FANUC Robot series

R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/ R-30*i*B Mate Plus CONTROLLER

Basic/ Intelligent Interference Check

OPERATOR'S MANUAL

B-83244EN/02

- **Original Instructions**

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

The products in this manual are controlled based on Japan's "Foreign Exchange and Foreign Trade Law". The export from Japan may be subject to an export license by the government of Japan.
Further, re-export to another country may be subject to the license of the government of the country from where the product is re-exported. Furthermore, the product may also be controlled by re-export regulations of the United States government.
Should you wish to export or re-export these products, please contact FANUC for advice.

In this manual we have tried as much as possible to describe all the various matters.
However, we cannot describe all the matters which must not be done, or which cannot be done, because there are so many possibilities.
Therefore, matters which are not especially described as possible in this manual should be regarded as "impossible".

SAFETY PRECAUTIONS

This chapter describes the precautions which must be followed to ensure the safe use of the robot.
Before using the robot, be sure to read this chapter thoroughly.

For detailed functions of the robot operation, read the relevant operator's manual to understand fully its specification.
For the safety of the operator and the system, follow all safety precautions when operating a robot and its peripheral equipment installed in a work cell.
In addition, refer to the "FANUC Robot SAFETY HANDBOOK (**B-80687EN)**".

1 DEFINITION OF USER

The user can be defined as follows.

Operator:
- Turns ON/OFF power to the robot
- Starts the robot program from the operator's panel

Programmer:
- Operates the robot
- Teaches the robot inside the safety fence

Maintenance engineer:
- Operates the robot
- Teaches the robot inside the safety fence
- Performs maintenance (repair, adjustment, replacement)

- Operator is not allowed to work in the safety fence.
- Programmers and maintenance engineers are allowed to work in the safety fence. The work inside the safety fence includes lifting, setting, teaching, adjustment, maintenance, etc.
- To work inside the safety fence, the person must receive a professional training for the robot.

During the operation, programming, and maintenance of your robotic system, the programmer, operator, and maintenance engineer should take additional care of their safety by wearing the following safety items.

- Adequate clothes for the operation
- Safety shoes
- A helmet

2 DEFINITION OF SAFETY NOTATIONS

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

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

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

3 SAFETY OF THE USER

User safety is the primary safety consideration. Because it is very dangerous to enter the operating space of the robot during automatic operation, adequate safety precautions must be observed.
The following lists the general safety precautions. Careful consideration must be made to ensure user safety.

(1) Have the robot system users attend the training courses held by FANUC.

FANUC provides various training courses. Contact our sales office for details.

(2) Even when the robot is stationary, it is possible that the robot is still in a ready to move state, and is waiting for a signal. In this state, the robot is regarded as still in motion. To ensure user safety, provide the system with an alarm to indicate visually or aurally that the robot is in motion.
(3) Install a safety fence with a gate so that no user can enter the work area without passing through the gate. Install an interlocking device, a safety plug, and so forth in the safety gate so that the robot is stopped as the safety gate is opened.

The controller is designed to receive this interlocking signal of the door switch. When the gate is opened and this signal received, the controller stops the robot (Please refer to "STOP TYPE OF ROBOT" in "SAFETY PRECAUTIONS" for detail of stop type). For connection, see Fig. 3 (b).

(4) Provide the peripheral equipment with appropriate earth (Class A, Class B, Class C, and Class D).
(5) Try to install the peripheral equipment outside the robot operating space.
(6) Draw an outline on the floor, clearly indicating the range of the robot operating space, including the tools such as a hand.
(7) Install a mat switch or photoelectric switch on the floor with an interlock to a visual or aural alarm that stops the robot when a user enters the work area.
(8) If necessary, install a safety lock so that no one except the user in charge can turn on the power of the robot.

The circuit breaker installed in the controller is designed to disable anyone from turning it on when it is locked with a padlock.

(9) When adjusting each peripheral equipment independently, be sure to turn off the power of the robot.
(10) Operators should be ungloved while manipulating the operator panel or teach pendant. Operation with gloved fingers could cause an operation error.
(11) Programs, system variables, and other information can be saved on memory card or USB memories. Be sure to save the data periodically in case the data is lost in an accident. (refer to Controller OPERATOR'S MANUAL.)
(12) The robot should be transported and installed by accurately following the procedures recommended by FANUC. Wrong transportation or installation may cause the robot to fall, resulting in severe injury to workers.
(13) In the first operation of the robot after installation, the operation should be restricted to low speeds. Then, the speed should be gradually increased to check the operation of the robot.
(14) Before the robot is started, it should be checked that no one is inside the safety fence. At the same time, a check must be made to ensure that there is no risk of hazardous situations. If detected, such a situation should be eliminated before the operation.
(15) When the robot is used, the following precautions should be taken. Otherwise, the robot and peripheral equipment can be adversely affected, or workers can be severely injured.
- Avoid using the robot in a flammable environment.
- Avoid using the robot in an explosive environment.
- Avoid using the robot in an environment full of radiation.
- Avoid using the robot under water or at high humidity.
- Avoid using the robot to carry a person or animal.
- Avoid using the robot as a stepladder. (Never climb up on or hang from the robot.)
- Outdoor

(16) When connecting the peripheral equipment related to stop (safety fence etc.) and each signal (external emergency, fence etc.) of robot, be sure to confirm the stop movement and do not take the wrong connection.
(17) When preparing footstep, please consider security for installation and maintenance work in high place according to Fig. 3 (c). Please consider footstep and safety belt mounting position.

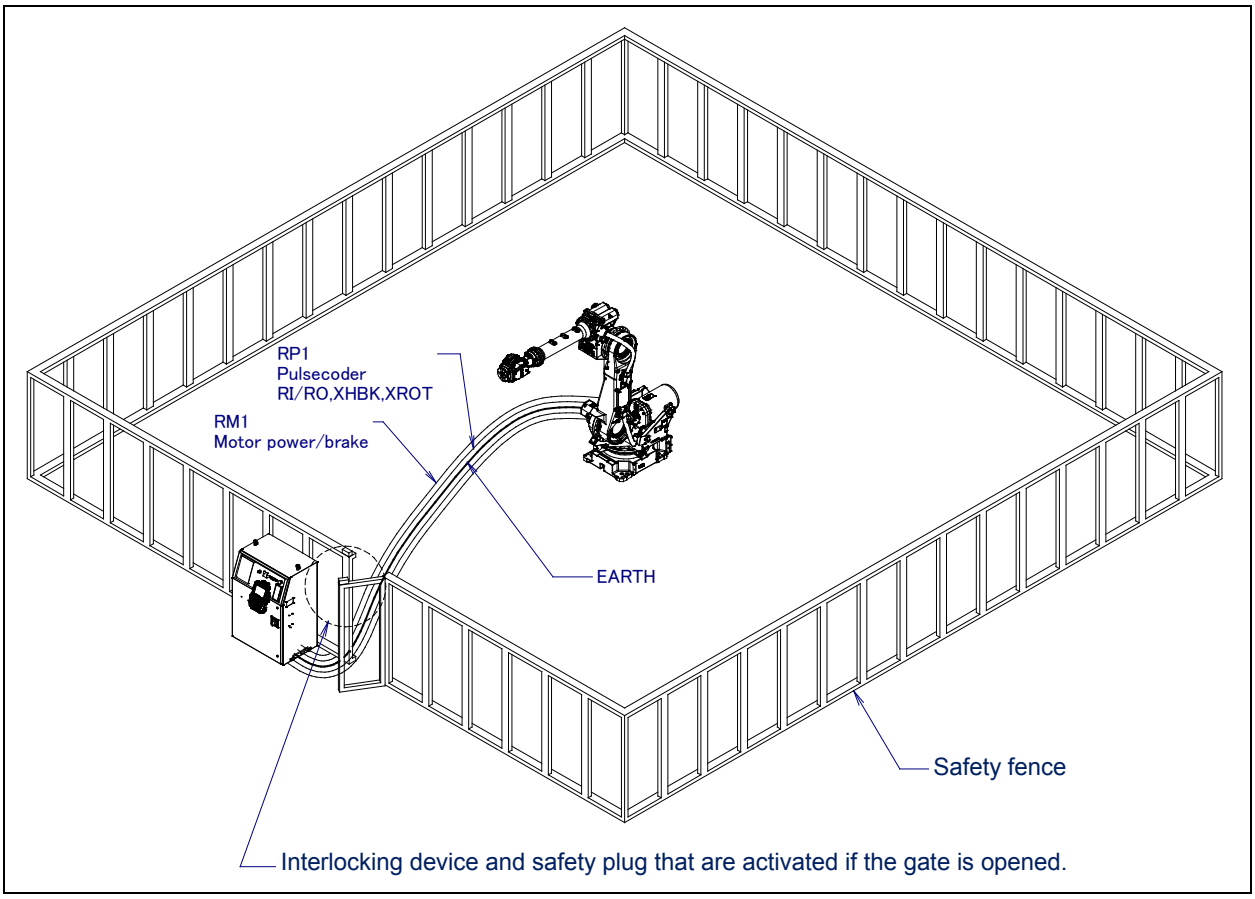

Fig. 3 (a) Safety fence and safety gate

⚠WARNING
When you close a fence, please confirm that there is not a person from all directions of the robot.

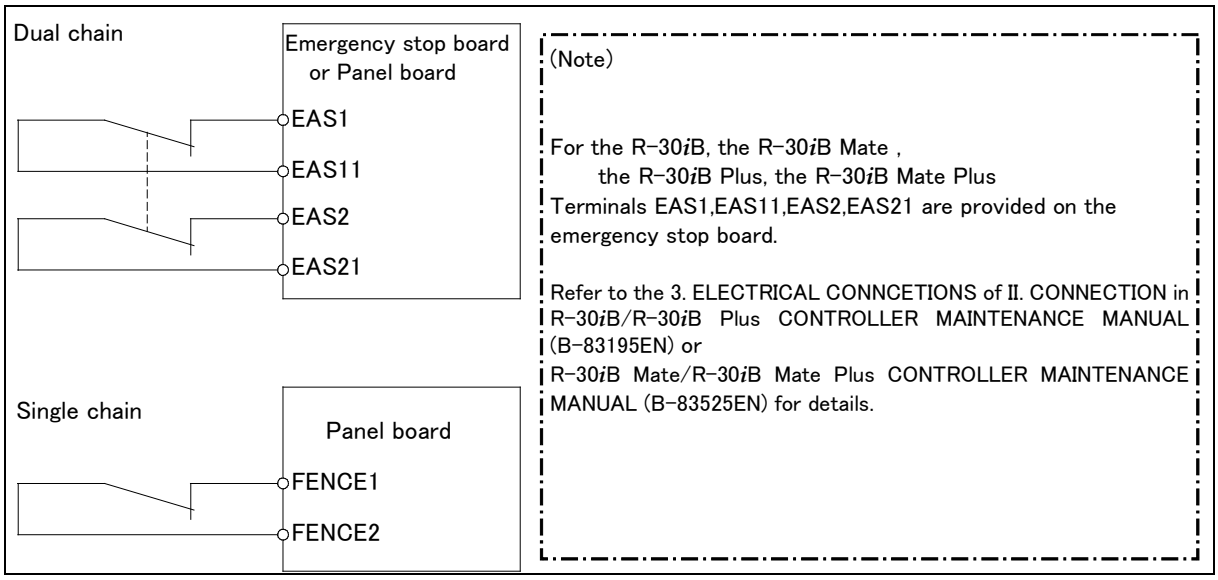

Fig. 3 (b) Connection diagram for the signal of safety fence

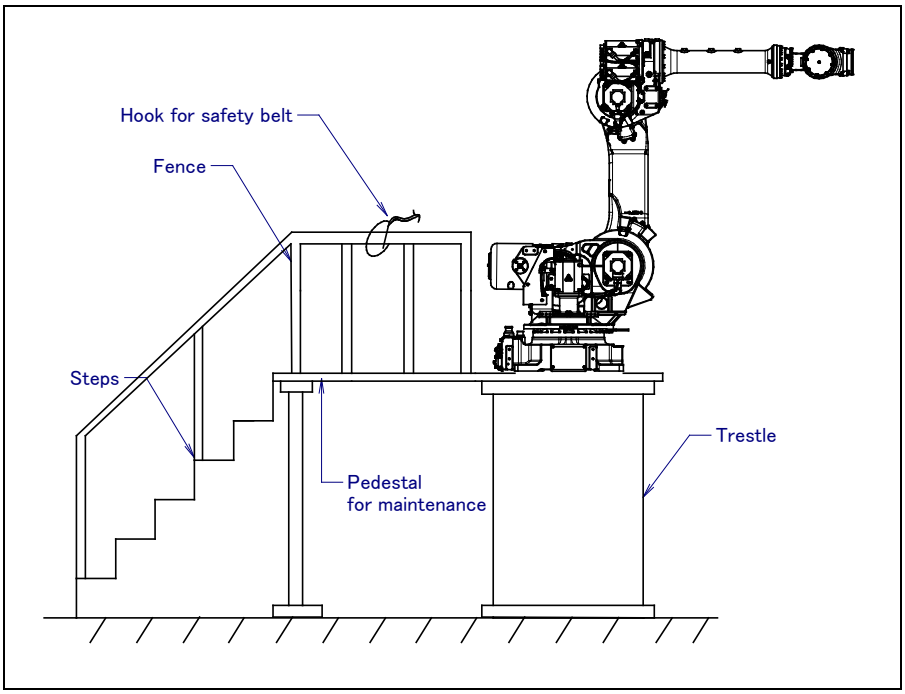

Fig. 3 (c) Pedestal for maintenance

3.1 SAFETY OF THE OPERATOR

An operator refers to a person who turns on and off the robot system and starts a robot program from, for example, the operator panel during daily operation.
Operators cannot work inside of the safety fence.

(1) If the robot does not need to be operated, turn off the robot controller power or press the EMERGENCY STOP button during working.
(2) Operate the robot system outside the operating space of the robot.
(3) Install a safety fence or safety door to avoid the accidental entry of a person other than an operator in charge or keep operator out from the hazardous place.
(4) Install one or more necessary quantity of EMERGENCY STOP button(s) within the operator's reach in appropriate location(s) based on the system layout.

The robot controller is designed to be connected to an external EMERGENCY STOP button. With this connection, the controller stops the robot operation (Please refer to "STOP TYPE OF ROBOT" in "SAFETY PRECAUTIONS" for detail of stop type) when the external EMERGENCY STOP button is pressed. See the diagram below for connection.

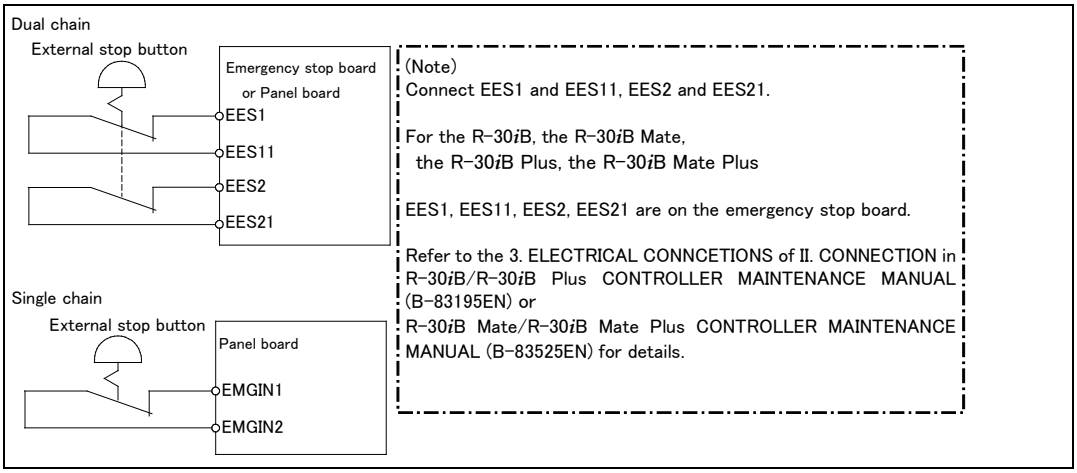

Fig. 3.1 Connection diagram for external emergency stop button

3.2 SAFETY OF THE PROGRAMMER

While teaching the robot, the operator may need to enter the robot operation area. The programmer must ensure the safety especially.

(1) Unless it is specifically necessary to enter the robot operating space, carry out all tasks outside the operating space.
(2) Before teaching the robot, check that the robot and its peripheral equipment are all in the normal operating condition.
(3) If it is inevitable to enter the robot operating space to teach the robot, check the locations, settings, and other conditions of the safety devices (such as the EMERGENCY STOP button, the DEADMAN switch on the teach pendant) before entering the area.
(4) The programmer must be extremely careful not to let anyone else enter the robot operating space.
(5) Programming should be done outside the area of the safety fence as far as possible. If programming needs to be done inside the safety fence, the programmer should take the following precautions:
   - Before entering the area of the safety fence, ensure that there is no risk of dangerous situations in the area.
   - Be prepared to press the emergency stop button whenever necessary.
   - Robot motions should be made at low speeds.
   - Before starting programming, check the whole robot system status to ensure that no remote instruction to the peripheral equipment or motion would be dangerous to the user.

Our operator panel is provided with an emergency stop button and a key switch (mode switch) for selecting the automatic operation (AUTO) and the teach modes (T1 and T2). Before entering the inside of the safety fence for the purpose of teaching, set the switch to a teach mode, remove the key from the mode switch to prevent other people from changing the operation mode carelessly, then open the safety gate. If the safety gate is opened with the automatic operation set, the robot stops (Please refer to "STOP TYPE OF ROBOT" in "SAFETY PRECAUTIONS" for detail of stop type). After the switch is set to a teach mode, the safety gate is disabled. The programmer should understand that the safety gate is disabled and is responsible for keeping other people from entering the inside of the safety fence.

Our teach pendant is provided with a DEADMAN switch as well as an emergency stop button. These button and switch function as follows:

(1) Emergency stop button: Causes the stop of the robot (Please refer to "STOP TYPE OF ROBOT" in "SAFETY PRECAUTIONS" for detail of stop type) when pressed.
(2) DEADMAN switch: Functions differently depending on the teach pendant enable/disable switch setting status.
   (a) Enable: Servo power is turned off when the operator releases the DEADMAN switch or when the operator presses the switch strongly.
   (b) Disable: The DEADMAN switch is disabled.
   (Note) The DEADMAN switch is provided to stop the robot when the operator releases the teach pendant or presses the pendant strongly in case of emergency. The R-30*i*B/R-30*i*B Mate/R-30*i*B Plus/R-30*i*B Mate Plus employs a 3-position DEADMAN switch, which allows the robot to operate when the 3-position DEADMAN switch is pressed to its intermediate point. When the operator releases the DEADMAN switch or presses the switch strongly, the robot stops immediately.

The operator's intention of starting teaching is determined by the controller through the dual operation of setting the teach pendant enable/disable switch to the enable position and pressing the DEADMAN switch. The operator should make sure that the robot could operate in such conditions and be responsible in carrying out tasks safely.

Based on the risk assessment by FANUC, number of operation of DEADMAN SW should not exceed about 10000 times per year.

The teach pendant, operator panel, and peripheral equipment interface send each robot start signal. However the validity of each signal changes as follows depending on the mode switch and the DEADMAN switch of the operator panel, the teach pendant enable switch and the remote condition on the software.

Mode	Teach pendant enable switch	Software remote condition	Teach pendant	Operator panel	Peripheral equipment
AUTO mode	On	Local	Not allowed	Not allowed	Not allowed
		Remote	Not allowed	Not allowed	Not allowed
	Off	Local	Not allowed	Allowed to start	Not allowed
		Remote	Not allowed	Not allowed	Allowed to start
T1, T2 mode	On	Local	Allowed to start	Not allowed	Not allowed
		Remote	Allowed to start	Not allowed	Not allowed
	Off	Local	Not allowed	Not allowed	Not allowed
		Remote	Not allowed	Not allowed	Not allowed

T1,T2 mode: DEADMAN switch is effective.

(6) To start the system using the operator box or operator panel, make certain that nobody is the robot operating space area and that there are no abnormalities in the robot operating space.
(7) When a program is completed, be sure to carry out a test operation according to the following procedure.
   (a) Run the program for at least one operation cycle in the single step mode at low speed.
   (b) Run the program for at least one operation cycle in continuous operation at low speed.
   (c) Run the program for one operation cycle in continuous operation at the intermediate speed and check that no abnormalities occur due to a delay in timing.
   (d) Run the program for one operation cycle in continuous operation at the normal operating speed and check that the system operates automatically without trouble.
   (e) After checking the completeness of the program through the test operation above, execute it in the automatic operation.
(8) While operating the system in the automatic operation, the programmer should leave the safety fence.

3.3 SAFETY OF THE MAINTENANCE ENGINEER

For the safety of maintenance engineer personnel, pay utmost attention to the following.

(1) During operation, never enter the robot operating space.
(2) A hazardous situation may arise when the robot or the system, are kept with their power-on during maintenance operations. Therefore, for any maintenance operation, the robot and the system should be put into the power-off state. If necessary, a lock should be in place in order to prevent any other person from turning on the robot and/or the system. In case maintenance needs to be executed in the power-on state, the emergency stop button must be pressed as far as possible.
(3) If it becomes necessary to enter the robot operating space while the power is on, press the emergency stop button on the operator box or operator panel, or the teach pendant before entering the range. The maintenance worker must indicate that maintenance work is in progress and be careful not to allow other people to operate the robot carelessly.
(4) When entering the area enclosed by the safety fence, the worker must check the whole robot system in order to make sure no dangerous situations exist. In case the worker needs to enter the safety area whilst a dangerous situation exists, extreme care must be taken, and whole robot system status must be carefully monitored.
(5) Before the maintenance of the pneumatic system is started, the supply pressure should be shut off and the pressure in the piping should be reduced to zero.
(6) Before the start of maintenance work, check that the robot and its peripheral equipment are all in the normal operating condition.
(7) Do not operate the robot in the automatic operation while anybody is in the robot operating space.
(8) When you maintain the robot alongside a wall or instrument, or when multiple users are working nearby, make certain that their escape path is not obstructed.
(9) When a tool is mounted on the robot, or when any movable device other than the robot is installed, such as belt conveyor, pay careful attention to its motion.
(10) If necessary, have a user who is familiar with the robot system stand beside the operator panel and observe the work being performed. If any danger arises, the user should be ready to press the EMERGENCY STOP button at any time.
(11) When replacing a part, please contact your local FANUC representative. If a wrong procedure is followed, an accident may occur, causing damage to the robot and injury to the user.
(12) When replacing or reinstalling components, take care to prevent foreign material from entering the system.
(13) When handling each unit or printed circuit board in the controller during inspection, turn off the circuit breaker to protect against electric shock.
If there are two cabinets, turn off the both circuit breaker.
(14) A part should be replaced with a part recommended by FANUC. If other parts are used, malfunction or damage would occur. Especially, a fuse that is not recommended by FANUC should not be used. Such a fuse may cause a fire.
(15) When restarting the robot system after completing maintenance work, make sure in advance that there is no person in the operating space and that the robot and the peripheral equipment are not abnormal.
(16) When a motor or brake is removed, the robot arm should be supported with a crane or other equipment beforehand so that the arm would not fall during the removal.
(17) Whenever grease is spilled on the floor, it should be removed as quickly as possible to prevent dangerous falls.
(18) The following parts are heated. If a maintenance user needs to touch such a part in the heated state, the user should wear heat-resistant gloves or use other protective tools.
- Servo motor
- Inside the controller
- Reducer
- Gearbox

- Wrist unit

(19) Maintenance should be done under suitable light. Care must be taken that the light would not cause any danger.
(20) When a motor, reducer, or other heavy load is handled, a crane or other equipment should be used to protect maintenance workers from excessive load. Otherwise, the maintenance workers would be severely injured.
(21) The robot should not be stepped on or climbed up during maintenance. If it is attempted, the robot would be adversely affected. In addition, a misstep can cause injury to the worker.
(22) When performing maintenance work in high place, secure a footstep and wear safety belt.
(23) After the maintenance is completed, spilled oil or water and metal chips should be removed from the floor around the robot and within the safety fence.
(24) When a part is replaced, all bolts and other related components should put back into their original places. A careful check must be given to ensure that no components are missing or left not mounted.
(25) In case robot motion is required during maintenance, the following precautions should be taken :
- Foresee an escape route. And during the maintenance motion itself, monitor continuously the whole robot system so that your escape route will not become blocked by the robot, or by peripheral equipment.
- Always pay attention to potentially dangerous situations, and be prepared to press the emergency stop button whenever necessary.

(26) The robot should be periodically inspected. (Refer to the robot mechanical manual and controller maintenance manual.) A failure to do the periodical inspection can adversely affect the performance or service life of the robot and may cause an accident
(27) After a part is replaced, a test execution should be given for the robot according to a predetermined method. (See TESTING section of "Controller operator's manual".) During the test execution, the maintenance worker should work outside the safety fence.

4 SAFETY OF THE TOOLS AND PERIPHERAL EQUIPMENT

4.1 PRECAUTIONS IN PROGRAMMING

(1) Use a limit switch or other sensor to detect a dangerous condition and, if necessary, design the program to stop the robot when the sensor signal is received.
(2) Design the program to stop the robot when an abnormality occurs in any other robots or peripheral equipment, even though the robot itself is normal.
(3) For a system in which the robot and its peripheral equipment are in synchronous motion, particular care must be taken in programming so that they do not interfere with each other.
(4) Provide a suitable interface between the robot and its peripheral equipment so that the robot can detect the states of all devices in the system and can be stopped according to the states.

4.2 PRECAUTIONS FOR MECHANISM

(1) Keep the component cells of the robot system clean, operate the robot where insulated from the influence of oil, water, and dust.
(2) Don't use unconfirmed liquid for cutting fluid and cleaning fluid.
(3) Adopt limit switches or mechanical stoppers to limit the robot motion, and avoid the robot from collisions against peripheral equipment or tools.
(4) Observe the following precautions about the mechanical unit cables. Failure to follow precautions may cause problems.
- Use mechanical unit cable that have required user interface.

- Do not add user cable or hose to inside of the mechanical unit.
- Please do not obstruct the movement of the mechanical unit when cables are added to outside of mechanical unit.
- In the case of the model that a cable is exposed, please do not perform remodeling (Adding a protective cover and fix an outside cable more) obstructing the behavior of the outcrop of the cable.
- When installing user peripheral equipment on the robot mechanical unit, please pay attention that the device does not interfere with the robot itself.

(5) The frequent power-off stop for the robot during operation causes the trouble of the robot. Please avoid the system construction that power-off stop would be operated routinely. (Refer to bad case example.) Please perform power-off stop after reducing the speed of the robot and stopping it by hold stop or cycle stop when it is not urgent. (Please refer to "STOP TYPE OF ROBOT" in "SAFETY PRECAUTIONS" for detail of stop type.)
(Bad case example)

- Whenever poor product is generated, a line stops by emergency stop and power-off of the robot is incurred.
- When alteration is necessary, safety switch is operated by opening safety fence and power-off stop is incurred for the robot during operation.
- An operator pushes the emergency stop button frequently, and a line stops.
- An area sensor or a mat switch connected to safety signal operates routinely and power-off stop is incurred for the robot.
- Power-off stop is regularly incurred due to an inappropriate setting for Dual Check Safety (DCS).

(6) Power-off stop of Robot is executed when collision detection alarm (SRVO-050) etc. occurs. Please try to avoid unnecessary power-off stops. It may cause the trouble of the robot, too. So remove the causes of the alarm.

5 SAFETY OF THE ROBOT MECHANICAL UNIT

5.1 PRECAUTIONS IN OPERATION

(1) When operating the robot in the jog mode, set it at an appropriate speed so that the operator can manage the robot in any eventuality.
(2) Before pressing the jog key, be sure you know in advance what motion the robot will perform in the jog mode.

5.2 PRECAUTIONS IN PROGRAMMING

(1) When the operating spaces of robots overlap, make certain that the motions of the robots do not interfere with each other.
(2) Be sure to specify the predetermined work origin in a motion program for the robot and program the motion so that it starts from the origin and terminates at the origin. Make it possible for the operator to easily distinguish at a glance that the robot motion has terminated.

5.3 PRECAUTIONS FOR MECHANISMS

(1) Keep the robot operation area clean, and operate the robot in an environment free of grease, water, and dust.

5.4 PROCEDURE TO MOVE ARM WITHOUT DRIVE POWER IN EMERGENCY OR ABNORMAL SITUATIONS

For emergency or abnormal situations (e.g. persons trapped in or pinched by the robot), brake release unit can be used to move the robot axes without drive power.
Please refer to controller maintenance manual and mechanical unit operator's manual for using method of brake release unit and method of supporting robot.

6 SAFETY OF THE END EFFECTOR

6.1 PRECAUTIONS IN PROGRAMMING

(1) To control the pneumatic, hydraulic and electric actuators, carefully consider the necessary time delay after issuing each control command up to actual motion and ensure safe control.
(2) Provide the end effector with a limit switch, and control the robot system by monitoring the state of the end effector.

7 STOP TYPE OF ROBOT (R-30*i*B, R-30*i*B Mate)

There are following four types of Stopping Robot.

Power-Off Stop (Category 0 following IEC 60204-1)

Servo power is turned off, and the robot stops immediately. Servo power is turned off when the robot is moving, and the motion path of the deceleration is uncontrolled.
"**Power-Off stop**" performs following processing.

- An alarm is generated, and then the servo power turns off. Instantly the robot stops.
- Execution of the program is paused.

Frequent Power-Off stop of the robot during operation can cause mechanical problems of the robot.
Avoid system designs that require routine or frequent Power-Off stop conditions.

Controlled stop (Category 1 following IEC 60204-1)

The robot is decelerated until it stops, and servo power is turned off.
"**Controlled stop**" performs following processing.

- The alarm "**SRVO-199 Controlled stop**" occurs along with a decelerated stop. The program execution is paused.
- An alarm is generated, and then the servo power turns off.

Smooth stop (Category 1 following IEC 60204-1)

The robot is decelerated until it stops, and servo power is turned off.
"**Smooth stop**" performs following processing.

- The alarm "**SRVO-289 Smooth Stop**" occurs along with a decelerated stop. The program execution is paused.
- An alarm is generated, and then the servo power turns off.
- In Smooth stop, the robot decelerates until it stops with the deceleration time shorter than Controlled stop.

Hold (Category 2 following IEC 60204-1)

The robot is decelerated until it stops, and servo power remains on.
"**Hold**" performs following processing.

- The robot operation is decelerated until it stops. Execution of the program is paused.

⚠ WARNING

1 The stopping distance and time of Controlled stop and Smooth stop are longer than those of Power-Off stop. A risk assessment for the whole robot system which takes into consideration the increased stopping distance and stopping time is necessary when Controlled stop or Smooth Stop is used. Please refer to the operator's manual of a particular robot model for the data of stopping distance and time.
2 In multi arm system, the longest stopping distance and time of Controlled Stop or Smooth Stop among each robot are adopted as those for the system. A risk assessment for the whole robot system which takes into consideration a possibility that the stopping distance and time increase, is necessary on the multi arm system.
3 In the system which has extended axis, the longer stopping distance and time of Controlled Stop or Smooth Stop among robot and extended axis are adopted as those for the system. A risk assessment for the whole robot system which takes into consideration a possibility that the stopping distance and time increase, is necessary on the system which has extended axis. Please refer to the extended axis setup procedure of the controller operator's manual for considering the stopping distance and time of the extended axis.
4 When Smooth stop occurs during deceleration by Controlled stop, the stop type of robot is changed to Power-Off Stop.
When Smooth stop occurs during deceleration by Hold, the stop type of robot is changed to Power-Off Stop.
5 In case of Controlled stop or Smooth Stop, motor power shutdown is delayed for a maximum of 2 seconds. In this case, a risk assessment for the whole robot system is necessary, including the 2 seconds delay.

When the emergency stop button is pressed or the FENCE is open, the stop type of robot is Power-Off stop, Controlled stop, or Smooth stop. The configuration of stop type for each situation is called stop pattern. The stop pattern is different according to the option configuration.

There are the following 3 Stop patterns.

Stop pattern	Mode	Emergency stop button	External Emergency stop	FENCE open	SVOFF input	Deadman switch (*)
A	AUTO	P-Stop	P-Stop	C-Stop	C-Stop	-
	T1	P-Stop	P-Stop	-	C-Stop	P-Stop
	T2	P-Stop	P-Stop	-	C-Stop	P-Stop
C	AUTO	C-Stop	C-Stop	C-Stop	C-Stop	-
	T1	P-Stop	P-Stop	-	C-Stop	P-Stop
	T2	P-Stop	P-Stop	-	C-Stop	P-Stop
D	AUTO	S-Stop	S-Stop	C-Stop	C-Stop	-
	T1	S-Stop	S-Stop	-	C-Stop	S-Stop
	T2	S-Stop	S-Stop	-	C-Stop	S-Stop

P-Stop: Power-Off stop
C-Stop: Controlled stop
S-Stop: Smooth stop

-: Disable
(*) The stop pattern of NTED input is same as Deadman switch.

The following table indicates the Stop pattern according to the controller type or option configuration.

Option	R-30*i*B/ R-30*i*B Mate
Standard	A(**)
Controlled stop by E-Stop (A05B-2600-J570)	C(**)
Smooth E-Stop (A05B-2600-J651)	D(**)

(**)R-30*i*B Mate does not have SVOFF input.

The stop pattern of the controller is displayed in "Stop pattern" line in software version screen. Please refer to "Software version" in operator's manual of controller for the detail of software version screen.

"Controlled stop by E-Stop" option

When "**Controlled stop by E-Stop**" (A05B-2600-J570) option is specified, the stop type of the following alarms become Controlled stop but only in AUTO mode. In T1 or T2 mode, the stop type is Power-Off stop which is the normal operation of the system.

Alarm	Condition
SRVO-001 Operator panel E-stop	Operator panel emergency stop is pressed.
SRVO-002 Teach pendant E-stop	Teach pendant emergency stop is pressed.
SRVO-007 External emergency stops	External emergency stop input (EES1-EES11, EES2-EES21) is open.
SRVO-408 DCS SSO Ext Emergency Stop	In DCS Safe I/O connect function, SSO[3] is OFF.
SRVO-409 DCS SSO Servo Disconnect	In DCS Safe I/O connect function, SSO[4] is OFF.

Controlled stop is different from **Power-Off stop** as follows:

- In Controlled stop, the robot is stopped on the program path. This function is effective for a system where the robot can interfere with other devices if it deviates from the program path.
- In Controlled stop, physical impact is less than Power-Off stop. This function is effective for systems where the physical impact to the mechanical unit or EOAT (End Of Arm Tool) should be minimized.
- The stopping distance and time of Controlled stop is longer than those of Power-Off stop, depending on the robot model and axis.

When this option is loaded, this function cannot be disabled.

The stop type of DCS Position and Speed Check functions is not affected by the loading of this option.

> ⚠ **WARNING**
> The stopping distance and time of Controlled stop are longer than those of Power-Off stop. A risk assessment for the whole robot system which takes into consideration the increased stopping distance and stopping time, is necessary when this option is loaded.

"Smooth E-Stop Function" option

When "**Smooth E-Stop Function**" (A05B-2600-J651) option is specified, the stop type of the following alarms becomes Smooth stop in all operation modes (AUTO, T1 and T2 mode).

Alarm	Condition
SRVO-001 Operator panel E-stop	Operator panel emergency stop is pressed.
SRVO-002 Teach pendant E-stop	Teach pendant emergency stop is pressed.
SRVO-003 Deadman switch released	Both deadman switches on Teach pendant are released.

Alarm	Condition
SRVO-007 External emergency stops	External emergency stop input (EES1-EES11, EES2-EES21) is open.
SRVO-037 IMSTP input (Group: %d)	IMSTP input (*IMSTP signal for a peripheral device interface) is OFF.
SRVO-232 NTED input	NTED input (NTED1-NTED11, NTED2-NTED21) is open.
SRVO-408 DCS SSO Ext Emergency Stop	In DCS Safe I/O connect function, SSO[3] is OFF.
SRVO-409 DCS SSO Servo Disconnect	In DCS Safe I/O connect function, SSO[4] is OFF.
SRVO-410 DCS SSO NTED input	In DCS Safe I/O connect function, SSO[5] is OFF.
SRVO-419 DCS PROFIsafe comm. error	PROFINET Safety communication error occurs.

Smooth stop is different from **Power-Off stop** as follows:

- In Smooth stop, the robot is stopped along the program path. This function is effective for a system where the robot can interfere with other devices if it deviates from the program path.
- In Smooth stop, physical impact is less than Power-Off stop. This function is effective for systems where the physical impact to the mechanical unit or EOAT (End Of Arm Tool) should be minimized.
- The stopping distance and time of Smooth stop is longer than those of Power-Off stop, depending on the robot model and axis.

Smooth stop is different from **Controlled stop** as follows:

- The stopping distance and time of Smooth stop is normally shorter than those of Controlled stop, depending on the robot model and axis.

When this option is loaded, this function cannot be disabled.

The stop type of DCS Position and Speed Check functions is not affected by the loading of this option.

> ⚠ **WARNING**
> The stopping distance and time of Smooth stop are longer than those of Power-Off stop. A risk assessment for the whole robot system which takes into consideration the increased stopping distance and stopping time, is necessary when this option is loaded.

8 STOP TYPE OF ROBOT (R-30*i*B Plus, R-30*i*B Mate Plus)

There are following three types of Stop Category.

Stop Category 0 following IEC 60204-1 (Power-off Stop)

Servo power is turned off, and the robot stops immediately. Servo power is turned off when the robot is moving, and the motion path of the deceleration is uncontrolled.

"**Stop Category 0**" performs following processing.

- An alarm is generated, and then the servo power turns off. Instantly the robot stops.
- Execution of the program is paused.

Frequent Category 0 Stop of the robot during operation can cause mechanical problems of the robot.
Avoid system designs that require routine or frequent Category 0 Stop conditions.

Stop Category 1 following IEC 60204-1 (Controlled Stop, Smooth Stop)

The robot is decelerated until it stops, and servo power is turned off.

"**Stop Category 1**" performs following processing.

- The alarm "**SRVO-199 Controlled stop**" or "**SRVO-289 Smooth Stop**" occurs along with a decelerated stop. The program execution is paused.
- An alarm is generated, and then the servo power turns off.

In Smooth stop, the robot decelerates until it stops with the deceleration time shorter than Controlled stop. The stop type of Stop Category 1 is different according to the robot model or option configuration. Please refer to the operator's manual of a particular robot model.

Stop Category 2 following IEC 60204-1 (Hold)

The robot is decelerated until it stops, and servo power remains on.
"**Stop Category 2**" performs following processing.

- The robot operation is decelerated until it stops. Execution of the program is paused.

⚠ WARNING

1 The stopping distance and time of Stop Category 1 are longer than those of Stop Category 0. A risk assessment for the whole robot system which takes into consideration the increased stopping distance and stopping time is necessary when Stop Category 1 is used. Please refer to the operator's manual of a particular robot model for the data of stopping distance and time.
2 In multi arm system, the longest stopping distance and time of Stop Category 1 among each robot are adopted as those for the system. A risk assessment for the whole robot system which takes into consideration a possibility that the stopping distance and time increase, is necessary on the multi arm system.
3 In the system which has extended axis, the longer stopping distance and time of Stop Category 1 among robot and extended axis are adopted as those for the system. A risk assessment for the whole robot system which takes into consideration a possibility that the stopping distance and time increase, is necessary on the system which has extended axis. Please refer to the extended axis setup procedure of the controller operator's manual for considering the stopping distance and time of the extended axis.
4 When Stop Category 1 occurs during deceleration by Stop Category 2, the stop type of robot is changed to Stop Category 0.
5 In case of Stop Category 1, motor power shutdown is delayed for a maximum of 2 seconds. In this case, a risk assessment for the whole robot system is necessary, including the 2 seconds delay.

When the emergency stop button is pressed or the FENCE is open, the stop type of robot is Stop Category 0 or Stop Category 1. The configuration of stop type for each situation is called *stop pattern*. The stop pattern is different according to the option configuration.

There are the following 3 Stop patterns.

Stop pattern	Mode	Emergency stop button	External Emergency stop	FENCE open	SVOFF input	Deadman switch (*)
A	AUTO	Category 0	Category 0	Category 1	Category 1	-
	T1	Category 0	Category 0	-	Category 1	Category 0
	T2	Category 0	Category 0	-	Category 1	Category 0
C	AUTO	Category 1	Category 1	Category 1	Category 1	-
	T1	Category 0	Category 0	-	Category 1	Category 0
	T2	Category 0	Category 0	-	Category 1	Category 0
D	AUTO	Category 1	Category 1	Category 1	Category 1	-
	T1	Category 1	Category 1	-	Category 1	Category 1
	T2	Category 1	Category 1	-	Category 1	Category 1

Category 0: Stop Category 0
Category 1: Stop Category 1
-: Disable
(*) The stop pattern of NTED input is same as Deadman switch.
The following table indicates the Stop pattern according to the controller type or option configuration.
The case R651 is specified.

Option	R-30*i*B Plus/ R-30*i*B Mate Plus
Standard	C(**)
Old Stop Function (A05B-2670-J680)	A(**)
All Smooth Stop Function (A05B-2670-J651)	D(**)

The case R650 is specified.

Option	R-30*i*B Plus/ R-30*i*B Mate Plus
Standard	A(**)
Stop Category 1 by E-Stop (A05B-2670-J521)	C(**)
All Smooth Stop Function (A05B-2670-J651)	D(**)

(**)R-30*i*B Mate Plus does not have SVOFF input.

The stop pattern of the controller is displayed in "Stop pattern" line in software version screen. Please refer to "Software version" in operator's manual of controller for the detail of software version screen.

"Old Stop Function" option

When "**Old Stop Function**" (A05B-2670-J680) option is specified, the stop type of the following alarms becomes Stop Category 0 in AUTO mode.

Alarm	Condition
SRVO-001 Operator panel E-stop	Operator panel emergency stop is pressed.
SRVO-002 Teach pendant E-stop	Teach pendant emergency stop is pressed.
SRVO-007 External emergency stops	External emergency stop input (EES1-EES11, EES2-EES21) is open.
SRVO-408 DCS SSO Ext Emergency Stop	In DCS Safe I/O connect function, SSO[3] is OFF.
SRVO-409 DCS SSO Servo Disconnect	In DCS Safe I/O connect function, SSO[4] is OFF.

Stop Category 0 is different from **Stop Category 1** as follows:

- In Stop Category 0, servo power is turned off, and the robot stops immediately. Servo power is turned off when the robot is moving, and the motion path of the deceleration is uncontrolled.
- The stopping distance and time of Stop Category 0 is shorter than those of Stop Category 1, depending on the robot model and axis.

When this option is loaded, this function cannot be disabled.

The stop type of DCS Position and Speed Check functions is not affected by the loading of this option.

"All Smooth Stop Function" option

When "**All Smooth Stop Function**" (A05B-2670-J651) option is specified, the stop type of the following alarms becomes Stop Category 1 in all operation modes (AUTO, T1 and T2 mode).

Alarm	Condition
SRVO-001 Operator panel E-stop	Operator panel emergency stop is pressed.
SRVO-002 Teach pendant E-stop	Teach pendant emergency stop is pressed.
SRVO-003 Deadman switch released	Both deadman switches on Teach pendant are released.
SRVO-007 External emergency stops	External emergency stop input (EES1-EES11, EES2-EES21) is open.
SRVO-037 IMSTP input (Group: %d)	IMSTP input (*IMSTP signal for a peripheral device interface) is ON.
SRVO-232 NTED input	NTED input (NTED1-NTED11, NTED2-NTED21) is open.
SRVO-408 DCS SSO Ext Emergency Stop	In DCS Safe I/O connect function, SSO[3] is OFF.
SRVO-409 DCS SSO Servo Disconnect	In DCS Safe I/O connect function, SSO[4] is OFF.
SRVO-410 DCS SSO Ext Emergency Stop	In DCS Safe I/O connect function, SSO[5] is OFF.
SRVO-419 DCS PROFIsafe comm. error	PROFINET Safety communication error occurs.

Stop Category 1 is different from **Stop Category 0** as follows:

- In Stop Category 1, the robot is stopped along the program path. This function is effective for a system where the robot can interfere with other devices if it deviates from the program path.
- In Stop Category 1, physical impact is less than Stop Category 0. This function is effective for systems where the physical impact to the mechanical unit or EOAT (End of Arm Tool) should be minimized.
- The stopping distance and time of Stop Category 1 is longer than those of Stop Category 0, depending on the robot model and axis.

When this option is loaded, this function cannot be disabled.

The stop type of DCS Position and Speed Check functions is not affected by the loading of this option.

> ⚠ **WARNING**
> The stopping distance and time of Stop Category 1 are longer than those of Stop Category 0. A risk assessment for the whole robot system which takes into consideration the increased stopping distance and stopping time, is necessary when this option is loaded.

"Stop Category 1 by E-Stop" option

When "**Stop Category 1 by E-Stop**" (A05B-2670-J521) option is specified, the stop type of the following alarms become Category 1 Stop but only in AUTO mode. In T1 or T2 mode, the stop type is Category 0 Stop which is the normal operation of the system.

Alarm	Condition
SRVO-001 Operator panel E-stop	Operator panel emergency stop is pressed.
SRVO-002 Teach pendant E-stop	Teach pendant emergency stop is pressed.
SRVO-007 External emergency stops	External emergency stop input (EES1-EES11, EES2-EES21) is open.
SRVO-408 DCS SSO Ext Emergency Stop	In DCS Safe I/O connect function, SSO[3] is OFF.
SRVO-409 DCS SSO Servo Disconnect	In DCS Safe I/O connect function, SSO[4] is OFF.

Stop Category 1 is different from **Stop Category 0** as follows:

- In Stop Category 1, the robot is stopped along the program path. This function is effective for a system where the robot can interfere with other devices if it deviates from the program path.

- In Stop Category 1, physical impact is less than Stop Category 0. This function is effective for systems where the physical impact to the mechanical unit or EOAT (End of Arm Tool) should be minimized.
- The stopping distance and time of Stop Category 1 is longer than those of Stop Category 0, depending on the robot model and axis.

