valid/Invalid	Axis range limit Condition file 11 Valid/Invalid	Axis range limit Condition file 10 Valid/Invalid	Axis range limit Condition file 9 Valid/Invalid

52037	52036	52035	52034	52033	52032	52031	52030
SOUT#1624	SOUT#1623	SOUT#1622	SOUT#1621	SOUT#1620	SOUT#1619	SOUT#1618	SOUT#1617
Axis range limit Condition file 24 Valid/Invalid	Axis range limit Condition file 23 Valid/Invalid	Axis range limit Condition file 22 Valid/Invalid	Axis range limit Condition file 21 Valid/Invalid	Axis range limit Condition file 20 Valid/Invalid	Axis range limit Condition file 19 Valid/Invalid	Axis range limit Condition file 18 Valid/Invalid	Axis range limit Condition file 17 Valid/Invalid

52047	52046	52045	52044	52043	52042	52041	52040
SOUT#1632	SOUT#1631	SOUT#1630	SOUT#1629	SOUT#1628	SOUT#1627	SOUT#1626	SOUT#1625
Axis range limit Condition file 32 Valid/Invalid	Axis range limit Condition file 31 Valid/Invalid	Axis range limit Condition file 30 Valid/Invalid	Axis range limit Condition file 29 Valid/Invalid	Axis range limit Condition file 28 Valid/Invalid	Axis range limit Condition file 27 Valid/Invalid	Axis range limit Condition file 26 Valid/Invalid	Axis range limit Condition file 25 Valid/Invalid

- 52050 to 52087

Output the monitoring valid /invalid status of the axis speed monitor function.

ON: the monitoring is valid

OFF: the monitoring is invalid

52057	52056	52055	52054	52053	52052	52051	52050
SOUT#1640	SOUT#1639	SOUT#1638	SOUT#1637	SOUT#1636	SOUT#1635	SOUT#1634	SOUT#1633
Axis speed monitor Condition file 8	Axis speed monitor Condition file 7	Axis speed monitor Condition file 6	Axis speed monitor Condition file 5	Axis speed monitor Condition file 4	Axis speed monitor Condition file 3	Axis speed monitor Condition file 2	Axis speed monitor Condition file 1
Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid

52067	52066	52065	52064	52063	52062	52061	52060
SOUT#1648	SOUT#1647	SOUT#1646	SOUT#1645	SOUT#1644	SOUT#1643	SOUT#1642	SOUT#1641
Axis speed monitor Condition file 16	Axis speed monitor Condition file 15	Axis speed monitor Condition file 14	Axis speed monitor Condition file 13	Axis speed monitor Condition file 12	Axis speed monitor Condition file 11	Axis speed monitor Condition file 10	Axis speed monitor Condition file 9
Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid

52077	52076	52075	52074	52073	52072	52071	52070
SOUT#1656	SOUT#1655	SOUT#1654	SOUT#1653	SOUT#1652	SOUT#1651	SOUT#1650	SOUT#1649
Axis speed monitor Condition file 24	Axis speed monitor Condition file 23	Axis speed monitor Condition file 22	Axis speed monitor Condition file 21	Axis speed monitor Condition file 20	Axis speed monitor Condition file 19	Axis speed monitor Condition file 18	Axis speed monitor Condition file 17
Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid

52087	52086	52085	52084	52083	52082	52081	52080
SOUT#1664	SOUT#1663	SOUT#1662	SOUT#1661	SOUT#1660	SOUT#1659	SOUT#1658	SOUT#1657
Axis speed monitor Condition file 32	Axis speed monitor Condition file 31	Axis speed monitor Condition file 30	Axis speed monitor Condition file 29	Axis speed monitor Condition file 28	Axis speed monitor Condition file 27	Axis speed monitor Condition file 26	Axis speed monitor Condition file 25
Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid

- 52090 to 52127

Output the monitoring valid /invalid status of the robot range limit function.

ON: the monitoring is valid

OFF: the monitoring is invalid

52097	52096	52095	52094	52093	52092	52091	52090
SOUT#1672	SOUT#1671	SOUT#1670	SOUT#1669	SOUT#1668	SOUT#1667	SOUT#1666	SOUT#1665
Robot range limit Condition file 8 Valid/Invalid	Robot range limit Condition file 7 Valid/Invalid	Robot range limit Condition file 6 Valid/Invalid	Robot range limit Condition file 5 Valid/Invalid	Robot range limit Condition file 4 Valid/Invalid	Robot range limit Condition file 3 Valid/Invalid	Robot range limit Condition file 2 Valid/Invalid	Robot range limit Condition file 1 Valid/Invalid

52107	52106	52105	52104	52103	52102	52101	52100
SOUT#1680	SOUT#1679	SOUT#1678	SOUT#1677	SOUT#1676	SOUT#1675	SOUT#1674	SOUT#1673
Robot range limit Condition file 16 Valid/Invalid	Robot range limit Condition file 15 Valid/Invalid	Robot range limit Condition file 14 Valid/Invalid	Robot range limit Condition file 13 Valid/Invalid	Robot range limit Condition file 12 Valid/Invalid	Robot range limit Condition file 11 Valid/Invalid	Robot range limit Condition file 10 Valid/Invalid	Robot range limit Condition file 9 Valid/Invalid

