FANUC Robot series

R-30*i*B/ R-30*i*B Mate CONTROLLER
Dual Check Safety Function

OPERATOR'S MANUAL

MAROBDLCH04121E REV F

Applies to Version 8.10 and later

FANUC America Corporation
3900 W. Hamlin Road
Rochester Hills, Michigan 48309–3253

B-83184EN/06

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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

FANUC America Corporation
Training Department
3900 W. Hamlin Road
Rochester Hills, Michigan 48309-3253
www.fanucamerica.com

For customer assistance, including Technical Support, Service, Parts & Part Repair, and Marketing Requests, contact the Customer Resource Center, 24 hours a day, at 1-800-47-ROBOT (1-800-477-6268). International customers should call 011-1-248-377-7159.

Send your comments and suggestions about this manual to:
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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.

- **Original Instructions**

Thank you very much for purchasing FANUC Robot.
Before using the Robot, be sure to read the "FANUC Robot SAFETY HANDBOOK (B-80687EN)" and understand the content.

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.

SAFETY PRECAUTIONS

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

Before using the functions related to robot operation, read the relevant operator's manual to become familiar with those functions.

For the safety of the operator and the system, follow all safety precautions when operating a robot and its peripheral devices installed in a work cell.
In addition, refer to the "FANUC Robot SAFETY HANDBOOK (**B-80687EN**)".

1 DEFINITON OF USER

The user can be classified as follows.

Operator:
- Turns the robot controller power ON/OFF
- Starts the robot program with 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
- Maintenance (repair, adjustment, replacement)

- "An operator" ***cannot*** work inside the safety fence
- "Programmer", "Teaching operator", and "Maintenance engineer" ***can*** work inside the safety fence. The working activities inside the safety fence include lifting, setting, teaching, adjusting, maintenance, etc.
- To work inside the safety fence, the person must be trained on proper robot operation.

During the operation, programming, and maintenance of your robotic system, programmer, teaching operator and maintenance engineer must operate with circumspection by using following safety precautions.

- 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 or "**WARNING**" or "**CAUTION**" according to its severity. Supplementary information is indicated by "**NOTE**". Please read each "**WARNING**", "**CAUTION**" and "**NOTE**" before using the robots.

Symbol	Definitions
⚠**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 USER SAFETY

User safety is the primary safety consideration. As it is very dangerous to enter the operating-area of the robot during its 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) We obligate the User to take a FANUC training courses.

FANUC provides various training courses. Contact your local FANUC representative 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 safety fence inside 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 safety fence 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, refer to below **Fig.3 (b).**

(4) Provide the peripheral devices with appropriate grounding (Class A, Class B, Class C, and Class D).
(5) Recommend to install the peripheral device outside of the operating space.
(6) Draw an outline on the floor, clearly indicating the range of the robot motion, 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 operating space.
(8) If necessary, install a safety lock so that no one except the user in charge can turn the power on 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 device independently, make sure to turn the power off the robot.
(10) Operators must take the gloves off while manipulating the operator's panel or teach pendant. Operation with gloved fingers may 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.
(12) The robot must be transported and installed by accurate procedure 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 in the area of 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) Do not operate the robot under the following conditions. Otherwise, the robot and peripheral equipment can be adversely affected, or workers can be severely injured.
- Flammable
- Explosive
- Massive dose of Radiation
- Under water, high (heavy) Humidity
- Transport human or animals
- Stepladder (climb or hang down)
- Outdoor

(16) When connecting the peripheral devices 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) In preparing the trestle, please secure the maintenance engineer safety at high place in reference to Fig. 3 (c). Design with the Scaffolding and Safety-belt with circumspection.

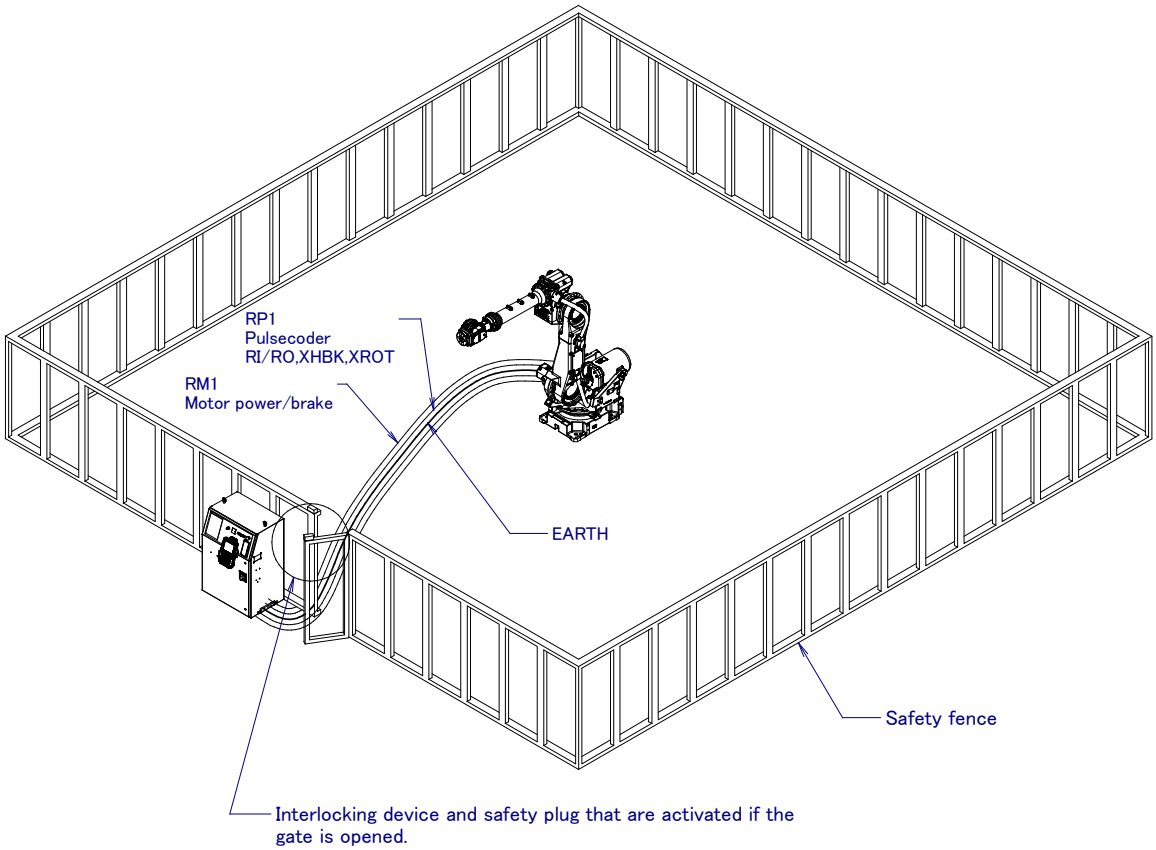

Fig. 3 (a) Safety fence and safety gate

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

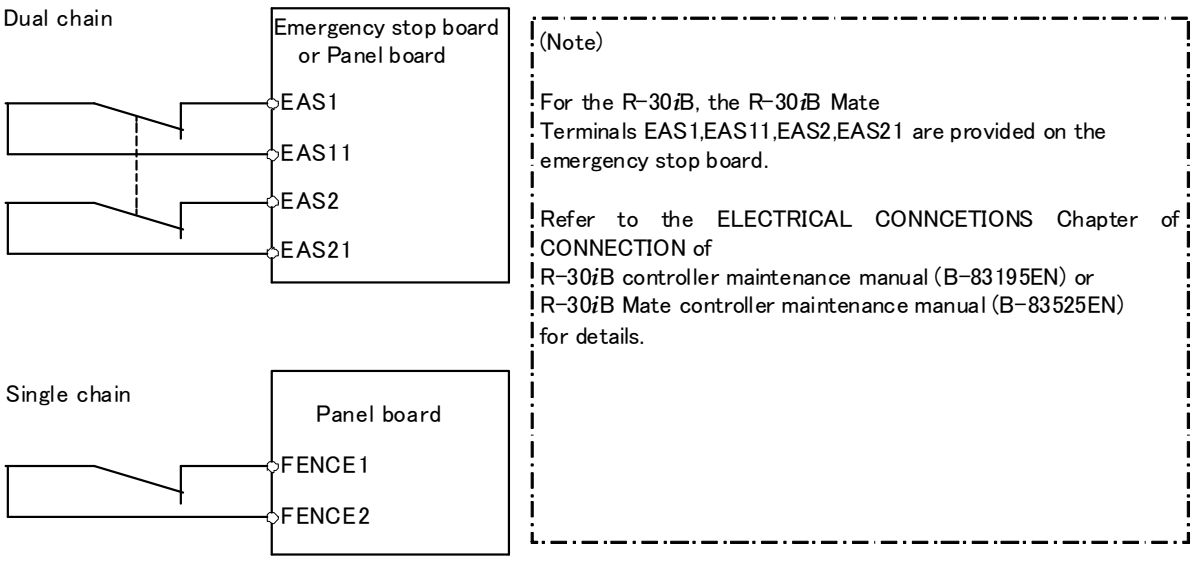

Fig. 3 (b) Connection diagram for the signal of safety fence

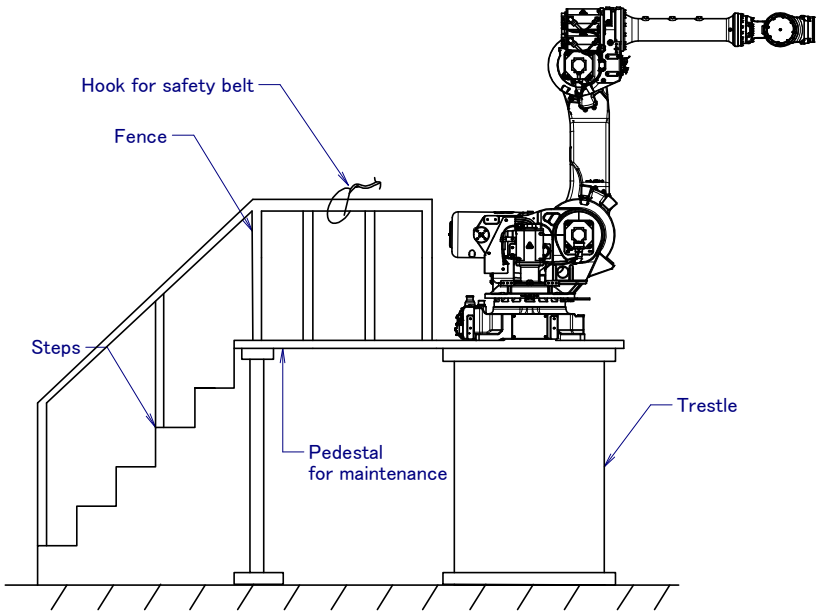

Fig. 3 (c) Pedestal for maintenance

3.1 SAFETY OF THE OPERATOR

The operator is a person who operates the robot system. In this sense, a worker who operates the teach pendant is also an operator. Operator cannot work inside the safety fence.

(1) If you don't need to operate the robot, turn the power off the robot controller, or press the "EMERGENCY STOP" button, and then proceed your work.
(2) Operate the robot system outside of the robot operating space.
(3) Install a safety fence with a safety gate to prevent any worker other than the operator from entering the dangerous area unexpectedly and the worker from entering a hazardous area.
(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.

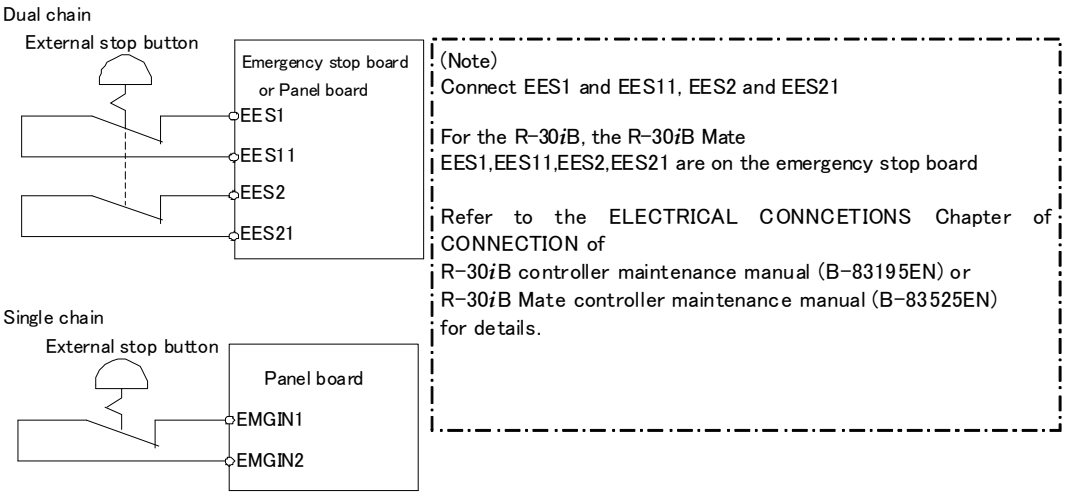

Fig. 3.1 Connection diagram for external emergency stop button

3.2 SAFETY OF THE PROGRAMMER

While teaching the robot, the operator must enter the operating space of the robot. Please ensure the safety of programmer.

(1) Unless it is specifically necessary to enter the robot operating space, carry out all tasks outside the area.
(2) Before teaching the robot, check that the robot and its peripheral devices are all in the normal 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 must be done outside of the safety fence as far as possible. If programming needs to be done in the area of the safety fence, the programmer must take the following precautions:
   − Before entering the safety fence area, ensure that there is no risk of hazardous situation in the area.
   − Be ready to press the emergency stop button whenever it is necessary.
   − Operate the Robot at low speed.
   − Before starting programming, check the entire system status to ensure that no remote instruction to the peripheral equipment or motion would harm user .

Our operator panel is provided with an emergency stop button and a key switch (mode switch) for selecting the automatic operation mode (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 mode 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.

Teach pendant is provided with a switch to enable/disable robot operation from teach pendant and DEADMAN switch as well as 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 are different depending on the teach pendant enable/disable switch setting status.
   (a) Enable: Servo power is turned off and robot stops 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 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 switch should not exceed about 10000 times per year.

The teach pendant, operator panel, and peripheral device 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 device
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's panel, make certain that nobody is in the robot operating space and that there are no abnormal conditions in the robot operating space.
(7) When a program is completed, be sure to carry out the 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 the continuous operation mode at low speed.
  (c) Run the program for one operation cycle in the continuous operation mode 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 the continuous operation mode 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 mode.
(8) While operating the system in the automatic operation mode, the teach pendant operator must 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) Must never be in the area during its operation.
(2) A hazardous situation may occur 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 must 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.
(3) If it becomes necessary to enter the robot operation area while the power is on, press the emergency stop button on the operator panel, or the teach pendant before entering the area. The maintenance personnel 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 maintenance engineer must check the entire system in order to make sure that there is no dangerous situation around. In case the worker needs to enter the safety area whilst a dangerous situation exists, extreme care must be taken, and entire 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, check the robot and its peripheral devices are all in the normal condition.
(7) Do not operate the robot in the automatic mode while anybody is in the robot operating space.
(8) In maintaining the robot parallel to a wall or instrument, or when multiple workers are working nearby, make certain that their escape path is not obstructed.
(9) When a tool is mounted on the robot, or any moving device other than the robot is installed, such as belt conveyor, careful attention required for those motion.
(10) Assign an expert near the operator panel who can press the EMERGENCY STOP button whenever he sees the potential danger.
(11) In case of replacing a part, please contact your local FANUC representative. Wrong procedure may cause the serious damage to the robot and the worker.
(12) Make sure that no impurity into the system in while (in) replacing or reinstalling components.
(13) Turn off the circuit breaker to protect again electric shock in handling each unit or printed circuit board in the controller during inspection. 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 not only a damage to the internal parts of the controller but also 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 devices are not abnormal.
(16) In case of remove the motor or brake, suspend the arm by crane or other equipment beforehand to avoid falling.
(17) Whenever grease is spilled on the floor, remove them as soon as possible to prevent from falling.
(18) The following parts are heated. If a maintenance engineer needs to touch such a part in the heated state, the worker should wear heat-resistant gloves or use other protective tools.
- Servo motor
- Inside of the controller
- Reducer
- Gearbox
- Wrist unit

(19) Maintenance must be done with appropriate lightning. Be careful that those lightning will not cause any further danger.
(20) When a motor, reducer, or other heavy load is handled, a crane or other equipment should be used to protect maintenance engineers from excessive load. Otherwise, the maintenance engineers would be severely injured.
(21) Must never climb or step on the robot even in the maintenance. If it is attempted, the robot would be adversely affected. In addition, a misstep can cause injury to the worker.
(22) Secure a pedestal and wear the safety belt in performing the maintenance work in high place.
(23) Remove all the spilled oil or water and metal chips around the robot in the safety fence after completing the maintenance.
(24) All the related bolts and components must return to the original place in replacing the parts. If some parts are missing or left (remained), repeat the replacement work until complete the installation.
(25) In case robot motion is required during maintenance, the following precautions should be taken :
- Secure an escape route. And during the maintenance motion itself, monitor continuously the whole system so that your escape route will not become blocked by the robot, or by peripheral equipment.
- Keep vigilant attention for the potential danger. and to press the emergency stop button whenever it is necessary.

(26) Periodic inspection required. (Refer to the robot mechanical manual and controller maintenance manual.) A failure to do the periodical inspection can may adversely affect the performance or service life of the robot and may cause an accident
(27) After replacing some parts, a test run required by the predetermined method. (See TESTING section of "Controller operator's manual". During the test run, the maintenance staff must work outside the safety fence.

4 SAFETY OF THE TOOLS AND PERIPHERAL DEVICES

4.1 PRECAUTIONS IN PROGRAMMING

(1) Adopt a limit switch or other sensor to detect a dangerous state 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 abnormal condition occurs in any other robots or peripheral devices, even though the robot itself is normal.
(3) For a system in which the robot and its peripheral devices are in synchronous motion, particular care must be taken in programming in order not to interfere with each other.
(4) Provide a suitable interface between the robot and its peripheral devices 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 grease, 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 devices or tools.
(4) Observe the following precautions about the mechanical unit cables. Failure to follow precautions may cause mechanical troubles.
- Use mechanical unit cable that have required user interface.
- Do not add user cable or hose to inside of 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 equipment 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) 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 to comprehend the robot movement by the key in advance.

5.2 PRECAUTIONS IN PROGRAMMING

(1) Design to arrange avoiding mutual interfere when various robot's operation area crossover significantly.
(2) Be sure to specify the predetermined work origin in a motion program so that the robot starts from the origin and terminates at the origin. Make it possible for the operator to distinguish easily that the robot motion has terminated at a glance.

5.3 PRECAUTIONS FOR MECHANISMS

Keep the operating space areas of the robot 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) Circumspect program with sufficient delay required for the program after executing some control command in adopting actuators (pneumatic, hydraulic, and electric)
(2) Adopt limit switches for the end effector, and control the robot system by monitoring the state.

7 STOP TYPE OF ROBOT

There are following three 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.

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**
> 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 Controlled stop is used.

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

There are the following 3 Stop patterns.

Stop pattern	Mode	Emergency stop button	External Emergency stop	FENCE open	SVOFF input	Servo disconnect
A	AUTO	P-Stop	P-Stop	C-Stop	C-Stop	P-Stop
	T1	P-Stop	P-Stop	-	C-Stop	P-Stop
	T2	P-Stop	P-Stop	-	C-Stop	P-Stop
B	AUTO	P-Stop	P-Stop	P-Stop	P-Stop	P-Stop
	T1	P-Stop	P-Stop	-	P-Stop	P-Stop
	T2	P-Stop	P-Stop	-	P-Stop	P-Stop
C	AUTO	C-Stop	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

P-Stop: Power-Off stop
C-Stop: Controlled stop
-: Disable

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 (*)

(*) R-30*i*B / R-30*i*B Mate does not have servo disconnect. 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 becomes 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 the those of Power-Off stop, depending on the robot model and axis. Please refer to the operator's manual of a particular robot model for the data of stopping distance and time.

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.

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TABLE OF CONTENTS

1 OVERVIEW

Dual Check Safety (DCS) Position/Speed Check features check the speed and position data of motors with two independent CPUs in the robot controller. These functions can detect position and speed errors immediately and shut down the motor power by two independent channels. Safety data and processes are cross-checked by two CPUs. Self-diagnosis of safety hardware and software is executed periodically to prevent potential failure accumulation.

DCS Position/Speed Check features do not need additional external sensors to monitor speed and position. Only the built-in servo motor sensors are used for this function. (To use safety inputs or safety outputs, external electrical circuits are required.)

DCS functions are certified to meet the requirements of International Standard ISO13849-1 and IEC61508 by a notarized body.

1.1 DCS FUNCTION COMPONENTS

The DCS system consists of the following standard and optional functions. Safety Category, PL(Performance Level), SIL(Safety Integrity Level) are specified in the following table.

DCS function components

Function name	Standard / Option	ISO13849-1 IEC61508	Description
Emergency Stop function - Operator panel emergency stop - Teach pendant emergency stop - Deadman switch - External emergency stop (EES) - Fence input (EAS) - SVOFF input (EGS) - NTED input - Robot disable switch	Standard	Category 4 PL e SIL 3	Turn off servo motor power according to the status of emergency stop input. This manual does not explain this function because it is a standard function of the controller.
Position/Speed Check function - Joint Position Check function - Joint Speed Check function - Cartesian Position Check function - Cartesian Speed Check function - T1 Mode Speed Check function	Option A05B-2600-J567 (Includes Joint Speed check function and Basic Position check function)	Category 3 PL d SIL 2	These functions check robot position and speed. If the robot violates the programmed safety area or exceeds the programmed speed limit, servo motor power is turned off.
Joint Speed Check function	Option A05B-2600-J555 (This option is included in Position/Speed check function)	Category 3 PL d SIL 2	These functions check robot axis speed. If the axis exceeds the programmed speed limit, servo motor power is turned off. This function can be used as Stop check function when the speed limit is 0.
Basic Position Check function	Option A05B-2600-J556 (This option is included in Position/Speed check function)	Category 3 PL d SIL 2	These functions check robot position. If the axis exceeds the programmed safety area, servo motor power is turned off. This function is restricted function of Cartesian Position Check function.

Function name	Standard / Option	ISO13849-1 IEC61508	Description
Safe I/O Connect function	Option A05B-2600-J568	Category 4 PL e SIL 3 (*4)	This function executes logic calculations for safe I/O. For example, users can control safety outputs according to the status of Position/Speed Check functions.
External mode select function	Option A05B-2600-J569 (Includes Safe I/O Connect function)	Category 4 PL e SIL 3	Safe I/O SSO[6] and SSO[7] are used to select AUTO/T1/T2 operation mode in place of mode switch on operator panel. To use this option, the operator panel must be “No mode switch” type.
DeviceNet Safety function	Option (*1, *3) A05B-2600-J974 (Includes Safe I/O Connect function)	Category 4 PL e SIL 3	The robot controller works as a slave device of a DeviceNet Safety network and communicates safety signals with an external safety master device.
EtherNet/IP Safety function	Option (*2, *3) A05B-2600-R713 (Includes Safe I/O Connect function)	Category 4 PL e SIL 3	The robot controller works as an adapter device of an EtherNet/IP Safety network and communicates safety signals with an external safety scanner device.
PROFINET Safety function (*9)	Option (*3, *5) A05B-2600-J931 (Includes Safe I/O Connect function)	Category 4 PL e SIL 3	The robot controller works as a F-device of PROFIsafe and communicates safety signals with an external F-Host.
Safety function by FL-net	Option (*11) A05B-2600-J586 (Includes Safe I/O Connect function)	Category 4 PL e SIL 3	The robot controller communicates safety signals with the other robot controller or CNC controller.
Safety PMC function (*10)	Option (*6) A05B-2600-J764 (Includes Safe I/O Connect function)	Category 4 PL e SIL 3	The robot controller controls the sequence of safe I/O by executing sequence program of ladder language.
Auxiliary axis servo off (local stop) function	Option (*7) A05B-2600-J806	Category 4 PL e SIL 3	This function prevents the unexpected motion of auxiliary axis by cutting off the servo power of the auxiliary axis. This function needs the special hardware.
Safety I/O by additional safety I/O board (*10)	Option A05B-2600-J131	Category 4 PL e SIL 3	This function is able to add safety I/O signals.
Safety I/O by I/O Unit-MODEL A (*10)	Option (*8)	Category 3 PL d SIL 2	This function is able to add safety I/O signals.
Teach Pendant Hot Swap function	Option A05B-2600-J647	Category 4 PL e SIL 3	This function allows to connect / disconnect teach pendant without Emergency Stop alarm. This function requires special hardware for Teach Pendant Hot Swap.
Shared Teach Pendant function	Option A05B-2600-R844	Category 4 PL e SIL 3	Teach Pendant is able to operate other controllers in Shared Teach Pendant group.

Function name	Standard / Option	ISO13849-1 IEC61508	Description
I/O Link *i* Slave function	Standard (But the exclusive hardware is needed (*12))	Category 3 PL d SIL 2	The robot controller communicates safety signals with CNC controller by I/O Link i.
Safe I/O consistency check function	Standard	Category 4 PL e SIL 3	This function check consistency of a pair of safe I/O. Servo motor power is turned off on inconsistency status.

*1: To use DeviceNet Safety function, one of the following options is needed.
A05B-2600-J753 DeviceNet Master&Slave
A05B-2600-J754 DeviceNet Slave
*2: To use EtherNet/IP Safety function, one of the following options is needed.
A05B-2600-R784 EtherNet/IP Adapter
A05B-2600-R785 EtherNet/IP Scanner
(EtherNet/IP Scanner option includes EtherNet/IP Adapter function)
*3: A05B-2600-J974, A05B-2600-R713 and A05B-2600-J931 are exclusive. Only one of DeviceNet Safety, EtherNet/IP Safety or PROFINET Safety can be installed.
*4: When SFDO pulse check is enabled, SFDO output is safety function of Category 4, PL e, SIL 3. When it is disabled, SFDO output is safety function of Category 3, PL d, SIL 2.
*5: For R-30*i*B controller, one of the following options is needed to use PROFINET Safety function.
A05B-2600-J930 PROFINET I/O
A05B-2600-R834 Dual-Channel PROFINET (7DC3 series is required)
These options are exclusive. Either A05B-2600-J930 or A05B-2600-R834 can be ordered.
*6: To use Safety PMC function, the following option is needed.
A05B-2600-J760 Integrated PMC
*7: The complex system such as 3 axes positioner needs Safe I/O connect (A05B-2600-J568) option.
*8: To use Safety I/O by I/O Unit-MODEL A, please refer to the connection and maintenance manual of I/O Unit-MODEL A(B-61813).
*9: For R-30*i*B Mate controller, 7DC3 series is required for PROFINET Safety function. Order A05B-2600-J930 for open air type controller. Order A05B-2600-R834 if it is not open air type controller.
*10: To use Safety PMC function, Safety I/O by additional safety I/O board or Safety I/O by I/O Unit-MODEL A in R-30*i*B Mate controller, the main board that has PMC function is necessary.
*11: To use Safety function by FL-net, the following option is needed.
A05B-2600-J759 FL-net function
*12: To use I/O Link *i* Slave function, the special Main board and CPU card are needed. Please refer to section 14.1 in this manual

⚠WARNING
When Position/Speed Check function is used, adequate risk assessment for the whole robot system is necessary to verify that a Category 3, PL d, SIL 2 safety function is adequate.

⚠WARNING
When SFDO pulse check is disabled, adequate risk assessment for the whole robot system is necessary to verify that a Category 3, PL d, SIL 2 safety function is adequate. The external device connected to SFDO needs to check the discrepancy of redundant output signals when SFDO pulse check is disabled. If the external device detects the discrepancy in a given time, the system should be turned to the safe state like emergency stop condition.

⚠WARNING
When additional Safety I/O by I/O Unit-MODEL A is used, adequate risk assessment for the whole robot system is necessary to verify that a Category 3, PL d, SIL 2 safety function is adequate.

1.2 CAUTIONS AND LIMITATIONS

1.2.1 Hardware

⚠WARNING
At the initial start-up, the operation check and validation of the wiring for safety signals should be carried out, and then the wiring should be protected by the cable duct.

⚠CAUTION
R-30*i*B and R-30*i*B Mate are evaluated as a system with the high demand mode of operation defined in IEC61508. To confirm that the safety function can work correctly, please check the alarm detection by inputting emergency stop twice or more in a year, or please check the system operation by cycling power twice or more in a year.

1.2.2 Software

* Limitations for DCS Position/Speed Check functions is applied to DCS Joint Speed Check function and DCS Basic Position Check function. Please read "also cannot be used with DCS Joint Speed Check function and DCS Basic Position Check function" as "cannot be used with DCS Position/Speed Check function."

Robot model

DCS Position/Speed Check functions are supported on most, but not all, robot models. Contact your FANUC representative for a list of supported robot models.
If DCS Position/Speed Check is loaded into the system of an unsupported robot model, " SYST-218 DCS Unavailable robot model" or "SRVO-364 DCS PRMCRC alarm" occurs. This alarm cannot be cleared until the software option configuration is changed.

Servo gun axis, Independent axis

Servo gun axis and Independent axis cannot be used with DCS Position/Speed Check functions. These axes are regarded as EXCLUDED axes.

Positioner axis

To use DCS Position/Speed Check functions for a positioner axis of customer make, the positioner must be a Basic Positioner with Known Kinematics. If another positioner type is used, the alarm "SRVO-364 DCS PRMCRC alarm" occurs.

To use DCS Position/Speed Check functions for a positioner axis of FANUC make, some positioner models are supported, but not all. Contact your FANUC representative for a list of supported positioner models.

When a positioner axis of FANUC make is used with coordinated motion function, "unknown point calibration for positioner" is not available if the system has DCS Position/Speed Check option. Please use "known four point calibration" or "known direct calibration".

Continuous turn

Continuous turn axes are regarded as Speed Only axes, and the axis can be used only for Joint Speed Check function. The continuous turn axis cannot be used for Joint Position Check function.
When a motion group includes a continuous turn axis, except when it is an Auxiliary Extended Axis, the motion group cannot be used with the Cartesian Position Check and Cartesian Speed Check functions. The T1 Mode Speed Check function for the motion group checks regards the position of the continuous turn axis is always 0, and checks the DCS TCP speed and the wrist flange center speed.

* When the last robot axis of M-2iA or M-3iA is continuous turn axis, the axis is regarded as EXCLUDE axis. The continuous turn axis cannot be used for Joint Speed Check function.
* In 7DC1 series or 7DD0 series software, the continuous turn axis is regarded as EXCLUDE axis. The continuous turn axis cannot be used for Joint Speed Check function.

Extended Axis Control

Axes configured using the Extended Axis Control option are supported in the Position Check and Speed Check functions. In the case where the Extended Axis is being used as a robot transfer unit (RTU) and is configured as an Integrated Axis, the safe zone of the Cartesian Position Check will remain stationary as the robot moves along the transfer unit. If the Extended Axis is configured as an Auxiliary Axis, the safe zone will travel along the transfer unit with the robot.

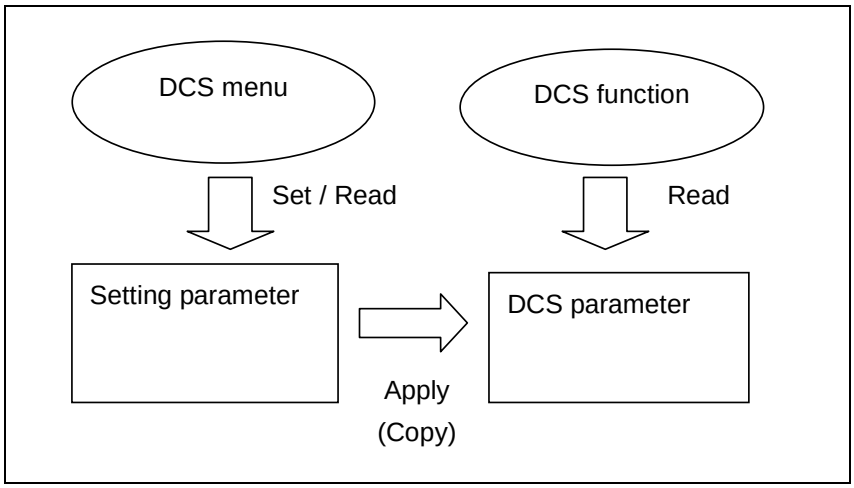
RAIL Unit

If the robot transfer unit (RTU) is configured as an independent group it should be setup as a Rail Unit (H894). In this case the safe zone will travel along the transfer unit with the robot

> **⚠CAUTION**
> When the robot is mounted on rail axis, the safe zone is moved if the world frame of the robot is moved according to the move of the rail axis. To fix the safe zone, the rail axis should be defined as Integrated Rail axis of the same motion group with the robot.

1.3 APPLY TO DCS PARAMETER

The parameters for DCS functions (DCS parameters) are stored in a different memory area from the parameters for other functions, and the data integrity is checked.
Users cannot change DCS parameters directly. To change DCS parameters, users must change the normal parameters (setting parameters) first, and then copy the parameters from the setting parameters to the DCS parameters. This operation is called "Apply to DCS parameter".



When an item in a DCS menu is changed, the setting parameter is changed. When the value of setting parameters and the value of DCS parameters are different, the alarm "SYST-212 Need to apply to DCS param" occurs. This alarm cannot be reset until the "Apply to DCS parameter" procedure is done.

Normally, the DCS menu is protected because an alarm occurs if a DCS menu item is changed unintentionally. When a numeric key or function key is pressed while in a DCS menu, the message "Do you want to change setting?" is displayed. If F4(YES) is pressed, the protection is released, and users can change items in the DCS menu.
When the Teach Pendant enable switch is turned off, the DCS menu is also protected. The protection cannot be released when Teach Pendant enable switch is off.

Robot setup data and mastering parameters are also referenced by DCS Position/Speed Check functions. These parameters are used for normal motion control as well as setting parameters for the DCS Position/Speed Check functions. These parameters are set by other areas of the controller software and are not changed in the DCS menu. However, if these parameters are changed, they will need to be applied to DCS parameters by using the “Apply to DCS parameter” procedure. When the DCS Position/Speed Check option is loaded, and the mastering data or robot setup data is changed, for example when robot mastering is changed, the alarm "SYST-212 Need to apply to DCS param" occurs. This alarm cannot be reset until the "Apply to DCS parameter" procedure is done.

When a backup file (for example SYSVARS.SV or SYSMAST.SV) is loaded, and the setting parameters (including mastering parameters and robot setup data) are changed, the alarm "SYST-212 Need to apply to DCS param" occurs. This alarm cannot be reset until the "Apply to DCS parameter" procedure is done.

⚠CAUTION
If an operator who does not know the code number changes Setting parameters, Mastering parameters or robot setup data by loading a backup file, the alarm "SYST-212 Need to apply DCS param" occurs, and the system will not work. An operator who knows the code number must change setting parameters, mastering parameters or robot setup data.

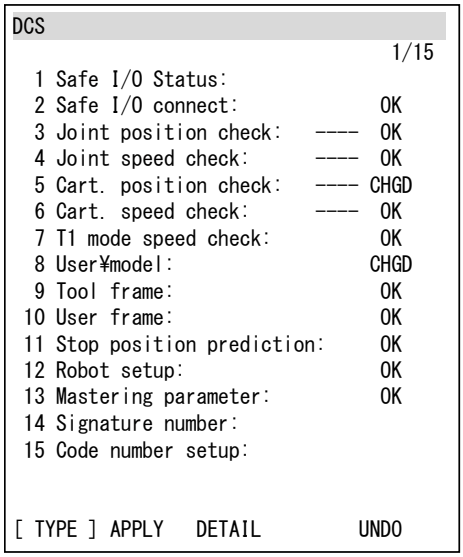
⚠CAUTION
The "SYST-212 Need to apply to DCS param" alarm is not a safety function. It is intended to guide the operator to apply the modified parameters. There are situations that the alarm can be cleared, but the modified parameters do not take affect until the apply process is complete and the power is cycled on the controller.

NOTE
If you removed a battery cable from a motor on a robot, you need to change mastering parameter. Before the correct mastering data is set and applied to DCS parameter, DCS uses the previous mastering parameter.
So, DCS Joint/Cartesian position check function may cause alarm. In this case, please disable the Joint/Cartesian position check to do mastering operation.

The operation to apply DCS parameters is the following.

Operation to apply DCS parameter

1. "MENU"→"SYSTEM"→"F1(TYPE)" →"DCS" shows the DCS top menu. When the DCS top menu is not displayed, press PREV until it is displayed.