When this option is loaded, this function cannot be disabled.

The stop type of DCS Position and Speed Check functions is not affected by the loading of this option.

> ⚠ **WARNING**
> The stopping distance and time of Stop Category 1 are longer than those of Stop Category 0. A risk assessment for the whole robot system which takes into consideration the increased stopping distance and stopping time, is necessary when this option is loaded.

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TABLE OF CONTENTS

1 PREFACE

Interference Check is for avoiding interference between a robot and its peripheral object by monitoring the distance between them in real time. It is necessary to set data (shape, size, position and so on) of robot and its peripheral object in advance.

There are Basic Interference Check and Intelligent Interference Check as Interference Check function. Please choose either of the two according to your purpose.

Basic Interference Check (R761)	Basic Interference Check monitors the distance from the tool or arm of a robot to a defined object in real time to avoid interference.
Intelligent Interference Check (R759)	Intelligent Interference Check includes all the functionality of Basic Interference Check plus adds real-time interference checking between robots within a controller or across controllers using Ethernet communication. Additionally, following functions for preventing interference are added. - Approach Waiting - Deadlock Prevention - RailZone Interference Check

NOTE
If you would like to check interference between robots, Intelligent Interference Check (R759) is necessary.

NOTE
If you would like to use RailZone, Intelligent Interference Check (R759) and Ethernet Global Data (R793) are necessary.

NOTE
If you use 4D Graphics (R764), it is possible to display the information (Model data and so on) is used by Interference Check on 4D Graphics.

2 OUTLINE

In Basic Interference Check, you can use the following function.

2.1. Interference Check (between a robot and a fixture)

In Intelligent Interference Check, you can use the following function.

2.1. Interference Check (between a robot and a fixture, between robots)
2.2. Approach Waiting function
2.3. Deadlock Prevention function
2.4. RailZone function

This section describes the outline about these functions.

2.1 INTERFERENCE CHECK FUNCTION

In Basic Interference Check, it is possible to check only between a robot and a fixture.
In Intelligent Interference Check, it is possible to check between robots in addition to that.

Item Common to Both Basic Interference Check and Intelligent Interference Check

1. Interference Check control is exercised over the following three types of objects: robot arm, hands, and fixture.
2. You can set multiple hands and switch to a desired hand by associating its number with a tool coordinate number.
3. Use spheres and cylinders to make an approximation to the figure of each of the robot arm, hands, and fixture. (Set representative points of each figure and the distance including the figure of each of the arm, tool, and fixture.)
4. You can set a model of hand, fixture up to 10 by default.
5. Robot arm model is set by default.
6. You can set a device installed on the robot arm such as a wire send-supply unit as an extension of the robot arm figure setting.
7. You can use copy model data set on a controller to one of other controller by using copy function.
8. You can set multiple combinations of objects over which Interference Check control is to be exercised (robots including hands, and a robot and fixture). It is possible to set combination up to 10 by default.
9. You can select a combination type from “Robot+Hand”, “Fixture”, “Critical Zone”, “Virtual Fence”, “DO Only” and “PLC DIN”. In Basic Interference Check, you can not select “Robot+Hand”.
10. When Interference Check combination type is Rob+Hnd or Fixture, number of model sets must not exceed 8 in this category.
11. When Interference Check combination type is Cr Zone, V Fence, DO Only or PLC DIN, number of model sets must not exceed 8 in this category.
12. If a robot is in the approach status, an alarm occurs, and the robot decelerates, and then stops. If there is a possibility that the robot will cause a collision after decelerating, then stopping, however, immediate stop is performed.
13. To teach the positional relationships among multiple robots, a calibration function is available. Perform calibration for each pair of robots. Make the TCPs of two robots touch at three different points and teach each position to determine the positional relationship between the robots. You can also enter numeric values directly. For more than two robots, determine a reference robot and perform calibration for another robot based on the reference robot.
14. If the operation speed of a robot is fast, this function detects the approach earlier than usual to avoid collisions.

15. When a model is in the approach status, pressing the RESET key, and then releasing it while holding the SHIFT key down disables the Interference Check function. The function remains disabled until the SHIFT key is released or program execution operation is performed. Use this operation if models cannot be released from the approach status because the distance between the models is decreased by jog feed in any direction. If no model is in the approach status and SHIFT + RESET operation is performed, this function is not performed (the Interference Check function is not disabled).

Difference between Basic Interference Check and Intelligent Interference Check

1. In only Intelligent Interference Check, you can select “Robot+Hand” as the type of Interference Check combination.
2. In Intelligent Interference Check, when you select “Fixture”, you can use DI to specify whether to enable or disable the Interference Check function for each combination.
3. In Basic Interference Check, it is possible to use only Comb Pair Enable/Disable instruction.

2.2 APPROACH WAITING FUNCTION

Approach Waiting function exercises approach-waiting control as follows:

1. Under approach waiting control, when the distance to the specified monitoring target reaches the specified distance (approach waiting distance), the robot automatically decelerates, and then stops. The robot waits until the distance to the monitoring target is increased (this status is called the approach waiting status).
2. You can specify the following three types of objects: another robot arm, hand, and fixture as monitoring targets of approach waiting control.
3. You can set multiple monitoring targets of approach waiting control. However, number of model sets must not exceed 8.
4. Set the approach waiting distance for each of another robot arm, hand, and fixture specified as monitoring targets of approach waiting control. Set the distance to each monitoring target based on the figure of the robot arm, hand, or fixture set for Interference Check control as the approach waiting distance.
5. Use program instructions to specify the operating range in which approach waiting control is to be applied.
6. If a robot enters the approach status in the operating range in which approach waiting control is applied, the robot automatically decelerates, then stops. When the distance to the monitoring target is increased after that, operation can automatically be restarted.
7. Within the operating range in which approach-waiting control is applied, you can use the status screen to check the current distance and shortest approach distance to each monitoring target.
8. If the operation speed of a robot is fast, this function detects the approach earlier than usual to avoid collisions.

2.3 DEADLOCK PREVENTION FUNCTION

Deadlock Prevention function analyzes specified TP programs and finds the overlapped motion space and insert instructions for controlling the entry to the space into TP programs.

1. You can specify TP programs that are executed at the same time on Deadlock Prevention Schedule.
2. Specified programs are analyzed by Deadlock Prevention function.
3. If there is overlapped motion space among specified programs, instructions for controlling the entry to the space is inserted into specified programs. When one robot enters the space, the other robots can not enter the space by inserted instructions.

2.4 RAILZONE FUNCTION

RailZone prevents interference between robots on the same rail. EtherNet Global Data option is necessary for using RailZone function. If you use RailZone function, it is not possible to use other Interference Check functions (Interference Check, Approach Waiting, and Deadlock Prevention).

1. You can set the zone which moves with a robot on the rail.
2. RailZone function checks adjacent boundaries of zone on the same rail. If the distance between adjacent boundaries becomes shorter than a certain value, a robot decelerates and waits until the adjacent robot is left. The robot resumes automatically when the adjacent robot is left.
3. The zone is automatically increased if robot posture and/or robot tooling extends beyond the user-defined minimum zone boundaries.

2.5 RESTRICTIONS

- It is necessary to use Intelligent Interference Check in order to check between robots.
- When you check between robots across controllers in Intelligent Interference Check, the software versions of all robot controllers that participate in the communication must be the same.
- Interference Check does not work correctly in Tracking motion.
- Automatic stop/restart by Approach Waiting function does not function during the following operations:
  - Follow-up operation of the slave by robot link synchronization
  - Use of the continuous rotation function
- Even if Constant Path function is enabled, when the approach is detected near the CNT motion corner and the robot is decelerated, the path during the deceleration will become nearer to the corner taught point.

3 SETTINGS

For Interference Check function, settings can roughly be divided into the following types:

- **Network setting**
- **Calibration setting**
- **Model setting**
- **Combination setting**
- **Approach waiting setting**
- **Deadlock Prevention setting**
- **RailZone setting**

This chapter explains each type of setting and how to make each setting.

NOTE
In Basic Interference Check, it is not possible to check interference across controllers. Therefore it is not necessary to set network for Interference Check function. Please start from Calibration setting.

NOTE
When you use Intelligent Interference Check to check interference across controllers, it is necessary to set network.
When you use Intelligent Interference Check on a single controller, it is not necessary to set network for Interference Check function. Please start from Calibration setting.

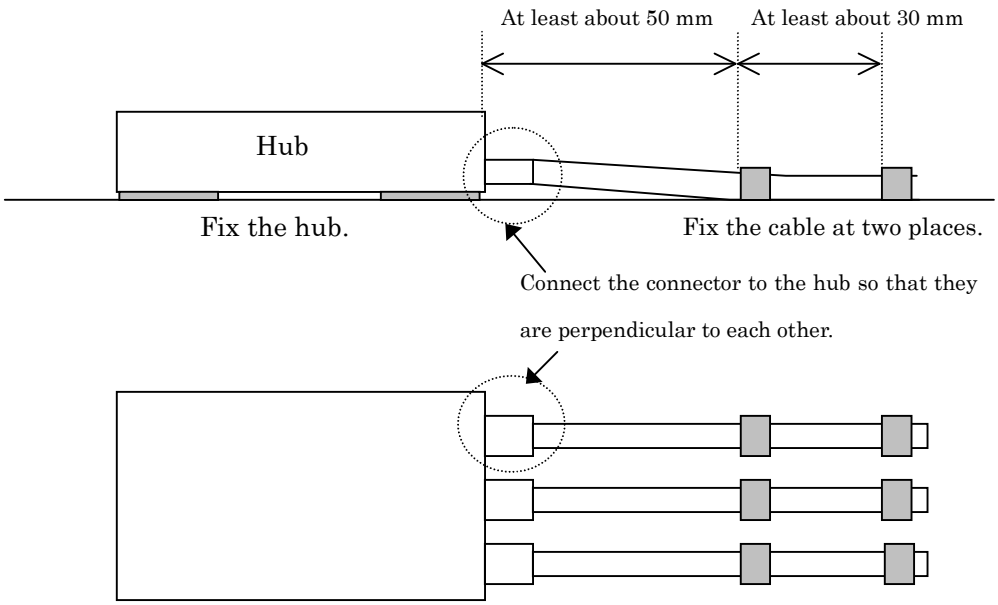
3.1 NETWORK

3.1.1 Wiring and Connection

3.1.1.1 Environment

- For Ethernet cables, use twisted pair cables for 10BASE-T that are protected against noise.
  For details, refer to APPENDIX D, "CABLE CONNECTION," in the Ethernet Function OPERATOR'S MANUAL (B-82974EN).
- A hub (concentrator) is required for constructing a network. Use a switching hub.
  To protect the robot link network against noise generated from the main line, use of a switching hub with no shield (metal) on the modular connectors is recommended.
- For Ethernet cables, use cross cables for two robots for which no switching hub is used. Use straight cables for three or more robots for which a switching hub is used.

- Run the Ethernet cables so that each cable can make a good contact with the hub.
  For example, install the Ethernet cables and hub as follows:

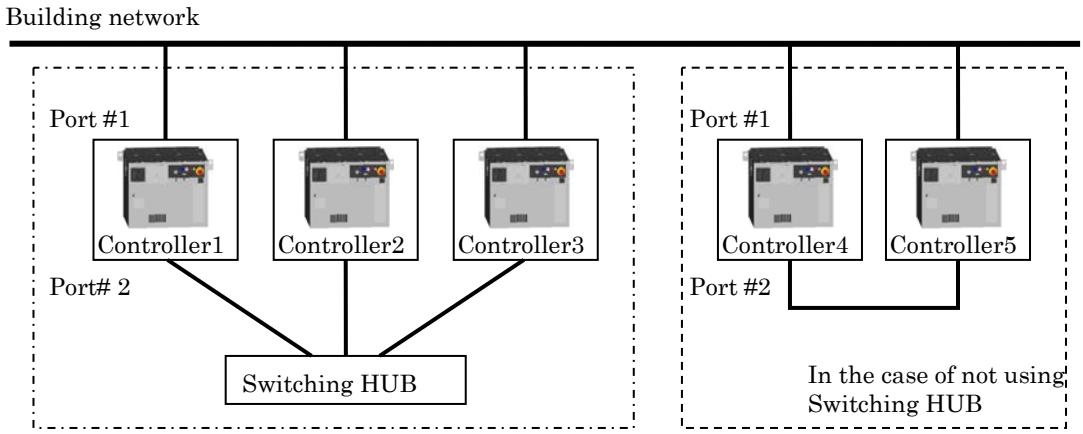


- Install the hub in an environment according to the specifications of the hub manufacturer. For example, the hub must be installed in a dustproof location that is free from vibrations.
- Full protection against noise is required.
  For details, refer to APPENDIX D, "CABLE CONNECTION" in the Ethernet Function OPERATOR'S MANUAL (B-82974EN).

The customer must prepare the cables and hub. Purchasing spares is recommended.

⚠ **CAUTION**
Interference check transmits a significant amount of information between controllers. If the interference check information is shared on a building network, it can be disruptive to other network traffic, or interference check performance might be impeded by other network traffic, which could allow a collision. For this reason, FANUC recommends to isolate interference check traffic on a local network. Two Ethernet ports are available, so each controller can be connected to both a wide-area network for general plant use and a local network for interference check communication.

- Configure the Ethernet network as follows in the configuration shown in the figure below, the controllers connect to the building network on Port #1, and form a RIPE ring using Port #2, so that the building network and interference check RIPE ring can be isolated from each other.



- RIPE (Ros Interface Packets over Ethernet) is used for a communication between controllers. It is necessary to set RIPE when you use Intelligent Interference Check across controllers. For details, refer to APPENDIX D, "ROS INTERFACE PACKETS OVER ETHERNET (RIPE)" in the Ethernet Function OPERATOR'S MANUAL (B-82974EN).

3.1.1.2 Notes

Basic notes on using Interference Check function are listed below. Your system must satisfy the following requirements at the minimum. You yourself need to add measures according to the safety standards for your system if required.

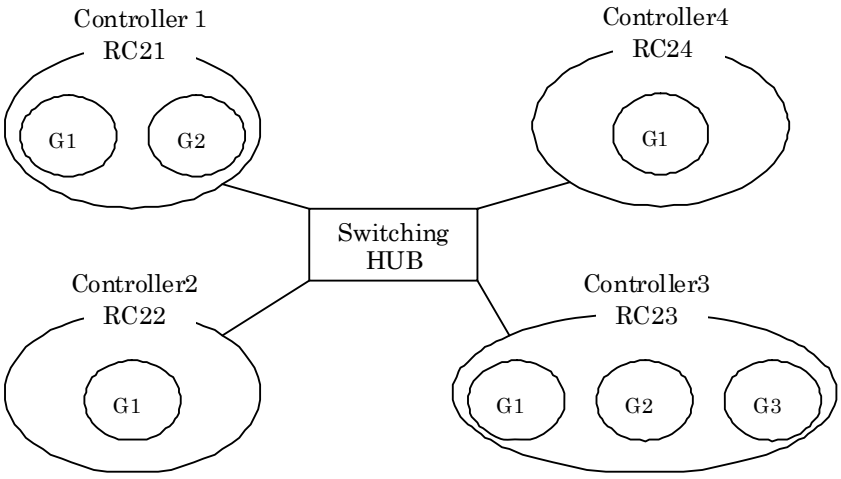
- The robot link network must completely be separated from the main Ethernet line. If not so, an unexpected robot connected to Ethernet may detect the approach.
- The Ethernet cables must be routed so that they will not be broken by any factor. For example, a worker may stumble over a cable, resulting in a break in the cable. Full protection against noise is required.
- The Ethernet cables must be routed so that noise **will not affect** them. Therefore, do not route any Ethernet cable near what is apt to cause noise.
- The power cable to the switching hub must be routed so that no worker will stumble over the cable and disconnect it.
- Consider the Ethernet cable routing and location where the switching hub is to be installed so that the connector of each cable can make a good contact with the hub. If the contact is poor, good communication cannot be established and wrong approach may be detected.
  This requirement is very important. Take great care.
- When an Ethernet cable is connected to the hub and the other end of the cable is inserted into the Ethernet cable socket on the main board on a robot controller, the orange LED on the printed circuit board at the back of the socket glows. At this time, the power to both the hub and robot controller must be on. If the LED does not glow, the main board may be faulty. Contact the FANUC Service Center.
- The front panel of the hub has an LED indicating the communication status. If the approach is not detected normally, this LED must be checked. For this reason, install the hub so that the LED can be checked easily.
- On the TCP/IP setting screen, the correct IP addresses and host names must be set. If not so, an unexpected robot connected to Ethernet may detect the approach.
  Check in particular that the common host name and IP address are used for each robot on the robot

link network. For example, assume that there are three robots A, B, and C. If robot B recognizes robot A with host name RC21, but robot C recognizes robot A with host name RC31, these robots does not operate normally. The same applies to the IP address.

- RIPE communication must be configured. Otherwise, interference checking cannot be performed. See the chapter titled "SETTINGS" in this manual for instructions to configure RIPE configuration.
- The settings on the robot link calibration screen must be correct and precise calibration must be performed. If not so, wrong approach may be detected or a robot may cause interference because it cannot detect the approach.

3.1.2 Settings

Intelligent Interference Check function uses Ethernet to share robot positions across controllers. Settings for using Ethernet must be made first.
This section explains how to make the settings using the following system configuration as an example:



Controller 1 is a two-group system. Its host name is RC21.
Controller 2 is a one-group system. Its host name is RC22.
Controller 3 is a three-group system. Its host name is RC23.
Controller 4 is a one-group system. Its host name is RC24.

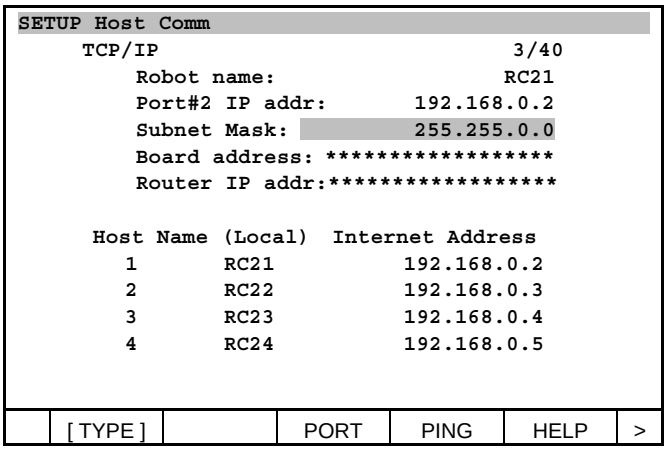
3.1.2.1 Setting the host names, internet (IP) addresses, and subnet mask

Display the host communication setting screen, then the TCP/IP menu. On this setting screen, the following items must be set:

- Node name of the local controller
- Subnet mask
- Port #2 IP address. If Port #1 will be used for RIPE communication, configure Port #1 IP address instead.
- Node names and IP addresses of all controllers (including the local controller)

> ⚠ **CAUTION:**
> Characters must be entered to set the items on this screen. If an entered character string contains a space (blank) (leading spaces are difficult to check in particular), communication cannot be performed properly. In this case, delete the entire line, and then reenter a character string.

Sample settings are shown below:



NOTE

When the IP address is set, the IP address of the port used in the communication of robots needs to be continuous number for RIPE setting. The controller which is set the first IP address of continuous number becomes Master of RIPE.

- The node name and Internet (IP) addresses must be unique in the system. Specify any desired name that is easy-to-understand.
- Make the above settings on all robot controllers on the robot link network. Only the settings for "Node name" and "Board address" differ depending on the controller.

3.1.2.2 Setting the full duplex mode (for each robot controller)

Set each robot controller to the full duplex mode. Set system variable $ENETMODE.$FULL_DUPLEX to TRUE.

3.1.2.3 Setting the full duplex mode (for the hub)

When the hub has a DIP switch for switching between full duplex and half duplex, set the switch to the full duplex mode. Some switching hub automatically switches between full duplex and half duplex. For an ordinary hub, the half duplex mode is set by default, so the full duplex mode must be set.

3.1.3 Checking the Network-Related Settings

After setting the above items, check the following items to confirm that the settings are correct:

1. Check whether an Ethernet cable is connected between the Ethernet switch and each robot controller. (or directly between controllers if there are only two.)

   If no cable is connected, connect a cable.

2. When the power to the hub and robot controllers are on, check whether the green LEDs on the printed circuit board at the back of the Ethernet cable socket on the main board in each robot controller glows.

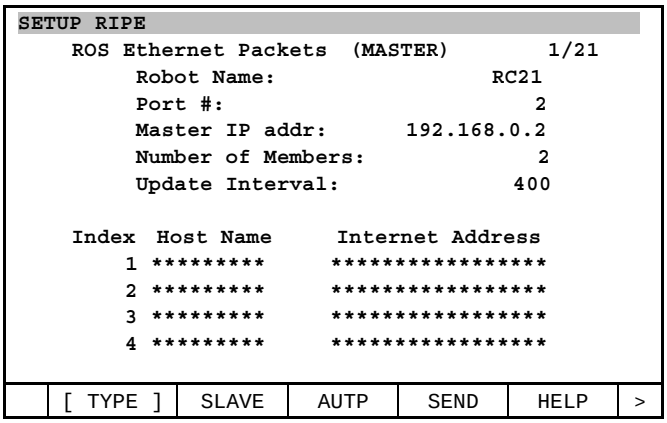
   If the LED does not glow, reinsert the cable, and turn the power to the hub and controller off, then on again. If the LED still does not glow, the main board may be faulty. Contact the FANUC Service Center.

3.1.4 Configuring RIPE

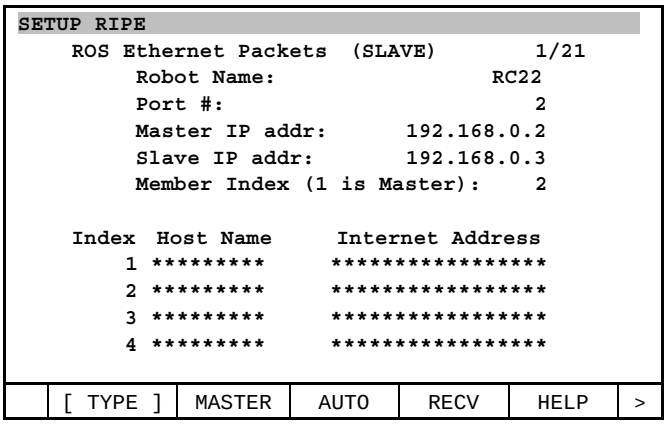
Interference Check uses RIPE (ROS Internet Packets over Ethernet) to share positions between one controller and another. Before intelligent interference check can be used, RIPE must be configured.
RIPE uses a “Master” controller which serves to coordinate the RIPE network ring, and one or more “Slave” controllers which share the RIPE ring.
RIPE can be configured automatically using the below procedure. RIPE configuration should be done after the host name, Port #2 IP address, and Port #2 subnet mask are configured in TCP/IP menu of Host Comm.
For details of RIPE setup and operations, please refer to APPENDIX D, “ROS INTERFACE PACKETS OVER ETHERNET (RIPE)” in the Ethernet Function OPERATOR’S MANUAL (B-82974EN).

Procedure RIPE setting

1. Press the MENU key.
2. Select [6 SETUP]
3. Select [Host Comm]. The master Host Comm menu will be displayed.
4. Move the cursor to RIPE and press F3 [DETAIL] to enter the RIPE setup menu. SETUP RIPE display for MASTER of RIPE is displayed. If Master IP addr is *, return Host Comm menu and select RIPE again.



5. Press F2[SLAVE]. The following screen is displayed.



6. Please confirm that IP address of each controller is continuous number. The controller set the top IP address of continuous number become MASTER for RIPE by following setup and the other controllers become SLAVE for RIPE.
   For example, in a case of 3.1.2.1, the controller set 192.168.0.2 become MASTER.

7. Set up the Controller as SLAVE by following procedure on “ROS Ethernet Packets (SLAVE)” menu.
   7.1. Set IP address of MASTER controller to “Master IP addr:” Select the controller set the f IP address of continuous number as MASTER.
   7.2 Set “Member Index. Input the IP address order of this robot controller from the top. According to this order setting, [Slave IP addr] is set automatically. Verify that the displayed IP address and the IP address which you assigned to this controller are same.
   7.3. After finishing the above procedure, press F3 AUTO.
   7.4. You will be asked whether this controller can cycle the power after receiving data, then press F3 YES.
8. Set up the Controller as MASTER by following procedure on “ROS Ethernet Packets (MASTER)” menu.
   8.1. Set up “Port #”. Input the port number is used for RIPE.
   8.2. Set up “Number of Members”. Input the number of controllers which join the ring.
   8.3. Set the Update Interval. 400ms is acceptable.
   8.4. Press F3 AUTO on the MASTER controller.
   8.5. When “Put all SLAVES in AUTO mode” is displayed, enter F4[CONTINUE].
   8.6. When Cycle power for setting to take effect?” is displayed, select YES to automatically cycle power and install RIPE configuration on all controllers in RIPE ring.

3.2 CALIBRATION

It is necessary to set the positional reference of robots by CALIBRATION in Interference Check. Calibration must be performed as many times as the number of robots because all robots are required to know the position of the reference coordinate system.
This section explains calibration data and then how to calibrate between robots.

NOTE
Even if you use one robot and Basic Interference Check, you need to set up the Manager and Member on Calibration Setup.

3.2.1 Calibration Data

As specific setting Calibration data, set the position (X, Y, Z) of the origin and posture (W, P, R) of the calibration coordinate system viewed from the world coordinate system of the reference robot.

Sample calibration data

Assume that two robots are installed as shown in Fig. 3.2.1(a). The zero points of these robots are deviated from each other by 3000 mm horizontally (X-axis direction). There is no deviation vertically (Z-axis direction) or perpendicularly (Y-axis direction). The following shows calibration data when R1 is set as the reference robot in this status:

Data to be set for R2 when R1 is set as the reference robot
(X, Y, Z, W, P, R) = (3000, 0, 0, 0, 0, 180)

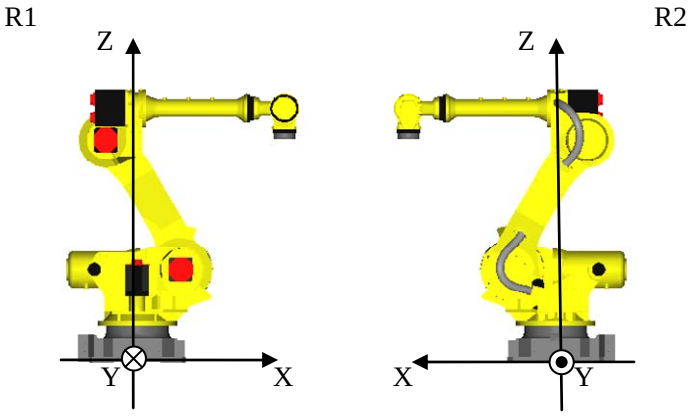


Fig. 3.2.1(a) Example of Calibration 1

Assume that two robots are installed as shown in Fig. 3.2.1(b). The zero points of these robots are deviated from each other by 2000 mm perpendicularly (Y-axis direction). There is no deviation vertically (Z-axis direction) or horizontally (X-axis direction). The following shows calibration data when R1 is set as the reference robot in this status:

Data to be set for R2 when R1 is set as the reference robot
(X, Y, Z, W, P, R) = (0, -2000, 0, 0, 0, 0)

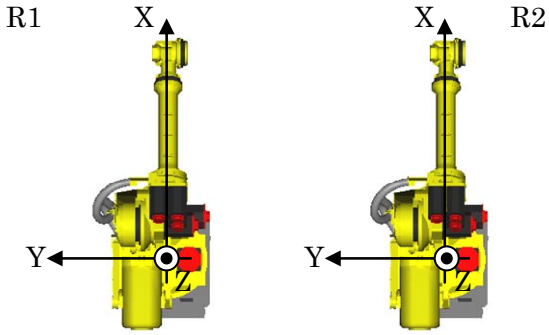


Fig. 3.2.1(b) Example of Calibration 2

3.2.2 Setting Calibration Data

You can calibrate by Direct Input Method or Three Point Method. When you use Direct Input Method, you need to enter the numeric values indicating the position and posture of the world coordinate system of a calibration robot viewed from a reference robot. When you use Three Point Method, you need to teach the same three points on each robot.

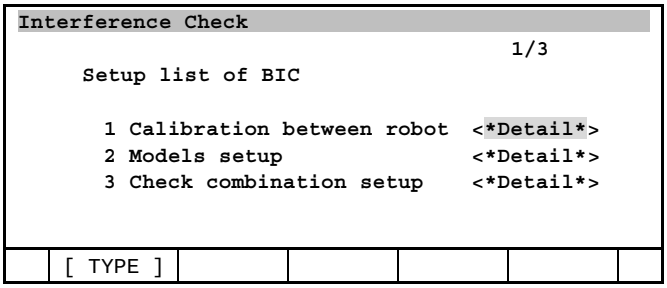
3.2.2.1 Calibration by direct input method

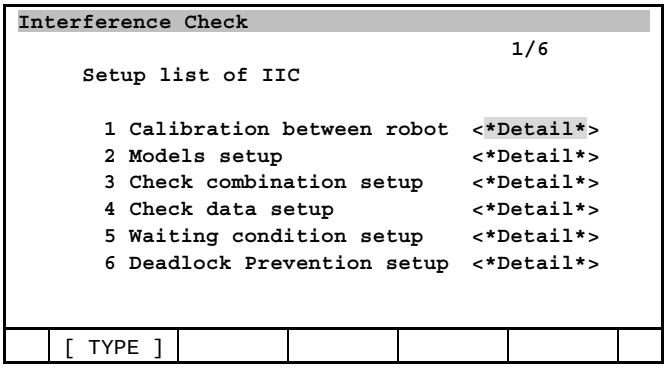
If you know the positional reference between robots in advance, you can use Direct Input Method.

Procedure of Direct Input Method

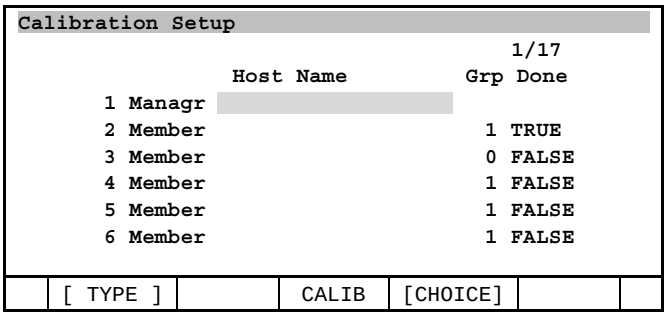
1. Press the MENU key.
2. Select SETUP.

3. Press F1[TYPE] and select “Interference”. The following (Up: Basic Interference Check, Bottom: Intelligent Interference Check) is displayed.

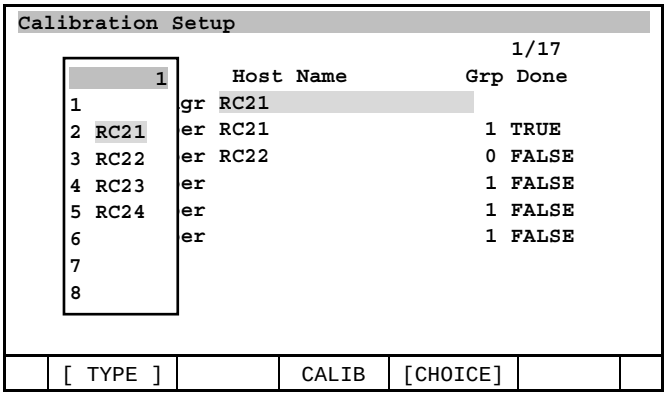




4. Position the cursor on <*DETAIL*> of “Calibration between robot” and press the Enter key. The following is displayed. Set up the Manager and Member of Interference Check.



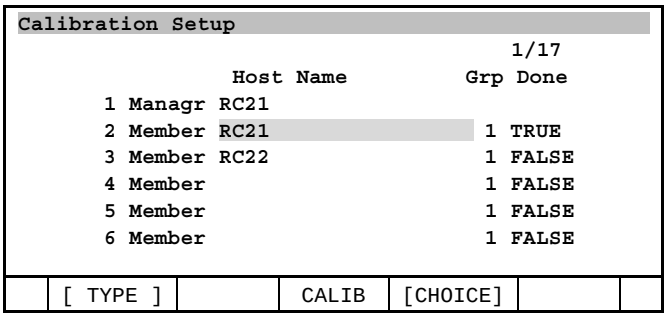
5. Press the [CHOICE] key. The list of host name is used by RIPE is appeared.



For the Manager Host Name the first name on the list should be chosen. Also use this host name for the first Member robot. The robots are members of the ring of robots that can be calibrated for Interference Check. The first Member robot is the reference robot for all robot calibration. The

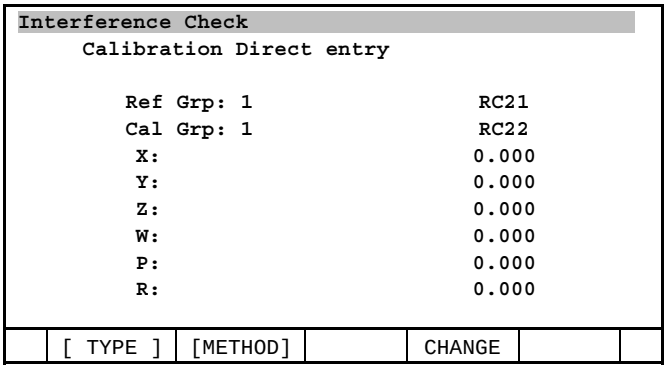
Calibration data for all other robots will be that robot position in the reference robot world frame. In this example the reference robot is Group 1 in the controller with host name RC21.

NOTE
The first Member host name, on line 2, must be the same as the Manager host name. When the first member robot host name is entered the DONE field becomes TRUE because this robot is the reference robot and does not need calibration data.

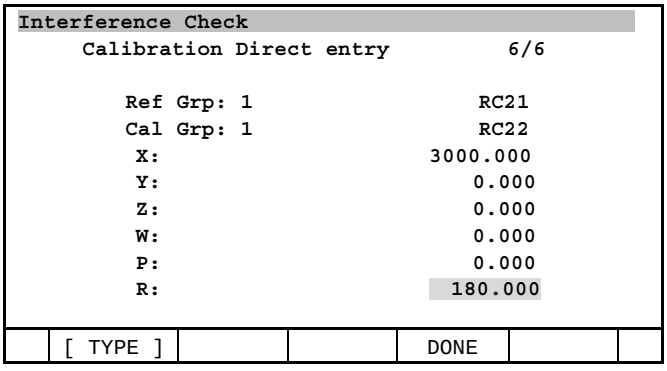


Repeat selecting the host names for all robot groups that will be calibrated.

6. After set the host name and the group numbers, select the group number for the robot you would like to calibrate and press F3 [CALIB] and then the following is displayed.



7. Press F4[CHANGE] to bring the screen for direct entry of calibration parameters. Cursor to the value associated with each element, X, Y, Z, W, P, R and enter the appropriate value. This is the location of the calibration robot world frame as seen from the reference robot world frame. When finished, press F4[DONE].



8. When finished, press F4[DONE]. A screen similar to the following should appear. “Done” field has change to TRUE indicating that the robot has been successfully calibrated to the reference robot.

```
Calibration Setup
                                                    1/17
                    Host Name                 Grp Done
      1 Managr RC21
      2 Member RC21                             1 TRUE
      3 Member RC22                             1 TRUE
      4 Member                                  1 FALSE
      5 Member                                  1 FALSE
      6 Member                                  1 FALSE

    [ TYPE ]          CALIB    [CHOICE]
```

3.2.2.2 Calibration by three point method

The positional relationships between two robots (reference robot and robot to be calibrated) can be determined by checking the positions of appropriately selected three points in the work area common to both robots that are seen in the world coordinate system of each robot. The three points used for determining the positional relationships between robots are called reference positions below.

Note the following points on selecting reference positions because the selected reference positions affect the precision of calibration:

- Avoid selecting a posture with which the precision of the absolute position of a robot is relatively low (near an operating area limit or specific point) as much as possible.
- If the selected reference positions are close or three reference positions are in line, the error generated through calculation for determining the positional relationships becomes larger. As a guide, for reference positions, select the vertexes of a triangle whose sides are about 1 m long so that both robots will not assume an unnatural posture at each position as much as possible.

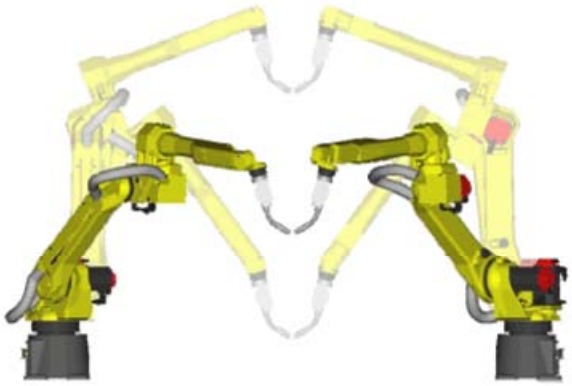


Fig. 3.2.2.2 (a) Example of robots touching TCPs

Fig. 3.2.2.2 (b) Example of robots touching the same points on a fixture

The points are recorded separately for each robot, so there are two method of teaching the reference points and the calibration points:

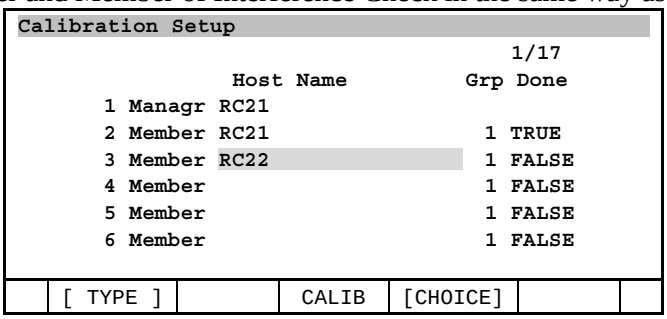
- The points can be where the robot TCPs are touching each other.
- The points can be where the robot TCPs are touching the same points in space, such as a mark or target on a fixture. It is essential that the order of the points be the same for each robot.

About TCP for Setting Calibration

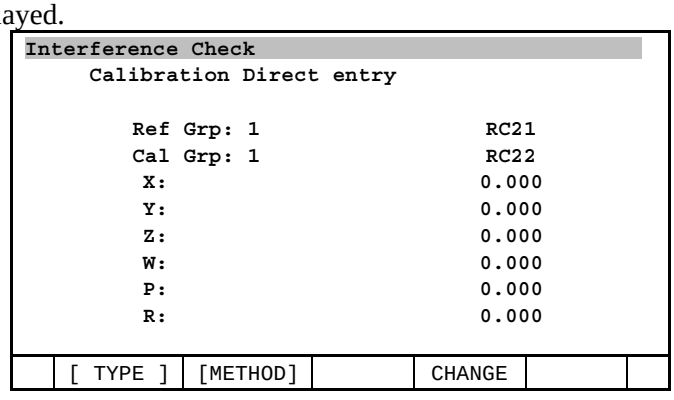
Calibration TCPs are used for teaching reference positions. In normal cases, attach an appropriate fixture (calibration fixture) with which reference positions can easily be taught to a robot and set a TCP at the end of the fixture. You can use a calibration fixture of any shape, which is convenient to teach reference positions, and will not be bent by a posture of the robot. A needle-shaped fixture can be thought of as a simple example, but a fixture pointed sharper than needed is dangerous. Round the tip and carefully handle the fixture to give due consideration to safety.
You need not prepare calibration fixtures unless teaching reference positions is hindered. You can use mechanical interface and hand TCPs in place of calibration TCPs.
Set TCPs on the ordinary TCP setting screen using the three-point teaching method or direct teaching method. The TCP setting precision greatly affects the precision of calibration. Set TCPs as precisely as possible, checking them with posture jog feed.

Procedure of Three Point Method

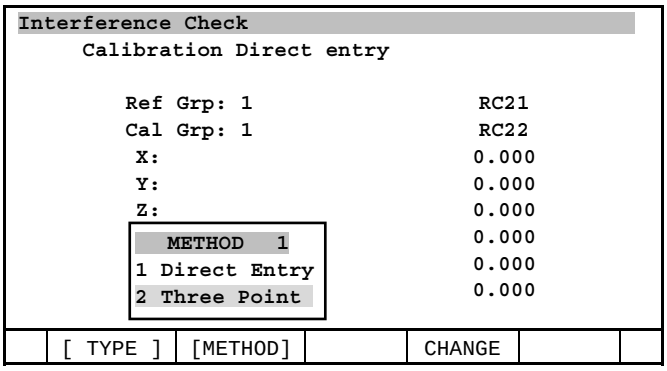
1. Press the MENU key.
2. Select SETUP.
3. Press F1[TYPE] and select “Interference”. Position the cursor on <*DETAIL*> of “1 Calibration between robot “ and press the Enter key.
4. Set up the Manager and Member of Interference Check in the same way as Direct Input Method.



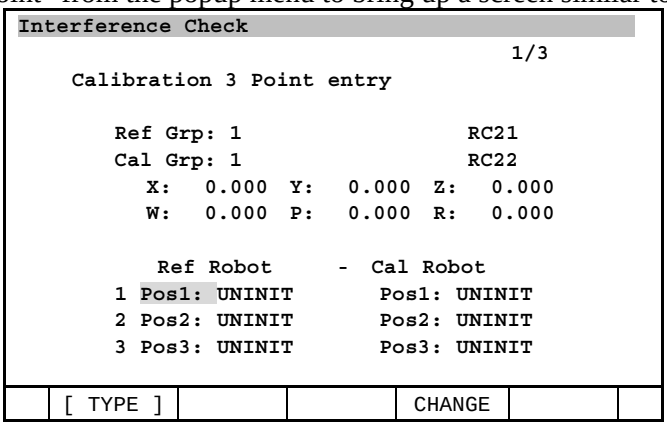
5. Select the group number for the robot you would like to calibrate and press F3 [CALIB] and then the following is displayed.



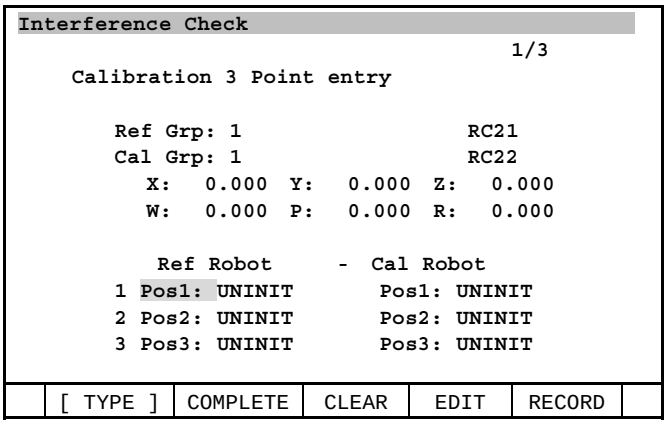
Press F2[METHOD] to bring the popup window that allows for selection of the Three Point Method, similar to the following



Select “2 Three Point” from the popup menu to bring up a screen similar to the following.



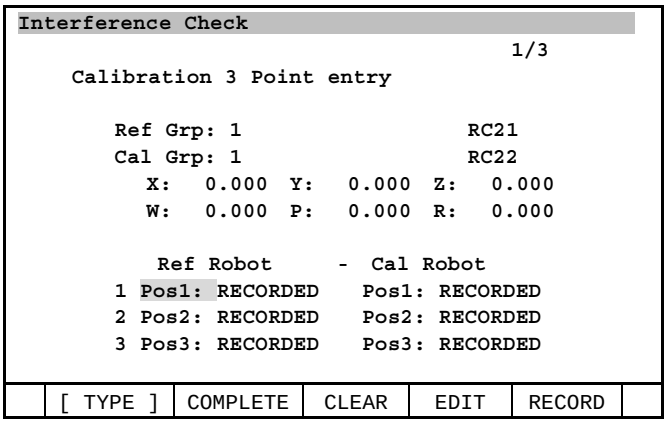
Press F4[CHANGE] to record the position data. The screen will remain the same but the softkey mapping will change to the following

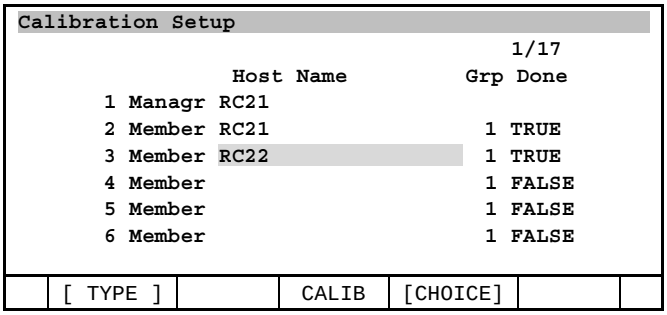


6. For each robot you must teach three positions, Pos1, Pos2, and Pos3. When you record the position, move a robot to the reference position and cursor to “Pos” you would like to teach and press F5[RECORD] key with the SHIFT key.
   - The positions must correspond to each other. For instance Pos1 on the Reference robot and Pos1 on the Calibration robot must be the same point. Similarly Pos2 and Pos3 on the Reference robot must be touching the same point as Pos2 and Pos3 on the Calibration robot.
   - You do not have to teach the points at the same time. For instance, if you would like to touch the same point on a fixture with each robot you can touch first with the Reference robot and teach one or more points then, when the Reference robot is out of the way you could teach the same points with the Calibration robot. You can touchup the points at any time.
   - If you inadvertently record the wrong position, press F3[CLEAR] key with the SHIFT key to make the position UNINIT.

- You must record the points on the controller for that robot. The points are automatically updated on both controllers when they are recorded.

7. After all positions have been recorded for both robots, press F2[COMPLETE] to calculate the calibration parameters. If calibration is successful, the menu will return to the Calibration Setup menu and the “Done” field has changed to TRUE.
   If the calibration is not successful then an error message will be displayed due to the cause. Please refer to 3.2.2.3.





