FANUC Robot series

R-30*i*B CONTROLLER

Rail Zone

USER'S GUIDE

Version 8.10, 8.20, and later

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FANUC conducts courses on its systems and products on a regularly scheduled basis at the company's world headquarters in Rochester Hills, Michigan. For additional information contact

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Patents

One or more of the following U.S. patents might be related to the FANUC products described in this manual.

FANUC America Corporation Patent List

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Conventions

WARNING

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

CAUTION

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

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

Safety

FANUC America Corporation is not and does not represent itself as an expert in safety systems, safety equipment, or the specific safety aspects of your company and/or its work force. It is the responsibility of the owner, employer, or user to take all necessary steps to guarantee the safety of all personnel in the workplace.

The appropriate level of safety for your application and installation can be best determined by safety system professionals. FANUC America Corporation therefore, recommends that each customer consult with such professionals in order to provide a workplace that allows for the safe application, use, and operation of FANUC America Corporation systems.

According to the industry standard ANSI/RIA R15-06, the owner or user is advised to consult the standards to ensure compliance with its requests for Robotics System design, usability, operation, maintenance, and service. Additionally, as the owner, employer, or user of a robotic system, it is your responsibility to arrange for the training of the operator of a robot system to recognize and respond to known hazards associated with your robotic system and to be aware of the recommended operating procedures for your particular application and robot installation.

Ensure that the robot being used is appropriate for the application. Robots used in classified (hazardous) locations must be certified for this use.

FANUC America Corporation therefore, recommends that all personnel who intend to operate, program, repair, or otherwise use the robotics system be trained in an approved FANUC America Corporation training course and become familiar with the proper operation of the system. Persons responsible for programming the system–including the design, implementation, and debugging of application programs–must be familiar with the recommended programming procedures for your application and robot installation.

The following guidelines are provided to emphasize the importance of safety in the workplace.

CONSIDERING SAFETY FOR YOUR ROBOT INSTALLATION

Safety is essential whenever robots are used. Keep in mind the following factors with regard to safety:

- The safety of people and equipment
- Use of safety enhancing devices
- Techniques for safe teaching and manual operation of the robot(s)
- Techniques for safe automatic operation of the robot(s)
- Regular scheduled inspection of the robot and workcell
- Proper maintenance of the robot

Keeping People Safe

The safety of people is always of primary importance in any situation. When applying safety measures to your robotic system, consider the following:

- External devices
- Robot(s)
- Tooling
- Workpiece

Using Safety Enhancing Devices

Always give appropriate attention to the work area that surrounds the robot. The safety of the work area can be enhanced by the installation of some or all of the following devices:

- Safety fences, barriers, or chains
- Light curtains
- Interlocks
- Pressure mats
- Floor markings
- Warning lights
- Mechanical stops
- EMERGENCY STOP buttons
- DEADMAN switches

Setting Up a Safe Workcell

A safe workcell is essential to protect people and equipment. Observe the following guidelines to ensure that the workcell is set up safely. These suggestions are intended to supplement and not replace existing federal, state, and local laws, regulations, and guidelines that pertain to safety.

- Sponsor your personnel for training in approved FANUC America Corporation training course(s) related to your application. Never permit untrained personnel to operate the robots.
- Install a lockout device that uses an access code to prevent unauthorized persons from operating the robot.
- Use anti–tie–down logic to prevent the operator from bypassing safety measures.
- Arrange the workcell so the operator faces the workcell and can see what is going on inside the cell.
- Clearly identify the work envelope of each robot in the system with floor markings, signs, and special barriers. The work envelope is the area defined by the maximum motion range of the robot, including any tooling attached to the wrist flange that extend this range.

- Position all controllers outside the robot work envelope.
- Never rely on software or firmware based controllers as the primary safety element unless they comply with applicable current robot safety standards.
- Mount an adequate number of EMERGENCY STOP buttons or switches within easy reach of the operator and at critical points inside and around the outside of the workcell.
- Install flashing lights and/or audible warning devices that activate whenever the robot is operating, that is, whenever power is applied to the servo drive system. Audible warning devices shall exceed the ambient noise level at the end–use application.
- Wherever possible, install safety fences to protect against unauthorized entry by personnel into the work envelope.
- Install special guarding that prevents the operator from reaching into restricted areas of the work envelope.
- Use interlocks.
- Use presence or proximity sensing devices such as light curtains, mats, and capacitance and vision systems to enhance safety.
- Periodically check the safety joints or safety clutches that can be optionally installed between the robot wrist flange and tooling. If the tooling strikes an object, these devices dislodge, remove power from the system, and help to minimize damage to the tooling and robot.
- Make sure all external devices are properly filtered, grounded, shielded, and suppressed to prevent hazardous motion due to the effects of electro–magnetic interference (EMI), radio frequency interference (RFI), and electro–static discharge (ESD).
- Make provisions for power lockout/tagout at the controller.
- Eliminate *pinch points*. Pinch points are areas where personnel could get trapped between a moving robot and other equipment.
- Provide enough room inside the workcell to permit personnel to teach the robot and perform maintenance safely.
- Program the robot to load and unload material safely.
- If high voltage electrostatics are present, be sure to provide appropriate interlocks, warning, and beacons.
- If materials are being applied at dangerously high pressure, provide electrical interlocks for lockout of material flow and pressure.

Staying Safe While Teaching or Manually Operating the Robot

Advise all personnel who must teach the robot or otherwise manually operate the robot to observe the following rules:

- Never wear watches, rings, neckties, scarves, or loose clothing that could get caught in moving machinery.
- Know whether or not you are using an intrinsically safe teach pendant if you are working in a hazardous environment.

- Before teaching, visually inspect the robot and work envelope to make sure that no potentially hazardous conditions exist. The work envelope is the area defined by the maximum motion range of the robot. These include tooling attached to the wrist flange that extends this range.
- The area near the robot must be clean and free of oil, water, or debris. Immediately report unsafe working conditions to the supervisor or safety department.
- FANUC America Corporation recommends that no one enter the work envelope of a robot that is on, except for robot teaching operations. However, if you must enter the work envelope, be sure all safeguards are in place, check the teach pendant DEADMAN switch for proper operation, and place the robot in teach mode. Take the teach pendant with you, turn it on, and be prepared to release the DEADMAN switch. Only the person with the teach pendant should be in the work envelope.

WARNING

Never bypass, strap, or otherwise deactivate a safety device, such as a limit switch, for any operational convenience. Deactivating a safety device is known to have resulted in serious injury and death.

- Know the path that can be used to escape from a moving robot; make sure the escape path is never blocked.
- Isolate the robot from all remote control signals that can cause motion while data is being taught.
- Test any program being run for the first time in the following manner:

WARNING

Stay outside the robot work envelope whenever a program is being run. Failure to do so can result in injury.

  - Using a low motion speed, single step the program for at least one full cycle.
  - Using a low motion speed, test run the program continuously for at least one full cycle.
  - Using the programmed speed, test run the program continuously for at least one full cycle.
- Make sure all personnel are outside the work envelope before running production.

Staying Safe During Automatic Operation

Advise all personnel who operate the robot during production to observe the following rules:

- Make sure all safety provisions are present and active.

- Know the entire workcell area. The workcell includes the robot and its work envelope, plus the area occupied by all external devices and other equipment with which the robot interacts.
- Understand the complete task the robot is programmed to perform before initiating automatic operation.
- Make sure all personnel are outside the work envelope before operating the robot.
- Never enter or allow others to enter the work envelope during automatic operation of the robot.
- Know the location and status of all switches, sensors, and control signals that could cause the robot to move.
- Know where the EMERGENCY STOP buttons are located on both the robot control and external control devices. Be prepared to press these buttons in an emergency.
- Never assume that a program is complete if the robot is not moving. The robot could be waiting for an input signal that will permit it to continue its activity.
- If the robot is running in a pattern, do not assume it will continue to run in the same pattern.
- Never try to stop the robot, or break its motion, with your body. The only way to stop robot motion immediately is to press an EMERGENCY STOP button located on the controller panel, teach pendant, or emergency stop stations around the workcell.

Staying Safe During Inspection

When inspecting the robot, be sure to

- Turn off power at the controller.
- Lock out and tag out the power source at the controller according to the policies of your plant.
- Turn off the compressed air source and relieve the air pressure.
- If robot motion is not needed for inspecting the electrical circuits, press the EMERGENCY STOP button on the operator panel.
- Never wear watches, rings, neckties, scarves, or loose clothing that could get caught in moving machinery.
- If power is needed to check the robot motion or electrical circuits, be prepared to press the EMERGENCY STOP button, in an emergency.
- Be aware that when you remove a servomotor or brake, the associated robot arm will fall if it is not supported or resting on a hard stop. Support the arm on a solid support before you release the brake.

Staying Safe During Maintenance

When performing maintenance on your robot system, observe the following rules:

- Never enter the work envelope while the robot or a program is in operation.
- Before entering the work envelope, visually inspect the workcell to make sure no potentially hazardous conditions exist.

- Never wear watches, rings, neckties, scarves, or loose clothing that could get caught in moving machinery.
- Consider all or any overlapping work envelopes of adjoining robots when standing in a work envelope.
- Test the teach pendant for proper operation before entering the work envelope.
- If it is necessary for you to enter the robot work envelope while power is turned on, you must be sure that you are in control of the robot. Be sure to take the teach pendant with you, press the DEADMAN switch, and turn the teach pendant on. Be prepared to release the DEADMAN switch to turn off servo power to the robot immediately.
- Whenever possible, perform maintenance with the power turned off. Before you open the controller front panel or enter the work envelope, turn off and lock out the 3–phase power source at the controller.
- Be aware that when you remove a servomotor or brake, the associated robot arm will fall if it is not supported or resting on a hard stop. Support the arm on a solid support before you release the brake.

⚠WARNING

Lethal voltage is present in the controller WHENEVER IT IS CONNECTED to a power source. Be extremely careful to avoid electrical shock. HIGH VOLTAGE IS PRESENT at the input side whenever the controller is connected to a power source. Turning the disconnect or circuit breaker to the OFF position removes power from the output side of the device only.

- Release or block all stored energy. Before working on the pneumatic system, shut off the system air supply and purge the air lines.
- Isolate the robot from all remote control signals. If maintenance must be done when the power is on, make sure the person inside the work envelope has sole control of the robot. The teach pendant must be held by this person.
- Make sure personnel cannot get trapped between the moving robot and other equipment. Know the path that can be used to escape from a moving robot. Make sure the escape route is never blocked.
- Use blocks, mechanical stops, and pins to prevent hazardous movement by the robot. Make sure that such devices do not create pinch points that could trap personnel.

⚠WARNING

Do not try to remove any mechanical component from the robot before thoroughly reading and understanding the procedures in the appropriate manual. Doing so can result in serious personal injury and component destruction.

- Be aware that when you remove a servomotor or brake, the associated robot arm will fall if it is not supported or resting on a hard stop. Support the arm on a solid support before you release the brake.
- When replacing or installing components, make sure dirt and debris do not enter the system.
- Use only specified parts for replacement. To avoid fires and damage to parts in the controller, never use nonspecified fuses.
- Before restarting a robot, make sure no one is inside the work envelope; be sure that the robot and all external devices are operating normally.

KEEPING MACHINE TOOLS AND EXTERNAL DEVICES SAFE

Certain programming and mechanical measures are useful in keeping the machine tools and other external devices safe. Some of these measures are outlined below. Make sure you know all associated measures for safe use of such devices.

Programming Safety Precautions

Implement the following programming safety measures to prevent damage to machine tools and other external devices.

- Back–check limit switches in the workcell to make sure they do not fail.
- Implement ‘‘failure routines” in programs that will provide appropriate robot actions if an external device or another robot in the workcell fails.
- Use *handshaking* protocol to synchronize robot and external device operations.
- Program the robot to check the condition of all external devices during an operating cycle.