52117	52116	52115	52114	52113	52112	52111	52110
SOUT#1688	SOUT#1687	SOUT#1686	SOUT#1685	SOUT#1684	SOUT#1683	SOUT#1682	SOUT#1681
Robot range limit Condition file 24 Valid/Invalid	Robot range limit Condition file 23 Valid/Invalid	Robot range limit Condition file 22 Valid/Invalid	Robot range limit Condition file 21 Valid/Invalid	Robot range limit Condition file 20 Valid/Invalid	Robot range limit Condition file 19 Valid/Invalid	Robot range limit Condition file 18 Valid/Invalid	Robot range limit Condition file 17 Valid/Invalid

52127	52126	52125	52124	52123	52122	52121	52120
SOUT#1696	SOUT#1695	SOUT#1694	SOUT#1693	SOUT#1692	SOUT#1691	SOUT#1690	SOUT#1689
Robot range limit Condition file 32 Valid/Invalid	Robot range limit Condition file 31 Valid/Invalid	Robot range limit Condition file 30 Valid/Invalid	Robot range limit Condition file 29 Valid/Invalid	Robot range limit Condition file 28 Valid/Invalid	Robot range limit Condition file 27 Valid/Invalid	Robot range limit Condition file 26 Valid/Invalid	Robot range limit Condition file 25 Valid/Invalid

• 52130 to 52167

Output the monitoring valid /invalid status of the speed limit function.

ON: the monitoring is valid

OFF: the monitoring is invalid

52137	52136	52135	52134	52133	52132	52131	52130
SOUT#1704	SOUT#1703	SOUT#1702	SOUT#1701	SOUT#1700	SOUT#1699	SOUT#1698	SOUT#1697
Speed limit Condition file 8 Valid/Invalid	Speed limit Condition file 7 Valid/Invalid	Speed limit Condition file 6 Valid/Invalid	Speed limit Condition file 5 Valid/Invalid	Speed limit Condition file 4 Valid/Invalid	Speed limit Condition file 3 Valid/Invalid	Speed limit Condition file 2 Valid/Invalid	Speed limit Condition file 1 Valid/Invalid

52147	52146	52145	52144	52143	52142	52141	52140
SOUT#1712	SOUT#1711	SOUT#1710	SOUT#1709	SOUT#1708	SOUT#1707	SOUT#1706	SOUT#1705
Speed limit Condition file 16 Valid/Invalid	Speed limit Condition file 15 Valid/Invalid	Speed limit Condition file 14 Valid/Invalid	Speed limit Condition file 13 Valid/Invalid	Speed limit Condition file 12 Valid/Invalid	Speed limit Condition file 11 Valid/Invalid	Speed limit Condition file 10 Valid/Invalid	Speed limit Condition file 9 Valid/Invalid

52157	52156	52155	52154	52153	52152	52151	52150
SOUT#1720	SOUT#1719	SOUT#1718	SOUT#1717	SOUT#1716	SOUT#1715	SOUT#1714	SOUT#1713
Speed limit Condition file 24 Valid/Invalid	Speed limit Condition file 23 Valid/Invalid	Speed limit Condition file 22 Valid/Invalid	Speed limit Condition file 21 Valid/Invalid	Speed limit Condition file 20 Valid/Invalid	Speed limit Condition file 19 Valid/Invalid	Speed limit Condition file 18 Valid/Invalid	Speed limit Condition file 17 Valid/Invalid

52167	52166	52165	52164	52163	52162	52161	52160
SOUT#1728	SOUT#1727	SOUT#1726	SOUT#1725	SOUT#1724	SOUT#1723	SOUT#1722	SOUT#1721
Speed limit Condition file 32 Valid/Invalid	Speed limit Condition file 31 Valid/Invalid	Speed limit Condition file 30 Valid/Invalid	Speed limit Condition file 29 Valid/Invalid	Speed limit Condition file 28 Valid/Invalid	Speed limit Condition file 27 Valid/Invalid	Speed limit Condition file 26 Valid/Invalid	Speed limit Condition file 25 Valid/Invalid

- 52130 to 52167

Output the monitoring valid /invalid status of the tool angle monitor function.

ON: the monitoring is valid

OFF: the monitoring is invalid

52177	52176	52175	52174	52173	52172	52171	52170
SOUT#1736	SOUT#1735	SOUT#1734	SOUT#1733	SOUT#1732	SOUT#1731	SOUT#1730	SOUT#1729
Tool angle monitor Condition file 8	Tool angle monitor Condition file 7	Tool angle monitor Condition file 6	Tool angle monitor Condition file 5	Tool angle monitor Condition file 4	Tool angle monitor Condition file 3	Tool angle monitor Condition file 2	Tool angle monitor Condition file 1
Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid

52187	52186	52185	52184	52183	52182	52181	52180
SOUT#1744	SOUT#1743	SOUT#1742	SOUT#1741	SOUT#1740	SOUT#1739	SOUT#1738	SOUT#1737
Tool angle monitor Condition file 16	Tool angle monitor Condition file 15	Tool angle monitor Condition file 14	Tool angle monitor Condition file 13	Tool angle monitor Condition file 12	Tool angle monitor Condition file 11	Tool angle monitor Condition file 10	Tool angle monitor Condition file 9
Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid

52197	52196	52195	52194	52193	52192	52191	52190
SOUT#1752	SOUT#1751	SOUT#1750	SOUT#1749	SOUT#1748	SOUT#1747	SOUT#1746	SOUT#1745
Tool angle monitor Condition file 24	Tool angle monitor Condition file 23	Tool angle monitor Condition file 22	Tool angle monitor Condition file 21	Tool angle monitor Condition file 20	Tool angle monitor Condition file 19	Tool angle monitor Condition file 18	Tool angle monitor Condition file 17
Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid

52207	52206	52205	52204	52203	52202	52201	52200
SOUT#1760	SOUT#1759	SOUT#1758	SOUT#1757	SOUT#1756	SOUT#1755	SOUT#1754	SOUT#1753
Tool angle monitor Condition file 32	Tool angle monitor Condition file 31	Tool angle monitor Condition file 30	Tool angle monitor Condition file 29	Tool angle monitor Condition file 28	Tool angle monitor Condition file 27	Tool angle monitor Condition file 26	Tool angle monitor Condition file 25
Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid	Valid/Invalid

- 52210 to 52367

Output the monitoring valid /invalid status of the tool change monitor function.