2. Press "F2(APPLY)" in the DCS top menu
   Note: If there is invalid setting (for example, invalid user frame number is used in Cartesian Position check), the menu page of the invalid parameter is displayed, and message is displayed on prompt line. In this case, please check the setting in the displayed page.
3. The message "Code number(Master):" is displayed. Please enter the 4 digit code number. (Default code number is "1111".)
   Apply to DCS parameter is not done until the correct code number is entered.
   When "Master" is displayed in parenthesis, the master code number must be entered.
   If “Base” or “Position/Speed Check” or “I/O Connect” is displayed in parenthesis, the corresponding local code number or master code number must be entered.
   (Refer to 2.5 DCS CODE NUMBER)

* At this time, the message " Enter previous code number:" may be displayed. Please refer to 2.5 DCS CODE NUMBER for detail.

⚠CAUTION
Make sure to change the code number from the default “1111” setting to prevent DCS parameters from being changed by unauthorized personnel.

```
DCS
Verify (diff)                              1/163
F Number: F00000
VERSION : HandlingTool
$VERSION: V8.1066       8/30/2012
DATE:     01-OCT-12 14:59
DCS Version: V3.1.0

--- Cartesian Position Check ----------
  Process time factor (Max.1000):    0
 No.         G M Status     Comment
  1 ENABLE  1 OA CHGD [                ]
  2 DISABLE 1 DI ---- [                ]
      :          :
 32 DISABLE 1 DI ---- [                ]

   No.  1              Status:CHGD
  1 Comment:  [                       ]
  2 Enable/Disable:           ENABLE
  3 Method(Safe side):Diagonal(IN)
  4 Group:                             1
  5 Target model 1:                   -1
  6 Target model 2:                    1
  7 Target model 3:                    0
     (0:Disable,-1:Robot,-2:Tool)
  8 User frame:                        0
    Position(mm):
       Current      Point 1     Point 2
  9 X    1827.0     3000.0    -3000.0
 10 Y       0.0     3000.0    -3000.0
 11 Z    1300.0     2000.0        0.0
 12 Stop type:         Emergency stop
 13 disabling input: ---[  0:          ]

                 ALL      OK     QUIT
```

4. DCS Verify menu is displayed. The contents of the DCS menus are displayed in the DCS verify menu. Verify the setting values at this time.
   Pressing "F3" toggles the display between the "DIFF" and "ALL" menu.
   The “DIFF“ menu only shows the items that were changed after the last verify was performed.
   The “ALL” menu shows all DCS parameters that are being applied by this operation including unchanged parameters.
5. When the DCS verify menu is displayed, the copy from setting parameter to DCS parameter is completed. The displayed values are read from the copied DCS parameters. The displayed values can be checked to verify that the copy to DCS parameters was achieved correctly.
   After verifying the displayed values, press "F4(OK)" if the displayed values are correct.
   If the displayed value are not correct, press "F5(QUIT)", change the settings and do apply operation again.
   When "F4(OK)" is pressed, it is recorded that the displayed DCS parameters are verified by the operator.
   If “F5(QUIT)” is pressed, the DCS parameters are updated but the values are not verified yet. In this situation, the alarm "SYST-219 Need to apply to DCS param" is displayed. To clear the alarm, perform the apply to DCS parameter procedure again.
6. After "F4(OK)" is pressed, cycle power on robot controller.
   Changed parameter values will be used after the cycle power.
   Until a cycle power is performed, the alarm "SYST-290 Cycle power to use new DCS parameter" will occur.
7. Perform the actual DCS function to verify that the changed parameters are set correctly.

⚠WARNING
If a robot is used with an incorrect DCS parameter setting, the safety function does not work correctly and serious personal injury could result. When the DCS parameter is changed, the value must be verified, and the related DCS functions must be tested again.

1.4 DCS PARAMETER REPORT FILE

The DCS parameter values are recorded when DCS parameters are verified. DCS parameter reports for the latest 3 times DCS parameters are verified can be output as a DCS parameter report file. DCS parameter values are recorded when F4(OK) is pressed in the DCS verify menu. The current DCS parameters can also be output as a DCS parameter report file.

DCS parameter report files are output by selecting "Diagnostic" or "All of above" from the F4(BACKUP) key in the file menu. They can also be read from MD: via FTP.

The DCS parameter report file is a text file containing the same information as displayed on the DCS verify menu.
There are 2 types of DCS parameter report files, one contains the same contents as the DCS verify(ALL) menu and the other contains the same contents as the DCS verify(DIFF) menu.

DCS parameter report files

File name	Description
DCSVRFY.DG	Current "ALL" contents of DCS parameters are written.
DCSDIFF.DG	Current "DIFF" contents of DCS parameters are written.
DCSCHGD1.DG	Last verified "DIFF" contents of DCS parameters are written.
DCSCHGD2.DG	1 previous from last verified "DIFF" contents of DCS parameters are written.
DCSCHGD3.DG	2 previous from last verified "DIFF" contents of DCS parameters are written.

1.5 BACKUP / RESTORE DCS SETTING PARAMETER

Backup DCS setting parameters

DCS setting parameters are backed up in the following files.

Backup files for DCS setting parameters

File	Included DCS setting parameters
DCSPOS.SV	Position/Speed Check function (Includes user setting of Stop Position Prediction)
DCSIOC.SV	Safe I/O Connect function and user comments of the Safe I/O signals.
SYSCIPS.SV	DeviceNet Safety or EtherNet/IP Safety (Items in DCS CIP safety menu) NOTE - DCS parameters set by an external configuration tool are not included.
SYSPASS.SV	Code numbers
SYSPNSF.SV	PROFINET Safety (Items in DCS PROFINET safety menu) NOTE - F-Parameter is not included.
SYSMAST.SV	Mastering parameters
SYSVARS.SV	Robot setup data, Robot model, Defaults for Stop Position Prediction, Safe I/O device, Auxiliary axis servo off (local stop).
LADDERS.PMC	Safety PMC program.
SYSFLSF.SV	Safety function by FL-net (Items in DCS Safety function by FL-net menu)

Restore DCS setting parameters

A code number is not required to restore DCS setting parameters, but the alarm "SYST-212 Need to apply to DCS param" occurs if the DCS setting parameters restored are different than the current DCS parameters.
To reset the alarm, the operation to apply the DCS parameter is needed, including the need to enter the appropriate code number, for this operation.

⚠CAUTION
If an operator who does not know the code number restores DCS Setting parameters and the alarm "SYST-212 Need to apply DCS param" occurs, the system will not work. An operator who knows the code number must restore DCS setting parameters.

NOTE
When DeviceNet Safety function is used, basic devicenet settings (such as Mac Id, baud rate) are held in SYSDNET.SV. Backup/restore SYSDNET.SV with SYSCIPS.SV if required.

NOTE
In both DeviceNet Safety and EtherNet/IP Safety function, the Safety PLC data set in the robot (eg. SNN) is not included in any application backup. It must be explicitly set on a robot from the Safety PLC configuration software.

NOTE
When PROFINET Safety function is used, basic PROFINET settings (such as I/O Device configuration) are held in PNIO.SV in A05B-2600-J930, or in PMIO.SV in A05B-2600-R834. Backup/restore PNIO.SV or PMIO.SV with SYSPNSF.SV if required.

NOTE
In PROFIsafe, F-Host is supposed to send F-Parameter to F-Device.
F-Parameter is not stored in any application backup.

NOTE
When Safety function by FL-net is used, basic FL-net settings (such as area 1/2 configuration) are held in FLNET.SV. Backup/restore FLNET.SV with SYSFLSF.SV if required.

1.6 INITIAL START, IMAGE RESTORE

In a system where the DCS Position/Speed Check option, Safe I/O Connect option, External mode select option, Safety PMC, DeviceNet Safety, EtherNet/IP Safety PROFINET Safety or Safety function by FL-net option is loaded, the following message is displayed at initial start or image restore. This question decides whether DCS parameters are initialized or not.

And in a system where those options are not loaded, if the safety I/O device is connected and the initialization of the safety I/O device is done, the following message is displayed at initial start or image restore too.

```
*** BOOT MONITOR ***

Initialize DCS parameters?
Yes:All DCS parameters are initialized.
   You must enter code number to apply
   settings if DCS options are used.
No :DCS parameters are kept.
   You must enter code number to apply
   settings if DCS settings in backup
   are different than current settings.
   Parity error will occur if the
   FROM/SRAM module has been changed
   or lost battery power.
(Yes=1, No = [else]):
```

Yes: All DCS parameters are initialized.
You must enter code number to apply DCS settings if any DCS options are used.

No: DCS parameters are kept.
You must enter code number to apply DCS settings if the DCS settings in the backup are different than the current settings.
Parity error will occur if the FROM/SRAM module has been changed or lost battery power.

- Normally, "No" is selected. Users do not need to enter code numbers when "No" is selected as long as the DCS parameters are not changed as follows.
  1 Backup files are loaded after initial start, and the DCS setting parameters are the same as the DCS setting parameters before the initial start.
  2 DCS setting parameters stored in the restored image file are the same as the DCS setting parameters before the image restore.
- If FROM/SRAM module has been changed or lost battery power, please select "Yes". If "No" is selected, SRAM parity error will occur, and system cannot be used.
- If "Yes" is selected when DeviceNet Safety or EtherNet/IP Safety is used, the parameters that are set by the external configuration tool via the safety network are cleared and the parameters must set by the configuration tool again. These parameter are not set by the apply to DCS parameter.
- In an image restore case, when the current DCS parameters and the DCS parameters in the image file are the same, the above question is not displayed and the DCS parameters are kept.
- In an image restore case, when the software in current FROM/SRAM module has no DCS related options, the above question is not displayed and the DCS parameters are initialized.
- In an image restore case, when "No" is selected, the alarm "SYST-219 Need to apply DCS param" and "SRVO-337 DCS PRMCHK alarm" occurs if the current DCS parameters and the DCS parameters in the image file are different. In this case, please perform the “Apply to DCS parameter” procedure.

1.7 STOPPING DISTANCE

Dual Check Safety (DCS) stops the robot by shutting down the motor power. When the motor power is shut down while the robot is moving, the robot’s momentum causes it to move some distance before it completely stops. This distance depends on the type of robot, payload, and speed.

The default scan time of the Position/Speed Check functions is 8 msec. This scan time might change according to your system configuration. The actual scan time is displayed in the DCS robot SETUP menu (Refer to Section 2.3 DCS Robot Setup Menu). DCS Position/Speed Check functions will detect an alarm within a maximum of one scan time.

The stop distance is calculated as follows:

(Speed x Scan time) + moving distance through momentum

⚠WARNING
The robot stopping distance must be considered when DCS Position/Speed Check is used. A risk assessment for the whole robot system is necessary.

⚠WARNING
If controlled stop is set as a stop type, 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.

⚠WARNING
If Safe I/O Connect feature is used, safety signal status could be delayed by a maximum of 2 ms. In this case, a risk assessment for the whole robot system is necessary, including the additional 2 ms delay.

⚠WARNING
If DeviceNet Safety or Ethernet/IP Safety feature is used, safety signal status could be delayed by a maximum of 2 ms. In this case, a risk assessment for the whole robot system is necessary, including the additional 2 ms delay.

⚠WARNING
If PROFINET Safety feature is used, safety signal status could be delayed by a maximum of 4 ms. In this case, a risk assessment for the whole robot system is necessary, including the additional 4 ms delay.

⚠WARNING
If Safety function by FL-net feature is used, safety signal status could be delayed by a maximum of "Timer for receive data + 4" ms. In this case, a risk assessment for the whole robot system is necessary, including the additional "Timer for receive data + 4" ms delay.
See item "Timer for receive data" in "Table9.2.3 (b) Parameters in Safety function by FL-net screen" for "Timer for receive data".

⚠WARNING
If Safety PMC feature is used, safety signal status that is output by the Level 1 sequence program could be delayed by a maximum of 2ms. And safety signal status that is output by the Level 2 sequence program could be delayed by a maximum of the execution period of Level 2. The execution period of Level 2 is displayed in DCS Safety PMC menu. In this case, a risk assessment for the whole robot system is necessary, including the additional signal status delay.

2 DCS MENU

In the DCS menu, users can change DCS setting parameters and apply these parameters to DCS parameters.

DCS menu is displayed if the option related to DCS function is loaded. In Multi-Arm system, DCS menu is displayed even though no option related to DCS function is loaded, because DCS parameter may need to be changed according to the robot configuration.
And DCS menu is displayed even though no option related to DCS function is loaded when new safety I/O device is connected too.

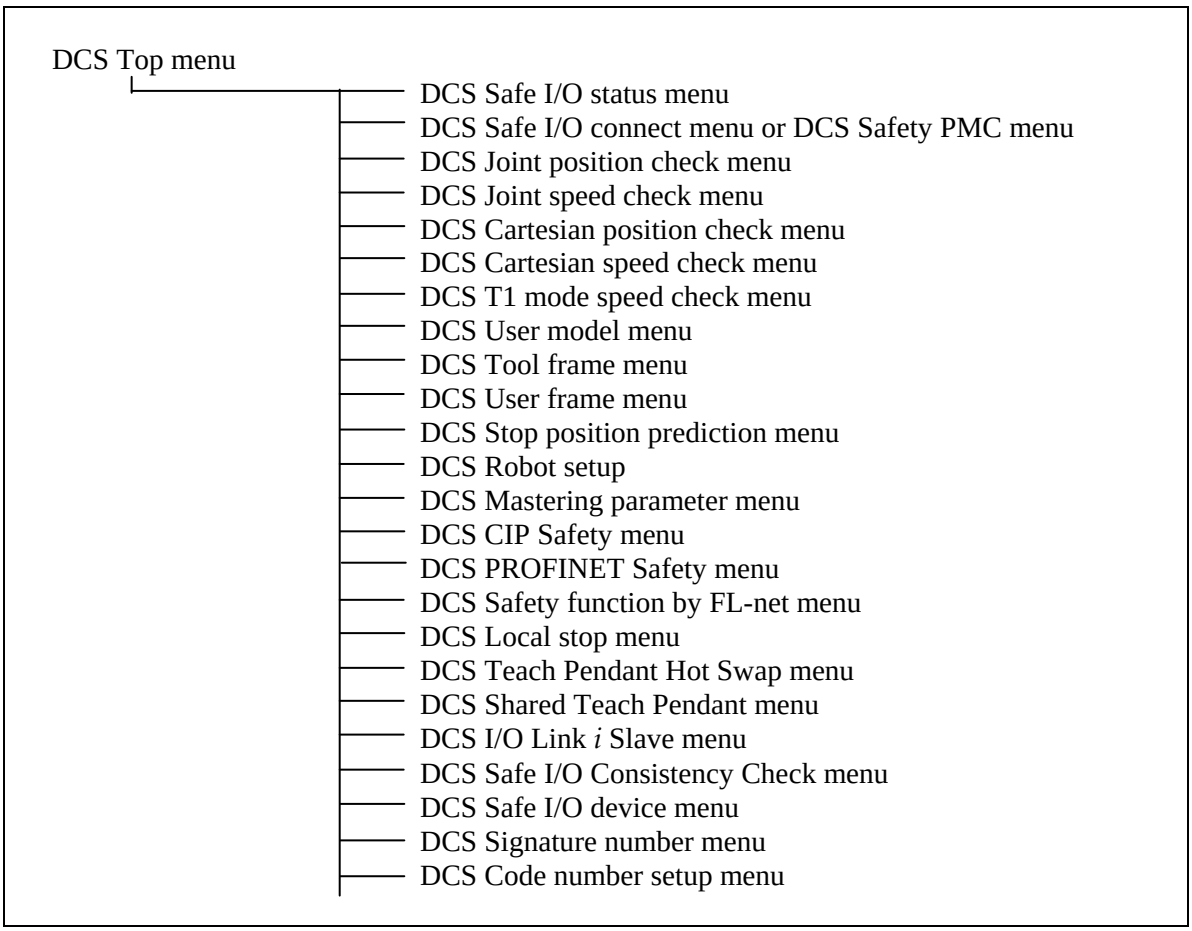
2.1 DCS MENU COMPONENTS

Display DCS menu

DCS menu is displayed by the following operation.
"MENU" → "SYSTEM" → "F1(TYPE)" → "DCS"

DCS menu components

DCS menu consists of the following menus.



In this Chapter, the following menus related to general DCS functions are described.

- DCS Top menu
- DCS Robot setup menu

- DCS Mastering parameter menu
- DCS Signature number menu
- DCS Code number setup menu

The following menus are described in "3 POSITION / SPEED CHECK FUNCTION".
- DCS Joint position check menu
- DCS Joint speed check menu
- DCS Cartesian position check
- DCS Cartesian speed check
- DCS Tool frame menu
- DCS User frame menu
- DCS Stop position prediction menu

The following menus are described in "5 SAFE I/O"
- DCS Safe I/O status menu
- DCS Safe I/O connect menu
- DCS Safe I/O device menu

The following menu is described in "6 DEVICENET SAFETY" and "7 ETHERNET/IP SAFETY"
- DCS CIP Safety menu

The following menu is described in "8 PROFINET SAFETY"
- DCS PROFINET Safety menu

The following menu is described in "9 SAFETY FUNCTION BY FL-NET".
- DCS Safety function by FL-net menu

The following menu is described in "10 SAFETY PMC FUNCTION".
- DCS Safety PMC function menu

The following menu is described in "0
AUXILIARY AXIS SERVO OFF (LOCAL STOP) FUNCTION".
- DCS Local stop menu

The following menu is described in "12 TEACH PENDANT HOT SWAP".
- DCS Teach Pendant Hot Swap menu

The following menu is described in "13 SHARED TEACH PENDANT".
- DCS Shared Teach Pendant menu

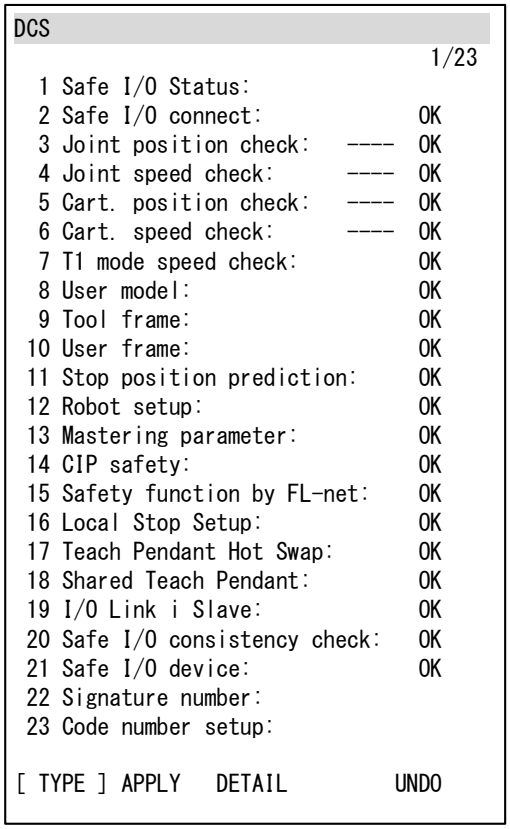
The following menu is described in "14 I/O LINK *i* SLAVE FUNCTION".
- DCS Safe I/O Consistency Check menu

The following menu is described in "15 SAFE I/O CONSISTENCY CHECK FUNCTION".
- DCS Safe I/O Consistency Check menu

2.2 DCS TOP MENU

This is the top level DCS menu and includes the operation to “Apply to DCS parameter”. Each DETAIL menu can be displayed from this menu. The DCS top menu can be displayed by pressing PREV from each DETAIL menu.

DCS Top menu



Items in DCS Top menu

Item	Description
Safe I/O status	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Safe I/O Status menu is displayed. This line is displayed when "Safe I/O Connect" or the option that includes it are loaded.
Safe I/O connect	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Safe I/O Connect menu is displayed. This line is displayed when "Safe I/O Connect" or the option that includes it are loaded. When "Safe I/O process" in Safe I/O device menu is set to "Safety PMC", this item is replaced by "Safety PMC".
Safety PMC	When the ENTER key or the F3(DETAIL) key is pressed on this item, the Safety PMC menu is displayed. This line is displayed when "Safety PMC" is loaded and "Safe I/O process" in Safe I/O device menu is set to "Safety PMC".
Joint position check	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Joint Position Check menu is displayed. This line is displayed when "DCS Position/Speed Check" option is loaded.
Joint speed check	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Joint Speed Check menu is displayed. This line is displayed when "DCS Position/Speed Check" option or "DCS Joint Speed check" option is loaded.

Item	Description
Cart. position check	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Cartesian Position Check menu is displayed. This line is displayed when "Position/Speed Check" option or "DCS Basic Position check" option is loaded.
Cart. speed check	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Cartesian Speed Check menu is displayed. This line is displayed when "DCS Position/Speed Check" option is loaded.
T1 mode speed check	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS T1 Mode Speed Check menu is displayed. This line is displayed when "DCS Position/Speed Check" option is loaded.
User model	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS User Model menu is displayed. This line is displayed when "DCS Position/Speed Check" option or "DCS Basic Position check" option is loaded.
Tool frame	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Tool Frame menu is displayed. This line is displayed when "DCS Position/Speed Check" option is loaded.
User frame	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS User Frame menu is displayed. This line is displayed when "DCS Position/Speed Check" option is loaded.
Stop position prediction	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Stop Position Prediction menu is displayed. This line is displayed when "DCS Position/Speed Check" option or "DCS Basic Position check" option is loaded.
Robot setup	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Robot Setup menu is displayed. This line is displayed when "DCS Position/Speed Check" option or "DCS Joint Speed check" option or "DCS Basic Position check" option is loaded.
Mastering parameter	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Mastering Parameter menu is displayed. This line is displayed when "DCS Position/Speed Check" option or "DCS Joint Speed check" option is or "DCS Basic Position check" option loaded.
CIP Safety	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS CIP Safety menu is displayed. This line is displayed when "DeviceNet Safety", or “EtherNet/IP Safety” option is loaded.
PROFINET Safety	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS PROFINET Safety menu is displayed. This line is displayed when "PROFINET Safety" option is loaded.
Safety function by FL-net	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Safety function by FL-net menu is displayed. This line is displayed when "Safety function by FL-net" option is loaded.
Local Stop Setup	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Local stop setup menu is displayed. This line is displayed when "Axiliary axis servo off (local stop) function" option is loaded.
Teach Pendant Hot Swap	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Teach Pendant Hot Swap menu is displayed. This line is displayed when "Teach Pendant Hot Swap function" option is loaded.
Shared Teach Pendant	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Shared Teach Pendant menu is displayed. This line is displayed when "Shard Teach Pendant function" option is loaded.
I/O Link *i* Slave	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS I/O Link *i* Slave menu is displayed. This line is displayed when the special hardware for I/O Link *i* Slave is used.
Safe I/O consistency check	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Safe I/O consistency check menu is displayed. This line is always displayed.

Item	Description
Safe I/O device	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Safe I/O device menu is displayed. This line is always displayed.
Signature number	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Signature Number menu is displayed. This line is always displayed.
Code number setup	When the ENTER key or the F3(DETAIL) key is pressed on this item, the DCS Code Number Setup menu is displayed. This line is always displayed.
OK / CHGD / PEND	For menus that allow setting parameters to be changed in the detail menu, OK/CHGD/PEND is displayed in the right column. OK: Setting parameter and DCS parameter are the same. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.
---- / SAFE / UNSF / DSBL	On Joint Position Check and Cartesian Position Check lines, ----/SAFE/UNSF/DSBL is displayed in the second column from the right. ----: Disabled by settings. SAFE: Enabled, and in the safe zone now. UNSF: Enabled, and out of the safe zone now. DSBL: Disabled by disabling input now.
---- / SAFE / OVER / DSBL	On Joint Speed Check and Cartesian Speed Check lines, ----/SAFE/OVER/DSBL is displayed in the second column from the right. ----: Disabled by settings. SAFE: Enabled, and speed is less than the limit now. OVER: Enabled, and speed is over the limit now. DSBL: Disabled by disabling input now.

Operation in DCS Top menu

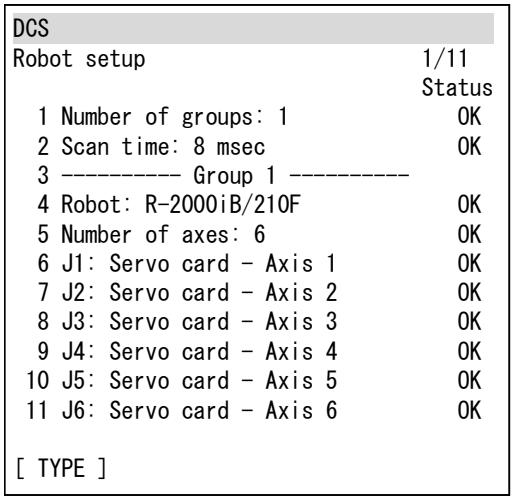
Operation	Description
F2(APPLY	Apply to DCS parameters.
F3(DETAIL) or ENTER	Display the detail menu of the highlighted item.
F5(UNDO)	UNDO all items in the DCS menu except robot setup data, mastering parameters and Safety PMC program, all DCS setting parameters are reset to be the same as the current DCS parameters.

2.3 DCS ROBOT SETUP MENU

This menu is available when the "DCS Position/Speed Check" option or "DCS Basic Joint Speed check" option or "DCS Basic Position check" option is loaded. This menu displays the robot setup data related to DCS Position/Speed Check functions.

When robot setup data is changed in the Maintenance menu at Control Start, CHGD is displayed on the status column of the changed item in this menu. In this situation, "SYST-212 Need to apply to DCS param" occurs and cannot be reset until "Apply to DCS parameter" is done.

DCS Robot setup menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "Robot setup" item in the DCS Top menu.



Items in DCS Robot setup menu

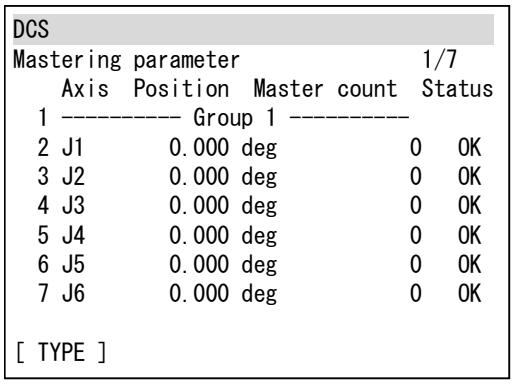
Item	Description
Number of groups	This item indicates the number of DCS motion groups.
Scan time	This item indicates the scan time of position / speed checking process.
Robot	This item indicates the robot model name of the group assigned to this DCS motion group.
Number of axes	This item indicates the number of axes in this motion group.
J1 - J9	This item indicates the hardware configuration of each axis. Servo card : This axis is connected to axis control card on main board. Axis board : This axis is connected to auxiliary axis board. The slot name that the auxiliary axis board is inserted is displayed in the parenthesis. Excluded! : This axis is excluded by DCS Position/Speed Check functions. Joint Position Check and Joint Speed Check cannot be enabled for this axis. When a motion group includes an excluded axis, except when it is an Auxiliary Extended Axis, the motion group cannot be used with the Cartesian Position Check, Cartesian Speed Check and T1 Mode Speed Check functions. Speed only! : This axis can be used only for Joint Speed Check. Joint Position Check cannot be enabled for this axis. When a motion group includes an speed only axis, except when it is an Auxiliary Extended Axis, the motion group cannot be used with the Cartesian Position Check and Cartesian Speed Check functions. The T1 Mode Speed Check function regards the position of the speed only axis is always 0, and checks the DCS TCP speed and the wrist flange center speed.
Direction	This item indicates the direction of the Extended axis or Positioner. [Extended axis] Auxiliary axes : No direction X : X direction, Y : Y direction, Z : Z direction [Positioner axis] +X : +X direction, -X : -X direction +Y : +Y direction, -Y : -Y direction +X : +Z direction, -Z : -Z direction
Arm length	This item indicates the arm length of the extended axis
Offset	This item indicates the offset of the extended axis
Offset X Offset Y Offset Z	This item indicates the offset of the positioner axis
Axis type	This item indicates the axis type of extended axis, positioner axis or independent axis. Linear axis or Rotary axis.
Motor direction	This item indicates the motor direction of extended axis, positioner axis or independent axis
Gear ratio	This item indicates the gear ratio of extended axis, positioner axis or independent axis

Item	Description
Pos. tolerance	This item indicates the position tolerance of the extended axis, positioner axis or independent axis. If the difference between the command position and feedback position exceeds this value, the alarm "SRVO-365 DCS FB_CMP alarm" occurs.
Status	This item indicates the status of each item displayed. OK : Robot setting is the same as DCS parameter CHGD : Robot setting is changed but not applied to DCS parameter. The alarm "SYST-212 Need to apply to DCS param" occurs. PEND : Robot setting is changed and applied to DCS parameter, but controller power is not cycled yet, and the new setting is not used. Power must be cycled.

2.4 DCS MASTERING PARAMETER MENU

This menu is available when the "DCS Position/Speed Check" option or "DCS Basic Joint Speed check" option or "DCS Basic Position check" option is loaded. The mastering parameters of the setting parameters are displayed in this menu, they are not set from this menu. The mastering parameters are changed by the normal mastering procedure.

When the standard mastering parameters are changed by mastering procedure, CHGD is displayed on the status column of the changed item in this menu. "SYST-212 Need to apply to DCS param" occurs and cannot be reset until "Apply to DCS parameter" is done.
DCS Mastering Parameter menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "Mastering Parameter" item in the DCS Top menu.



Items in DCS Mastering parameter menu

Item	Description
Axis	This item indicates the axis number.
Position	This item indicates the current position calculated from the applied mastering parameters. Verify that the displayed position shows the correct robot position when mastering parameters are applied to DCS parameters.
Master count	This item indicates the value of the standard mastering parameters.
Status	This item indicates the status of each axes' mastering parameters. OK : Mastering parameters are the same as DCS parameters CHGD : Mastering parameters are changed but not applied to DCS parameters. The alarm "SYST-212 Need to apply to DCS param" occurs. PEND : Mastering parameters are changed and applied to DCS parameter, but controller power is not cycled yet, and the new setting is not used. Power must be cycled Not displayed: This axis is excluded by DCS Position/Speed Check functions. Mastering parameters of this axis are not copied to DCS parameters.

2.5 DCS CODE NUMBER

This menu is used to change the DCS code numbers. These 4 digit code numbers are used to “Apply to DCS parameter”.

There are 2 types of code numbers, a master code number and local code numbers.

Master code number

The master code number can be used to apply any changed parameters.

Local code number

There are 3 local code numbers, Base, Position/Speed Check and Safe I/O Connect. Each of these local code numbers only allow changes in each specified area to be applied.

When multiple setting parameters are changed, the master code number or all local code numbers corresponding to the changed setting parameters need to be entered to apply to DCS parameter.

For example, if setting parameters for Position/Speed Check and setting parameters for Safe I/O Connect are changed, master code number or the local code numbers for both Position/Speed Check and Safe I/O Connect must be entered.

Local code numbers are not defined by default. When the local code number for a changed setting parameter is not defined, the master code number must be used.
The default master code number is "1111".
In the message to apply to DCS parameter, the name of the required code number is displayed (i.e. "Code number(pos./speed):"). The “Apply to DCS parameter” is not performed until the specified local code number or master code number is entered.

To change a code number, the current local code number or master code number must be entered.
To clear a local code number, the current master code number must be entered.

Code numbers are saved as part of the robot backup in SYSPASS.SV. When code numbers are changed by loading the SYSPASS.SV file, the alarm "SYST-219 Need to apply DCS param" occurs. To clear the alarm, the “Apply to DCS parameter” operation must be performed. In this operation, the previous master code number must be entered as follows.

- The message "Previous code number(master):" is displayed, please enter the master code number that was used before SYSPASS.SV is loaded.
- Then the message "Code number(Master)" is displayed, please enter the master code number that is loaded from the SYSPASS.SV.

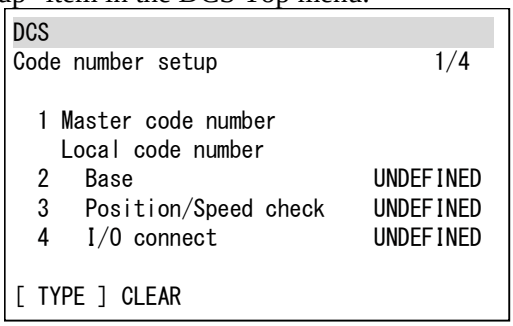
When code numbers are changed by loading the image file, the alarm "SYST-219 Need to apply DCS param" occurs. To clear the alarm, the “Apply to DCS parameter” operation must be performed. In this operation, the previous master code number must be entered as follows.

- The message "Previous code number(master):" is displayed, please enter the master code number that was used before the image file is loaded. (If Yes was selected for "Initialize DCS parameters?" at image restore, please enter "1111".)
- Then the message "Code number(Master)" is displayed, please enter the master code number that is loaded from the image file.

⚠CAUTION
Make sure to change the master code number from the default “1111” setting to prevent DCS parameters from being changed by an unauthorized personnel.

2.5.1 DCS Code Number Setup Menu

The DCS Code Number Setup menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "Code number setup" item in the DCS Top menu.



Items in DCS code number setup menu

Item	Description
Master code number	When the ENTER key is pressed on this item, the master code number can be changed. The current master code number must be entered.
Base	The code number to change the DCS parameters for robot setup date, mastering parameter, CIP Safety, PROFINET Safety, Safety function by FL-net and Auxiliary axis servo off (local stop) function. When the ENTER key is pressed on this item, the local code number for Base DCS parameters can be changed. The current Base code number or Master code number must be entered. If the Base code number is not defined, "UNDEFINED" is displayed. If the Base code number is defined, "DEFINED" is displayed.
Position/Speed check	The code number to change the DCS parameters for the Position/Speed Check function. When the ENTER key is pressed on this item, the local code number for Position/Speed Check DCS parameters can be changed. The current Position/Speed Check code number or Master code number must be entered. If the Position/Speed Check code number is not defined, "UNDEFINED" is displayed. If the Position/Speed Check code number is defined, "DEFINED" is displayed.
I/O connect	The code number to change the DCS parameters for the Safe I/O Connect function, Safe I/O device, Safety PMC program, Teach Pendant Hot Swap and Shared Teach Pendant. When the ENTER key is pressed on this item, the local code number for Safe I/O Connect DCS parameters can be changed. The current Safe I/O Connect code number or Master code number must be entered. If the Safe I/O Connect code number is not defined, "UNDEFINED" is displayed. If the Safe I/O Connect code number is defined, "DEFINED" is displayed.

Operation in DCS code number setup menu

Operation	Description
F2(CLEAR)	When F2 is pressed on a local code number, the local code number becomes undefined. The Master code number must be entered.
PREV	DCS Top menu is displayed.

2.6 DCS SIGNATURE NUMBER

The DCS Signature Number menu displays the signature numbers of the various types of DCS parameters.
A signature number is a CRC of the DCS parameter values. When DCS parameters are changed, the corresponding signature number is also changed. These signature numbers can be used to indicate that DCS parameters have been changed.

DCS code numbers are not included as part of the signature numbers. Changing the DCS code numbers will not change the DCS signature numbers.

2.6.1 DCS Signature Number Menu

The DCS Signature Number menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "Signature number" item in the DCS Top menu.

```
DCS
Signature number (Dec)
                Current        Latch
1 Total:         357145112           0
  Time:27-MAY-09 14:49            None
2 Base:         2084717660          0
  Time:26-MAY-09 15:50            None
3 Pos./Speed:    998197839          0
  Time:27-MAY-09 14:49            None
4 I/O connect:   273305809          0
  Time:26-MAY-09 15:48            None

[ TYPE ]         Dec/Hex          Annun
```

Items in DCS Signature number menu

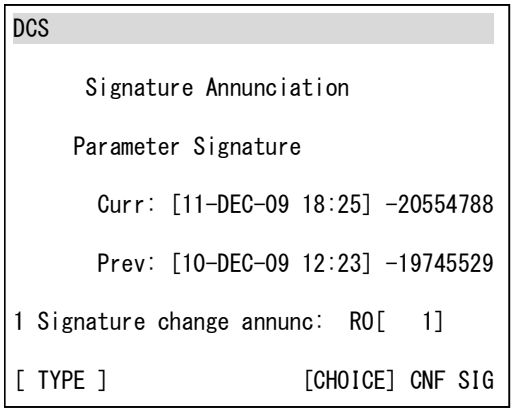
Item	Description
Current	This column displays the Current signature numbers.
Latch	When one of the CCR[1-4] signals are changed from OFF to ON using the Safe I/O Connect function, the current signature number is copied to the latched signature number. When a current signature number matches its latched signature number, the corresponding CCL[1-4] signal is set ON. When they are different, the corresponding CCL[1-4] signal is set OFF.
Time	The Time setting for "Current" signatures is the time that the signature number was changed to this value. The Time setting for "Latch" signatures is the time that the current signature was copied to the latched signature number by using the Safe I/O Connect function. NOTE- In DCS parameter verify menu or in report file, "Changed" is displayed on the "Current" time of the signature that is changed by this APPLY operation. The "Current" time will be set to the time when the new DCS parameter setting is enabled at next power up.
Total	Displays the signature number of all DCS parameters.
Base	Displays the signature number of the DCS parameters for robot setup date, mastering parameter, CIP Safety, PROFINET Safety, Safety function by FL-net and Auxiliary axis servo off (local stop) function.
Pos./Speed	Displays the signature number of the DCS parameters for the Position/Speed Check function.
I/O connect	Displays the signature number of the DCS parameters for the Safe I/O Connect function, Safe I/O device, Safety PMC program, Teach Pendant Hot Swap and Shared Teach Pendant.