Mechanical Safety Precautions

Implement the following mechanical safety measures to prevent damage to machine tools and other external devices.

- Make sure the workcell is clean and free of oil, water, and debris.
- Use DCS (Dual Check Safety), software limits, limit switches, and mechanical hardstops to prevent undesired movement of the robot into the work area of machine tools and external devices.

KEEPING THE ROBOT SAFE

Observe the following operating and programming guidelines to prevent damage to the robot.

Operating Safety Precautions

The following measures are designed to prevent damage to the robot during operation.

- Use a low override speed to increase your control over the robot when jogging the robot.
- Visualize the movement the robot will make before you press the jog keys on the teach pendant.
- Make sure the work envelope is clean and free of oil, water, or debris.
- Use circuit breakers to guard against electrical overload.

Programming Safety Precautions

The following safety measures are designed to prevent damage to the robot during programming:

- Establish *interference zones* to prevent collisions when two or more robots share a work area.
- Make sure that the program ends with the robot near or at the home position.
- Be aware of signals or other operations that could trigger operation of tooling resulting in personal injury or equipment damage.
- In dispensing applications, be aware of all safety guidelines with respect to the dispensing materials.

NOTE: Any deviation from the methods and safety practices described in this manual must conform to the approved standards of your company. If you have questions, see your supervisor.

ADDITIONAL SAFETY CONSIDERATIONS FOR PAINT ROBOT INSTALLATIONS

Process technicians are sometimes required to enter the paint booth, for example, during daily or routine calibration or while teaching new paths to a robot. Maintenance personnel also must work inside the paint booth periodically.

Whenever personnel are working inside the paint booth, ventilation equipment must be used. Instruction on the proper use of ventilating equipment usually is provided by the paint shop supervisor.

Although paint booth hazards have been minimized, potential dangers still exist. Therefore, today's highly automated paint booth requires that process and maintenance personnel have full awareness of the system and its capabilities. They must understand the interaction that occurs between the vehicle moving along the conveyor and the robot(s), hood/deck and door opening devices, and high–voltage electrostatic tools.

CAUTION

Ensure that all ground cables remain connected. Never operate the paint robot with ground provisions disconnected. Otherwise, you could injure personnel or damage equipment.

Paint robots are operated in three modes:

- Teach or manual mode
- Automatic mode, including automatic and exercise operation
- Diagnostic mode

During both teach and automatic modes, the robots in the paint booth will follow a predetermined pattern of movements. In teach mode, the process technician teaches (programs) paint paths using the teach pendant.

In automatic mode, robot operation is initiated at the System Operator Console (SOC) or Manual Control Panel (MCP), if available, and can be monitored from outside the paint booth. All personnel must remain outside of the booth or in a designated safe area within the booth whenever automatic mode is initiated at the SOC or MCP.

In automatic mode, the robots will execute the path movements they were taught during teach mode, but generally at production speeds.

When process and maintenance personnel run diagnostic routines that require them to remain in the paint booth, they must stay in a designated safe area.

Paint System Safety Features

Process technicians and maintenance personnel must become totally familiar with the equipment and its capabilities. To minimize the risk of injury when working near robots and related equipment, personnel must comply strictly with the procedures in the manuals.

This section provides information about the safety features that are included in the paint system and also explains the way the robot interacts with other equipment in the system.

The paint system includes the following safety features:

- Most paint booths have red warning beacons that illuminate when the robots are armed and ready to paint. Your booth might have other kinds of indicators. Learn what these are.

- Some paint booths have a blue beacon that, when illuminated, indicates that the electrostatic devices are enabled. Your booth might have other kinds of indicators. Learn what these are.
- EMERGENCY STOP buttons are located on the robot controller and teach pendant. Become familiar with the locations of all E–STOP buttons.
- An intrinsically safe teach pendant is used when teaching in hazardous paint atmospheres.
- A DEADMAN switch is located on each teach pendant. When this switch is held in, and the teach pendant is on, power is applied to the robot servo system. If the engaged DEADMAN switch is released or pressed harder during robot operation, power is removed from the servo system, all axis brakes are applied, and the robot comes to an EMERGENCY STOP. Safety interlocks within the system might also E–STOP other robots.

WARNING

An EMERGENCY STOP will occur if the DEADMAN switch is released on a bypassed robot.

- Overtravel by robot axes is prevented by software limits. All of the major and minor axes are governed by software limits. DCS (Dual Check Safety), limit switches and hardstops also limit travel by the major axes.
- EMERGENCY STOP limit switches and photoelectric eyes might be part of your system. Limit switches, located on the entrance/exit doors of each booth, will EMERGENCY STOP all equipment in the booth if a door is opened while the system is operating in automatic or manual mode. For some systems, signals to these switches are inactive when the switch on the SOC is in teach mode.
- When present, photoelectric eyes are sometimes used to monitor unauthorized intrusion through the entrance/exit silhouette openings.
- System status is monitored by computer. Severe conditions result in automatic system shutdown.

Staying Safe While Operating the Paint Robot

When you work in or near the paint booth, observe the following rules, in addition to all rules for safe operation that apply to all robot systems.

WARNING

Observe all safety rules and guidelines to avoid injury.

WARNING

Never bypass, strap, or otherwise deactivate a safety device, such as a limit switch, for any operational convenience. Deactivating a safety device is known to have resulted in serious injury and death.

WARNING

Enclosures shall not be opened unless the area is known to be nonhazardous or all power has been removed from devices within the enclosure. Power shall not be restored after the enclosure has been opened until all combustible dusts have been removed from the interior of the enclosure and the enclosure purged. Refer to the Purge chapter for the required purge time.

- Know the work area of the entire paint station (workcell).
- Know the work envelope of the robot and hood/deck and door opening devices.
- Be aware of overlapping work envelopes of adjacent robots.
- Know where all red, mushroom–shaped EMERGENCY STOP buttons are located.
- Know the location and status of all switches, sensors, and/or control signals that might cause the robot, conveyor, and opening devices to move.
- Make sure that the work area near the robot is clean and free of water, oil, and debris. Report unsafe conditions to your supervisor.
- Become familiar with the complete task the robot will perform BEFORE starting automatic mode.
- Make sure all personnel are outside the paint booth before you turn on power to the robot servo system.
- Never enter the work envelope or paint booth before you turn off power to the robot servo system.
- Never enter the work envelope during automatic operation unless a safe area has been designated.
- Never wear watches, rings, neckties, scarves, or loose clothing that could get caught in moving machinery.
- Remove all metallic objects, such as rings, watches, and belts, before entering a booth when the electrostatic devices are enabled.
- Stay out of areas where you might get trapped between a moving robot, conveyor, or opening device and another object.
- Be aware of signals and/or operations that could result in the triggering of guns or bells.
- Be aware of all safety precautions when dispensing of paint is required.
- Follow the procedures described in this manual.

Special Precautions for Combustible Dusts (Powder Paint)

When the robot is used in a location where combustible dusts are found, such as the application of powder paint, the following special precautions are required to insure that there are no combustible dusts inside the robot.

- Purge maintenance air should be maintained at all times, even when the robot power is off. This will insure that dust can not enter the robot.
- A purge cycle will not remove accumulated dusts. Therefore, if the robot is exposed to dust when maintenance air is not present, it will be necessary to remove the covers and clean out any accumulated dust. Do not energize the robot until you have performed the following steps.

1. Before covers are removed, the exterior of the robot should be cleaned to remove accumulated dust.
2. When cleaning and removing accumulated dust, either on the outside or inside of the robot, be sure to use methods appropriate for the type of dust that exists. Usually lint free rags dampened with water are acceptable. Do not use a vacuum cleaner to remove dust as it can generate static electricity and cause an explosion unless special precautions are taken.
3. Thoroughly clean the interior of the robot with a lint free rag to remove any accumulated dust.
4. When the dust has been removed, the covers must be replaced immediately.
5. Immediately after the covers are replaced, run a complete purge cycle. The robot can now be energized.

Staying Safe While Operating Paint Application Equipment

When you work with paint application equipment, observe the following rules, in addition to all rules for safe operation that apply to all robot systems.

⚠ WARNING

When working with electrostatic paint equipment, follow all national and local codes as well as all safety guidelines within your organization. Also reference the following standards: NFPA 33 Standards for Spray Application Using Flammable or Combustible Materials, and NFPA 70 National Electrical Code.

- **Grounding**: All electrically conductive objects in the spray area must be grounded. This includes the spray booth, robots, conveyors, workstations, part carriers, hooks, paint pressure pots, as well as solvent containers. Grounding is defined as the object or objects shall be electrically connected to ground with a resistance of not more than 1 megohms.
- **High Voltage**: High voltage should only be on during actual spray operations. Voltage should be off when the painting process is completed. Never leave high voltage on during a cap cleaning process.
- Avoid any accumulation of combustible vapors or coating matter.
- Follow all manufacturer recommended cleaning procedures.
- Make sure all interlocks are operational.

- No smoking.
- Post all warning signs regarding the electrostatic equipment and operation of electrostatic equipment according to NFPA 33 Standard for Spray Application Using Flammable or Combustible Material.
- Disable all air and paint pressure to bell.
- Verify that the lines are not under pressure.

Staying Safe During Maintenance

When you perform maintenance on the painter system, observe the following rules, and all other maintenance safety rules that apply to all robot installations. Only qualified, trained service or maintenance personnel should perform repair work on a robot.

- Paint robots operate in a potentially explosive environment. Use caution when working with electric tools.
- When a maintenance technician is repairing or adjusting a robot, the work area is under the control of that technician. All personnel not participating in the maintenance must stay out of the area.
- For some maintenance procedures, station a second person at the control panel within reach of the EMERGENCY STOP button. This person must understand the robot and associated potential hazards.
- Be sure all covers and inspection plates are in good repair and in place.
- Always return the robot to the ‘‘home’’ position before you disarm it.
- Never use machine power to aid in removing any component from the robot.
- During robot operations, be aware of the robot’s movements. Excess vibration, unusual sounds, and so forth, can alert you to potential problems.
- Whenever possible, turn off the main electrical disconnect before you clean the robot.
- When using vinyl resin observe the following:
  - Wear eye protection and protective gloves during application and removal.
  - Adequate ventilation is required. Overexposure could cause drowsiness or skin and eye irritation.
  - If there is contact with the skin, wash with water.
  - Follow the Original Equipment Manufacturer’s Material Safety Data Sheets.
- When using paint remover observe the following:
  - Eye protection, protective rubber gloves, boots, and apron are required during booth cleaning.
  - Adequate ventilation is required. Overexposure could cause drowsiness.
  - If there is contact with the skin or eyes, rinse with water for at least 15 minutes. Then seek medical attention as soon as possible.
  - Follow the Original Equipment Manufacturer’s Material Safety Data Sheets.

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1 RAILZONE INTERFERENCE CHECK

1. RAILZONE INTERFERENCE CHECK

1.1 Overview

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 and its operation is independent of PLC control. The collision protection covers for carriages, rail robot and its tooling across the controllers.

1.1.1 Compatibilities and Limitations

- This function requires IIC (Intelligent Interference Check, option R759).
- This function only applies to rail robots.
- 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. Refer to the *FANUC Robotics SYSTEM R-30iB Ethernet Global Data Setup and Operations Manual* to correctly set up and apply EGD.