ON: the monitoring is valid

OFF: the monitoring is invalid

52217	52216	52215	52214	52213	52212	52211	52210
SOUT#1768	SOUT#1767	SOUT#1766	SOUT#1765	SOUT#1764	SOUT#1763	SOUT#1762	SOUT#1761
Tool change monitor(R1) Condition file 8 Valid/Invalid	Tool change monitor(R1) Condition file 7 Valid/Invalid	Tool change monitor(R1) Condition file 6 Valid/Invalid	Tool change monitor(R1) Condition file 5 Valid/Invalid	Tool change monitor(R1) Condition file 4 Valid/Invalid	Tool change monitor(R1) Condition file 3 Valid/Invalid	Tool change monitor(R1) Condition file 2 Valid/Invalid	Tool change monitor(R1) Condition file 1 Valid/Invalid

52227	52226	52225	52224	52223	52222	52221	52220
SOUT#1776	SOUT#1775	SOUT#1774	SOUT#1773	SOUT#1772	SOUT#1771	SOUT#1770	SOUT#1769
Tool change monitor(R1) Condition file 16 Valid/Invalid	Tool change monitor(R1) Condition file 15 Valid/Invalid	Tool change monitor(R1) Condition file 14 Valid/Invalid	Tool change monitor(R1) Condition file 13 Valid/Invalid	Tool change monitor(R1) Condition file 12 Valid/Invalid	Tool change monitor(R1) Condition file 11 Valid/Invalid	Tool change monitor(R1) Condition file 10 Valid/Invalid	Tool change monitor(R1) Condition file 9 Valid/Invalid

52237	52236	52235	52234	52233	52232	52231	52230
SOUT#1784	SOUT#1783	SOUT#1782	SOUT#1781	SOUT#1780	SOUT#1779	SOUT#1778	SOUT#1777
Tool change monitor(R2) Condition file 8 Valid/Invalid	Tool change monitor(R2) Condition file 7 Valid/Invalid	Tool change monitor(R2) Condition file 6 Valid/Invalid	Tool change monitor(R2) Condition file 5 Valid/Invalid	Tool change monitor(R2) Condition file 4 Valid/Invalid	Tool change monitor(R2) Condition file 3 Valid/Invalid	Tool change monitor(R2) Condition file 2 Valid/Invalid	Tool change monitor(R2) Condition file 1 Valid/Invalid

52247	52246	52245	52244	52243	52242	52241	52240
SOUT#1792	SOUT#1791	SOUT#1790	SOUT#1789	SOUT#1788	SOUT#1787	SOUT#1786	SOUT#1785
Tool change monitor(R2) Condition file 16 Valid/Invalid	Tool change monitor(R2) Condition file 15 Valid/Invalid	Tool change monitor(R2) Condition file 14 Valid/Invalid	Tool change monitor(R2) Condition file 13 Valid/Invalid	Tool change monitor(R2) Condition file 12 Valid/Invalid	Tool change monitor(R2) Condition file 11 Valid/Invalid	Tool change monitor(R2) Condition file 10 Valid/Invalid	Tool change monitor(R2) Condition file 9 Valid/Invalid

52257	52256	52255	52254	52253	52252	52251	52250
SOUT#1800	SOUT#1799	SOUT#1798	SOUT#1797	SOUT#1796	SOUT#1795	SOUT#1794	SOUT#1793
Tool change monitor(R3) Condition file 8 Valid/Invalid	Tool change monitor(R3) Condition file 7 Valid/Invalid	Tool change monitor(R3) Condition file 6 Valid/Invalid	Tool change monitor(R3) Condition file 5 Valid/Invalid	Tool change monitor(R3) Condition file 4 Valid/Invalid	Tool change monitor(R3) Condition file 3 Valid/Invalid	Tool change monitor(R3) Condition file 2 Valid/Invalid	Tool change monitor(R3) Condition file 1 Valid/Invalid

52267	52266	52265	52264	52263	52262	52261	52260
SOUT#1808	SOUT#1807	SOUT#1806	SOUT#1805	SOUT#1804	SOUT#1803	SOUT#1802	SOUT#1801
Tool change monitor(R3) Condition file 16 Valid/Invalid	Tool change monitor(R3) Condition file 15 Valid/Invalid	Tool change monitor(R3) Condition file 14 Valid/Invalid	Tool change monitor(R3) Condition file 13 Valid/Invalid	Tool change monitor(R3) Condition file 12 Valid/Invalid	Tool change monitor(R3) Condition file 11 Valid/Invalid	Tool change monitor(R3) Condition file10 Valid/Invalid	Tool change monitor(R3) Condition file 9 Valid/Invalid