Operation in DCS Signature number menu

Operation	Description
F3(Dec/Hex)	Toggles the display of the signature numbers between decimal and hexadecimal format.
F5 (Annun)	Displays the DCS Signature number annunciation setup menu
PREV	DCS Top menu is displayed.

2.6.2 DCS Signature Annunciation Menu

The Dual Check Safety (DCS) Signature Annunciation menu provides a means to see at a glance that DCS settings have been changed. It displays two Parameter Signature numbers with dates, and a Signature Change Annunciation output.



The Parameter Signature numbers represent a summary of all DCS parameter values and are equal to the Total signature number on the Signature Number menu.
There are two Parameter Signature numbers: a *Current number* and a *Previous number*. On initial load of the DCS Position and Speed Check option, the Signature is calculated and displayed as the Current (Curr:) value. The Previous (Prev:) value is uninitialized. After initial load, a new Signature is calculated each power up. If changes have been made to any of the DCS setup parameters, a new value and date are displayed as the Current item. Otherwise, the value and date will remain the same.
The Previous value is set by confirming the signature using the CNF SIG function key. See "Procedure 2-6-2 Confirming Changes to the Parameter Signature" for instructions on confirming the current signature. Once confirmed, the Previous signature and date are set equal to the Current values.
In addition to the Signatures indicating changes to DCS setup parameters, this feature also indicates changes with a digital output called the Signature Change Annunciation output. Either a Digital output or a Robot output can be selected along with specifying the output index. After this output has been set up, it will turn on and stay on as long as the Current and Previous Signatures are the same. If they are different, the output will turn off. This output can be connected to an annunciating lamp or to a PLC to provide status of the Signatures.

⚠CAUTION
Note that this **is not a safety output** and should not be used as one. It only provides status information.

2.6.2.1 DCS signature change management utility setup

As an option, you can set up a digital output to indicate that the Current and Previous Signature values have changed. The Current and Previous Signature values will still indicate changes to DCS parameters whether or not you set up a digital output. If you set up the digital output, and the Current and Previous Signature values change, the digital output will turn on and stay on as long as the values are the same. As soon as the Current and Previous values are different, the output will turn off.
The only setup required for this function is the selection of a Robot or Digital output that will be used to annunciate changes to the Signature value. It is not necessary to set up this output. If this output is set up, it will turn on and stay on as long as the Current and Previous Signature values are the same. If they are different, the output will turn off. Use the following procedure to set up a digital output that will annunciate Signature changes.

⚠CAUTION
Note that this **is not a safety output** and should not be used as one. It only provides status information.

Procedure 2-6-1 Setting up the DCS Signature Change Management Utility

Steps :

1. Press MENU key.
2. Select SYSTEM.
3. Press F1, [TYPE].
4. Select DCS.
5. Press the ENTER key or the F3(DETAIL) key while on the “Signature Number” item.
6. Press the F5(Annun) key. You will see a screen similar to the following:

```
DCS

      Signature Annunciation

     Parameter Signature

       Curr: [11-DEC-09 18:25] -20554788

       Prev: [10-DEC-09 12:23] -19745529

1 Signature change annunc:  RO[   1]

[ TYPE ]                [CHOICE] CNF SIG
```

7. Move the cursor to the output field of Signature change annunc which should display DO or RO, and press F4, [CHOICE]. Select the output type desired.
8. Move the cursor to the index number in the brackets, and set the desired index number.
9. Cycle power to finalize the setup.

2.6.2.2 DCS signature change management utility operation

The Parameter Signature numbers represent a summary of all DCS parameter values and are equal to the Total signature number on the Signature Number menu.
There are two Parameter Signature numbers: a *Current number* and a *Previous number*. On initial load of the DCS Position and Speed Check option, the Signature is calculated and displayed on the Signature Annunciation menu as the Current (Curr:) value. The Previous (Prev:) value is uninitialized. After initial load, a new Signature is calculated each power up. If changes have been made to any of the DCS setup parameters, a new value and date are displayed as the Current item. Otherwise, the value and date will remain the same.
The Previous value is set by confirming the signature using the CNF SIG function key. See "Procedure 2-6-2 Confirming Changes to the Parameter Signature" for instructions on confirming the current signature. Once confirmed, the Previous signature and date are set equal to the Current values.

Procedure 2-6-2 Confirming Changes to the Parameter Signature

Steps :

1. On the DCS Signature Annunciation menu, the CNF SIG function key should be displayed when the cursor is on any item.
2. Press the CNF SIG function key. You will be prompted to enter the DCS Code number (master). The correct code number must be provided to confirm the Signature. You will be prompted to “Confirm new parameter signature?”
3. Press the YES function key. The message “New parameter signature saved” will be displayed and the Previous value of the Parameter Signature and date will be changed to equal the value and date of the Current signature. If the annunciating output has been set up, the output will turn on to indicate that the Current and Previous Signature values are the same.

If the Signature values are the same and a Signature Change Annunciator output has been set up, the output will be on. If the Signature values are different, the output will turn off.

2.6.3 DCS Signature Number Output

The DCS Signature numbers can be output through normal (non-safe) group outputs. Each 32-bit signature output requires two 16-bit groups.

This is configured by setting $DCS_CRC_OUT[x].$START_GRP to the starting group number. There are eight values accessible :

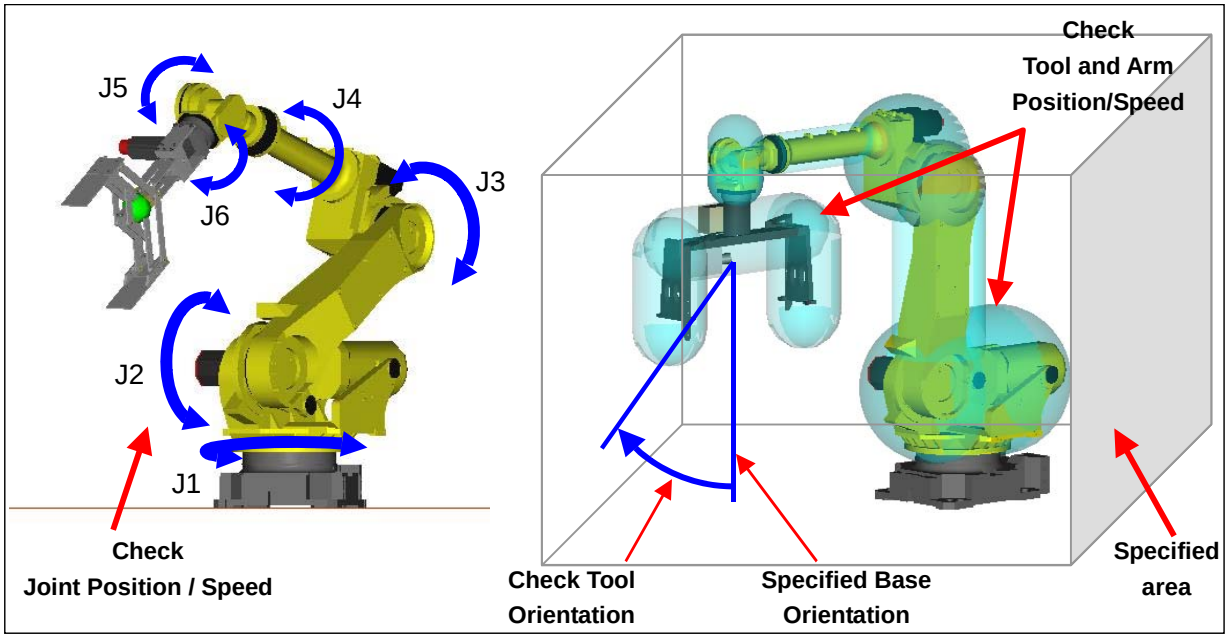
- Current Total CRC : $DCS_CRC_OUT[1].$START_GRP
- Current Base CRC : $DCS_CRC_OUT[2].$START_GRP
- Current Pos/Speed CRC : $DCS_CRC_OUT[3].$START_GRP
- Current I/O Connect CRC : $DCS_CRC_OUT[4].$START_GRP
- Latch Total CRC : $DCS_CRC_OUT[5].$START_GRP
- Latch Base CRC : $DCS_CRC_OUT[6].$START_GRP
- Latch Pos/Speed CRC : $DCS_CRC_OUT[7].$START_GRP
- Latch I/O Connect CRC : $DCS_CRC_OUT[8].$START_GRP

For example, if $DCS_CRC_OUT[1].$START_GRP is set to 1 then GO[1] and GO[2] are set to the lower and upper 16-bits of the Current Total CRC. If the Total Current CRC is 0x46A61511 (hex value) then GO[1] will be set to 0x1511 and GO[2] will be set to 0x46A6.

3 POSITION / SPEED CHECK FUNCTION

The Position / Speed Check option checks the position or speed of the robot and shuts down the motor power if these are out of the specified limit.

- Joint position and speed can be checked.
- It can be checked whether the shape models of robot arm and tool are in the specified zone or not.
- Speed of tool center point can be checked.
- The difference between current tool orientation and base orientation can be checked.
- The checking is enabled / disabled by safe I/O signal.



3.1 COMPONENTS OF POSITION / SPEED CHECK FUNCTION

Position / Speed Check option consists of the following functions.

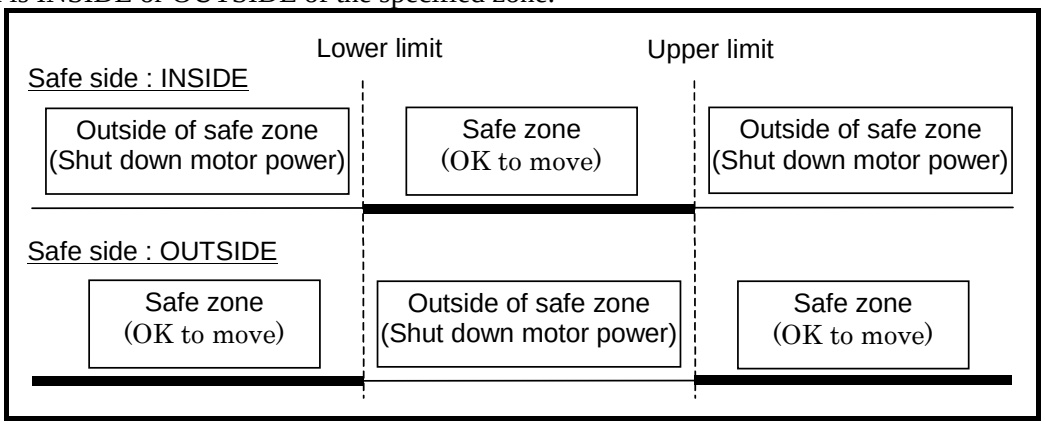
Components of Position / Speed Check function

Function name	Description
Joint Position Check function	When Joint position is out of the specified safe zone, shut down the motor power.
Joint Speed Check function	When Joint speed exceeds the specified limit, shut down the motor power.
Cartesian Position Check function - Zone Check function - Orientation check function	This function includes a zone check function and an orientation check function. Zone check function: When the shape model mounted on the tool or robot arm is out of the specified safe zone, shut down the motor power. Orientation check function: When robot orientation (W,P,R) is out of the specified limit, , shut down the motor power.
Cartesian Speed Check function	When the TCP speed exceeds the specified limit, shut down the motor power.
T1 Mode Speed Check function	When the TCP or Face Plate speed exceeds the specified limit (Max. 250mm/sec), shut down the motor power.
Basic Position Check function	This function is restricted function of Cartesian Position Check function. Restriction is described in 3.6 Basic Position Check function.

3.2 JOINT POSITION CHECK FUNCTION

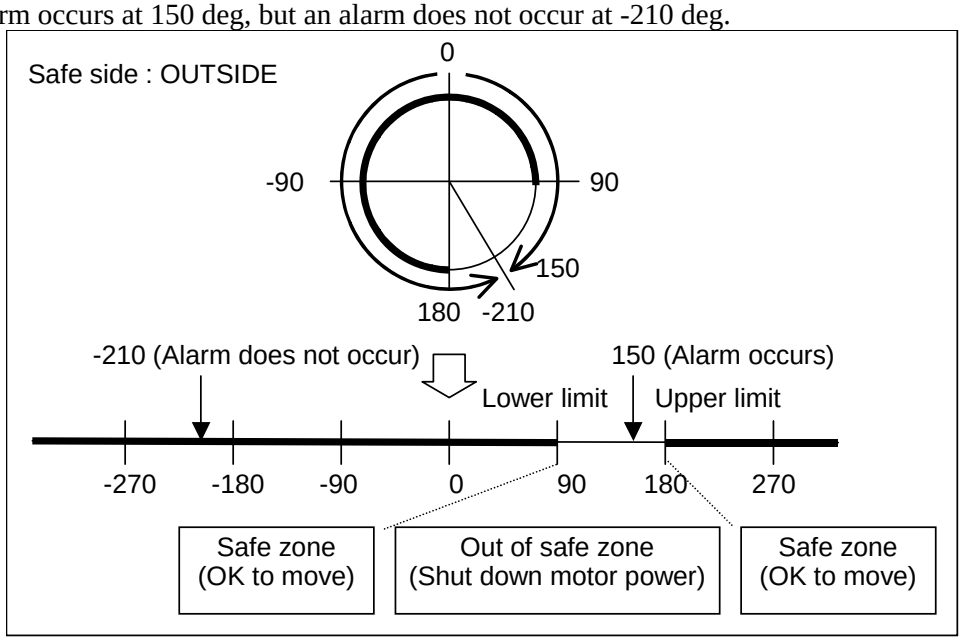
Joint Position Check checks the Joint position of an axis and shuts down the motor power if the Joint position is outside of the safe zone.

The safe zone is configured based on an upper and lower limit. The mode setting can select whether the safe area is INSIDE or OUTSIDE of the specified zone.



- Maximum of 40 zones can be defined.
- When one of the target axes of the Joint Position Check function is out of the safe zone, the alarm "SRVO-404 DCS Joint pos. limit" occurs, and motor power is shut down.
- When Safe I/O is set as a disabling I/O, it is possible to ENABLE / DISABLE Joint Position Check by using the safe I/O for each Joint Position check. When the specified Safe I/O is ON, Joint Position Check is disabled. When it is OFF, it is enabled.
- It is possible to set 2 or more zones for one axis. In this case, the Safe zone is the area where all Safe zones are overlapped.
- The status of Joint Position check can be monitored by a DI when the DI is assigned to rack 36, slot 8, start point 1-40. The start point corresponds to the Joint Position check number. When the Joint Position check is enabled and robot is in the safe zone (Status:SAFE), the DI is ON. Otherwise, the DI is OFF.

In the case of rotary axis, positions that differ by 360 degrees such as 150 deg and -210 deg are processed as different positions. For example, when the area from 90 deg to 180 deg is defined as an OUTSIDE safe zone, an alarm occurs at 150 deg, but an alarm does not occur at -210 deg.



> **⚠WARNING**
> If Joint Position Check is set incorrectly, the safety function will not work, and serious personal injury could result. When Joint Position Check is changed, the values must be verified and the function must be tested again.

Recovery from alarm

When the robot is outside of the safe zone, the alarm cannot be cleared. To move the robot to the safe zone, select T1 mode, and enable the Teach pendant and press and hold the SHIFT and RESET keys, and jog the robot. If the SHIFT key is released while still outside of the safe zone, or the robot moves in a direction away from the safe zone, the alarm occurs again and motor power is shut down.

When servo power is turned on, the robot moves slightly. To avoid DCS alarms by this motion, a very short motion is allowed even though the robot moves away from the safe zone. The robot can move slightly away from the safe zone, because the DCS alarm occurs when the moved distance of the robot exceeds the allowed short motion. If the payload setting of the robot is not correct, the motion at the servo power on becomes big, and the DCS alarm may occur. In this case, please check the payload setting or change the setting of the position check to disable temporarily.

3.2.1 Stop Position Prediction

When the motor power is shut down while the robot is moving, the robot's momentum causes it to move some distance before it completely stops. Stop Position Prediction is a function to predict the stop position according to the current moving direction and speed, and predicts that the axis will exit the safe zone when the predicted stop position is out of the safe zone. In this case, the robot will shut down motor power earlier to minimize the stopping distance beyond the defined safe zone.

The stop position prediction is disabled by default. In this case, the alarm occurs when the shape model exits the safe zone, and the stop position of robot is out of the safe zone for the stopping distance. Please refer to "1.7 STOPPING DISTANCE" about stopping distance.

To enable the stop position prediction, select "DEFAULT" or "USER" for mode of the target axis in DCS stop position prediction menu.

> **⚠CAUTION**
> The stop position prediction of Joint Position Check is disabled by default. To enable the stop position prediction, select "DEFAULT" or "USER" for mode of the target axis in DCS stop position prediction menu.

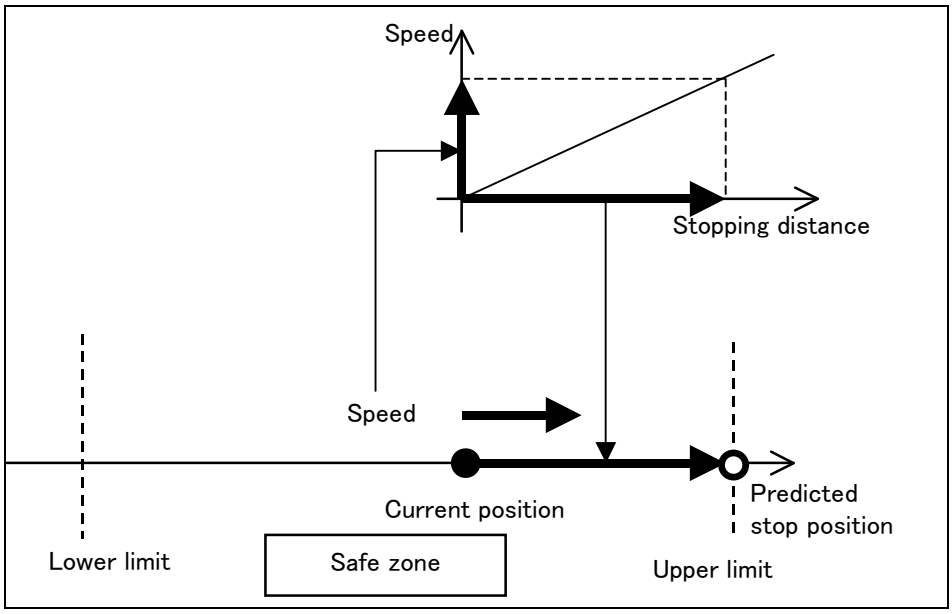
This distance depends on the type of robot, payload, and speed, but mostly it is proportional to the speed. Stop Position Prediction predicts the stop position so that the stopping distance is 0 mm at 0 mm/sec and is increased proportionally with increased speed. The proportion factor is setup in the DCS Stop Position Prediction menu.

The default of the proportion factor is set as 1.5 times the value of the stopping distance at the maximum speed and maximum payload for each robot. When Stop Position Prediction is used with the default setting, motor power is shut off farther away from the border of the zone when speed is increased.

The proportion factor is different between Power-off stop and control stop, and set up individually.
When the stop type of Joint Position Check is Power-off stop, the proportion factor of Power-off stop is used.
When the stop type of Joint Position Check is control stop, both the proportion factor of Power-off stop and control stop are used. When the predicted stop position calculated by the proportion factor of control

stop is out of the safe zone, a control stop is performed. When the predicted stop position calculated by the proportion factor of Power-off stop is out of the safe zone, an Power-off stop is performed. This means that Power-off stop is always done if the stopping distance of an Power-off stop is greater than a control stop.

When the stop type is set to "Not stop", Stop Position Prediction is not used.
Please refer to section 0
SETUP STOP POSITION PREDICTION for details of the Stop Position Prediction menu.

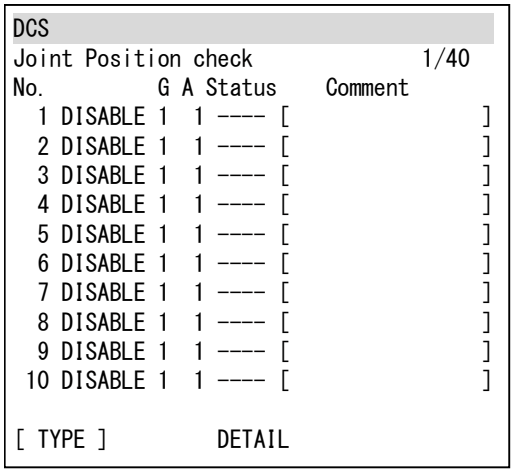


⚠WARNING
If Stop Position Prediction is set incorrectly, the robot will exit the safety zone, and serious personal injury could result. When Stop Position Prediction is changed, the values must be verified and the function must be tested again.

⚠WARNING
When an axis does not have mechanical brake, the axis can move freely when motor power is shutdown, and the stop position prediction does not work correctly for the axis. In this case, a risk assessment for the whole robot system is necessary, including the free movement of the axis that does not have mechanical brake.

3.2.2 DCS Joint Position Check List Menu

DCS Joint Position Check list menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "Joint Position Check" item in DCS Top menu.



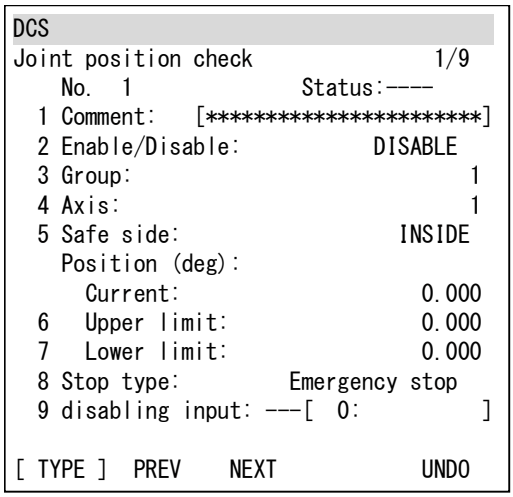
Items in DCS Joint Position Check list menu

Item	Description
No.	The Joint Position Check number is displayed.
ENABLE/DISABLE	The Enable/Disable status of each Joint Position Check is displayed.
G	The target motion group number is displayed.
A	The target axis number is displayed.
Status	The status of the Joint Position Check is displayed. ----: Disabled by setting SAFE: Enabled, and in safe zone. UNSF: Enabled, and out of safe zone. DSBL: Disabled by disabling input. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.
Comment	The comment of the Joint Position Check is displayed.

Operation in DCS Joint Position Check list menu

Operation	Description
F3(DETAIL) or ENTER	The Joint Position Check detail menu of the item the cursor is on is displayed.
PREV	The DCS Top menu is displayed.

3.2.3 DCS Joint Position Check Detail Menu



DCS Joint Position Check detail menu

Item	Description
No.	The Joint Position Check number is displayed.
Status	The status of the Joint Position Check is displayed. ----: Disabled by setting SAFE: Enabled, and in safe zone. UNSF: Enabled, and out of safe zone. DSBL: Disabled by disabling input. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.
Comment	Used to set the comment of the Joint Position Check. The comment set in this menu is also used as the comment of the Safe I/O JPC[ ].
Enable/Disable	Used to set the Enable / Disable of the Joint Position Check. When this is disabled, other settings in this menu are ignored.
Group	Used to set the target motion group number.
Axis	Used to set the target axis number. NOTE – J3 axis limit values are relative to the robot world X-Y plane (similar to the normal axis limits function).
Safe side	Used to set the safe side, INSIDE or OUTSIDE
Current	Current position of the target axis is displayed.
Upper limit Lower limit	Used to set the upper and lower limit of the range.
Stop type	Used to select the action to be performed when the target axis is out of the safe zone. Power-off stop: Motor power is shut down immediately. Control stop: Deceleration stop, then motor power is shut down. (Motor power shutdown is delayed for a maximum of 2 seconds.) Not stop: Robot does not stop. The status is set in Safe I/O JPC.
Disabling input	To enable / disable the Joint Position Check dynamically, a Safe I/O can be set as a disabling input. When the specified Safe I/O is ON, this function disabled. When the specified Safe I/O is OFF, this function is enabled. When the specified Safe I/O is undefined(--), this function is enabled. NOTE - Safety input (SPI) is hardware option. However, SPI[1-2] are available as standard in A cabinet controller of R-30*i*B. NOTE - Zone Status can be used as disabling input; refer to section 5.1 for zone status (CPC, CSC, JPC, & JSC) definitions

Operation in DCS Joint Position Check detail menu

Operation	Description
F2(PREV	The previous Joint Position Check detail menu is displayed.
F3(NEXT)	The next Joint Position Check detail menu is displayed.
F5(UNDO)	UNDO the items in this menu. The setting parameters become the same as the current DCS parameters.
PREV	The Joint Position Check list menu is displayed.

3.3 JOINT SPEED CHECK FUNCTION

The Joint Speed Check function checks the Joint speed of the robot, and shuts down motor power if the Joint speed exceeds the specified limit.

- Maximum 40 speed limits can be defined.
- When one of the axes exceeds the speed limit, the "SRVO-405 DCS Joint speed limit" alarm occurs, and motor power is shut down.

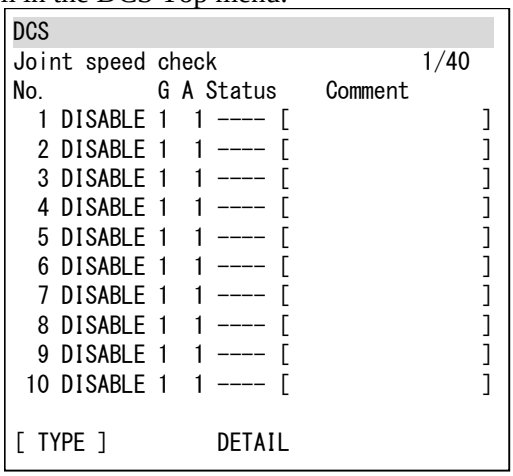
- This function can be used to check if the axis is stationary by setting the speed limit to 0. False alarms caused by vibration during servo ON can be avoided by tuning of the Permissible Distance.
- When Safe I/O is set as a disabling I/O, it is possible to ENABLE / DISABLE Joint Speed Check by using safe I/O. It is possible to specify the Safe I/O for each Joint Speed check. When the specified Safe I/O is ON, Joint Speed Check is disabled. When it is OFF, it is enabled.
- The status of Joint Speed check can be monitored by a DI when the DI is assigned to rack 36, slot 9, start point 1-40. The start point corresponds to the Joint Speed check number. When the Joint Speed check is enabled and speed does not exceeds the limit (Status:SAFE), the DI is ON. Otherwise, the DI is OFF.

⚠WARNING
If Joint Speed Check is set incorrectly, the safety function will not work, and serious personal injury could result. When Joint Speed Check is changed, the values must be verified and the function must be tested again.

⚠WARNING
When the Limit is set to 0 and the Permissible Distance is not set to 0, motor power does not shut down immediately when the axis moves. The stopping distance can be increased by acceleration in the Permissible Distance. Adequate risk assessment for whole robot system is necessary to determine Permissible Distance.

3.3.1 DCS Joint Speed Check List Menu

DCS Joint Speed Check list menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "Joint Speed Check" item in the DCS Top menu.



DCS Joint Speed Check list menu

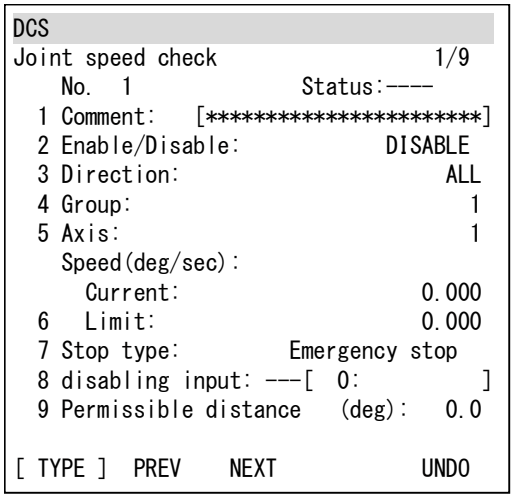
Item	Description
No.	The Joint Speed Check number is displayed.
ENABLE/DISABLE	The Enable/Disable status of each Joint Speed Check is displayed.
G	The target motion group number is displayed.
A	The target axis number is displayed.

Status	The status of Joint Speed Check is displayed. ----: Disabled by setting SAFE: Enabled, and less than the limit. OVER: Enabled, and over the limit. DSBL: Disabled by disabling input. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.
Comment	The comment of the Joint Speed Check is displayed.

Operation of DCS Joint Speed Check list menu

Operation	Description
F3(DETAIL) or ENTER	The Joint Speed Check detail menu of the item the cursor is on is displayed.
PREV	The DCS Top menu is displayed.

3.3.2 DCS Joint Speed Check Detail Menu



DCS Joint Speed Check detail menu

Item	Description
No.	The Joint Speed Check number is displayed.
Status	The status of the Joint Speed Check is displayed. ----: Disabled by setting SAFE: Enabled, and less than the limit. OVER: Enabled, and over the limit. DSBL: Disabled by disabling input. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.
Comment	Used to set the comment of the Joint Speed Check. The comment set in this menu is also used as comment of the Safe I/O JSC[ ].
Enable/Disable	Used to set the Enable / Disable of the Joint Speed Check. When this is disable, all other settings in this menu is ignored.
Direction	Used to set the direction of the speed check. ALL: Direction is not considered. -: Only - direction speed is checked +: Only + direction speed is checked
Group	Used to set the target motion group number.
Axis	Used to set the target axis number.
Current	Current speed of the target axis is displayed.

Item	Description
Limit	Used to set the speed limit. When it is set to 0, this function checks if the axis is stationary. In this case, the axis movement is detected when the axis moves more than the "Permissible distance".
Stop type	Used to select the action to be performed when the target axis speed exceeds the limit Power-off stop: Motor power is shut down immediately. Control stop: Deceleration stop, then motor power is shut down. (Motor power shutdown is delayed for a maximum of 2 seconds.) Not stop: Robot does not stop. The status is set in Safe I/O JSC. NOTE - When the robot starts motion from a stopped position with the limit set to 0 and the stop type set to “Control stop”, motor power is shut down immediately to minimize the robot stopping distance. When the Joint Speed Check is changed from disable to enable by disabling I/O during robot motion, a control stop is performed. NOTE - When the robot starts motion from a stopped position with the limit set to 0 and the stop type set to "Not stop", the state changes to “OVER” when the robot begins motion, but does not change back to "SAFE" if the robot stops later. To return to the "SAFE" status, please turn off motor power, or disable the Joint Speed Check by disabling I/O. To use a “Not Stop” zone to dynamically indicate robot motion in the Safe I/O Connect function without shutting down motor power, set the stop type to “Not Stop” and the speed limit to a small value greater than zero.
Disabling input	To enable / disable the Joint Speed Check dynamically, a Safe I/O can be set as a disabling input. When the specified Safe I/O is ON, this function disabled. When the specified Safe I/O is OFF, this function is enabled. When the specified Safe I/O is undefined(--), this function is enabled. NOTE - Safety input (SPI) is hardware option. However, SPI[1-2] are available as standard in A cabinet controller of R-30*i*B. NOTE - Zone Status can be used as disabling input; refer to section 5.1 for zone status (CPC, CSC, JPC, & JSC) definitions
Permissible distance	This item indicates the motor power is not shut down even though the Joint speed exceeds the speed limit, and the distance moved is less than the Permissible distance. This item is used to avoid false alarms caused by vibration during servo ON. This parameter is used only when the "Limit" is 0. Unit : mm for linear axis, deg for rotary axis.

Operation in DCS Joint Position Check menu

Operation	Description
F2(PREV	The previous Joint Speed Check is displayed.
F3(NEXT)	The next Joint Speed Check is displayed.
F5(UNDO)	UNDO the items in this menu. The setting parameters become the same as the current DCS parameters.
PREV	The Joint Speed Check list menu is displayed.

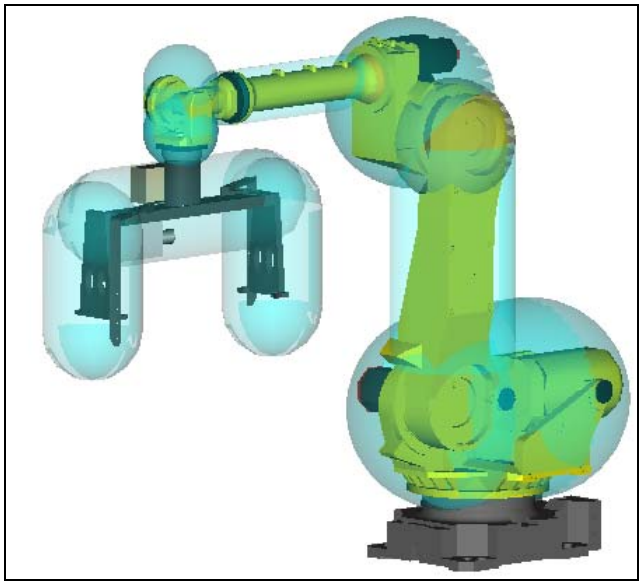
3.4 ZONE CHECK FUNCTION (CARTESIAN POSITION CHECK FUNCTION)

The Zone Check portion of the Cartesian Position Check function checks the shape models that are mounted on the robot tool or arm and shuts down motor power if the shape model is not in the defined safe zone.

- A maximum of 32 zones can be defined.
- When one of the target shape models is out of the safe zone, the alarm "SRVO-402 DCS Cart. pos. limit" occurs, and motor power is shut down.

- It is possible to ENABLE / DISABLE Cartesian Position Check by using safe I/O for each safe zone. When the specified Safe I/O is ON, Cartesian Position Check is disabled. When it is OFF, it is enabled.
- The status of Cartesian Position check can be monitored by a DI when the DI is assigned to rack 36, slot 6, start point 1-32. The start point corresponds to the Cartesian Position check number. When the Cartesian Position check is enabled and robot is in the safe zone (Status:SAFE), the DI is ON. Otherwise, the DI is OFF.

3.4.1 Shape Model



A shape model is a geometric shape, like a sphere, that is mounted on the robot flange or arm. The Zone Check function checks if the shape model is in the defined safe zone.

There are 2 types of shape models, User model and Robot model.

User model

A User model is a shape model that is defined by the user. A maximum of 16 User models can be defined. No User model is defined by default. The User model is used for the following functions.
- Set to the zone check function as target (Maximum 3 user model can be set for each zone.)
- Set to tool frame as Tool model (1 user model can be set for each user frame.)

The user model that is set to tool frame is called Tool model. The Tool model is used for Tool change function that is used when the shape of the tool is changed dynamically. The Tool model of the current selected tool frame can be used as the target of Zone check by setting the target model number to -2.

The motion group number is not set as an item of the shape model. The shape model is attached to the motion group of the Cartesian Position Check zone that uses the shape model as target model or the motion group of the Tool frame that uses the shape model as Tool model. One shape model can be used as a target model by multiple Cartesian Position Check zones or Tool frames as long as the zones or tool frames use the same motion group.