1.1.2 Supported Robot and Carriage Configurations

- Carriage axis is an independent axis in robot group.
- Carriage axis is an independent axis in a separate motion group.
- Carriage axis is an integral rail axis.
- Carriage axis is a J1 axis of a top loader robot.
- Multiple robots in separate controllers

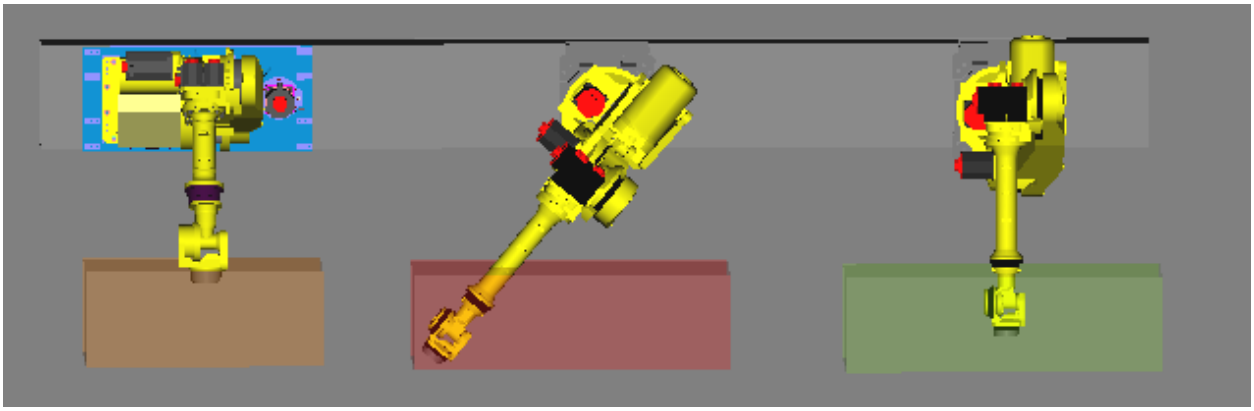
1.1.3 Supported Rail Configurations

- A common rail zero master position for all rail robots.
- Each robot has its own zero master position

1.1.4 Supported Motion Types

- Towards motion: rail robots are moving towards each other.
- Same direction motion: rail robots are moving in same direction.
- Sync motion: rail robots are moving synchronously.
- Non-Sync motion: rail robots are moving non-synchronously.

Figure 1-1 Rail Robots



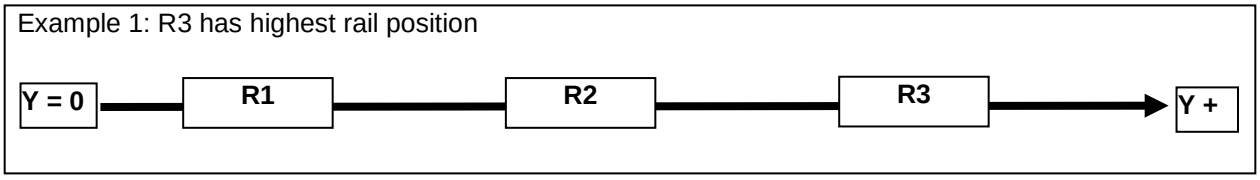
1.1.5 Terminology

Throughout this manual we will be frequently reference to following terms that are defined as:

- **L**eft **R**obot (LR) refers to an immediate adjacent rail robot that has lower rail position.
- **R**ight **R**obot (RR) refers to an immediate adjacent rail robot that has higher rail position.
- **LB** refers to low boundary for a rail robot in rail axis direction.
- **HB** refers to 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.

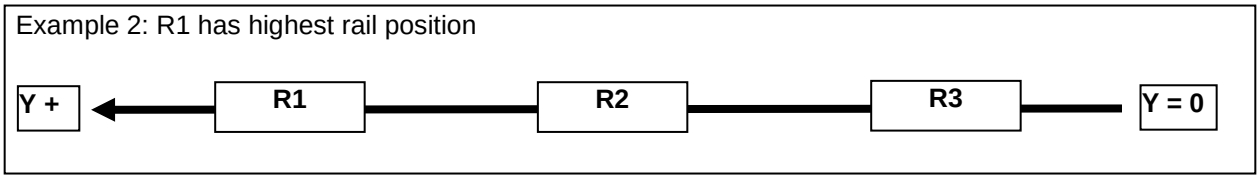
Figure 1-2 Left & Right Rail Robot Example 1



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

Figure 1-3 Left & Right Rail Robot Example 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

1.1.6 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:

1. 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.
2. User-defined boundaries establish minimum size of a RailZone.
3. A zone size is automatically increased if robot posture and/or robot tooling extends beyond the user-defined minimum zone boundaries.
4. A RailZone is dynamically updated based on robot's rail position, robot posture, robot tool, and rail motion speed and direction.
5. RailZone data are continuously communicated to adjacent robot controllers using EGD.
6. A RailZone can be enabled or disabled at any time.
7. A rail robot can switch to a different RailZone at any time.
8. Each controller has maximum 10 zones, but allows one active zone at one time.
9. 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.

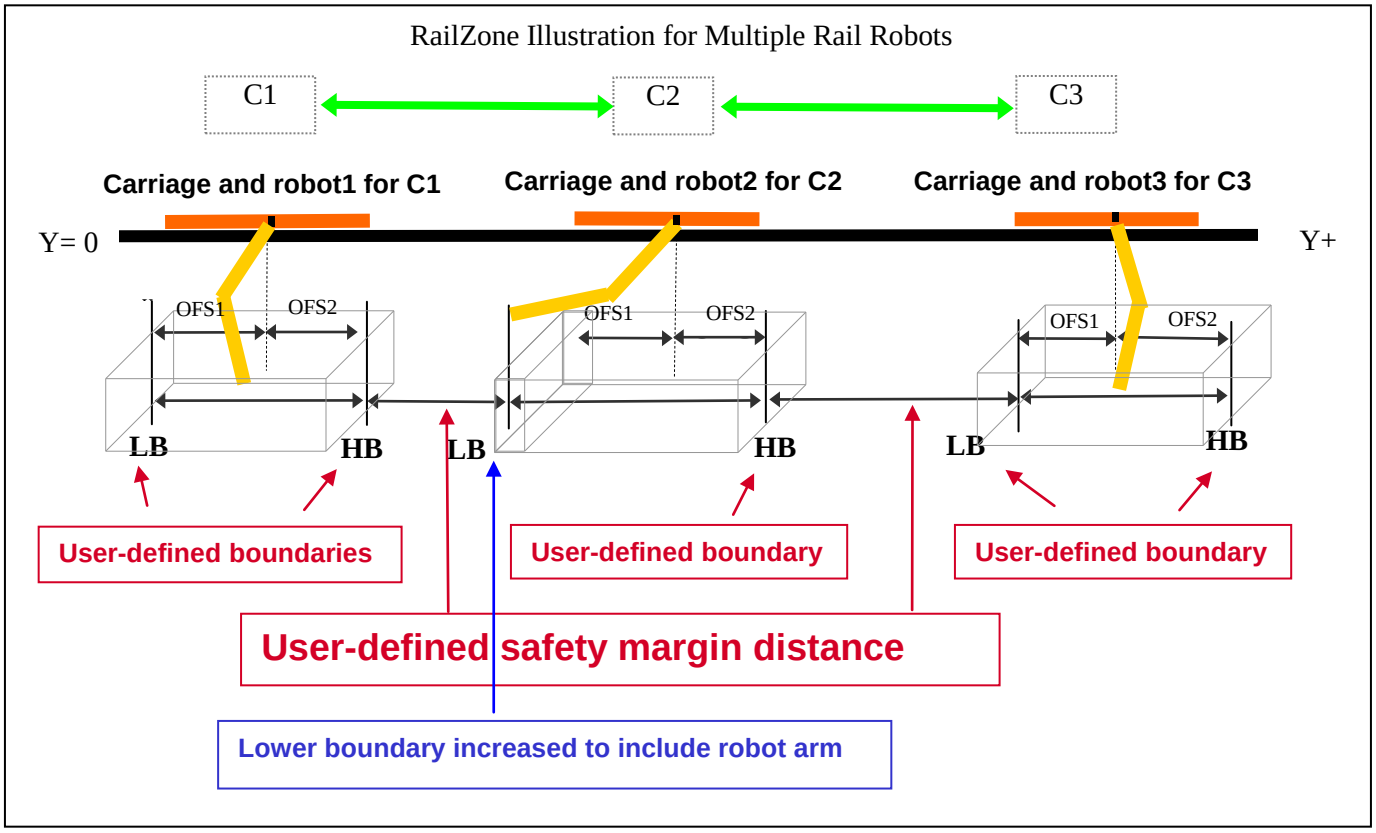
⚠ WARNING

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.

1.1.6.1 RailZone Example

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.

Figure 1-4 RailZone Illustration



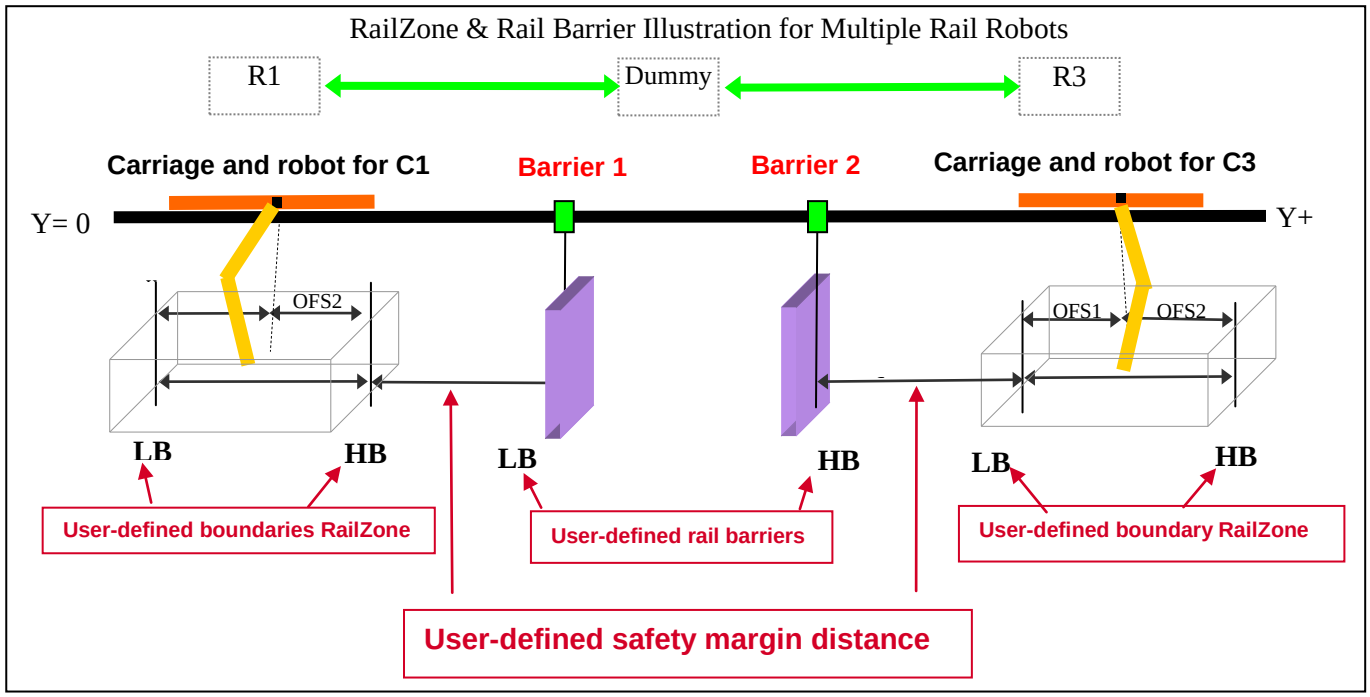
1.1.7 Rail Barrier Function

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.

1.1.7.1 Rail Barrier Example

A schematic below illustrates the concept of multiple robots with rail barriers. Barrier 1 is the LB of a dummy, acting as right robot of R1 and Barrier 2 is the HB of a dummy left robot for R3.