3.2.2.3 Troubleshooting for calibration

1. “Position not recorded” is displayed when trying to record a position in Three Point Method.
   Check that you are recording with the teach pendant for the robot being recorded. You must use the teach pendant of the reference robot to record the reference robot positions. You must use the teach pendant of the calibration robot to record the calibration robot positions.
2. “Points too close” is displayed when trying to COMPLETE a calibration in Three Point Method.
   Check that the distances between points are at least 200mm and form a triangle and are not close to a straight line.
3. “Unable to create triangle” is displayed when trying to COMPLETE a calibration in Three Point Method.
   Check that positions form a triangle and are not close to a straight line.

3.3 SETTING MODELS

This section covers the following topics related to models:
- Description of elements of each model and how to set them
- How to set each model (hand, fixture, or robot)

3.3.1 Definition of Elements

This subsection explains elements common to models. The following parameters are set for each element:
- Enabled/Disabled
- Link No.
- Link type
- Shape
- Size
- Pos1, Pos2, Pos3 and Pos4

These parameters are explained in detail below.

Enabled/Disabled

When this parameter is set to “ENABLED”, the element is set for the relevant model. The initial value is “DISABLED” (except for the parameters factory-set for a robot).

Link No.

This parameter indicates the number of the robot link attached to the coordinate system for describing the position of the element. It is mainly used for setting an element of a robot. For an element of a hand, set this item to 99. This setting indicates that the reference coordinate system indicating the position of the element matches the coordinate system of the mechanical interface of the robot. The world coordinate system is used as the reference coordinate system for setting an element of a fixture regardless of which number is set (the setting is ignored).

Link type

This parameter indicates how the link is attached. It is mainly used for setting an element of a robot. The initial value is “NORMAL”.

Shape

This parameter indicates the geometrical shape of an element. When an element of robot and hand is set, it is possible to use “Sphere” and “Cylinder”. When an element of fixture is set, it is possible to use “Sphere”, “Cylinder”, “Plane finite”, “Plane infinite” and “Box”.

Size

This parameter is used for determining a size of “Sphere” and “Cylinder”. This parameter is used for determining whether to perform Interference Check. When shape is “Plane finite”, “Plane infinite” or “Box”, this parameter is not used.

> **⚠CAUTION**
> Set at least 24 mm for this value. If the set value is less than 24 mm, the robot may come into collision with an object depending on the speed of the robot even if the function operates as specified.

Pos1, Pos2, Pos3 and Pos4

- When “Sphere” is set for “Shape” of an element, set the coordinates of the element viewed from the description coordinate system for “Pos1”. At this time, the other position data is not used.

- When “Cylinder” is set for “Shape” of an element, set the positions of both ends for “Pos1” and “Pos2” (“Pos1” and “Pos2” may be specified in no particular order). At this time, the other position data is not used.
- When “Plane finite” or “Plane infinite” is set for “Shape” of an element, set “Pos1” as an origin of the plane and set “Pos2” as X axis direction of the plane and set “Pos3” as Y axis direction of the plane. At this time, “Pos4” is not used.
- When “Box” is set for “Shape” of an element, set “Pos1” as an origin of the box and set “Pos2” as X axis direction and the length of the box and set “Pos3” as Y axis direction and the length of the box and set “Pos4” as Z axis direction and the length of the box.

Conceptual drawings of elements

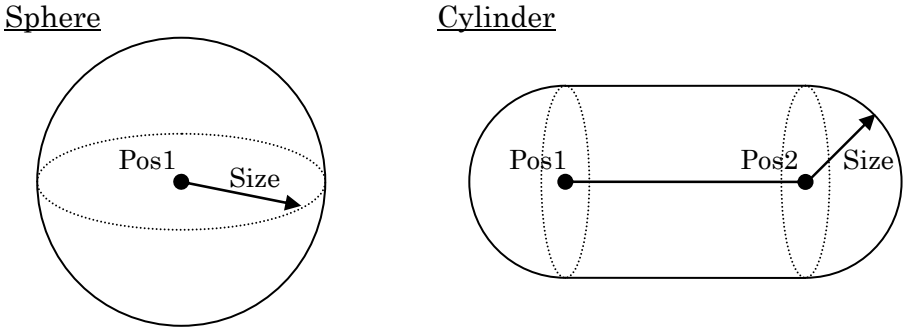


Fig. 3.3.1 (a) Sphere and Cylinder

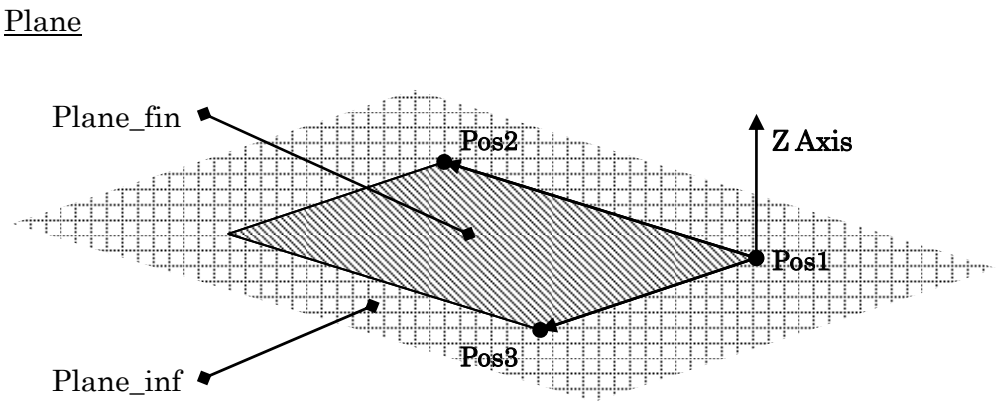


Fig. 3.3.1 (b) Plane_fin and Plane_inf

NOTE
- When you define “Plane finite” or “Plane infinite”, set Pos1, Pos2 and Pos3 as these positions form almost 90 degrees.
- If a shape is “Plane finite”, the plane is defined as a rectangle formed by Pos1, Pos2 and Pos3.
- If a shape is “Plane infinite”, the width of the plane formed by Pos1, Pos2 and Pos3 become infinity.
- If a shape is “Plane infinite”, the direction of Z axis of the plane affects a judgment of interference check. The direction of Z axis is defined by positional relationship among Pos1, Pos2 and Pos3. Please refer to Fig. 3.3.1(b).

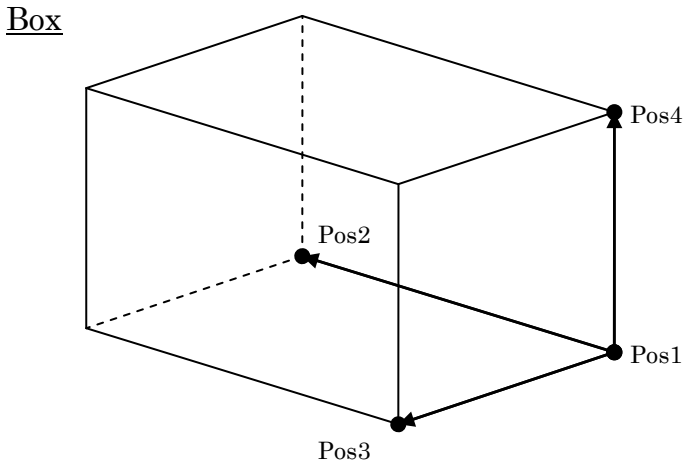


Fig. 3.3.1 (c) Box

NOTE
- When you define “Box”, set Pos1, Pos2, Pos3 and Pos4 as positional relationship among these positions become like Fig.3.3.1(c).
- When you define “Box”, set positions as Pos1 and other two positions form almost 90 degrees.

Each Hand model can have up to five geometric elements, while each fixture model can have up to two geometric elements. A robot can have up to 10 geometric elements. To reduce the computation time, the least number of graphical elements possible should be used.

NOTE
The more settings are made, the longer the processing time becomes. If the processing time becomes longer, the interference check period also becomes longer, so the interference is detected earlier than usual if the distance between robots is long.

3.3.2 Setting up a Hand Model

This subsection explains how to set a hand model. Set the following items:

- **Enter a Comment**
  The comment can be used for assigning a name to each model. This field is optional. When set it can be used to conveniently distinguish between different elements.
- **Create a Model**
  Each hand may have up to five geometric elements defined. If too many geometric elements are defined in a cell, an SSPC-185 error will be posed.
  When “Link No.” is set to 99, the position of each element is with respect to the faceplate coordinate system.
- **Associate a hand number to a tool model**
  The hand model is not used if it is not associated with a user tool and the user tool has to be active for that robot. To map a hand model to a tool, you have to go into the UT-Hand definition menu to define the relationship between the user tool number and the hand model number. If the hand number is 0, the function operates, assuming that the relevant robot has no hand.

You can also clear all settings for a hand model or those for each element at a time.

3.3.2.1 Sample hand modeling

This subsection explains an example of setting a hand model using drawing data. Assume that a model is set for the hand mounted on the mechanical interface as shown below when the robot assumes a posture in which all axes are placed in the 0-degree position. Use the drawing data at left and determine the type, size, and position of each element that covers each section in the drawing data. The drawings at right show sample element settings. The coordinate system in the right drawings that consists of X, Y, and Z coordinates indicates the mechanical interface coordinate system (reference coordinate system used for indicating the position of an element, “Line No.” = 99) when the J6-axis is placed in the 0-degree position.

Hand drawings and element drawings

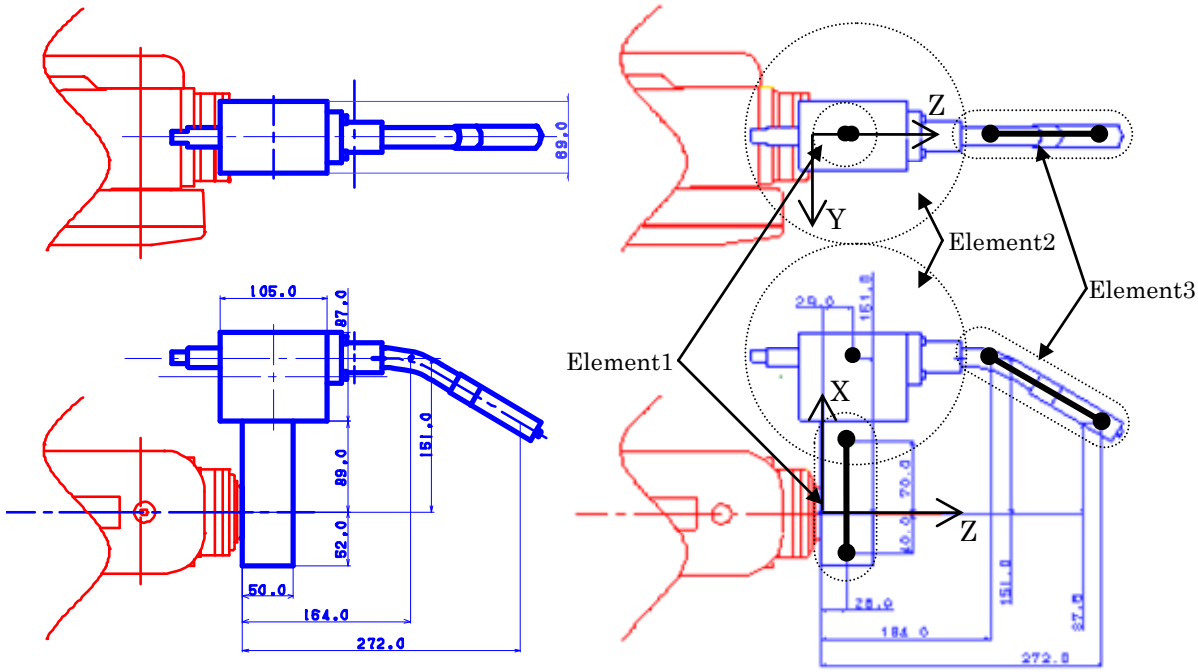


Fig. 3.3.2.1 Sample Hand Modeling

Elements 1 to 3 are set as follows.

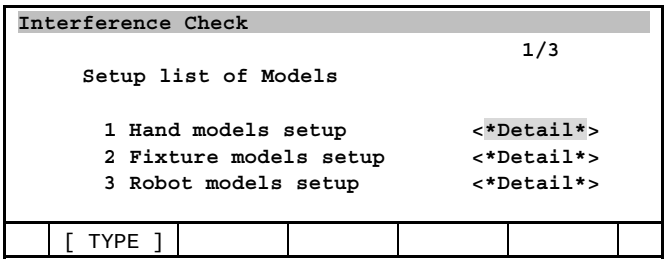
Settings for each element

Item/element	Element 1	Element 2	Element 3
Enabled/Disabled	ENABLED	ENABLED	ENABLED
Link No.	99	99	99
Link type	NORMAL	NORMAL	NORMAL
Shape	Cylinder	Sphere	Cylinder
Size	40.0	100.0	30.0
Pos1 X	-40.0	151.0	151.0
Y	0.0	0.0	0.0
Z	25.0	29.0	164.0
Pos2 X	70.0	-	87.5
Y	0.0	-	0.0
Z	25.0	-	272.0

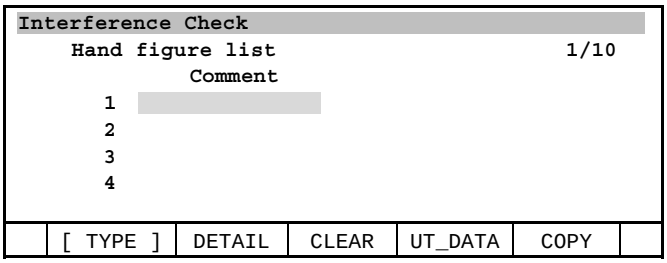
3.3.2.2 Setting a hand model (entering a comment statement)

Procedure

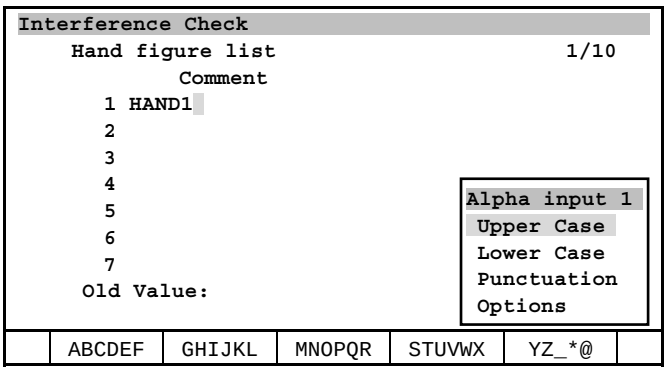
1. Press the MENU key.
2. Select SETUP.
3. Press F1[TYPE] and select “Interference”. Position the cursor on <*DETAIL*> of “Models setup” and press the Enter key. The following appears.



4. Position the cursor on <*DETAIL*> of “Hand models setup” and press the Enter key. The hand model list screen appears.



5. Press the Enter key. The comment edit screen appears. Press the F1 to F5 keys and enter a comment statement.

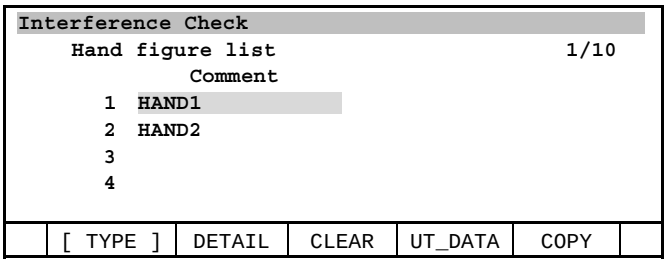


3.3.2.3 Setting a hand model (element list)

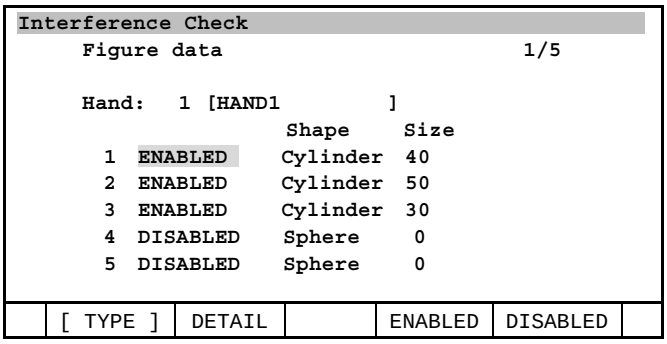
You can check and edit element settings for each hand model.

Procedure for setting a model

1. Display the Hand figure list screen



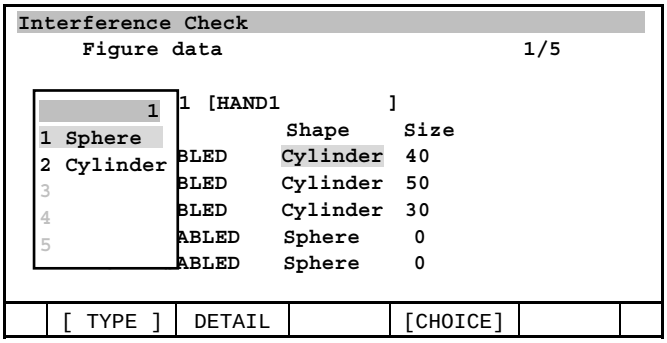
2. Position the cursor on the number of a hand of which settings are to be checked or edited and press F2[DETAIL] key. The element list screen appears.



3. You can use this screen to specify whether to enable or disable each element, change its shape, and set its size. You can also set these parameters on the detail data screen for each element (displayed by pressing the F2 key on this screen).

   - Specifying whether to enable or disable an element
     Position the cursor on “ENABLED” or “DISABLED” for a desired element and press F4[ENABLED] or F5[DISABLED] key.

   - Changing the shape
     Position the cursor on the field under “Shape” for a desired element and press the F4[CHOICE] key. The screen for selecting “Sphere” or “Cylinder” appears. On this screen, you can set a desired shape.



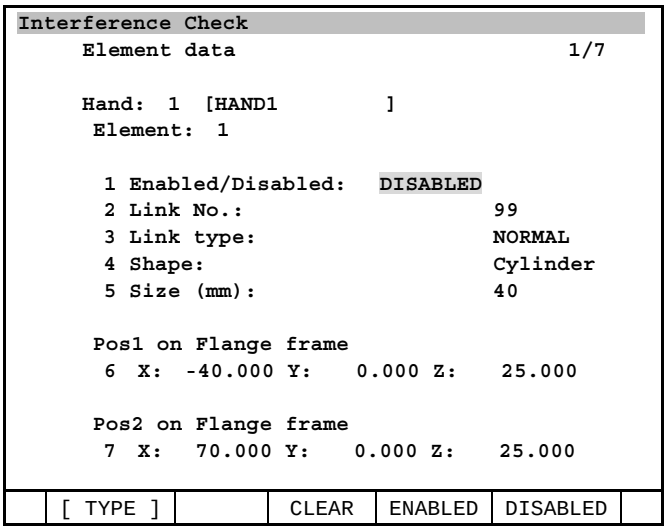
- Setting the size
  Position the cursor on the field under “Size” for a desired element and directly enter size data.
- Displaying detail data for each element
  On the Figure data screen, press the F2 key. The detail screen for the element on which the cursor is positioned appears. For how to set detail data, see “3.3.2.4 Setting details of a hand element”.

3.3.2.4 Setting details of a hand element

Set items for each element of a hand. The items include the position of data that cannot be set using the Figure data list screen. For the elements of hands, always set “Link No.” to 99 and “Link type” to “NORMAL”.
For details of each element, see “3.3.1 Definition of Elements.”

Setting an element

1. Press F2[DETAIL] key on the Figure data list screen. The detail element data screen appears.



- Specifying whether to enable or disable the element
  Position the cursor on “ENABLED” or “DISABLED” and press the F4[ENABLED] or F5[DISABLED] key.

- Changing data set for “Link No.” and “Link type”
  For hands, set “Link No.” to 99 and “Link type” to “NORMAL” and do not change the settings. (Except when a hand is mounted on a section other than the mechanical interface)

- Changing the shape
  Position the cursor on data set for “Shape” and press the F4[CHOICE] key. The screen for selecting “Sphere” or “Cylinder” appears. On this screen, you can set a desired shape.

- Entering the size
  Position the cursor on the field indicating the size and directly enter size data.

- Entering position data
  For both “Pos1” and “Pos2”, position the cursor on the field for a coordinate axis to be set and directly enter data. When the shape of the element is set to “Sphere”, set the coordinates of the center for “Pos1”. For “Sphere”, data set for “Pos2” is ignored. When the shape is “Cylinder”, “Pos1” and “Pos2” may be specified in no particular order. The coordinate system of the mechanical

interface is used as the reference coordinate system. Use drawing data and enter values, referencing "3.3.2.1 Sample hand modeling."

Clearing an element

> **⚠CAUTION**
> Once an element is cleared, all data of the element is deleted. Carefully clear an element.

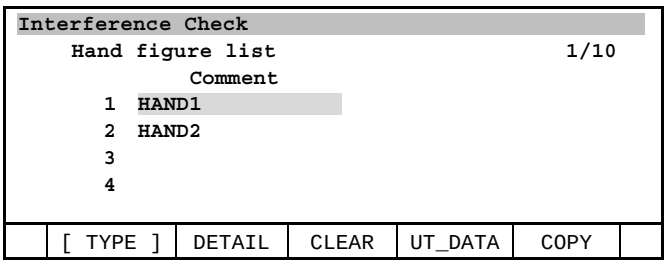
1. You can restore all data of an element to its initial values.
   Press the [CLEAR] (F3) key on the detail element data screen. The following message appears:
   "Clear this element? [Y=1/N=else]:"
   To clear the element, enter 1.

3.3.2.5 Table listing a correspondence between hand numbers and tool coordinate system numbers

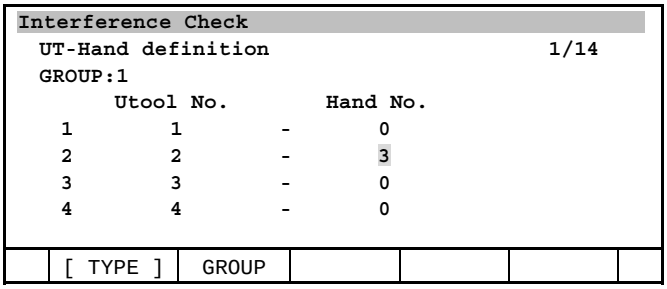
The Interference Check function uses the currently set table listing a correspondence between tool coordinate system numbers and hand numbers to determine which hand the robot is currently using. Note that the function does not recognize a hand model unless it is set in the correspondence table. If the hand number is 0, the function operates, assuming that the relevant robot has no hand.

Setting a hand correspondence table

1. Display the Hand figure list screen.



2. Select the F4[UT_DATA] key. The UT-Hand definition screen appears. (This screen is displayed regardless of where the cursor is positioned on the Hand figure list screen.)



3. Check the value set for "GROUP" and enter the number of a desired hand for the corresponding tool coordinate system number. In the above sample screen, hand number 3 corresponds to tool coordinate system number 2 in group 1. According to this setting, the function operates, assuming that the hand model having number 3 is mounted when the tool coordinate system number is 2 in group 1. According to the settings on this screen, the function performs a calculation, assuming that no hand is mounted when the hand model number is 0.

4. Press the F2[GROUP] key and make the setting for each group. You can select the same hand model for different groups (when you would like to use a hand identical in shape). You can also select the same hand for difference tool coordinate systems.

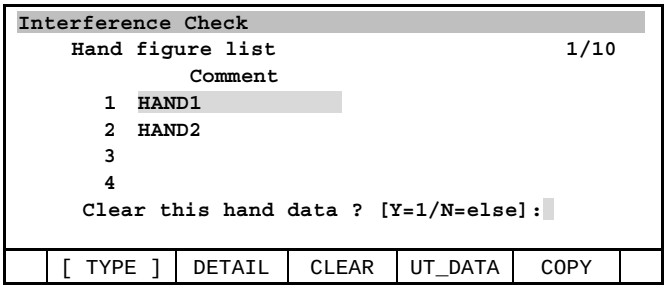
3.3.2.6 Deleting a hand model

You can clear the settings of a hand model. The comment statement and all element settings are reset.

> **⚠CAUTION**
> Once a model is cleared, the comment statement and element data settings are all deleted. Carefully clear a model.

Procedure for deleting a model

1. Display the Hand figure list screen.
2. Position the cursor on a hand to be cleared and press F3[CLEAR] key. The following confirmation message appears:
   "Clear this hand data? [Y=1/N=else]:"
   To clear the hand, enter 1. All data is initialized.



3.3.3 Setting a Fixture Model

This subsection explains how to set a fixture model. For a fixture, set the model with up to two elements. Set the following items:

- **Comment**
  Describe the name and comment of each fixture. No problem will arise if this item is not set. Describe the name and comment to easily make distinctions among fixtures.

- **Setting a taught group**
  Specify the group having the world coordinate system to be used as the reference of the position of the fixture.

- **Setting a model**
  Set a model as described in "3.3.1 Definition of Elements". Up to two elements can be set for each fixture. If many elements are set, however, an alarm may occur.
  You can teach a position using a robot in the specified group to specify the position of an element.
  Data specified for "Link No." and "Link type" as element settings are ignored. The position of each element is described based on the world coordinate system of the specified group.

You can also clear all settings for a fixture model or those for each element at a time.

3.3.3.1 Settings for an element of a fixture model

This subsection shows an example of setting a fixture model. Assume that a robot and fixture are installed as shown in the following figure. The coordinate system in the figure indicates the world coordinate system of the robot used as the reference of the position of elements.

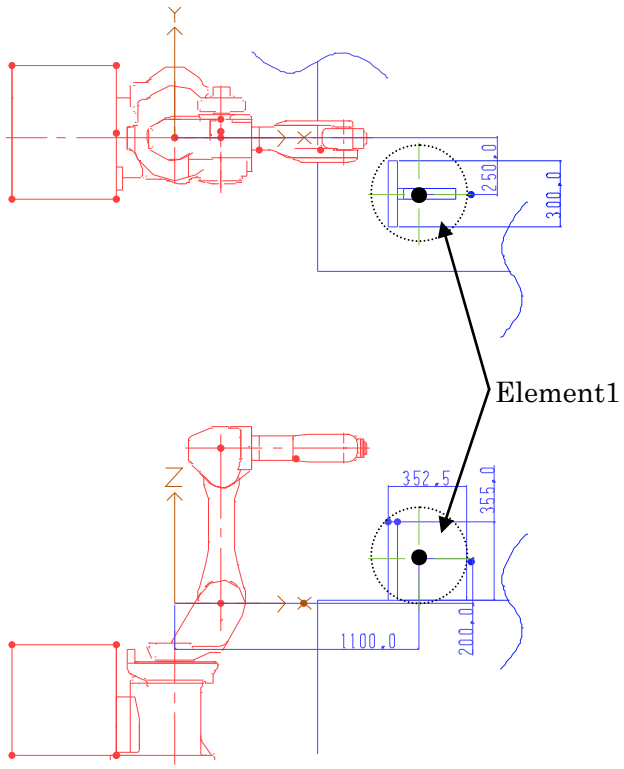


Fig. 3.3.3.1 Sample fixture model

The settings for the element in this example are as follows. (Note: No value is set for “Pos2” because the shape is set to “Sphere”.)

Settings for the element

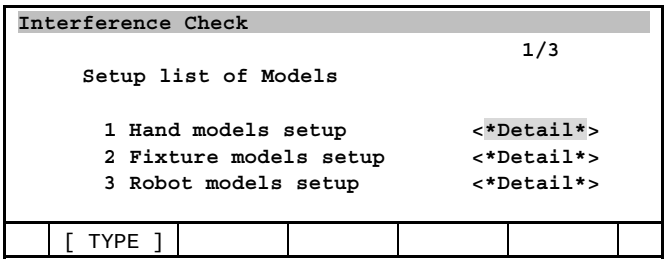
Item/element	Element 1
Enabled/Disabled	ENABLED
Link No.	0
Link type	NORMAL
Shape	Sphere
Size	230
Pos1 X	1100.0
Y	-250.0
Z	200.0
Pos2 X	——
Y	——
Z	——

In the above figure, the position relative to the robot in the world coordinate system has been known. You can also teach the position using a robot to specify it.

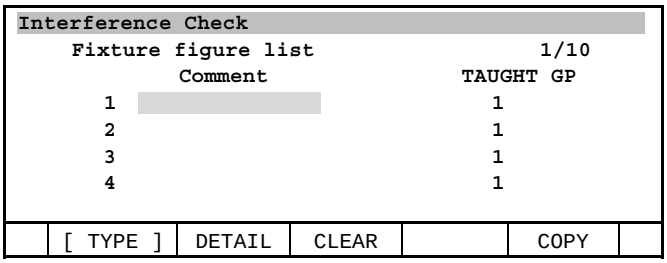
3.3.3.2 Setting a fixture model (entering a comment statement)

Procedure

1. Press the MENU key.
2. Select SETUP.
3. Press F1[TYPE] and select “Interference”. Position the cursor on <*DETAIL*> of “Models setup” and press the Enter key. The following appears.



4. Position the cursor on “2 Fixture models setup” and press the Enter key. The Fixture figure list screen appears.



5. Press the Enter key. The comment edit screen appears. Press the F1 to F5 keys and enter a comment statement.

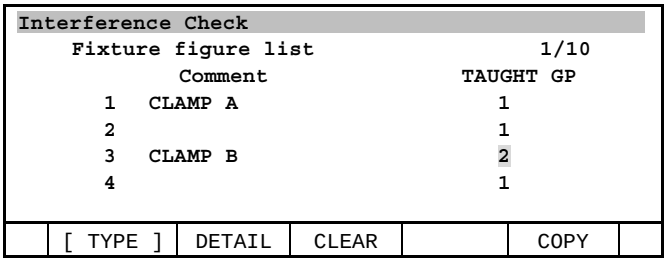
3.3.3.3 Setting a fixture model (setting a taught group)

To set a fixture model, before its elements are determined, the robot having the world coordinate system to be used as the reference of its positions (robot from which the positions viewed are to be set) must be specified.
This group setting is used to determine the reference and does not put restrictions on combinations set for the Interference Check function. For example, you can specify a fixture taught using group 1 for a combination for group 2. Position data of each element of a fixture all indicates the positions viewed from the world coordinate system of the same taught group.

> **⚠ CAUTION**
> If this taught group is omitted, invalid data may be set. Before setting elements, always check the taught group.

Procedure

1. Display the Fixture figure list screen. Position the cursor on the field under “TAUGHT GP” for a target fixture and directly enter a value.

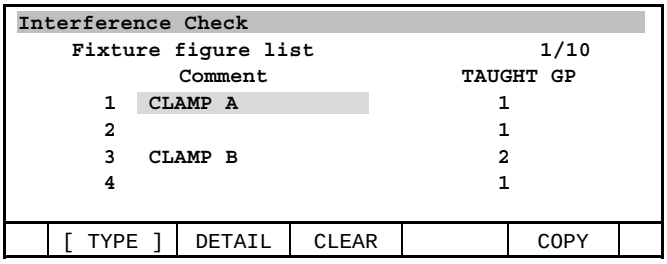


3.3.3.4 Setting a fixture model (element list)

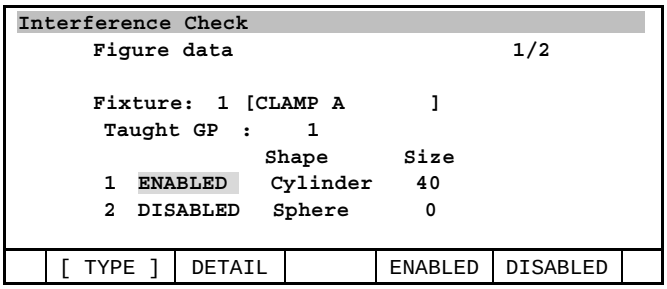
You can check and edit element settings for each fixture model. Up to two elements can be set for each fixture model on the screen.

Procedure for setting a model

1. Display the Fixture figure list screen.



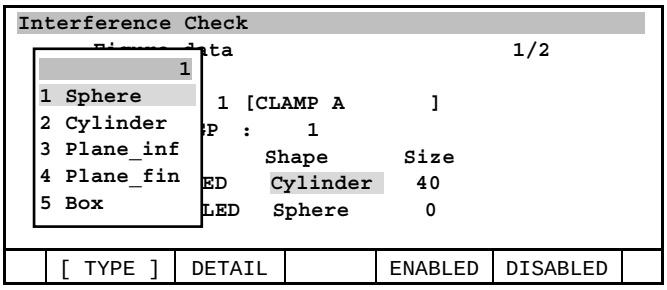
2. Position the cursor on the number of a fixture of which settings are to be checked or edited and press F2[DETAIL] key. The Figure data list screen appears.



3. You can use this screen to specify whether to enable or disable each element, change its shape, and set its size. You can also set these parameters on the detail data screen for each element (displayed by pressing the F2 key on this screen).

   - Specifying whether to enable or disable an element
     Position the cursor on “ENABLED” or “DISABLED” for a desired element and press F4[ENABLED] or F5[DISABLED] key.

   - Changing the shape
     Position the cursor on the field under “Shape” for a desired element and press F4[CHOICE] key. The screen for selecting appears. On this screen, you can set a desired shape.



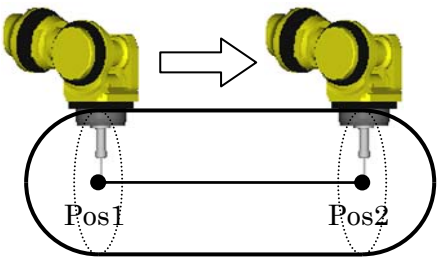
- Setting the size
  Position the cursor on the field under “Size” for a desired element and directly enter size data.

- Displaying detail data for each element
  On the Figure data screen, press the F2 key. The detail screen for the element on which the cursor is positioned appears. For how to set detail data, see “3.3.3.5 Setting a fixture model (details of an element).”

3.3.3.5 Setting a fixture model (details of an element)

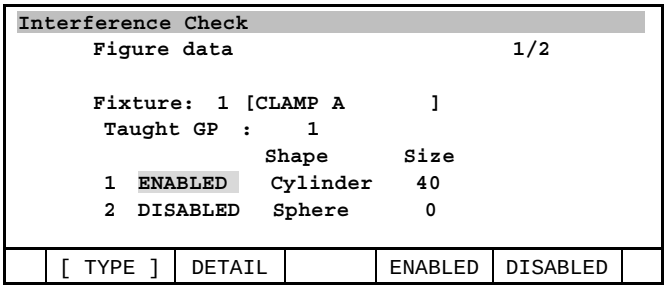
Set each element of a fixture. For fixture elements, “Link No.” and “Link type” need not be set. Describe the position of an element based on the world coordinate system of the group set for the taught group. You can also move the TCP of a robot in the taught group to the set position by jog feed and record the position using the setting screen to specify data for “Pos”.

Conceptual drawing of teaching position data (recorded using the detail element data screen)

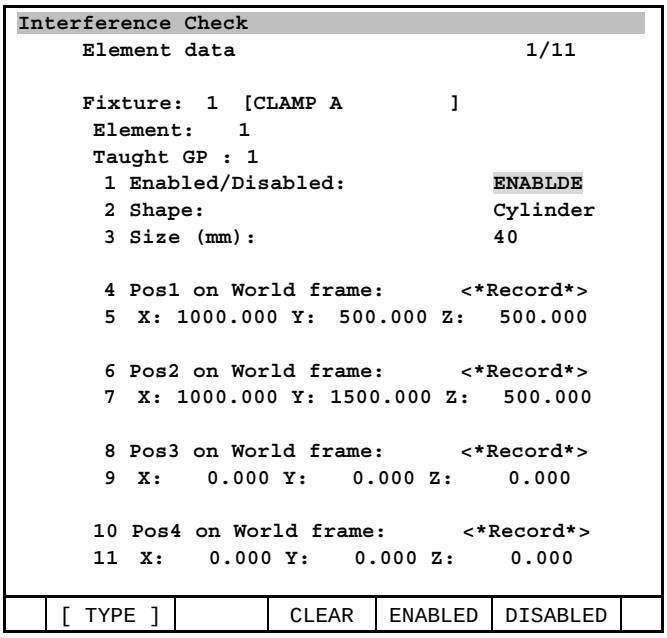


Recorded Pos1 and Pos2
and Input Size.

Setting details of an element



1. Press the F2[DETAIL] key on the Figure data list screen. The detail element data screen appears.



- Specifying whether to enable or disable the element
  Position the cursor on "ENABLED" or "DISABLED" and press the F4[ENABLED] or F5[DISABLED] key.

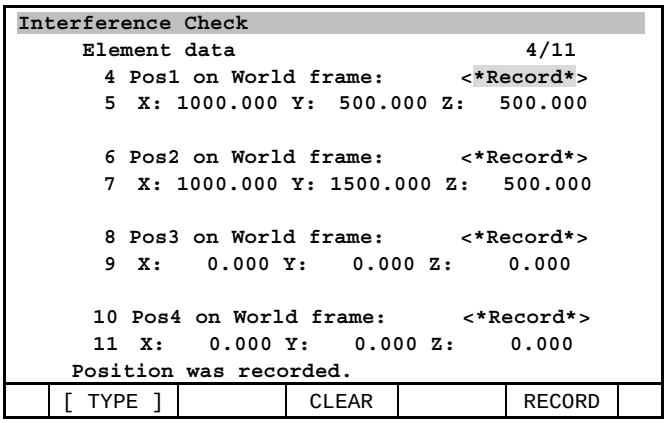
- Changing the shape
  Position the cursor on the field under "Shape" for a desired element and press F4[CHOICE] key. The screen for selecting appears. On this screen, you can set a desired shape.

- Entering the size
  Position the cursor on the field indicating the size and directly enter size data.

- Setting the position data
  It is possible to set the position data by teaching with a robot or by directly input.
  1. Setting the position data by teaching with a robot.
     1.1. Position the cursor on <*Record*> of the position which you would like to set.
     1.2. Operate a robot in the taught group (already set) and make the tool center point (TCP) of the robot point to the set point.

> ⚠**CAUTION**
> The currently selected group is not always the taught group. Use the specified taught group for teaching the position.

     1.3. Press the F5[RECORD] key while holding the SHIFT key down. When the position has been recorded, the message "Position was recorded." appears and position data is updated.



1.4. After setting, check that the displayed position data indicates the position based on the set group. You can perform the same operation for the other position.

2. Directly entering position data
For both “Pos”, position the cursor on the field for a coordinate axis to be set and directly enter data. When the shape of the element is set to “Sphere”, set the coordinates of the center for “Pos1”. When the shape is “Cylinder”, “Pos1” and “Pos2” may be specified in no particular order. When the shape of the element is set to “Plane finite” or “Plane infinite”, set “Pos1”, “Pos2” and “Pos3”. When the shape of the element is set to “Box”, set “Pos1”, “Pos2”, “Pos3” and “Pos4”. The world coordinate system of the taught group is used as the reference coordinate system.

Clearing an element

You can restore all data of an element to its initial values.

1. Press the [CLEAR] (F3) key on the detail element data screen. The following message appears:
“Clear this element? [Y=1/N=else]:”
To clear the element, enter 1.

> **⚠CAUTION**
> Once an element is cleared, all data of the element is deleted. Carefully clear an element.

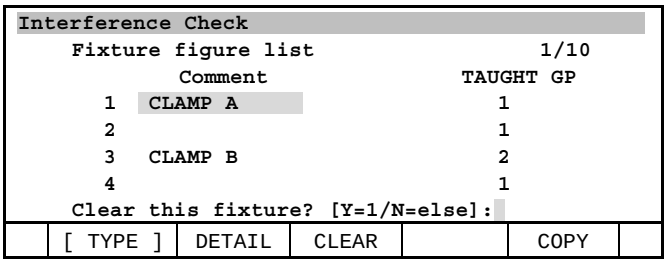
3.3.3.6 Deleting a fixture model

You can clear the settings of a fixture model. The comment statement and all element settings are reset.

> **⚠CAUTION**
> Once a model is cleared, the comment statement and element data settings are all deleted. Carefully clear a model.

Procedure for deleting a fixture model

1. Display the Fixture figure list screen.
2. Position the cursor on a fixture to be cleared and press F3[CLEAR] key. The following confirmation message appears:
“Clear this fixture? [Y=1/N=else]:”
To clear the fixture, enter 1. All data is initialized.



3.3.4 Setting up a Robot Model

This subsection explains how to view and add additional geometric elements to an existing robot model. The geometric model of a robot is defined in the factory and it should not be altered. However, you can view the robot's model using the Interference Check menu. In addition, you can add geometric elements to the existing robot model to represent physical parts that are attached to the robot arm, such as a repeater box.
This subsection explains how to check factory-set data and set an element.

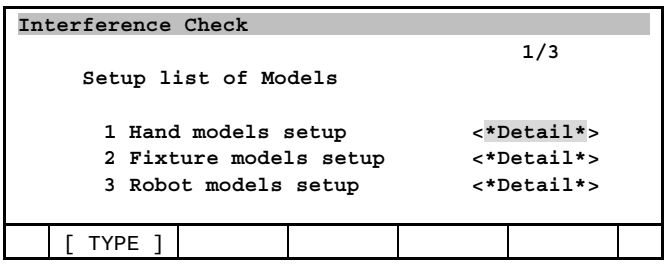
- Setting an additional element for a model
  Up to ten elements (including factory-set data) can be set for each robot on the screen. If many elements are set, however, an alarm may occur during operation.

3.3.4.1 Robot list

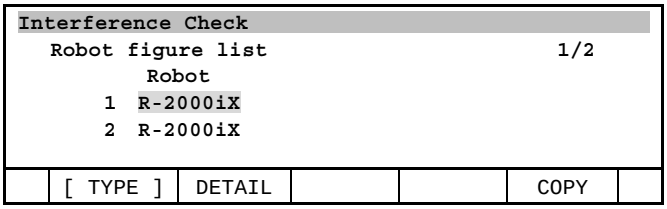
You can use the following procedure to check the name and group number of each robot connected to the controller.

Procedure

1. Press the MENU key.
2. Select SETUP.
3. Press F1[TYPE] and select "Interference". Position the cursor on <*DETAIL*> of "Models setup" and press the Enter key. The following appears.



4. Position the cursor on <*DETAIL*> of "3 Robot models setup" and press the Enter key. The model list screen appears. On this screen, press F2[DETAIL] key. The detail screen for the robot on which the cursor is positioned appears. You cannot edit data on this screen.

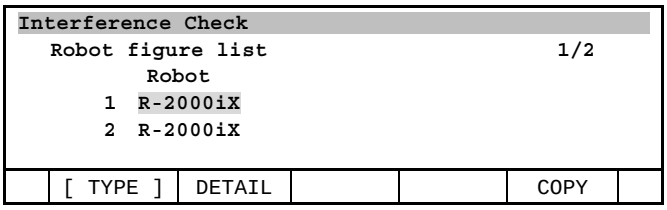


3.3.4.2 Robot model (element list)

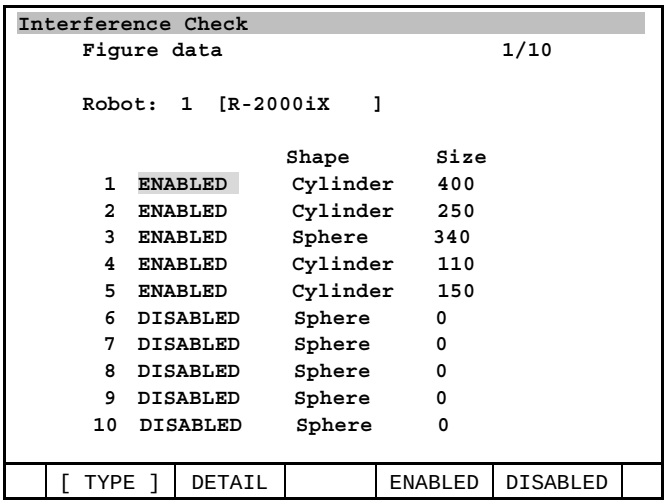
You can check element settings and edit some elements for each robot model.

Element list screen

1. Display the Robot figure list screen.



2. Position the cursor on the number of a robot of which elements are to be checked or edited and press the F2[DETAIL] key. The figure data list screen appears.



3. For factory define elements, you can enable or disable these elements, but you cannot change its shape, nor can you change its size. You can view the detail of these elements by press F2[DETAIL] key, but you cannot modify these data in the Element data menu.

NOTE
Basically do not disable a factory define elements. If you would like to disable it, you need to consider enough.

4. The number of elements, which can be edited, differs depending on the robot. The element of which the cursor is positioned on setting items can be set and edited. For such an element, you can specify whether to disable or enable the element, change its shape, and set its size. You can also set these parameters on the detail data screen for each element (displayed by pressing the F2 key on this screen).

   - Specifying whether to enable or disable an element
     Position the cursor on “ENABLED” or “DISABLED” for a desired element and press F4[ENABLED] or F5[DISABLED] key.

   - Changing the shape
     Position the cursor on the field under “Shape” for a desired element and press F4[CHOICE]

key. The screen for selecting “Sphere” or “Cylinder” appears. On this screen, you can set a desired shape.

- Setting the size
  Position the cursor on the field under “Size” for a desired element and directly enter size data.

- Displaying detail data for each element
  On the Figure data screen, press the F2 key. The detail screen for the element on which the cursor is positioned appears. For how to set detail data, see “3.3.4.3 Detail element data list”.

3.3.4.3 Robot element data list

For the robot's geometric elements that are defined by the factory, you can view these elements in the Element data screen, but this screen prevents you from editing any item on the menu. For the added on elements, you can edit them in the Element data screen.
For details of each element, see “3.3.1 Definition of Elements.”