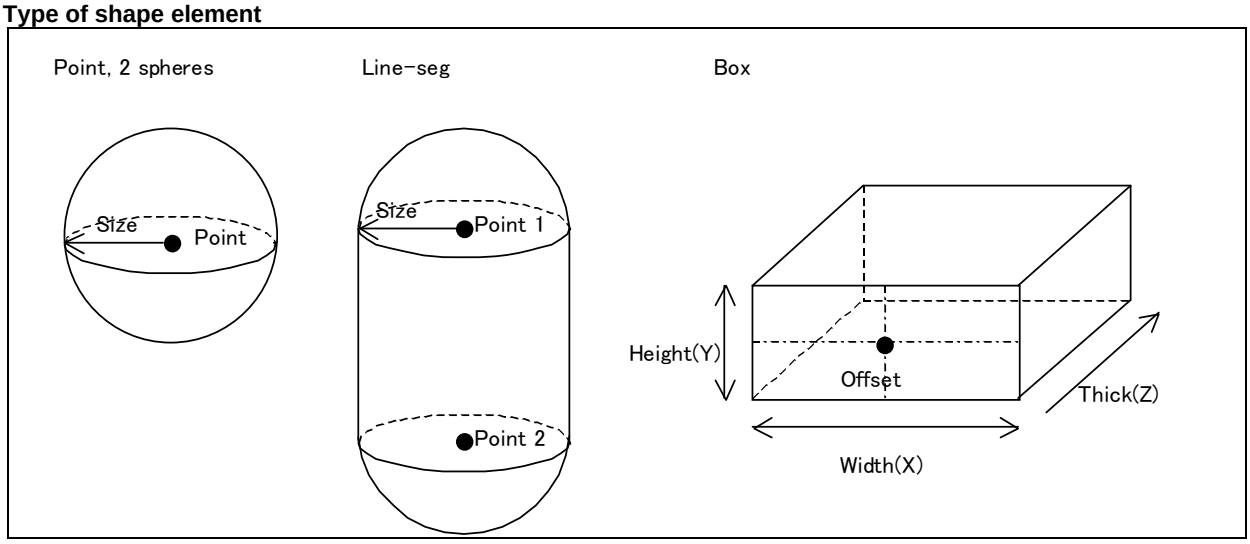
Robot model

A Robot model is a shape model of the robot arm. The Robot model is defined by default and cannot be changed. The base frame of each robot arm (link frame) is defined for each robot type. The Robot model is used for the following functions.
- Set to the zone check function as target

- Copy to user model by the operation in user model element list menu.
When the target model is set to -1 in the Zone check function, the robot model of the specified motion group is used as the target of the Zone check.
The robot model covers whole robot arm, and the robot model includes the space that actual robot arm does not exist.
The robot model cannot be changed, but it can be copied to user model. To copy robot model data to a user model, press F4(ROBOT) in user model element list menu, and enter the motion group number. After the copy, please use the user model number instead of -1 as the target model of a Zone check. The robot model data can be customized by changing the user model data.

Each User model consists of a maximum of 10 shape elements. Each shape element can be set to "Point", "Line-seg", "2 spheres" or a "Box".
Box element cannot be selectable when DCS Basic Position check function is ordered.

Type of shape element



* Each of these shape types can be used as one of the 10 shape elements.
* "Point" and "2 spheres" are very similar, but "2 spheres" can define 2 spheres for each shape element for a total of 20 spheres in one user model. When the size of a sphere is 0, the sphere is disabled. In the "Point" case, a total of 10 spheres can be defined in one user model, and the center point is checked when the size is 0.
* Only one box can be used in one User model.
* The position of a box is defined as an offset of the position at the center of Width(X) and Height(Y) on the plane of Thick(Z)=0.

Each shape element can be mounted on the robot flange or each individual robot arm (link frame). The mounting point can be specified individually for each shape element. The mounting point is set by link number and link type.

When link number is set to 99, the robot flange frame is used as the base frame of the shape element. In this case, link type is not used.

When link number is the axis number of the robot, the link frame fixed on the specified robot axis is used as the base frame of the shape element. Some robot types have axes that have two or more link frames. In this case, the link frame is selected by link type. Normally, please set "NORMAL" for link type. The corresponded link frame is displayed graphically in 4D Graphics DCS display menu when the cursor is on link number or link type item in DCS User Model Element Detail menu. The following system variables show the current position of each link frame.
$DCSS_GSTAT[Group No.].$LINK_BASE[Link No.] : Link frame for link type "NORMAL"
$DCSS_GSTAT[Group No.].$LINK_BASE_V[Link No.] : Link frame for link type "VERTICAL"

$DCSS_GSTAT[Group No.].$LINK_BASE_H[Link No.] : Link frame for link type "HORIZON"

To set a shape model on the robot arm, the robot data may be helpful for reference. The robot model data can be read by the copying it to a user model in user model detail menu.

When tool frame number is set in shape element setting, the tool frame is used as the base frame of the shape element when link number is set to 99. When link number is not 99 and tool number is set, the base frame of the shape element is the frame that is calculated by applying the matrix of the specified tool frame to the link frame of the specified link number. Please use tool frame when the orientation of a box should be defined. When a tool frame is used, the tool frame must be defined in DCS tool frame menu.

⚠WARNING
If a Shape model is set incorrectly, the safety function will not work, and serious personal injury could result. When a Shape model is changed, the values must be verified and the function must be tested again.

3.4.2 Safe Zone

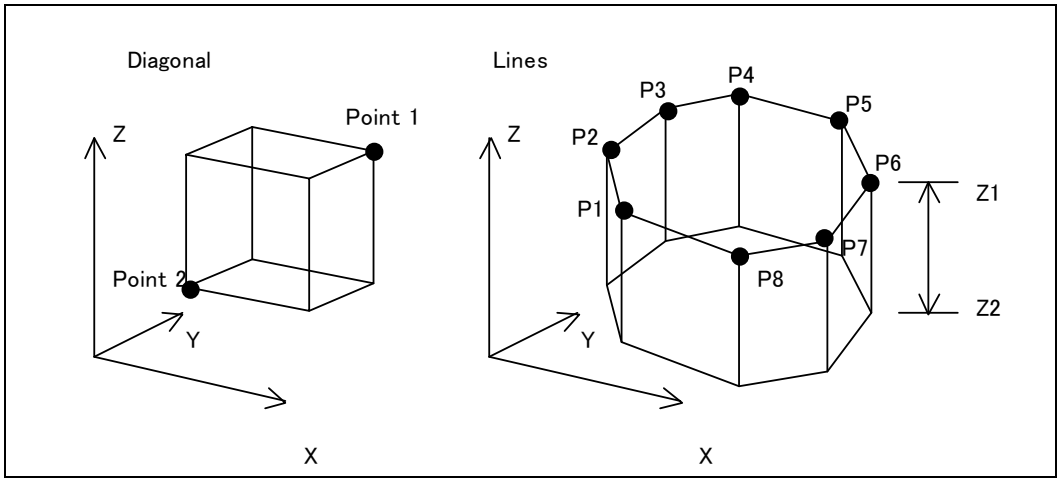
A Safe zone is the fixed zone relative to a user frame. Zone check functions check to see if the shape model is in the defined Safe zone.

⚠CAUTION
When the robot is mounted on rail axis, the safe zone is moved if the world frame of the robot is moved according to the move of the rail axis. To fix the safe zone, the rail axis should be defined as Integrated Rail axis of the same motion group with the robot.

3.4.2.1 Define the safe zone

There are 2 methods to define a safe zone, ”Diagonal” and “Lines”. The safe side can be defined as Inside or Outside for each zone individually. A maximum 32 zones can be defined.

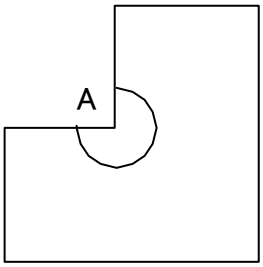
Methods to define a Safe zone



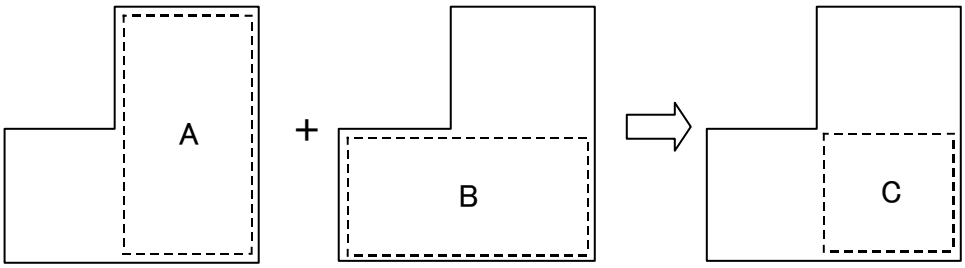
Diagonal
The Safe zone is defined as the upper and lower limits of X, Y and Z in the DCS User Frame. This defines the two end points of the diagonal of a box.

Lines
The Safe zone is defined as the vertexes of a polygon on the X-Y plane in the DCS User Frame. The

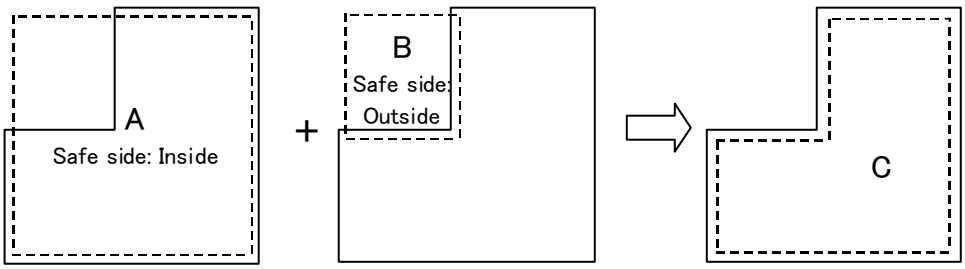
maximum number of vertexes is 8. The angle of each corner in the polygon must be less than 180 deg. The upper and lower limits are defined along the Z axis on the DCS User Frame.
The following zone cannot be set because the angle of corner A is more than 180 deg.



When two or more zones are combined, the only safe area (allow to move) is the overlapping area of all zones. In the following figure, zone A and zone B are combined. C is the actual safe zone.



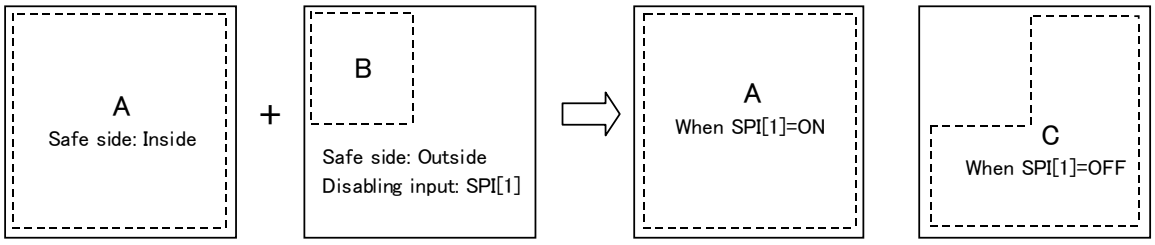
To create the following zone C that has a dent, combine Inside zone A as the surrounding area and Outside zone B as the dent.



⚠WARNING
If a Safe zone is set incorrectly, the safety function will not work, and serious personal injury could result. When a Safe zone is changed, the values must be verified and the function must be tested again.

3.4.2.2 Enable and disable zones by disabling input

Safe zones can be enabled and disabled by using the disabling input. The following figure shows an example of enabling and disabling zones by using Safe I/O (SPI[1]). The two zones A and B are defined, and the disabling input of zone B is set to SPI[1]. When SPI[1] is ON, the Cartesian Position check of zone B is disabled, and only the zone A is used. When SPI[1] is OFF, the Cartesian Position check of zone B is enabled, and the zone C is the safe zone.



3.4.2.3 Define the target shape model

Each Safe zone can check a maximum of 3 shape models. These target shape models are defined by the target model number as follows.

User model

When the target model number is 1-16 , the user model is checked in the zone check.

Robot model

When the target model number is -1, the robot model of the target motion group is checked in the zone check.

Tool model

Tool model is used when the Tool Change Function is used (refer to 3.9.1 Tool Change Function). When the target model number is -2, the tool model of the target motion group is checked in the zone check. In this case, the tool model is the user model that is assigned to the DCS Tool Frame that is currently selected (refer to 3.9 DCS TOOL FRAME). When the Tool Change Function is not used, the target model should not be -2, the user model number of the tool shape should be set to the target model directly.

Tool model cannot be selectable when DCS Basic Position check function is ordered.

> **⚠WARNING**
> If the target model number is set incorrectly, the safety function will not work, and serious personal injury could result. When the target model number is changed, the values must be verified and the function must be tested again.

3.4.2.4 Process time factor

The number of zones and models are limited to prevent processing time from becoming too long when too many zones and models are checked.

The following table shows the process time factor of each shape element. The process time factor is different for each method of safe zone to be checked.

Process time factor of shape elements

Method of safe zone	Shape of element		
	Point *	Line-seg	Box
Diagonal（Inside）	2	3	20
Diagonal（Outside）	4	7	130
Lines（Inside）	3	5	30
Lines（Outside）	5	12	220

* In "2 spheres" case, each sphere is regarded as one Point if the size is not 0.

* When DeviceNet Safety, EtherNet/IP Safety or PROFINET Safety is used, 400 is added to the process time factor.
* When Safety function by FL-net is used ("Enable/Disable" in DCS Safety function by FL-net menu is "ENABLE"), 200 is added to the process time factor.
* When Safety PMC is used ("Safe I/O process" in DCS Safe I/O device menu is "Safety PMC"), 100 is added to the process time factor.
* The process time factor of “Point” type and “2 spheres” type shape elements are calculated as “Line-seg” type when the “Expand point as line” is set “ENABLE” in stop position prediction menu.

The process time factor of one safe zone is calculated as the total of all the elements in the target model.
The system total process time factor is the total of the process time factors of all enabled safe zones. If the system total process time factor is greater than 1000 and you apply DCS parameters, the message " Too many zone or models!" will be displayed. The number displayed with this message is the system total process time factor of the current setting parameters.
The system total process time factor is also displayed in the DCS Cartesian Position Check list menu.

The process time factor of Box is much greater than Point and Line-seg. To make the process time factor small, it is effective to replace the Box by combination of Point or Line-seg.

3.4.2.5 Recovery from alarm

When any shape model is outside of the defined safe zone, a DCS Cartesian Position Check alarm occurs and cannot be cleared. To move the robot to the safe zone, select T1 mode, and enable the Teach Pendant and press and hold the SHIFT and RESET keys, and jog the robot. If the SHIFT key is released while the shape model is still outside of the defined safe zone, the alarm occurs again and motor power is shut down. The frame position and orientation just before the DCS Cartesian Position Check alarm occurs is recorded. The robot can be jogged toward the recorded position and orientation, but if the robot moves away from the recorded position, the alarm occurs again and motor power is shut down.

When a DCS Cartesian Position Check alarm occurs because the DCS Cartesian Position Check is changed from disable to enable by a disabling input, the robot can only return to the position just before the alarm occurred by this operation. If this position is not in the safe zone, the alarm occurs again. To recover from the alarm, DCS Cartesian Position Check should be disabled by the disabling input. In this case, the robot can move as far as the stopping distance when the alarm occurred even out of the safe zone. Please take care especially in the case where the stopping distance is large, for example when stop type is set to control stop.
When servo power is turned on, the robot moves slightly. To avoid DCS alarms by this motion, a very short motion is allowed even though the robot moves away from the recorded position. The robot can move slightly away from the recorded position, because the DCS alarm occurs when the moved distance of the robot exceeds the allowed short motion. If the payload setting of the robot is not correct, the motion at the servo power on becomes big, and the DCS alarm may occur. In this case, please check the payload setting or change the setting of the position check to disable temporarily.

The following describe the cases where the recorded position and orientation data are lost and cannot be recovered. To recover from the alarm in these cases, please temporarily disable the Cartesian Position Check.
- The motor or Pulsecoder is replaced, and the robot position becomes out of the safe zone.
  (In this case, the position check temporary disable function that is explained later can be used.)
- The Zone or shape model is changed and applied to DCS parameters, power to the controller is cycled, and the current position becomes out of the safe zone.
- The controller power is turned off while the robot is moving, and the robot exits the safe area by momentum movement.
- The mastering parameters or robot setup data is changed and applied to DCS parameters, power to the controller is cycled, and the robot becomes out of the safe zone.

3.4.2.6 Position check temporary disable function

When the motor or Pulsecoder is replaced and the robot position becomes out of the safe zone, the robot sometimes cannot move far enough to recover from the situation by the above SHIFT and RESET operation. In this case, the operator needs to disable position check temporarily, then do some operation to recover from the situation such as mastering, then the setting of the position check is restored to enable. The position check temporary disable function supports the operation to recover in this situation by changing the setting of the position check to DISABLE automatically when calibration is not completed (the calibration becomes not completed when the motor or Pulsecoder is replaced), and restoring the setting to ENABLE automatically when the calibration is completed.
This function is disabled by default. To enable this function, please set the system variable $DCSS_SETUP.$CALMD_ENB to 1 (DISABLE is 0). When this function is enabled, the operation to recover the situation is the following.

1. When the calibration of the motion group that is used for the Cartesian position check or the Joint position check is not completed, the alarm "SYST-212 Need to apply to DCS param" occurs.
2. Do the operation to apply DCS parameter in DCS menu.
   At this time, the setting of the all Cartesian position check and the all Joint position check that are setup for the motion group that the calibration is not completed are changed to DISABLE. Please check the setting displayed in the verify menu that is displayed after the code number is entered, and press F4(OK). (At this time, detail menu of the position check that is disabled automatically shows the message "Not calibrated! DISABLED temporarily!".)
   If the local code number is defined, the required code number of this operation is "Base" code number. (Because this operation is a part of mastering operation, and the same code number with the operation to change the mastering parameter is used.)
3. Cycle power to the robot controller.
4. The position check function is disabled now. Do the operation to recover the situation such as mastering.
5. When the calibration is completed, the alarm "SYST-212 Need to apply to DCS param" occurs.
6. Do the operation to apply DCS parameter in DCS menu.
   At this time, the setting of the all Cartesian position checks and the all Joint position checks are restored to ENABLE. Please check the setting displayed in the verify menu that is displayed after the code number is entered, and press F4(OK). (At this time, detail menu of the position check that is restored to enable shows the message "Calibrated! Restored to ENABLE!".)
   If the local code number is defined, the required code number of this operation is "Base" code number.
7. Cycle power to the robot controller.

CAUTION
- When this function is enabled, the alarm "SYST-212 Need to apply to DCS param" always occurs when the calibration of the motion group that is used for the Cartesian position check or the Joint position check is not completed, and the operation to apply DCS parameter is necessary.
- If any setting of Cartesian position check or Joint position check is changed such as the setting of safe zone, the position check temporary disable function is cancelled. For example, when the setting of the safe zone is changed during the operation of the above step 4, the operation will be the following.
  1. The alarm "SYST-212 Need to apply to DCS param" occurs.
  2. Do the operation to apply DCS parameter in DCS menu.
     At this time, the new safe zone setting is applied, and the setting of the all Cartesian position check and the all Joint position check restored to ENABLE.
     If the local code number is defined, the required code number of this operation is "Pos/Speed" code number.
  3. Cycle power the robot controller.

4. The alarm "SYST-212 Need to apply to DCS param" occurs. (Because the calibration of the motion group that is used for the Cartesian position check or the Joint position check is not completed.)

After that, go to step 2 in the above operation.

3.4.2.7 Approach warning signal output function

This function turns ON a DO signal when the shape model approaches the border of a safe zone in a DCS zone check function. When the distance from the border of the safe zone is less than the specified margin, the DO signal stays ON.
The index of the DO is set in $DCSS_SETUP.$DO_IDX.
The margin is set in $DCSS_SETUP.$DO_MGN. The unit is mm. The default value is 100 mm.
When the value is changed, cycle power is necessary to use the new value.
Please note the following about the approach warning signal output function.

- The approach is checked by the position relationship between the shape model and the safe zone. The stop position prediction function and operation to recover from alarm does not affect this function.
- When the setting of DCS zone check function (safe zone, shape model, tool frame and so on) is invalid, the approach warning signal output is always set to OFF.

> **⚠WARNING**
> Approach warning signal output function is not a safety function. If the DO of this function is used where a safety function is required, the safety function will not work under some fault conditions and serious personal injury could result. Do not use Approach warning signal output function for safety purposes.

3.4.3 Stop Position Prediction

When the motor power is shut down while the robot is moving, the robot's momentum causes it to move some distance before it completely stops. Stop Position Prediction is a function to predict the stop position of each shape model according to the current moving direction and speed, and enlarge the shape model to includes both the current position and the predicted stop position, and predicts that the model will exit the safe zone when the enlarged shape model is out of the safe zone. In this case, the robot will shut down motor power earlier to minimize the stopping distance beyond the defined safe zone.

The stop position prediction is disabled by default. In this case, the alarm occurs when the shape model exits the safe zone, and the stop position of robot is out of the safe zone for the stopping distance. Please refer to "1.7 STOPPING DISTANCE" about stopping distance.

To enable the stop position prediction, select "DEFAULT" or "USER" for mode of Cartesian in DCS stop position prediction menu.

⚠CAUTION
- The stop position prediction for Cartesian Position Check is disabled by default. To enable the stop position prediction, select "DEFAULT" or "USER" for mode of Cartesian in DCS stop position prediction menu.
- Stop position prediction for each zone of Cartesian Position Check can be disabled individually. The stop position prediction for the zone is disabled when “Use Stop Position Prediction” is set “No” in DCS Cartesian Position Check detail menu, even though the mode of Cartesian is set "DEFAULT" or "USER" in DCS stop position prediction menu.
- The stop position prediction for Cartesian Position Check is disabled when the mode of Cartesian is set "DISABLE" in DCS stop position prediction menu, even though “Use Stop Position Prediction” is set “Yes” in DCS Cartesian Position Check detail menu.

This distance depends on the type of robot, payload, and speed, but mostly it is proportional to the speed. Stop Position Prediction predicts the stop position so that the stopping distance is 0 mm at 0 mm/sec and is increased proportionally with increased speed. The proportion factor is setup in the DCS Stop Position Prediction menu.

The default of the proportion factor is set as 1.5 times the value of the stopping distance at the maximum speed and maximum payload for each robot. When Stop Position Prediction is used with the default setting, motor power is shut off farther away from the border of the zone when speed is increased.

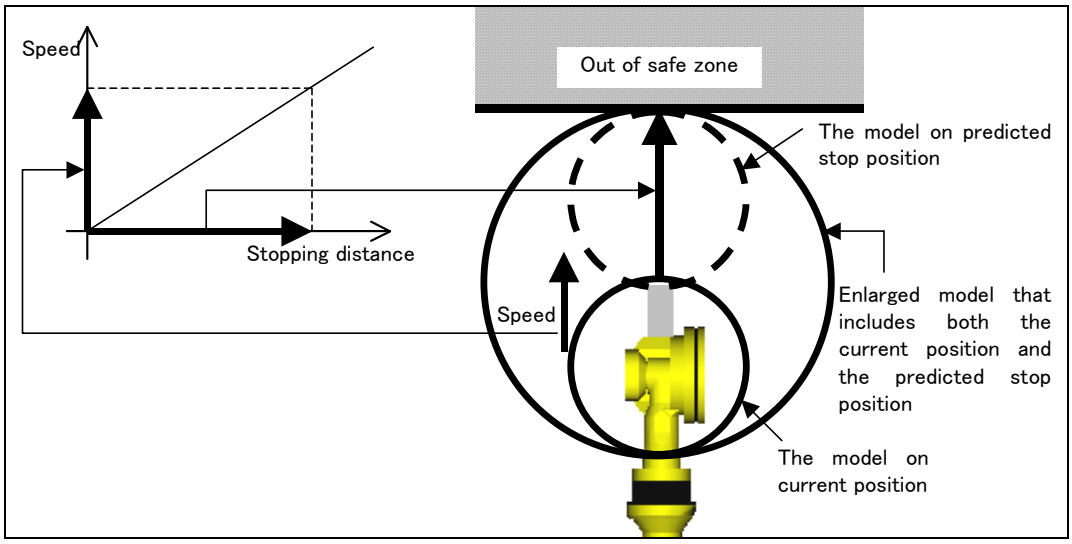
The proportion factor is different between Power-off stop and control stop, and set up individually.
When the stop type of Cartesian Position Check is Power-off stop, the proportion factor of Power-off stop is used.
When the stop type of Cartesian Position Check is control stop, both the proportion factor of Power-off stop and control stop are used. When the predicted stop position calculated by the proportion factor of control stop is out of the safe zone, a control stop is performed. When the predicted stop position calculated by the proportion factor of Power-off stop is out of the safe zone, a Power-off stop is performed. This means that Power-off stop is always done if the stopping distance of a Power-off stop is greater than a control stop.

When the stop type is set to "Not stop", Stop Position Prediction is not used.

Please refer to section 0
SETUP STOP POSITION PREDICTION for details of the Stop Position Prediction menu.

When a shape model moves parallel to the border of a safe zone, alarms may occur due to Stop Position Prediction because the model may also be enlarged to the side direction. In this case, please reduce the motion speed or change the motion path to be farther away from the border of the safe zone.

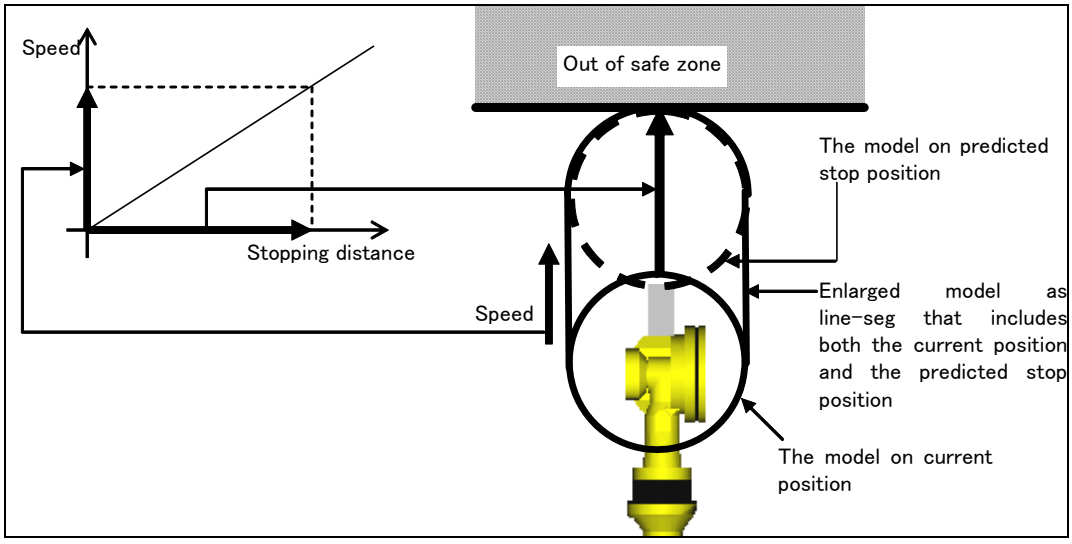
When robot wrist rotates at high speed, a shape element that is far from the robot wrist, for example the end of robot tooling, may be detected to be out of the safe zone by Stop Position Prediction. In this case, please reduce the motion speed or change the motion path to be farther away from the border of the safe zone.



⚠WARNING
If Stop Position Prediction is set incorrectly, the robot will exit the safety zone, and serious personal injury could result. When Stop Position Prediction is changed, the values must be verified and the function must be tested again.

⚠WARNING
When an axis does not have mechanical brake, the axis can move freely when motor power is shutdown, and the stop position prediction does not work correctly for the axis. In this case, a risk assessment for the whole robot system is necessary, including the freely movement of the axis that does not have mechanical brake.

When the “Expand point as line” is set “ENABLE” in DCS stop position prediction menu, shape elements of “Point” type and “2 spheres” type are processed as “Line-seg” type that is expanded to the moving direction as the following figure. In this case, alarm will not occur when the shape element moves parallel with the boarder of the zone that is near to the shape element, because the shape element is not expanded to the direction other than the moving direction. But actual direction of the stopping motion can be different from the moving direction, and the stop position can be out of the safe zone.



⚠WARNING
When the “Expand point as line” is set “ENABLE” in stop position prediction menu, actual direction of the stopping motion can be different from the moving direction, and the stop position can be out of the safe zone, and serious personal injury could result. When the “Expand point as line” is set “ENABLE”, a risk assessment for the whole robot system is necessary including the stop position can be out of the safe zone.

⚠CAUTION
- The shape element expansion process of the stop position prediction for “Point” type and “2 spheres” type is changed by the setting of the “Expand point as line” in stop position prediction menu, but the process of shape element expansion for “Line-seg” type and “Box” type is not affected.
- The process time factor of “Point” type and “2 spheres” type shape elements are calculated as “Line-seg” type when the “Expand point as line” is set “ENABLE” in stop position prediction menu.

3.4.4 DCS Cartesian Position Check List Menu

The DCS Cartesian Position Check list menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "Cartesian Position Check" item in the DCS Top menu.

```
DCS
Cartesian position check                1/32
  Process time factor (Max.1000):       36
 No.        G M Status     Comment
  1 ENABLE 1 DO CHGD [                    ]
  2 DISABL 1 DI ---- [                    ]
  3 DISABL 1 DI ---- [                    ]
  4 DISABL 1 DI ---- [                    ]

[ TYPE ]          DETAIL
```

Items in DCS Cartesian Position Check list menu

Item	Description
Process time factor	Process time factor of the current setting parameters. When this value is greater than 1000, DCS parameter changes cannot be applied.
No.	The Cartesian Position Check number is displayed.
ENABLE/DISABLE	The Enable/Disable status of the Cartesian Position Check is displayed.
G	The target motion group number is displayed.
M	The method of Cartesian Position Check is displayed. DI: Diagonal (Inside) DO: Diagonal (Outside) LI: Lines (Inside) LO: Lines (Outside) OA: Orientation Fix (ALL) OZ: Orientation Fix (User Z)
Status	The status of the Cartesian Position Check is displayed. ----: Disabled by setting SAFE: Enabled, and in safe zone. UNSF: Enabled, and out of safe zone. DSBL: Disabled by disabling input. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled
Comment	The comment of the Cartesian Position Check is displayed.

Operation in DCS Cartesian Position Check

Operation	Description
F3(DETAIL) or ENTER	The Cartesian Position Check detail menu of the item the cursor is on is displayed.
PREV	The DCS Top menu is displayed.

3.4.5 DCS Cartesian Position Check (Diagonal) Menu

The DCS Cartesian Position Check detail menu is displayed by pressing the ENTER key or the F3(DETAIL) key while in the DCS Cartesian Position Check list menu. When the method is set to "Diagonal(Inside)" or "Diagonal(Outside)", the DCS Cartesian Position Check (Diagonal) menu is displayed.

```
DCS
Cartesian position check            1/13
    No.  1              Status:CHGD
  1 Comment:  [**********************]
  2 Enable/Disable:           ENABLE
  3 Method(Safe side):Diagonal(OUT)
  4 Group:                         1
  5 Target model 1:               -1
  6 Target model 2:                1
  7 Target model 3:                0
      (0:Disable,-1:Robot,-2:Tool)
  8 User frame:                    0
    Position(mm):
       Current      Point 1     Point 2
  9 X    1827.0     3000.0    -3000.0
 10 Y       0.0     3000.0    -3000.0
 11 Z    1300.0     2000.0        0.0
 12 Stop type:         Emergency stop
 13 disabling input: ---[  0:          ]
 14 Use Stop Position Prediction: Yes

[ TYPE ]  PREV    NEXT   RECORD  UNDO  >
```

Items in Cartesian Position Check (Diagonal) menu

Item	Description
No.	The Cartesian Position Check number is displayed.
Status	The status of the Cartesian Position Check is displayed. ----: Disabled by setting SAFE: Enabled, and in safe zone. UNSF: Enabled, and out of safe zone. DSBL: Disabled by disabling input. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled
Comment	Used to set the comment of the Cartesian Position Check The comment set in this menu is also used as comment of the Safe I/O CPC[ ].
Enable/Disable	Used to set the Enable / Disable of the Cartesian Position Check. When set to disable, all other settings in this menu are ignored.
Method(Safe side)	Used to set the method of defining the zone. Diagonal (Inside): Setup the safe zone using the two end points of the diagonal of a box in the DCS User Frame. Inside the box is the safe zone. Diagonal (Outside): Setup the safe zone using the two end points of the diagonal of a box in the DCS User Frame. Outside the box is the safe zone.
Group	Used to set the target motion group number.
Target model 1-3	Used to set the number of the target shape model that is checked. A maximum of 3 shape models can be defined. When set to 0, the target model is disabled. When set to 1-16, the user model is checked. When set to -1, the robot model of the target motion group is checked. When set to -2, the tool model of the target motion group is checked.
User frame	Used to set the user frame number that is used as the base frame of the zone. When set to 0, the motion group World frame is used. To use a DCS User Frame, setup the user frame origin and orientation in the DCS User Frame menu.
Current	The current position is displayed. This is the position of the ordinary TCP (not the DCS TCP) and the base frame is the DCS User Frame that is specified in this menu.
Point 1, Point 2	Both ends of the diagonal of the box defined as the safe zone. When the cursor is on this item, the current ordinary TCP position (displayed current position) is recorded to point 1 or point 2 by pressing SHIFT + F4(RECORD).
Stop type	Used to set the action when the target model is out of the defined safe zone. Power-off stop: Motor power is shut down immediately. Control stop: Deceleration stop, then motor power is shut down. (Motor power shutdown is delayed for maximum 2 seconds.) Not stop: Robot does not stop. The status is set in Safe I/O CPC.
Disabling input	To enable / disable the Cartesian Position Check dynamically, a Safe I/O can be set as a disabling input. When the specified Safe I/O is ON, this function disabled. When the specified Safe I/O is OFF, this function is enabled. When the specified Safe I/O is undefined(--), this function is enabled. NOTE - Safety input (SPI) is hardware option. However, SPI[1-2] are available as standard in A cabinet controller of R-30*i*B. NOTE - Zone Status can be used as disabling input; refer to section 5.1 for zone status (CPC, CSC, JPC, & JSC) definitions
Use Stop Position Prediction	Yes: The stop position prediction is enabled for this zone when the mode of Cartesian is set "DEFAULT" or "USER" in DCS stop position prediction menu. No: The stop position prediction is disabled for this zone.

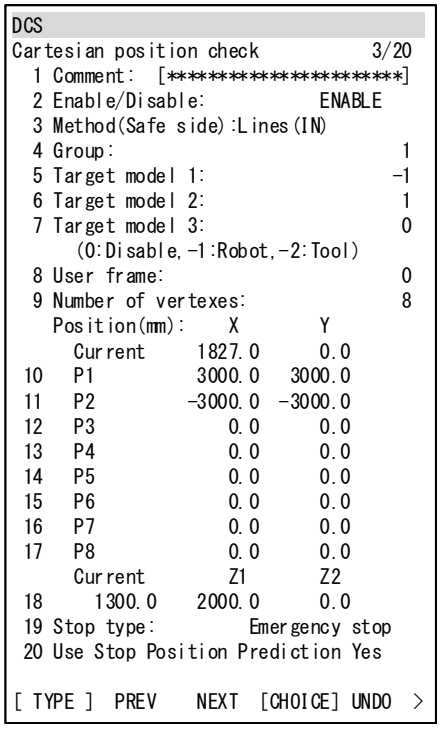
⚠CAUTION
- The stop position prediction for Cartesian Position Check is disabled by default. To enable the stop position prediction, select "DEFAULT" or "USER" for mode of Cartesian in DCS stop position prediction menu.
- Stop position prediction for each zone of Cartesian Position Check can be disabled individually. The stop position prediction for the zone is disabled when “Use Stop Position Prediction” is set “No” in DCS Cartesian Position Check detail menu, even though the mode of Cartesian is set "DEFAULT" or "USER" in DCS stop position prediction menu.
- The stop position prediction for Cartesian Position Check is disabled when the mode of Cartesian is set "DISABLE" in DCS stop position prediction menu, even though “Use Stop Position Prediction” is set “Yes” in DCS Cartesian Position Check detail menu.

Operation in Cartesian Position Check (Diagonal) menu

Operation	Description
F2(PREV	The previous Cartesian Position Check is displayed.
F3(NEXT)	The next Cartesian Position Check is displayed.
SHIFT+F4(RECORD)	When cursor is on point 1 or point 2, the current position of the ordinary TCP is set.
F5(UNDO)	UNDO the items in this menu. The setting parameters become the same as the current DCS parameters.
NEXT, SHIFT+F4(MOVETO)	When the cursor is on point 1 or point 2, the robot (ordinary TCP) moves to that position. The robot moves in linear motion, if the robot cannot reach the position, please jog to a different position and try again. If the SHIFT key is released while moving, the robot stops.
PREV	The Cartesian Position Check list menu is displayed.

3.4.6 DCS Cartesian Position Check (Lines) Menu

The DCS Cartesian Position Check detail menu is displayed by pressing the ENTER key or the F3(DETAIL) key while in the DCS Cartesian Position Check list menu. When the method is set to "Lines(Inside)" or "Lines(Outside)", the DCS Cartesian Position Check (Lines) menu is displayed.