Figure 1-5 Rail Barrier Illustration



2 RAILZONE OPERATION

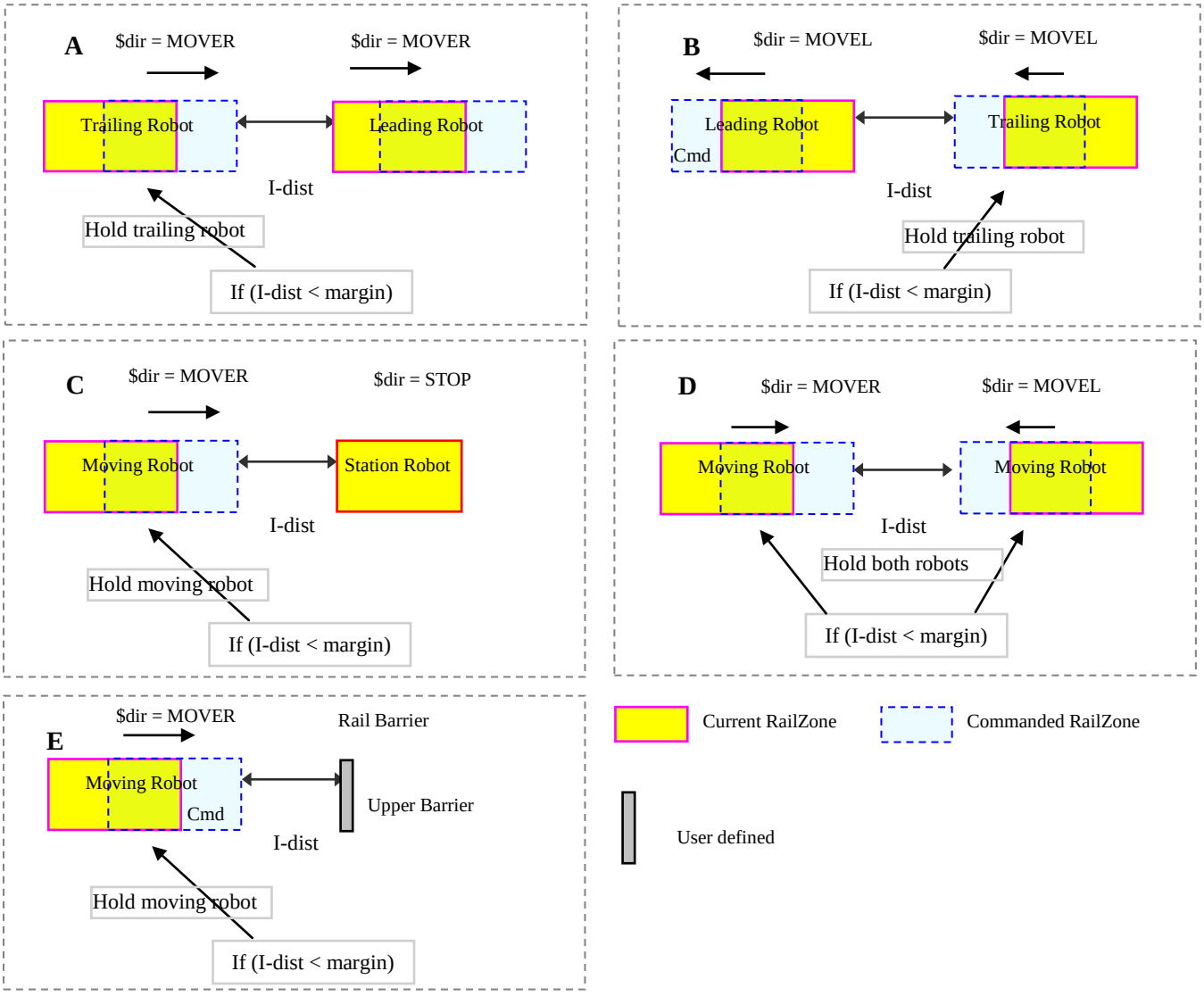
2. RAILZONE OPERATION

2.1 RailZone Interference Control Rules

A control objective is to prevent RailZones 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. When interference occurs it holds rail robot as

- 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 diagrams 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 diagram 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 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 below).

Figure 2-1 RailZone Control Method



2.2 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:

- Enable →Disable a RailZone 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.

- Disable→Enable a RailZone 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.

2.3 Manual Functions

2.3.1 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.

Note User defined PLC logic assumes this responsibility.

2.3.2 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.

2.3.3 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:

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

3 RAILZONE SETUP

3. RAILZONE SETUP

3.1 RailZone Setup Menu

RailZone provides FULL and SHORT setup menu. The full menu lists all setup items for **I**ntelligent **I**nterference **C**heck (**IIC**). The short menu only lists necessary setup items used by RailZone function. You can select MENU display by setting system variables:

- Full menu items: when $ic_rz_cfg.$enable = TRUE and $ic_rz_cfg.$full_menu = TRUE
- Short menu items: when $ic_rz_cfg.$enable = TRUE and $ic_rz_cfg.$full_menu = FALSE
- Hidden menu items: when $ic_rz_cfg.$enable = FALSE

Follow the procedures below to get railzone setup menu

1. Press MENU.
2. Select SETUP.
3. Press F1, [TYPE].
4. Select Interference. You will see screens of full menu, short menu and hidden menu item respectively.

Figure 3-1 Full MENU

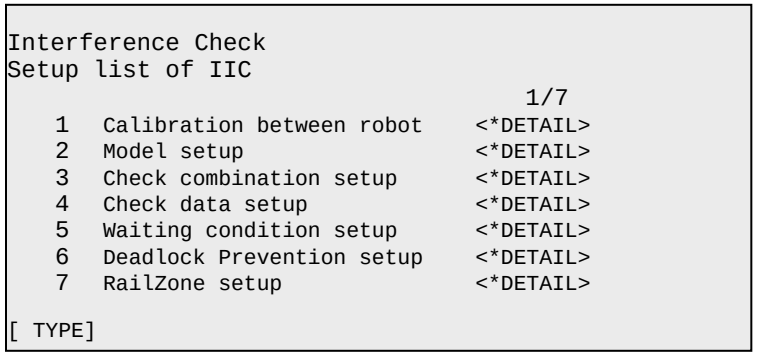


Figure 3-2 Short MENU

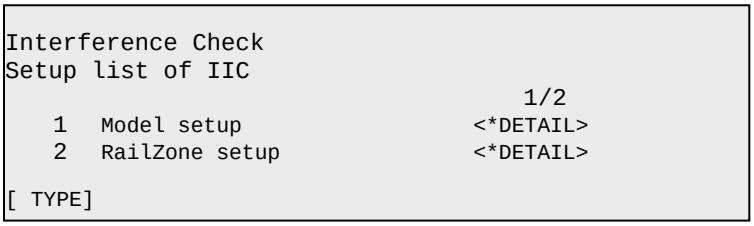
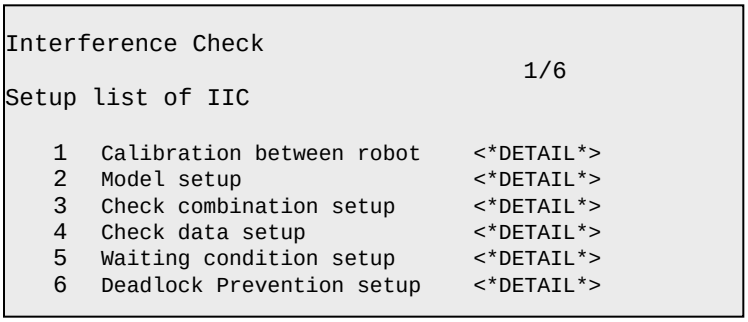


Figure 3-3 Hidden MENU ITEM



3.2 Robot and Tool Model Setup

RailZone provides full protection for rail robot and its attached tooling. It requires setting up robot and tool model. Refer to FANUC Robotics SYSTEM R-30iB IIC (intelligent interference check) Manual for information on how to set up robot model and user defined tooling.

3.3 RailZone Setup

Move cursor to RailZone setup you will see a screen similar to the following. RailZone Setup involves rail robot setup and zone setup.

Figure 3-4 RailZone Setup Screen

3.3.1 Rail Robot Setup

Move cursor to Robot setup and press ENTER. You will see a screen similar to the following.

Figure 3-5 Host Robot Setup Screen

```
 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 Left  Rail Robot          <*DETAIL*>
  12 Right Rail Robot          <*DETAIL*>

[ TYPE]
```

Table 3-1 Host Robot Setup Description

ITEM	DESCRIPTION
Robot Number	This item indicates rail robot group or rail motion group is being edited.
Robot Name	This item defines the robot name (10 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 types as Integral: rail axis is the robot extended axis. Toploader: rail axis is the J1 of the robot group. 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.
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 zero master position with respect to a common rail reference location.
Rail Axis Direction	This item defines plus rail axis move direction w/r robot world coordinate.

3.3.1.1 Right Rail Robot Setup

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

Figure 3-6 Right Robot Setup Screen

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

[ TYPE]
```

Table 3-2 Right Robot Setup Description

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 (10 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.

3.3.1.2 Left Rail Robot Setup

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

Figure 3-7 Left Robot Setup Screen

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

[ TYPE]
```

Table 3-3 Left Robot Setup Description

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 (10 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.

3.3.1.3 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.

1. Setup system variable. In this method, you must set all group I/O index to -1 and then 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. ***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.

Figure 3-8 Upper Barrier Setup Example 1

```
RailZone R-Robot setup
                                    1/6
 1  Right Robot Check           TRUE
 2  Right Robot name            Barrier
 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[ -1]

[ TYPE]
```

2. Use group input. In this method, the rail barrier position is transmitted via specified group input. In the example below, an upper limit barrier position is transmitted via GI[2], and the rest of group I/O index are set to -1. The system will update the value of $ic_rz_stat[g].$lb_righ_rob automatically. Following screen shows the setup example for upper limit barrier, the right robot is a dummy.

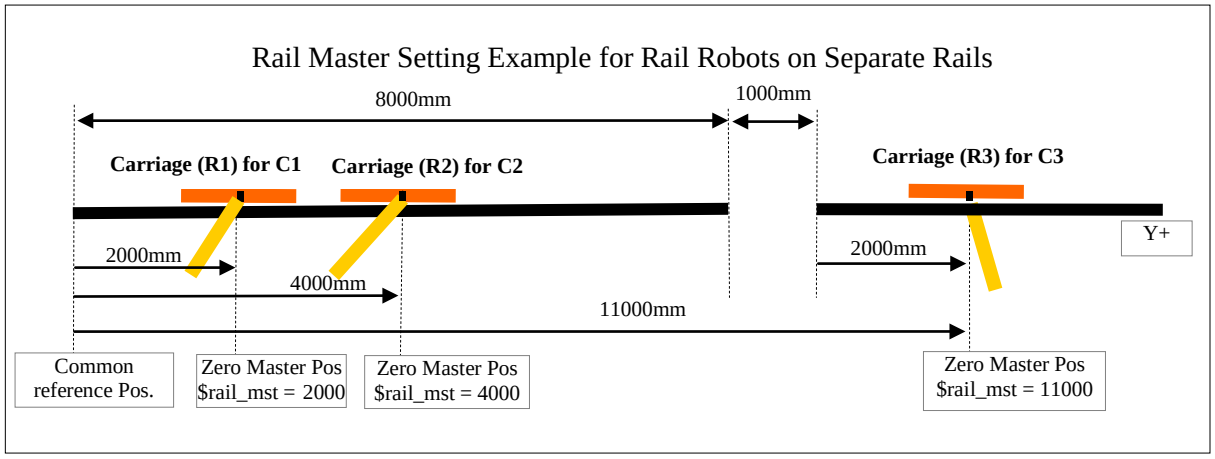
Figure 3-9 Upper Barrier Setup Example 2

```
RailZone R-Robot setup
                                        1/6
 1  Right Robot Check            TRUE
 2  Right Robot name             barrier
 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]
```

3.3.1.4 Rail Master Position Setup

When rail robots are setup at different rail zero master position on a single rail or on multiple segments of rails, it is necessary to setup item 9, Rail Master Position correctly, so that the rail zones for each rail robot are with respect to a common rail reference point. The example below illustrates the setup of the rail master position for each rail robot according to different zero master positions on rails.