Detail element data screen

1. Press F2[DETAIL] key on the Figure data list screen. The detail element data screen appears.

Detail factory-set element data screen (cannot be edited)

```
Interference Check
   Element data                              1/7

    Robot:     1  [R-2000iX        ]
    Element:      1

       1 Enabled/Disabled              ENABLED
       2 Link No.:                     1
       3 Link type:                    NORMAL
       4 Shape:                        Cylinder
       5 Size (mm):                    400

     Pos1 on specified Link frame
         X: -512.000  Y:  -50.000 Z:   -80.000

     Pos2 on specified Link frame
         X:   -72.000  Y:  -50.000 Z:   -80.000

 |  [ TYPE ]  |          |          |          |          |  |
```

Detail data screen for an element, which can be set

```
Interference Check
   Element data                              1/7

    Robot:     1  [R-2000iX        ]
    Element:      6

       1 Enabled/Disabled:             ENABLED
       2 Link No.:                     3
       3 Link type:                    NORMAL
       4 Shape:                        Cylinder
       5 Size (mm):                    100

     Pos1 on specified Link frame
         X:   200.000  Y:   0.000 Z:     0.000

     Pos2 on specified Link frame
         X:   200.000  Y:   0.000 Z:  -800.000

 |  [ TYPE ]  |          |  CLEAR   |  ENABLED  |  DISABLED  |  |
```

- Specifying whether to enable or disable the element
  Position the cursor on “ENABLED” or “DISABLED” and press the F4[ENABLED] or F5[DISABLED] key.

- Changing data set for “Link No.” and “Link type”
  For robots, set “Link No.” and “Link type”.

- Changing the shape
  Position the cursor on data set for “Shape” and press the F4[CHOICE] key. The screen for selecting “Sphere” or “Cylinder” appears. On this screen, you can set a desired shape.

- Entering the size
  Position the cursor on the field indicating the size and directly enter size data.

- Entering position data
  For both “Pos1” and “Pos2”, position the cursor on the field for a coordinate axis to be set and directly enter data. When the shape of the element is set to “Sphere”, set the coordinates of the center for “Pos1”. For “Sphere”, data set for “Pos2” is ignored. When the shape is “Cylinder”, “Pos1” and “Pos2” may be specified in no particular order. The specified link coordinate system is used as the reference coordinate system.

3.3.5 Using 4D Graphics in Model Setup Menus

If the 4D Graphics (R764) option is installed in the controller, you can use the 4D graphics to set up the geometric models for the Hand, Fixture and Robot. You can check to see if the 4D graphics is loaded or not by holding the *i* key and press the MENU button at the same time. This will bring the Top Menu, check the F3 key, if the key is marked “4D”, the 4D graphics is loaded.

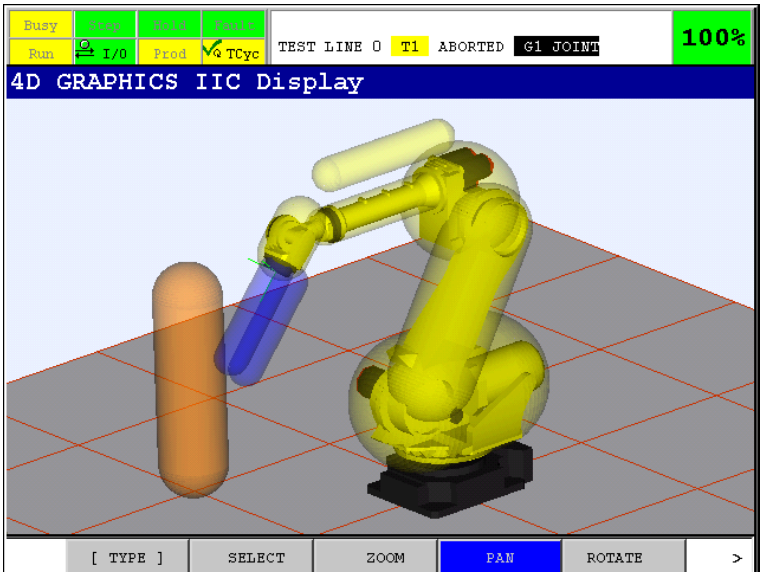
NOTE
Please refer to 4D GRAPHICS FUNCTION in R-30*i*B/ R-30*i*B Mate CONTROLLER Optional Function OPERATOR’S MANUAL B-83284EN-2 about the details of it.

When you just hold down the i-key on the teach pendant (TP) and press the Fctn key at the same time. This will bring up the relative view selection window in the top right corner of the TP. Select the 4D Visualization and press the Enter key will bring up the relative view for the Intelligent Basic Interference Check (IIC/BIC) software.

If the TP has only one pane before bring up the relative view, the screen will split into two panes, the left pane displays the IIC/BIC menu and the right pane shows the 4D graphics for the cell. If the screen already has two panes, the right pane is then taken over by IC/BIC graphics. If the screen has three panes before the relative view, the relative view will also be displayed in the right upper pane. For the screen that is split horizontally before the relative view, the relative view will take the lower pane.

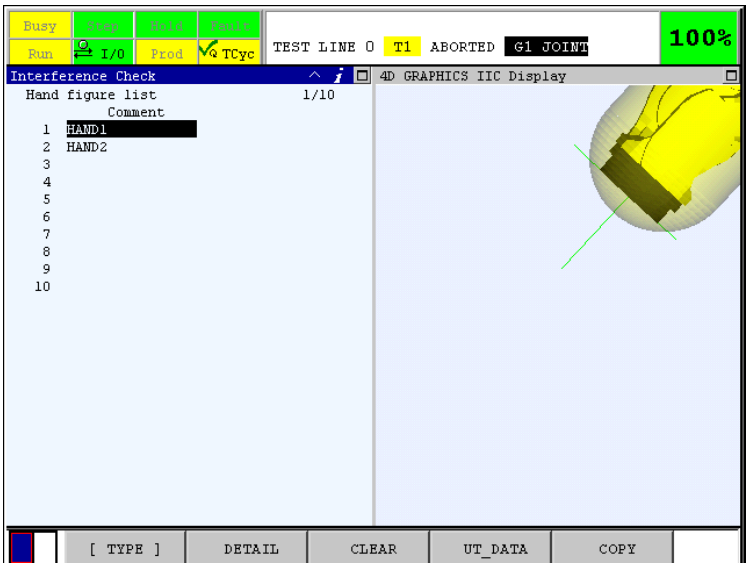
The relative view will display the 4D graphics based on the current IIC/BIC menu. If you are not in the detail model setup menus for the Hand, Fixture or the Robot, the relative view will display the whole IIC/BIC cell, which includes:

1. All robots that are defined in the IIC/BIC calibration menu with their geometric model. If any these robots have their tool defined with hand model, the geometric model for the hand will also be displayed with the robot.
2. Fixture models will be displayed if they are included in the check combination setup.

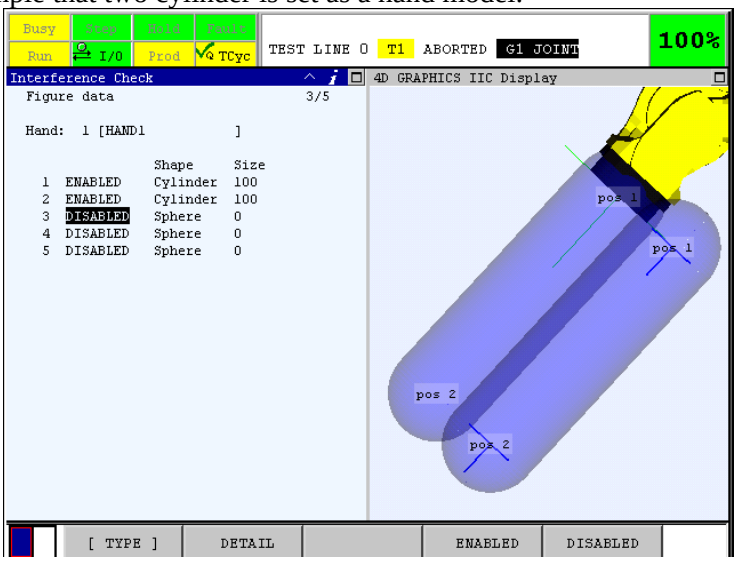


3.3.5.1 Using 4D graphics in hand model setup menu

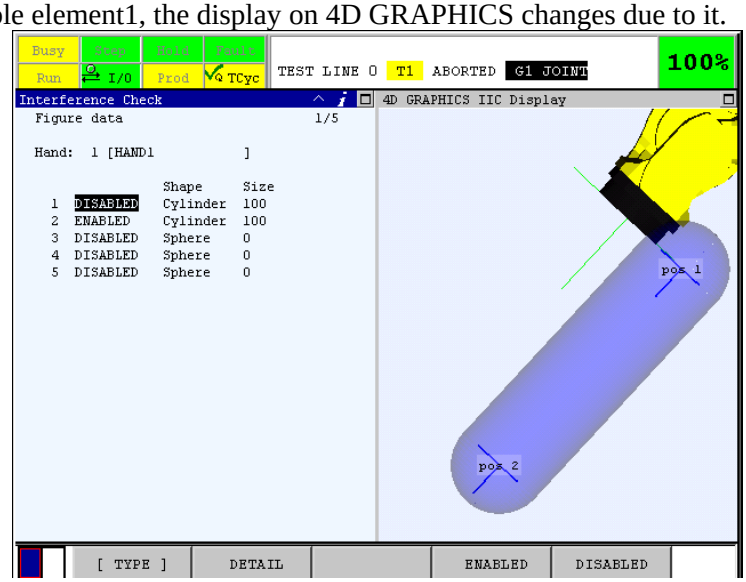
When you set up a hand model, you can confirm and set it by using 4D GRAPHICS. Press F2[DETAIL] key on Hand figure list while 4D GRAPHICS is displayed.



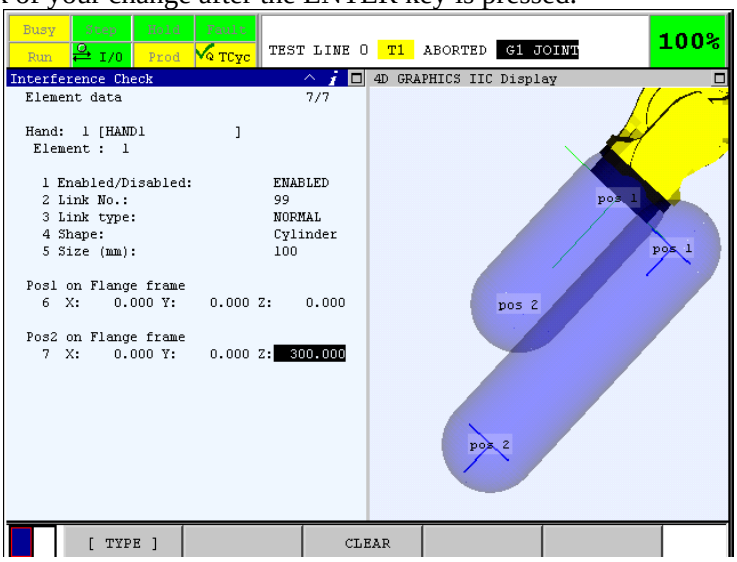
The following is example that two cylinder is set as a hand model.



For example, if disable element1, the display on 4D GRAPHICS changes due to it.



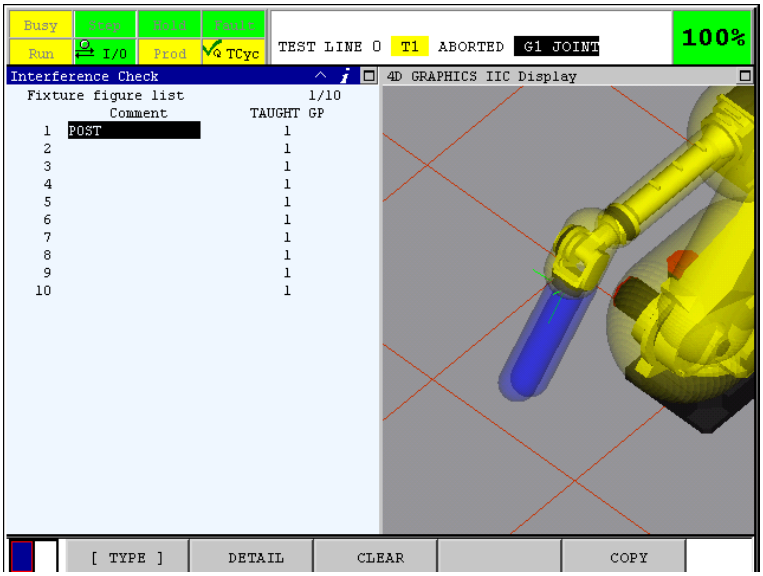
For example, you can change the length of the cylinder to 300mm in Z. The graphics will give you instant visualization feedback of your change after the ENTER key is pressed.



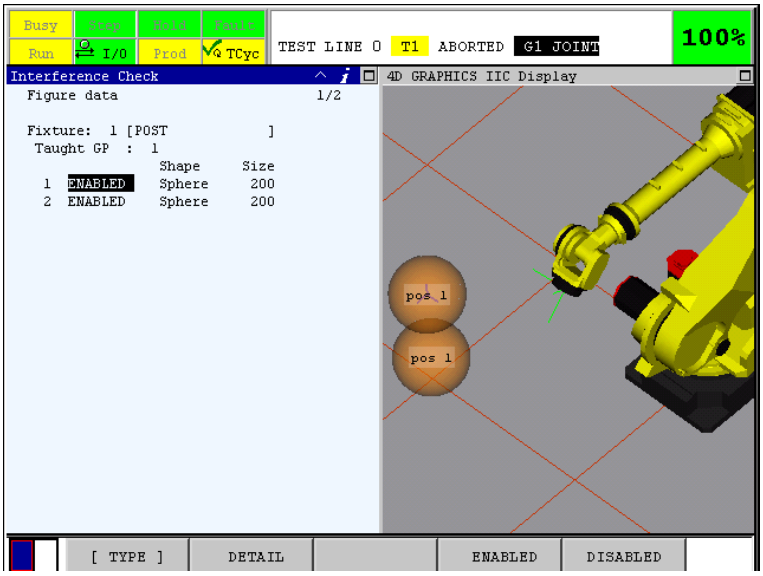
3.3.5.2 Using 4D graphics in fixture model setup menu

The 4D graphic can also help you to define and to fine tune a fixture's model you are working on. The following example shows how to change a post fixture that was modeled as two spheres into a more appropriate cylinder model.

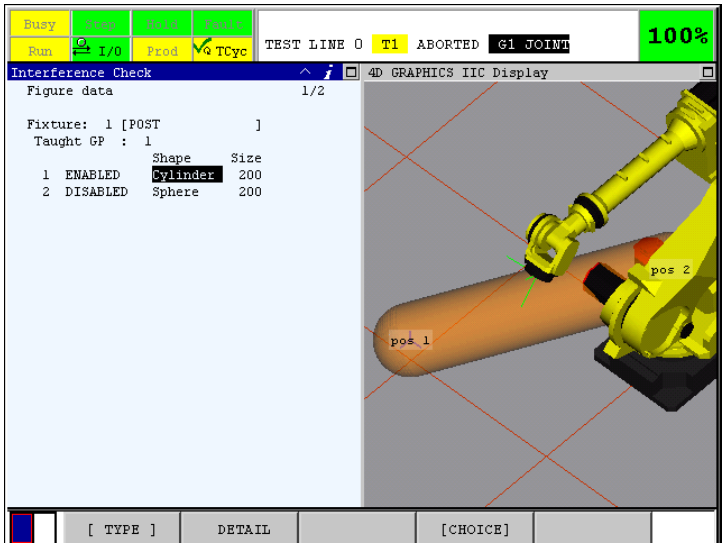
Select the fixture model which you would like to edit from Fixture figure list while 4D GRAPHICS is displayed. The 4D GRAPHICS display does not include the fixture which it is not defined in the combination check yet.



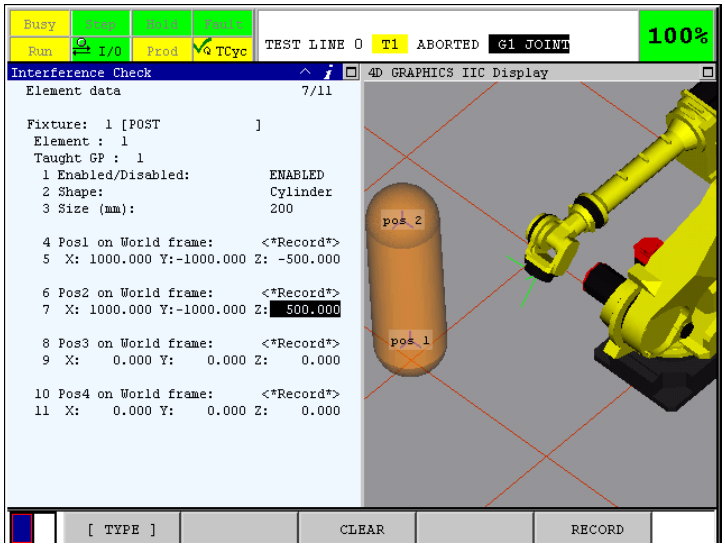
Press F2[DETAIL] key, the fixture model is displayed on the 4D GRAPHICS.



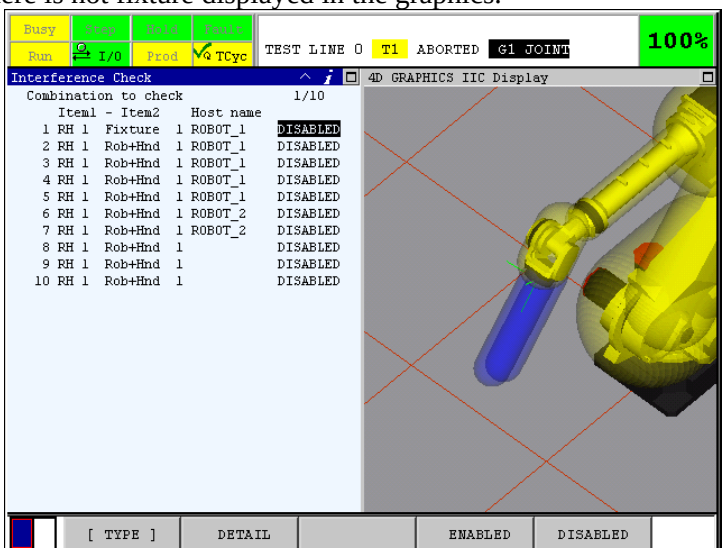
Disable element 2 and Change the shape of element 1 to “Cylinder”, then the fixture model become like the following. Note, since the Pos2 for the cylinder was set to world frame origin of robot as default, the cylinder is now displayed from the Pos1 to the world frame origin of robot.



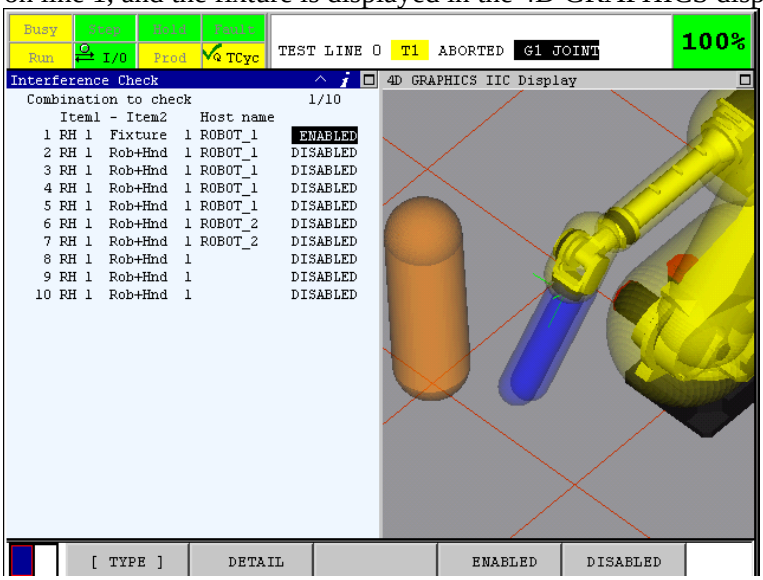
In order to set the cylinder in correct location, press the F2[DETAIL] key and set up X, Y, Z of element 1 of the fixture model.



Even if the fixture model is defined, it will not show up in the 4D GRAPHICS display for the whole cell. If the fixture is included in the combination checking, it will show up. Therefore, when leaving the fixture model setup screen, there is not fixture displayed in the graphics.

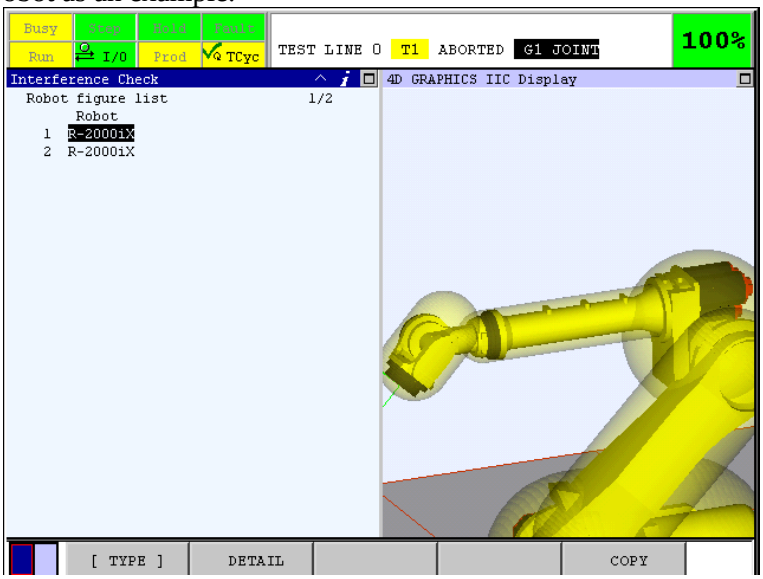


Enable the Fixture 1 on line 1, and the fixture is displayed in the 4D GRAPHICS display.

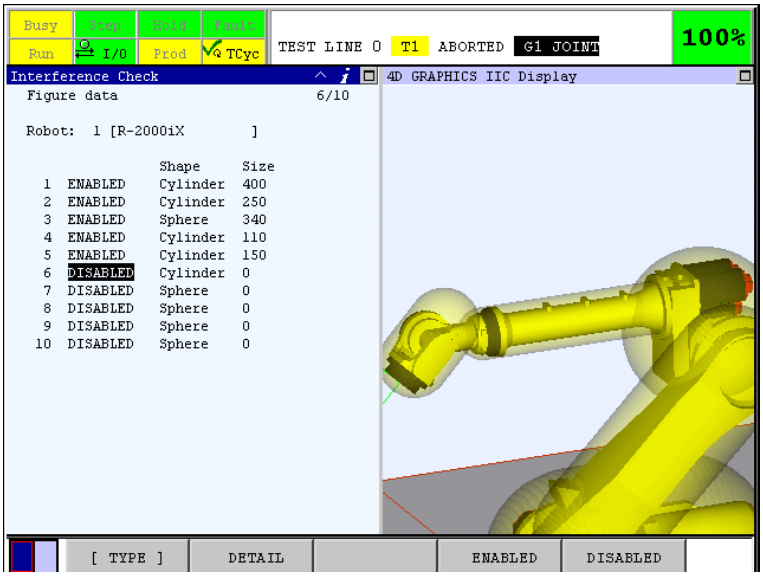


3.3.5.3 Using 4D graphics in robot model setup menu

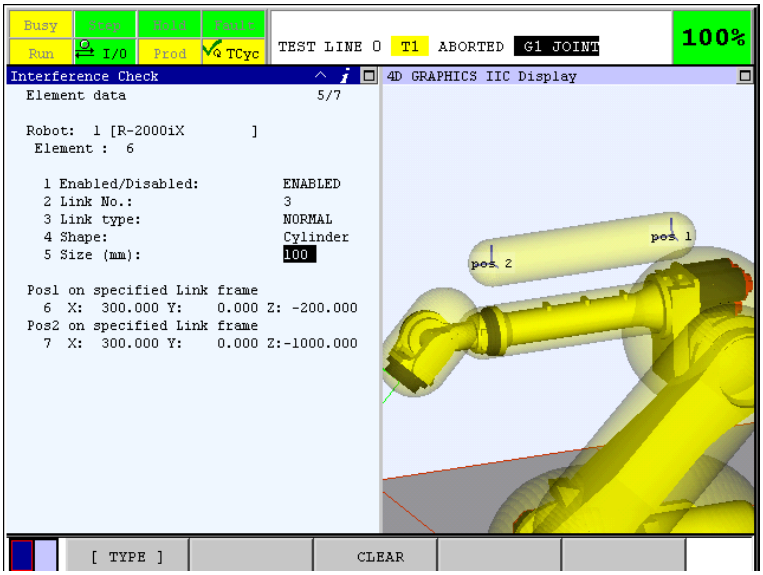
The 4D graphics can help you to put a dress up on a robot. In the following example, a “Cylinder” is added to link 3 of a robot as an example.



Move the cursor to a element which is not defined and press F2[DETAIL] key on Figure data of the robot, then Element Data setup menu is displayed.



Set up the element data that you would like to add on Element data setup menu. The following is an example that “Cylinder” is added to link 3 of the robot.



3.3.6 Data Storage of Model Data

Model data for the Interference Check is all stored in system variables that have name starting with $IA_**. When system files are saved onto a memory card or another medium, the data is all saved in SYSVARS.SV except for hand model data. Geometric data related to hands is saved in system file IA_HAND.SV. To transfer hand model data from a controller to another controller, load the system file IA_HAND.SV at control start for the second controller.
When you use a model data on another controller, you can copy it to another controller by using “3.3.7 Copying Models” feature too.

3.3.7 Copying Models

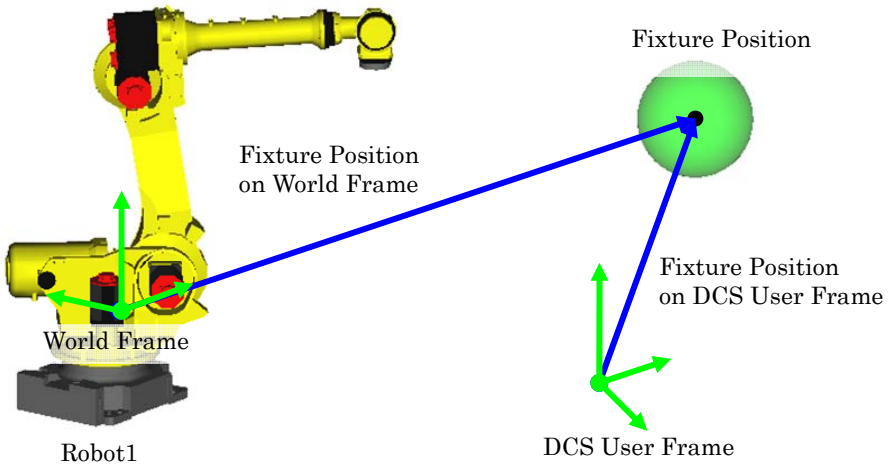
In this section the model copy feature is explained. This feature allows a user to copy the models for Interference Check from the same or the other controllers. This feature allows a user to copy the model for DCS to the model for Interference Check too. The source of the copy is called “From Model” while the destination of the copy is called “To Model". Also, the user can copy to/from an XML file.

Because the number of the available model elements might be different in Interference Check from that of the "From Model", the elements are copied only until all the available elements in the selected model are filled or all the elements of the "From Model" are copied over, whichever is reached first. As a result of the first case, there might be elements that are not copied over.
Moreover, if the "To Model" has elements that are enabled, the screen will ask for the confirmation of the user to proceed with the copy. When the user presses F4, YES, the copy will be preformed. In case the user presses F5, NO, the copy will not be done.

NOTE
Please refer to R-30*i*B/R-30*i*B Mate CONTROLLER Dual Check Safety Function OPERATOR'S MANUAL B-83184EN about the details of Dual Check Safety Function.

3.3.7.1 Copy from DCS

With this feature a user can import the models created in DCS to Interference Check. The DCS User Models can be imported to either the hand or robot models in IIC. The DCS Cartesian Position Check (CPC) zones are imported to fixture models for Interference Check. When copying the models, the user should consider the following:



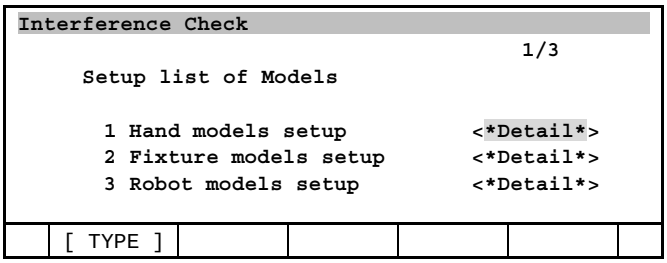
- In case of CPC zones, each zone is considered a single element and not a fixture model by itself. So several CPC zones can be copied into different elements of a fixture model to create a single model.
- In DCS, each CPC model is represented in a User Frame. In Interference Check the fixture models are represented in the World Frame of one of the groups. As a result, when a CPC model is copied from DCS to Interference Check, the copy feature transforms the CPC model such that its position in the world remains the same. The following figure displays a fixture as it is defined in DCS and in Interference Check.
- In copying user model, the model is directly copied to the Interference Check model without considering the tool frame.

The following table shows how the elements are converted during the copy from the DCS to IIC:

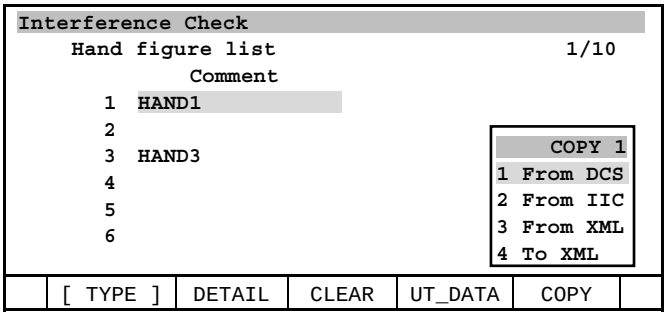
DCS		Interference Check	
User Models	Point	Hand and Robot models	Sphere
	Line Seg		Cylinder
	2 Spheres		Not Supported
CPC Zones	Diagonal In	Fixture Models	Box
	Diagonal Out		Box
	Lines		Not Supported

Procedure for copying from DCS User Models

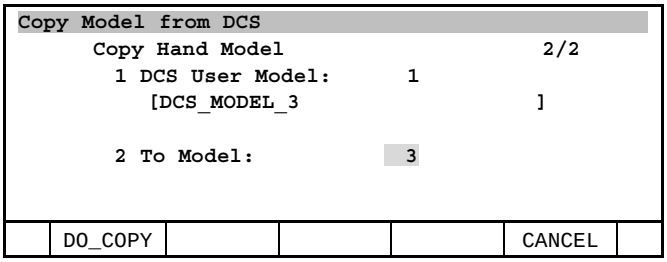
1. Press the MENU key.
2. Select SETUP.
3. Press F1[TYPE] and select “Interference”. Position the cursor on <*DETAIL*> of “Models setup” and press the Enter key. The following appears.

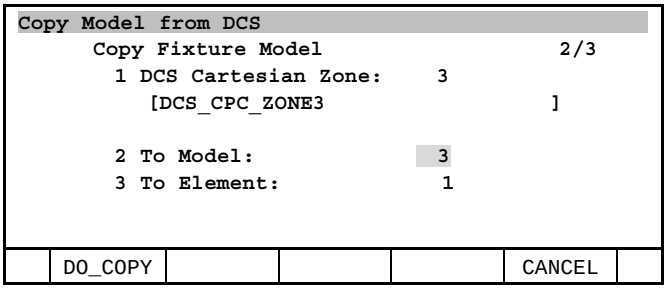


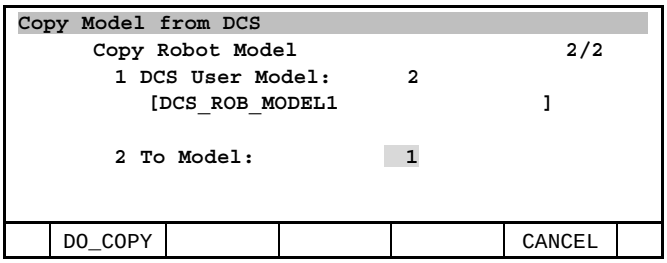
4. Select a models setup that you would like to copy.
5. Press F5[COPY] key and Select “From DCS” on each list menu. For example, the following is displayed on Hand figure list.



6. Move to the following display for Copy feature from each list menu after “From DCS” is selected.



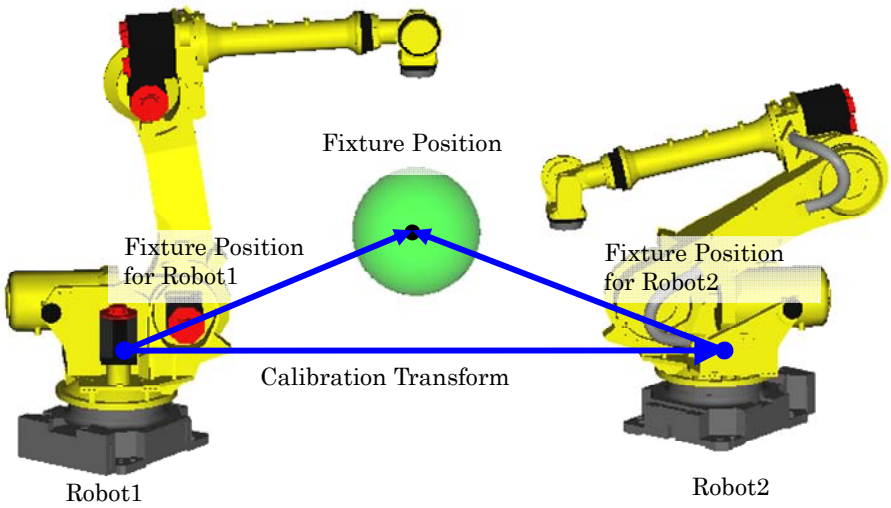




7. Enter the number of the DCS model that is the source of the copy operation in the first line. The comment of the selected DCS model is updated on the second line to make the selection more convenient.
8. Enter the "To Model" and "To Element" in order that DCS User Model copy to Hand or Robot Models for Interference Check. Enter the "To Model" in order that DCS Cartesian Position Check zones to fixture models for Interference Check.
9. Press F1[DO_COPY], for the copy to be performed. Alternatively, you can press F5[CANCEL] to cancel the copy operation.

3.3.7.2 Copy from interference check

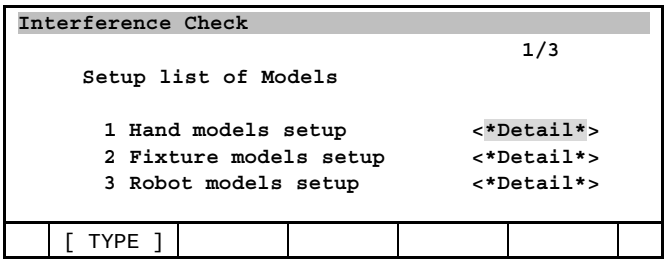
The user can use this method to copy the models that are already created on other controllers or for other motion groups on the ring to the current controller. The hand and robot models are copied directly. For the fixture models, the calibration data for Interference Check is used to calculate the fixture position with respect to the “To Robot”, the copy destination, to maintain the absolute position of the fixture in the cell as was set in the “From Robot”.



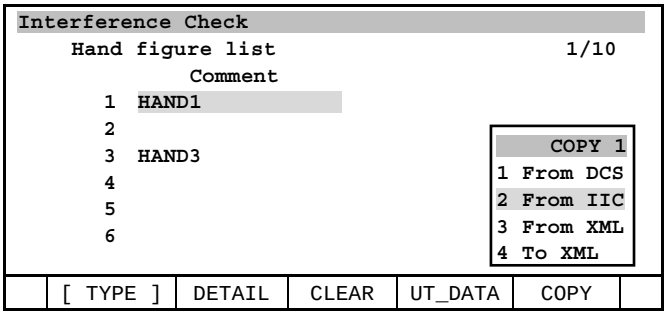
- If the calibration data of any of the robots are changed, any fixture model that was created with the copy from Interference Check feature should be recopied for the effect of the new calibration data to be included in the calculation of the fixture model's position.
- In case of the hand model copy, only the data related to the model is copied and the user should assigned each hand model to its tool frame manually.

Procedure for copying from other controllers

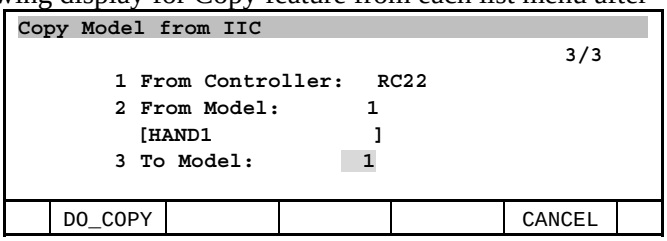
1. Press the MENU key.
2. Select SETUP.
3. Press F1[TYPE] and select “Interference”. Position the cursor on <*DETAIL*> of “Models setup” and press the Enter key. The following appears.

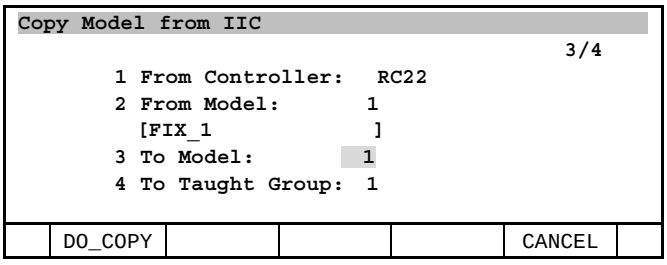


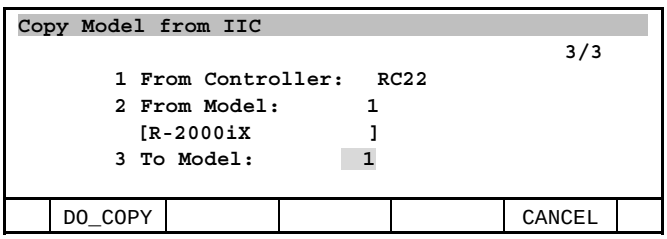
4. Select a models setup that you would like to copy.
5. Press F5[COPY] key and Select “From IIC” on each list menu. For example, the following is displayed on Hand figure list.



6. Move to the following display for Copy feature from each list menu after “From IIC” is selected.







7. Press F4[CHOICE] and select the "From Controller" from the drop down menu.
8. Enter the number of the "From Model". The comment line will be updated by the comment of the selected model.
9. Enter the “To Model” in order to copy Hand and Robot models. Enter the “To Model” and the “To Taught Group” in order to copy Fixture models.
10. Press F1[DO_COPY], for the copy to be performed. Alternatively, you can press F5[CANCEL] to cancel the copy operation.

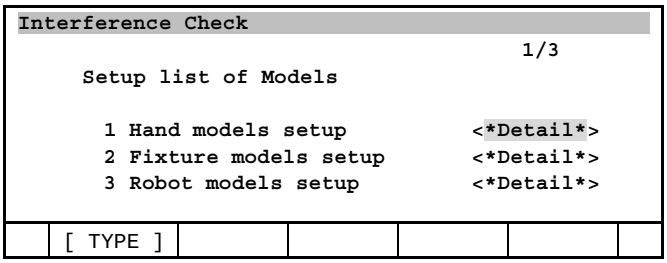
3.3.7.3 Copy from XML and copy to XML

This feature can be used for export and import of Interference Check models to/from XML files. The XML files are saved and read from the current path. Three separate xml files, each for one type of models are created.
The names of these files are as follows:

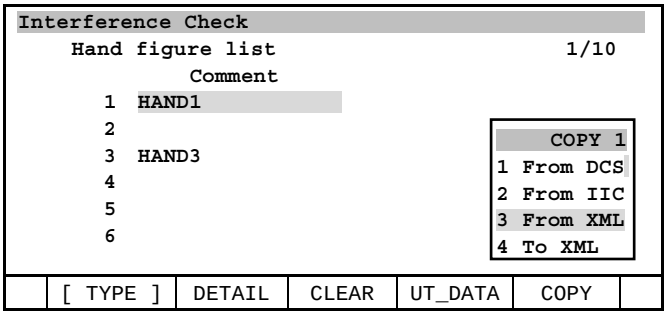
Model Type	File Name
Hand	iic_handmodel.xml
Fixture	iic_fixtmodel.xml
Robot	iic_robomodel.xml

Procedure for copying from/to XML

1. Press the MENU key.
2. Select SETUP.
3. Press F1[TYPE] and select “Interference”. Position the cursor on <*DETAIL*> of “Models setup” and press the Enter key. The following appears.



4. Select a models setup that you would like to copy. Press F5[COPY] key and Select “To XML” for copying to an XML file or “From XML” for copying from an XML file on each list menu. When “From XML” is selected and there is not the XML file in current selected device, model data is not changed For example, the following is displayed on Hand figure list.



3.4 SETTING INTERFERENCE CHECK COMBINATIONS

To use the interference check function, a combination of target models must be set. For some combinations the necessary signals must also be set. There are six combination types that can be used in Interference Check.

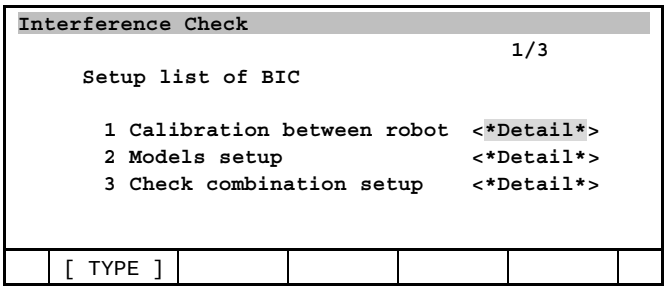
- Robot+Hand
- Fixture
- Critical Zone
- Virtual Fence
- DO Only
- PLC DIN

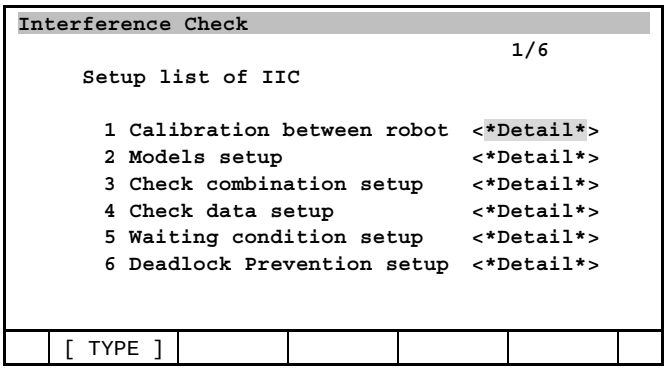
NOTE
When Interference Check combination type is Rob+Hnd or Fixture, number of model sets must not exceed 8 in this category.
When Interference Check combination type is Cr Zone, V Fence, DO Only or PLC DIN, number of model sets must not exceed 8 in this category.

3.4.1 Combination Setup

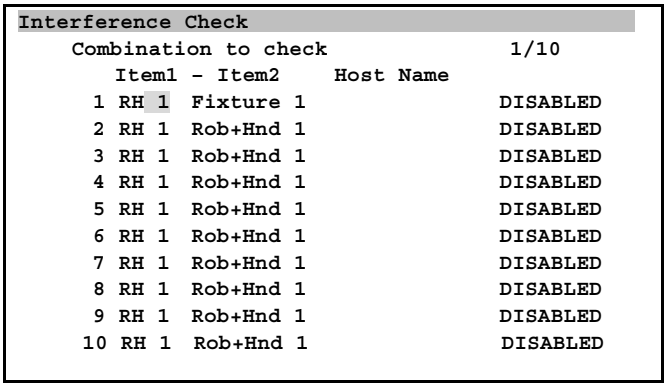
Procedure of Combination Setup

1. Press the MENU key.
2. Select SETUP.
3. Press F1[TYPE] and select “Interference”. The following (UP: Basic Interference Check, Bottom: Intelligent Interference Check) is displayed.

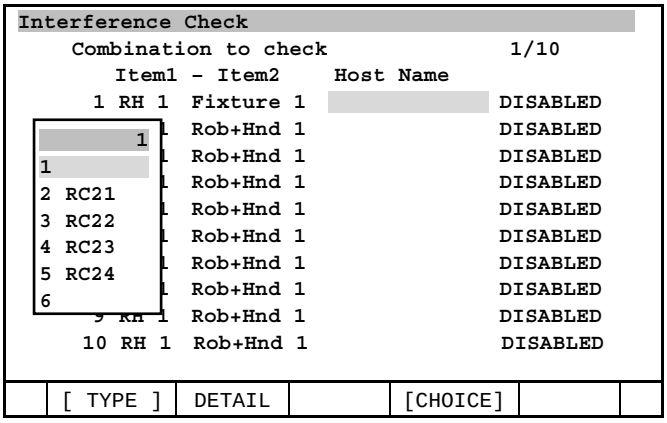




4. Position the cursor on <*DETAIL*> of “Check combination setup” and press the Enter key. The following is displayed. “RH” of Item1 shows “Robot+Hand”. The next number shows the group number.

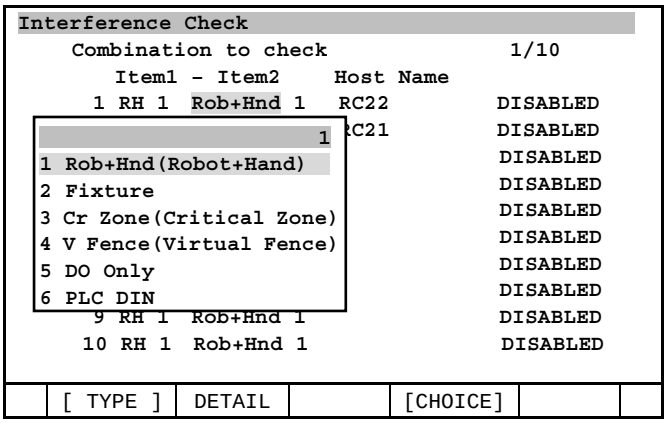


5. Position the cursor to Host name and pressing F4 [CHOICE] brings up the valid host name list. Always set the host name for every combination being used.
   - For Robot+Hand the host name can be another controller or the current controller if multiple robot groups exist on the controller.
   - For all other objects, fixtures, critical zones, virtual fences, DO Only, and PLC DIN, you must set the host name of the current controller.
   - To erase the host name select the first item.