Items in Cartesian Position Check (Lines) menu

Item	Description
Method(Safe side)	Used to set the method of defining the zone Lines (Inside): Setup the safe zone using a maximum of 8 vertexes on the X-Y plane and the upper and lower limits along the Z axis of the DCS User Frame. The angle of each corner in the polygon must be less than 180 deg. Inside the polygon is the safe zone. Lines (Outside): Setup the safe zone using a maximum 8 vertexes on the X-Y plane and the upper and lower limits along the Z axis of the DCS User Frame. The angle of each corner in the polygon must be less than 180 deg. Outside the polygon is the safe zone.
Number of vertexes	Number of vertexes of the polygon on the X-Y plane. The range is 3-8. Default is 8.
P1-8	Used to set the position of the vertexes. The polygon is made by connecting the vertexes as P1→ P2→ P3→.. →P8 in the X-Y plane. The angle of each corner must be less than 180 deg. Vertexes beyond the number of vertexes are ignored.

NOTE – For items that are not described in this table, please refer to "Items in DCS Cartesian Position Check (Diagonal) menu".

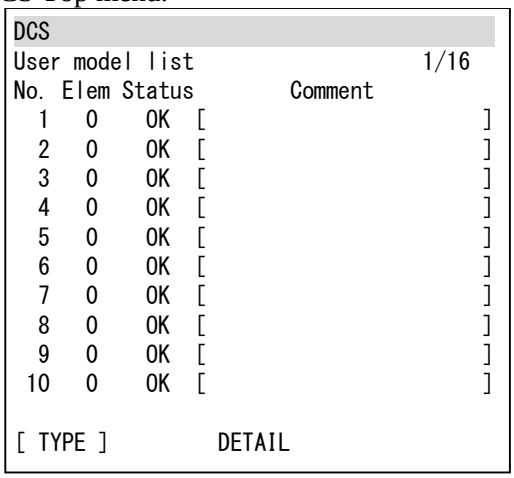
Operation in Cartesian Position Check (Lines) menu

Operation	Description
SHIFT+F4(RECORD)	When cursor is on P1-8, the current position of the ordinary TCP is set.
NEXT, SHIFT+F4(MOVETO)	When the cursor is on P1-8, the robot (ordinary TCP) moves to that position. The robot moves in linear motion, if the robot cannot reach the position, please jog to a different position and try again. If the SHIFT key is released while during moving, the robot stops.

NOTE - For operations that are not described in this table, please refer to "Items in DCS Cartesian Position Check (Diagonal) menu".

3.4.7 DCS User Model List Menu

The DCS User Model List menu is displayed by pressing ENTER key or the F3(DETAIL) key while on the "User model" item in the DCS Top menu.



Items in DCS User model list menu

Item	Description
No.	The User Model number is displayed
Elem	The number of elements that are enabled in the User Model is displayed.

Item	Description
Status	The status of the User model is displayed. OK: Setting parameter and DCS parameter are the same. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.
Comment	The comment of the User Model is displayed.

Operation in DCS User model menu

Operation	Description
F3(DETAIL) or ENTER	The DCS User Model Element List menu of the item the cursor is on is displayed.
PREV	The DCS Top menu is displayed.

3.4.8 DCS User Model Element List Menu

```
DCS
User model detail(10 elements)     1/11
No.   1  [**********************]
 Elements
  No.          Link  Shape    Size Status
  1 ENABLE     99  Point    200.0   CHGD
  2 DISABLE    99  Point      0.0     OK
  3 DISABLE    99  Point      0.0     OK
  4 DISABLE    99  Point      0.0     OK
  5 DISABLE    99  Point      0.0     OK
  6 DISABLE    99  Point      0.0     OK
  7 DISABLE    99  Point      0.0     OK
  8 DISABLE    99  Point      0.0     OK
  9 DISABLE    99  Point      0.0     OK
 10 DISABLE    99  Point      0.0     OK

[ TYPE ]                 ROBOT   UNDO
```

Items in DCS User model element list menu

Item	Description
No.	The number of the User Model is displayed.
Comment	Used to set the comment of the User Model.
Element No.	The element number is displayed.
ENABLE/DISABLE	The Enable / Disable status of the element is displayed.
Link	The link number that the element is mounted to is displayed.
Shape	The shape of the element is displayed.
Size	The size of the element is displayed. When the shape is "2 spheres", the size of sphere 1 is displayed. When the shape is "Box", 0 is always displayed.
Status	The Status of the element is displayed. OK: Setting parameter and DCS parameter are the same. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.

Operation in DCS User model element list menu

Operation	Description
F3(DETAIL) or ENTER	The DCS User Model element detail menu of the item the cursor is on is displayed.
F4(ROBOT)	Copy the Robot Model data to this User Model. The message "Group of copy source robot model:" is displayed. Please enter the group number.

Operation	Description
F5(UNDO)	UNDO the items in this user model. The setting parameters become the same as the current DCS parameters.
PREV	The DCS User Model List menu is displayed.

3.4.9 DCS User Model Detail (Point/Line-Seg) Menu

```
DCS
User element detail                1/9
No.   1  [**********************]
Element:  1    Status: CHGD

  1 Enable/Disable:            ENABLE
  2 Link No.(99:FacePlate):          99
  3 Link type:                 NORMAL
  4 Tool frame:                       0
  5 Shape:                     Point
  6 Size (mm):                   200.0
  Pos1
  7  X:    0.000 Y:    0.000 Z:  100.000
  Pos2
  8  X:    0.000 Y:    0.000 Z:    0.000

[ TYPE ]                          UNDO
```

Items in DCS User Model Detail (Point/Line-seg) menu

Item	Description
No.	The User Model number is displayed.
Comment	Used to set the comment of the User Model.
Element	The element number is displayed.
Status	The status of the element is displayed. OK: Setting parameter and DCS parameter are the same. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.
Enable/Disable	Used to set Enable / Disable of the element.
Link No.	Used to set the link number that the element is mounted to. When 99 is set, the element is mounted to the flange. The corresponded link frame is displayed graphically in 4D Graphics DCS display menu when the cursor is on this item.
Link type	Used to set the type of the link connection. When link No. is set to 99, this setting is ignored. The available link type of each link is defined by each robot model. Please refer to the robot model setting for the link type setting. The corresponded link frame is displayed graphically in 4D Graphics DCS display menu when the cursor is on this item.
Tool frame	When link No. is 99, this item defines the base tool frame of the element instead of the flange. When it is set to 0, the element is mounted on the flange. NOTE - When the link No. is not 99, the element applies the specified tool frame values to the specified link frame. This setting can be used to rotate a box element, but care must be taken to ensure that the element is mounted in the correct base frame and tested carefully.

Item	Description
Shape	Used to select the shape of the element from "Point", "Line-seg", "2 Spheres" and "Box". When "Point" or "Line-seg" is selected, the DCS User Model Element Detail (Point/Line-seg) menu is displayed. When "2 Spheres" is selected, DCS User Model Element Detail (2 Spheres) menu is displayed. When "Box" is selected, DCS User Model Element Detail (Box) menu is displayed. NOTE - Only one "Box" element is allowed in a User Model. If 2 or more "Box" elements are defined and enabled, an alarm occurs.
Size	In a "Point" element, this is used to set the radius of the sphere. In a "Line-seg" element, this is used to set the radius of the cylinder.
Pos1	In a "Point" element, this is used to set the center of the sphere. In a "Line-seg" element, this is used to set one end point of the center line of the cylinder.
Pos2	In a "Point" element, this item is ignored. In a "Line-seg" element, this is used to set the other end point of center line of the cylinder.

Operation in DCS User Model Detail (Point/Line-seg) menu

Operation	Description
F5(UNDO)	UNDO the items in this menu. The setting parameters become the same as the current DCS parameters.
PREV	The DCS User model element list menu is displayed.

3.4.10 DCS User Model Element Detail (2 Spheres) Menu

```
DCS
User element detail(2 spheres)     6/10
No.   1  [**********************]
Element:  1    Status: CHGD

  1 Enable/Disable:             ENABLE
  2 Link No.(99:FacePlate):           99
  3 Link type:                  NORMAL
  4 Tool frame:                        0
  5 Shape:                      2spheres
  Pos1
  6 Size (mm):                     200.0
  7  X:    0.000 Y:    0.000 Z:  100.000
  Pos2
  8 Size (mm):                       0.0
  9  X:    0.000 Y:    0.000 Z:    0.000

[ TYPE ]                           UNDO
```

Items in DCS User Model Element Detail (2 Spheres) menu

Item	Description
Pos1 Size	Used to set the size of sphere 1. When this is set to 0, sphere 1 is disabled.
Pos1 X,Y,Z	Used to set the center position of sphere 1.
Pos2 Size	Used to set the size of sphere 2. When this is set to 0, sphere 2 is disabled.
Pos2 X,Y,Z	Used to set the center position of sphere 2.

NOTE - For items that are not described in this table, please refer to "Items in DCS User model element detail (Point/Line-seg) menu".

3.4.11 DCS User Model Element Detail (Box) Menu

```
DCS
User model detail(Box)              6/10
No.   1  [**********************]
Element:  1    Status: CHGD

  1 Enable/Disable:             ENABLE
  2 Link No.(99:FacePlate):          99
  3 Link type:                  NORMAL
  4 Tool frame:                       0
  5 Shape:                      Box
 Box
  6 Width (X) (mm):                0.0
  7 Height(Y) (mm):                0.0
  8 Thick (Z) (mm):                0.0
  Offset
  9 X:    0.0  Y:    0.0  Z:  100.0

[ TYPE ]                          UNDO
```

Items in DCS User Model Element Detail (Box) menu

Item	Description
Width(X)	Used to set the width (size of X) of the box.
Height(Y)	Used to set the height (size of Y) of the box.
Thick(Z)	Used to set the thickness (size of Z) of the box.
Offset	Used to set the offset of the box.

NOTE - For items that are not described in this table, please refer to "Items in DCS User model element detail (Point/Line-seg) menu".

NOTE - Box element cannot be selectable when DCS Basic Position check function is ordered.

3.5 ORIENTATION CHECK FUNCTION (CARTESIAN POSITION CHECK FUNCTION)

The Orientation Check function checks the difference between the current robot faceplate orientation and the base faceplate orientation, and shuts down the motor power if it is greater than the defined limit.
The Orientation Check function cannot be used when DCS Basic Position check function is ordered.
There are 2 modes of the orientation check, "ALL" and "User Z".

ALL

Checks if the rotation angle around X, Y, and Z between the current robot faceplate orientation and the base faceplate orientation is greater than the limit.

User Z

Checks if the rotation angle around X and Y between the current robot faceplate orientation and the base faceplate orientation is greater than the limit. In this case, it is possible to rotate around the Z axis of the DCS User Frame without causing an alarm while not allowing rotation beyond the defined limit in the X and Y directions.

⚠WARNING

If DCS Orientation check is set incorrectly, the safety function will not work, and serious personal injury could result. When DCS Orientation check is changed, the values must be verified and the function must be tested again.

Recover from alarm

The operation to recover from the alarm is the same as the Zone Check function. (Refer to 3.4 ZONE CHECK FUNCTION (CARTESIAN POSITION CHECK FUNCTION))

3.5.1 DCS Cartesian Position Check (Orientation Fix) Menu

The DCS Cartesian Position Check Detail menu is displayed by pressing ENTER key or F3(DETAIL) key while in the DCS Cartesian Position Check List menu. When the method is "OrntFix(ALL)" or "OrntFix(UserZ)", the DCS Cartesian Position Check (Orientation Fix) menu is displayed.

```
DCS
Cartesian position check          3/11
    No.  1              Status:CHGD
  1 Comment:  [**********************]
  2 Enable/Disable:           ENABLE
  3 Method(Safe side):OrntFix(ALL)
  4 Group:                         1
  5 User frame:                    0
    Face Plate orientation(deg):
       Current      Base
  6 W   180.000   3000.000
  7 P   -90.000   3000.000
  8 R     0.000   2000.000
  9 Angle of any direction(deg):
       Current     Limit
       90.000      0.000
 10 Stop type:         Emergency stop
 11 disabling input: ---[  0:          ]

[ TYPE ]  PREV    NEXT  [CHOICE] UNDO  >
```

Items in DCS Cartesian Position Check (Orientation Fix) menu

Item	Description
Method(Safe side)	Used to set the method of orientation check. Orientation Fix (ALL): The difference between the current orientation and the base orientation is checked. Orientation of all directions is checked. Orientation Fix (UserZ): The difference between the current orientation and the base orientation is checked. Rotation of the Z axis in the DCS User Frame is ignored. Orientation of all other directions is checked.
Face plate orientation Current	The current orientation (W,P,R) of the Face Plate is displayed. The values are relative to the DCS User Frame specified in this menu.
Face plate orientation Base	Used to set the Base orientation (W,P,R) of the Face Plate. The values are relative to the DCS User Frame specified in this menu.
Angle Current	The difference between current orientation and the Base orientation is displayed.
Angle Limit	Used to set the limit of the difference between the current orientation and the Base orientation.

NOTE - For items that are not described in this table, please refer to "Items in DCS Cartesian Position Check (Diagonal) menu".

Operation of DCS Cartesian Position Check (Orientation Fix) menu

Operation	Description
SHIFT+F4(RECORD)	When the cursor is on "Face plate orientation, Base", the current orientation is set.
NEXT, SHIFT+F4(MOVETO)	When cursor is on "Face plate orientation, Base", the robot moves to that orientation. The robot moves in linear motion, it the robot can not reach the position, please jog to a different position and try again. If the SHIFT key is released while moving, the robot stops.

NOTE - For operations that are not described in this table, please refer to "Items in DCS Cartesian Position Check (Diagonal) menu".

3.6 BASIC POSITION CHECK FUNCTION

The Basic Position Check function is restricted version of Cartesian Position check function. Refer to the 3.4 Zone Check Function to use.

3.6.1 Restriction of Basic Position function

Following functions are restricted in The Basic Position Check function compared to Cartesian Position Check function.

- Safe zone is only one.
- Safe zone method is Diagonal(IN/OUT) or Line(IN/OUT). Orientation method is not supported.
- Tool Change is not supported. Therefore Cannot input -2 (tool model) as target model. If use tool model, user model number directory input in target model.
- User frame is not supported.
- Box element is not supported in user model.

If select unsupported functions, "Need J567(DCS Pos.speed check option" displayed and reset the value.

3.7 CARTESIAN SPEED CHECK FUNCTION

The Cartesian Speed Check function checks the DCS TCP (base of the DCS tool frame) speed of the robot and shuts down the motor power if the DCS TCP speed exceeds the speed limit.

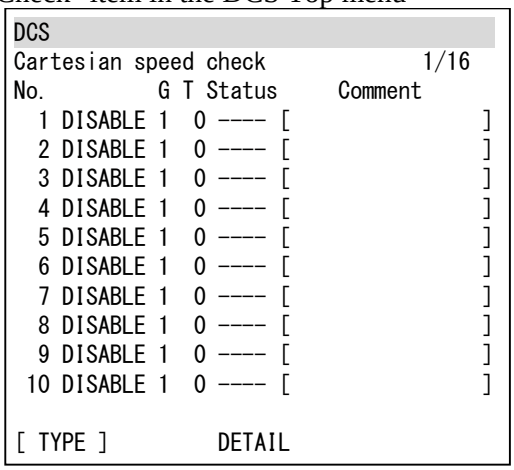
- A maximum of 16 speed limits can be defined.
- Cartesian Speed Check checks the speed of the selected DCS TCP (Refer to Section 3.9 DCS TOOL FRAME)
- If a motion exceeds the speed limit set by Cartesian Speed Check, the alarm “SRVO-403 DCS Cart. speed limit” occurs, and the motor power is shut down.
- This function can be used to check if the robot is stationary by setting the speed limit to 0. False alarms caused by vibration during servo ON can be avoided by tuning of the permissible distance.
- When Safe I/O is set as a disabling I/O, it is possible to ENABLE / DISABLE Cartesian Speed Check by using Safe I/O for each Cartesian Speed Check. When the specified Safe I/O is ON, Cartesian Speed Check is disabled. When it is OFF, it is enabled.
- The status of Cartesian Speed check can be monitored by a DI when the DI is assigned to rack 36, slot 7, start point 1-16. The start point corresponds to the Cartesian Speed check number. When the Cartesian Speed check is enabled and speed does not exceed the limit (Status:SAFE), the DI is ON. In the other case, the DI is OFF.

⚠WARNING
If Cartesian Speed Check is set incorrectly, the safety function will not work, and serious personal injury could result. When Cartesian Speed Check is changed, the values must be verified and the function must be tested again.

⚠WARNING
When the Limit is set to 0 and the Permissible distance is not set to 0, the motor power does not shut down immediately when the DCS TCP moves. The stopping distance can be increased by acceleration in Permissible distance. Adequate risk assessment for the whole robot system is necessary to determine Permissible distance.

3.7.1 DCS Cartesian Speed Check List Menu

The DCS Cartesian Speed Check list menu is displayed by pressing the ENTER key or F3(DETAIL) key while on the "Cartesian Speed Check" item in the DCS Top menu



DCS Cartesian Speed Check list menu

Item	Description
No.	The Cartesian Speed Check number is displayed.
ENABLE/DISABLE	The Enable/Disable status of the Cartesian Speed Check is displayed.
G	The Target motion group number is displayed.
T	The Target DCS Tool Frame number is displayed.
Status	The Status of the Cartesian Speed Check is displayed. ----: Disabled by setting SAFE: Enabled, and less than the limit. OVER: Enabled, and over the limit. DSBL: Disabled by disabling input. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.
Comment	The comment of Cartesian Speed Check is displayed.

Operation of DCS Cartesian Speed Check list menu

Operation	Description
F3(DETAIL) or ENTER	The DCS Cartesian Speed Check detail menu of the item the cursor is on is displayed.
PREV	The DCS Top menu is displayed.

3.7.2 DCS Cartesian Speed Check Detail Menu

```
DCS
Cartesian speed check                1/10
    No.  1              Status:----
  1 Comment:   [**********************]
  2 Enable/Disable:             DISABLE
  3 Direction:                      ALL
  4 Group:                            1
  5 Tool frame:                       0
    (0:FacePlate, -1:Current tool)
  6 User frame:                       0
    Speed of the direction(mm/sec):
      Current:                    0.000
  7   Limit:                      0.000
  8 Stop type:          Emergency stop
  9 disabling input: ---[  0:           ]
 10 Permissible distance(mm):       0.0

[ TYPE ]  PREV    NEXT            UNDO
```

DCS Cartesian Speed Check detail menu

Item	Description
No.	The Cartesian Speed Check number is displayed.
Status	Status of Cartesian Speed Check is displayed. ----: Disabled by setting SAFE: Enabled, and less than the limit. OVER: Enabled, and over the limit. DSBL: Disabled by disabling input. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.
Comment	Used to set the comment of the Cartesian Speed Check. The comment set in this menu is also used as the comment of Safe I/O CSC[ ].
Enable/Disable	Used to set Enable / Disable of the Cartesian Speed Check. When this is disabled, all other settings in this menu are ignored.
Direction	Used to set the direction of the speed check. ALL: The composite speed is checked (Direction is not considered.) X: Only X direction speed is checked. (+/- is not considered) Y: Only Y direction speed is checked. (+/- is not considered) Z: Only Z direction speed is checked. (+/- is not considered) -X: Only -X direction speed is checked -Y: Only -Y direction speed is checked -Z: Only -Z direction speed is checked +X: Only +X direction speed is checked +Y: Only +Y direction speed is checked +Z: Only +Z direction speed is checked
Group	Used to set the target motion group number.
Tool frame	Used to set the target DCS Tool Frame number. When this is set to 0, the target is the Face Plate. When this is set to -1, the target is the DCS Tool Frame that is selected. In this case, the target tool frame is the DCS tool frame specified by "Tool select" in the DCS Tool Frame menu. When "Tool select" in the DCS Tool Frame menu is also -1, the DCS Tool Change function is enabled and the target tool frame is changed when the ordinary TCP is changed.
User frame	Used to set the DCS User Frame number that is used as the base frame of the direction to check when direction is not ALL.
Current	The current speed of the target DCS Tool Frame is displayed.

Item	Description
Limit	Used to set the speed limit. When it is set to 0, this function checks if the DCS TCP is stationary. In this case, the DCS TCP movement is detected when the DCS TCP moves more than the "Permissible distance".
Stop type	Used to set the action when the target DCS TCP speed exceeds the limit Power-off stop: Motor power is shut down immediately. Control stop: Deceleration stop, then motor power is shut down. (Motor power shutdown is delayed for maximum 2 seconds.) Not stop: Robot does not stop. The status is set in Safe I/O CSC. NOTE – When the robot starts motion from a stopped position with the limit set to 0 and the stop type set to “Control Stop”, motor power is shut down immediately to minimize the robot stopping distance. When the Cartesian Speed Check is changed from disable to enable by disabling I/O during robot motion, a control stop is performed. NOTE – When the robot starts motion from a stopped position with the limit set to 0 and the stop type set to “Not Stop”, the state changes to “OVER” when the robot begins motion, but does not change back to "SAFE" if the robot stops later. To return to the "SAFE" status, please turn off motor power, or disable the Cartesian speed check by disabling I/O. To use a “Not Stop” zone to dynamically indicate robot motion in the Safe I/O Connect function without shutting down motor power, set the stop type to “Not Stop” and the speed limit to a small value greater than zero.
Disabling input	To enable / disable the Cartesian Speed Check dynamically, a Safe I/O can be set as a disabling input. When the specified Safe I/O is ON, this function disabled. When the specified Safe I/O is OFF, this function is enabled. When the specified Safe I/O is undefined(--), this function is enabled. NOTE - Safety input (SPI) is hardware option. However, SPI[1-2] are available as standard in A cabinet controller of R-30*i*B. NOTE - Zone Status can be used as disabling input; refer to section 5.1 for zone status (CPC, CSC, JPC, & JSC) definitions
Permissible distance	This item indicates that if the distance moved is less than the Permissible distance, motor power is not shut down even though the DCS TCP speed exceeds the speed limit. This item is used to avoid false alarms caused by vibration during servo ON. This parameter is used only when the "Limit" is 0. Unit : mm

Operation in DCS Joint Position Check menu

Operation	Description
F2(PREV	The previous Cartesian Speed Check is displayed.
F3(NEXT)	The next Cartesian Speed Check is displayed.
F5(UNDO)	UNDO the items in this menu. The setting parameters become the same as the current DCS parameters.
PREV	The Cartesian Speed Check list menu is displayed.

3.8 T1 MODE SPEED CHECK FUNCTION

The standard Robot control software limits the TCP speed and the wrist flange center speed so it does not exceed 250 mm/sec in T1 Mode. In addition, DCS will shut down motor power if the TCP speed or the wrist flange canter speed exceeds 250 mm/sec in T1 Mode. The T1 Mode Speed Check function allows the user to further restrict the TCP Speed and wrist flange center speed to a speed lower than 250 mm/sec while in T1 mode.

- T1 Mode Speed Check can be enabled / disabled for each motion group. (Default is disable)
- The speed limit of the T1 Mode Speed Check can be changed, but it cannot exceed 250mm/sec.
- In T1 Mode, when the DCS TCP speed exceeds the specified speed limit, the alarm "SRVO-340 DCS T1 TCP speed" occurs and motor power is shut down immediately.

- In T1 Mode, when the DCS flange center speed exceeds the specified speed limit, the alarm "SRVO-341 DCS T1 flange speed" occurs and motor power is shut down immediately.
- The target TCP is the DCS Tool Frame that is selected by the "Tool select" item in the DCS Tool frame menu. When "Tool select" in the DCS Tool Frame menu is set to -1, the DCS Tool Change function is enabled and the target tool frame number is changed when the ordinary TCP is changed.

⚠WARNING
If T1 Mode Speed Check is set incorrectly, the safety function will not work, and serious personal injury could result. When T1 Mode Speed Check is changed, the values must be verified and the function must be tested again.

⚠WARNING
Set the most distant point of the end-effector from the wrist flange center as the DCS TCP. If not, a point on the end-effector more distant from the wrist flange center than the DCS TCP might exceed 250 mm/sec

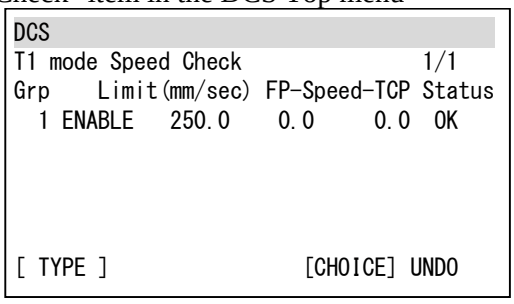
⚠WARNING
When multiple end-effectors are used, please use dynamic tool change or set the TCP of the largest end-effector as the DCS TCP. If the TCP of a smaller end effector is set as the DCS TCP, the TCP of a larger end-effector might exceed 250mm/sec.

⚠CAUTION
When the DCS TCP is different from the ordinary TCP, especially if the DCS TCP is longer than the ordinary TCP, the T1 Mode Speed Check alarm can occur. In this case, decrease the override.

⚠CAUTION
When the limit of T1 Mode Speed Check is set less than 250 mm/s, the alarm occurs if the speed exceeds the specified limit. In this case, decrease the override.

3.8.1 DCS T1 Mode Speed Check Menu

The DCS T1 Mode Speed Check menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "T1 Mode Speed Check" item in the DCS Top menu



Items in DCS T1 Mode Speed Check menu

Item	Description
Grp	The motion group number is displayed.
ENABLE/DISABLE	Used to Enable / Disable T1 Mode Speed Check.
Limit	Used to set the speed limit This item cannot be greater than 250mm/sec.

Item	Description
FP speed	The current flange center speed is displayed.
TCP	The current TCP speed is displayed.
Status	The status of T1 Mode Speed Check is displayed. OK: Setting parameter and DCS parameter are the same. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.

Operation in DCS T1 Mode Speed Check menu

Operation	Description
F5(UNDO)	UNDO the items in this menu. The setting parameters become the same as the current DCS parameters.
PREV	The DCS Top menu is displayed.

3.9 DCS TOOL FRAME

Some DCS functions use a DCS Tool Frame that is part of the DCS parameters. These tool frames are separate from the standard tool frames. The DCS Tool Frames are used by the following DCS functions.
- The target of the Speed Check in Cartesian Speed Check function.
- The target of the Speed Check in T1 Mode Speed Check function.
- The base frame of the shape element in the Zone Check function.

All DCS Tool Frames are disabled (DCS tool frame number is 0 in the DCS Tool Frame Menu) by default. A DCS tool frame is enabled by setting the DCS tool frame number to something other than 0. If the tool frame number is set to a value that corresponds to a standard tool frame, the data from the standard tool frame (X,Y,Z,W,P,R) is then copied to the setting parameters of the DCS tool frame automatically.
When the standard tool frame data is changed, the setting parameters of the corresponding DCS tool frame are updated automatically and the alarm "SYST-212 Need to apply to DCS param" occurs.

When the DCS tool frame number is set to a value that does not correspond to a standard tool frame number (for example 100), the DCS tool frame data (X,Y,Z,W,P,R) can be manually entered in the DCS Tool Frame menu.

A maximum of 10 DCS tool frames can be defined.

One DCS tool frame is selected as the current DCS tool frame for each motion group. If the target tool frame is set to -1, the DCS Tool Change function is enabled and the tool frame used as the target of the T1 Mode Speed Check function and the Cartesian Speed Check function changes with the status of the Verify I/O signals as described below.
The current DCS tool frame is used by the following DCS functions.
- The target of the Speed Check in Cartesian Speed Check function when the Tool Frame is set to -1.
- The target of the Speed Check in T1 Mode Speed Check function.

Each DCS tool frame can have one user model as the tool model. When the target model is set to Tool Model (-2) in the Zone Check function, the tool model of the current DCS tool frame is checked by the Zone check function.

It is not necessary to select the same DCS Tool Frame number as the current selected standard tool frame number. Changing the standard tool frame selection does not affect the DCS functions. For example, the target of the Speed Check in Cartesian Speed Check function is not changed even though the standard tool frame selection is changed by program execution.

DCS tool frame menu is not displayed when "DCS Basic Position check function" is ordered (DCS tool frame number 0 is used)

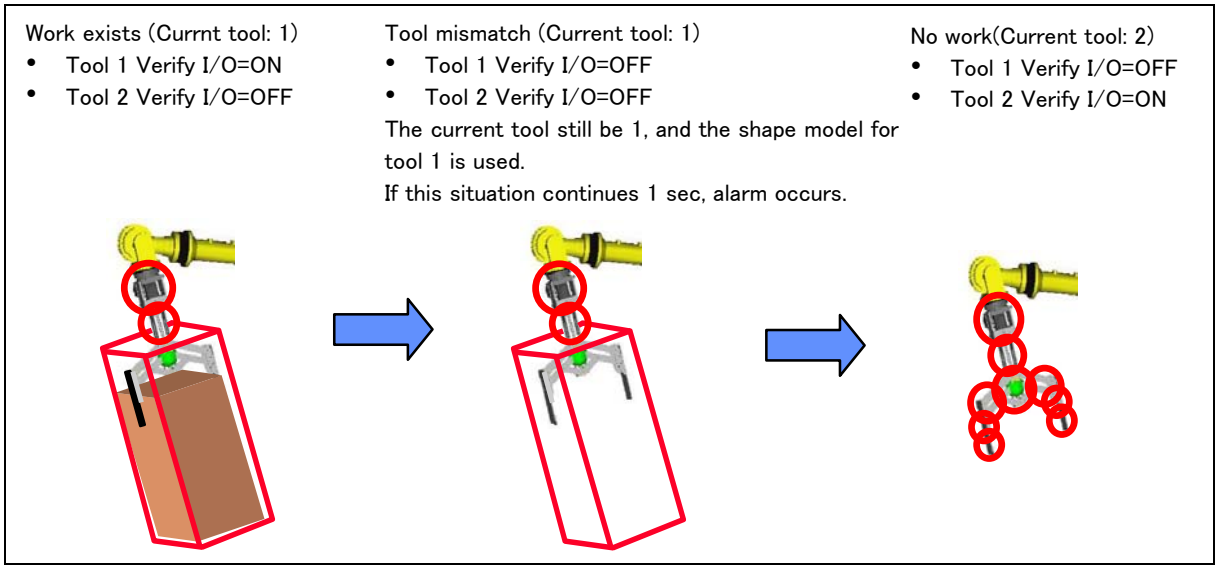
> ⚠**WARNING**
> If the DCS tool frame is set incorrectly, the safety function will not work, and serious personal injury could result. When the DCS tool frame is changed, the values must be verified and the function must be tested again.

3.9.1 Tool Change Function

The DCS Tool Change function switches shape models dynamically, for example to handle a big work piece. The DCS Tool Change function is enabled when "Tool select" in the DCS Tool Frame menu is set to -1.
When the DCS Tool Change function is enabled, the DCS Tool Frame is changed dynamically according to the Safe I/O status that is defined as the Verify I/O of the DCS Tool Frames. The shape model assigned to the selected DCS Tool Frame is then enabled.

When the DCS Tool Change function is enabled, Safe I/O must be defined as the Verify I/O for all the DCS Tool Frames that can be selected as the current DCS Tool Frame. A DCS Tool Frame is selected when the defined Verify I/O is ON. When all Verify I/O are OFF or two or more Verify I/O are ON, this situation is called "Tool mismatch". If a "Tool mismatch" condition continues for 1 second, the alarm "SRVO-416 DCS Tool mismatch" occurs. To clear the alarm, you need to set the Verify I/O status correctly. In a "Tool mismatch" condition, the current tool becomes the tool that was most recently selected for more than 1sec. When a "Tool mismatch" condition occurs at power up, the current tool becomes 0. Tool 0 means that the TCP is the Face Plate and no Tool model is enabled.

Changing the DCS Tool Frame by Tool Change Function does not affect the standard tool frame selection and changing the standard tool frame selection does not affect the DCS Tool Frame selection.



Current tool number according to the Verify I/O status when 3 DCS Tool Frames are used.

Tool 1 Verify I/O	OFF	**ON**	OFF	**ON**	OFF	**ON**	OFF	**ON**
Tool 2 Verify I/O	OFF	OFF	**ON**	**ON**	OFF	OFF	**ON**	**ON**
Tool 3 Verify I/O	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	**ON**
Current tool	Tool mismatch	1	2	Tool mismatch	3	Tool mismatch	Tool mismatch	Tool mismatch

⚠WARNING
If Tool change is set incorrectly, the safety function will not work, and serious personal injury could result. When the Tool change setting is changed, the values must be verified and the function must be tested again.

3.9.2 DCS Tool Frame Menu

The DCS Tool Frame menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "Tool frame" item in the DCS Top menu.
In this menu, the DCS tool frame and tool select are setup.

```
DCS
Tool frame                              1/12
Group: 1                               Status
Tool select:                          0   OK
(0:FacePlate,-1:Tool change)
Current Tool:                         0
  No. Model  VerifyI/O
    0  0   ---[  0:          ]       OK
         X:      0.0  W:      0.0
         Y:      0.0  P:      0.0
         Z:      0.0  R:      0.0
    0  0   ---[  0:          ]       OK
         X:      0.0  W:      0.0
         Y:      0.0  P:      0.0
         Z:      0.0  R:      0.0

[ TYPE ] GROUP                        UNDO
```

Items in the DCS Tool frame menu

Item	Description
Group	The motion group number is displayed.
Tool select	Used to set the DCS tool frame number that is selected for this motion group. When this is set to 0, the currently selected DCS tool frame is the flange frame and tool model is disabled. When this is set to -1, tool change is enabled. The DCS tool frame is switched dynamically according to the status of the Verify I/O signal. To use tool change, you need to set the Verify I/O for all selectable DCS tool frames, and the Verify I/O must be controlled to be the correct status according to the current tool frame.
Current tool	The currently selected DCS tool frame number is displayed.
No.	Used to set the DCS tool frame number. If a standard tool frame with the same tool frame number exists, the data (X,Y,Z,W,P,R) is copied from the standard tool frame to the setting parameter of the DCS tool frame.
Model	Used to set the user model number that is used as the tool model of this DCS tool frame. When this is set to 0, tool model is disabled. When this DCS tool frame is selected, the tool model is enabled.
Verify I/O	Used to set the Safe I/O to be used as the Verify I/O for this DCS tool frame. When tool change is used ("Tool select" is set to -1), all DCS tool frames that can be selected need to have a Verify I/O. The DCS Tool frame whose Verify I/O is ON is selected. NOTE - Safety input (SPI) is hardware option. However, SPI[1-2] are available as standard in A cabinet controller of R-30*i*B.
Status	The status of the DCS tool frame is displayed. OK: Setting parameter and DCS parameter are the same. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.

Item	Description
X,Y,Z,W,P,R	The data of the DCS tool frame is displayed. When a standard tool frame which has the same tool frame number exists, these items cannot be changed directly. When a standard tool frame with the same frame number does not exist, these items can be set directly.

Operation of DCS Tool frame menu

Operation	Description
F2(GROUP)	Used to change the motion group
F5(UNDO)	UNDO the items in this menu. The setting parameters become the same as the current DCS parameters.
PREV	The DCS Top menu is displayed.

3.10 DCS USER FRAME

Some DCS functions use a DCS User Frame that is part of the DCS parameters. These user frames are separate from the standard user frames. The DCS User Frame are used by the following DCS functions.

- The base frame of the safe zone in the Zone Check function
- The base frame of the base orientation safe zone in the Orientation Check function
- The base frame of the direction in the Cartesian Speed Check function when the direction is not ALL.

All DCS User Frames are disabled (DCS user frame number is 0 in the DCS User Frame menu) by default. A DCS User Frame is enabled by setting the DCS user frame number to something other than 0. The standard user frame data (X,Y,Z,W,P,R) of the same user frame number is then copied to the setting parameter of the DCS user frame automatically.
When the standard user frame data is changed, the setting parameter of the corresponding DCS user frame is updated automatically and the alarm "SYST-212 Need to apply to DCS param" occurs.
When the DCS user frame number is set to a value that does not correspond to a standard user frame number (for example 100), the DCS user frame data (X,Y,Z,W,P,R) can be manually entered in the DCS User Frame menu.

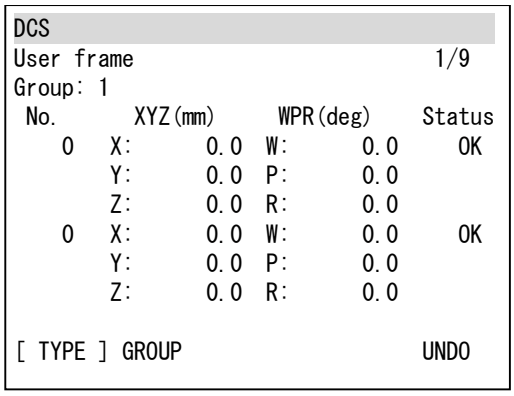
A maximum 9 DCS user frames can be defined.