52277	52276	52275	52274	52273	52272	52271	52270
SOUT#1816	SOUT#1815	SOUT#1814	SOUT#1813	SOUT#1812	SOUT#1811	SOUT#1810	SOUT#1809
Tool change monitor(R4) Condition file 8 Valid/Invalid	Tool change monitor(R4) Condition file 7 Valid/Invalid	Tool change monitor(R4) Condition file 6 Valid/Invalid	Tool change monitor(R4) Condition file 5 Valid/Invalid	Tool change monitor(R4) Condition file 4 Valid/Invalid	Tool change monitor(R4) Condition file 3 Valid/Invalid	Tool change monitor(R4) Condition file 2 Valid/Invalid	Tool change monitor(R4) Condition file 1 Valid/Invalid

52287	52286	52285	52284	52283	52282	52281	52280
SOUT#1824	SOUT#1823	SOUT#1822	SOUT#1821	SOUT#1820	SOUT#1819	SOUT#1818	SOUT#1817
Tool change monitor(R4) Condition file 16 Valid/Invalid	Tool change monitor(R4) Condition file 15 Valid/Invalid	Tool change monitor(R4) Condition file 14 Valid/Invalid	Tool change monitor(R4) Condition file 13 Valid/Invalid	Tool change monitor(R4) Condition file 12 Valid/Invalid	Tool change monitor(R4) Condition file 11 Valid/Invalid	Tool change monitor(R4) Condition file10 Valid/Invalid	Tool change monitor(R4) Condition file 9 Valid/Invalid

52297	52296	52295	52294	52293	52292	52291	52290
SOUT#1832	SOUT#1831	SOUT#1830	SOUT#1829	SOUT#1828	SOUT#1827	SOUT#1826	SOUT#1825
Tool change monitor(R5) Condition file 8 Valid/Invalid	Tool change monitor(R5) Condition file 7 Valid/Invalid	Tool change monitor(R5) Condition file 6 Valid/Invalid	Tool change monitor(R5) Condition file 5 Valid/Invalid	Tool change monitor(R5) Condition file 4 Valid/Invalid	Tool change monitor(R5) Condition file 3 Valid/Invalid	Tool change monitor(R5) Condition file 2 Valid/Invalid	Tool change monitor(R5) Condition file 1 Valid/Invalid

52307	52306	52305	52304	52303	52302	52301	52300
SOUT#1840	SOUT#1839	SOUT#1838	SOUT#1837	SOUT#1836	SOUT#1835	SOUT#1834	SOUT#1833
Tool change monitor(R5) Condition file 16 Valid/Invalid	Tool change monitor(R5) Condition file 15 Valid/Invalid	Tool change monitor(R5) Condition file 14 Valid/Invalid	Tool change monitor(R5) Condition file 13 Valid/Invalid	Tool change monitor(R5) Condition file 12 Valid/Invalid	Tool change monitor(R5) Condition file 11 Valid/Invalid	Tool change monitor(R5) Condition file10 Valid/Invalid	Tool change monitor(R5) Condition file 9 Valid/Invalid

52317	52316	52315	52314	52313	52312	52311	52310
SOUT#1848	SOUT#1847	SOUT#1846	SOUT#1845	SOUT#1844	SOUT#1843	SOUT#1842	SOUT#1841
Tool change monitor(R6) Condition file 8 Valid/Invalid	Tool change monitor(R6) Condition file 7 Valid/Invalid	Tool change monitor(R6) Condition file 6 Valid/Invalid	Tool change monitor(R6) Condition file 5 Valid/Invalid	Tool change monitor(R6) Condition file 4 Valid/Invalid	Tool change monitor(R6) Condition file 3 Valid/Invalid	Tool change monitor(R6) Condition file 2 Valid/Invalid	Tool change monitor(R6) Condition file 1 Valid/Invalid

52327	52326	52325	52324	52323	52322	52321	52320
SOUT#1856	SOUT#1855	SOUT#1854	SOUT#1853	SOUT#1852	SOUT#1851	SOUT#1850	SOUT#1849
Tool change monitor(R6) Condition file 16 Valid/Invalid	Tool change monitor(R6) Condition file 15 Valid/Invalid	Tool change monitor(R6) Condition file 14 Valid/Invalid	Tool change monitor(R6) Condition file 13 Valid/Invalid	Tool change monitor(R6) Condition file 12 Valid/Invalid	Tool change monitor(R6) Condition file 11 Valid/Invalid	Tool change monitor(R6) Condition file10 Valid/Invalid	Tool change monitor(R6) Condition file 9 Valid/Invalid

52347	52346	52345	52344	52343	52342	52341	52340
SOUT#1872	SOUT#1871	SOUT#1870	SOUT#1869	SOUT#1868	SOUT#1867	SOUT#1866	SOUT#1865
Tool change monitor(R7) Condition file 8 Valid/Invalid	Tool change monitor(R7) Condition file 7 Valid/Invalid	Tool change monitor(R7) Condition file 6 Valid/Invalid	Tool change monitor(R7) Condition file 5 Valid/Invalid	Tool change monitor(R7) Condition file 4 Valid/Invalid	Tool change monitor(R7) Condition file 3 Valid/Invalid	Tool change monitor(R7) Condition file 2 Valid/Invalid	Tool change monitor(R7) Condition file 1 Valid/Invalid