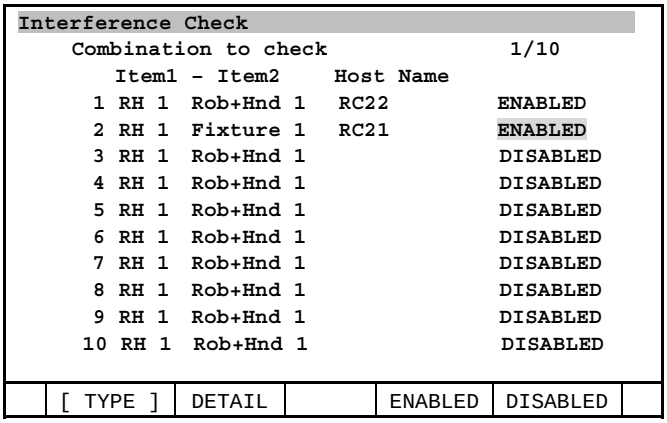
NOTE
After setting the host name, turn the power off, then on again.

6. Position the cursor to the Item2 and pressing F4, [CHOICE] brings up the combination type selection menu. There are six combination types that can be used in Interference Check. If you select Rob+Hnd, set the next number to the group number of the corresponding robot. If you select the other types, set the next number to the number of the corresponding fixture model.



NOTE
In Basic Interference Check, it is not possible to check a interference between robots. Therefore, it is not possible to select “Robot+Hand” on Item2

7. Specify whether to enable or disable the combination. Position the cursor on “ENABLED” or “DISABLED” and press F4[ENABLED] key or F5[DISABLED] key.



3.4.1.1 Setting up combination for Robot + Hand

“Robot + Hand” is only available for Intelligent Interference Check. In this case, interference between robots is checked. Robot will stop and post an alarm when the approach to the object robot is detected. It is possible to set the following items on detail menu.

Disable signal

Assign an input signal for each specified combination. When the specified signal is ON, the Interference Check function does not operate for the combination. A DI, WI, or RI signal can be specified. If no disable signal is defined for a combination, the Interference Check function always operates for the combination.

Approach deterrence signal

The Interference Check signal is turned on when the combination enters in the Interference Check status. A DO, RO, or WO signal can be set. If the index is set to 0, the Interference Check signal is not output.

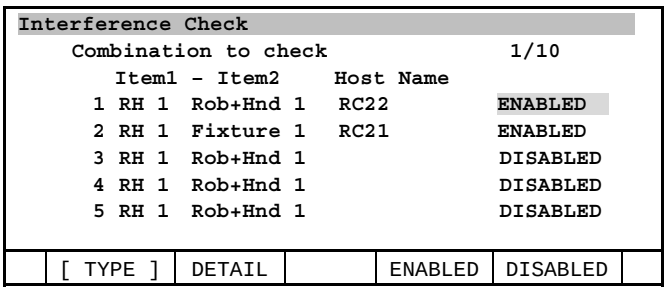
Temporary disable signal

The temporary disable signal is on when the approach deterrence function is temporarily disabled for the combination. For details of when this signal is turned on and off and the approach deterrence instructions, see “4.2 APPROACH DETERRENCE FUNCTION ENABLE/DISABLE INSTRUCTION.”

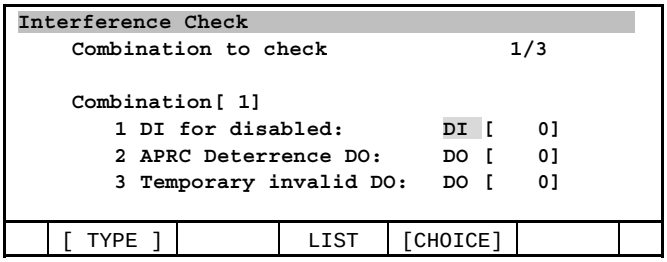
A DO, RO, or WO signal can be set. If the index is set to 0, the temporary disable signal is not output.

Assigning each signal

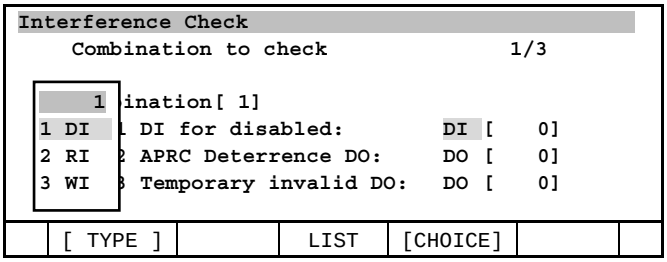
1. Position the cursor on the line of a combination “Rob+Hnd” for which signals are to be assigned

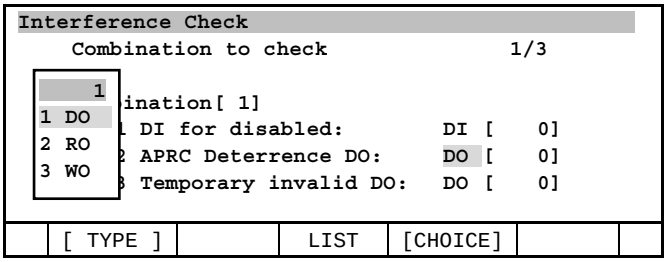


2. Press F2[DETAIL] key. The signal setting screen appears.



3. Position the cursor on the type of signal and press F4[CHOICE] key. The signals, which can be selected, are displayed to set a signal





4. Directly enter a signal assignment number.
5. Pressing the PREV key or F3[LIST] key will bring you back to the Combination to Check main menu.

3.4.1.2 Setting up combination for Fixture

If a combination type is “Fixture”, a robot will stop and post an alarm when the approach to the fixture is detected.
When you use Intelligent Interference Check, It is possible to set the following items on detail menu.

Disable signal

Assign an input signal for each specified combination. When the specified signal is ON, the Interference Check function does not operate for the combination. For example, set a signal with associating it with the clamp signal for the fixture. A DI, WI, or RI signal can be specified. If no disable signal is defined for a combination, the Interference Check function always operates for the combination.

Approach deterrence signal

The Interference Check signal is turned on when the combination enters in the Interference Check status. A DO, RO, or WO signal can be set. If the index is set to 0, the Interference Check signal is not output.

Temporary disable signal

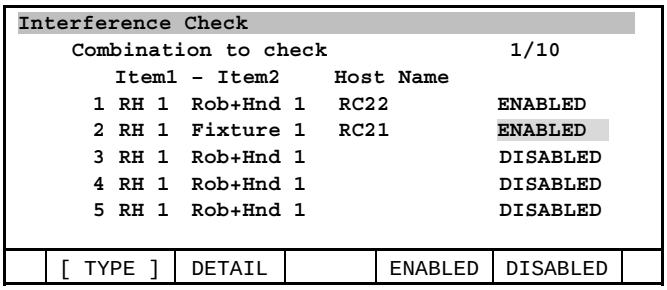
The temporary disable signal is on when the approach deterrence function is temporarily disabled for the combination. For details of when this signal is turned on and off and the approach deterrence instructions, see "4.2 APPROACH DETERRENCE FUNCTION ENABLE/DISABLE INSTRUCTION."
A DO, RO, or WO signal can be set. If the index is set to 0, the temporary disable signal is not output.

NOTE
In Basic Interference Check, it is not available above signals.

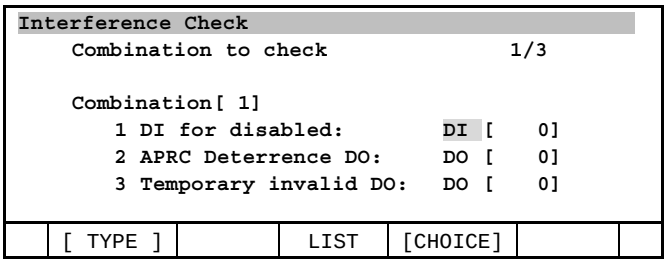
NOTE
If the model of "Fixture" is "Plane_inf", a robot will stop when a robot goes into the minus side of Z axis of the plane.

Assigning each signal

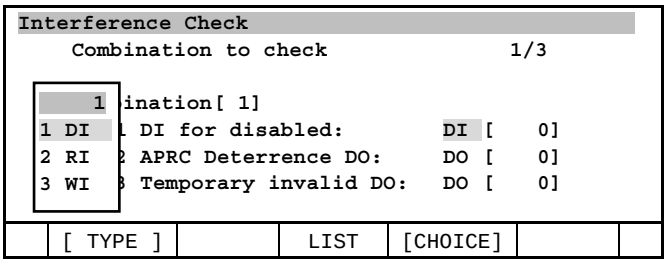
1. Position the cursor on the line of a combination "Fixture" for which signals is to be assigned.

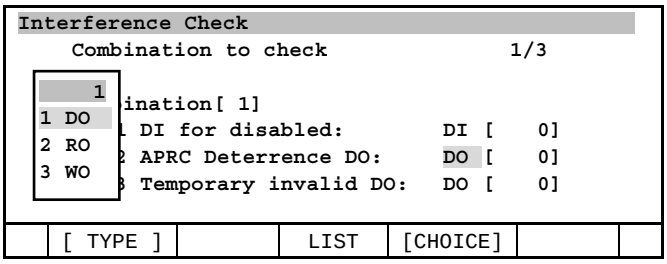


2. Press F2[DETAIL] key. The signal setting screen appears.



3. Position the cursor on the type of signal and press F4[CHOICE] key. The signals, which can be selected, are displayed to set a signal





4. Directly enter a signal assignment number.
5. Pressing the PREV key or F3[LIST] key will bring you back to the Combination to Check main menu.

3.4.1.3 Setting up combination for Critical Zone

If a combination type is "Critical Zone", Interference Check controls the entry of two robots into the zone defined by Fixture model setup by using I/O.
You must set the following items before you use “Critical Zone”.

Input signal

An input signal must be defined for Critical Zones. If the input signal is ON then the robot is free to enter the zone defined by Fixture model setup. It is necessary to input the output signal of another robot that uses Critical Zone. If the input signal is OFF then the robot will wait at the zone boundary until the value becomes ON. A DI, RI, or WI signal can be set.

Output signal

An output signal must be defined for Critical Zones. The critical zone signal is turned OFF when the robot enters the critical zone. When the robot exits the critical zone the signal is turned ON. It is necessary to input this output signal to another robot that uses Critical Zone. A DO, RO, or WO signal can be set.

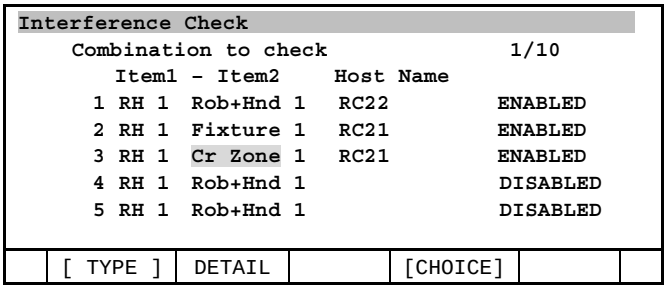
This robot priority

Priority is used when two robots enter the zone at the same time. If a robot has low priority then it will wait when the input signal becomes OFF. In this condition the robot will be a small amount inside the zone. The output signal becomes ON, allowing the high priority robot to operate normally inside the zone. When the input signal becomes ON this robot will set output to OFF and operate normally inside the zone. If both robots are high priority and both enter the zone at the same time then both robots will stop and an alarm will be posted.

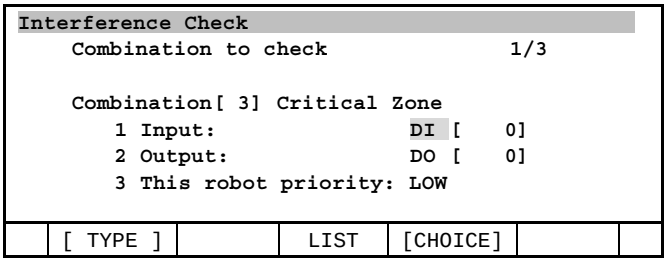
NOTE
If the model of “Critical Zone” is “Plane_inf”, Interference Check controls the entry of a robot into the minus side of Z axis of the plane by I/O.

Assigning each signal

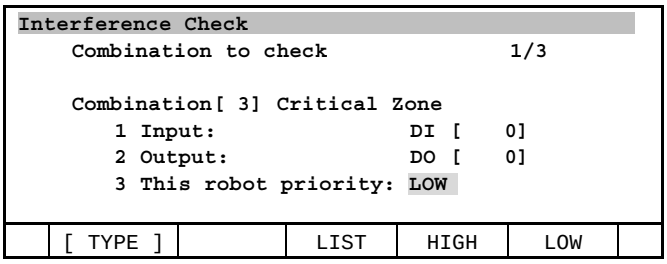
1. Position the cursor on the line of a combination “Critical Zone” for which signals is to be assigned.



2. Press F2[DETAIL] key. The signal setting screen appears.



3. Position the cursor on the type of signal and press F4[CHOICE] key. The signals, which can be selected, are displayed to set a signal

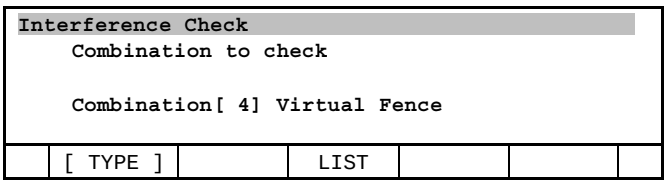


4. Position the cursor to the priority field and set the value by F4[HIGH] key for HIGH priority or F5[LOW] for Low priority.

3.4.1.4 Setting up combination for Virtual Fence

If a combination type is "Virtual Fence", a robot will stop and post an alarm when the robot goes outside the zone defined by Fixture model setup. After the robot encounters a virtual fence alarm, a SHIFT + RESET will allow the robot to be jogged away.

There is no detailed setup required for Virtual Fence.



NOTE
If the model of “Virtual Fence” is “Sphere”, “Cylinder” and “Box”, a robot will stop when the robot goes outside it.
If the model of “Virtual Fence” is “Plane_inf”, a robot will stop when a robot goes into the minus side of Z axis of the plane.
It is not possible to use “Plane_fin” as “Virtual Fence”.

3.4.1.5 Setting up combination for DO Only

If a combination type is "DO Only", the specified output signal turns OFF when the robot goes into the zone defined by Fixture model setup.
You must set the following items before you use “DO only”.

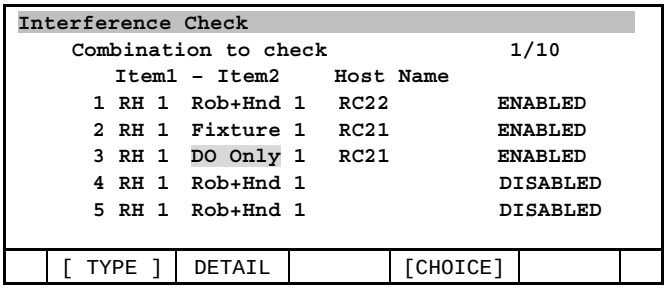
Output signal

An output signal must be defined for “DO Only”. The DO Only signal is turned OFF when the robot enters the zone. When the robot exits the zone the signal is turned OFF.
A DO, RO, or WO signal can be set

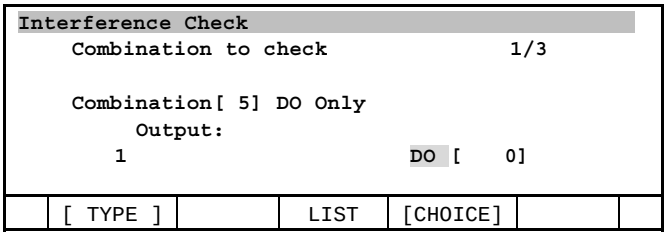
NOTE
If the model of “DO Only” is “Plane_inf”, DO become OFF when the robot goes into the minus side of Z axis of the plane.
If the model of “DO Only” is “Plane_fin”, DO become OFF when the robot touches the plane.

Assigning each signal

1. Position the cursor on the line of a combination “DO Only” for which signals is to be assigned.



2. Press F2[DETAIL] key. The signal setting screen appears.



3. Position the cursor on the type of signal and press F4[CHOICE] key. The signals, which can be selected, are displayed to set a signal

3.4.1.6 Setting up combination for PLC DIN

If a combination type is "PLC DIN", Interference Check controls the motion of the robot in the zone defined by Fixture model setup by using I/O.
You must set the following items before you use “PLC DIN”.

Input signal

An input signal must be defined for PLC DIN. If the input signal is ON then the robot is free to enter the zone defined by Fixture model setup. If the input signal is OFF then the robot will wait at or inside the zone boundary until the value becomes ON. No alarm is posted if the robot is inside the zone and the input signal becomes low. A DI, RI, or WI signal can be set.

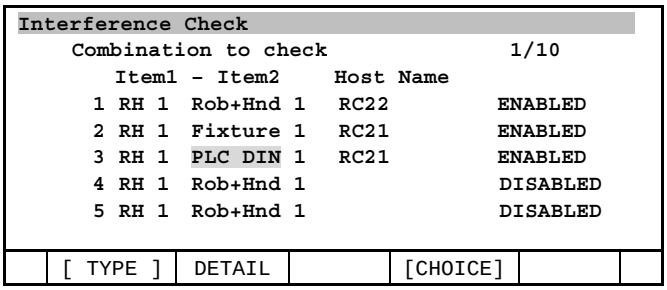
Output signal

An output signal must be defined for PLC DIN. The output signal is turned OFF when the robot enters the critical zone. When the robot exits the zone the signal is turned ON. A DO, RO, or WO signal can be set.

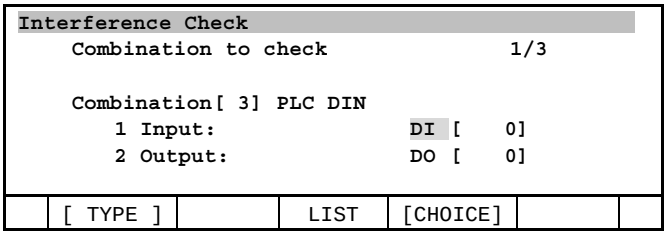
NOTE
If the model of “Critical Zone” is “Plane_inf”, Interference Check controls the motion of a robot in the minus side of Z axis of the plane by I/O.
If the model of “Critical Zone” is “Plane_fin”, Interference Check controls the motion of a robot by I/O while the robot touches the plane.

Assigning each signal

1. Position the cursor on the line of a combination “Critical Zone” for which signals is to be assigned.



2. Press F2[DETAIL] key. The signal setting screen appears.



3. Position the cursor on the type of signal and press F4[CHOICE] key. The signals, which can be selected, are displayed to set a signal

3.5 SETTING OTHER PARAMETERS

This section explains other data for the Interference Check function. The data is provided for each group. Do not change the data except for special cases.

NOTE
When you use Basic Interference Check, this setting menu is not displayed.

Use command at M-lock

When FALSE (default value) is set, Interference Check uses the true current positions of the robots. When TRUE is set, Interference check uses the commanded robot positions. This setting is used to simulate the Interference Check when the machine lock is enabled. **In most cases, do not change this setting.**

Speed slope factor

Constant used to calculate the stopping distance as a function of speed. This setting is factory tuned for each robot model. **In most cases, do not change this setting.**

Model size offset

Constant used to calculate the stopping distance as a function of speed. **This setting is factory tuned for each robot model. In most cases, do not change this setting**

Max margin

Constant used to calculate the stopping distance as a function of speed. **This setting is factory tuned for each robot model. In most cases, do not change this setting.**

Max speed

Constant used to calculate communication latency margins. **In most cases, do not change this setting.**

Max margin

Constant used to calculate communication latency margins. **In most cases, do not change this setting.**

Approach stop rate

The interference check function continuously monitors the distance between a modeled robot and other modeled robots (or fixtures). As the robot approaches the other robot (or fixture), the function smoothly decelerates the robot to a stop. If the approach becomes too close to stop smoothly before collision, the interference check function performs an immediate stop. The approach stop rate adjusts the distance between models that triggers deceleration of a robot. The robot will begin decelerating earlier when the approach stop rate is larger. **In most cases, do not change this setting.**

When the approach stop rate is set to 100, the robot considers a deceleration distance so that it can stop smoothly without causing a collision.

When the approach stop rate is set to 0, the deceleration distance is not used. The robot will perform an immediate stop to prevent imminent collision.

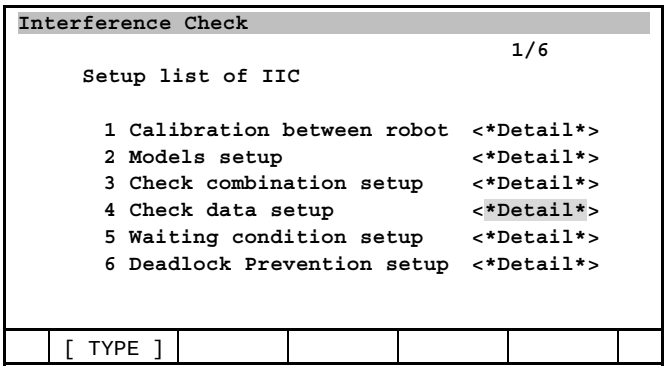
- When the robot moves away from another robot (or fixture), the direction of movement allows the robot to continue moving without stopping.
- When an approach waiting combination affects the same combination pair as an interference check combination, the deceleration distance is disabled for the interference check combination. For details, see “4.3.4 Disabling Deceleration Stop Based on Approach Waiting.”

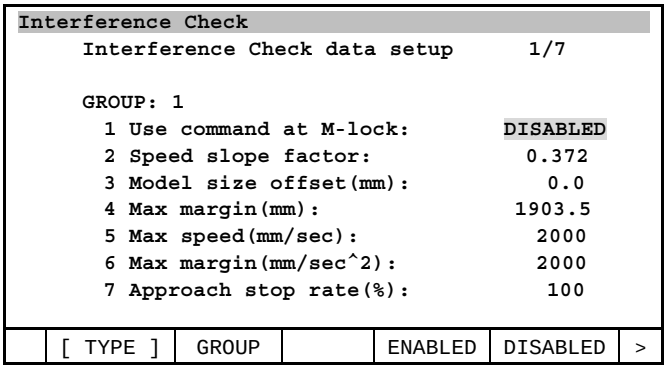
- When in SHIFT-RESET mode, the deceleration distance is disabled. Immediate stop will still take effect. This behavior will persist until the SHIFT key is released or a program is executed.

Interference Check function data list

> **⚠WARNING**
> The default values of these settings are set during initial start. When one of these settings is changed, the stop distance may change significantly as compared with the prior setting. Before changing a setting, keep a record of the setting before the change. Be careful not to change the settings unintentionally. Setting a robot at control start will restore the data to factory-settings.

1. Press the MENU key.
2. Select SETUP.
3. Press F1[TYPE] and select “Interference”. Position the cursor on <*DETAIL*> of “Check setup” and press the Enter key. The following appears.





4. To check data for another group, press F2[GROUP] key and enter the group number.

3.6 ENABLING DSP COMPUTATION

When an extra DSP is available and not needed for motion, Intelligent Interference Check can support distance computations on the available DSP, which reduces the processor load on the controller main CPU.

To enable IIC DSP computation, set this system variable:

$IIC_DSP.$DSP_ENABLE = TRUE (default: FALSE)

This system variable requires power cycle to take effect.

When enabled and DSP hardware exists, DSP computation can be verified with $IIC_DSP.$DSP_ON. When there is an available DSP, the $IIC_DSP.$DSP_ON become TRUE. When there is not available DSP, the following alarm is posted.

SSPC-240 "IIC DSP not available"

When this alarm is posted, it is not available DSP for Interference Check. Set $IIC_DSP.$DSP_ENABLE to FALSE and Power Off/ON.

3.7 APPROACH WAITING COMBINATIONS

NOTE
If you would like to use Approach Waiting function, Intelligent Interference Check is necessary.

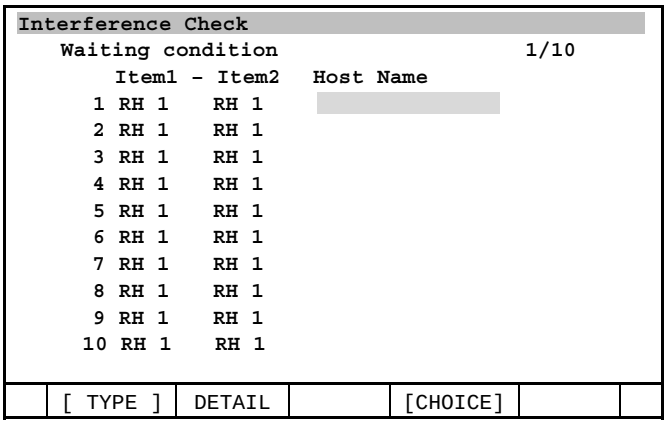
To use the Approach Waiting function, a combination of target models must be set. For some combinations the necessary signals must also be set. To configure approach waiting combinations, use the approach waiting combination list menu and approach waiting combination detail menu.

3.7.1 Approach Waiting Combination List Screen

Use the approach waiting combination list screen to set a combination of models for which the approach waiting function is to be used.
Display the approach waiting condition list screen using the following procedure:

Procedure

1. Press the MENU key.
2. Select SETUP.
3. Press F1[TYPE] and select “Interference”. Position the cursor on <*DETAIL*> of “Waiting Condition setup” and press the Enter key. The following appears.



3.7.1.1 Setting items

Item1

Indicate the group on the local controller that will wait. The type is always “RH”, which indicates Robot+Hand. The number indicates the group on the local host.

Item2

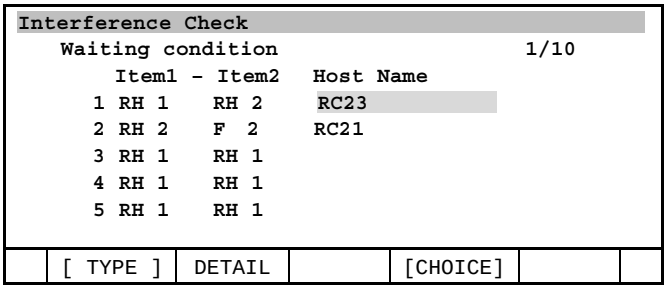
Specify the type and number of the other model of the approach waiting combination. The type can be “F” for fixture or “RH” for Robot+Hand, which can be selected from F4[CHOICE] key. The number indicates the fixture number or group number. “F” must be on the local host, and “RH” can be on the local host or a remote host.

Host name

The host name of Item2. Usable hosts can be selected from the [CHOICE] key.

Sample settings

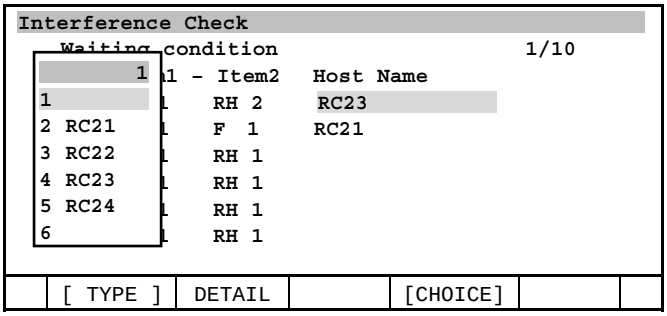
Assume that the following settings are made on the controller having host name RC21:



- Approach waiting combination 1 is:
  A combination of robot/hand corresponding to the tool in use in group 1 on RC21 and robot/hand corresponding to the tool in use in group 2 on RC23.
- Approach waiting combination 2 is:
  A combination of robot/hand corresponding to the tool in use in group 2 on RC21 and fixture 2 on RC21.

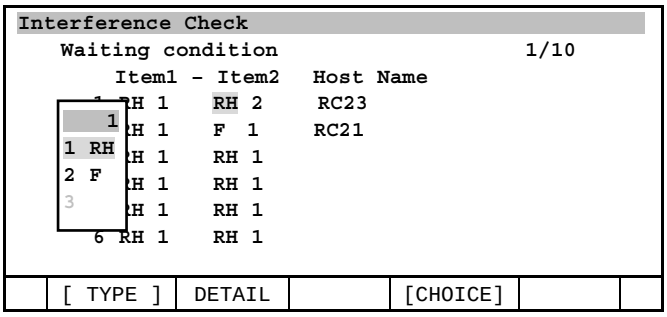
Setting a combination of models

1. Display the approach waiting combination list screen.
2. Position the cursor on the number of a combination to be set and set the following items.
3. Position the cursor on the host name. Press F4[CHOICE] key. The screen for selecting a hostname appears. Select the host name of the controller for other model. When you would like to erase the hostname, select the top of the list.



After setting the host name, turn the power off, then on again.

4. Position the cursor on “Item1” and “Item2”. Select the type of model. Specify RH for a robot (including a hand) and F for a fixture. Position the cursor on RH (or F) on the screen and press the F4[CHOICE] key. The submenu appears. On this submenu, you can select RH or F. Position the cursor on the number following RH or F and directly enter a model number. For RH, enter the group number of the corresponding robot. For F, enter the number of the corresponding fixture model.

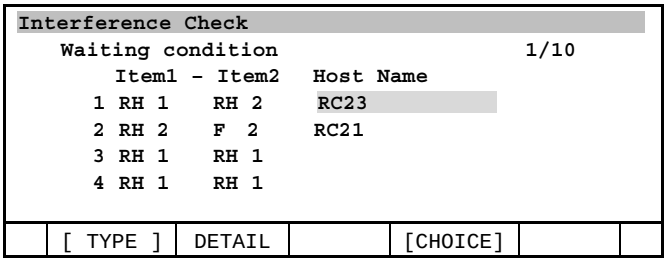


3.7.2 Detail Approach Waiting Combination Screen

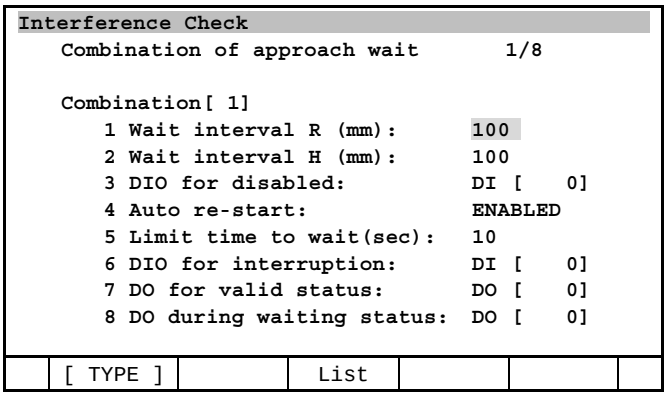
Use the detail approach waiting combination screen to set the approach waiting distances, specify various types of signals, and set the restart mode and waiting time. Display the detail screen using the following procedure.

Procedure

1. Display the approach waiting combination list screen.
2. Move the cursor to the line of the combination number for which details are to be set.



3. Press F2[DETAIL] key. The detail screen appears.



3.7.2.1 Setting items

Wait interval R

Specifies the distance between an element of a robot model and the other model that triggers the robot model to wait (or pause).

Example: Assume that the size of robot model 1 of RC21 is X mm.
Also assume that “Wait interval R” is set to 100 mm.
The condition is assumed to be satisfied when the distance from a line segment or point to the other model becomes X + 100 mm + other margins.

Wait interval H

Specifies the distance between an element of a hand model and the other model that triggers the hand model to wait (or temporarily stop).

DI for disabled

The corresponding approach waiting combination is disabled when this signal is input. When disabled, the robot or hand does not wait or temporarily stop even if the condition is satisfied.
For example, use this signal when you would not like to decelerate and stop a robot during spot welding operation by Approach Waiting function. A DO, DI, RO, RI, WO, or WI signal can be used.

Example: The spot signal can be set for “DI for disabled” to disable the approach waiting function during spot welding.

Auto re-start: ENABLED/DISABLED

Auto restart can be enabled or disabled.

When the robot comes within the approach waiting distance, the robot turns ON the signal set for "DO during waiting status" and begins decelerating to a stop.

When auto restart is enabled, the robot waits for the other model to move away. The waiting robot automatically restarts operation when the distance to the other model becomes larger than the distance that triggered the waiting status.

When auto restart is disabled, the program pauses. To restart the program, an external START signal is required. The signal set for "DO during waiting status" can be used to check when the waiting distance is exceeded.

Limit time to wait

If a robot is not auto-restarted within the specified time, the program is paused for safety. After the limit time to wait expires, the robot does not restart operation unless an external START signal is input, even if the distance between models becomes larger than the approach waiting distance.

- Time measurement for “Limit time to wait” starts when a robot begins the approach waiting status.
- The elapsed time is reset when a robot in the approach waiting status temporarily stops.
- The default setting is 10 seconds.
- When a value of 0 is set, the robot waits forever.
- The elapsed time is not reset by changing the time in the waiting status.

Example: Assume that a value of 0 (endless waiting) is first set for “Limit time to wait”. Four seconds after a robot enters the approach waiting status:

- Setting 2 to “Limit time to wait” immediately causes a time-out.
- Setting 10 to “Limit time to wait” causes a time-out 6 seconds after that time (10 seconds after the robot enters the approach waiting status).

DI for interruption

When the signal set for “DI for interruption” is input in the approach waiting status, the following alarm occurs and the program temporarily stops:

SSPC-157 “Interrupt signal (combination-number)”

The robot requires an external START signal to resume. The robot will not automatically restart operation even if the distance between models becomes larger than the approach waiting distance. A DO, DI, RO, RI, WO, or WI signal can be used.

DO for valid status

This signal is on when the corresponding combination is enabled by an approach waiting instruction.
When the enable instruction is executed, this signal is turned ON. The signal remains ON until one of the following events occur:

- Program end
- Temporary stop, then line change and restart
- Execution of the disable instruction

This signal is on in the status in which the corresponding robot temporarily stops.

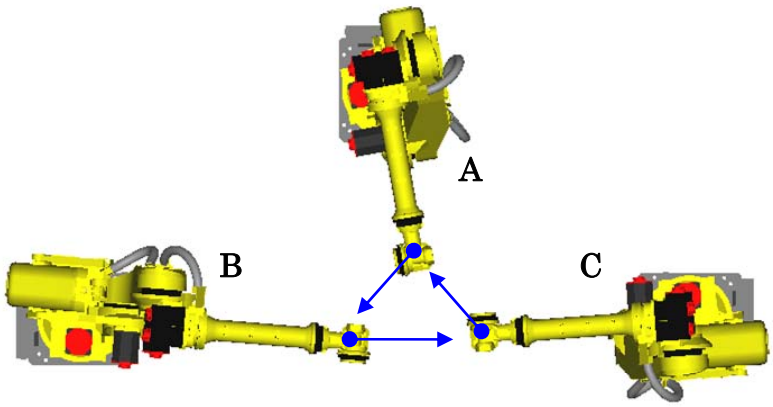
DO during waiting status

This signal is turned on when the corresponding combination is enabled and the distance between models reaches the approach waiting distance.
This signal is turned off when the distance between models becomes larger than the approach waiting distance.
When auto restart is disabled or limit time to wait has expired, this signal can be used to determine whether restart can be performed safely.

3.8 SETTING DEADLOCK PREVENTION

NOTE
If you would like to use Approach Waiting function, Intelligent Interference Check is necessary.

This section explains Deadlock Prevention function. It analyzes TP programs offline on the controller to determine deadlock zones, and inserts multiple arm synchronization instructions in the TP programs to prevent deadlocks among multiple robots across multiple controllers.
The following example illustrates deadlock conditions:



- Robot A is waiting for robot C
- Robot C is waiting for robot D
- Robot D is waiting for robot A

There are prerequisites to set up and utilize Deadlock Prevention function:

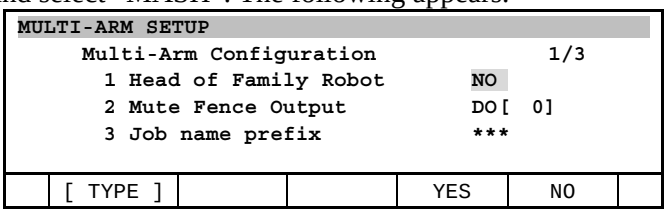
- Setup RIPE
- Calibration among multiple robots
- Hand model setup to protect robot tooling
- Robot to robot protection setup
- Multiple arm synchronization instruction MASH setup

3.8.1 Multi Arm Shell Setup

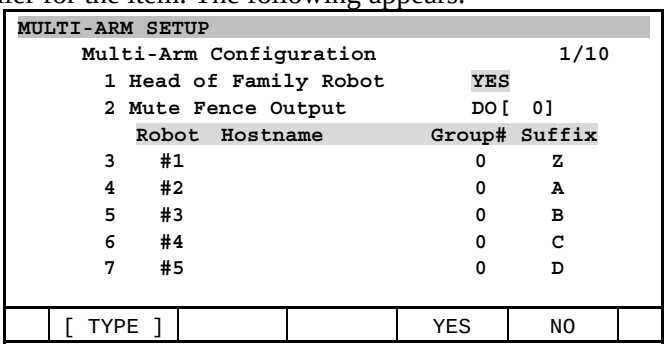
In order to Deadlock Prevention function, it is necessary to setup Multi Arm Shell (MASH). Before MASH is set, it is necessary to setup the RIPE. Always set up RIPE even for the case where only one controller exists.

Procedure (7DC1, 7DD0)

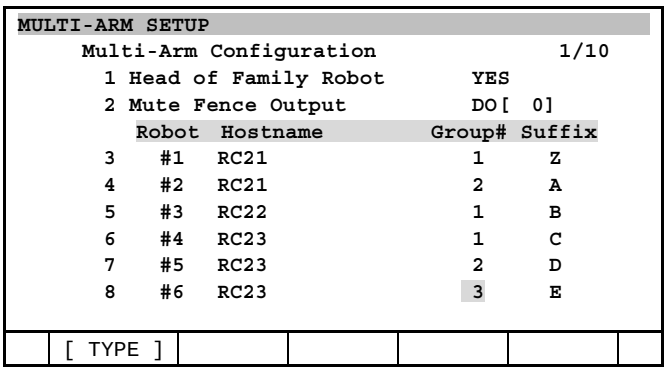
1. Press the MENU key.
2. Select SETUP.
3. Press F1[TYPE] and select “MASH”. The following appears.



4. Press F4[YES] key when cursor is on item 1 “Head of Family Robot”. NOTE: only select YES on the Master controller for the item. The following appears.



5. It is not necessary to set item 2 “Mute Fence Output”.
6. Move cursor to item 3 to select correct Hostname from [CHOICE], type in correct Group# for all involved robots (devices), respectively. Note: the very first one in the list must be the Master controller; all other controllers become slave controllers in multi controller case.
7. Choose correct Hostname from the list and then specify correct group #. NOTE that group # is the group number in a given controller (associated with the Hostname), as shown above.



8. It is not necessary to change the item of Suffix.
9. Cycle power on the Master controller and then cycle power on the all involved controllers.
10. Check the system variable $RKMASHCONF.$I_AM_MASTER is TRUE for master controller.

Procedure (from 7DC2)

1. Press the MENU key.
2. Select SETUP.
3. Press F1[TYPE] and select “MASH”. The following appears.

```
MULTI-ARM SETUP
     Multi-Arm Configuration                1/17
       1 Bypassed Robot Output       GO[  0]
          Robot Hostname       Grp# Suffix  Bypas
       3    #1                    0      Z     NO
       4    #2                    0      A     NO
       5    #3                    0      B     NO
       6    #4                    0      C     NO
       7    #5                    0      D     NO

    [ TYPE ]
```

4. Bypassed Robot Output is used for Robot Bypass function. When you would like to use Robot Bypass function, set this item. Please refer to 3.9 ROBOT BYPASS FUNCTION.
5. Move cursor to item 2 to select correct Hostname from [CHOICE], type in correct Group# for all involved robots (devices), respectively. Note: the very first one in the list must be the Master controller; all other controllers become slave controllers in multi controller case.
6. Choose correct Hostname from the list and then specify correct group #. NOTE that group # is the group number in a given controller (associated with the Hostname), as shown above.

```
MULTI-ARM SETUP
     Multi-Arm Configuration                1/17
       1 Bypassed Robot Output       GO[  0]
          Robot Hostname       Grp# Suffix  Bypas
       2    #1   RC21          1      Z     NO
       3    #2   RC21          2      A     NO
       4    #3   RC22          1      B     NO
       5    #4   RC23          1      C     NO
       6    #5   RC23          2      D     NO
       7    #6   RC23          3      E     NO

    [ TYPE ]
```

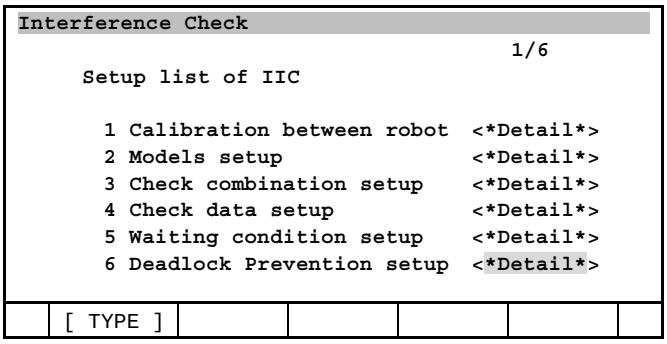
7. It is not necessary to change the item of Suffix.
8. The item of Bypass is used for Robot Bypass function. When you don’t use Robot Bypass function, you need to set the item to “NO”.
9. Cycle power on the Master controller and then cycle power on the all involved controllers.
10. Check the system variable $RKMASHCONF.$I_AM_MASTER is TRUE for master controller.

3.8.2 Deadlock Prevention Setup Menu

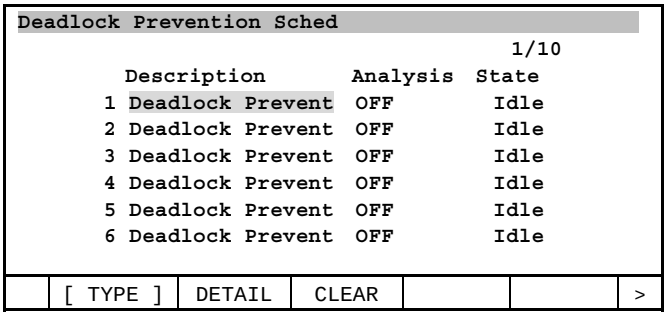
Deadlock Prevention Setup Menu is displayed by the following procedure.

Procedure

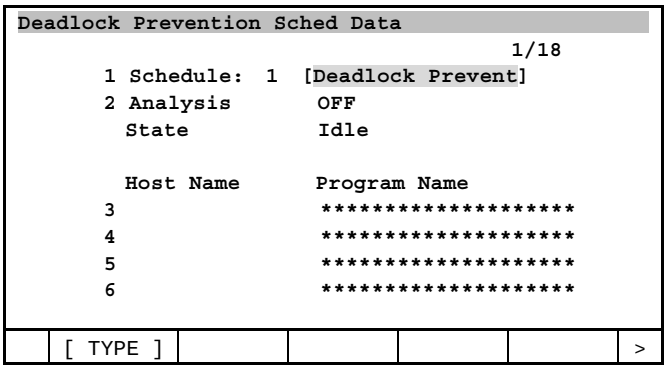
1. Press the MENU key.
2. Select SETUP.
3. Press F1[TYPE] and select “Interference”. Position the cursor on <*DETAIL*> of “Deadlock Prevention setup” and press the Enter key.



4. Deadlock Prevention Schedule list is displayed. There are 10 deadlock prevention schedules by default.



5. When you would like to change the number of the schedule, set $IC_DP_CONF.$MAX_DP_SCHD and Cold Start the controller to take effect. The maximum of it is 32.
6. Press F2[DETAIL] key to enter the Deadlock Prevention Schedule detail setup.

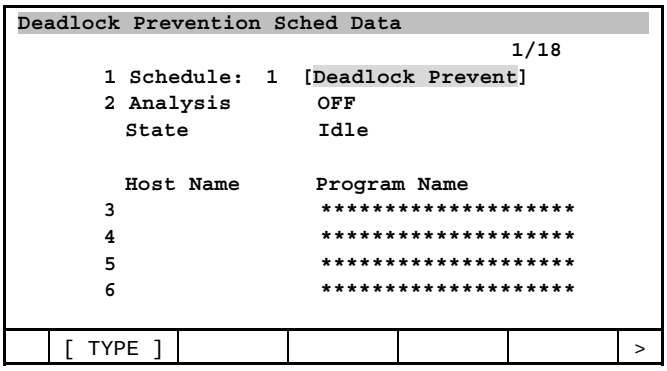


3.8.3 How to Use Deadlock Prevention Function

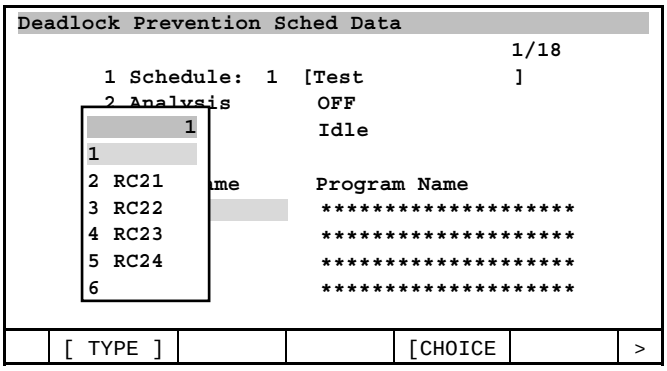
You can analysis TP programs on Deadlock Prevention Schedule detail setup. Before an analysis, you need to specify TP programs you would like to analysis.