DCS user frame menu is not displayed when "DCS Basic Position check function" is ordered (DCS user frame number 0 is used)

⚠WARNING
If the DCS user frame is set incorrectly, the safety function will not work, and serious personal injury could result. When the DCS user frame is changed, the values must be verified and the function must be tested again.

3.10.1 DCS User Frame Menu

The DCS User Frame menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "User frame" item in the DCS Top menu.



Items in DCS user frame menu

Item	Description
Group	The motion group number is displayed.
No.	Used to set the DCS user frame number. If a standard user frame with the same user frame number exists, the data (X,Y,Z,W,P,R) is copied from the standard user frame to the setting parameter of the DCS user frame.
Status	The status of this DCS user frame is displayed. OK: Setting parameter and DCS parameter are the same. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.
X,Y,Z,W,P,R	The data of the DCS user frame is displayed. When a standard user frame which has the same user frame number exists, these items cannot be changed directly. When a standard user frame with the same frame number does not exist, these items can be set directly.

Operation of DCS user frame menu

Operation	Description
F2(GROUP)	Used to change the motion group
F5(UNDO)	UNDO the items in this menu. The setting parameters become the same as the current DCS parameters.
PREV	The DCS Top menu is displayed.

3.11 SETUP STOP POSITION PREDICTION

The Stop Position Prediction parameters for Joint Position Check and Cartesian Position Check are setup in DCS Stop Position Prediction menu.

3.11.1 DCS Stop Position Prediction Menu

The DCS Stop Position Prediction menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "Stop position prediction" item in the DCS Top menu.

```
DCS
Stop position prediction            1/50
Group: 1                            Status
Cartesian
  1 Mode:                    DISABLE  OK
  2 Expand Point as line:    DISABLE  OK
    Power-Off stop
  3   Stopping distance (mm):    0.0  OK
  4   Speed          (mm/sec):   0.0  OK
    Controlled stop
  5   Stopping distance (mm):    0.0  OK
  6   Speed          (mm/sec):   0.0  OK
Joint J1
  7 Mode:                    DISABLE  OK
    Power-Off stop
  8   Stopping distance(deg):    0.0  OK
  9   Speed         (deg/sec):   0.0  OK
    Controlled stop
 10   Stopping distance(deg):    0.0  OK
 11   Speed         (deg/sec):   0.0  OK
Joint J2
 12 Mode:                    DISABLE  OK
    Power-Off stop
 13   Stopping distance(deg):    0.0  OK

[ TYPE ] GROUP          [CHOICE]  UNDO
```

Items in DCS Stop Position Prediction menu

Item	Description
Group	The motion group number is displayed
Status	The status of the Stop Position Prediction is displayed. OK: Setting parameter and DCS parameter are the same. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.
Expand Point as line	When it is set “ENABLE”, shape elements of “Point” type and “2 spheres” type are processed as “Line-seg” type that is expanded to the moving direction for the stop position prediction. (Refer to 3.4.3 Stop Position Prediction)
Cartesian	Used to set the Stop Position Prediction parameters for Cartesian Position Check (Zone check).
Joint J1-J6	Used to set the Stop Position Prediction parameter for Joint Position Check.
Power-off stop	Used to set the parameters to predict the stop position for Power-off stop.
Controlled stop	Used to set the parameters to predict the stop position for Control stop.
Mode	DISABLE: Stop Position Prediction is disabled. DEFAULT: The default setting is used. The default value is defined according to the stopping distance at maximum speed and maximum payload. USER: The stopping distance and the speed can be changed.
Stopping distance Speed	The Stop Position Prediction function predicts the stop position. The stopping distance is proportional to the speed. A user defined proportion factor can be setup by entering a speed and the stopping distance at this speed. When you set the stopping distance value to be greater than the actual stopping distance, the robot will stop in the safe zone. This value can be changed only when "Mode" is set to "USER".

Operation in DCS Stop Position Prediction menu

Operation	Description
F2(GROUP)	Used to change the motion group
F5(UNDO)	UNDO the items in this menu. The setting parameters become the same as the current DCS parameters.
PREV	The DCS Top menu is displayed.

⚠WARNING
When the “Expand point as line” is set ENABLE in stop position prediction menu, actual stop position can leave from the moving direction, the stop position can be out of the safe zone, and serious personal injury could result. When the “Expand point as line” is set ENABLE, a risk assessment for the whole robot system is necessary including the stop position can be out of the safe zone.

⚠CAUTION
- The shape element expansion process of the stop position prediction for “Point” type and “2 spheres” type is changed by the setting of the “Expand point as line” in stop position prediction menu, but the process of shape element expansion for “Line-seg” type and “Box” type is not affected.
- The process time factor of “Point” type and “2 spheres” type shape elements are calculated as “Line-seg” type when the “Expand point as line” is set “ENABLE” in stop position prediction menu.

⚠CAUTION
- The stop position prediction for Cartesian Position Check is disabled by default. To enable the stop position prediction, select "DEFAULT" or "USER" for mode of Cartesian in DCS stop position prediction menu.
- Stop position prediction for each zone of Cartesian Position Check can be disabled individually. The stop position prediction for the zone is disabled when “Use Stop Position Prediction” is set “No” in DCS Cartesian Position Check detail menu, even though the mode of Cartesian is set "DEFAULT" or "USER" in DCS stop position prediction menu.
- The stop position prediction for Cartesian Position Check is disabled when the mode of Cartesian is set "DISABLE" in DCS stop position prediction menu, even though “Use Stop Position Prediction” is set “Yes” in DCS Cartesian Position Check detail menu.

⚠CAUTION
The stop position prediction of Joint Position Check is disabled by default. To enable the stop position prediction, select "DEFAULT" or "USER" for mode of the target axis in DCS stop position prediction menu.

4 DCS VISUALIZATION

In order to use DCS Visualization please be sure the following software option is loaded:

- DCS Speed and Position Check (A05B-2600-J567)

DCS Visualization enables you to view a graphical representation of the DCS settings from many of the menus described above.

The view that is presented relates to the feature currently selected in the DCS Setup menu. The following features provide a graphical view:

- DCS Robot setup
- DCS User model setup
- DCS Cartesian position check
- DCS Joint position check

The DCS settings that are displayed come from the setup pages so you can view the effects of your changes before they have been applied.

The views are also “live”. That is – they update to follow the robot as it moves and reflect the current state of position check zones.

Both simple and 4D Graphics views are provided.

Simple Views

Simple views are launched by pressing F5 (VIEW) on the > (NEXT) page of function keys.

In the Simple view, the robot, user model and Cartesian position check zones are displayed as wire frames projected in one of the three orthographic planes (X-Y, X-Z or Y-Z). Colors help you discriminate between the robot, user models and Cartesian position check zones.

The controls you have for adjusting the simple view are described in the next section entitled “Viewing the Robot Model”. However, they apply to viewing User models and Cartesian position check as well.

4D Graphics Views

The 4D Graphics view is launched as a related view to the DCS Setup menu.

In the 4D Graphics view, the robot, user model and Cartesian position check zones are displayed as 4D Graphics. Colors help you discriminate between the robot, user models and Cartesian position check zones.

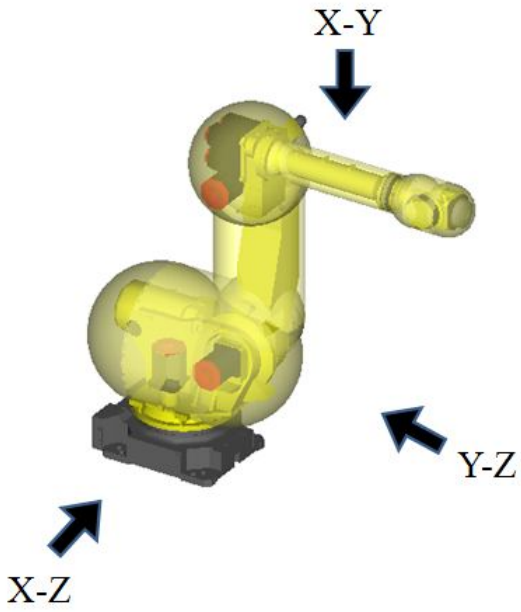
The 4D Graphics automatically updates as you navigate the DCS Setup menus and make changes.

Please refer to section "4.2 4D Graphics DCS display" for the operation of the 4D Graphics DCS menu.

4.1 VIEWING THE ROBOT MODEL

You can launch the robot model Simple view from the main DCS menu or DCS Robot Setup menu. Pressing F5 (VIEW) in the main menu when the cursor is on the Robot Setup line will launch the viewer for the currently selected robot group. Pressing F5 (VIEW) when in the DCS Robot Setup menu will launch the viewer for the robot group of the parameter selected by the cursor.

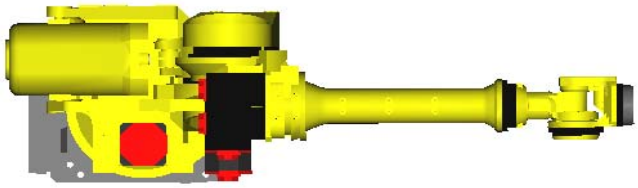
The robot model is always shown in the 4D Graphics. Its DCS model will be shown as in the figure below whenever it is active and always shown when the current menu is DCS Robot Setup.

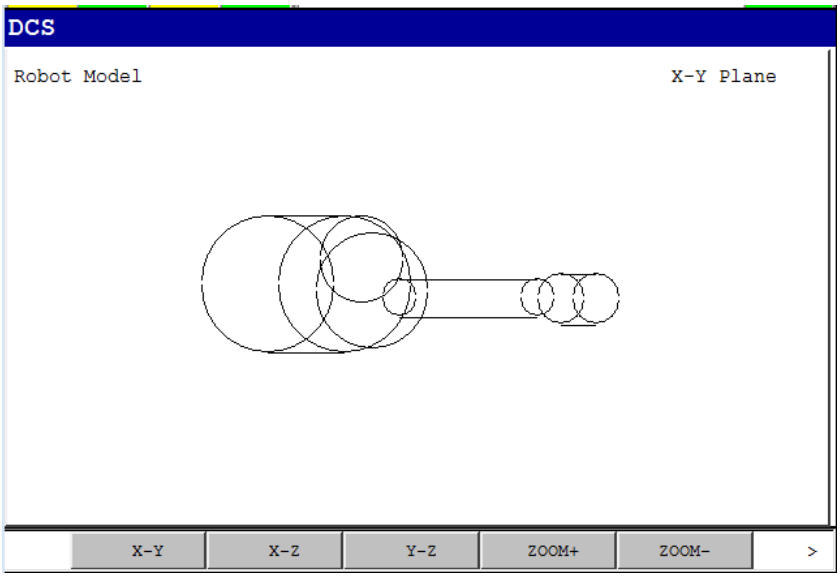


All Simple views show orthogonal projections of the wire frame of the models used for DCS calculations. These projections show the robot as if you were looking at the robot in the directions shown by the arrows above.

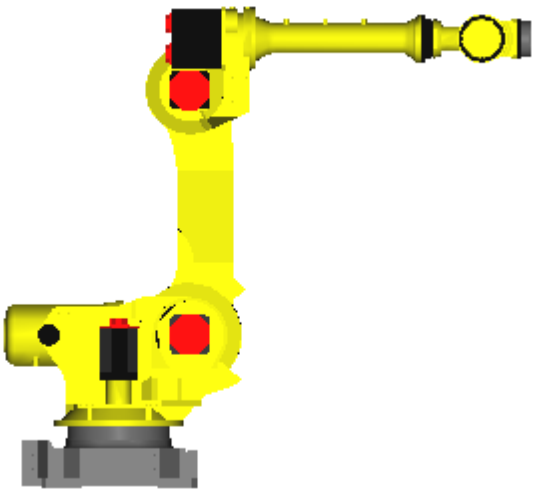
DCS models the robot using cylinders and spheres so there is much less detail than the real robot. The following pictures demonstrate the three orthogonal views and how the robot model appears in 4D Graphics and Simple view for each. (The R-2000 is shown. Each robot has its own DCS model)

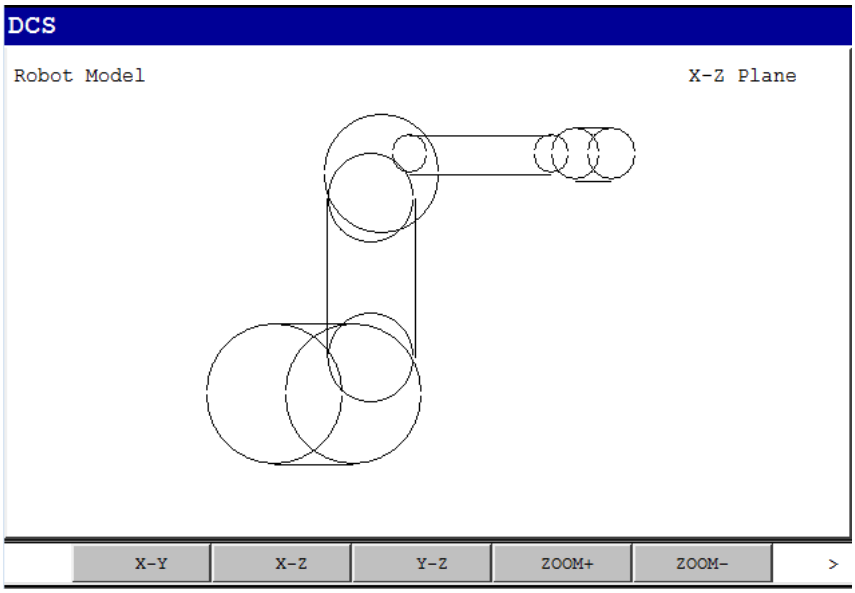
X-Y plane



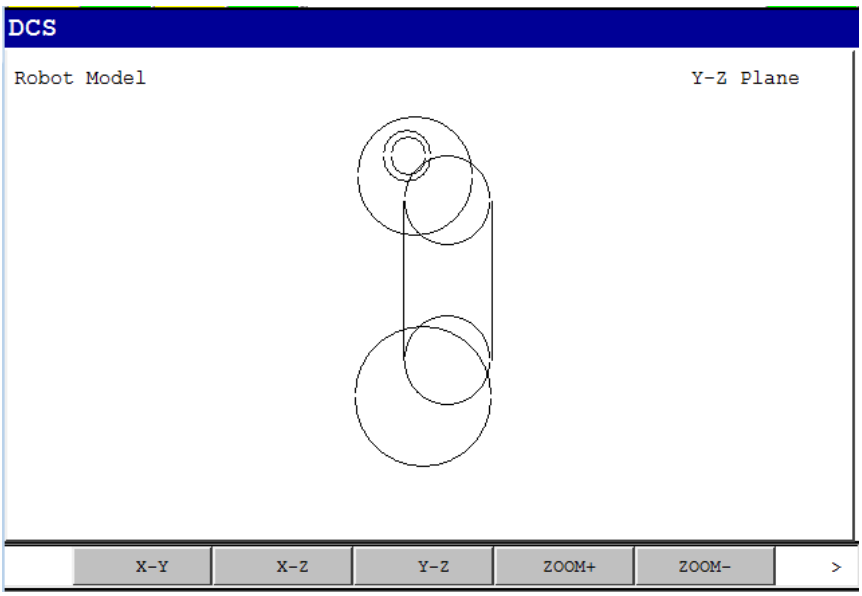


X-Z plane





Y-Z plane



4.1.1 Controlling the Simple View

4.1.1.1 Selecting an orthographic view

Select the desired orthographic view by pressing the F1 (X-Y), F2 (X-Z) and F3 (Y-Z) function keys.

4.1.1.2 Panning and zooming

When a view is first launched, a center coordinate and scale are calculated so that all elements will fit on the screen.

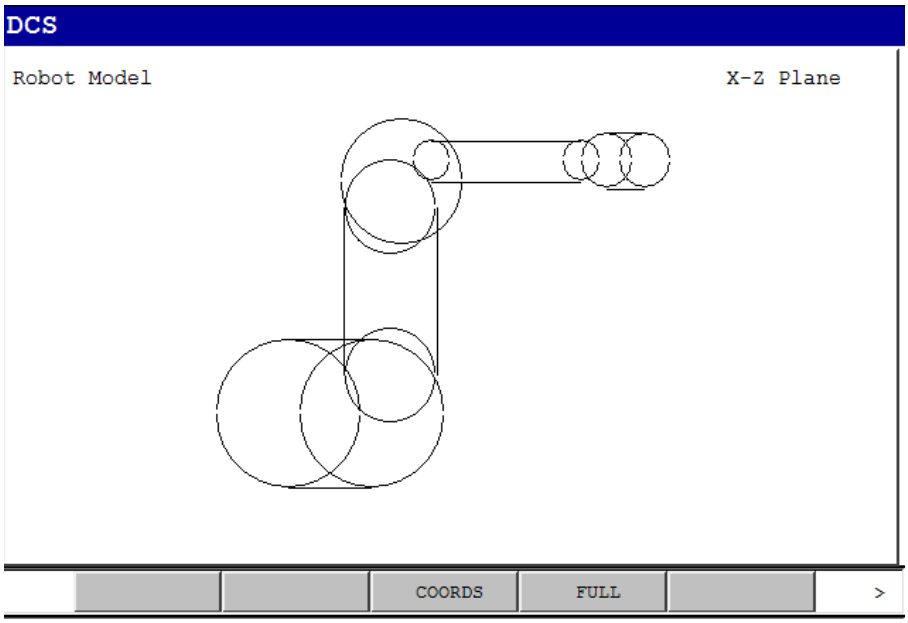
The arrow keys change the center coordinate in the plane of the view, effectively shifting the picture up and down, left and right.

The two function keys F4 (ZOOM+) and F5 (ZOOM-) change the scale and the display is resized around the center if the display.

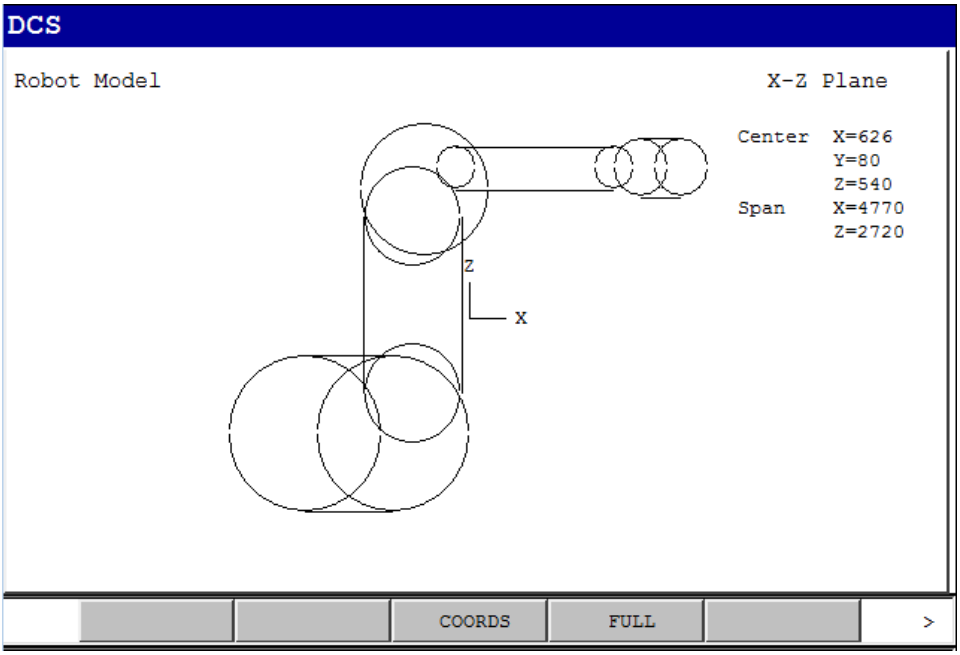
Pressing and holding the SHIFT key while shifting or zooming increases the rate of change by 10X.

4.1.1.3 Coordinate displays

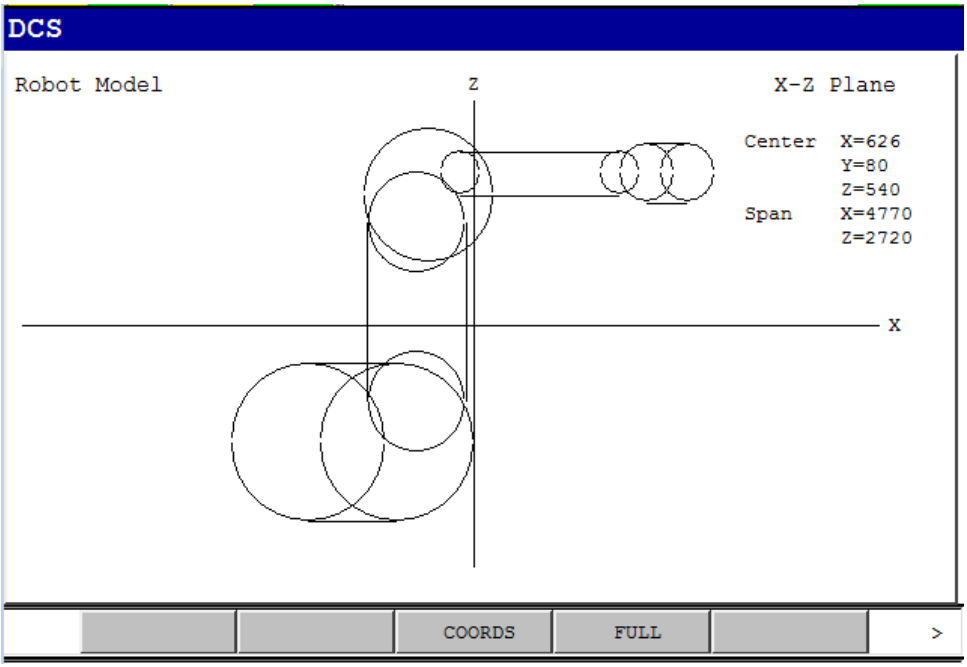
You can select the level of detail you want for the display of the active coordinates. Press > (NEXT) to show the second page of function keys. Press the F3 (COORDS) function key to cycle through the available coordinate display formats.



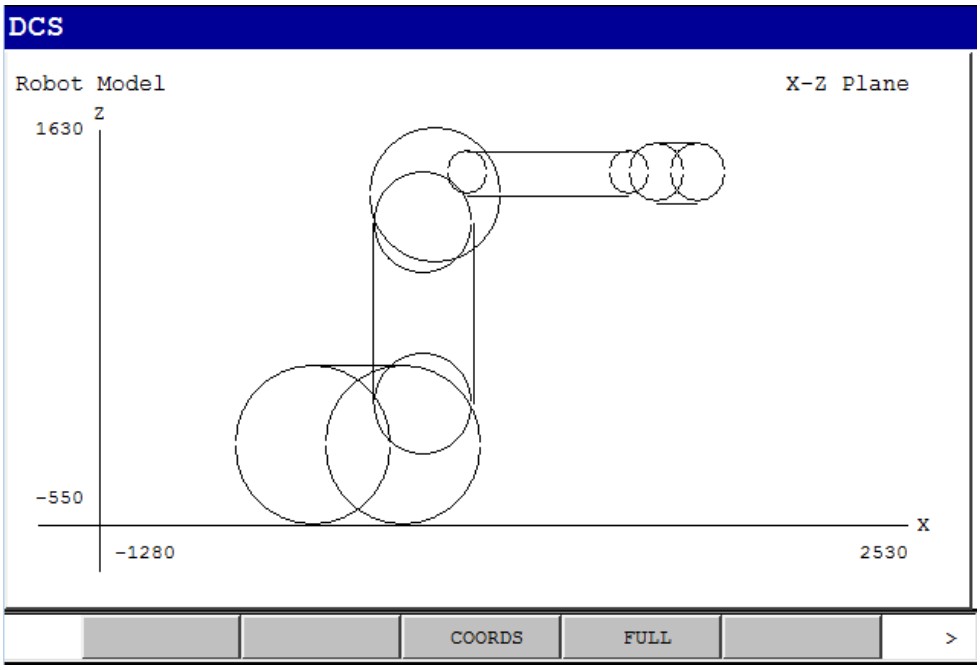
No coordinates (This is the default.)



Small triad in the center with center and span values.
Span indicates the area of the full display.



Same as the one above except the coordinate lines extend across the majority of the display area.



The more traditional coordinate display.

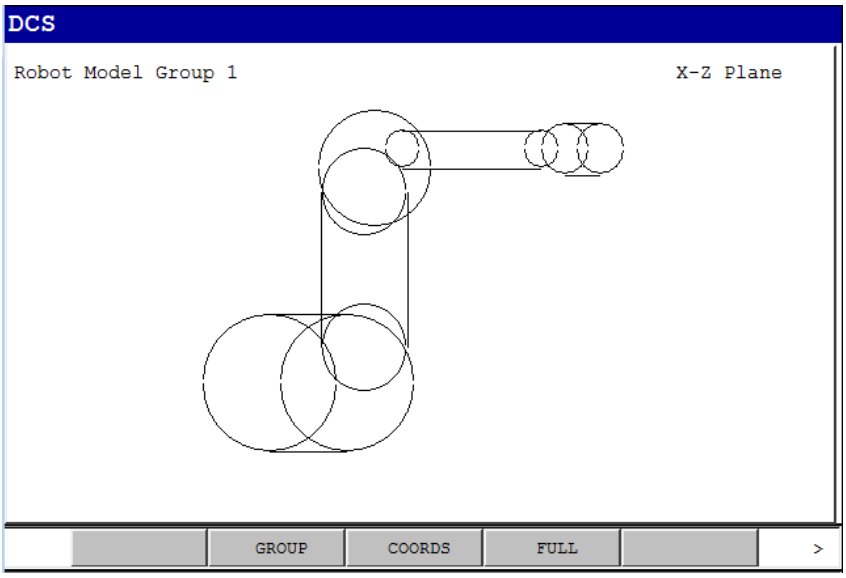
4.1.1.4 Persistence

The selected orthogonal view and coordinate display are remembered when you exit the viewing screen and restored when you view the same item again.

The center coordinates and span (zoom) are also remembered and restored when you view the same item (zone, model, robot). Pressing F4 (FULL) resets these so that the full item fits within the display window.

4.1.1.5 Robot group select

On multi-group controllers, the F2 (GROUP) key is provided on the second page of function keys.

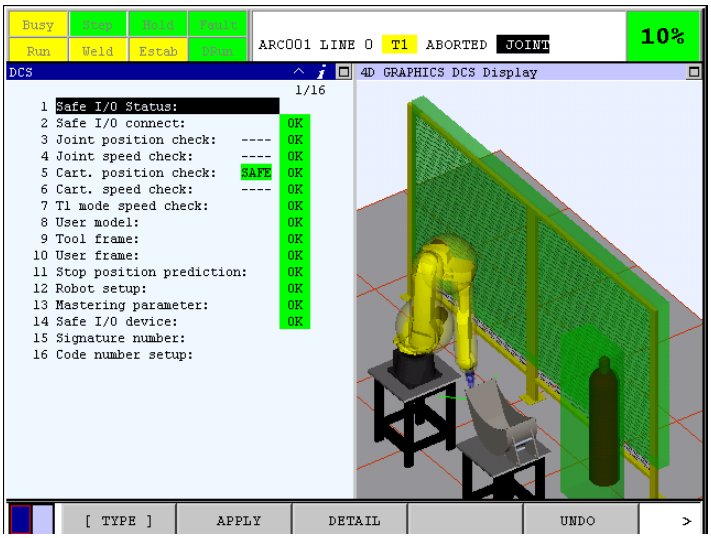


Press F2 (GROUP), to cycle through the available groups. The current group being shown is indicated in the title.

4.1.1.6 Exiting the viewer

The DCS simple viewer is a full page window that covers the entire menu area. The MENU, FCTN and DISP keys are ignored while the viewer is up. You must dismiss the viewer by pressing the PREV key to return to menu operations.

4.2 4D GRAPHICS DCS DISPLAY



Procedure 4-1 4D GRAPHICS DCS

Step

The following is the operation to display 4D GRAPHICS DCS display.

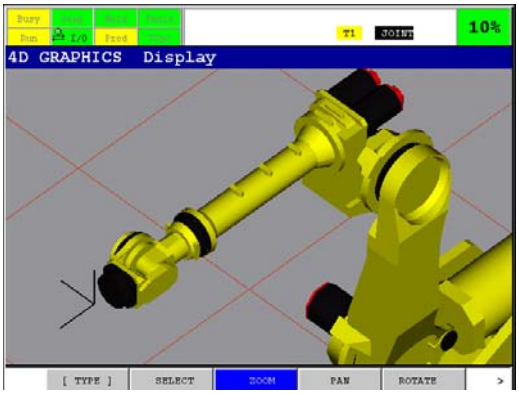
1 Press MENU key and display MENU pop up screen.
2 Select [0 -- NEXT --] and select [6 SYSTEM].
3 Press F1, [TYPE] and select [DCS].
4 Press *i* key and FCTN key on DCS screen. Related View menu will be displayed.
5 Select “4D DCS Display”.

4.2.1 Operation Procedure

In 4D GRAPHICS screen, view is adjusted by the following operation modes.
- ZOOM
- PAN
- ROTATE

And the following functions are prepared.
- Preset Views
- User Views

ZOOM



ZOOM consists of changing the magnification. Increasing the magnification makes the objects larger but the field of view is narrow. Press F3, ZOOM to set the system to zoom mode. Then, the label F3, ZOOM turns blue in color.

There are two ways for ZOOM operation. One is the *i*Pendant key input and the other is touch panel operation.

Zoom by *i*Pendant key input

Increase the magnification
- Press the up arrow key on *i*Pendant.
- Press the SHIFT + up arrow key on *i*Pendant. (High magnification)

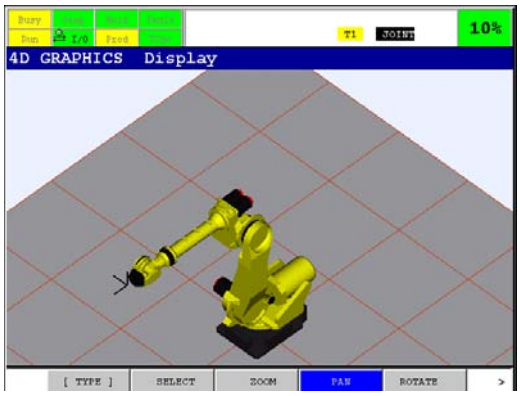
Decrease the magnification
- Press the down arrow key on *i*Pendant.
- Press the SHIFT + down arrow key on *i*Pendant. (High magnification)

Zoom by touch panel

Increase the magnification
- Touch and release near the top of the screen.
- Touch the screen and drag your finger up or right,

Decrease the magnification
- Touch and release near the bottom of the screen.
- Touch the screen and drag your finger down or left,

PAN



PAN consists of moving the view up, down, left and right. Press F4, PAN to set the system to PAN mode. Then, the label F4, PAN turns blue in color.

There are two ways for PAN operation. One is the *i*Pendant key input and the other is touch panel operation.

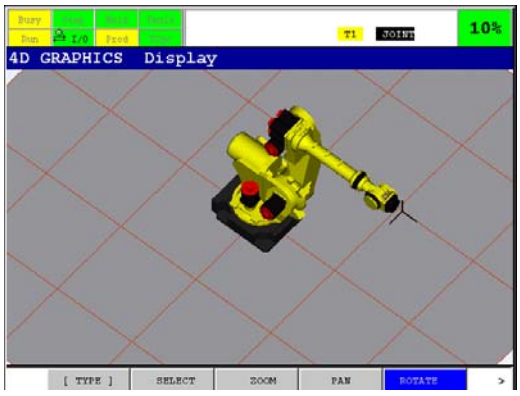
PAN by *i*Pendant key input

- Press the arrow key on *i*Pendant up, down, left and right.

PAN by touch panel

- Touch the screen and drag your finger up, down, left and right.
- Click the screen so the point you click become center on the screen.

ROTATE



ROTATE consists of rotating the view up, down, left and right. Press F5, ROTATE to set the system to ROTATE mode. Then, the label F5, ROTATE turns blue in color.

There are two ways for ROTATE operation. One is the *i*Pendant key input and the other is touch panel operation.

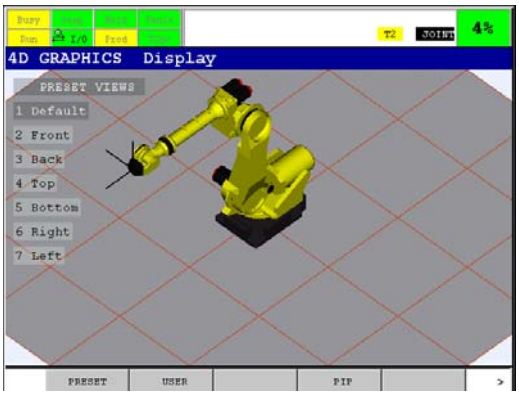
ROTATE by *i*Pendant key input

- Press the arrow key on *i*Pendant up, down, left and right.
- Press the SHIFT + arrow key on *i*Pendant up, down, left and right. (High magnification)

ROTATE by touch panel

- Touch the screen and drag your finger up, down, left and right.

Preset Views



4D GRAPHICS screen provides seven preset views. The default view provides a view from 45 degree. This view is good starting point for setting the view. It also put information back on the screen in the case where it has inadvertently been lost. All preset views will center the floor in the middle of the view.

- Default Set the view to default
- Front Set the view in front of the robot
- BackSet the view behind the robot
- Top Set the view right above the robot
- Bottom Set the view right below the robot
- Left Set the view on the left side of the robot
- Right Set the view on the right side of the robot

To select Preset Views, press NEXT key and press F2, [VIEWS]. Select one of the preset views above.

Please refer to section "4D GRAPHICS FUNCTION" in R-30*i*B/R-30*i*B Mate CONTROLLER Optional Function OPERATOR'S MANUAL(B-83284EN-2) for details.

4.3 VIEWING USER MODELS

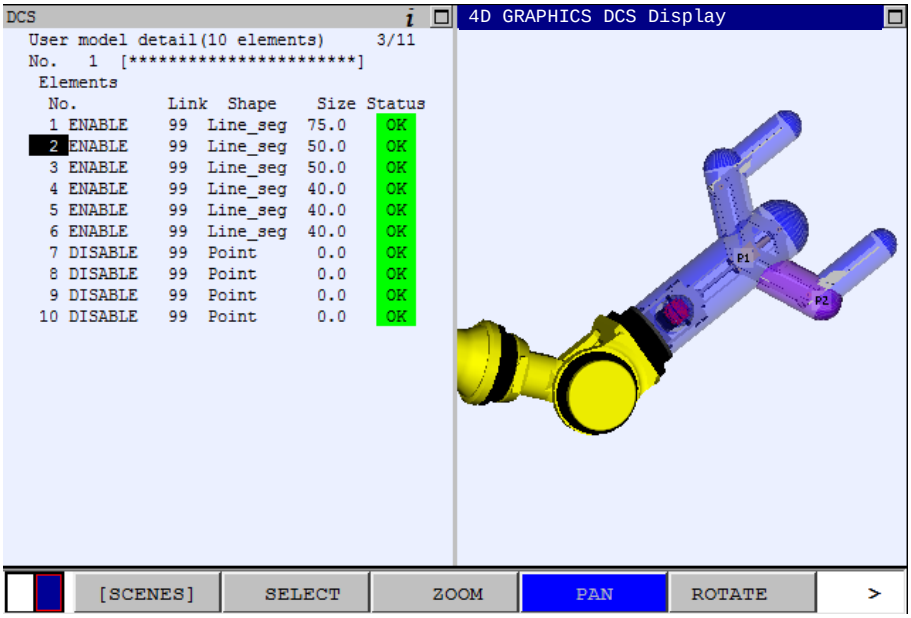
F5 (VIEW) is available on the NEXT page of function keys to launch the simple user model viewer from the following user model setup screens:

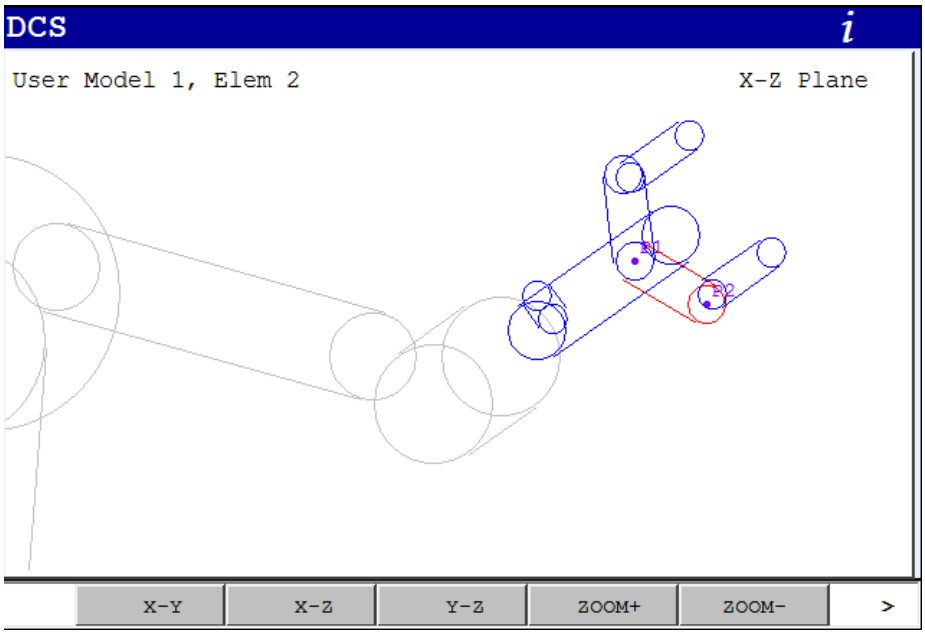
- User Model List menu
- User Model Element List menu
- User Model Element Detail

The 4D Graphics follows your actions in these menus and automatically displays the appropriate detail described below.