Figure 3-10 Rail Master Setup Example



3.3.1.5 Integrated Rail Robot Setup Example

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

Figure 3-11 Integral Rail Setup Screen

```
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 Left  Rail Robot     <*DETAIL*>
   12 Right Rail Robot     <*DETAIL*>

[ TYPE]
```

3.3.1.6 Top Loader Rail Robot R-2000iB/200T Setup Example

This is a setup example for a toploader robot.

Figure 3-12 Toploader Setup Screen

```
Rail Robot Setup
                                       1/12
   1  Robot Number:  1 [R-2000iB/200T    ]
   2  Robot Name:          Robot-C
   3  Enable/Disable       ENABLED
   4  Robot Grp Num        1
   5  Active Zone Num      1
   6  Rail Type            Toploader
   7  Rail Axis Group      1
   8  Rail Axis Number     1
   9  Rail Master Position 0
   10 Rail Axis Direction  +Y
   11 Left  Rail Robot     <*DETAIL>
   12 Right Rail Robot     <*DETAIL>

[ TYPE]
```

3.3.1.7 Independent Rail Axis Group Setup

Independent rail axis can be installed to robot group or to a separate motion group. The two examples below show how to setup independent rail axis.

- Example 1. 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. You will see a screen similar to the following. Set each item as shown below.

Figure 3-13 Independent Rail Robot Group Setup Screen

```
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 Left  Rail Robot     <*DETAIL>
   12 Right Rail Robot     <*DETAIL>

[ TYPE]
```

Since the independent rail axis 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. You will see a screen similar to the following. Set each item as shown below.

Figure 3-14 Independent Rail Group Setup Screen

```
Rail Robot Setup
                                1/12
   1  Robot Number:  2 [POSITION       ]
   2  Robot Name:          POSITION
   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 Left  Rail Robot     <*DETAIL*>
   12 Right Rail Robot     <*DETAIL*>

[ TYPE]
```

- Example 2. 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. You will see a screen similar to the following. Set each item as shown below.

Figure 3-15 Independent Rail/Robot Group Setup Screen

```
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      1
   8  Rail Axis Number     7
   9  Rail Master Position 0
   10 Rail Axis Direction  +Y
   11 Left  Rail Robot     <*DETAIL>
   12 Right Rail Robot     <*DETAIL>

[ TYPE]
```

- Example 3. This is a special configuration that rail robot axis is ± 90^o or ±180^o different from the rail axis direction. You can set $ic_rz_stat[rob_grp].$param_i[3] to specify robot axis relative to rail axis as shown table below.

Table 3-4 Special Rail Configurations

$param_i[3]	Robot dir	X-Rail	Robot dir	Y-Rail
0: default	X	X	Y	Y
1: 180^o rotation	-X	X	-Y	Y
2: 90^o rotation	Y	X	X	Y
3: -90^o rotation	-Y	X	-X	Y

3.3.2 Zone Setup

Move cursor to Zone setup you will see a screen similar to the following.

Figure 3-16 RailZone List Screen

```
RailZone list
                                    1/10
  1  Zone 1
  2  Zone 2
  3  Zone 3
  4  Zone 4
  5  Zone 5
  6  Zone 6
  7  Zone 7
  8  Zone 8
  9  Zone 9
  10 Zone 10

[ TYPE]    DETAIL
```

Move cursor to a selected zone, press DETAIL (F2). You will see a screen similar to the following.

Figure 3-17 RailZone Setup Screen

```
Railzone setup

                                     1/5
  1  Zone Number:    1 [Zone 1           ]
  2  L_offset [mm]                    1000
  3  R_offset [mm]                    1000
  4  L_margin [mm]                     100
  5  L_margin [mm]                     100

[ TYPE]
```

Table 3-5 Zone Item Description

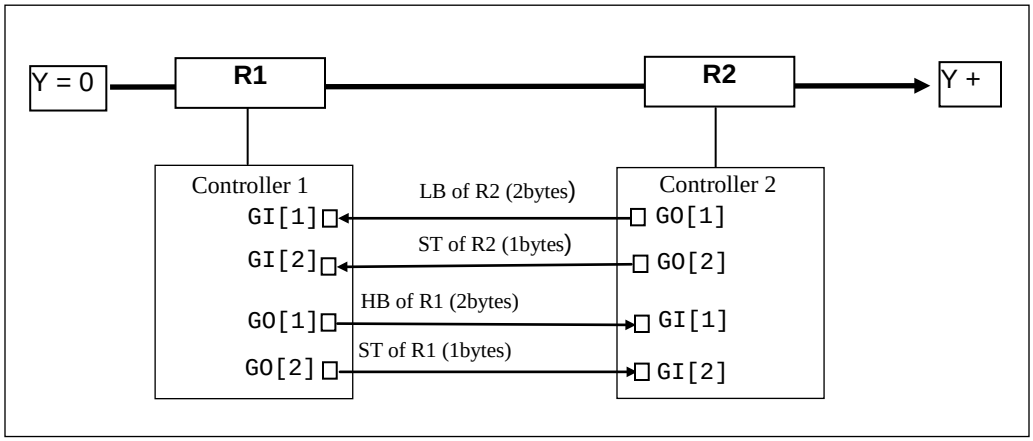
ITEM	DESCRIPTION
Zone Number	This item indicates selected zone number.
L_offset [mm]	This item defines distance from low boundary (**LB**) to rail axis position.
R_offset [mm]	This item defines distance from high boundary (**HB**) to rail axis position.
L_margin [mm]	This item defines marginal distance 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.

4 COMMUNICATION SETUP

4. COMMUNICATION SETUP

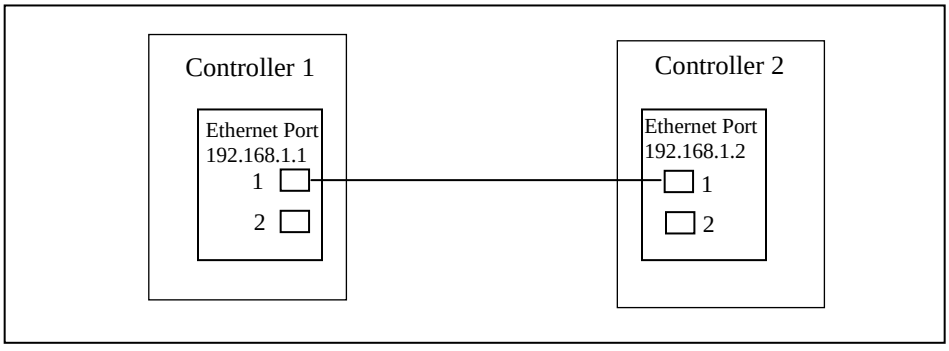
RailZone function uses Group I/O via Ethernet Global Data (EGD) to exchange RailZone information across the controllers. Each host rail robot must send 3 bytes data (boundary and status) to its right or left robot. The host robot must also receive 3 bytes data (boundary and status) from its right or left robot. The schematic below shows group I/O assignment for two rail robots, R1 and R2.

Figure 4-1 Group I/O Assignment



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. The schematic below shows the direct Ethernet connection between two controllers.

Figure 4-2 Ethernet Connection



Note Refer to the FANUC Robotics SYSTEM R-30iB Ethernet Global Data Setup and Operations Manual to correctly set up and apply EGD.

The following figures show EGD configuration for R1 and R2. **Note** It is recommended to set the producer interval value to 8-16 milliseconds so that the railzone data will be produced to its adjacent robots without causing a big delay.

Figure 4-3 R1 (192.168.1.1) EGD Configuration

```
  EGD Detail                          1/17
  EGD Producer Configuration:
          Host          Id Size   Int  Slot
    1 192.168.1.2        12   3    10    1
    2 ***********         0   0    100   2
…
  EGD Consumer Configuration:
      Id Size   Timeout  Status
    1  21   3    300         ON
    2   0   0    300        OFF
…
```

Figure 4-4 R2 (192.168.1.2) EGD Configuration

```
  EGD Detail                          1/17
  EGD Producer Configuration:
          Host          Id Size   Int  Slot
    1 192.168.1.1        21   3    10    1
    2 ***********         0   0    100   2
…
  EGD Consumer Configuration:
      Id Size   Timeout  Status
    1  12   3    300         ON
    2   0   0    300        OFF
…
```

The following figures show the Digital I/O configuration for R1 and R2

Figure 4-5 R1 (192.168.1.1) Digital Out Configuration

```
I/O Digital Out              JOINT 100 %
                                1/2
  #      RANGE    RACK  SLOT  START STAT.
  1 DO[  1-  24]    88     1      1 ACTIV
  1 DO[ 24- 512]     0     0      0 UNASG
```

Figure 4-6 R1 (192.168.1.1) Digital In Configuration

```
I/O Digital In               JOINT 100 %
                                1/2
  #      RANGE    RACK  SLOT  START STAT.
  1 DI[  1-  24]    88     1      1 ACTIV
  2 DI[ 24- 512]     0     0      0 UNASG
```

Figure 4-7 R2 (192.168.1.2) Digital Out Configuration

```
I/O Digital Out              JOINT 100 %
                                1/2
  #      RANGE    RACK  SLOT  START STAT.
  1 DO[  1-  24]    88     1      1 ACTIV
  2 DO[ 24- 512]     0     0      0 UNASG
```

Figure 4-8 R2 (192.168.1.2) Digital In Configuration

```
I/O Digital In               JOINT 100 %
                                1/2
  #      RANGE    RACK  SLOT  START STAT.
  1 DI[   1- 24]    88     1      1 ACTIV
  1 DI[ 24- 512]     0     0      0 UNASG
```

The following figures show the Group I/O configuration for R1 and R2

Figure 4-9 R1 (192.168.1.1) Group Out Configuration

```
I/O Group Out
                                   1/100
  GO #   RACK   SLOT  START  NUM_PTS
   1      88      1      1     16
   2      88     1      17     8
```

Figure 4-10 R1 (192.168.1.1) Group In Configuration

```
I/O Group In
                                   1/100
  GI #   RACK   SLOT  START  NUM_PTS
   1      88      1      1     16
   2      88      1      17     8
```

Figure 4-11 R2 (192.168.1.2) Group Out Configuration

```
I/O Group Out
                                   1/100
  GO #   RACK   SLOT  START  NUM_PTS
   1      88      1      1     16
   2      88      1      17     8
```

Figure 4-12 R2 (192.168.1.2) Group In Configuration

```
I/O Group In
                                   1/100
  GI #   RACK   SLOT  START  NUM_PTS
   1      88      1      1     16
   2      88     1      17     8
```

5 RAILZONE STATUS DISPLAY

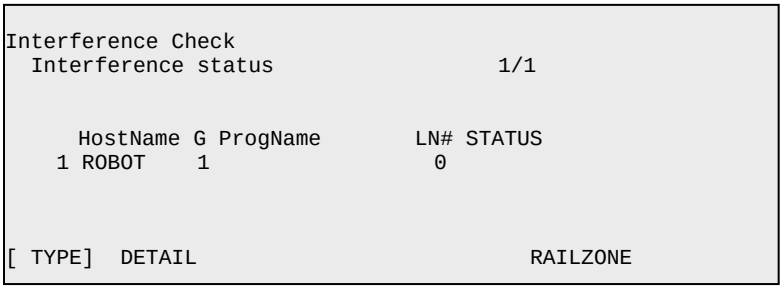
5. RAILZONE STATUS DISPLAY

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

1. Press MENU.
2. Select STATUS.
3. Press F1, [TYPE].
4. Select Interference. You will see a screen similar to the following.