Procedure

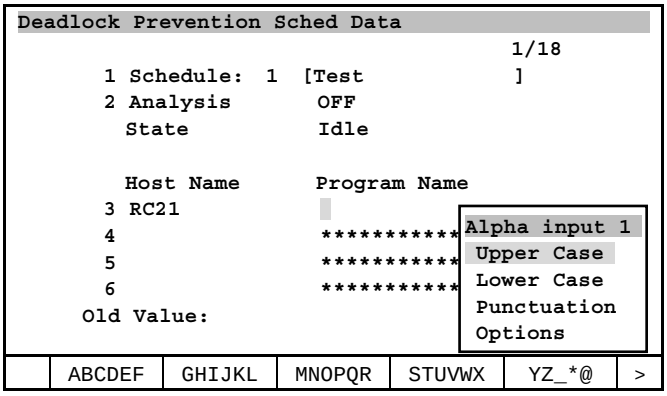
1. Display Deadlock Prevention Schedule detail setup.
2. Position the cursor to item 1 “Schedule”. You can set the name of the schedule.



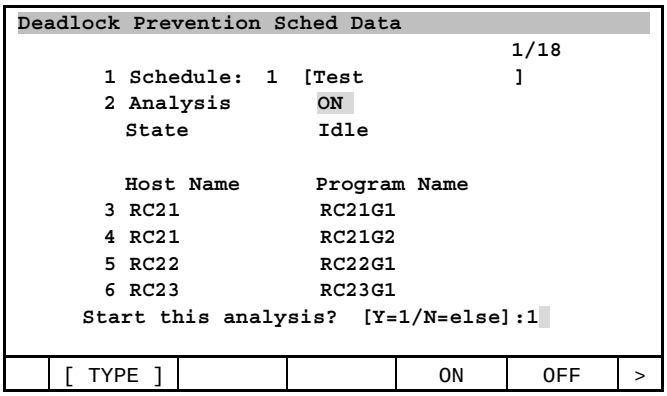
3. Position the cursor below item 3. Set Host Name and Program Name of TP program you would like to analysis. You can select Host Name by pressing F4[CHOICE] key.



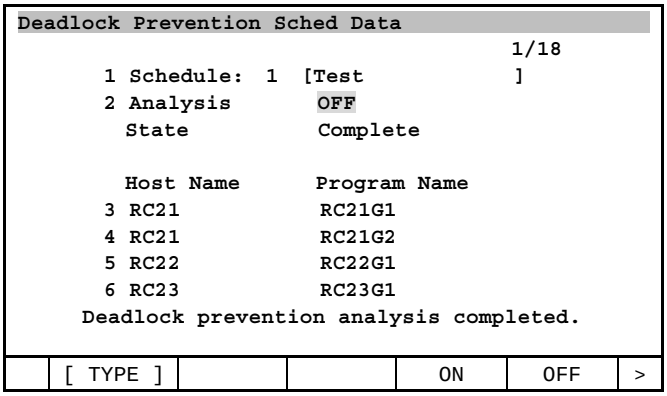
Move the cursor to Program Name and press enter key and input Program Name directly.



4. After you finish specifying TP programs, move the cursor to item 2 “Analysis” and press F4[YES] key to initiate the deadlock prevention analysis on the main controller, then enter 1 to confirm the analysis.

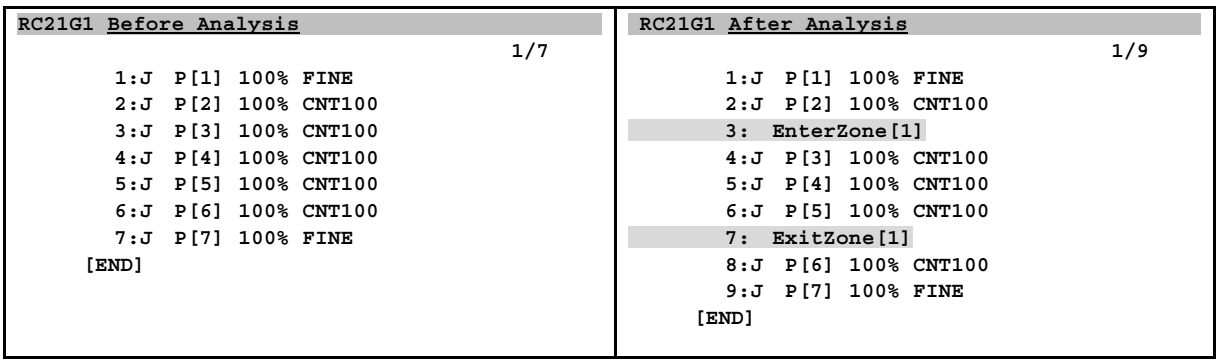


5. During the analysis, the menu item “State” will transit to “Process”, and then “Complete” when the analysis is complete. If an error condition occurred during the analysis process, the analysis state will display “Error” to indicate that the analysis process has failed.



6. After the analysis process has been completed, deadlock zones have been identified, and then multiple arm synchronization instructions will be inserted in TP programs automatically. EnterZone[] and ExitZone[] instructions for the synchronization between robots have been inserted in the TP programs

   The following example: if Deadlock Prevention function judge that the interference between robots occurs during the motion to P[3], P[4] and P[5] by the analysis. EnterZone and ExitZone are inserted before and after it.



NOTE
Please refer to 4.5 Multi Arm Synchronization Instructions about the details of it.

3.8.4 Deadlock Prevention Limitation

Deadlock Prevention function has limitations including:

- The following TP instructions are not supported and they will be ignored during offline analysis: Don't use these instructions in TP programs that are analyzed by Deadlock Prevention.
  - Branch and conditional logic instructions
  - RUN command
- EnterZone[] and ExitZone[] synchronization instructions will only be inserted in the first level of specified programs.
- It is not possible to analyze TP program without motion instruction.
- TP programs must be evaluated on the motion program level. Any subprogram will be evaluated as a single logical block, and Zone synchronization instructions will not be inserted in the subprogram.
- Previous Enter/Exit Zone instructions will be removed, and new Enter/Exit Zone instructions will be inserted in TP programs after a new deadlock prevention analysis has been completed.
- A new analysis is required if TP programs have been modified after the analysis.
- During the deadlock prevention analysis, an alarm ATZN-029"Dup prg (program name) schd (schedule id)" will be posted if duplicated host name and program name found in other schedule that has been completed the analysis.
- The time to complete deadlock prevention analysis may vary based on the complexity of the TP programs.
- After the deadlock prevention analysis is complete, multiple TP programs from the same deadlock prevention schedule can be executed simultaneously without deadlock. It's user's responsibility to ensure that multiple programs executed are from same schedule, i.e. programs analyzed from different schedules can not be executed simultaneously.
- Deadlock Prevention function supports deadlock free and interference free among multiple robots across multiple controllers. Nonetheless, it is recommended to enable robot to robot checking in check combination setup menu.

3.9 ROBOT BYPASS FUNCTION

This section explains Robot Bypass function. This function is available from 7DC2/07. It is useful for fault recovery when one robot unit in the chain is down and the work cell needs to recover and continue without that faulted robot.

When a robot is bypassed, the bypassed robot is not checked interference between robots. Robot bypass setup is configured by the user. The robot bypass system does not detect dynamic controller online or offline network condition.

NOTE
If you would like to use Approach Waiting function, Intelligent Interference Check is necessary.

⚠CAUTION
A bypassed robot is a faulted robot. The bypassed robot is not checked interference between robots. User has responsibility to move the bypassed robot to a safe position to avoid any potential interference from other working robots.

3.9.1 Robot Bypass Setup Menu

When you use this function, you need to set Multi Arm Shell in advance. Please refer to 3.8.1 Multi Arm Shell Setup.
Bypassed robot is configured in MASH Multi-Arm Setup menu.

- When you would like to use Bypassed Robot Output, please set the index of GO for it. When you don't use this output, please set to "0".
- When you would like to bypass the robot, please set its item of "Bypass" to "YES".
- After you change Bypass setting, you need to power off/on all controllers.

Each bit of the group output indicates a bypassed robot, the least significant bit being the robot #1. For example, if only #1 is bypassed, the value of GO is 1(=2^0). If #1 and #3 are bypassed, the value of GO is 5 (=2^0+2^2).

For example, the group 1 robot in the controller RC22 is bypassed in the following menu:

```
MULTI-ARM SETUP
     Multi-Arm Configuration                1/17
       1 Bypassed Robot Output      GO[  0]
          Robot Hostname       Grp# Suffix  Bypas
       2    #1   RC21          1     Z     NO
       3    #2   RC21          2     A     NO
       4    #3   RC22          1     B     YES
       5    #4   RC23          1     C     NO
       6    #5   RC23          2     D     NO
       7    #6   RC23          3     E     NO

    [ TYPE ]
```

When the robot is configured as bypassed in the MASH menu, the enabled Arm-to-Arm checking in the corresponding combination pair will be marked automatically from "ENABLED" to "ENABLED*". For example, the group#1 robot in controller RC22 is bypassed as indicated in the following combination setup menu:

```
Interference Check
    Combination to check                 1/10
       Item1 - Item2     Host Name
      1 RH 1  Rob+Hnd 1   RC22          ENABLED*
      2 RH 1  Fixture 1   RC21          ENABLED
      3 RH 1  Cr Zone 2   RC21          ENABLED
      4 RH 1  Rob+Hnd 1                 DISABLED
      5 RH 1  Rob+Hnd 1                 DISABLED

    [ TYPE ]  DETAIL        ENABLED  DISABLED
```

3.9.2 Robot Bypass Runtime Check

Interference between robots runtime check:

If interference between robots is checked and the target robot is bypassed, SSPC-226 will be posted.

Approach Wait runtime check:

If Approach Wait is enabled by TP instruction and the target robot is bypassed, SSPC-226 will be posted. For information about TP instruction of Approach Wait, please refer to 4.3 APPROACH WAITING ENABLE/DISABLE INSTRUCTION.

Deadlock Prevention analysis:

If the robot of the specified TP program in the deadlock prevention schedule is bypassed, the alarm SSPC-226 will be posted and fail the deadlock prevention analysis process.

3.9.3 Robot Bypass Limitation

- Robot Bypass function is available from 7DC2/07.
- Robot bypass supports Intelligent Interference Check only, it does not support Basic Interference Check.

- Robot bypass setup is configured by the user. The system does not detect dynamic controller online or offline network condition.
- A warning alarm will be posted for the following cases if the checked robot is configured as bypassed
  - Interference between robots runtime check
  - Approach Wait runtime check
  - Deadlock Prevention analysis
- Robot bypass only applies to Robot as checked item. It does not apply to the others (Fixture, Critical Zone, Virtual Fence, DO Only or PLC DIN).

3.10 RAILZONE FUNCTION

NOTE
If you would like to use RailZone function, Intelligent Interference Check and Ethernet Global Data (EGD) I/O is necessary.

This function provides collision protection between rail robots moving on a same rail. It also provides a flexible method to setup rail barriers (software rail stopper) to control RailZone working range. The RailZone interference check function requires no additional hardware. The collision protection covers for carriages, rail robot and its tooling across the controllers.

3.10.1 RailZone Limitation

- This function requires IIC (Intelligent Interference Check, option R759).
- This function only applies to robot which has a rail as following.
  - Carriage axis is an independent axis in robot group or the other group.
  - Carriage axis is an integral extended rail axis.
  - Carriage axis is a J1 axis of robot which is linear axis.
- This function requires Ethernet Global Data (EGD) I/O and Ethernet capability for data exchanging across the controllers. FANUC Robotics recommends completely isolating the RailZone Interference Check EGD network as a separate control network to optimize the RailZone Interference Check functionality. This can be done by dedicating one Ethernet port on each robot controller for EGD I/O exchange.
- This function supports multiple robots in separate controllers. (Each controller has one robot.)
- It is possible to set zero master position of each robot separately.
- It is necessary to set a common rail zero master position for all rail robots.

3.10.2 Terminology for RailZone

Throughout this manual we will be frequently reference to following terms

Term	Description
Left Robot	An immediate adjacent rail robot that has lower rail position.
Right Robot	An immediate adjacent rail robot that has higher rail position.
LB	Low boundary for a rail robot in rail axis direction.
HB	High boundary for a rail robot in rail axis direction.

Note The left and right robot definition is relative to rail plus direction, not relevant to your viewing position. Following two examples illustrate how to identify left and right robot to a host rail robot.

Example 1 of Left and Right Rail Robot

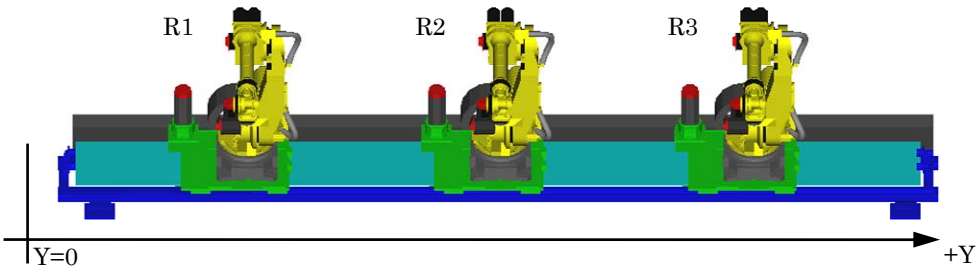


Fig 3.10.2(a) Left and Right Robot 1

In above example, there are three rail robots, R1, R2 and R3. The R3 has highest rail position. Thus,
- R1 has no left robot and has right robot R2
- R2 has left robot R1 and right robot R3
- R3 has left robot R2 and has no right robot

Example 2 of Left and Right Rail Robot

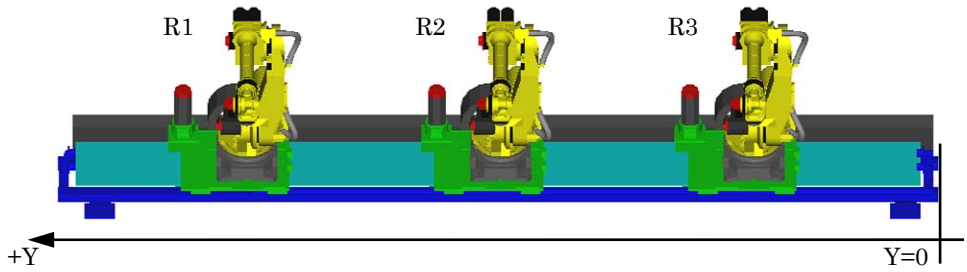


Fig 3.10.2(b) Left and Right Robot 2

In above example, there are three rail robots, R1, R2 and R3. The R1 has highest rail position. Thus,
- R1 has no right robot and has left robot R2
- R2 has left robot R3 and has right robot R1
- R3 has right robot R2 and has no left robot

3.10.3 RailZone Function Description

A RailZone for a rail robot is defined by its low bound (LB) and high bound (HB) along rail direction (one dimensional) relative to rail position. A RailZone travels with rail robot and specifies an operational working space for rail robot. An active RailZone space can only be accessed by a designated rail robot. A RailZone has following characteristics:

- User defines low and high boundaries (LB & HB) by L_offset and R_offset in relative to rail position for each zone. Refer to Zone Setup section for how to setup values of L_offset and R_offset.
- User-defined boundaries establish minimum size of a RailZone.
- A zone size is automatically increased if robot posture and/or robot tooling extends beyond the user-defined minimum zone boundaries.
- A RailZone is dynamically updated based on robot's rail position, robot posture, robot tool, and rail motion speed and direction.
- RailZone data are continuously communicated to adjacent robot controllers using EGD.
- A RailZone can be enabled or disabled at any time.
- A rail robot can switch to a different RailZone at any time.

- Each controller has maximum 10 zones, but allows one active zone at one time.
- User defines a safety margin distance for each zone. It is a minimum allowed distance between RailZones for adjacent robots. Refer to Zone Setup section for how to setup margin distance.

> ⚠ **WARNING**
> You must set a proper safety margin distance based on real-world testing under the worst motion condition, two adjacent rail robots moving towards each other at highest operational speed. Otherwise, you will injure personnel or damage equipment.

A schematic below illustrates RailZone concept for multiple rail robots. Each rail robot claims its own RailZone space by its LB and HB along the rail.

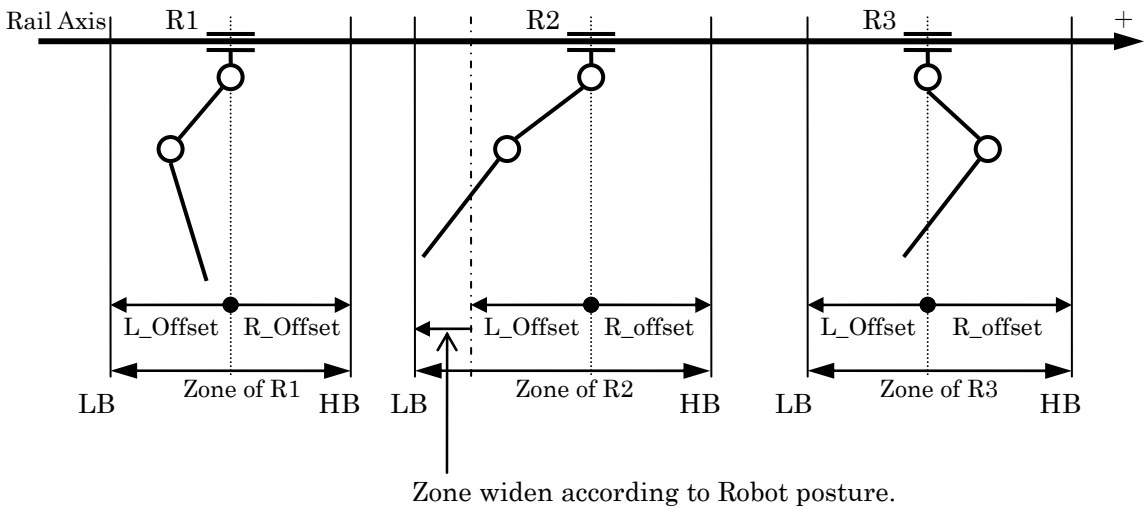


Fig. 3.10.3(a) Example of RailZone

A rail barrier is similar to a hard stopper, but it is set by software. A rail barrier is used to limit motion range of a rail robot. You can set low limit barrier or high limit barrier for a rail robot. A high boundary (HB) of a left dummy robot serves for a low limit barrier. A low boundary (LB) of a right dummy robot serves for high limit barrier. A limit barrier can be set or reset dynamically.

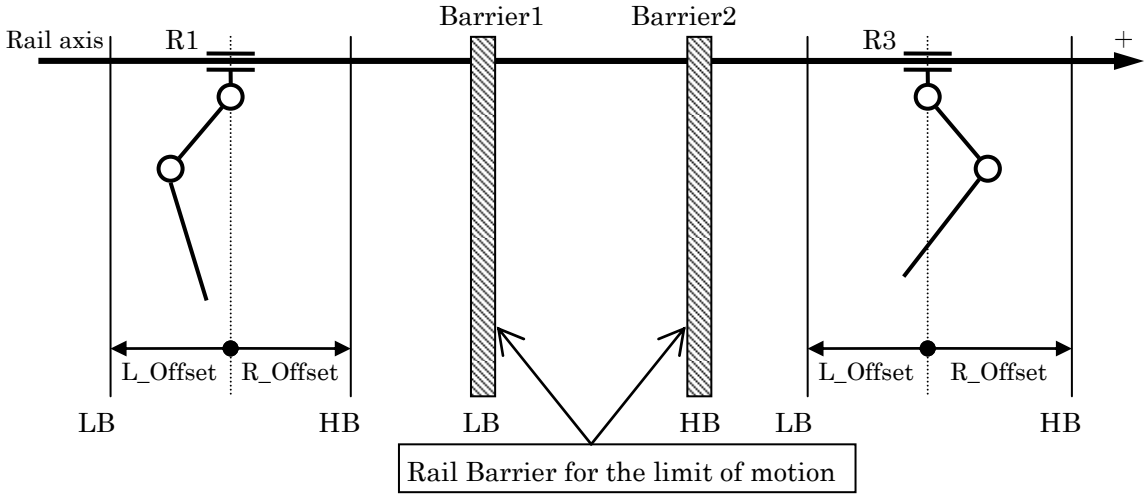
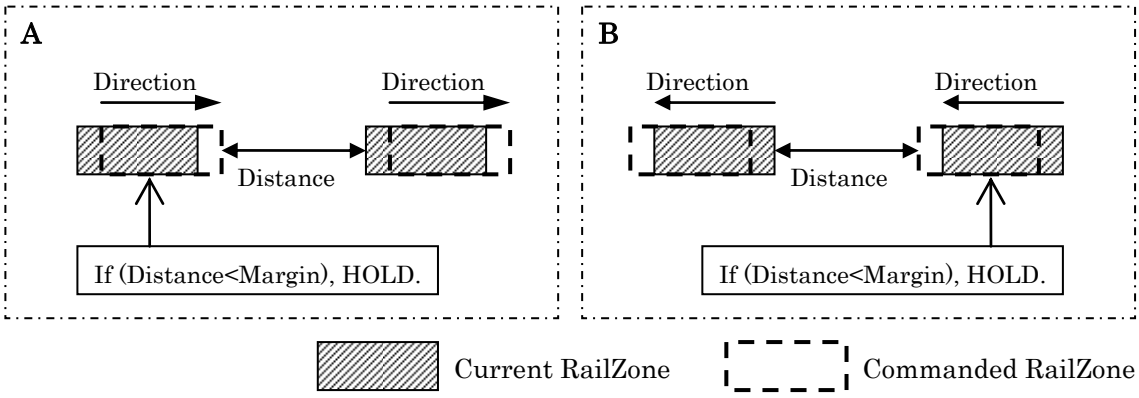


Fig. 3.10.3(b) Example of Rail Barrier

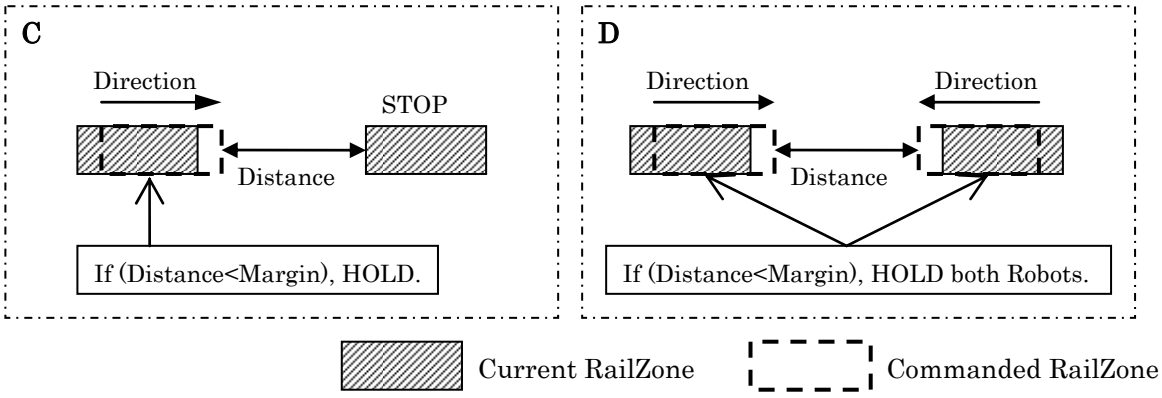
RailZone Interference Control Rules

A control objective is to prevent RailZone of adjacent rail robots from overlapping at any circumstance. When a RailZone is close to other zone of its adjacent rail robot, for example, when distance between the two zones is less than a safety marginal distance, the rail robot will be held automatically. The held rail robot is un-held automatically as soon as the zone interference condition is cleared.

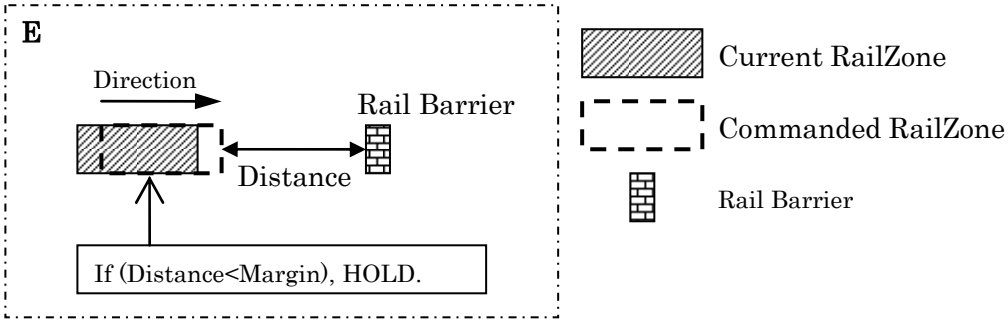
- If two adjacent rail robots are moving in the same rail direction, system will only hold the trailing robot upon detection of interference (see A and B of figures below). When interference is cleared due to a motion of the leading robot, the trailing robot will be automatically un-held to resume its motion along the rail.



- If one robot is in stationary while the other robot is moving toward to it (see C of figure below), the system will only hold the moving robot upon detection of the interference. The moving robot can be controlled by jog operation or program execution.
- If adjacent rail robots are moving toward each other (see D of figure below), system will hold both robots upon detection of the interference. It requires manual intervention to clear the situation.



- If one robot is moving toward to a rail barrier, the system will hold the moving robot upon detection of the interference between the RailZone and the rail barrier (see E of figure below).



RailZone Enable or Disable

A RailZone can be enabled or disabled at any time. However, changing state of a RailZone for rail robot will affect its adjacent rail robots. For safety requirement, certain actions are required as the state of the transition occurs.

- When RailZone is changed from Enable to Disable for a host robot
  - Host robot will stop RailZone interference check immediately.
  - If host robot is being held during program execution, system will un-hold the robot and will generate a stop severity alarm (ICRZ-007 Zone disabled while the robot is held).
  - Host robot will stop updating RailZone data to its adjacent robots.
  - Adjacent robot will post a warning (ICRZ-012 Right Robot Not Defined or ICRZ-012 Right Robot Not Defined).
  - Adjacent robots will use the last received RailZone data for interference check.

- When RailZone is changed from Enable to Disable for a host robot
  - Host robot will start RailZone interface check immediately.
  - Adjacent robot will use updated RailZone data for interference check.

> ⚠ **WARNING**
> You should not dynamically disable RailZone function while rail robots are moving. Otherwise, you will injure personnel or damage equipment.

T1/T2 Mode Control

- RailZone can work at T1/T2 or Auto-Mode. However, when any controller is set to T1/T2 mode, the rail robot on other controllers for same rail should stop program execution at AUTO-Mode.

Manual Unhold Robot or Rail Group

When rail robot or rail axis group is being held, you can unhold it manually by following methods:

- Enable TP if it is in the auto mode or,
- Press reset if it is in jog mode or,
- Disable RailZone of the rail robot.

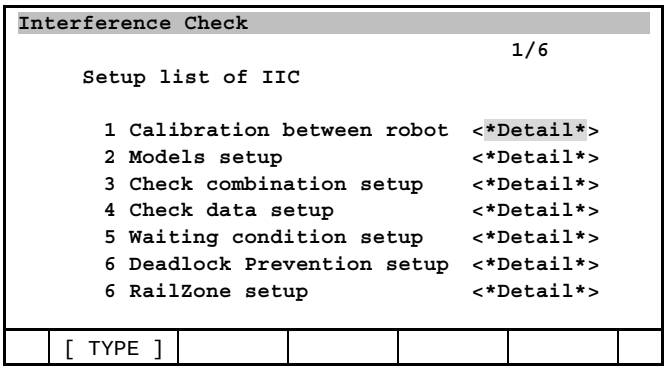
Deadlock Handling

Deadlock happens when host robot and its adjacent robot are moving toward each other during the program execution and both robots are being held at interference. To get out from the deadlock situation you can follow the procedures below:

- Manually unhold the robot and its rail axis group and, jog robot away from the interference condition.
- Adjust the programming sequence to prevent the deadlock from occurring in the future.

3.10.4 RailZone Setup

You can setup RailZone in Interference Check setup menu. When there is linear extended axis or rail axis in a controller and $IC_RZ_CFG.$ENABLE is set to TRUE, “RailZone setup” is appeared on Setup list of IIC.

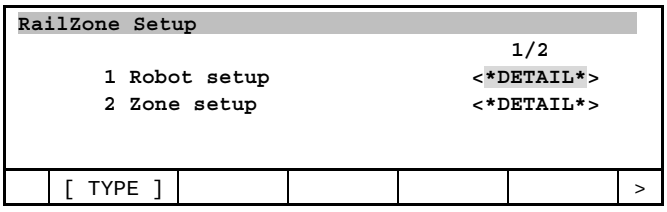


3.10.4.1 Robot and tool model setup

RailZone provides full protection for rail robot and its attached tooling. It requires setting up robot and tool model. Please refer to “3.3.2 Setting Up a Hand Model”

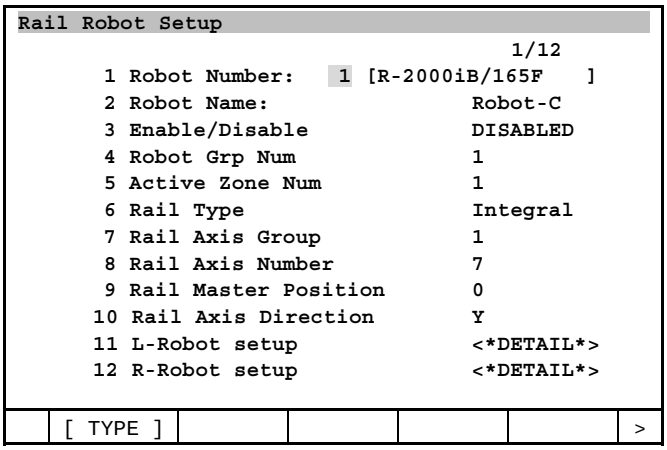
3.10.4.2 Robot setup of RailZone setup

When you position the cursor on <*DETAIL*> of “RailZone setup” and press the Enter key in Setup list of IIC, the following display is appeared



Robot Setup

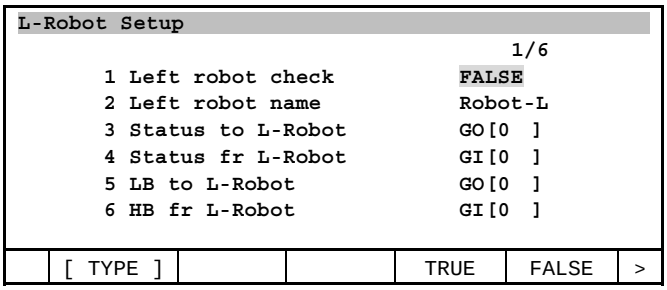
Move the cursor to Robot setup and press Enter key, you will see a screen similar to the following.



Item	Description
Robot Number	This item indicates rail robot group or rail motion group is being edited.
Robot Name	This item defines robot name (9 characters).
Enable/Disable	This item enables/disables RailZone for this rail robot.
Robot Grp Num	This item defines the robot group number.
Active Zone Num	This item defines the zone number being used
Rail Type	This item defines rail type as the following. Integral: Rail axis is the robot extended axis. Independent: Rail group is independent axis, same or different from robot group. If rail group is different from robot group you must setup rail group. Toploader: Rail axis is the J1 of the robot group.
Rail Axis Group	This item defines rail axis motion group.
Rail Axis Number	This item defines rail axis number.
Rail Master Position	This item defines rail master position. Rail master position is a distance from a common zero position on the rail axis to zero master position of this robot.
Rail Axis Direction	This item defines plus rail axis move direction on robot world coordinate. Select “X” or ”Y”

Left Robot setup

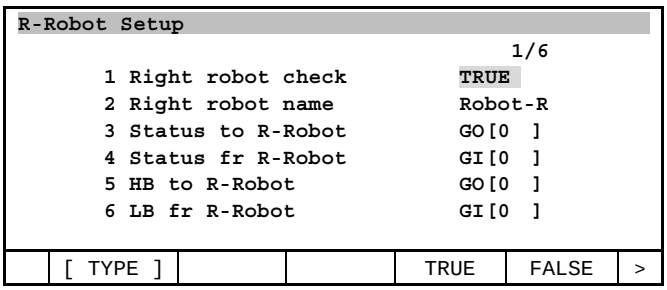
Move cursor to Left Rail Robot on host robot setup screen, press ENTER. You will see a screen similar to the following. Setup Left Rail Robot



Item	Description
Left robot check	Set to TRUE if host robot needs to check its left robot or lower barrier.
Left robot name	This item defines left robot name (9 characters).
Status to L-Robot	This item defines group output index that host robot will send its status to left robot.
Status fr L-Robot	This item defines group input index that host robot will receive status from its left robot.
HB to L-Robot	This item defines group output index that host robot will send its high boundary of RailZone to its left rail robot.
LB fr L-Robot	This item defines group input index that host robot will receive the low boundary of the RailZone from its left rail robot.

Right Robot Setup

Move cursor to Right Rail Robot on host robot setup screen, press ENTER. You will see a screen similar to the following. Setup Right Rail Robot.



Item	Description
Right robot check	Set to TRUE if host robot needs to check its right robot or upper barrier.
Right robot name	This item defines right robot name (9 characters).
Status to R-Robot	This item defines group output index that host robot will send its status to right rail robot.
Status fr R-Robot	This item defines group input index that host robot will receive status from its right rail robot.
HB to R-Robot	This item defines group output index that host robot will send its high boundary of RailZone to its right rail robot.
LB fr R-Robot	This item defines group input index that host robot will receive the low boundary of the RailZone from its right rail robot.

Rail Barrier for Dummy Rail Robot Setup

This example shows how to setup a rail barrier for a rail robot such that the RailZone of this rail robot never passes through this barrier. There are two ways you can setup a rail barrier. Please use either of the two according to your system.
Rail Barrier is set by using Left Robot Setup menu or Right Robot Setup menu.

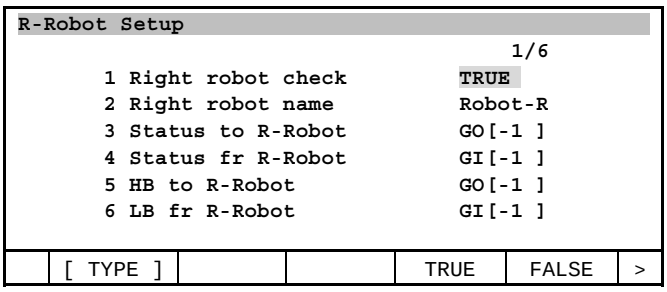
1. The method to setup with system variable
   1.1. Set all group I/O index to "-1".
   1.2. Set following two system variables for desired barrier location on the rail.

   $IC_RZ_STAT[g].$LB_RIGH_ROB for upper limit barrier
   $IC_RZ_STAT[g].$HB_LEFT_ROB for lower limit barrier

   The g is the host rail robot group number. These system variables are write protected. You must use TP or KAREL program to set the values.

NOTE
These values will be initialized to zero if the RailZone function is disabled for its host robot.

Following screen shows the setup example for upper limit barrier, the right robot is a dummy.



2. The method to setup with group input
   2.1. The rail barrier position is transmitted via specified group input. Set the number of the specified group input to “LB fr R-Robot” or “HB fr L-Robot”.

   Following screen shows the setup example for upper limit barrier, the right robot is a dummy. In the example, an upper limit barrier position is transmitted via GI[2], and the rest of group I/O index are set to -1.

```
R-Robot Setup
                                                1/6
      1 Right robot check          TRUE
      2 Right robot name           Robot-R
      3 Status to R-Robot          GO[-1 ]
      4 Status fr R-Robot          GI[-1 ]
      5 HB to R-Robot              GO[-1 ]
      6 LB fr R-Robot              GI[2  ]

[ TYPE ]                          TRUE  FALSE  >
```

3.10.4.3 RailZone robot setup example

Setup Example of Extended Axis (Integrated Rail)

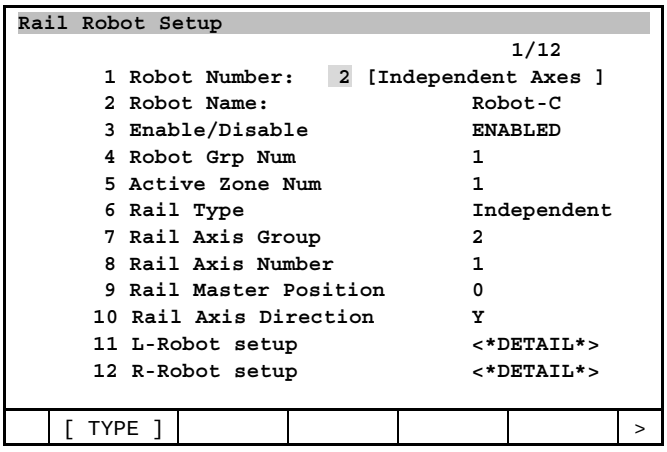
This is a setup example for an integrated rail robot in group 1 and its rail axis is 7 in the direction of Y.

```
Rail Robot Setup
                                                1/12
      1 Robot Number:   1 [R-2000iB/165F    ]
      2 Robot Name:                Robot-C
      3 Enable/Disable             ENABLED
      4 Robot Grp Num              1
      5 Active Zone Num            1
      6 Rail Type                  Integral
      7 Rail Axis Group            1
      8 Rail Axis Number           7
      9 Rail Master Position       0
     10 Rail Axis Direction        Y
     11 L-Robot setup              <*DETAIL*>
     12 R-Robot setup              <*DETAIL*>

[ TYPE ]                                       >
```

Setup Example of Independent Auxiliary Axis

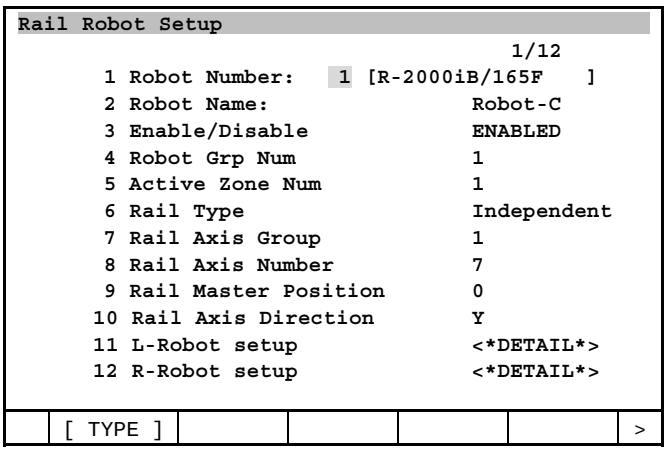
This is a setup example for an independent rail group where robot is in motion group 1 and rail group is in motion group 2 and rail axis number is 1. Move cursor to Robot Number and enter 1 for the robot motion group. Since the independent rail axis group is different from the robot group, you MUST set rail group. But you can skip the setting for Left Rail Robot or Right Rail Robot as these settings are always handled by robot group. Move cursor to Robot Number and enter 2 for this rail motion group.

```
Rail Robot Setup
                                                1/12
      1 Robot Number:   1 [R-2000iB/165F    ]
      2 Robot Name:                Robot-C
      3 Enable/Disable             ENABLED
      4 Robot Grp Num              1
      5 Active Zone Num            1
      6 Rail Type                  Independent
      7 Rail Axis Group            2
      8 Rail Axis Number           1
      9 Rail Master Position       0
     10 Rail Axis Direction        Y
     11 L-Robot setup              <*DETAIL*>
     12 R-Robot setup              <*DETAIL*>

[ TYPE ]                                       >
```



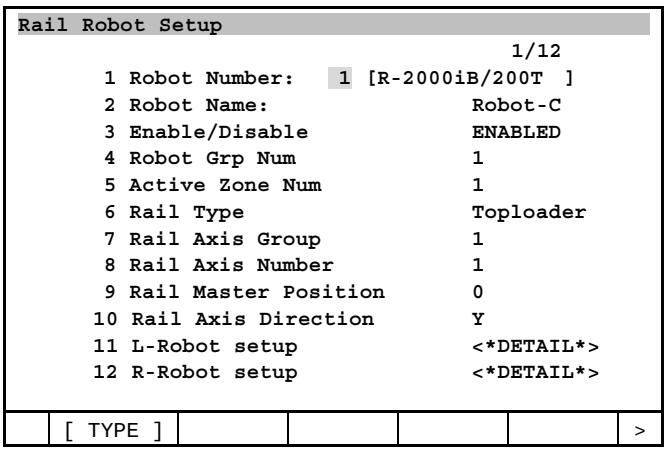
Setup Example of Extended Axis (Auxiliary)

This is a setup example for an independent rail where robot and rail axis are in the same motion group 1 and rail axis number is 7. Move cursor to Robot Number and enter 1 for the robot motion group.

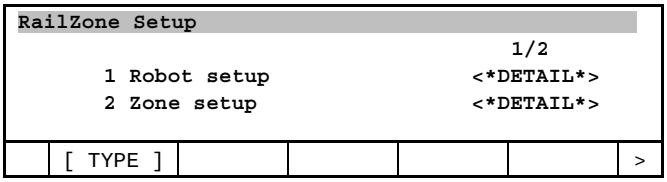


Setup Example of Toploader

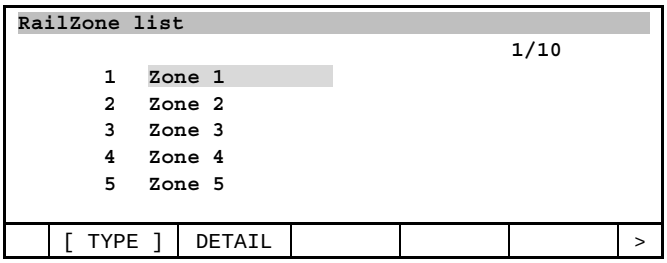
This is a setup example for a toploader robot.



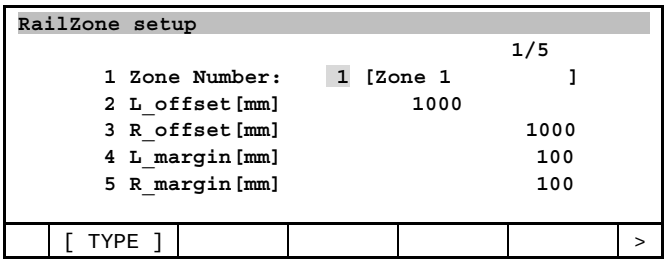
3.10.4.4 Zone setup



Move cursor to Zone setup on the above screen. You will see a screen similar to the following.



Move cursor to a selected zone, press F2[DETAIL] key. You will see a screen similar to the following.



Item	Description
Zone Number	This item indicates selected zone number.
L_offset [mm]	This item defines distance from low boundary (LB) to rail axis position.
R_offset [mm]	This item defines distance from high boundary (HB) to rail axis position.
L_margin [mm]	This item defines marginal distance from low boundary of host rail robot to high boundary of left rail robot. When this distance is less than L_margin, interference alarm will be triggered.
R_margin [mm]	This item defines marginal distance from high boundary of host rail robot to the low boundary of right rail robot. When this distance is less than R_margin, interference alarm will be triggered.

3.10.4.5 Communication setup for Rail Zone

RailZone function uses Group I/O via Ethernet Global Data (EGD) to exchange RailZone information across the controllers. It is necessary to set TCP/IP before EGD setting. It is recommended to completely isolating the RailZone Interference Check EGD network as a separate control network to optimize the RailZone Interference Check functionality. This can be done by dedicating one Ethernet port on each robot controller for EGD I/O exchange.
Each host rail robot must send 3 bytes data (boundary and status) to its right or left robot. The host robot must also receive 3 bytes data (boundary and status) from its right or left robot.

Procedure of Communication Setup for RailZone

This procedure explains the way to set up Communication Setup for RailZone with the following figure. R1 is Left Robot of R2 and R2 is Right Robot of R1. Let us assume that TCP/IP has already been set.

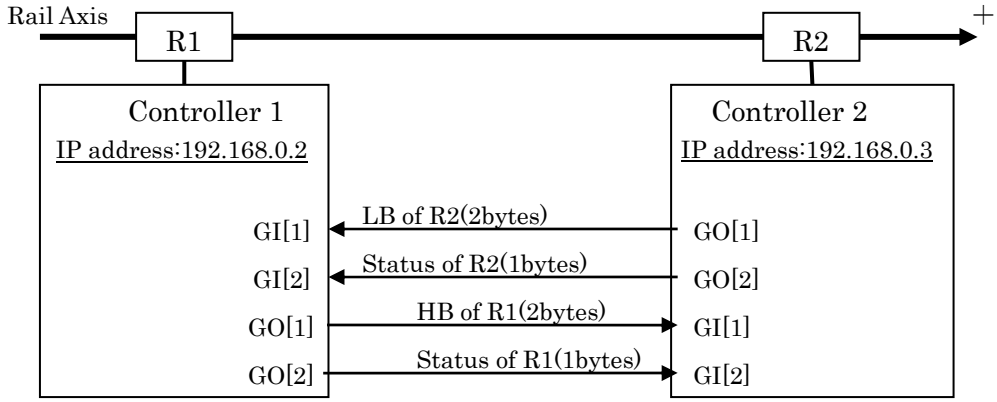


Fig. 3.10.4.5 Example of Communication setup

1. Ethernet Global Data Setup
   1.1. Press the MENU key and select I/O.
   1.2. Press F1[TYPE] and select EGD I/O. The following appears.

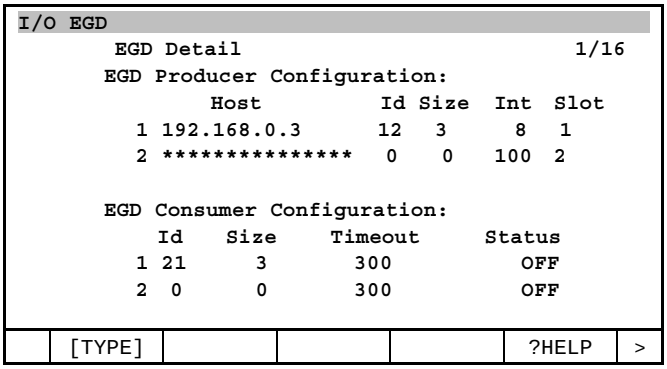
```
I/O EGD
        EGD Detail                                  1/16
       EGD Producer Configuration:
                Host            Id Size  Int  Slot
          1 ***************     0    0   100  1
          2 ***************     0    0   100  2
          3 ***************     0    0   100  3
          4 ***************     0    0   100  4

       EGD Consumer Configuration:
            Id    Size     Timeout      Status
          1  0       0        300          OFF
          2  0       0        300          OFF
          3  0       0        300          OFF
          4  0       0        300          OFF

    [TYPE]                                ?HELP  >
```

   1.3. Set EGD Producer Configuration
   “Host”: This item is the IP address that the data is sent to.
   “Id”: This is EGD exchange ID that will be sent along with the data to the remote device.
   “Size”: This item is the size of the data in bytes that should be sent to the remote device.
   “Int”: This item is the time interval in milliseconds that the data should be produced. Set a value from 8 to 16.
   “Slot”: This item is the slot number for rack 88 that should be sent out.