The user model viewer always displays all enabled elements independent of which model menu you are currently in. When viewed from the Element List menu or Element Detail screen, however, the currently selected element is always displayed whether it is enabled or not and highlighted in a different color.

Below is an example of an end-of-arm effector described by a DCS user model and presented by the user model viewer. Both 4D Graphics and Simple views are shown.





There is a great deal of flexibility when defining elements of a model. Each element can be referenced relative to the faceplate or a specific link and be offset by a tool frame. These reference frames are applied when the user model is used in a Cartesian position check setup and associated with a robot group.

On multi-group systems, the simple user model viewer does not know this association so it defaults to displaying all elements relative to group 1. You can cycle through groups using F2 (GROUP) on the second page of function keys.

The 4D Graphics model viewer looks for where the model is used and selects the related robot group for displaying the user model. If the model has not been referenced in a Cartesian position check zone yet, group 1 is selected.

4.4 VIEWING CARTESIAN POSITION CHECKS

F5 (VIEW) is available on the NEXT page of function keys to launch the simple Cartesian position check (CPC) viewer from the following DCS setup screens:

- DCS Main menu
- Cartesian Position Check List menu
- Cartesian Position Check Detail

The 4D Graphics follows your actions in these menus and automatically displays the appropriate detail described below.

Viewing CPC status from the DCS main menu when the cursor must is on the DCS Cartesian position check item shows all enabled zones. Zones will appear and disappear if they are enabled and disabled by safety I/O.

Multi-group configurations are handled differently between Simple and 4D Graphics. The Simple viewer displays only one group at a time and the 4D Graphics viewer displays all of them simultaneously.

When launched from the List menu or Detail screen, the CPC viewer will display the zone even if it is disabled.

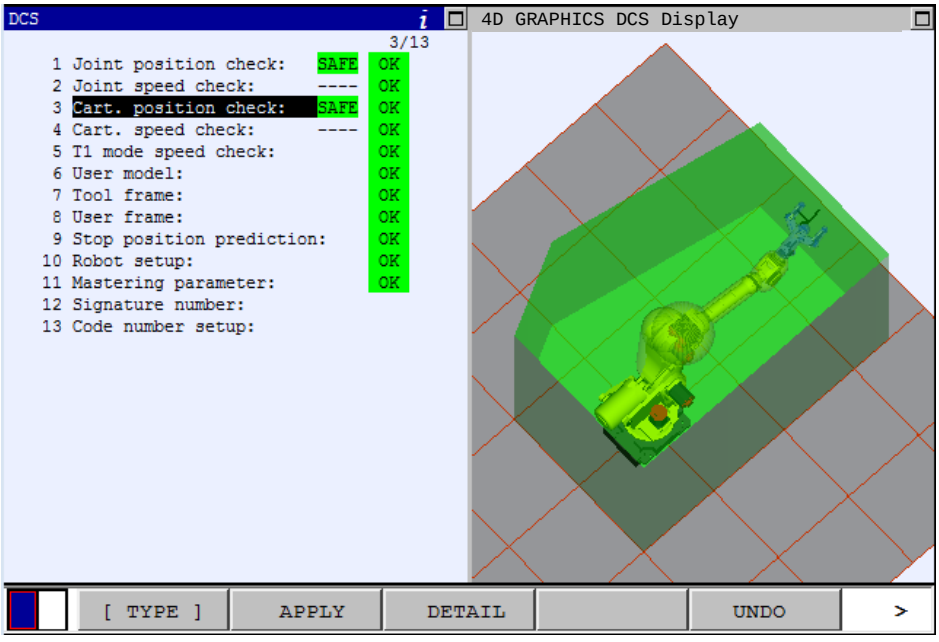
Zones are displayed in green if they are safe and red if unsafe.

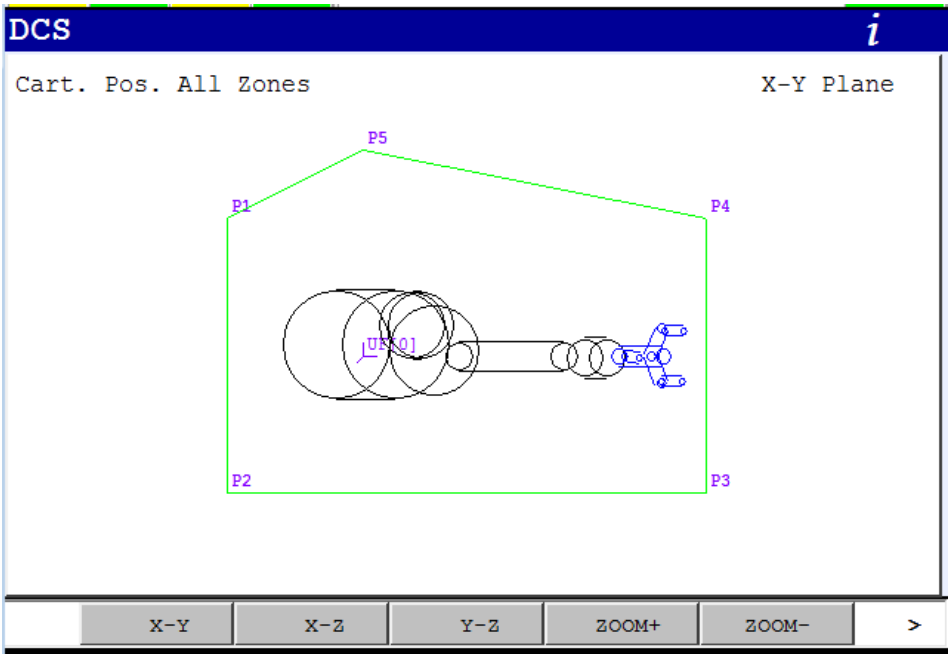
In the Simple view, the robot model is displayed in black if it is being checked by the zone and gray if it is not. The 4D Graphics view always shows the robot image and adds the DCS robot model when that is being checked by the zone.

User models being checked by the zone are displayed in blue.

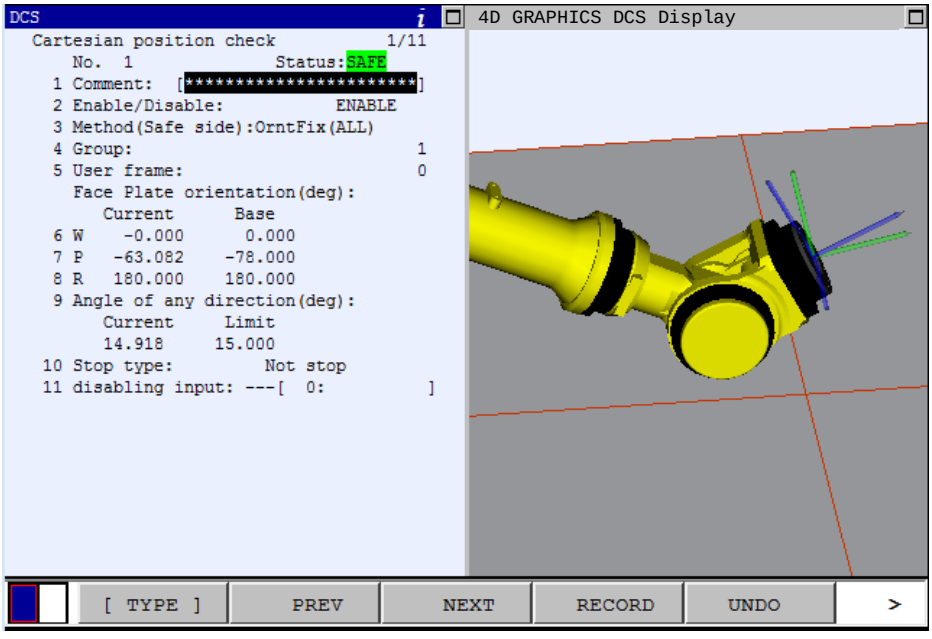
The DCS user frame employed is displayed in purple in the Simple viewer.

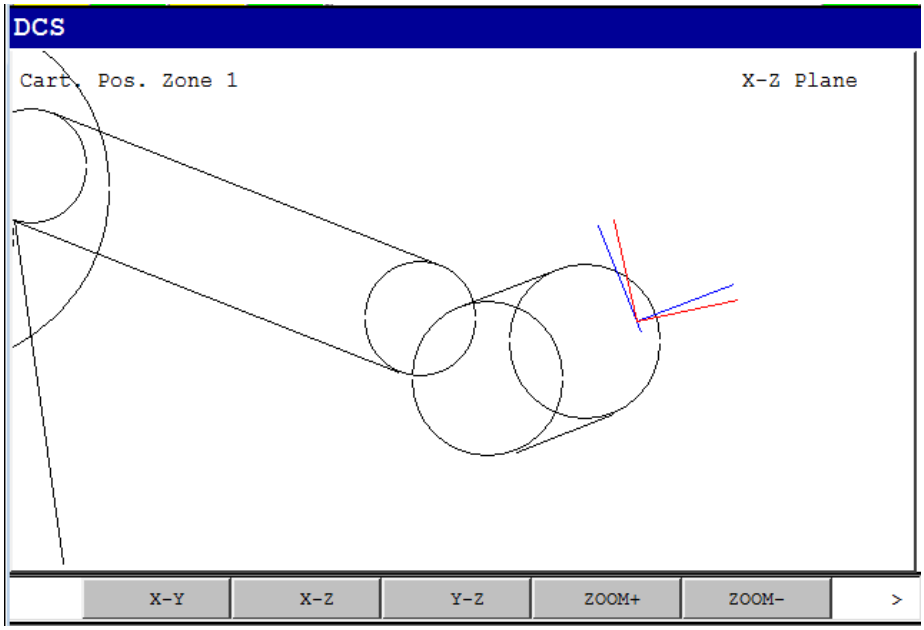
Below is an example of a Cartesian position check zone using the Lines (IN) safe side method checking the robot and one user model. Both 4D Graphics and Simple views are shown.



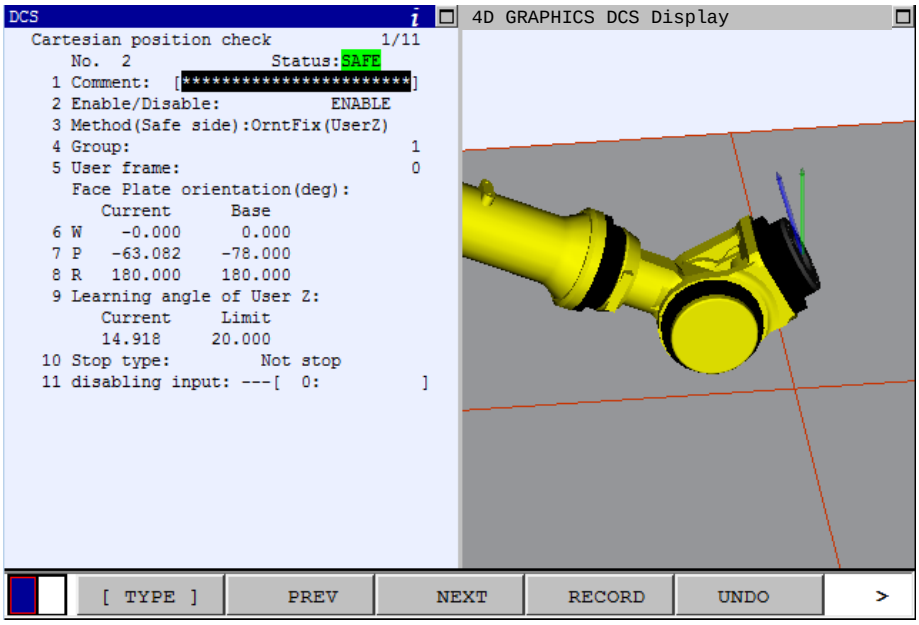


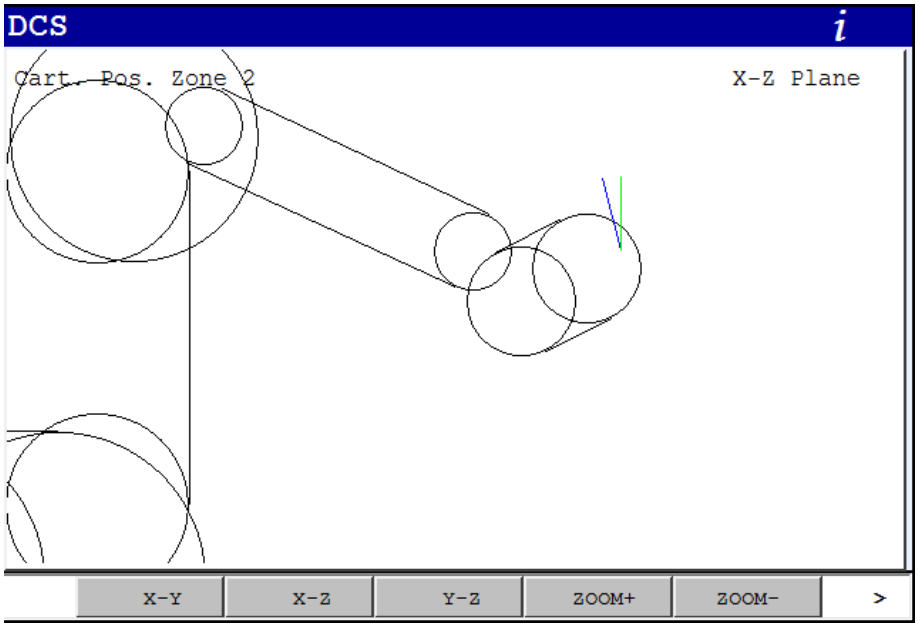
The CPC viewer displays two triads to represent a position check zone that uses the OrntFix (ALL) method. The current orientation of the faceplate is displayed with a blue triad. The zone check orientation is displayed in green or red depending on its safe status. Both 4D Graphics and Simple views of the ALL method are shown below.





The CPC viewer displays two single line vectors to represent a position check zone that uses the OrntFix (UserZ) method. The vector relative to current orientation of the faceplate is displayed with a blue line. The zone check orientation (normal to the DCS user frame) is displayed in green or red depending on its safe status. Both 4D Graphics and Simple views of the UserZ method are shown below.





4.5 VIEWING JOINT POSITION CHECKS

F5 (VIEW) is available on the NEXT page of function keys to launch the joint position check (JPC) Simple viewer from the following DCS setup screens:

- DCS Main menu
- Joint Position Check List menu
- Joint Position Check Detail screen

The 4D Graphics follows your actions in these menus and automatically displays the appropriate detail described below.

The Simple and 4D Graphics views of joint position check are very different from each other. They are described in separate sections.

4.5.1 Joint Position Check – Simple Viewer

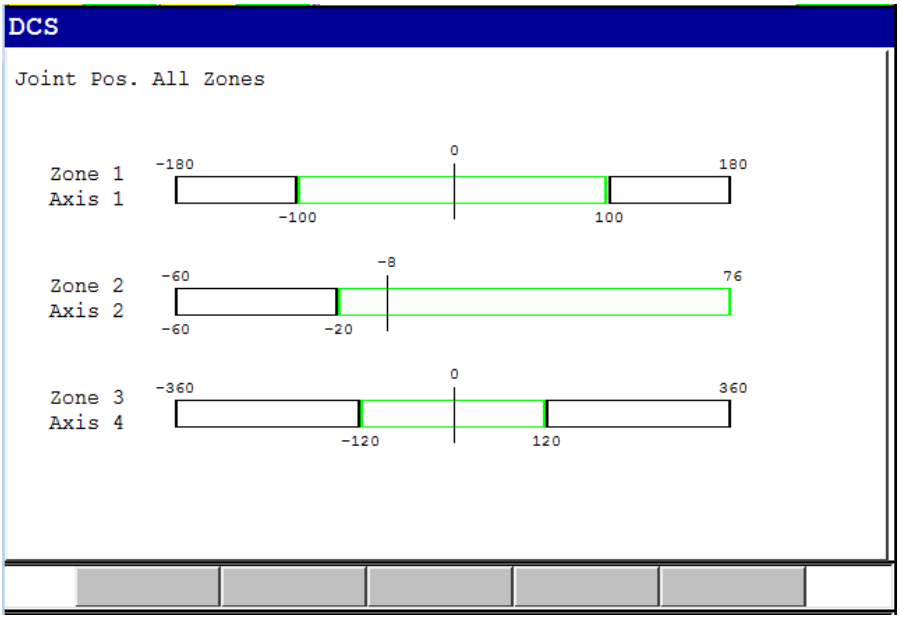
To launch the JPC viewer from the DCS main menu the cursor must be on the DCS Joint position check item. This will cause the viewer to display all enabled zones for the current robot group. Zones will appear and disappear if they are enabled and disabled by safety I/O.

When launched from the List menu or Detail screen, the JPC viewer will display the zone even if it is disabled.

Zones are displayed as a horizontal bar scaled to span from the lower to the upper axis travel limits. The portion covered by the DCS limits is displayed in green if the robot is currently in the safe zone or red if it is unsafe .

The current joint position is displayed as a vertical line.

Below is an example of a robot with three enabled joint position check zones when the JPC viewer is launched from the DCS main menu.



4.5.2 Joint Position Check – 4D Graphics Viewer

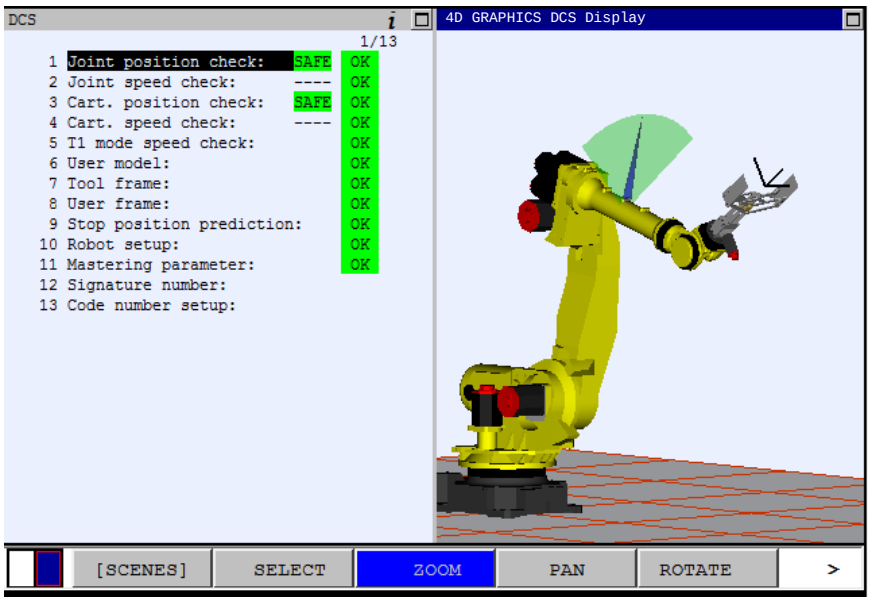
JPC settings are displayed when the 4D Graphics DCS Display related view is active and one of the JPC setup screens is selected in the DCS Setup menus.

When the cursor is on Joint position check: in the DCS main menu the 4D Graphics will display all enabled JPC zones. Zones will appear and disappear as they are enabled and disabled by safety I/O.

When the List menu or Detail screen is active, the 4D Graphics will display the zone even if it is disabled.

JPC zones are displayed as a fan for rotational axes and as a bar for linear axes. These are superimposed on the robot itself and a needle shows the current joint position of the robot. The zone is green if the robot is currently in the safe zone or red if it is unsafe .

Below is an example of a robot with a joint position check zone on axis 4. It is shown when the cursor is on Joint position check: in the DCS main menu.



5 SAFE I/O

5.1 SAFE I/O

Safe I/O are safe signals that can be used in DCS. Safe I/O is expressed by a 3 character type and an index number, such as "SPI[1]".
For example, safety input signal SFDI1 is represented as Safe I/O SPI[1]. To switch the safety zone according to SFDI1, set SPI[1] to the disabling I/O.
Some Safe I/O show the internal status of DCS. For example, the Safe I/O CPC[1] shows the status of Cartesian Position Check No.1. The status of the Cartesian Position Check can be output to the safety output signal SFDO1 by connecting CPC[1] to SPO[1] in Safe I/O connect function.

The following is a list of the Safe I/O types. In the Input/Output column, the safe I/O that can be specified on the left side of an I/O connect is "Output", the other Safe I/O is "Input".
The status of the "Output" Safe I/O is set by Safe I/O connect function or Safety PMC only.
All "Output" Safe I/O except SSO[1-5] are OFF at power up. SSO[1-5] are ON.

Safe I/O has redundancy internally, therefore one safe I/O signal works as safety signal. A Dual channel input signal (Ex. SFDI11 and SFDI21) corresponds to one safe I/O signal (SPI[1]), and the safe I/O signal becomes ON when the both of the dual channel signals are ON.

The Safe I/O Connect function is a Cat.4, PL e, SIL 3 function, but some safe I/O are Cat.3, PL d, SIL 2 because the source function is Cat.3, PL d, SIL 2. The column "Cat.,PL,SIL" shows the Cat., PL and SIL of each Safe I/O. The number in "Slot" column is used for " Safe I/O status monitoring" that is described later.

Type of Safe I/O

Type	Range of index	Input / Output	Cat. PL SIL	Slot	Description
SPI	1-64	Input	Cat.4 PL e SIL 3 (note3)	1	Safe Peripheral Input In B cabinet controller of R-30*i*B, SPI[1-8] are safety input on Safety I/O board SFDI1-8. Safety I/O board is hardware option. When the hardware is not equipped, SPI[1-8] are always OFF. In A cabinet controller of R-30*i*B, SPI[1-2] are safety input SFDI1-2 on emergency stop board. SPI[3-8] are always OFF. In R-30*i*B Mate, additional safety I/O device is needed to use safety input. ON: Both of dual circuit are CLOSED, OFF: Either circuit is OPEN When additional safety I/O device is connected, the additional safety input signals are assigned to SPI. Please refer to "5.4 ADDITIONAL SAFETY SIGNALS".

Type	Range of index	Input / Output	Cat. PL SIL	Slot	Description
SPO	1-64	Output	Cat.4 PL e SIL 3 (note2) (note3)	2	Safe Peripheral Output In B cabinet controller of R-30*i*B, SPO[1-8] are safety output on Safety I/O board SFDO1-8. Safety I/O board is hardware option. In A cabinet controller of R-30*i*B, SPO[1-2] are safety output on emergency stop board SFDO1-2. There is no hardware signal corresponded to SPO[3-8]. In R-30*i*B Mate, additional safety I/O device is needed to use safety output. When additional safety I/O device is connected, the additional safety output signals are assigned to SPO. Please refer to "5.4 ADDITIONAL SAFETY SIGNALS". When SFDO pulse check is disabled, SFDO output is safety function of Category 3, PL d. Actual output becomes OFF in fault situation even though SPO is set to ON.(Note 1)
SSI	1-11	Input	Cat.4 PL e SIL 3	3	Safe System Input Status of system safety information such as emergency stop button. Detail is specified in the table "Detail of SSI".
SSO	1-7	Output	Cat.4 PL e SIL 3	4	Safe System Output Commands to system such as request emergency stop. Detail is specified in the table "Detail of SSO".
SIR	1-64	Output	Cat.4 PL e SIL 3	5	Safe Internal Relay Internal relay that can be used in Safe I/O connect. Status is OFF at power up.
CPC	1-32	Input	Cat.3 PL d SIL 2	6	Cartesian Position Check Status of Cartesian Position Check functions. When the status is SAFE, it is ON. Otherwise, it is OFF.
CSC	1-16	Input	Cat.3 PL d SIL 2	7	Cartesian Speed Check Status of Cartesian Speed Check functions. When the status is SAFE, it is ON. Otherwise, it is OFF.
JPC	1-40	Input	Cat.3 PL d SIL 2	8	Joint Position Check Status of Joint Position Check functions. When the status is SAFE, it is ON. Otherwise, it is OFF.
JSC	1-40	Input	Cat.3 PL d SIL 2	9	Joint Speed Check Status of Joint Speed Check functions. When the status is SAFE, it is ON. Otherwise, it is OFF.
CSI	1-64	Input	Cat.4 PL e SIL 3	10	CIP Safety Input Inputs from the DeviceNet Safety, EtherNet/IP Safety or PROFINET Safety network. It is OFF when safety communication error occurs or the Enable/Bypass setting is BYPASS. OFF should be Safe(Stop) side.
CSO	1-64	Output	Cat.4 PL e SIL 3	11	CIP Safety Output Outputs to the DeviceNet Safety, EtherNet/IP Safety or PROFINET Safety network. Actual output becomes OFF in fault situation even though CSO is set to ON.(Note 1)

Type	Range of index	Input / Output	Cat. PL SIL	Slot	Description
CCL	1-4	Input	Cat.4 PL e SIL 3	12	Configuration Change Latch Shows whether the DCS parameters are changed or not. When the current signature and the latched signature are the same in the DCS signature menu, it is ON. When they are different, it is OFF. Index 1-4 correspond to the items in DCS signature menu as follows. 1: Total (CCL[1] is ON when 2, 3 and 4 are ON even though the current signature and latched signature are different) 2: Base 3: Pos./Speed 4: I/O Connect
CCR	1-4	Output	Cat.4 PL e SIL 3	13	Configuration Change Reset When this Safe I/O is changed from OFF to ON, the current signature is copied to the latched signature for corresponding items in the DCS signature menu and the corresponding CCL is turned ON. The correspondence of the index is the same as CCL. When CCR[1] is changed from OFF to ON, the current signature is copied to the latched signature for all items in the DCS signature menu and all CCL[1-4] are turned ON.
RPI	1-4	Input	Cat.4 PL e SIL 3	14	Robot Power Input In the system that two or more robots are connected to the robot controller, RPI shows the status of robot disable switch. ON: The robot disable switch selects enable. OFF: The robot disable switch selects disable. In this case, the servo power of this robot is turned OFF. The index is the robot number of the robot disable switch. The robot number is displayed in DCS Safe I/O device menu.
RPO	1-4	Output	Cat.4 PL e SIL 3	15	Robot Power Output When RPO is OFF, the servo power of the corresponded robot is turned OFF. The index is the robot number. RPO works as the same as robot disable switch. The initial value of this signal is ON, and the servo power of robot is not turned off when this signal is not used (this signal is not specified in Safe I/O connect).
FSI	1-272	Input	Cat.4 PL e SIL 3	16	Safety function by FL-net Input Inputs from the Safety function by FL-net network.
FSO	1-80	Output	Cat.4 PL e SIL 3	17	Safety function by FL-net Output Outputs to the Safety function by FL-net network. Actual output becomes OFF in fault situation even though FSO is set to ON.(Note 1)
SLI	1-64	Input	Cat.3 PL d SIL 2	18	Input for I/O Link i Slave Safety input signals for I/O Link i Slave function.
SLO	1-64	Output	Cat.3 PL d SIL 2	19	Output for I/O Link i Slave Safety output signals for I/O Link i Slave function. Actual output becomes OFF in fault situation even though SLO is set to ON.(Note 1)

Type	Range of index	Input / Output	Cat. PL SIL	Slot	Description
---	0				Not defined. This means no safe I/O is defined.
ON	0	Input	Cat.4 PL e SIL 3		Always ON
OFF	0	Input	Cat.4 PL e SIL 3		Always OFF
NSI	1-32	Input	Non-safety data	0 (DO)	Non-safety input NSI can be assigned to DO as rack 36 slot 0. When the assigned DO is ON, the NSI is ON. When the DO is OFF, the NSI is OFF. NSI is non-safety data. If NSI is used for safety purpose, it will not work as safety function, and serious personal injury could result. Adequate risk assessment for the whole robot system is necessary to use NSI. Please refer to "5.3 EXAMPLE OF SAFE ZONE SWITCHING BY USING NSI".

⚠WARNING

NSI is non-safety data. If NSI is used for safety purpose, it will not work as safety function, and serious personal injury could result. Adequate risk assessment for the whole robot system is necessary to use NSI.

Especially, when operation (AND,OR) is used between NSI and other Safe I/O, the result will be non-safety data. (Ex. "SIR[1]=NSI[1] OR SPI[1]". In this case, SIR[1] is non-safety data.)
When NSI and other Safe I/O are mixed in logic of safe I/O connect function, adequate analysis of logic is necessary.

You can save the current setting of safe I/O connect function to memory card as text file (DCSVRFY.DG) in FILE menu. It may be helpful to analyze the logic, because you can read and print it by PC.

⚠WARNING

If the safety output signals such as SPO, CSO, FSO or SLO is used, the robot system should be designed as that the robot system becomes Safe (Stop) State when these safety output signals are OFF. These safety output signals are forced to OFF when internal fault is detected in robot controller.
If the robot system does not become Safe State when these safety output signals are OFF, the safety function will not work, and serious personal injury could result.

Note 1: The actual output of SPO, CSO, FSO and SLO becomes OFF when the following alarm occurs.
SRVO-248 Deadman switch status abnormal
SRVO-266 FENCE1 status abnormal
SRVO-267 FENCE2 status abnormal
SRVO-268 SVOFF1 status abnormal
SRVO-269 SVOFF2 status abnormal
SRVO-270 EXEMG1 status abnormal
SRVO-271 EXEMG2 status abnormal
SRVO-272 SVDISC1 status abnormal

SRVO-273 SVDISC2 status abnormal
SRVO-274 NTED1 status abnormal
SRVO-275 NTED2 status abnormal
SRVO-335 DCS OFFCHK alarm i, j
SRVO-336 DCS RAMCHK alarm i, j
SRVO-337 DCS PRMCHK alarm i, j
SRVO-338 DCS FLOW alarm i, j
SRVO-339 DCS MISC alarm i, j
SRVO-344 DCS GRP alarm(G i) j, k
SRVO-347 DCS AXS alarm(G i,A j) k, l
SRVO-348 DCS MCC OFF alarm i, j
SRVO-349 DCS MCC ON alarm i, j
SRVO-350 DCS CPU alarm i, j
SRVO-351 DCS CRC alarm i, j
SRVO-352 DCS COUNT1 alarm i, j
SRVO-353 DCS COUNT2 alarm i, j
SRVO-354 DCS DICHK alarm i, j
SRVO-355 DCS ITP_TIME alarm i, j
SRVO-356 DCS ITP_SCAN alarm i, j
SRVO-357 DCS ENABLED alarm i, j
SRVO-358 DCS INVPRM alarm i, j
SRVO-359 DCS SYSTEM alarm i, j
SRVO-360 DCS CC_TCP alarm(G i) j, k
SRVO-361 DCS CC_FP alarm(G i) j, k
SRVO-362 DCS CC_TCPS alarm(G i) j, k
SRVO-363 DCS CC_FPS alarm(G i) j, k
SRVO-364 DCS PRMCRC alarm(G i) j, k
SRVO-365 DCS FB_CMP alarm(G i,A j) k, l
SRVO-366 DCS FB_INFO alarm(G i,A j) k, l
SRVO-367 DCS CC_JPOS alarm(G i,A j) k, l
SRVO-368 DCS CC_JSPD alarm(G i,A j) k, l
SRVO-370 SVON1 status abnormal
SRVO-371 SVON2 status abnormal
SRVO-372 OPEMG1 status abnormal
SRVO-373 OPEMG2 status abnormal
SRVO-374 MODE11 status abnormal
SRVO-375 MODE12 status abnormal
SRVO-376 MODE21 status abnormal
SRVO-377 MODE22 status abnormal"
SRVO-378 SFDIxx status abnormal
SRVO-412 DCS COUNT3 alarm i, j
SRVO-413 DCS CC_SAFEIO alarm i, j
SRVO-414 DCS WORK CRC alarm i, j
SRVO-417 DCS APSP_C alarm (G i) j, k
SRVO-418 DCS APSP_J alarm (G i, A j) k, l
SRVO-447 DCS LS STO-FB alarm
SRVO-448 DCS PLSCHK alarm
SRVO-449 DCS DOMON alarm
SRVO-471 I/O Link i slave(i-j) status abnormal

Note 2: Regarding SFDO output,

- When SFDO pulse check is enabled, an application involving the SFDO and an external diagnostic device may achieve cat 4, Pl=e, SIL 3.
- When SFDO pulse check is disabled, an application involving the SFDO and an external diagnostic device may achieve cat 3, Pl=d, SIL 2.

Note 3: When SFDI and SFDO of I/O Unit-MODEL A is used, an application involving the SFDI and SFDO may achieve cat 3, Pl=d, SIL 2.

Detail of SSI

Index	Name	Description
SSI[1]	SVOFF	The status of EGS1 and EGS2 on the emergency stop board. ON: Both are CLOSED, OFF: Either circuit is OPEN In R-30*i*B Mate, SSI[1] is always ON.
SSI[2]	FENCE	The status of EAS1 and EAS2 on the emergency stop board. ON: Both are CLOSED, OFF: Either circuit is OPEN
SSI[3]	EXEMG	The status of EES1 and EES2 on the emergency stop board. ON: Both are CLOSED, OFF: Either circuit is OPEN In R-30*i*B Mate, SSI[3] becomes OFF when EES1 or EES2 is OPEN or the Operator Panel E-Stop button is pressed or the Teach Pendant E-Stop button is pressed. In addition, when Shared Teach Pendant function is enabled, SSI[3] becomes OFF in the following case; - Panel E-Stop button is pressed or the Teach Pendant E-Stop button is pressed. - E-stop occurs in other controllers in Shared Teach Pendant group. In this case SRVO-422 occurred. - SRVO-423, SRVO-424 or SRVO-725 occurs.
SSI[4]		Not used.
SSI[5]	NTED	The status of NTED1 and NTED2 on the emergency stop board and the Teach Pendant deadman (Enable) switches. ON: Both NTED1 and NTED2 are CLOSED, and either deadman switch on the Teach Pendant is gripped normally. OFF: NTED1 or NTED2 is OPEN or both deadman switches are released or gripped strongly.
SSI[6]	OPEMG	The status of the Operator Panel Emergency Stop button and the Teach Pendant Emergency Stop button ON: Both are released., OFF: Either Emergency Stop is pressed. In R-30*i*B Mate, SSI[6] is always ON. Please use SSI[3].
SSI[7]	AUTO	ON: AUTO mode, OFF: Not AUTO mode
SSI[8]	T1	ON: T1 Mode, OFF: Not T1 Mode
SSI[9]	T2	ON: T2 Mode, OFF: Not T2 Mode
SSI[10]	MCC	ON: Servo power supply is ON, OFF: Servo power supply is OFF. In the system that two or more robots are connected to the robot controller, This is ON when servo power of one or more robot is turned ON. It is OFF when servo power of all robots are turned OFF.
SSI[11]	CSBP	CIP Safety ByPassed ON: "Enable/Bypass" in DCS CIP safety menu is BYPASS, OFF: Not BYPASS When PROFINET Safety is installed, ON: "Enable/Bypass" in DCS PROFINET safety menu is BYPASS, OFF: Not BYPASS

Detail of SSO

Index	Name	Description
SSO[1]	C_SVOFF	When this Safe I/O is OFF, the robot decelerates then stops and the servo power supply is turned off. "SRVO-406 DCS SSO SVOFF input" occurs. The initial value of this signal is ON, and the alarm does not occur when this signal is not used (this signal is not specified in Safe I/O connect). SVOFF(EGS) signal on emergency stop board and this signal work independently. When this signal is used instead of SVOFF signal, SVOFF signal should be jumpered.