52357	52356	52355	52354	52353	52352	52351	52350
SOUT#1880	SOUT#1879	SOUT#1878	SOUT#1877	SOUT#1876	SOUT#1875	SOUT#1874	SOUT#1873
Tool change monitor(R7) Condition file 16 Valid/Invalid	Tool change monitor(R7) Condition file 15 Valid/Invalid	Tool change monitor(R7) Condition file 14 Valid/Invalid	Tool change monitor(R7) Condition file 13 Valid/Invalid	Tool change monitor(R7) Condition file 12 Valid/Invalid	Tool change monitor(R7) Condition file 11 Valid/Invalid	Tool change monitor(R7) Condition file10 Valid/Invalid	Tool change monitor(R7) Condition file 9 Valid/Invalid

52357	52356	52355	52354	52353	52352	52351	52350
SOUT#1880	SOUT#1879	SOUT#1878	SOUT#1877	SOUT#1876	SOUT#1875	SOUT#1874	SOUT#1873
Tool change monitor(R8) Condition file 8 Valid/Invalid	Tool change monitor(R8) Condition file 7 Valid/Invalid	Tool change monitor(R8) Condition file 6 Valid/Invalid	Tool change monitor(R8) Condition file 5 Valid/Invalid	Tool change monitor(R8) Condition file 4 Valid/Invalid	Tool change monitor(R8) Condition file 3 Valid/Invalid	Tool change monitor(R8) Condition file 2 Valid/Invalid	Tool change monitor(R8) Condition file 1 Valid/Invalid

52367	52366	52365	52364	52363	52362	52361	52360
SOUT#1888	SOUT#1887	SOUT#1886	SOUT#1885	SOUT#1884	SOUT#1883	SOUT#1882	SOUT#1881
Tool change monitor(R8) Condition file 16 Valid/Invalid	Tool change monitor(R8) Condition file 15 Valid/Invalid	Tool change monitor(R8) Condition file 14 Valid/Invalid	Tool change monitor(R8) Condition file 13 Valid/Invalid	Tool change monitor(R8) Condition file 12 Valid/Invalid	Tool change monitor(R8) Condition file 11 Valid/Invalid	Tool change monitor(R8) Condition file10 Valid/Invalid	Tool change monitor(R8) Condition file 9 Valid/Invalid

• 52370 to 52407

Output the monitoring results for each condition file at the axis range limit function.

For the details of the output value, refer to *section 5.4 "Safety Signal Output Value"* on page 5-10.

52377	52376	52375	52374	52373	52372	52371	52370
SOUT#1896	SOUT#1895	SOUT#1894	SOUT#1893	SOUT#1892	SOUT#1891	SOUT#1890	SOUT#1889
Axis range limit Condition file 8 Monitoring result	Axis range limit Condition file 7 Monitoring result	Axis range limit Condition file 6 Monitoring result	Axis range limit Condition file 5 Monitoring result	Axis range limit Condition file 4 Monitoring result	Axis range limit Condition file 3 Monitoring result	Axis range limit Condition file 2 Monitoring result	Axis range limit Condition file 1 Monitoring result

52387	52386	52385	52384	52383	52382	52381	52380
SOUT#1904	SOUT#1903	SOUT#1902	SOUT#1901	SOUT#1900	SOUT#1899	SOUT#1898	SOUT#1897
Axis range limit Condition file 16 Monitoring result	Axis range limit Condition file 15 Monitoring result	Axis range limit Condition file 14 Monitoring result	Axis range limit Condition file 13 Monitoring result	Axis range limit Condition file 12 Monitoring result	Axis range limit Condition file 11 Monitoring result	Axis range limit Condition file 10 Monitoring result	Axis range limit Condition file 9 Monitoring result

52397	52396	52395	52394	52393	52392	52391	52390
SOUT#1912	SOUT#1911	SOUT#1910	SOUT#1909	SOUT#1908	SOUT#1907	SOUT#1906	SOUT#1905
Axis range limit Condition file 24 Monitoring result	Axis range limit Condition file 23 Monitoring result	Axis range limit Condition file 22 Monitoring result	Axis range limit Condition file 21 Monitoring result	Axis range limit Condition file 20 Monitoring result	Axis range limit Condition file 19 Monitoring result	Axis range limit Condition file 18 Monitoring result	Axis range limit Condition file 17 Monitoring result

52407	52406	52405	52404	52403	52402	52401	52400
SOUT#1920	SOUT#1919	SOUT#1918	SOUT#1917	SOUT#1916	SOUT#1915	SOUT#1914	SOUT#1913
Axis range limit Condition file 32 Monitoring result	Axis range limit Condition file 31 Monitoring result	Axis range limit Condition file 30 Monitoring result	Axis range limit Condition file 29 Monitoring result	Axis range limit Condition file 28 Monitoring result	Axis range limit Condition file 27 Monitoring result	Axis range limit Condition file 26 Monitoring result	Axis range limit Condition file 25 Monitoring result

• 52410 to 52447

Output the monitoring results for each condition file at the axis speed monitor function.