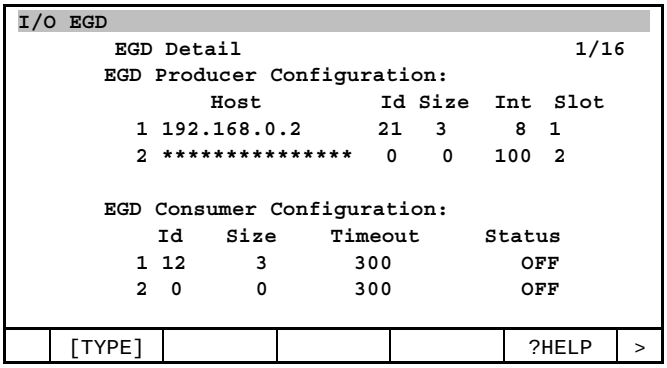
   1.4. Set EGD Consumer Configuration
   “Id”: This item is the ID that will be sent with the data by the remote device.
   “Size”: This item is the maximum size of data in bytes that will be sent by the remote device.
   “Timeout”: This item represents the time in milliseconds between two messages that the tag will wait before posting an error indicating a timeout. A value of 150 ms or larger is recommended.
   “Status”: This item is a display only field. A status of OFF indicates that the tag has not been initialized and is not being used. A status of IDLE indicates that data is not being received. A status of ON indicates that data is being received periodically from the remote producer.

The following shows the example of EGD setting with the above figure (Fig. 3.9.4.5). Set “Size” of EGD Producer Configuration to “3” because a rail robot must send 3 bytes data.

- Example of R1

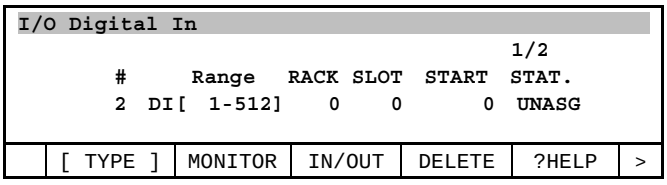


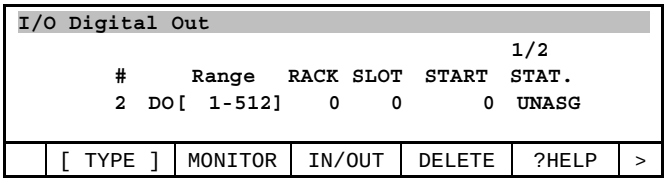
- Example of R2



2. Digital I/O and Group I/O Setup.

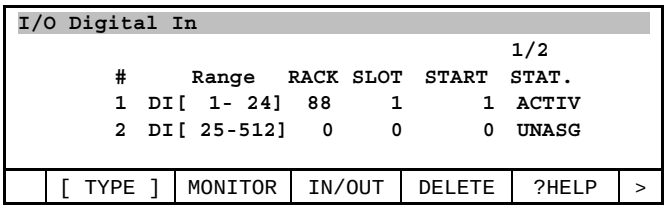
2.1. Press F1[TYPE] and select Digital and Press F2[CONFIG] key. The following display is appears. Set configuration of Digital I/O in this display. Digital Out and Digital In display are switched alternately by pressing F3[IN/OUT].

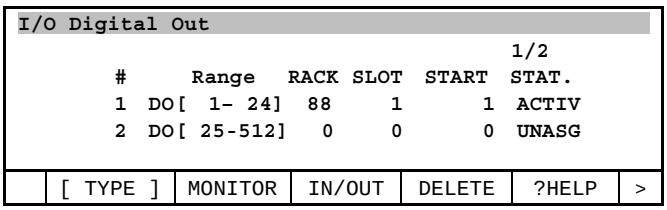




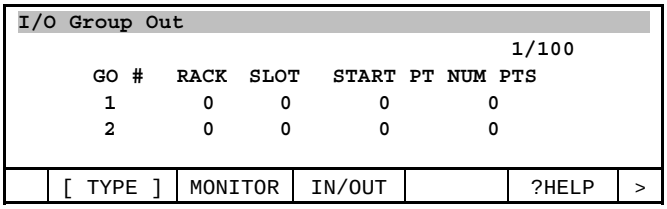
2.2. Set RACK to “88” to use EGD. Set SLOT to the value is set on EGD setup. Set Range and START according to the size of data. Power OFF/ON after setup.

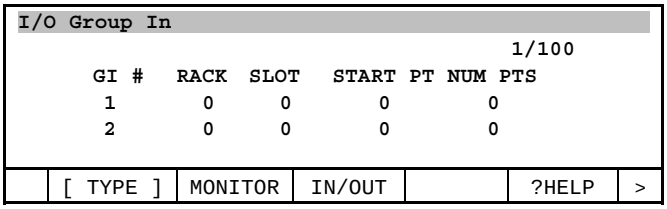
- Example of R1 and R2





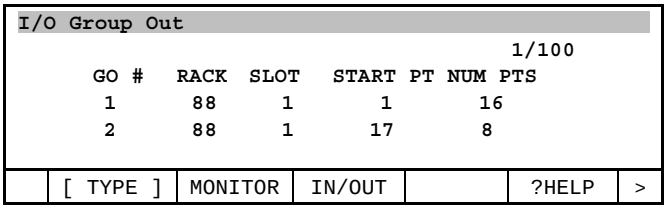
2.3. Press F1[TYPE] and select Group and Press F2[CONFIG] key. The following display is appears. Set configuration of Group I/O in this display. Group Out and Group In display are switched alternately by pressing F3[IN/OUT].

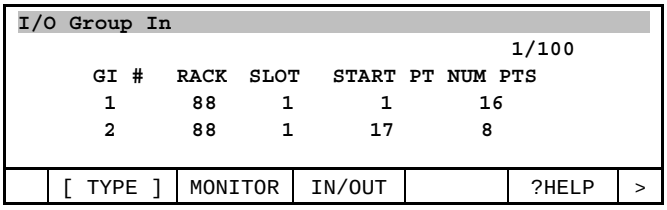




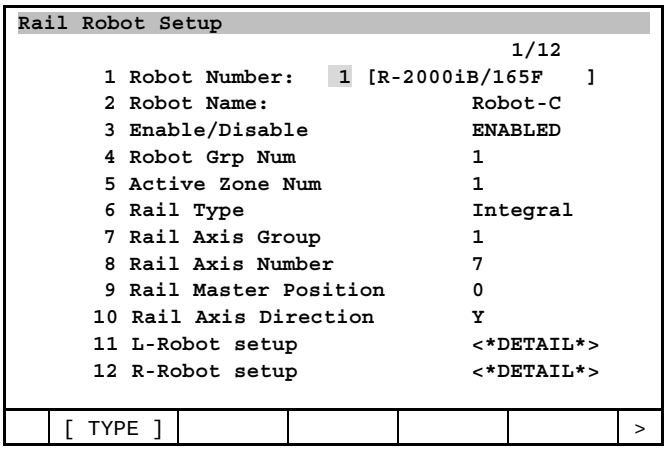
2.4. Set RACK to “88” to use EGD. Set SLOT to the value is set on EGD setup. Set START PT and NUM PTS for RailZone. Assign 8 digital signals to one group and 16 digital signals to another group. Power OFF/ON after setup.

- Example of R1 and R2



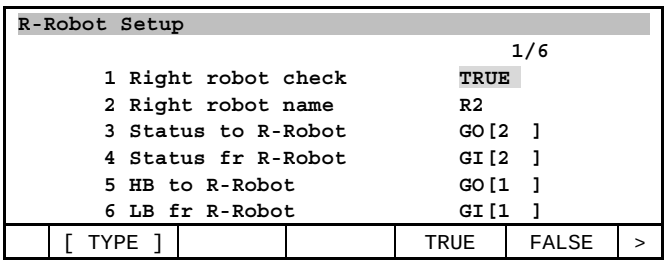


3. Setup Group I/O of L-Robot/R-Robot
   3.1 Display Rail Robot Setup for RailZone

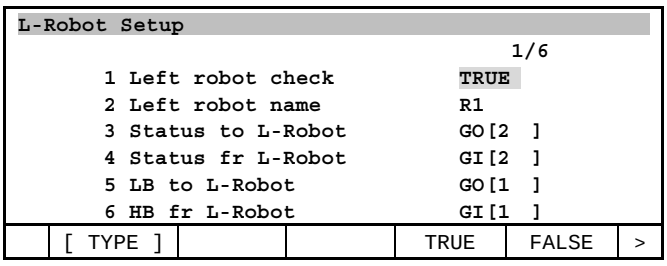


3.2. Position the cursor to L-Robot or R-Robot and Press Enter key. Set up the above Group I/O.

- Example of R1



- Example of R2



4 PROGRAM INSTRUCTIONS

This section describes instructions of Interference Check function. There is a difference in available instructions between Basic Interference Check and Intelligent interference Check.

Function	Available Instruction	Description
Basic Interference Function	Comb Pair Instruction	This instruction enables/disables the specified Interference Check combination pair.
Intelligent Interference Function	Comb Pair Instruction	This instruction enables/disables the specified Interference Check combination pair.
	Approach STOP ENABLE/DISABLE Instruction	This instruction disables the specified combination pair the type of which is “Robot+Hand” or “Fixture” temporarily.
	Approach WAIT ENABLE/DISABLE Instruction	This instruction enables/disables the specified approach waiting combination pair.
	Approach RATE Instruction	This instruction modifies Interference Check Sensitivity.
	Multiarm Synchronization Instruction	This instruction synchronizes robots.

4.1 COMB PAIR ENABLE/DISABLE INSTRUCTION

This instruction enables/disables the specified combination pair.

NOTE
COMB PAIR DISABLE is the instruction for disable the specified Interference Check combination. Interference Check does not work on the specified combination after this instruction is executed.

4.1.1 Details

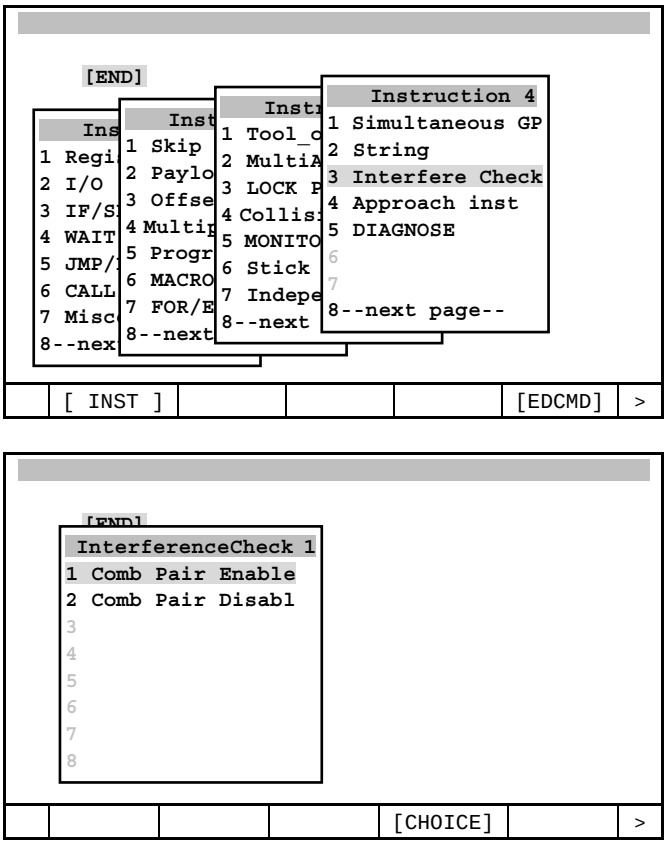
When you would like to enable an Interference Check combination, you can use COMB PAIR ENABLE instruction.

IC Comb Pair [n] Enable (“n” is a list number of Interference Check combination.)

When you would like to disable an Interference Check combination, you can use COMB PAIR DISABLE instruction.

IC Comb Pair [n] Disable (“n” is a list number of Interference Check combination.)

When you teach these instructions, press F1[INST] and select [Interfere Check] on a editor on the program edit screen.



4.2 APPROACH STOP ENABLE/DISABLE INSTRUCTION

The interference check function is independent of the structure and instructions of a program. No special program instructions need to be taught to use the interference check function. After configuring combination check pairs, the interference check function is typically enabled at all times.

However, an interference check combination pair may need to be disabled temporarily when the robot needs to work in an area that may trigger interference detection.

The Approach_STOP instruction can be used to temporarily disable an interference check combination pair, or to enable a combination pair.

⚠CAUTION
Approach Stop instruction can be used for “Robot+Hand” or “Fixture”.
When a combination type is the others (“Critical Zone”, “Virtual Fence”,”DO only” and ”PLC DIN”), it is not possible to use this instruction.

⚠CAUTION
Approach Stop Disable instruction disables a combination (“Robot+Hand” or “Fixture”) temporarily. While a combination is disabled, interference can occur even if the setting is correct. Use this instruction only when it is necessary.

4.2.1 Details

When TMP_DISABLE is set, the instruction temporarily disables the specified Interference Check combination pair.

Approach_STOP[n] = TMP_DISABLE
("n" is a list number of Interference Check combination.)

When TMP_DISABLE is set, the instruction enables the specified Interference Check combination pair.

Approach_STOP[n] = ENABLE
("n" is a list number of Interference Check combination.)

⚠CAUTION
The combination pair is listed as "enabled" on the check combination setup menu even while the function is temporarily disabled.

The specified interference check combination pair number is either enabled or temporarily disabled. The table below indicates the relationship between program status after instruction execution and combination pair status.

Program execution status	After ENABLE instruction execution	After TMP_DISABLE instruction execution
During execution	Enabled	Disabled
Temporary stop → Resume	Enabled →Enabled	Enabled →Disabled
Restart from different line	Enabled	Enabled
End of program	Enabled	Enabled automatically

When the Approach_STOP[] = TMP_DISABLE instruction is executed, the **Temporary invalid DO** signal is turned on. This signal remains on while the combination pair is temporarily disabled. The signal remains on until any of the following is performed:

- Temporary stop
- Program termination
- Restart from a different line
- Reverse program execution
- ENABLE instruction execution

⚠CAUTION
If BWD program execution occurs after the temporary disable instruction is executed, the temporary disable status is canceled, and the combination pair is re-enabled.

4.2.2 Sample Program

Suppose that interference check combination pair 1 is initially enabled in the setup menu.

```
1:  J P[1] 100% FINE
2:  Approach_STOP[1]=TMP_DISABLE
3:  L P[2] 200mm/sec FINE
4:  L P[3] 500mm/sec FINE
5:  Approach_STOP[1]=ENABLE
6:  L P[4] 100mm/sec FINE
```

Combination [1] is disabled in this section.

Combination pair 1 is temporarily disabled on line 2 and is enabled on line 4. Combination pair 1 is disabled between P[1] and P[3].
In other portions, combination pair 1 is enabled. Even in the disable section (between P[1] and P[3]), combination pair 1 is enabled when a temporary stop occurs.

4.2.3 Reverse Program Execution

Reverse program execution of Approach Stop instruction

During BWD program execution, the Approach_STOP[1]=TMP_DISABLE/ENABLE instructions are not executed.

Example: The program below is BWD executed starting with line 6. Initially, Interference Check combination pair 1 is enabled in the setup menu.

```
1:  J P[1] 100% FINE
2:  Approach_STOP[1]=TMP_DISABLE
3:  L P[2] 200mm/sec FINE
4:  L P[3] 500mm/sec FINE
5:  Approach_STOP[1]=ENABLE
6:  L P[4] 100mm/sec FINE
```

During BWD program execution of line 5 and line 2, the status of combination pair 1 is unchanged. During this BWD program execution, combination pair 1 is enabled at all times.

Reverse program execution after temporary disable instruction execution

When BWD program execution is performed after temporary disable instruction execution, the temporary disable status is canceled and the combination pair is enabled.

Example: The program below is executed. Initially, interference check combination pair 1 is enabled in the setup menu.

```
1:  J P[1] 100% FINE
2:  Approach_STOP[1]=TMP_DISABLE
3:  L P[2] 200mm/sec FINE
4:  L P[3] 500mm/sec FINE
5:  Approach_STOP[1]=ENABLE
6:  L P[4] 100mm/sec FINE
```

Suppose that a temporary stop occurs on line 4. Since a temporary stop occurs, the combination is enabled. If the program is resumed directly, the temporary disable status occurs, and the disable status is canceled on line 5.
If the program is not restarted directly, but reverse program execution is performed from line 4 where a temporary stop occurred, the following is issued:

SSPC-161 App_STOP is enabled (ST,C:%d)

Then, the temporary disable status is canceled. If the program is restarted later, the temporary disable status does not occur.

4.2.4 Notes

Setup menu display during temporary disable status

When a combination pair is temporarily disabled by a program instruction, the combination pair status is still “enabled” on the setup menu.

Reverse program execution

If reverse program execution is performed after a combination pair is temporarily disabled, the following is issued:

SSPC-161 App_STOP is enabled (ST,C:%d)

Then, the temporary disable status of the combination pair is canceled.

Use with the multitask function

When the multitask function is used, multiple programs may be executed simultaneously. Multiple tasks may try to control the status of the same check combination pair. It is risky for different tasks to control the same check combination pair, so the following restriction is imposed:

When a task executes Approach_STOP TMP_DISABLE instruction, the instruction is dedicated to the task until the any of the following is performed:

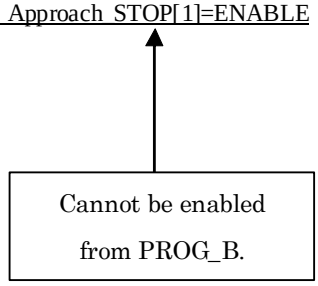
- The check combination pair is enabled with Approach_STOP ENABLE instruction.
- The program of the task is terminated.

A combination pair dedicated to a task cannot be enabled or disabled by another task.
Only the execution status of a task that executes the temporary disable instruction affects the status of the combination pair.

Example: The program below is executed.

```
PROG_A
1: J P[1] 100% FINE
2: Approach_STOP[1]=TMP_DISABLE
3: RUN PROG_B
4: L P[2] 200mm/sec FINE
5: L P[3] 500mm/sec FINE
6: Approach_STOP[1]=ENABLE
7: L P[4] 100mm/sec FINE
```

```
PROG_B
1:
2: Approach_STOP[1]=ENABLE
3:
```



In this example, PROG_A first temporarily disables check combination 1.
An attempt is made to cancel the disable status from PROG_B executed from PROG_A. However, combination 1 is being used by another task (PROG_A), so PROG_B cannot cancel the disable status. In this case, the following is issued:

SSPC-154 (ST,C:%d) is disabled by other

The results of executing the Approach_STOP TMP_DISABLE instruction and ENABLE instruction vary according to the status of combination use by another task as described below.

Approach_STOP[ ]=TMP_DISABLE

Setting screen	Disabling task	Processing
Enabled	Local task	(Already disabled) No processing is performed.
	Another task	SSPC-154 (STOP.G)
	None	Disables approach deterrence, and has exclusive control. SSPC-160 (WARNING)
Disabled	Local task	SSPC-151 (WARNING)
	Another task	SSPC-154 (STOP.G)
	None	SSPC-151 (WARNING)

Approach_STOP[ ]=ENABLE

Setting screen	Disabling task	Processing
Enabled	Local task	Enables approach deterrence, and allows any task to disable approach deterrence.
	Another task	SSPC-154 (STOP.G)
	None	No processing is performed.
Disabled	Local task	SSPC-152 (WARNING)
	Another task	SSPC-154 (STOP.G)
	None	SSPC-152 (WARNING)

4.3 APPROACH WAITING ENABLE/DISABLE INSTRUCTION

An approach waiting combination pair cannot be enabled or disabled in the Waiting condition setup menu. Only a program instruction can enable an approach waiting combination pair.
With the approach waiting function, the robot can be automatically stopped/restarted only during program execution. The Approach_WAIT enable instruction must be used in order to automatically stop/restart the robot with the approach waiting function.

⚠CAUTION
Approach Waiting function, when simply set, does not operate. This function operates only after a condition is enabled in the program. When using the Approach Waiting function, be sure to use the Approach_Wait instruction.

4.3.1 Details

The following instruction is used to enable an approach waiting combination pair.

Approach_WAIT[n] = ENABLE
("n" is a list number of Approach Waiting combination.)

The following instruction is used to disable an approach waiting combination pair.

Approach_WAIT[n] = DISABLE
("n" is a list number of Approach Waiting combination.)

The specified approach waiting combination pair number is either enabled or disabled. An approach waiting condition includes the specification of an approach waiting distance. So, when modifying the approach waiting distance, switch between approach waiting conditions with this instruction.

The table below indicates the relationship between program status and function status.

Program execution status	After ENABLE instruction execution	After DISABLE instruction execution
During execution	**Enabled**	Disabled
Temporary stop → Restart	Enabled (However, automatic restart is not performed) →**Enabled**	Disabled →Disabled
Restart from different line	Disabled	Disabled
Termination	Disabled	Disabled automatically

⚠CAUTION
If BWD program execution is performed after Approach_WAIT ENABLE instruction execution, approach waiting combination pair is disabled.

Waiting signal

When the Approach_WAIT enable instruction is executed, the combination pair "DO for valid status" signal is turned ON. This signal remains ON until the combination is disabled. This remains ON until any of the following occurs

- Program termination
- Restart from a different line after a temporary stop
- Reverse program execution
- Enable instruction execution

This signal is on simply in the temporary stop status.

If an approach waiting combination pair is enabled and the robot approaches within the waiting distance, the robot will wait as described below according to whether automatic restart is enabled or disabled.

When automatic restart is disabled

- The program is paused.
- The combination pair "DO during waiting status" signal is turned ON.
- The robot can be jogged. If the combination pair distance exceeds the approach waiting distance due to jogging or by the operation of another robot, the "DO during waiting status" signal is turned OFF.

Before automatic restart when the combination pair distance exceeds the approach waiting distance, check that the "DIO for interruption" signal is off.
When automatic restart is enabled

- The robot automatically stops. At this time, the program continues running.
- The "DO during waiting status" signal is turned ON.
- The program is running, so that the robot cannot be jogged.
- When the combination pair distance exceeds the approach waiting distance, the "DO during waiting status" signal is turned OFF, and the robot restarts operation.

If hold operation is performed when the program is being executed and the robot is waiting, the processing below is performed.

- The "DO during waiting status" signal continues to be on.
- The program pauses, so that the robot can be jogged.
- If the combination pair distance exceeds the approach waiting distance due to jogging or the operation of another robot, the "DO during waiting status" signal is turned OFF.
- If the robot approaches within the waiting distance due to jogging, the "DO during waiting status" signal is turned on again. However, the robot is not stopped, so the robot can jog as close as allowed by the interference check distance.

4.3.2 Sample Program

Suppose that approach waiting combination pair 1 is already configured in the setup menu.

```
1:  J P[1] 100% FINE
2:  Approach_WAIT[1]=ENABLE
3:  L P[2] 200mm/sec FINE
4:  L P[3] 500mm/sec FINE
5:  Approach_WAIT[1]=DISABLE
6:  L P[4] 100mm/sec FINE
```

Approach wait combination pair [1] is enabled in this

Approach waiting combination pair 1 is enabled on line 2. At this time, the "DO for valid status" signal is turned on.

Approach waiting combination pair 1 is disabled on line 5. Approach waiting combination pair 1 is enabled between P[1] and P[3].

In other portions of the program, approach waiting combination pair 1 is disabled. Even when a temporary stop occurs in the enable section (between P[1] and P[3]), approach waiting combination pair 1 remains enabled. However, during a temporary stop, the program is not restarted automatically.

Suppose that a temporary stop occurs on line 4. The robot can be jogged because a temporary stop occurred. If jogging causes the combination pair distance to be less than the approach waiting distance, the “DO during waiting status” signal is turned on. During jogging, approach waiting does not stop the robot.

4.3.3 Reverse Program Execution

Reverse program execution of Approach Waiting instruction

During BWD program execution, Approach_WAIT[1]=ENABLE (DISABLE) is not executed.

Example: Suppose that the program below is in the terminated state. The program is executed reversely from line 6.

```
1:  J P[1] 100% FINE
2:  Approach_WAIT[1]=ENABLE
3:  L P[2] 200mm/sec FINE
4:  L P[3] 500mm/sec FINE
5:  Approach_WAIT[1]=DISABLE
6:  L P[4] 100mm/sec FINE
```

During this reverse program execution, approach waiting combination pair 1 is disabled at all times.

Reverse program execution after Approach Waiting instruction execution

During BWD program execution Approach_WAIT enable instruction execution, the enable status is canceled and the approach waiting combination pair is disabled.

Example: The program below is executed.

```
1:  J P[1] 100% FINE
2:  Approach_WAIT[1]=ENABLE
3:  L P[2] 200mm/sec FINE
4:  L P[3] 500mm/sec FINE
5:  Approach_WAIT[1]=DISABLE
6:  L P[4] 100mm/sec FINE
```

Suppose that a temporary stop occurs on line 4. If the program is resumed, approach waiting combination 1 continues to be enabled.

If the program is not resumed, but reverse program execution is performed from line 4 where a temporary stop occurred, the following is issued:

SSPC-163 App_WAIT is disabled (WT,C:%d)

Then, the combination is disabled.

4.3.4 Disabling Deceleration Stop Based on Approach Waiting

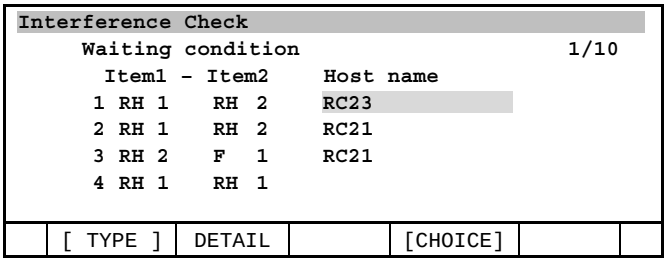
When an approach waiting combination pair is enabled, an equivalent interference check combination pair is not subject to deceleration stop. The interference check combination pair will perform an immediate stop if collision is imminent.

Detection of an equivalent combination pair depends on whether a monitoring target belongs to the local host (in the same controller).
An approach waiting combination pair that is equivalent to an interference check combination pair is determined as described below.

- When the monitoring target host is another host (separate controller)
  Combination pairs with a match in both Item 1 and Item 2
- When the monitoring target host is the local host (same controller)
  The order of Item 1 and Item 2 may be reversed.

Example

Suppose that the setting below is made on the controller of a host named RC21.



While No. 1 is enabled, deceleration stop is disabled for the following Interference Check combination pair (when the monitoring target is another host):

RH1-RH2 RC23

While No. 2 is enabled, deceleration stop is disabled for the following Interference Check combinations (when the monitoring target is the local host):

RH1-RH2 RC21
RH2-RH1 RC21

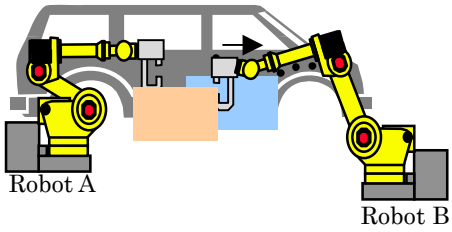
While No. 3 is enabled, deceleration stop is disabled for the following Interference Check combination pair:

RH2-F1 RC21

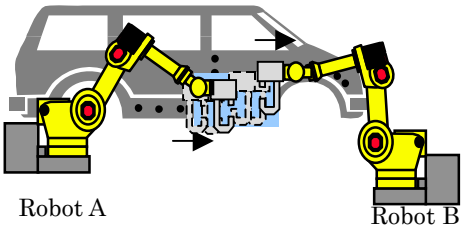
With No. 3, the monitoring target belongs to the local host. Item 1 can never be a fixture, so that the target is the combination above only.

4.3.5 Example of Use

The approach waiting function is useful when multiple robots are used close to each other.
An example of spot welding system is shown below. In this system, robots A and B perform spot welding for the same car body. The work areas of robots A and B overlap each other at the bottom of the car body.



For cycle time reduction, the robots are operated from left to right so that robot A moves after robot B. In such a case, the approach waiting function can be used so that robot A monitors robot B. This eliminates the need for interlocking at each spot welding point.

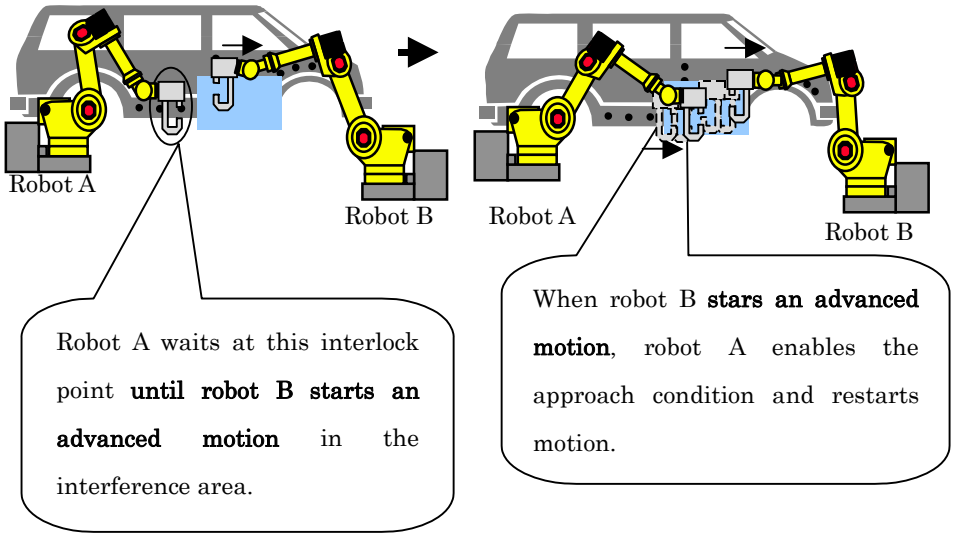


Robot A waits when it catches up with robot B. Robot A moves again when robot B is sufficiently apart.

For this use, robot B needs to move ahead of robot A. So, robot A needs to wait for robot B to start operation. Interlocking is needed to prevent robot A from entering the shared work area before robot B is ready.

> **⚠CAUTION**
> The approach waiting function does not eliminate the need for interlocking.
> The function is useful if the sequence of operations of robots is clearly defined.
> Interlocking may be required to make an operation sequence clear.

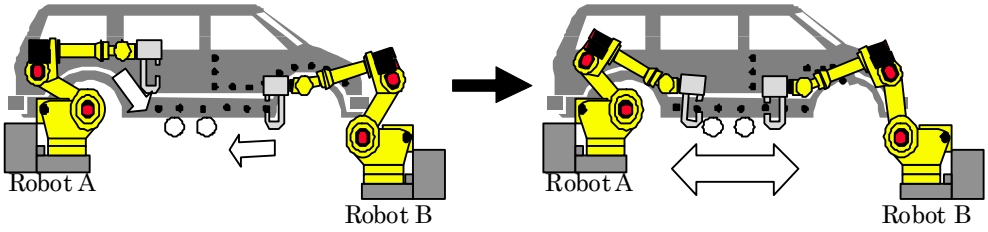
In this system, the following operations are performed:



First, ensure by interlocking that robot B moves ahead of robot A. Then, robot A can approaches and waits for robot B.

4.3.6 Deadlock Caused by the Approach Waiting Function

When the approach waiting function is used, the motion of a robot can be restarted automatically after another robot moves away. However, if multiple robots regard each other as targets of the approach waiting function, the robots may be deadlocked. This deadlock state occurs because the robots wait for each other to move away.



In the example above, robots A and B move to their target points, but the approach waiting function causes both robots to wait.
In the right-hand figure, robot A is waiting for robot B to move away. On the other hand, robot B is waiting for robot A to move away. The robots are deadlocked.
The approach waiting function cannot protect against such a deadlock. In order to avoid such a deadlock, interlocking may be required.

> ⚠ **CAUTION**
> The approach waiting function does not eliminate the need for interlocking. To avoid a deadlock, interlocking may be required.

4.3.7 Notes

Power supply of a communication destination

Other controllers can't communicate robot positions when they are turned off. When using the approach waiting function, turn on the power to the controller of the combination partner. If an approach waiting combination pair is enabled when the power to the partner is off, the following alarm is issued:

SSPC-190 No communication (%s)

Reverse program execution

If reverse program execution is performed after an approach waiting combination pair is enabled, the following alarm is issued:

SSPC-163 App_WAIT is disabled (WT,C:%d)

Then, approach waiting combination pair is disabled.

Need for interlocking

The approach waiting function does not eliminate the need for interlocking.
Interlocking may be needed to ensure the sequence of operations of the robots and avoid a deadlock.

Approach Waiting immediately before motion statement termination

If an approach waiting occurs immediately before the termination of a motion statement, the target point may be reached during deceleration. In this case, the motion statement ends, and the next line is executed while waiting. An "approach wait time-out" can then occur during approach waiting before the next motion statement begins.

Example:

```
1:  Approach_WAIT[1]=ENABLE
2:  L P[1] 2000mm/sec FINE
3:  WAIT 100sec
```

- The approach waiting state is entered immediately before line 2 is terminated.
- The target point is reached during deceleration.
- WAIT is started by line 3.
- Ten seconds after, an "approach waiting time-out" occurs, resulting in a temporary stop.

Restart based on the “DO during waiting status” signal

If automatic restart is disabled, the program needs to be restarted (for example, by PLC). At this time, “DO during waiting status” signal can be used as a guideline for restarting the program.
If “DO during waiting status” signal is shared with another function, the program can be restarted with an incorrect timing.
Use a dedicated signal for “DO during waiting status” signal.

Disabling deceleration stop

When an approach waiting combination pair is enabled, deceleration stop is disabled for an equivalent interference check combination pair. For details, see Subsection 4.3.4, "Disabling Deceleration Stop Based on Approach Waiting".

Use with the multitask function

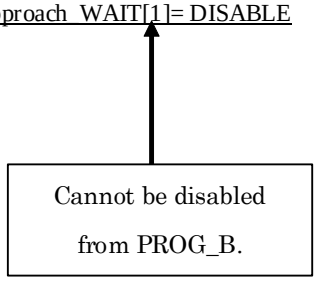
When the multitask function is used, multiple programs may be executed simultaneously. Multiple tasks may try to control the status of the same check combination pair.
It is risky for different tasks to control the same check combination pair, so the following restriction is imposed:

When a task executes the Approach_WAIT ENABLE instruction, the instruction is dedicated to that task until the any of the following is performed:

- The approach waiting combination pair is disabled with the Approach_WAIT DISABLE instruction.
- The program of the task is terminated.

A combination pair dedicated to a task cannot be enabled or disabled by another task.
Only the execution status of a task that executes the enable instruction affects the status of the combination pair.
Example: The program below is executed.

```
PROG_A                          PROG_B
1: J P[1] 100% FINE             1:
2 :Approach_WAIT[1]=ENABLE      2: Approach_WAIT[1]= DISABLE
3: RUN PROG_B                   3:
4: L P[2] 200mm/sec FINE
5: L P[3] 500mm/sec FINE
6: Approach_WAIT[1]=DISABLE
7: L P[4] 100mm/sec FINE
```



In this example, PROG_A first enables combination pair 1.
An attempt is made to disable combination pair 1 from PROG_B executed from PROG_A. However, combination pair 1 is being used by another task (PROG_A), so PROG_B cannot disable combination pair 1. In this case, the following alarm is issued:

SSPC-153 (WT,C:%d) is enabled by other

The results of executing the DISABLE instruction and ENABLE instruction vary according to the status of combination pair use by another task as described below.

Approach_WAIT[ ]=ENABLE

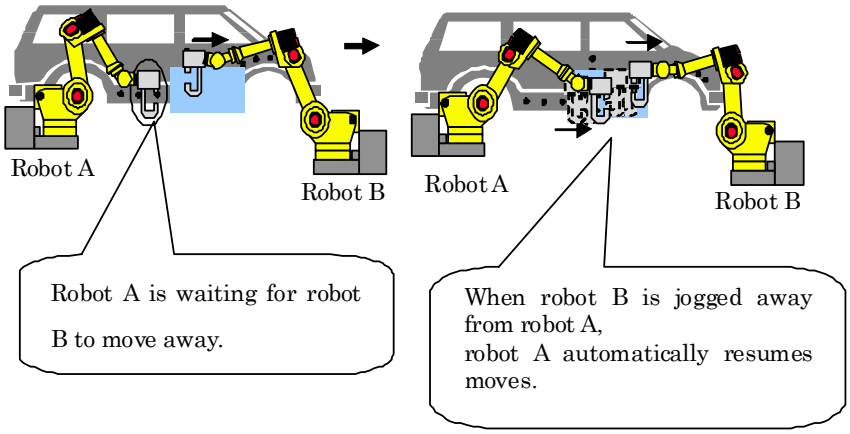
Enabling task	Processing
Local task	No processing is performed.
Another task	SSPC-153 (STOP.G)
None	SSPC-162 (WARNING) Enables approach waiting, and has exclusive control.

Approach_WAIT[ ]=DISABLE

Enabling task	Processing
Local task	Disables approach waiting, and allows any task to enable approach waiting.
Another task	SSPC-153 (STOP.G)
None	No processing is performed.

Safety considerations for the approach waiting function

If automatic restart is enabled with the approach waiting function, and a robot that moves ahead is jogged away, the waiting robot can start motion automatically, causing a dangerous situation.



When manually manipulating a robot that moves ahead in a waiting enabled section, ensure that the waiting robot (robot A in the figure above) is held.

For example, when "the waiting enable signal of robot A is on" and "TP enabled of robot B is on", ensure that robot A is held.

4.4 APPROACH RATE INSTRUCTION

The interference check sensitivity can be modified using the Approach Rate instruction. Refer to “Approach stop rate” in Section 3.5, " SETTING OTHER PARAMETERS."

4.4.1 Details

Approach Rate instruction modifies the interference check sensitivity.

Approach_RATE[GP:g] = 100% (g is Group number.)

Unlike the Approach_STOP instruction and Approach_WAIT instruction, the result of executing this instruction is not affected by a change in the subsequent program execution status.

4.4.2 Reverse Program Execution

Even when reverse program execution is performed, Approach Rate instruction is not executed.

4.4.3 Notes

Modifying the approach deterrence sensitivity

Once "Approach_RATE[GP:1]=0%" is executed, 0% remains unchanged even when the program is terminated or the power is turned off.
In order to modify the rate again, use the setup menu or execute the Approach Rate instruction again.

4.5 MULTIARM SYNCHRONIZATION INSTRUCTIONS

Multi Arm Synchronization Instructions provide users with the following stand-alone TPE instructions to control TP program execution sequences among robots (that could be in different controllers).

- EnterZone
- ExitZone

These instructions are used by Deadlock Prevention function. If you would like to use these instructions, setup Multiarm Shell. Please refer to 3.8.1 MULTIARM SHELL SETUP.

EnterZone and ExitZone

EnterZone and ExitZone can be used for robots that share the same work space but are only allowed to enter the space one by one. EnterZone and ExitZone is a pair to be used for each robot. The robot with EnterZone instruction will request to enter the specified space and will wait until it is permitted to get in the space. Once a robot is in the specified space, other robots have to wait until the robot releases the space with ExitZone statement.

4.5.1 Usage of the Multiarm Synchronization function

4.5.1.1 EnterZone and ExitZone

If there are motion instructions which must not be executed at the same time, these instructions are usable.

When you use EnterZone and ExitZone, you have to specify “space_ID”. “space_ID” is used for relating these instructions among TP programs.

Usage of EnterZone and ExitZone

EnterZone is used for requesting permission to start the next instruction. EnterZone and ExitZone in multiple TP programs are related by “space_ID”.

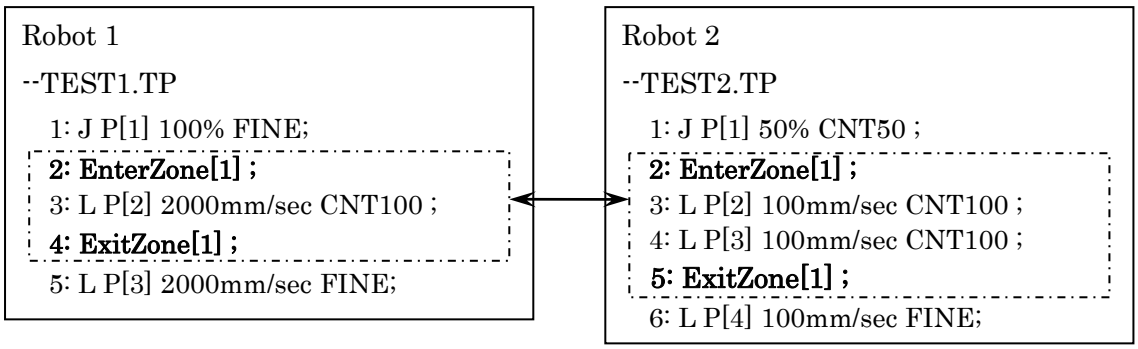
EnterZone[space_ID]

ExitZone is used for informing the end of the target part of TP program. EnterZone and ExitZone in multiple TP programs are related by “space_ID”.

ExitZone[space_ID]

> ⚠ **CAUTION**
> When use EnterZone[space_ID] instruction in one TPE program, ExitZone[space_ID] instruction with same "space_ID" must be used for the same robot that uses the EnterZone[ ] instruction. Otherwise, other robot(s) may be busy/running and cause deadlock condition.

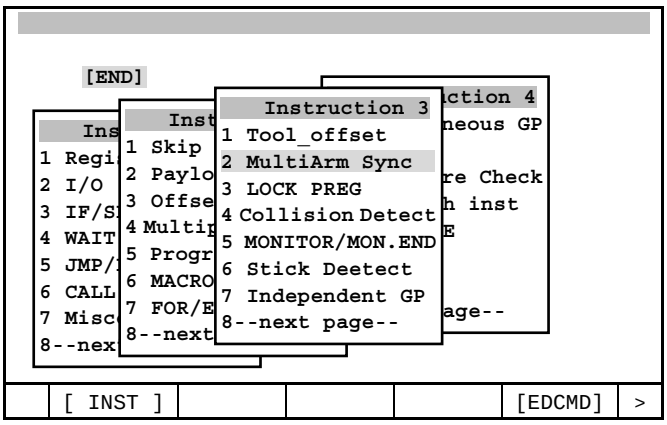
Example

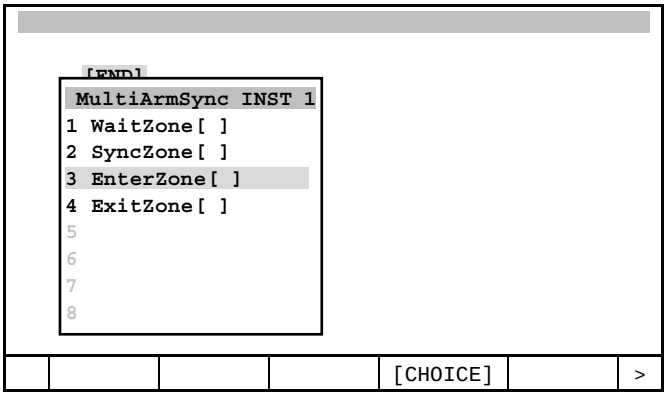


The robot which executes EnterZone[1] first start the next motion instruction. the other robot can not start the next motion instruction and has to wait until ExitZone[1] is executed. When ExitZone[1] is executed, the next motion instruction is started.
The same space_ID (= 1) is specified in both TP programs for relating these instructions.

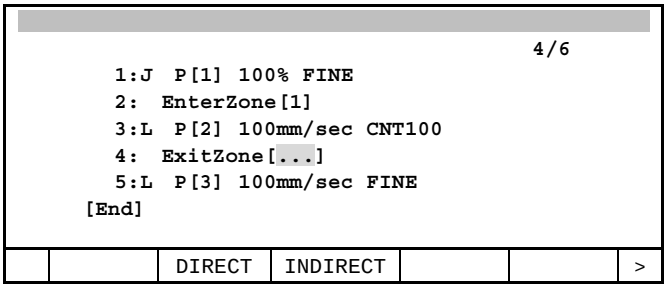
4.5.2 Insert/Edit Instructions in TP Program

When you insert EnterZone or ExitZone, Press F1[INST] key and Select [MultiArm Sync] and then Select EnterZone of ExitZone.





When you use EnterZone and ExitZone, you have to specify “space_ID”. You can select DIRECT or INDIRECT. You can input the value from 1 to 32767 as “space_ID”.



4.5.3 Abort Program after EnterZone

If TP program is aborted after EnterZone is executed and the cursor moves to between EnterZone and ExitZone. Please execute the following procedure.

1. Make sure to move all involved robots with the aborted program to safe places.
2. Either runs a designated program, EXITALLi.TP (where i represents the i-th group on the controller).

Another procedure:

1. Make sure to stop executing motions with all involved robots.
2. Move all robots out of the areas that collision may occur.
3. Enable Teach Pendant at Master controller.
4. Abort all tasks on Master controller.
5. On Teach Pendant of the Master controller, press zero key first, hold it and then press SHIFT and RESET keys, i.e. press zero key first and then hold zero-key, SHIFT key and RESET key together.