Note The RAILZONE function key will not be shown if $IC_RZ_CFG.$ENABLE is set to FALSE.

Figure 5-1 Interference Status Screen



5. Press RAILZONE (F5). You will see a screen similar to the following.

Figure 5-2 RailZone Status Screen

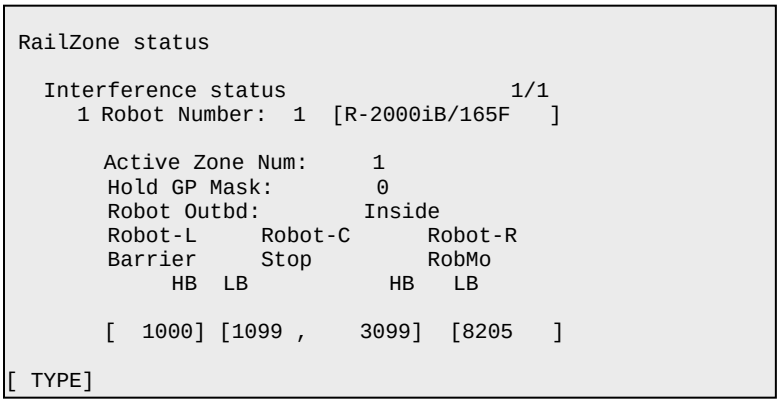


Table 5-1 Status Item Description

Display item	Description
Robot Number	This is the only selectable item in status display screen. You can select a valid host 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.
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. NONE: robot/tool model is disabled and robot posture does not affect RailZone boundaries.
Robot Name line	This line displays names of host robot and its adjacent robot on left and right.
Status line	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. WaitL: wait for left robot or reach to lower limit barrier. WaitR: wait for right robot or reach to upper limit barrier. RobMo: only robot axes move. NONE: RailZone is not defined or not enabled. ERROR: Rail robot is in error condition. Barrier: A dummy robot set for rail barrier.
Boundary Name line	This line specifies boundary names of host robot and its left and right robot.
Boundary value line	This line 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 RAIL ROBOT MAINTENANCE OPERATION

6. RAIL ROBOT MAINTENANCE OPERATION

When one rail robot is parked and powered off for maintenance, it is desired that the neighboring rail robots can continue their normal operation and the RailZone can perform its normal function to protect the collision between rail robots. However, in the default EGD configuration, once the service robot is powered off, its neighboring robots will receive "PRIO-225 EGD Consumer timeout" alarm. This is a STOP alarm by default. In order for these robots to be able to continue their normal operation, you must follow the steps in the table below. The second column lists the actions for the maintenance robot and the last column lists the actions for the rail robots that are next to the maintenance robot.

Table 6-1 Rail Robot Maintenance Procedures

Step	**Maintenance Rail Robot**	**Neighboring Rail Robots**
1		Stop normal operation
2	Jog robot to safe service zone and remain power on.	
3		▪ Set $EGD_CFG.$ERR_SV = 1. This will change the error severity level of EGD consumer timeout alarm to warn level. ▪ Set $EGD_CFG.$KEEP_IO = 1. This will allow the robot to keep the last state values of the inputs from the robot to be serviced. ▪ Re-power the robot. ▪ Wait power on to be completed.
4	Power off the robot	Make sure that the zone boundary for the service robot is unchanged. If desired, user can also setup rail barrier temporally during the service time to reserve a larger zone space for the maintenance robot.
5	Maintenance service	Start normal operation.
6	Service is complete & power on robot	Stop normal operation.
7		▪ Set $EGD_CFG.$ERR_SV = 0. This will change the error severity of EGD consumer timeout alarm to STOP level. ▪ Set $EGD_CFG.$KEEP_IO = 0. The last state values of the inputs will be zero. ▪ Remove any temporal rail barrier setup. ▪ Re-power the robot.
8	Start normal operation	Start normal operation.

⚠ WARNING

You must restore the EGD timeout alarm to STOP level after the maintenance service is complete. Failure to re-enable EGD in the product state could result in a robot to robot collision, resulting in damage or injury.

7 RAIL ZONE WITH 4D GRAPHICS

7. RAIL ZONE WITH 4D GRAPHICS

In V8.10, the rail zone software can display 4D graphics if the 4D graphics option is loaded and a graphic teach pendant is attached to the controller.

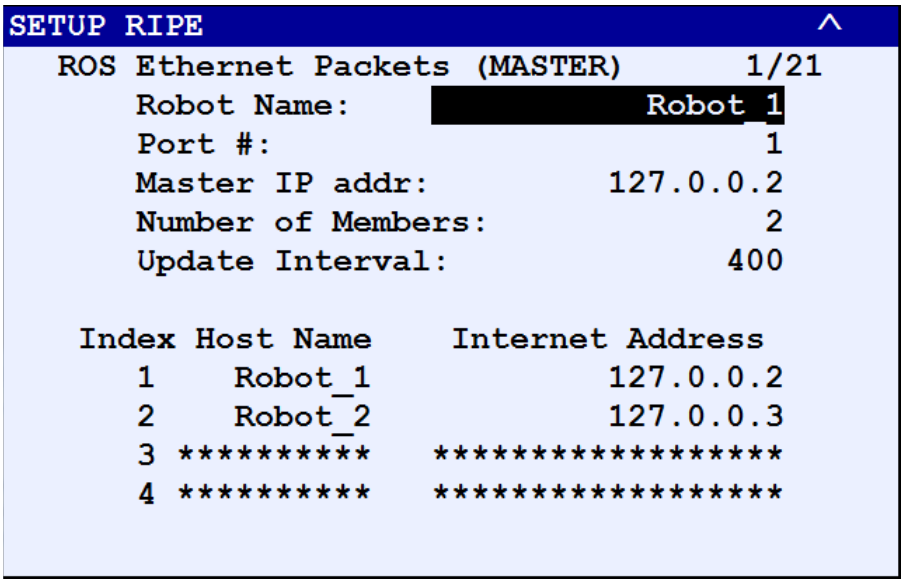
In this section, we assume that the necessary rail zone setup has been done. We will use an example of two controllers , with each controller has one R-2000iB 165R robot with integrated rail, to illustrate the extra steps that are required to display both robots correctly in the teach pendant. The following steps are required:

1. Set up the RIPE so 4D graphics can be displayed across controllers.
2. Set up the IIC Calibration so the 2nd controller (slave) is part of the IIC cell.
3. Set up the Cell Frame for 1st controller (master).
4. Setup the Cell Frame for 2nd controller (slave). If the group mask bit is enabled for the $iic_cfg.$update_cfrm and $iic_cfg.$ ovrwrt_cfrm, the cell frame is updated automatically via IIC calibration.
5. Set up Rail Master Position for each rail robot based on Cell Frame component in rail direction.
6. Display rail zones under 4D graphics menu.

7.1 RIPE Setup For Multiple Controllers

To setup the RIPE, go to the Setup/Host Comm menu. A simple RIPE setup is display as follows:

Figure 7-1 Ripe Setup



7.2 IIC Calibration Setup

To include the 2nd controller into the IIC cell, it is required to set up IIC calibration menu by going to the IIC menu and select the Calibration between robot then press Enter key:

Figure 7-2 Calibration Robots

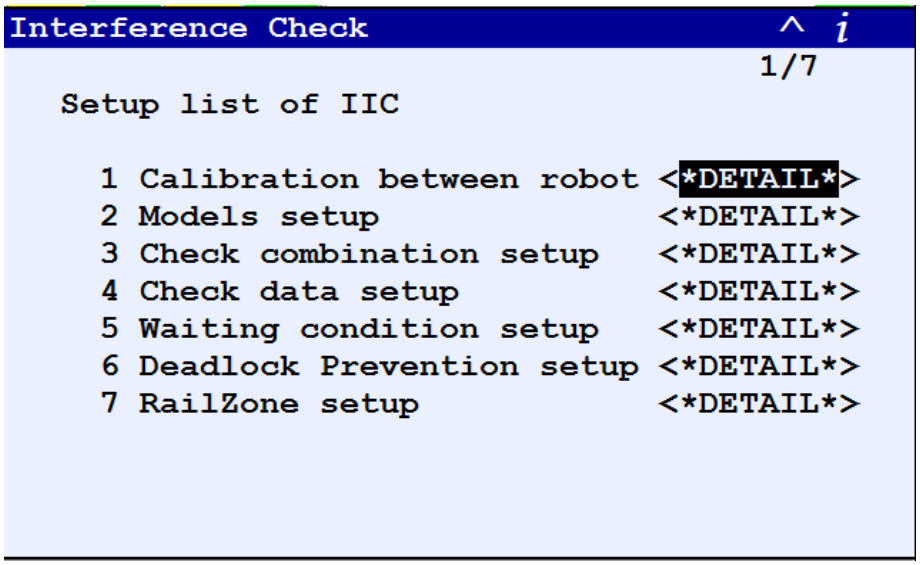
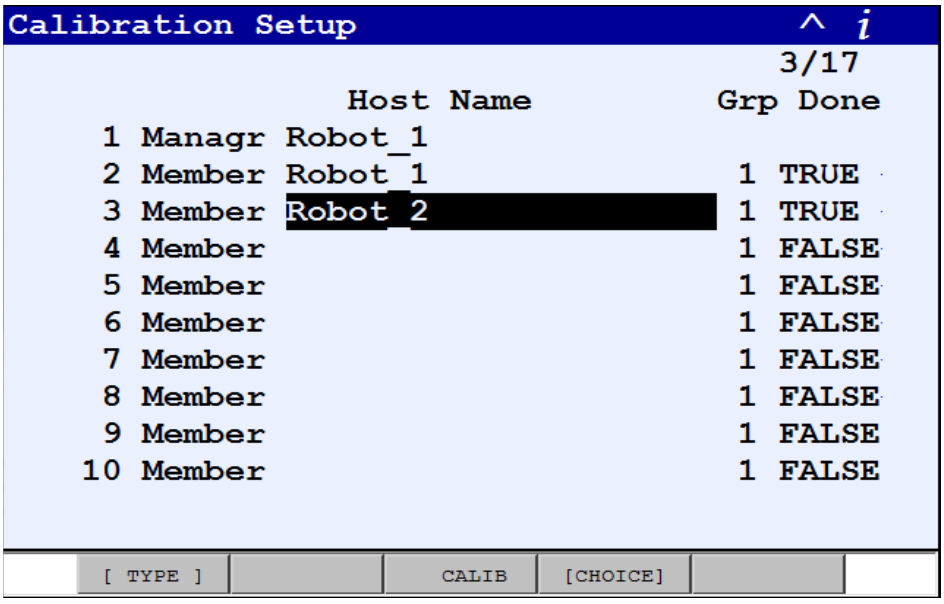


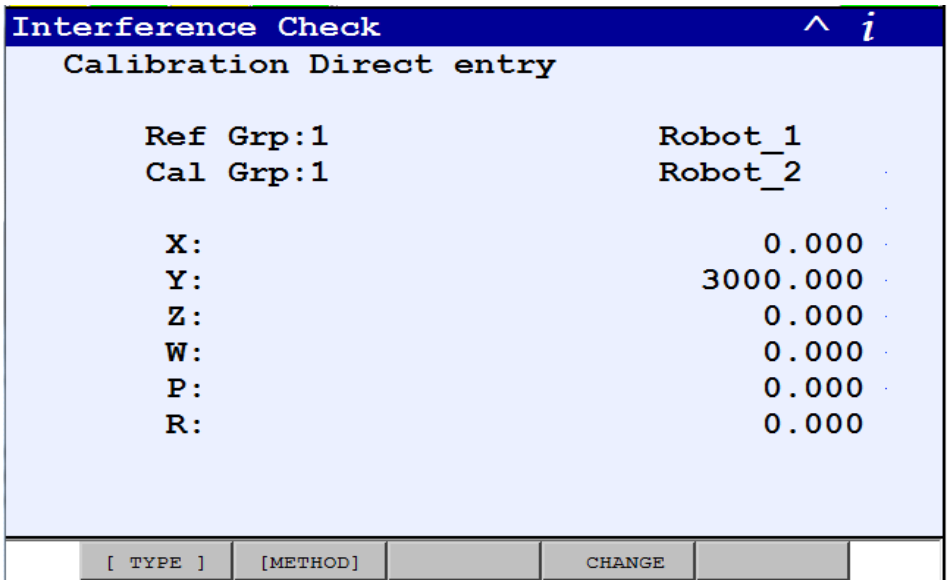
Figure 7-3 Calibration Setup



Since Rotob_1 is the master robot, there is no need to calibrate it. So select the Robot_2 and press the F3, CALIB, to enter the calibration data. Since the rail is Y rail and robot 2's origin is 3000 mm from the

Robot_1, enter the Y offset of 3000 and press F4, CHANGE, then press F4, DONE, again to make the change permanent.