For the details of the output value, refer to *section 5.4 "Safety Signal Output Value" on page 5-10.*

52417	52416	52415	52414	52413	52412	52411	52410
SOUT#1928	SOUT#1927	SOUT#1926	SOUT#1925	SOUT#1924	SOUT#1923	SOUT#1922	SOUT#1921
Axis speed monitor Condition file 8 Monitoring result	Axis speed monitor Condition file 7 Monitoring result	Axis speed monitor Condition file 6 Monitoring result	Axis speed monitor Condition file 5 Monitoring result	Axis speed monitor Condition file 4 Monitoring result	Axis speed monitor Condition file 3 Monitoring result	Axis speed monitor Condition file 2 Monitoring result	Axis speed monitor Condition file 1 Monitoring result

52427	52426	52425	52424	52423	52422	52421	52420
SOUT#1936	SOUT#1935	SOUT#1934	SOUT#1933	SOUT#1932	SOUT#1931	SOUT#1930	SOUT#1929
Axis speed monitor Condition file 16 Monitoring result	Axis speed monitor Condition file 15 Monitoring result	Axis speed monitor Condition file 14 Monitoring result	Axis speed monitor Condition file 13 Monitoring result	Axis speed monitor Condition file 12 Monitoring result	Axis speed monitor Condition file 11 Monitoring result	Axis speed monitor Condition file 10 Monitoring result	Axis speed monitor Condition file 9 Monitoring result

52437	52436	52435	52434	52433	52432	52431	52430
SOUT#1944	SOUT#1943	SOUT#1942	SOUT#1941	SOUT#1940	SOUT#1939	SOUT#1938	SOUT#1937
Axis speed monitor Condition file 24 Monitoring result	Axis speed monitor Condition file 23 Monitoring result	Axis speed monitor Condition file 22 Monitoring result	Axis speed monitor Condition file 21 Monitoring result	Axis speed monitor Condition file 20 Monitoring result	Axis speed monitor Condition file 19 Monitoring result	Axis speed monitor Condition file 18 Monitoring result	Axis speed monitor Condition file 17 Monitoring result

52447	52446	52445	52444	52443	52442	52441	52440
SOUT#1952	SOUT#1951	SOUT#1950	SOUT#1949	SOUT#1948	SOUT#1947	SOUT#1946	SOUT#1945
Axis speed monitor Condition file 32 Monitoring result	Axis speed monitor Condition file 31 Monitoring result	Axis speed monitor Condition file 30 Monitoring result	Axis speed monitor Condition file 29 Monitoring result	Axis speed monitor Condition file 28 Monitoring result	Axis speed monitor Condition file 27 Monitoring result	Axis speed monitor Condition file 26 Monitoring result	Axis speed monitor Condition file 25 Monitoring result

• 52450 to 52487

Output the monitoring results for each condition file at robot range limit function.

For the details of the output value, refer to *section 5.4 "Safety Signal Output Value"* on page 5-10.

52457	52456	52455	52454	52453	52452	52451	52450
SOUT#1960	SOUT#1959	SOUT#1958	SOUT#1957	SOUT#1956	SOUT#1955	SOUT#1954	SOUT#1953
Robot range limit Condition file 8 Monitoring result	Robot range limit Condition file 7 Monitoring result	Robot range limit Condition file 6 Monitoring result	Robot range limit Condition file 5 Monitoring result	Robot range limit Condition file 4 Monitoring result	Robot range limit Condition file 3 Monitoring result	Robot range limit Condition file 2 Monitoring result	Robot range limit Condition file 1 Monitoring result

52467	52466	52465	52464	52463	52462	52461	52460
SOUT#1968	SOUT#1967	SOUT#1966	SOUT#1965	SOUT#1964	SOUT#1963	SOUT#1962	SOUT#1961
Robot range limit Condition file 16 Monitoring result	Robot range limit Condition file 15 Monitoring result	Robot range limit Condition file 14 Monitoring result	Robot range limit Condition file 13 Monitoring result	Robot range limit Condition file 12 Monitoring result	Robot range limit Condition file 11 Monitoring result	Robot range limit Condition file 10 Monitoring result	Robot range limit Condition file 9 Monitoring result

52477	52476	52475	52474	52473	52472	52471	52470
SOUT#1976	SOUT#1975	SOUT#1974	SOUT#1973	SOUT#1972	SOUT#1971	SOUT#1970	SOUT#1969
Robot range limit Condition file 24 Monitoring result	Robot range limit Condition file 23 Monitoring result	Robot range limit Condition file 22 Monitoring result	Robot range limit Condition file 21 Monitoring result	Robot range limit Condition file 20 Monitoring result	Robot range limit Condition file 19 Monitoring result	Robot range limit Condition file 18 Monitoring result	Robot range limit Condition file 17 Monitoring result

52487	52486	52485	52484	52483	52482	52481	52480
SOUT#1984	SOUT#1983	SOUT#1982	SOUT#1981	SOUT#1980	SOUT#1979	SOUT#1978	SOUT#1977
Robot range limit Condition file 32 Monitoring result	Robot range limit Condition file 31 Monitoring result	Robot range limit Condition file 30 Monitoring result	Robot range limit Condition file 29 Monitoring result	Robot range limit Condition file 28 Monitoring result	Robot range limit Condition file 27 Monitoring result	Robot range limit Condition file 26 Monitoring result	Robot range limit Condition file 25 Monitoring result

• 52490 to 52527

Output the monitoring results for each condition file at speed limit function.

For the details of the output value, refer to *section 5.4 "Safety Signal Output Value"* on page 5-10.