4.5.4 Limitations

These instructions have the following limitations:

- In order for the function work correctly, all involved controllers (especially the MASTER controller) must be power ON without communication issue
- The instructions support only TP program.
- The instructions do NOT work with Backward execution of a TP program.
- The instructions do NOT work as expected if a user changes cursor to different TP program line and continue execution from there.
- After power off and then on, a user may have to restart the program execution from beginning, instead of resuming the execution, to avoid waiting conditions.

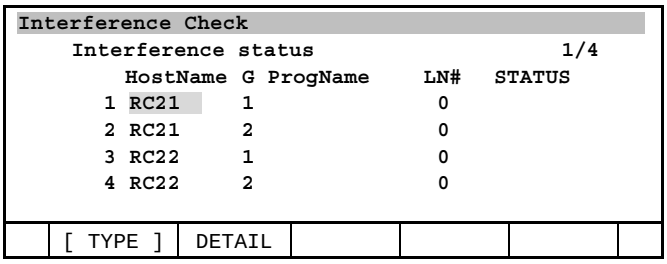
5 INTERFERENCE CHECK STATUS MENU

5.1 INTERFERENCE CHECK STATUS MENU

Current status of Interference Check can be checked on Interference Check status menu.

Display of Interference Check Status

1. Press MENU key.
2. Select [STATUS]
3. Select [Interference]. The Interference Check status menu will be displayed.

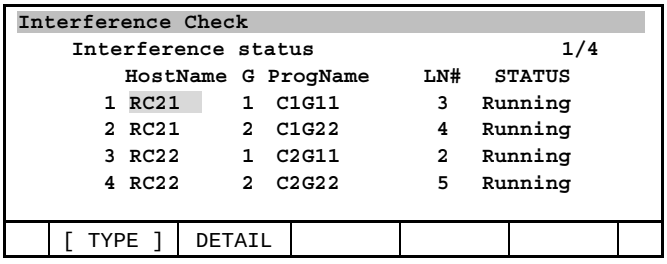


The HostName is the host name of the controllers. The G is the group number for the robot. The ProgName is the program name for the current running program (or the recently completed program). The line number denotes the current running program's line number (or the last line of the program if the program has completed).

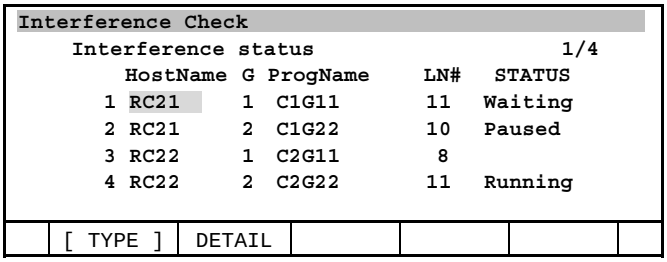
The Status will be either

1. Blank/Aborted: No program is running. For the remote controller, the status is a blank. For the local controller, the status is Aborted.
2. Running: The program is running
3. Waiting: The robot is waiting for another robot for the critical zone.
4. Paused: The robot is paused due to an error. Check the alarm for detail. If you aborted the programs, the status will go back to Blank/Aborted.

For example, the following is displayed.



If the combination G1 of RC21 and G2 of RC22 uses “Critical Zone” and the G1 waits till the G2 comes out “Critical Zone”, the following is displayed.



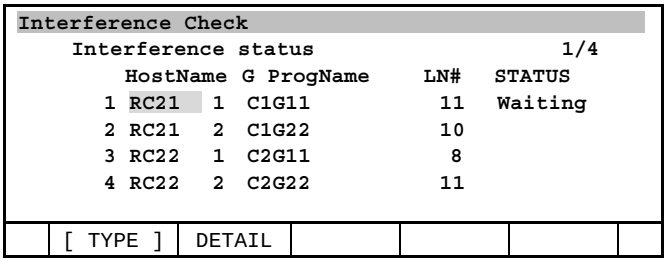
NOTE
Single Step Execution and Backward Execution are not supported.

5.1.1 Interference Check Combination Status

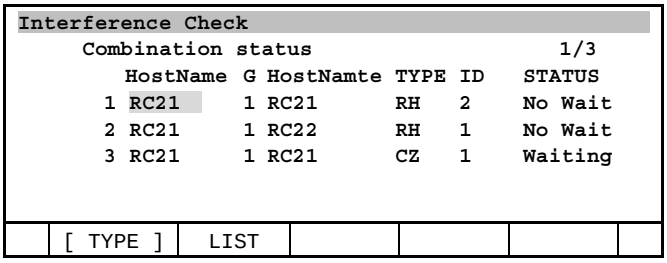
When a robot has Waiting in its status, you can put the cursor on that robot and press the F2[DETAIL] key to see the detail explanation of what the robot is wait for.

Display of Interference Check Combination Status

1. Move the cursor to the line the status of which is Waiting.



2. Press F2[DETAIL] key. Interference Combination status is displayed.



The combination status shows the combination checks that have been defined. The first two fields are the host name and group number of the robot. The second host name denotes the controller’s name for the object the robot is waiting for. The TYPE shows the type of Interference Check.

The Status field can only be either “No Wait”, indicates the robot is not waiting for the other robot or is not waiting to move into a critical zone. “Waiting” indicates the robot is waiting for another robots or the critical zone is already been occupied and it has to wait for it. When the programs are completed, all the status will turn to “No Wait”.

The combination check status is most useful in checking the status of local robots, since the IIC/BIC combination check is only setup for the local controller. You can check the status on the remote robots,

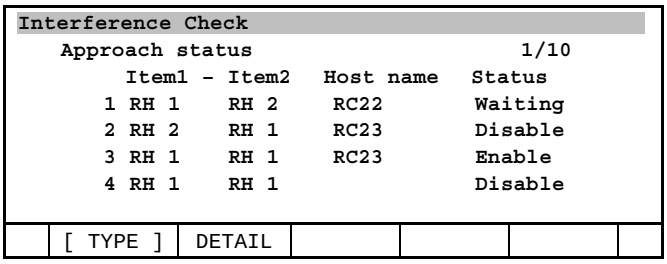
but it has limited information. If you would like to check the detail status of the robot on the remote controller, you have to go to the remote controller and use its teach pendant to check the reason for it.

5.2 APPROACH WAITING STATUS MENU

The statuses of Approach Waiting function combinations can be checked on Approach Waiting status screen. The statuses include Enable and Disable. For Enable, whether the robot is waiting is indicated.

5.2.1 Approach Waiting Status List Screen

The statuses of all approach waiting combinations are displayed. The both elements of a combination, remote host name, and status are displayed. This screen is updated as the status changes.



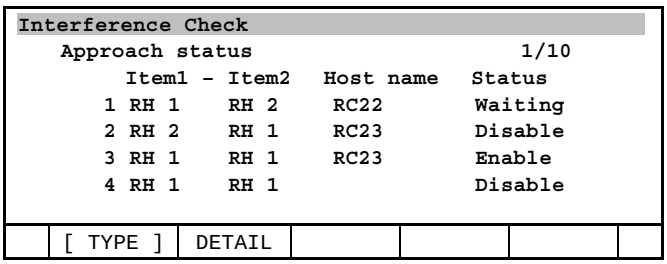
Status

The following statuses are available:

Display	Description
Disable	The combination is currently disabled.
Enable	The combination is currently enabled. However, the approach waiting distance is not reached.
Paused	The combination is enabled. This status is set when an enabled program is stopped temporarily. For a disabled combination, Disable remains unchanged.
Waiting	The combination is enabled, and the approach waiting status is set.
Transit*	The asterisk (*) represents a character, which is 1, 5, 8, 9, C, E, or F. This status means that processing is being performed. Another status is set immediately.
Error*	The asterisk (*) represents a number, which is 2, 3, 10, and 11. This status represents an internal error. When this status is set, an alarm is issued for an internal error. Contact your FANUC service representative.

Display of Approach Waiting status list screen

1. Press the MENU key to display the screen menu, and then select [STATUS].
2. Press F1[TYPE] key, then select [AP Wait]. The Approach Waiting function list screen appears.

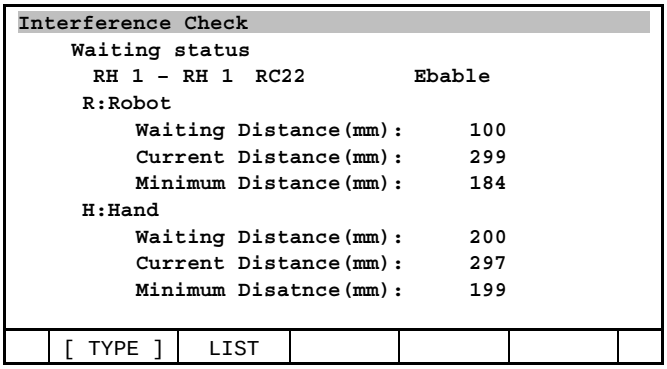


5.2.1.1 Approach waiting detail status screen

Detailed information can be obtained on Approach Waiting status screen.

Display of Approach Waiting detail status

1. Approach Waiting function list screen appears.
2. Move the cursor to a condition whose detailed information is to be displayed.
3. Press F2[DETAIL] key.



For each of the robot and hand specified in an approach waiting combination, the information indicated below can be obtained. The screen above displays an example of such information. If the status changes while this screen is displayed, the information currently displayed is not updated.

Waiting Distance

A value set on the combination setting screen is set.

Current Distance

The **current** shortest distance between the model with the indicated robot/hand and the remote model. When the combination is disabled, "******" is displayed.

Minimum Distance

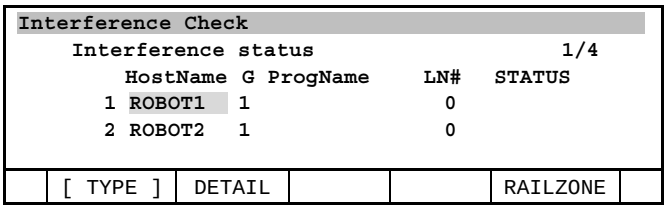
The shortest distance from the remote model during the period from the enabling of the combination to the present time.
This value is not cleared when the combination is disabled. Each time a combination is enabled, the value is initialized.

5.3 RAILZONE STATUS DISPLAY

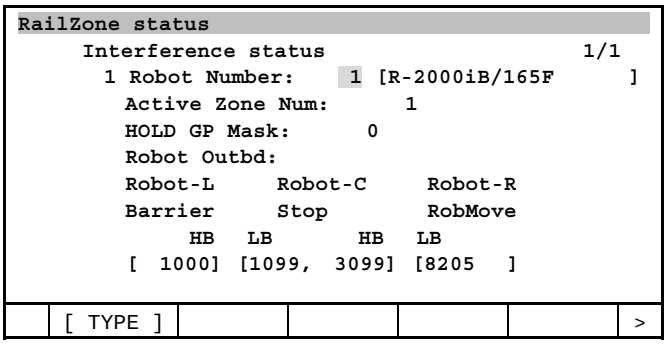
RailZone status screen displays status and boundaries for host rail robot and its adjacent rail robots. Follow the procedures below to get RailZone status screen display

Display of RailZone status

1. Press the MENU key to display the screen menu, and then select [STATUS].
2. Press F1[TYPE] key, and then select [Interference]. If you can use RailZone, the display of F5 becomes RAILZONE.



3. Press F3[RAILZONE] key. RailZone status is displayed.



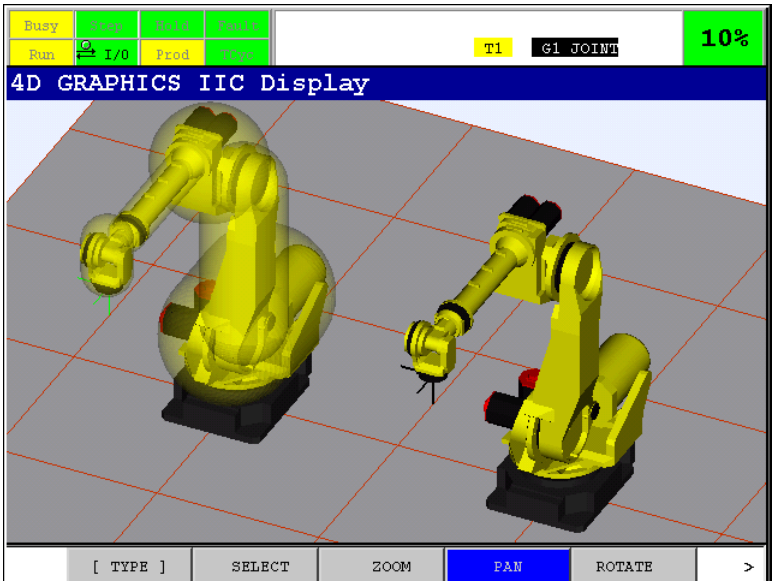
Item		Description
Robot Number		This is the only selectable item in status display screen. You can select a valid rail robot that uses a RailZone. If you select an invalid group, the system will prompt you “Illegal Robot Group”.
Active Zone Num		This item indicates active zone number being used for this rail robot.
HOLD GP Mask		This item indicates group mask for robot(s) that is (are) being held when interference occurs. Ex. If this item is 1, it indicates that group 1 is held. If this item is 3, it indicates that group1 and group2 is held.
Robot Outbd		This item indicates working envelope of robot/tooling in relative to minimum zone. Inside: robot/tool is inside of the minimum zone. L-BD: robot/tool is outside of LB of minimum zone. H-BD: robot/tool is outside of HB of minimum zone.
Status	Robot Name	This displays names of the robot and its adjacent robot on left and right.
	Status	This item displays status of host robot and its adjacent robots on left and right. Stop: robot or rail motion group stops. MoveR: move to right direction alone rail. MoveL: move to left direction alone rail. WaitR: wait for right robot or reach to upper limit barrier. WaitL: wait for left robot or reach to lower limit barrier. RobMove: only robot axes move. NONE: RailZone is not defined or not enabled. Barrier: dummy robot set for rail barrier.
	Boundary Name	This line specifies boundary names of host robot and its left and right robot.
	Boundary value	This displays the active boundary values for host robot and high and low boundary values for left and right robot respectively. If a robot does not use RailZone, its boundary value becomes 0.

6 INTERFERENCE CHECK 4D GRAPHICS

Both Basic Interference Check (BIC) and Intelligent Interference Check (IIC) supports 4D graphics providing that the 4D graphics option (R764) is already installed in the controller. Robot, Hand and Fixture and so on is displayed on 4D GRAPHICS.

NOTE
Please refer to 4D GRAPHICS FUNCTION in R-30*i*B/R-30*i*B Mate CONTROLLER Optional Function OPERATOR'S MANUAL B-83284EN-2 about the details of it.

An IIC cell may have multiple controllers and it is advised that if one controller has the 4D graphics option, all other controllers should have the same to take advantage of the graphics displaying of the IIC and BIC cell. It is permissible to have some controller with 4D graphics and some don't in an IIC cell. The IIC and BIC function still works, but the whole work cell display will have limit usage since the graphic display will not be able to show IIC and BIC geometric shapes for robots in those controllers that don't have 4D graphics option loaded. The following graphics displays a cell with one controller loaded with the 4D graphics option and one controller does not.



The robot on the left belongs to the first controller that has 4D graphics loaded. The right robot belongs to the second controller that does not have the 4D graphics option.

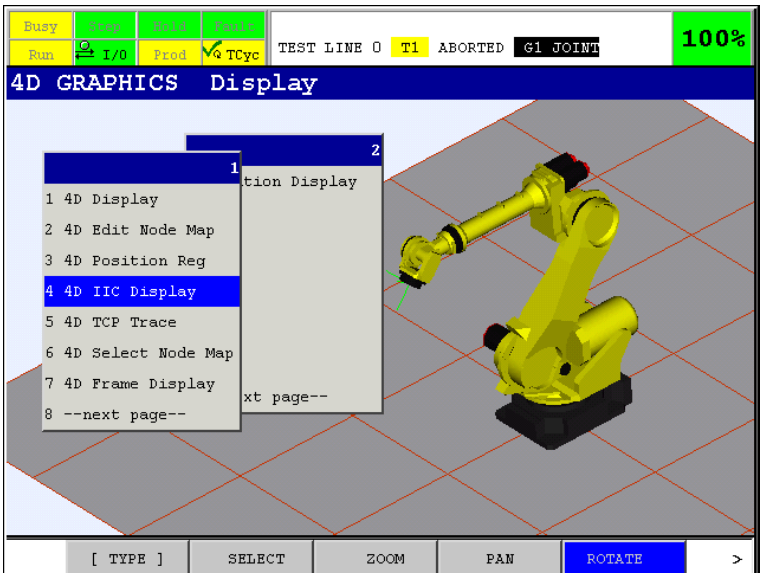
6.1 INTERFERENCE CHECK 4D DISPLAY

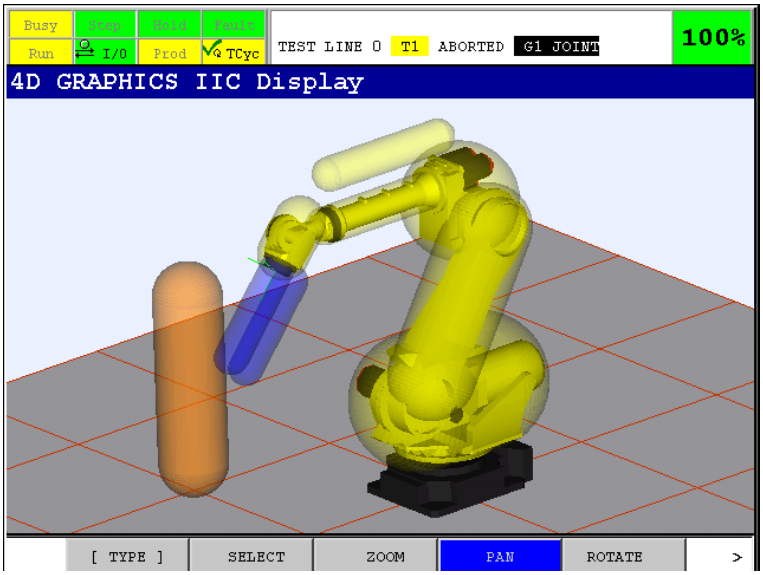
The 4D cell graphics for IIC allows you to see the interaction between robots, tools, fixtures and critical zones. When the robots are in motion, the graphics of elements on the robot move at the same time. This allows you to see clearly which robot is in a zone and which robot is waiting, combine with the IIC status menu, you can debug your programs or find tune them so the robots can run more efficiently.
Position of a Robot on 4D graphics is determined by cell frame. In IIC the cell frame of the calibrated robots is automatically determined from the calibration information. The cell frames are calculated with respect to the IIC manager. The cell frames are updated whenever one of the following events happens:

- The calibration data is updated.
- The cell frame of the IIC manager is updated.

Display 4D Graphics

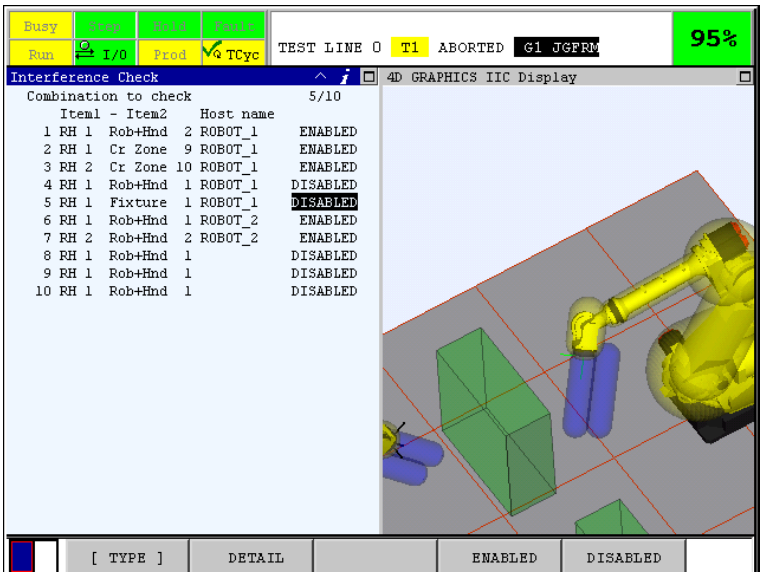
1. Press the MENU key. Select [0 – NEXT --] and select [5 4D GRAPHICS] and 4D GRAPHICS Display is displayed. (You can display by pushing *i* key and Posn key instead of this way.)
2. Press F1[TYPE] and select 4D IIC Display. 4D display is changed into a display for Interference Check.

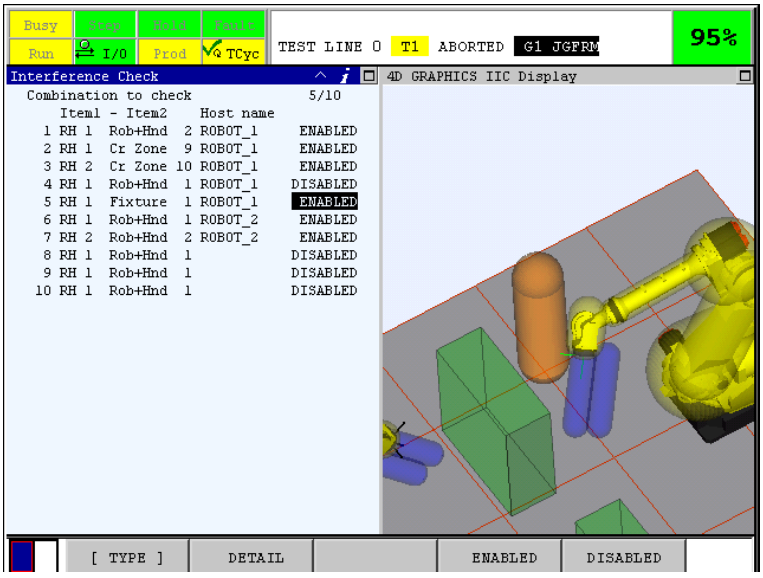




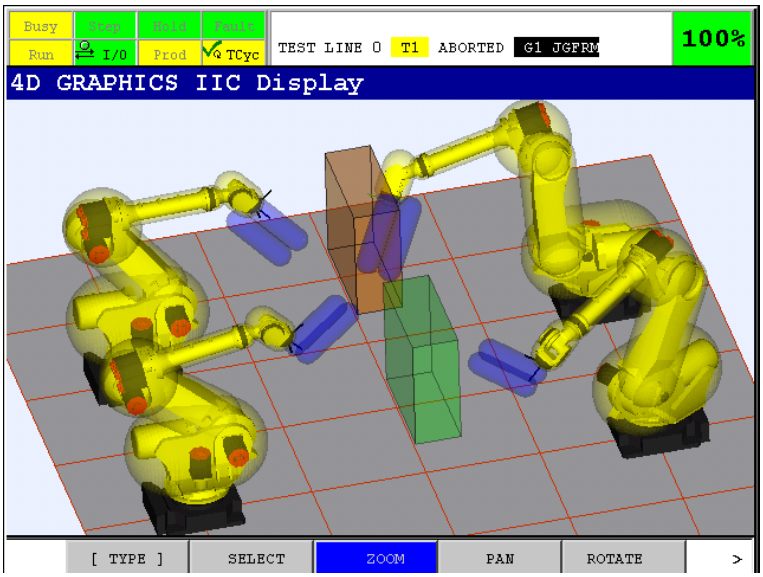
6.2 INTERFERENCE CHECK 4D DISPLAY IN INTERFERENCE CHECK MENU

The 4D IIC and BIC graphics display in the Interference check menu has been discussed in section 3.3.5. Please refer to that section for detail description on how to utilize the 4D graphics in visualizing geometric models for the hand, fixtures and robots.
For example, when a combination to check is enabled, the model of the combination is displayed on 4D Graphics.



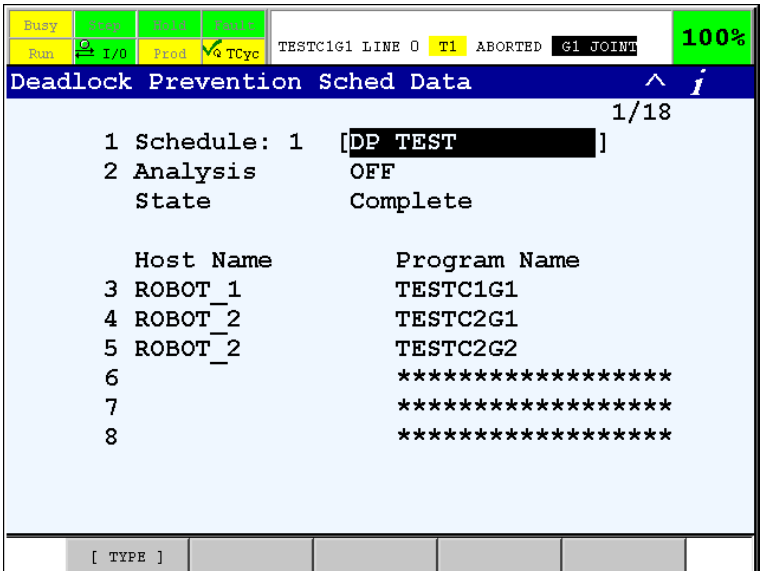


When combination is set to “Critical Zone”, a critical zone changes its color from green to red if a robot is inside it. Therefore, you can check where a zone is occupied or not by just looking at the color of the critical zone.

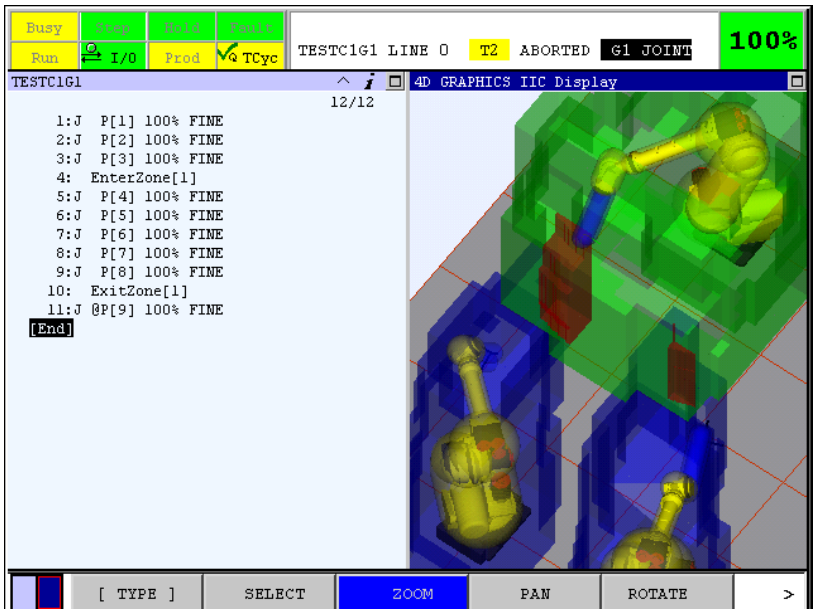


6.3 DEADLOCK PREVENTION 4D DISPLAY

To display the dead lock zone voxel data for a TP program, the program has to be part of a dead lock prevention schedule and the analysis on the schedule has been done to generate the voxel data. For example, the dead lock prevention schedule one has the following TP programs defined and the status is Complete.

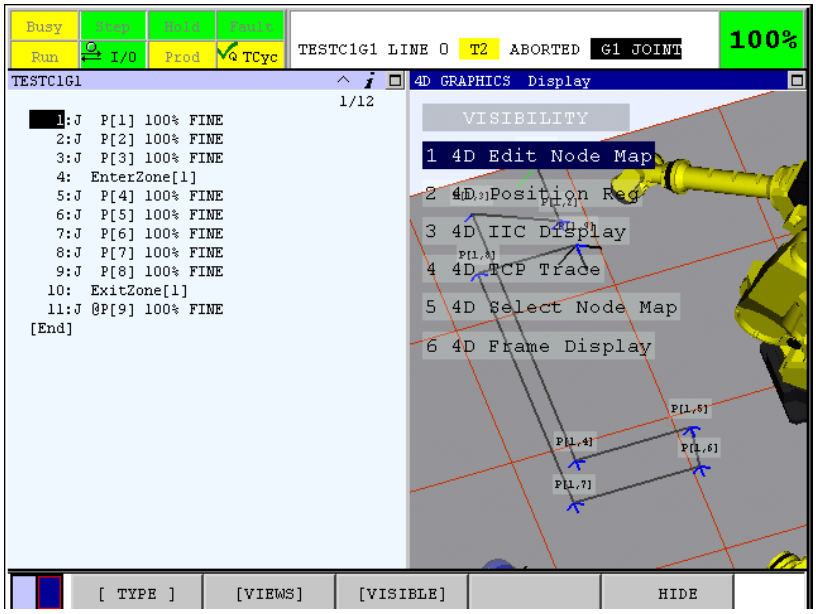


In the Editor menu, press and hold the *i* key and press the Fctn key at the same time will bring up the relative view menu: Use the Down arrow key to select the 4D IIC Display, the TP becomes

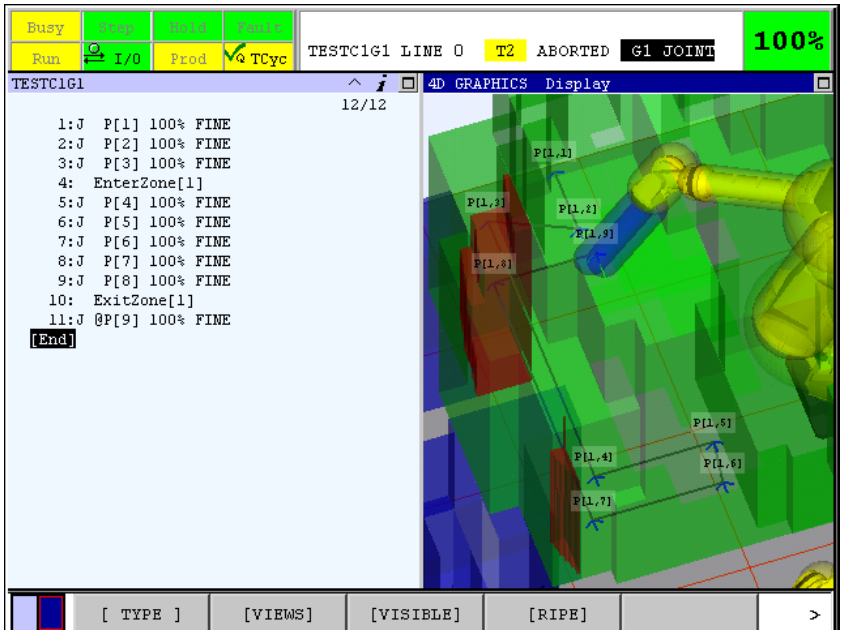


The green spaces are the dead lock zone voxel spaces. To see the relationship between the program and the voxel display, you can turn on the node map on the 4D display by the following step:

- Select the left pane so the left pane is on focus
- Press F1 [TYPE] and select 1, 4D display.
- Press the next button and then press F3, visibility to turn on the node map



- Select the IIC 4D displays from the Visibility pull down menu.



Rotate the 4D graphics and zoom in to the dead lock zones, you can see that by adjusting the taught point points, the robot can avoid the right dead lock zone, and therefore, reduce the possible waiting time.

6.4 RAILZONE 4D DISPLAY

Rail Zone software can display 4D Graphics. However, only extended axis set as Integrated Rail is supported. It is required RIPE setting and Calibration for Interference Check.

6.4.1 RIPE Setting

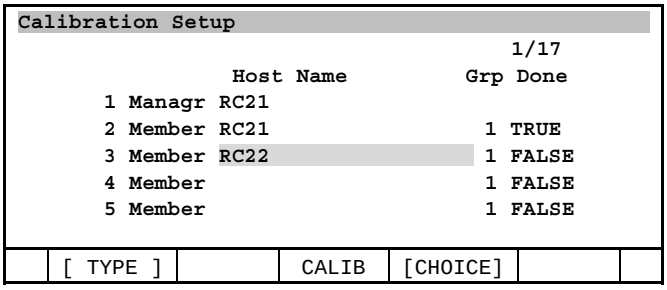
Please set up the RIPE so that 4D graphics can be displayed across controllers. Please refer to “3.1.4 RIPE Setting”.

6.4.2 Calibration for Interference Check Setting

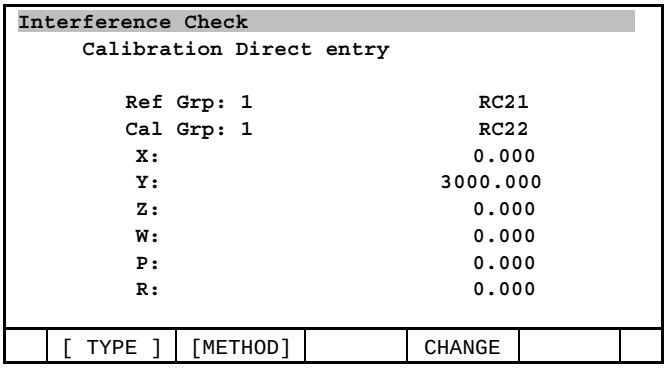
Please set up Calibration for Interference Check. Please refer to “3.2 CALIBRATION”.

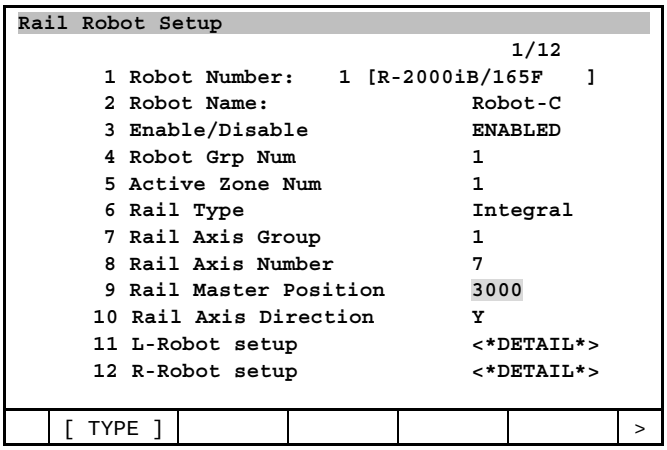
Example

There are RC21 and RC22. Group 1 of RC21 is the reference robot. Therefore, it is not necessary to calibrate group 1 of RC21. When you calibrate group 1 of RC22, move the cursor to line 3 and F3[CALIB] key.



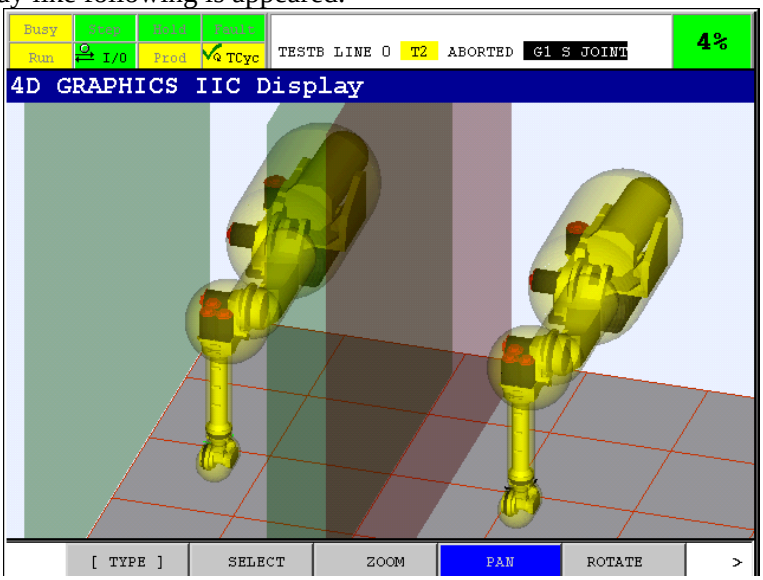
If the origin of group 1 of RC22 is 3000 mm off on the rail, it is necessary to set as the following on Calibration setup. Please set Rail Master Position to 3000 on Rail Robot Setup of RC22 too.





6.4.3 RailZone Display on 4D Graphics

To see the 4D graphical display of the rail zone, press the MENU key and select the 4D graphics, then press F1[TYPE] to select the 4D IIC Display.
For example, a display like following is appeared.



The 2 green planes that surround the left robot is the left and right bound of the left robot. The red plane is the left bound from the right robot. The left and right boundary moves with the left robot, but the right plane does not move unless the right robot moves.

7 TIP

- To increase the maximum settable number of hands and fixtures (The initial value is 10.)
  → In the system variables $IA_NUM_HAND (for hands) and $IA_NUM_FOBJ (for fixtures), maximum settable numbers are set. When modifying a number, set the corresponding system variable then perform a control start.

- To increase the number of Interference Check function combinations
  → In the system variable $IA_NUM_CHK, a maximum settable number is set. When modifying the number, set the system variable then perform a control start.

- To load hand data into a separate controller
  → When a backup operation is performed or the system files are saved, all hand data is saved to a file named IA_HAND.SV. To read hand model data, read the file when performing a control start.
  Or, it is possible to copy hand model data from a separate controller by copying Models function.
  Or, it is possible to export to XML file (iic_handmodel.xml) and import it to a separate controller by copying Models function.

- When you attempt to jog a robot, the alarm 「SSPC-101 (G:%d) is close to target」, 「SSPC-102 (G:%d) is close to target(qstop)」, or 「SSPC-103 (G:%d) is near to target」 is issued immediately, and the robot cannot be moved in any direction.
  → While holding down the SHIFT key, press the RESET key to release the alarm. Interference Check function is disabled and this disable status continues until the SHIFT key is released or a program execution operation (pressing of the FWD key) is performed. While maintaining this status, jog the robot. Use special care because this jogging is performed while the function is disabled.

- The alarm 「SSPC-105 Too many settings」 is issued.
  → Too many settings are made. Reduce the number of model elements or the number of combinations.

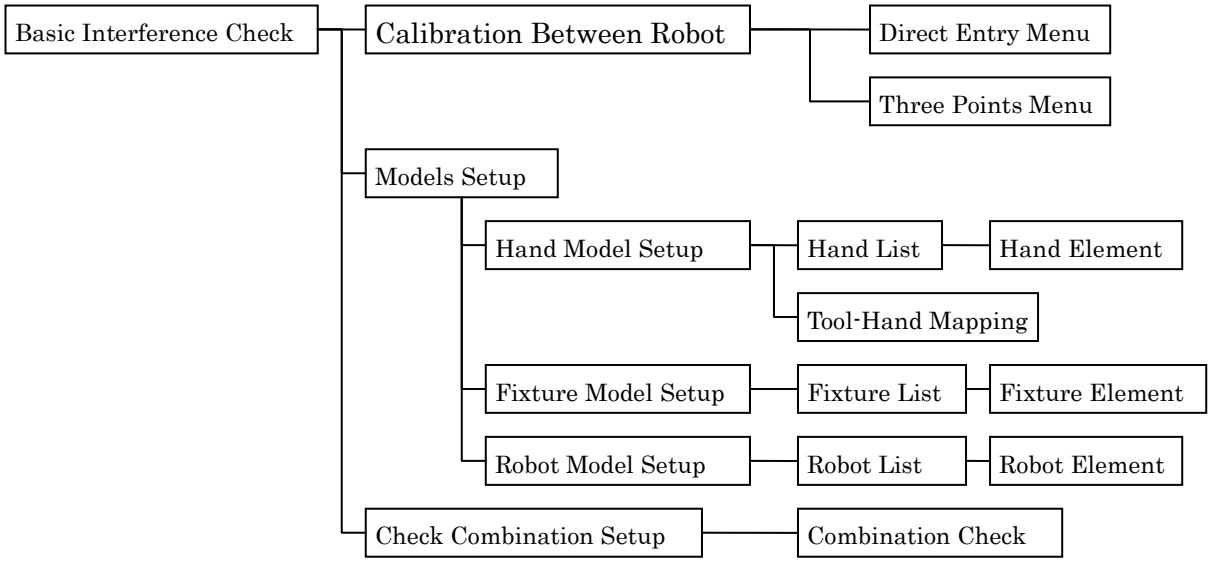
- When the override is increased, the alarm 「SSPC-101 (G:%d) is close to target」, 「SSPC-102 (G:%d) is close to target(qstop)」, or 「SSPC-103 (G:%d) is near to target」 is issued where these alarms have not been issued so far.
  → As a model moves faster, Interference Check function detects an approach and stops the model at an earlier time. So, the alarms (SSPC-101/SSPC-102/SSPC-103) tend to be issued. The reason is that as a higher speed is used, a longer coasting distance is required, and therefore a collision can occur unless deceleration starts earlier. In this case, decrease the taught speed in the program, or move the taught point away. If the operation ensures that no collision occurs, disable Interference Check function only for the motion in question with the TMP_DISABLE instruction.

- A robot stops during the execution of a motion statement. The program continues running.
  → Approach Waiting function may be enabled, and the robot may be waiting for the partner robot to move away. On the status screen, check the approach waiting combination status.
  In combination detail setting, set "Limit time to wait" to a desired value. After the approach waiting status lasts for the specified time, an alarm is issued and the robot stops. (Standard value: 10 seconds)

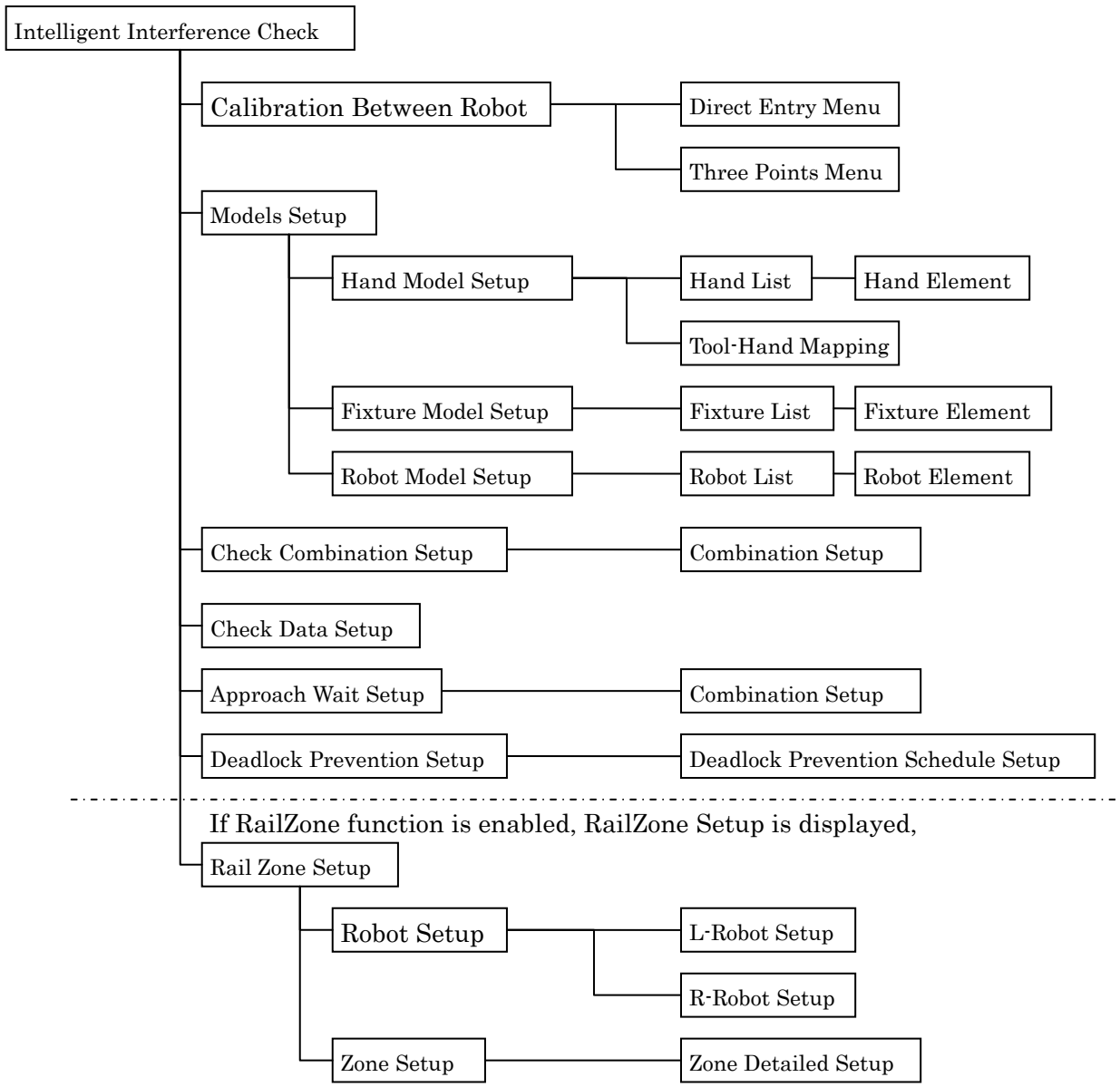
APPENDIX

A MENU STRUCTURE

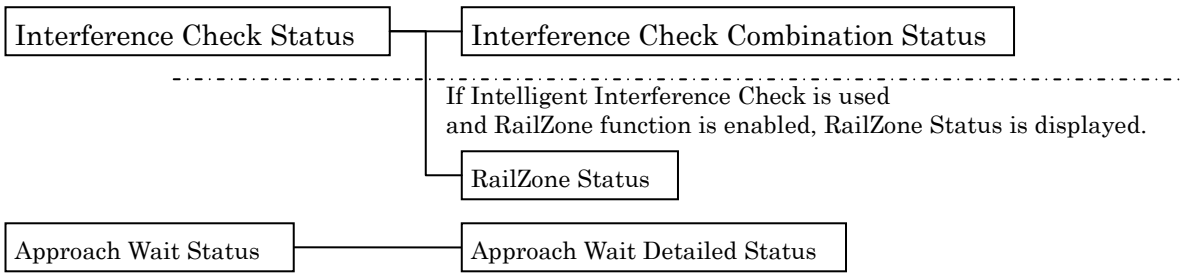
- Basic Interference Check Menu Structure



- Intelligent Interference Check Menu Structure



- Status Menu Structure (Basic/Intelligent Interference Check)



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REVISION RECORD

Edition	Date	Contents
02	Jan.,2014	• Addition of Robot Bypass Function.
01	May,2013	

B-83244EN/02

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