Figure 7-4 Calibration Data Entry

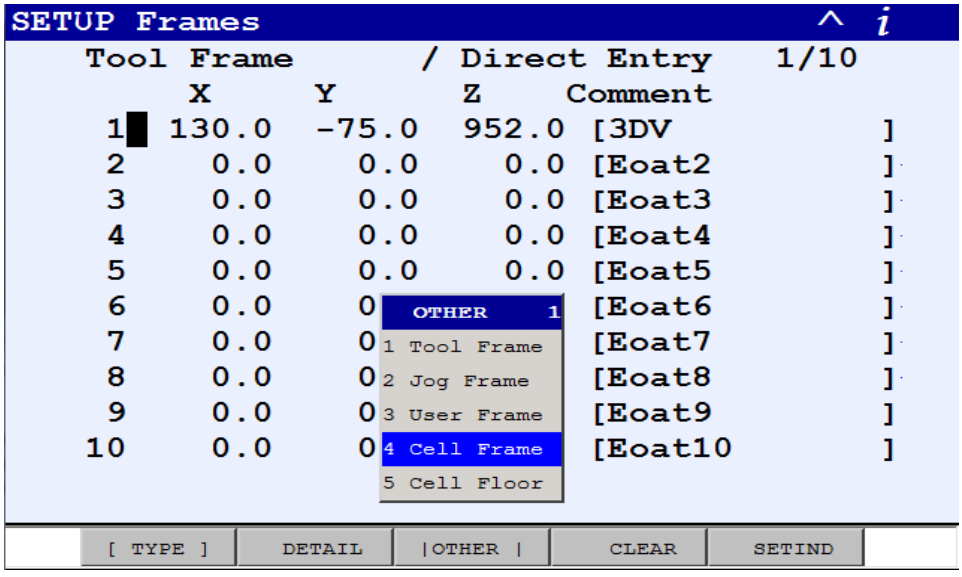


7.3 Cell Frame Setup

4D graphic has the concept of a cell frame and all geometrical elements (including robots) are draw with respect to the origin of the cell frame. Therefore, to display the robot correctly, you need to set up the cell frame for each robot. However, the cell frame setup for each rail robot must agree with the rail master position setup such that each rail robot master location is also relative to rail zero location.

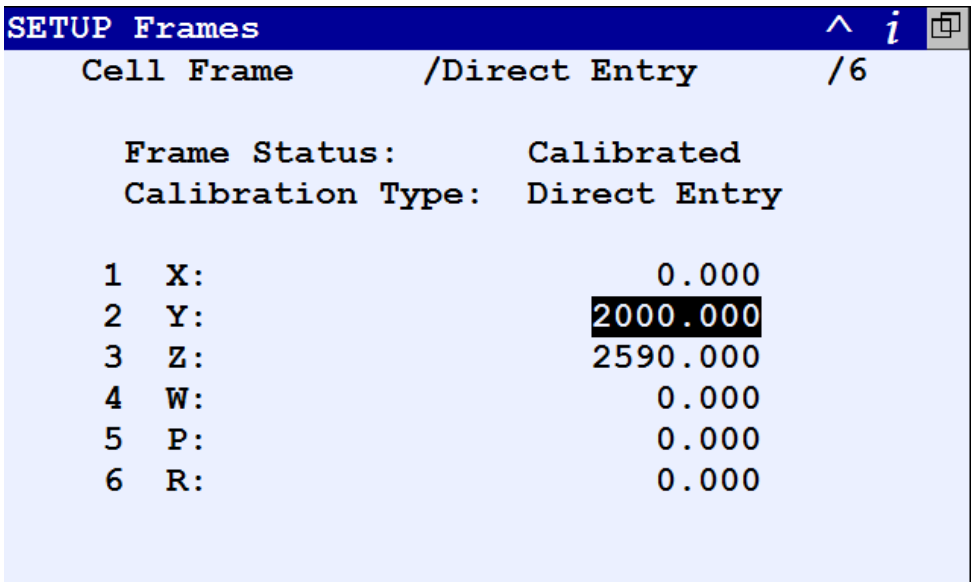
To setup the cell frame, go to the SETUP/Frame menu and press F3, Others, to select the Cell Frame:

Figure 7-5 Cell Frame Setup



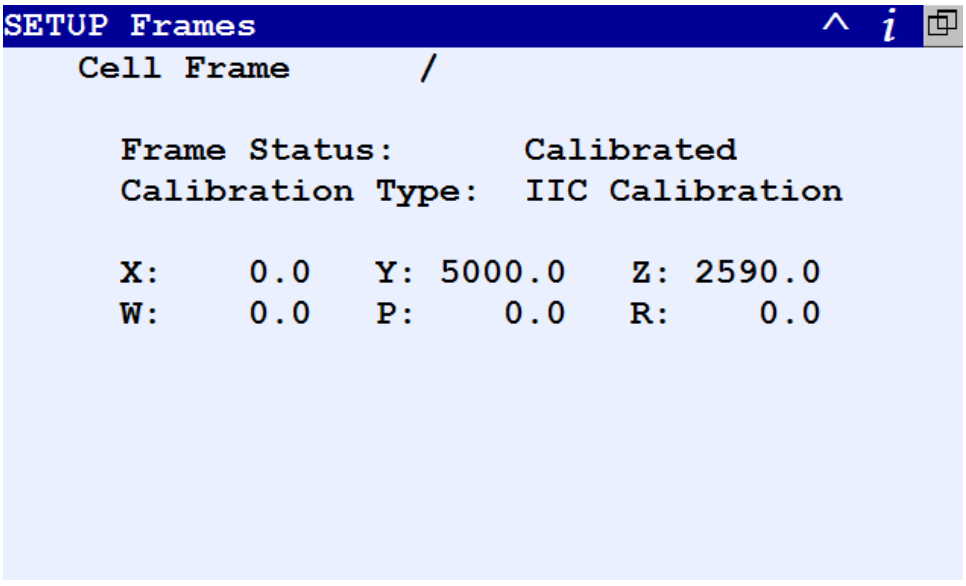
Since the robot is on top of a rail, the Robot_1 has a Z offset of 2590. Also, the 1st robot is mastered at 2000 mm from the rail zero in Y direction, so the Y offset is 2000. ***Note that the offset value in Y (rail direction) must be the same as the Rail Master Position in the rail zone setup menu.***

Figure 7-6 Cell Frame Data Entry for Robot_1



For the Robot_2 on the 2nd controller, its cell frame is defined as

Figure 7-7 Cell Frame Data Entry for Robot_2

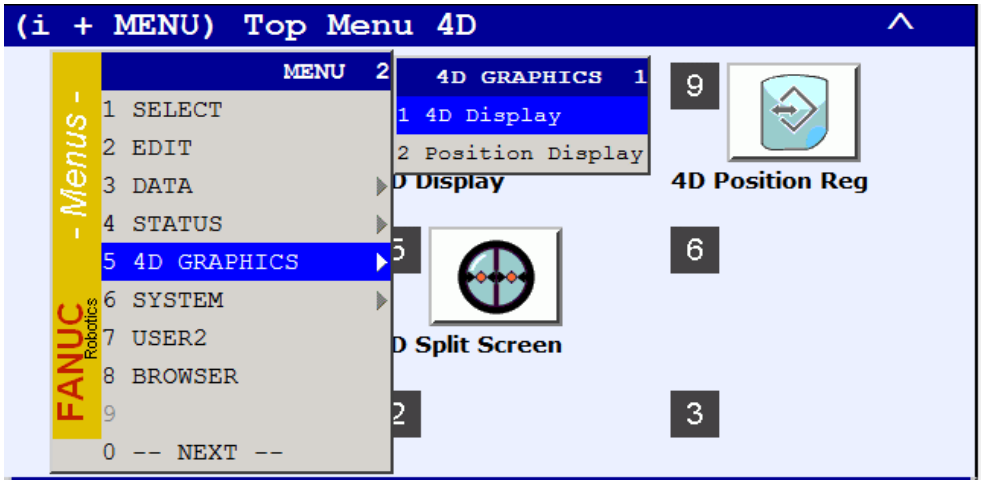


The origin of Robot_2 is 3000 mm off from the Robot_1 as defined in the IIC Calibration menu. Since the Robot_1 has 2000 mm offset in Y and 2590 mm offset in Z relative to Cell Frame Origin, the Cell Frame for robot_2 has 5000 mm offset in Y and 2590 offset in Z relative to the Cell Frame Origin. ***Note that the offset value in Y (rail direction) must be the same as the Rail Master Position in the rail zone setup menu.***

7.4 4D IIC Rail Zone Graphics Display

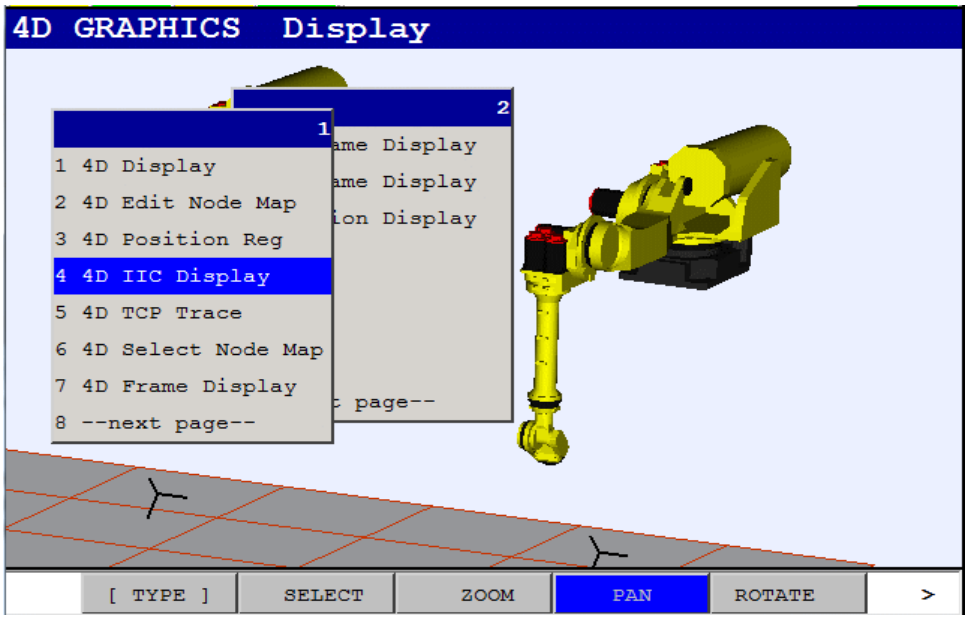
To see the 4D graphical display of the rail zone, go to the new page of the main menu and select the 4D graphics