52497	52496	52495	52494	52493	52492	52491	52490
SOUT#1992	SOUT#1991	SOUT#1990	SOUT#1989	SOUT#1988	SOUT#1987	SOUT#1986	SOUT#1985
Speed limit	Speed limit	Speed limit	Speed limit	Speed limit	Speed limit	Speed limit	Speed limit
Condition file 8 Monitoring result	Condition file 7 Monitoring result	Condition file 6 Monitoring result	Condition file 5 Monitoring result	Condition file 4 Monitoring result	Condition file 3 Monitoring result	Condition file 2 Monitoring result	Condition file 1 Monitoring result

52507	52506	52505	52504	52503	52502	52501	52500
SOUT#2000	SOUT#1999	SOUT#1998	SOUT#1997	SOUT#1996	SOUT#1995	SOUT#1994	SOUT#1993
Speed limit	Speed limit	Speed limit	Speed limit	Speed limit	Speed limit	Speed limit	Speed limit
Condition file 16 Monitoring result	Condition file 15 Monitoring result	Condition file 14 Monitoring result	Condition file 13 Monitoring result	Condition file 12 Monitoring result	Condition file 11 Monitoring result	Condition file 9 Monitoring result	Condition file 8 Monitoring result

52517	52516	52515	52514	52513	52512	52511	52510
SOUT#2008	SOUT#2007	SOUT#2006	SOUT#2005	SOUT#2004	SOUT#2003	SOUT#2002	SOUT#2001
Speed limit	Speed limit	Speed limit	Speed limit	Speed limit	Speed limit	Speed limit	Speed limit
Condition file 24 Monitoring result	Condition file 23 Monitoring result	Condition file 22 Monitoring result	Condition file 21 Monitoring result	Condition file 20 Monitoring result	Condition file 19 Monitoring result	Condition file 18 Monitoring result	Condition file 17 Monitoring result

52527	52526	52525	52524	52523	52522	52521	52520
SOUT#2016	SOUT#2015	SOUT#2014	SOUT#2013	SOUT#2012	SOUT#2011	SOUT#2010	SOUT#2009
Speed limit	Speed limit	Speed limit	Speed limit	Speed limit	Speed limit	Speed limit	Speed limit
Condition file 32 Monitoring result	Condition file 31 Monitoring result	Condition file 30 Monitoring result	Condition file 29 Monitoring result	Condition file 28 Monitoring result	Condition file 27 Monitoring result	Condition file 26 Monitoring result	Condition file 25 Monitoring result

• 52530 to 52567

Output the monitoring results for each condition file at tool angle monitor function.

For the details of the output value, refer to *section 5.4 "Safety Signal Output Value"* on page 5-10.

52537	52536	52535	52534	52533	52532	52531	52530
SOUT#2024	SOUT#2023	SOUT#2022	SOUT#2021	SOUT#2020	SOUT#2019	SOUT#2018	SOUT#2017
Tool angle monitor Condition file 8 Monitoring result	Tool angle monitor Condition file 7 Monitoring result	Tool angle monitor Condition file 6 Monitoring result	Tool angle monitor Condition file 5 Monitoring result	Tool angle monitor Condition file 4 Monitoring result	Tool angle monitor Condition file 3 Monitoring result	Tool angle monitor Condition file 2 Monitoring result	Tool angle monitor Condition file 1 Monitoring result

52547	52546	52545	52544	52543	52542	52541	52540
SOUT#2032	SOUT#2031	SOUT#2030	SOUT#2029	SOUT#2028	SOUT#2027	SOUT#2026	SOUT#2025
Tool angle monitor Condition file 16 Monitoring result	Tool angle monitor Condition file 15 Monitoring result	Tool angle monitor Condition file 14 Monitoring result	Tool angle monitor Condition file 13 Monitoring result	Tool angle monitor Condition file 12 Monitoring result	Tool angle monitor Condition file 11 Monitoring result	Tool angle monitor Condition file 10 Monitoring result	Tool angle monitor Condition file 9 Monitoring result

52557	52556	52555	52554	52553	52552	52551	52550
SOUT#2040	SOUT#2039	SOUT#2038	SOUT#2037	SOUT#2036	SOUT#2035	SOUT#2034	SOUT#2033
Tool angle monitor Condition file 24 Monitoring result	Tool angle monitor Condition file 23 Monitoring result	Tool angle monitor Condition file 22 Monitoring result	Tool angle monitor Condition file 21 Monitoring result	Tool angle monitor Condition file 20 Monitoring result	Tool angle monitor Condition file 19 Monitoring result	Tool angle monitor Condition file 18 Monitoring result	Tool angle monitor Condition file 17 Monitoring result

52567	52566	52565	52564	52563	52562	52561	52560
SOUT#2048	SOUT#2047	SOUT#2046	SOUT#2045	SOUT#2044	SOUT#2043	SOUT#2042	SOUT#2041
Tool angle monitor Condition file 32 Monitoring result	Tool angle monitor Condition file 31 Monitoring result	Tool angle monitor Condition file 30 Monitoring result	Tool angle monitor Condition file 29 Monitoring result	Tool angle monitor Condition file 28 Monitoring result	Tool angle monitor Condition file 27 Monitoring result	Tool angle monitor Condition file 26 Monitoring result	Tool angle monitor Condition file 25 Monitoring result

- 52570 to 52577

For R1 to R8, output the monitoring results of the tool change monitor function.

ON: Normal

OFF: Abnormal

52577	52576	52575	52574	52573	52572	52571	52570
SOUT#2056	SOUT#2055	SOUT#2054	SOUT#2053	SOUT#2052	SOUT#2051	SOUT#2050	SOUT#2049
Tool change monitor	Tool change monitor	Tool change monitor	Tool change monitor	Tool change monitor	Tool change monitor	Tool change monitor	Tool change monitor
(R8) Monitoring result	(R7) Monitoring result	(R6) Monitoring result	(R5) Monitoring result	(R4) Monitoring result	(R3) Monitoring result	(R2) Monitoring result	(R1) Monitoring result

- 52580 to 52583

Outputs the status of the function disable mode setting.

				52583	52582	52581	52580
				SOUT#2060	SOUT#2059	SOUT#2058	SOUT#2057
				Tool change monitor	Tool angle monitor	Robot range limit	Axis speed monitor
				Function disable mode	Function disable mode	Function disable mode	Function disable mode

11 Restriction

11.1 Functions Cannot Be Used Concurrently with Functional Safety Function

11.1.1 Functions which Modifies Parameter or File during Playback Operation

As explained in *chapter 7 "Data Protection"*, data of parameters or files are saved in a duplicated manner and are checked for safety.

When modifying these data, special procedures such as read back operations or re-setting of the FLASH data are required.

For this reason, functions that modify parameters or file when executing the play back operation cannot be used concurrently with the functional safety function.

- T-axis endless function
- Speed control function
- PMT function (SETTOOL instruction)

11.1.2 Functions with Intermittent Communication with the Encoder

The functional safety function is monitoring the safety by calculating the position or speed on the basis of the feedback from the encoder.

For this reason, this function cannot be used concurrently with the functions whose communication with the encoder disconnects temporarily.

- Gun change function
- Group change function

11.2 Functions Conditionally Used Concurrently with Functional Safety Function

11.2.1 Conveyor Synchronized Function, COMARC Function

To the conveyor synchronized function and COMARC function, the speed for other purposes are added along with the normal operation speed in this consequence, there may be a case where the TCP speed or the flange speed cannot be controlled as specified.

Alarms and their countermeasures

Alarm 4785: F-SAFE SPEED MONITOR ERROR

Countermeasure: Set the limit value on the condition file with the calculated value on the basis of the speed added by each function.

Alarm 4787: F-SAFE TEACH SAFETY SPEED ERROR

Countermeasure: The operation speed of the manipulator exceeds the speed limited for the teach mode (250 [mm/sec]). Input a full speed test signal and disable the teach mode speed limit.

For the details, refer to *section 4.4.5 "SPEED LIMIT in Teach Mode" on page 4-56*.

11.2.2 Servo Float Function

The manipulator position/speed and feedback position/speed may widely differ while the servo float function is executed. At this time, results of instruction monitoring and feed back monitoring vary.

The safety monitoring starts alarming at the earliest monitoring condition error in the instruction monitoring or feedback monitoring.

The monitoring is normally executed even in the system where the servo float function is available if this function is not executed (FLOATOF).

11.2.3 Motor Gun Function

The safety monitoring for the motor gun axis is not available. Functions such as the robot range limit function for the manipulator with the motor gun are available.

11.2.4 MotoPlus Function and MotoFit Function

When using the path correction function or the increment level movement function in the MotoPlus function or the Motofit function, the speed limit function is not available.

11.3 Restriction of Operation

When the functional safety function is available, operable security mode for the following data varies.

Data	Operation	Security (When functional safety function is available)	Security (When functional safety function is not available)
Tool file	Editing on the tool file window	Safety ¹⁾	Editing
	Tool calibration	Safety	Editing
	Automatic measurement of the tool load and the center of gravity	Safety	Editing
	Loading from the external memory device	Safety	Editing
	File initialization in the maintenance mode	Safety	Editing
Tool interference file	Editing on the tool interference file window	Safety ¹⁾	Editing
	Loading from the external memory device	Safety	Editing
	File initialization in the maintenance mode	Safety	Editing
Home position	Edit on the home position window	Safety	Management
	Loading from the external memory device	Safety	Management
	File initialization in the maintenance mode	Safety	Management
	Zeroing function	Safety	Management
Each parameter ²⁾	Loading from the external memory device	Safety	Management
	File initialization in the maintenance mode	Safety	Management

1 This setting can be changed. For the details, refer to *section 6.5 "Security Level Setting for Tool File and Tool Interference Files"* on page 6-15.

2 Object parameters: ALL, RC, SD, RO, FE, SV, SVM, MF, RE, FMS

11.3.1 Tool Calibration

After executing the tool calibration operation, re-set the data following the procedures described in *section 7.2 "FLASH Data Reset" on page 7-2*.

Following operation is restricted till the power supply to the DX200 is turned OFF.

- Servo cannot be turned ON

11.3.2 Automatic Measurement of the Tool Load and the Center of Gravity

After executing the measurement of the tool load /center of gravity, re-set the data following the procedures described in *section 7.2*.

Following operation is restricted till the power supply to the DX200 is turned OFF.

- Servo cannot be turned ON

11.3.3 Home Position Editing

After the home position is edited, re-set the data following the procedures described in *section 7.2*.

Following operation is restricted till the power supply to the DX200 is turned OFF.

- Operations other than jog operation (playback, test run, etc.) cannot be executed.
- Safety monitoring operations in the functional safety function become unavailable.

11.3.4 File/Parameter Loading

After loading the functional safety-relevant data, re-set the data following the procedures described in *section 7.2*.

(For the functional safety-relevant data, a message "Select 'Functional Safety Board FLASH Reset' in the maintenance mode.")

Following operation is restricted till the power supply to the DX200 is turned OFF.

- Servo cannot be turned ON
- Safety monitoring operations in the functional safety function become unavailable.

DX200 OPTIONS INSTRUCTIONS

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