Figure 7-8 4D Graphics Display



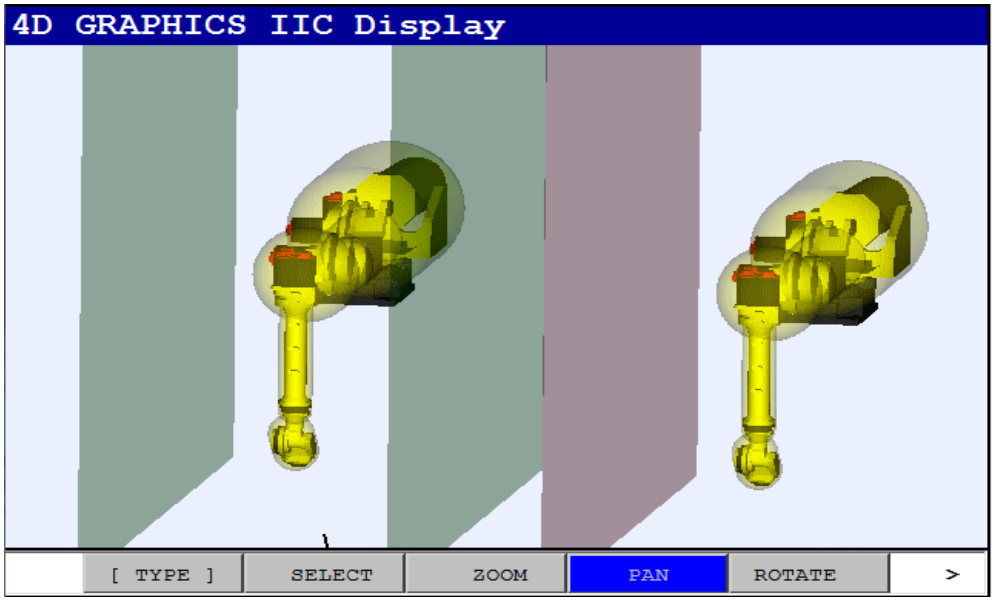
Press Enter on the 4D display brings up the 4D graphics, then press F1, TYPE to select the 4D IIC Display:

Figure 7-9 4D IIC Graphic Display



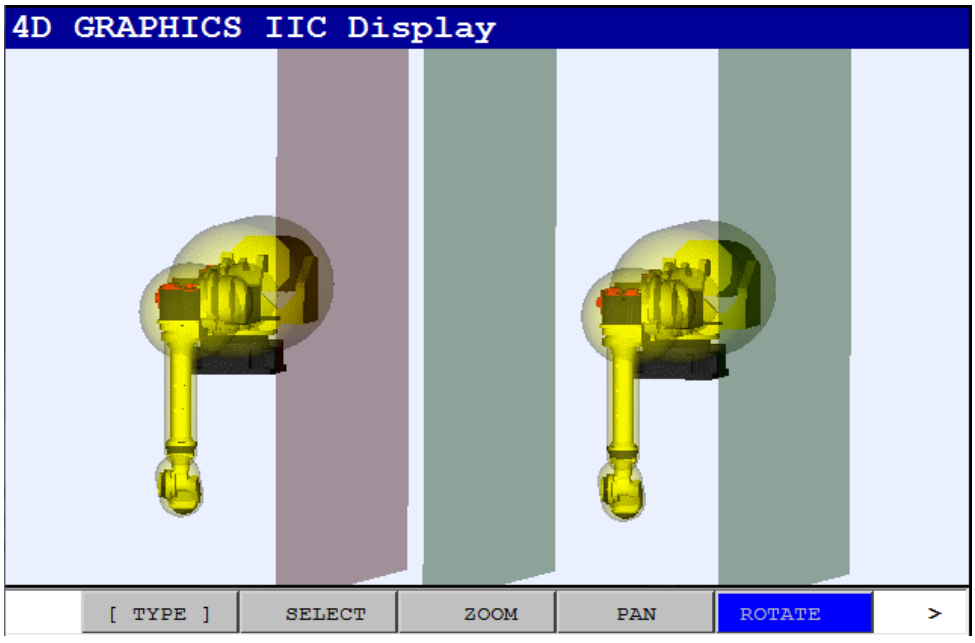
The 2 green planes that surround the Robot_1 is the left and right bound of Robot_1. The red plane is the left bound from Robot_2. The left and right boundary moves with the Robot_1, but the right plane does not move unless Robot_2 moves.

Figure 7-10 4D Graphics RailZone Display on Robot_1



If you look at the teach pendant of Robot_2 controller, it shows a similar display, but the red plane is denoted by the Robot_1's right bound.

Figure 7-11 4D Graphics RailZone Display on Robot_2



8 ALARMS

8. ALARMS

Table 8-1 Alarm Description

Alarm	Severity	Description
ICRZ-001 Wait for right robot	Warning	Host robot is being held and waits for the right robot to clear the RailZone.
ICRZ-002 Wait for left robot	Warning	Host robot is being held and waits for the left robot to clear the RailZone.
ICRZ-003 Unhold robot	Warning	Host robot is being un-held after toggling the mode switch
ICRZ-004 Right robot zone cleared	Warning	Host robot is being un-held when right robot zone is cleared.
ICRZ-005 Left robot zone cleared	Warning	Host robot is being un-held when left robot zone is cleared.
ICRZ-006 Deadlock condition	Warning	Two neighbor robots are moving towards each other to cause interference.
ICRZ-007 Zone disabled while robot held	Abort	Zone check is disabled when robot is being held.
ICRZ-008 GOUT is not set for right robot	Abort	GOUT is not set properly for right robot. The host rail robot can't send data to right robot.
ICRZ-009 GOUT is not set for left robot	Abort	GOUT is not set properly for left robot. The host rail robot can't send data to left robot.
ICRZ-010 GIN is not set for right robot	Abort	GIN is not set properly for right robot. The host rail robot can't receive data from right robot.
ICRZ-011 GIN is not set for left robot	Abort	GIN is not set properly for left robot. The host rail robot can't receive data from left robot.
ICRZ-012 Right Robot Not Defined	Warning	Host checks right robot but right robot is not defined.
ICRZ-013 Left Robot Not Defined	Warning	Host checks left robot but left robot is not defined.
ICRZ-014 Upper Barrier Limit	Warning	Reach upper rail barrier limit.
ICRZ-015 Lower Barrier Limit	Warning	Reach lower rail barrier limit.

9 SYSTEM VARIABLES

9. SYSTEM VARIABLES

9.1 $ic_rz_cfg

The table below gives a detailed description for each element under this data structure.

Table 9-1 $ic_rz_cfg

Variable name	Description
$enable	TRUE: enable RailZone function for this controller. FALSE: disable RailZone function for this controller.
$comp_sw	Internal use.
$debug	Internal use.
$full_menu	TRUE: Full IIC setup menu. FALSE: Short setup menu. Only for RailZone application.

9.2 $ic_rz_robot[grp_no]

The $ic_rz_robot is group based data structure for rail robot setup. The table below provides a detailed description for each element under this data structure.

Table 9-2 $ic_rz_robot[grp_no]

Variable name	Description
$rob_name	Robot name
$enable	TRUE: enable RailZone for this group. FALSE: disable RailZone for this group.
$zone_num	Zone number.
$rail_type	1: Integral rail 2: Independent rail 3: Toploader
$rail_dir	Plus rail move direction relative to rail robot world coordinate. 1: x 2: y 3: z
$rail_grp	Rail robot group number.
$rail_axis	Rail axis number.
$rail_mst	Rail axis zero master position relative to a common rail reference location.
$l_rob_chk	True: check left robot or lower barrier, False: no check.
$r_rob_chk	True: check right robot or upper barrier, False: no check.
$l_rob_name	Left rail robot name.

Table 9-2 $ic_rz_robot[grp_no]

$r_rob_name	Right rail robot name.
$go_st_left	Index for GO to send status to left robot.
$go_st_righ	Index for GO to send status to right robot.
$gi_st_left	Index for GIN to receive status from left robot.
$gi_st_righ	Index for GIN to receive status from right robot.
$go_lb_left	Index for GO to send low boundary to left robot.
$go_hb_righ	Index for GO to send high boundary to right robot.
$gi_hb_left	Index for GIN to receive high boundary from left robot.
$gi_lb_righ	Index for GIN to receive low boundary from right robot.

9.3 $ic_rz_stat[grp_no]

The $ic_rz_stat is group based data structure for rail robot status. The table below gives a detailed description for each element under this data structure.

Table 9-3 $ic_rz_stat[grp_no]

Variable name	Description
$zone_number	Active zone number.
$st_this_rob	Status for host robot. The value represents the status of host robot as 1: Stop: robot or rail motion group stops. 2: MoveR: move to right direction alone rail. 3: MoveL: move to left direction alone rail. 4: WaitL: wait for left robot or reach to lower limit barrier. 5: WaitR: wait for right robot or reach to upper limit barrier. 6: RobMo: only robot axes move. 7: NONE: RailZone is not defined or not enabled. 8: Error: Rail robot is in error condition 9: Barrier: A dummy robot set for rail barrier.
$st_left_rob	Status for left robot. The value represents the status of left robot as 1: Stop: robot or rail motion group stops. 2: MoveR: move to right direction alone rail. 3: MoveL: move to left direction alone rail. 4: WaitL: wait for left robot or reach to lower limit barrier. 5: WaitR: wait for right robot or reach to upper limit barrier. 6: RobMo: only robot axes move. 7: NONE: RailZone is not defined or not enabled. 8: Error: Rail robot is in error condition 9: Barrier: A dummy robot set for rail barrier.
$st_righ_rob	Status for right robot. The value represents the status of right robot as 1: Stop: robot or rail motion group stops.

Table 9-3 $ic_rz_stat[grp_no]

	2: MoveR: move to right direction alone rail. 3: MoveL: move to left direction alone rail. 4: WaitL: wait for left robot or reach to lower limit barrier. 5: WaitR: wait for right robot or reach to upper limit barrier. 6: RobMo: only robot axes move. 7: NONE: RailZone is not defined or not enabled. 8: Error: Rail robot is in error condition 9: Barrier: A dummy robot set for rail barrier.
$hb_left_rob	High boundary of the left robot.
$lb_this_rob	Low boundary of the host robot.
$hb_this_rob	High boundary of the host robot.
$lb_righ_rob	Low boundary of right robot.
$hold_gp_msk	Hold group mask bits.
$hold_status	0: no hold, 1: hold for left robot, 2: hold for right robot, 3: request hold for left robot, 4: request hold for right robot.
$hold_dist	Hold distance for the last hold event.
$cmd_rail_ps	Commanded rail position.
$act_rail_ps	Actual rail position.
$robot_outbd	Current robot and tooling envelope relative to minimum RailZone 1: robot is inside of minimum RailZone, 2: robot is outside of low boundary of minimum RailZone 3: robot is outside of high boundary of minimum RailZone 4: robot model is not defined.
$cmd_box	The max and min x, y, z of the bounding box for robot and tool envelope based on the commanded joint positions.
$act_box	The max and min x, y, z of bounding box for robot and tool envelope based on the actual joint positions.
$param_i[3]	This item is only used for special configuration for independent rail axis. Refer to Table 3-4 for detail setup.

9.4 $ic_rz_zone[zone_no]

The $ic_rz_zone is zone based data structure for zone setup. The table below gives a detailed description for each element under this data structure.

Table 9-4 $ic_rz_zone[zone_no]

Variable name	Description
$comments	Comments for selected zone.
$ofs1	Offset value added to rail position to form high boundary of RailZone.
$ofs2	Offset value subtract to rail position to form low boundary of RailZone.
$mrg1	Margin distance to hold rail robot when IC distance to right robot or upper barrier is less than the margin distance value.
$mrg2	Margin distance to hold rail robot when IC distance to left robot or lower barrier is less than the margin distance value.