Index	Name	Description
SSO[2]	C_FENCE	When this Safe I/O is OFF in AUTO mode, the robot decelerates then stops and the servo power supply is turned off. "SRVO-407 DCS SSO Fence Open" occurs. The initial value of this signal is ON, and the alarm does not occur when this signal is not used (this signal is not specified in Safe I/O connect). FENCE(EAS) signal on emergency stop board and this signal work independently. When this signal is used instead of FENCE signal, FENCE signal should be jumpered.
SSO[3]	C_EXEMG	When this Safe I/O is OFF, the servo power supply is turned off and the robot stops immediately. "SRVO-408 DCS SSO Ext Emergency Stop" occurs. The initial value of this signal is ON, and the alarm does not occur when this signal is not used (this signal is not specified in Safe I/O connect). External Emergency Stop(EES) signal on emergency stop board and this signal work independently. When this signal is used instead of External Emergency Stop signal, External Emergency Stop signal should be jumpered.
SSO[4]	C_SVDISC	When this Safe I/O is OFF, the servo power supply is turned off and the robot stops immediately. "SRVO-409 DCS SSO Servo Disconnect" occurs. The initial value of this signal is ON, and the alarm does not occur when this signal is not used (this signal is not specified in Safe I/O connect).
SSO[5]	C_NTED	When this Safe I/O is OFF in T1 or T2 mode, the servo power supply is turned off and the robot stops immediately. "SRVO-410 DCS SSO NTED input" occurs. The initial value of this signal is ON, and the alarm does not occur when this signal is not used (this signal is not specified in Safe I/O connect). NTED signal on emergency stop board and this signal work independently. When this signal is used instead of NTED signal, NTED signal should be jumpered.
SSO[6]	C_T1	SSO[6] and SSO[7] are used to select AUTO/T1/T2 operation mode in place of mode switch on operator panel. To use SSO[6] and SSO[7], “External mode select” option (A05B-2600-J569) is necessary and the operator panel must be “No mode switch” type. If the option is loaded to the robot controller that the operator panel has mode switch, the alarm “SYST-301 External mode select is not available” occurs. AUTO/T1/T2 mode is selected according to the status of SSO[6] and SSO[7] as follows.
SSO[7]	C_T2	SSO[6:C_T1] / SSO[7:C_T2] / Mode OFF / OFF / AUTO ON / OFF / T1 ON / ON / T2 OFF / ON / Invalid (SYST-037, SRVO-411) Note: When “External mode select” option is used, a risk assessment for the whole robot system is necessary, including the means to select the operational mode.

⚠WARNING

When “External mode select” option is used (AUTO/T1/T2 operational mode is selected by SSO[6] and SSO[7]), a risk assessment for the whole robot system is necessary, including the means to select the operational mode.
If a robot is used with an incorrect operational mode, the safety function does not work correctly and serious personal injury result.
The means to select the operational mode must fulfil the following requirement.

Operational modes shall be selectable with a mode selector which can be locked in each position (e.g. a key operated switch which can be inserted and extracted in each position). Each position of the selector shall be clearly identifiable and shall exclusively allow one control or operating mode.

Safe I/O status monitoring (Non-safety function)

Safe I/O except NSI can be assigned to digital inputs (DI). To read the status of the Safe I/O, you can monitor the DI that the Safe I/O is assigned to from a TP program, a KAREL program, etc.

Rack: 36
Slot: The number specified in "Slot" column" in the above table
Start point: Same as Safe I/O index.

Example: SPI[1-4] can be read as DI[1-4] by the following I/O assignment setting.

	RANGE	RACK	SLOT	START
DI[	1- 4]	36	1	1

⚠WARNING
Safe I/O status monitoring is not a safety function. If a DI that is assigned to Safe I/O is used where a safety function is required, the safety function will not work under some fault conditions and serious personal injury could result. Do not use Safe I/O monitoring for safety purposes.

Safe I/O assignment for Integrated PMC function (Non-safety function)

To use the Safe I/O in integrated PMC function, you can assign the Safe I/O in PMC external I/O assignment as follows.

Rack: 36
Slot: The number specified in "Slot" column" in the above table

- Safe I/O except NSI can be assigned to X of integrated PMC, and the integrated PMC function can read the Safe I/O. In the following example, SIR[1-64] can be read by X0.0 - X7.7.

	Type	Rack	Slot	Size	Addr
1	DI	36	5	8	1:X00000

- Non-safety input (NSI) can be assigned to Y of integrated PMC, and the integrated PMC function can output to NSI. In the following example, NSI[1-64] can be output by Y0.0 - Y7.7.

	Type	Rack	Slot	Size	Addr
1	DO	36	0	8	1:Y00000

⚠WARNING
The integrated PMC function is not a safety function. If the integrated PMC function is used where a safety function is required, the integrated PMC process will not work under some fault conditions and serious personal injury could result. Do not use the integrated PMC function for safety purposes.

5.1.1 SFDO Pulse Check

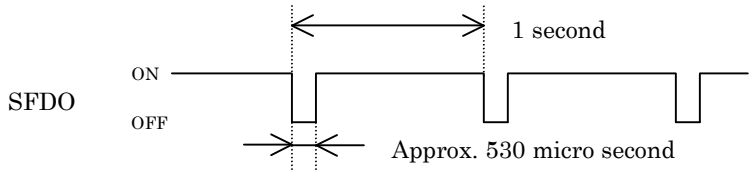
SFDO pulse check is diagnostic function to detect SFDO output circuit.

- SFDO pulse check can be ENABLE or DISABLE by the setting in DCS Safe I/O device menu (default is ENABLE).
- When SFDO pulse check is enabled, SFDO output is safety function of Category 4, PL e, SIL 3. When it is disabled, SFDO output is safety function of Category 3, PL d, SIL 2.
- When SFDO pulse check is enabled, pulse check is performed for all SFDO signals. It is not possible to enable/disable each SFDO signal individually.
- The pulse check is not performed for the safety output signal SFDO of I/O Unit-MODEL A even though SFDO pulse check is enabled.

⚠WARNING
When SFDO pulse check is disabled, adequate risk assessment for the whole robot system is necessary to verify that a Category 3, PL d, SIL 2 safety function is adequate. The external device connected to SFDO needs to check the discrepancy of redundant output signals when SFDO pulse check is disabled. If the external device detects the discrepancy in a given time, the system should be turned to the safe state like emergency stop condition.

When SFDO pulse check is enabled, OFF pulse is output periodically, and the status of the output signal is monitored. If the monitored signal does not include the pulse, it is diagnosed as trouble in output circuit or cabling.

⚠CAUTION
Please check the input response time of the device that is connected to the safety output not to work unexpectedly by the periodic OFF pulse.



When trouble is detected, the following alarm occurs, and the servo power is cut off, and all safety outputs turn OFF. The signal name where the trouble is detected is displayed after the alarm message.

SRVO-448 DCS PLSCHK alarm
This alarm occurs when the monitored signal of safety output is not OFF even though OFF pulse is output.

SRVO-449 DCS DOMON alarm
This alarm occurs when the monitored signal of safety output is different from the output command.

5.1.2 DCS Safe I/O Status Menu

The DCS Safe I/O status menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "Safe I/O status" item in the DCS Top menu.
In the DCS Safe I/O status menu, Safe I/O status and comment are displayed. The Safe I/O comment can be changed in this menu.

```
DCS
Safe I/O status                    1/8
        Status          Comment
 SPI[  1]  ON      [SFDI1              ]
 SPI[  2]  ON      [SFDI2              ]
 SPI[  3]  ON      [SFDI3              ]
 SPI[  4]  ON      [SFDI4              ]
 SPI[  5]  ON      [SFDI5              ]
 SPI[  6]  ON      [SFDI6              ]
 SPI[  7]  ON      [SFDI7              ]
 SPI[  8]  ON      [SFDI8              ]

[ TYPE ][ DATA ]
```

Items in DCS Safe I/O status menu

Item	Description
Safe I/O name	The Safe I/O name is displayed.
Status	The Safe I/O status (ON, OFF) is displayed.
Comment	The Safe I/O comment is displayed. Press ENTER key to change the comment.

Operation in DCS Safe I/O status

Operation	Description
F2(DATA)	A pull-up menu of the Safe I/O types is displayed for selection of which type is displayed in the menu.
PREV	The DCS Top menu is displayed.

5.2 SAFE I/O CONNECT FUNCTION

In order to use Safe I/O Connect please be sure the following software option is loaded:
- Safe I/O Connect (A05B-2600-J568)

The Safe I/O Connect function is used to read and set safety inputs and outputs.

When the status of safety input signal such as SPI is changed, nothing occurs by default. By the following setting of Safe I/O connect, SPI[1] (SFDI1) is connected to SSO[3] (C_EXEMG). By this setting, when SPI[1] is OFF, SSO[3] becomes OFF, and "SRVO-408 DCS SSO Ext Emergency Stop" alarm occurs, and robot stops as Power-Off stop.

```
SSO[3:C_EXEMG] =  SPI[1:SFDI1]
```

Safe I/O Connect supports logical operations (AND, OR, NOT) for Safe I/O. By the following setting, only when SPI[1] is ON AND SPI[2] is OFF, robot motion is available.

```
SSO[3:C_EXEMG] =  SPI[1:SFDI1] AND !SPI[2:SFDI2]
```

One AND or OR operation can be specified in one Safe I/O Connect setting. To process complex logical operations, please use safe internal relay (SIR). By the following setting, only when all of SPI[1] , SPI[2] and SPI[3] are ON, robot motion is available.

```
SIR[1]         =  SPI[1:SFDI1] AND  SPI[2:SFDI2]
SSO[3:C_EXEMG] =  SIR[1]       AND  SPI[3:SFDI3]
```

Safe internal relay can be used as disabling input of Position/Speed check function. If SIR[1] is used as disabling input of Position/Speed check, by the following setting, when both SPI[1] and SPI[2] are ON, the Position/Speed check is disabled.

```
SIR[1]  =  SPI[1:SFDI1] AND  SPI[2:SFDI2]
```

Safe I/O Connect can control safe outputs according to safety information. By the following setting, when the status of Cartesian Position Check No.1 is "SAFE", the safety output signal SFDO1 is ON.
When the "Stop type" of the Cartesian Position Check is set to "Not Stop", the Cartesian Position Check function can be used as the function that the safety output SFDO1 is set according to the robot position. (When the "Stop type" is "Not stop", stop position prediction does not work.)

```
SPO[1:SFDO1] =  CPC[1]
```

The following is the specification of the Safe I/O Connect function.

- Safe I/O connect is defined in the DCS Safe I/O connect menu.
- A maximum of 64 Safe I/O Connect settings can be defined.
- The lines that the Output (left) item is "---" are ignored.
- All Safe I/O Connect logic are processed every 2msec in order from the top of setting menu.
- When "Safe I/O process" item in DCS Safe I/O device menu is set to "Safety PMC", Safe I/O connect function is disabled.

⚠WARNING
If Safe I/O connect is set incorrectly, the safety function will not work, and serious personal injury could result. When Safe I/O connect settings are changed, the values must be verified and the function must be tested again.

⚠WARNING
If Safe I/O Connect feature is used, safety signal status could be delayed by a maximum of 2 ms. In this case, a risk assessment for the whole robot system is necessary, including the additional 2 ms delay.

⚠WARNING
If the safety output signals such as SPO, CSO, FSO or SLO is used, the robot system should be designed as that the robot system becomes Safe (Stop) State when these safety output signals are OFF. These safety output signals are forced to OFF when internal fault is detected in robot controller.
If the robot system does not become Safe State when these safety output signals are OFF, the safety function will not work, and serious personal injury could result.

Example of Safe I/O Connect - 1

By the following setting, when SFDI1 is open, robot stops as follows.

- In AUTO mode, "SRVO-406 DCS SSO SVOFF input" alarm occurs, and robot stops as Controlled stop.
- In T1/T2 mode, "SRVO-408 DCS SSO Ext Emergency Stop" alarm occurs, and robot stops as Power-Off stop.

```
SSO[1:C_SVOFF] = !SSI[7:AUTO] OR  SPI[1:SFDI1]
SSO[3:C_EXEMG] =  SSI[7:AUTO] OR  SPI[1:SFDI1]
```

Example of Safe I/O Connect - 2

By the following setting, when FENCE signal (EAS) is open in T2 mode, "SRVO-406 DCS SSO SVOFF input" alarm occurs, and robot stops as Controlled stop. This setting is useful to provide the system a situation where the robot can move only when safety fence is closed in T2 mode.

```
SSO[1:C_SVOFF] =  SSI[2:FENCE] OR !SSI[9:T2]
```

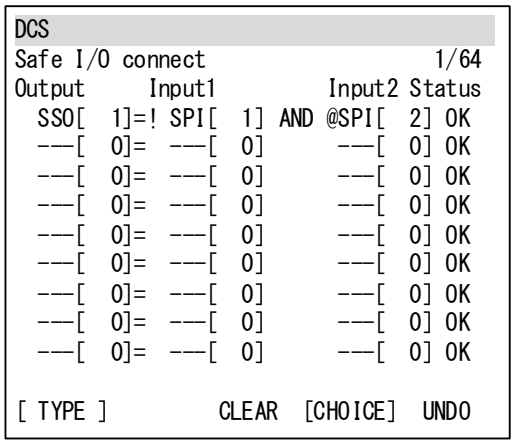
Example of Safe I/O Connect - 3

By the following setting, the status of Teach pendant deadman (enable) switch is output to the safety output signal SFDO1. When the deamdan switch is gripped, SFDO1 is ON.

```
SPO[1:SFDO1] =  SSI[5:NTED]
```

5.2.1 DCS Safe I/O Connect Menu

The DCS Safe I/O connect menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "Safe I/O connect" item in the DCS Top menu.



Items in DCS Safe I/O connect menu

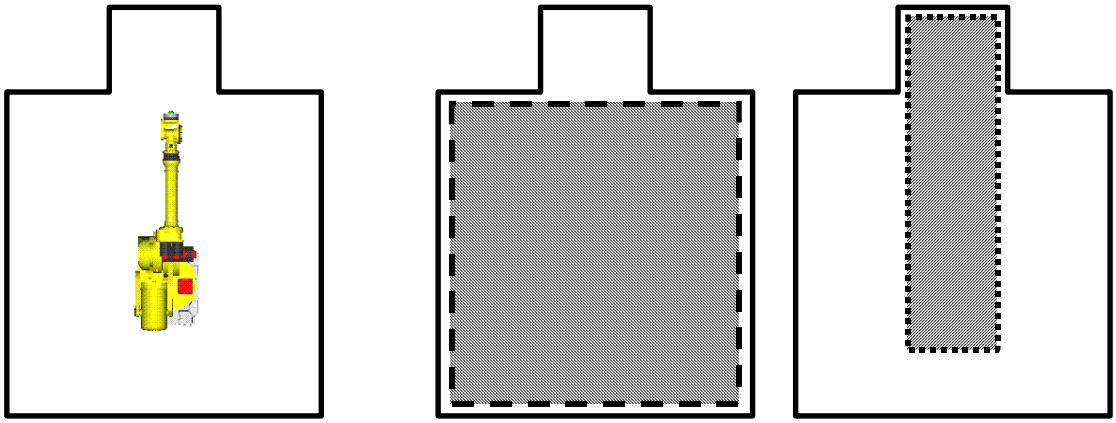
Item	Description
Output	Used to set the Safe I/O that is used for output. When "---" is selected, the line is disabled. When the specified Safe I/O is ON, "@" is displayed on the left side of the Safe I/O name. When the cursor is on this item, the comment of the specified Safe I/O is displayed on the prompt line at the bottom of the screen.
Input 1	Used to set the Safe I/O that is used for input 1. You can specify "!" on the left side of the Safe I/O name, this means the inverse value (NOT) is used. When the specified Safe I/O is ON, "@" is displayed on the left side of the Safe I/O name. When the cursor is on this item, the comment of the specified Safe I/O is displayed on the prompt line at the bottom of the screen.
Input 2	Used to set the Safe I/O that is used for input 2. You can specify "!" on the left side of the Safe I/O name, this means the inverse value (NOT) is used. When the specified Safe I/O is ON, "@" is displayed on the left side of the Safe I/O name. When the cursor is on this item, the comment of the specified Safe I/O is displayed on the prompt line at the bottom of the screen.
Operation	Used to set the operation of input 1 and input 2. (Space): No operation. Input 2 is ignored. AND: Logical AND of input 1 and input 2. OR: Logical OR of input 1 and input 2.
Status	The status of this Safe I/O connect is displayed. OK: Setting parameter and DCS parameter are the same. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.

Operation in DCS Safe I/O connect menu

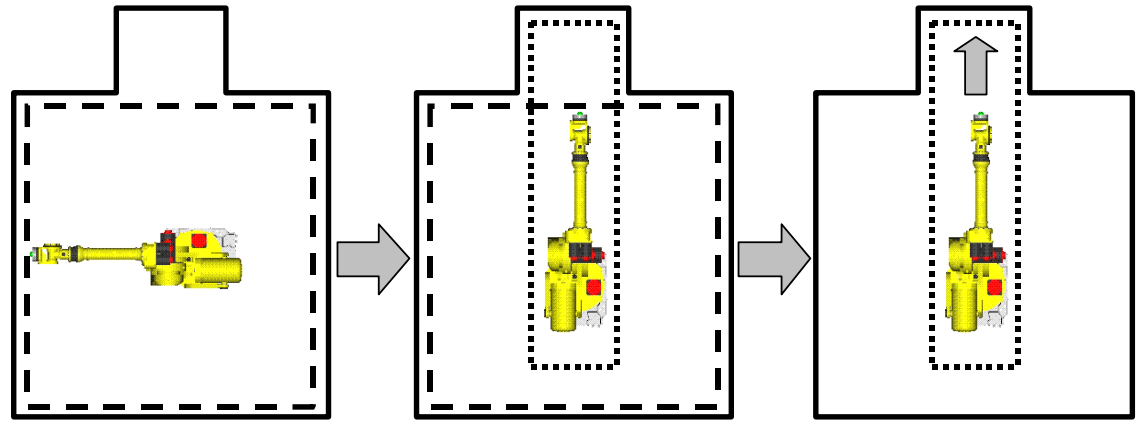
Operation	Description
F3(CLEAR)	Clear the items in the line of the cursor.
F5(UNDO)	UNDO the items in this menu. The setting parameters become the same as the current DCS parameters.
PREV	The DCS Top menu is displayed.

5.3 EXAMPLE OF SAFE ZONE SWITCHING BY USING NSI

NSI is Non-Safety Input signal. When NSI is used, the system should be designed so it does not create a dangerous situation even when the NSI has the wrong value. The following is an example of safe zone switching by using NSI.



- This example is to setup DCS so the robot does not go out of the restricted zone.
- Two zones, zone 1 and zone 2, are setup in the DCS position check function. Both are INSIDE zones. The switching of these must be timed properly because the robot goes out of the intersecting area of the two zones when both zones are enabled simultaneously.



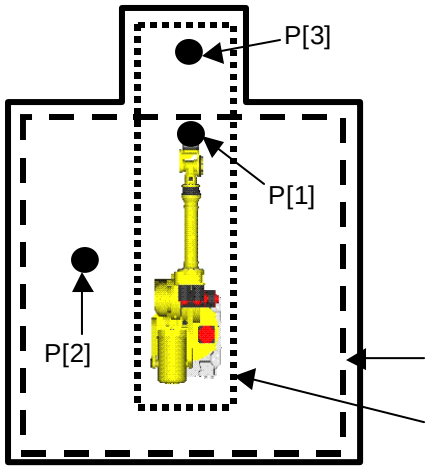
- In case 1 of the above figure, only zone 1 is enable, and the robot can move freely in zone 1. In case 2, no alarm occurs even though the both zones are enable, because the robot is in the intersecting area of the two zones. The zones are switched when the robot is in this position. In case 3, only zone 2 is enable, the robot can move forward.
- The timing of the zone switching is controlled from the robot program by using NSI. For example, when DO[1] is assigned to rack 36, slot 0, start port 1, then NSI[1] becomes ON(OFF) when DO[1] is set to ON(OFF). The robot program controls the zone switching by using DO[1].
- The following figure is an example of the setting and program for this system. Zone 1 and zone 2 are switched from the robot program by using DO[1]. The following table shows the status of each signal and zone depends on the DO[1] status.

I/O assignment
DO[1] → NSI[1]

Safe I/O connect
SIR[1] = NSI[1]
SIR[2] = ! NSI[1]

Zone 1
Safe side: INSIDE
Disabling input: SIR[1]

Zone 2
Safe side: INSIDE
Disabling input: SIR[2]



Example Program
```
1: L P[1] 100mm/sec FINE
2:   DO[1]=OFF (Enable zone 1)
3: L P[2] 100mm/sec FINE
4: L P[1] 100mm/sec FINE
5:   DO[1]=ON (Enabel zone 2)
6: L P[3] 100mm/sec FINE
```

DO[1]	NSI[1]	SIR[1]	SIR[2]	Zone 1	Zone 2
OFF	OFF	OFF	ON	Enable	Disable
ON	ON	ON	OFF	Disable	Enable

- NSI is a Non-safety signal. It may have wrong value because of hardware failure and so on. When NSI is used, DCS settings must be considered so they do not cause a dangerous situation even though the NSI has the wrong value. A dangerous situation would be the case where both zones are disabled at the same time. In this case, the robot can go out of the restricted zone. In the above setting, there is no possibility that both zones become disable even though the NSI has wrong value when the safety function works normally.
- If NSI[1] becomes ON when the robot is on P[2] in the above figure, zone 2 becomes enabled and the alarm of the DCS Cartesian position check occurs, and the servo power of the robot is cut off, the system becomes safety state.

Example of inappropriate setting

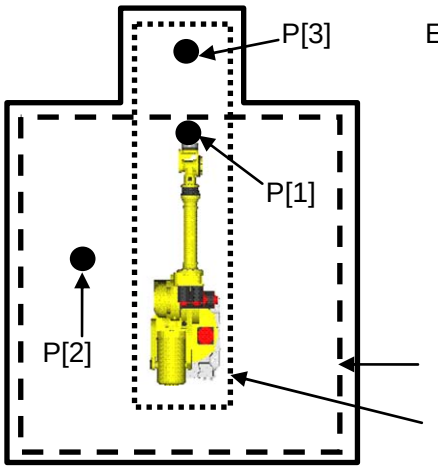
The system of the following setting and program work as the same as the above system, but the robot motion is not restricted in the restricted zone when the NSI has wrong value by hardware failure and so on.

I/O assignment
DO[1] → NSI[1]
DO[2] → NSI[2]

Safe I/O connect
SIR[1] = NSI[1]
SIR[2] = NSI[2]

Zone 1
Safe side: INSIDE
Disabling input: SIR[1]

Zone 2
Safe side: INSIDE
Disabling input: SIR[2]



Example Program
```
1: L P[1] 100mm/sec FINE
2:   DO[1]=OFF (Enable zone 1)
3:   DO[2]=ON  (Disable zone 2)
4: L P[2] 100mm/sec FINE
5: L P[1] 100mm/sec FINE
6:   DO[2]=OFF (Enable zone 2)
7:   DO[1]=ON  (Disable zone 1)
8: L P[3] 100mm/sec FINE
```

DO[1]	DO[2]	SIR[1]	SIR[2]	Zone 1	Zone 2
OFF	OFF	OFF	OFF	Enable	Enable
OFF	ON	OFF	ON	Enable	Disable
ON	OFF	ON	OFF	Disable	Enable
ON	**ON**	**ON**	**ON**	**Disable**	**Disable**

When both DO[1] and DO[2] (NSI[1] and NSI[2]) are set to ON (which is the case in the last line of the above table), both zone 1 and zone 2 become disabled, and the robot can go out of the restricted zone.
The program controls DO[1] and DO[2] so both are not ON at the same time, but it is not sufficient because program execution is not a safety function.

⚠WARNING
NSI is non-safety data. If NSI is used for safety purpose, it will not work as a safety function, and serious personal injury could result. Adequate risk assessment for the whole robot system is necessary when using NSI.

Especially, when an operation (AND,OR) is used between NSI and another Safe I/O, the result will be non-safety data. (Ex. "SIR[1]=NSI[1] OR SPI[1]". In this case, SIR[1] is non-safety data.)
When NSI and other Safe I/O are mixed in the logic of a safe I/O connect function, adequate analysis of logic is necessary.

You can save the current setting of the safe I/O connect function to memory card as a text file (DCSVRFY.DG) in FILE menu. It may be helpful to analyze the logic, because you can read and print it with a PC.

5.4 ADDITIONAL SAFETY SIGNALS

Safety signals can be added by additional safety I/O board or I/O Unit-MODEL A. The additional safety signals are assigned to SPI and SPO.

The slave controller is connected in multi-arm system or some robot models such as M-2000iA. The emergency stop board is in the slave controller, and the safety signals on the emergency stop board is assigned to SPI and SPO.

The assignment to SPI and SPO is assigned automatically according to the connected safety I/O device configuration, and the assignment cannot be changed by manual. When new safety I/O device is connected, at first, the INITIALIZATION of the safety I/O device is needed. By the initialization, the added safety I/O device is assigned to SPI and SPO. When the safety I/O device is disconnected after the initialization, the alarm "SRVO-217 E-STOP Board not found" occurs. To remove the additional safety I/O device, the initialization of the safety I/O device is needed.

In R-30*i*B controller, SPI[1-8] and SPO[1-8] are assigned to emergency stop board by default. The additional safety signals are assigned to SPI[9-64] and SPO[9-64].
In R-30*i*B Mate controller, SPI and SPO are not assigned by default. The additional safety signals are assigned to SPI[1-64] and SPO[1-64].

To use additional safety I/O in R-30*i*B Mate controller, the main board that has PMC function is necessary.

The safety I/O devices that are used in DCS are the following.

Additional safety I/O board

Additional safety I/O board has 8 safety input and 8 safety output. Maximum 3 additional safety I/O boards can be connected in R-30*i*B (Maximum 4 additional safety I/O boards can be connected in R-30*i*B Mate, but practically the maximum number of safety I/O boards is 2 because the number of min-slot is 2.). When it is used with I/O Unit-MODEL A, the maximum number of additional safety I/O board is decreased by 1. When the slave controller is connected, the maximum number of additional safety I/O board is decreased by the number of the slave controller.
Please refer to "16.2.3 In Case of Additional Safety I/O Board (mini-slot)" about the connection of the additional safety I/O board.

For the robot controller that the slave controller is connected such as M-2000iA, when the additional safety I/O board is connected, the alarm "SRVO-217 E-STOP Board not found" occurs. To clear the alarm, the initialization of the safety I/O device is needed.

The assignment of each additional safety I/O board is the following.

Additional safety I/O board	R-30*i*B		R-30*i*B Mate	
	Safety input	Safety output	Safety input	Safety output
#1	SPI[9] : SFDI1 : : SPI[16] : SFDI8	SPO[9] : SFDO1 : : SPO[16] : SFDO8	SPI[1] : SFDI1 : : SPI[8] : SFDI8	SPO[1] : SFDO1 : : SPO[8] : SFDO8
#2	SPI[17] : SFDI1 : : SPI[24] : SFDI8	SPO[17] : SFDO1 : : SPO[24] : SFDO8	SPI[9] : SFDI1 : : SPI[16] : SFDI8	SPO[9] : SFDO1 : : SPO[16] : SFDO8
#3	SPI[25] : SFDI1 : : SPI[32] : SFDI8	SPO[25] : SFDO1 : : SPO[32] : SFDO8	(SPI[17] : SFDI1) : : (SPI[24] : SFDI8)	(SPO[17] : SFDO1) : : (SPO[24] : SFDO8)
#4	-	-	(SPI[25] : SFDI1) : : (SPI[32] : SFDI8)	(SPO[25] : SFDO1) : : (SPO[32] : SFDO8)

I/O Unit-MODEL A

The I/O Unit-MODEL A can add maximum 56 safety input and 56 safety output in R-30*i*B (maximum 64 safety input and 64 safety output in R-30*i*B Mate). When it is used with the additional safety I/O board, the maximum number of safety input and safety output are decreased 8 ports by each one additional safety I/O board. When the slave controller is connected, the maximum number of safety input and safety output are decreased 16 ports by each one slave controller.

To use I/O Unit-MODEL A for safety signal, two base units are used. The I/O module configurations on the two base units must be completely same. A pair of the corresponded I/O modules is used as a safety I/O device. The maximum 7 safety I/O devices (pairs of the I/O modules) can be added. But the maximum number of safety signals is limited as the above. When additional safety I/O board or slave controller is connected, the maximum number of the pairs of I/O modules is decreased by the number of these safety I/O devices.

The signals on the I/O modules of a pair are used as dual channel safety signal.
Please refer to "16.1.4 In case of I/O Unit-MODEL A" about the connection of the I/O Unit-MODEL A.

The safety signals of the I/O Unit-MODEL A are safety function of Category 3, PL d, SIL 2.
The SFDO pulse check is not performed for the SFDO of the I/O Unit-MODEL A even though the SFDO pulse check is enabled.

⚠WARNING
When additional Safety I/O by I/O Unit-MODEL A is used, adequate risk assessment for the whole robot system is necessary to verify that a Category 3, PL d, SIL 2 safety function is adequate.

The signals in I/O Unit-MODEL A are assigned to SPI and SPO by the order of slot number. The following is an example of safety I/O assignment for I/O Unit-MODEL A.

Slot	Module name	R-30*i*B		R-30*i*B Mate	
		Safety input	Safety output	Safety input	Safety output
1	AOD08D	-	SPO[9] : SFD01 : : SPO[16] : SFD08	-	SPO[1] : SFD01 : : SPO[8] : SFD08
2	AOD16D	-	SPO[17] : SFD01 : : SPO[32] : SFD016	-	SPO[9] : SFD01 : : SPO[24] : SFD016
3	AID32E1	SPI[9] : SFDI1 : : SPI[40] : SFDI32	-	SPI[1] : SFDI1 : : SPI[32] : SFDI32	-

Emergency stop board in slave controller

The safety signals on the emergency stop board in the slave controller are assigned as follows. When the slave controller is A cabinet, only 2 safety input (SFDI1, SFDI2) and 2 safety output (SFDO1, SFDO2) are available. When the slave controller is B cabinet, safety signals are not available if safety I/O board (option) is not used. When the slave controller is Mate cabinet, safety signals are not available.

Slave controller	Safety input	Safety output
#1	SPI[49] : SFDI1 : : SPI[56] : SFDI8	SPO[49] : SFD01 : : SPO[56] : SFD08
#2	SPI[33] : SFDI1 : : SPI[40] : SFDI8	SPO[33] : SFD01 : : SPO[40] : SFD08
#3	SPI[17] : SFDI1 : : SPI[24] : SFDI8	SPO[17] : SFD01 : : SPO[24] : SFD08

5.4.1 DCS Safe I/O Device Menu

The DCS Safe I/O device menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "Safe I/O device" item in the DCS Top menu.

This menu can setup the following items.
- The function to process the safe I/O can be selected. The Safe I/O connect function is selected by default. The Safety PMC function can be selected when "DSC Safety PMC" option is loaded.
- Enable or disable of SFDO pulse check can be set.
- Safety I/O device configuration can be initialized to assign safety signals to SPI and SPO when the safety signals are added.

The configuration of the Safe I/O devices connected to the robot controller is displayed in this menu. The assignment of safety I/O signals of each Safe I/O device to SPI/SPO can be checked in this menu.

When two or more Safe I/O devices are connected, the Safe I/O device number that the alarm occurs is displayed such as (1) in the last of the message of the alarm that is related to the Safe I/O board (Ex.

SRVO-378 SFDIxx status abnormal). The displayed number is the Safe I/O device number that is displayed in this menu.

By pressing F2(INIT), the Safe I/O device configuration is initialized according to the current connected devices. The assignment of SPI and SPO is updated according to the Safe I/O device configuration when the type or order of the connected safety I/O device is changed. The new setting will be used by apply to DCS parameter operation.

At the initialization of the safety I/O device configuration, the initialization may be failed with the following message. In this case, please check the configuration or connection of the safety I/O devices.

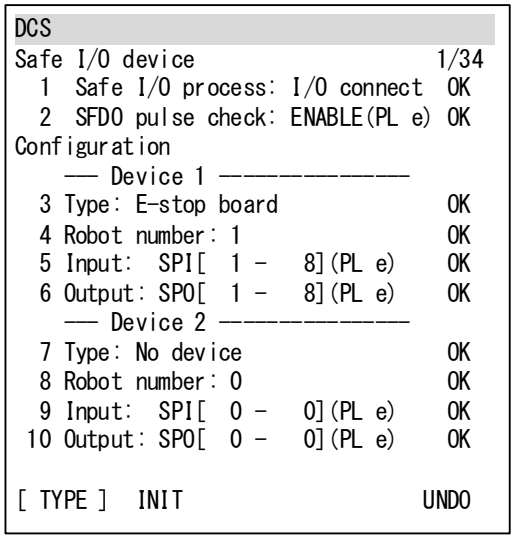
IO unit model A configuration mismatch.
Cause: I/O module configurations of a pair of I/O Unit-MODEL A base unit are not same.
Remedy: Check the I/O module configurations of a pair of I/O Unit-MODEL A base unit.

E-Stop board configuration mismatch.
Cause: There are too many safety signals or I/O modules on I/O Unit-MODEL A.
Remedy: Reduce the number of safety signals or I/O modules of I/O Unit-MODEL A.

Too many safe I/O device!
Cause: The emergency stop board configuration does not match with robot motion group.
Remedy: Check the connection of emergency stop board.

⚠WARNING
If Safe I/O device is set incorrectly, the safety function will not work, and serious personal injury could result. When Safe I/O device settings are changed, the values must be verified and the function must be tested again.

In the DCS safe I/O device menu, the following items are displayed.



Items in DCS Safe I/O device menu

Item	Description
Safe I/O process	Select the function to process Safe I/O. I/O connect: Safe I/O connect function is used (Safety PMC function is not used). Safety PMC: Safety PMC function is used (Safe I/O connect function is not used). To use Safety PMC function, the "DCS Safety PMC" option is needed.
SFDO pulse check	ENABLE(PL e): SFDO pulse check is enabled. SFDO is Cat.4, PL e, SIL 3. DISABLE(PL d): SFDO pulse check is disabled. SFDO is Cat.3, PL d, SIL 2.

Item	Description
Type	The type of the safe I/O device is displayed. No device: Safe I/O device is not connected. E-stop board: Normally one robot has one emergency stop board. In some robot model, one robot have two emergency stop boards or no emergency stop board. E-stop board D-SW: Emergency stop board that the robot disable switches are connected. This type is used for the emergency stop board in the 1st slave controller. Safe I/O board: Additional safety I/O board. General I/O device: A pair of the corresponded I/O Modules on I/O Unit-MODEL A. Mate Main board: This type is used for the device 1 of R-30*i*B Mate controller. This device controls the robot 1, but it does not have safety signal assigned to SPI and SPO. Mate E-stop board: This type of emergency stop board is used in slave controller of Mate cabinet. This device does not have safety signal assigned to SPI and SPO. Mate E-stop board D-SW: Emergency stop board that the robot disable switches are connected. This type is used for the emergency stop board in the 1st slave controller that is Mate cabinet.
Robot number	The robot number that the emergency stop board or main board is connected is displayed. The robot disable switch number is corresponded to the robot number.
Input	The SPI index range that the safety input signals of this Safe I/O device is assigned is displayed. The Performance Level (PL d or PL e) of the safety input signal is displayed.
Output	The SPO index range that the safety output signals of this Safe I/O device is assigned is displayed. The Performance Level (PL d or PL e) of the safety output signal is displayed.
Status	The status of each line is displayed. OK: Setting parameter and DCS parameter are the same. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.

Operation in DCS Safe I/O device menu

Operation	Description
F2(INIT)	Initialize Safe I/O device configuration according to the current connected devices.
F5(UNDO)	UNDO the items in this menu. The setting parameters become the same as the current DCS parameters.
PREV	The DCS Top menu is displayed.

6 DEVICENET SAFETY

6.1 INTRODUCTION

6.1.1 Overview

CIP-Safety is part of a suite of protocols specified by the Open DeviceNet Vendors Association (www.odva.org). This chapter covers Integrated DeviceNet Safety option that is based on the CIP-Safety protocol.

This option allows the robot to act as a slave to a safety plc (such as Rockwell GuardLogix or Omron Safety Controller) exchanging I/O using the CIP-Safety protocol.

> **⚠WARNING**
> At the initial start-up, the operation check and validation of the wiring for safety signals should be carried out, and then the wiring should be protected by the cable duct.

6.1.2 CIP Safety Requirements

This product has been designed to be a part of larger safety devices/systems, each one having different properties.

The robot controller safety configuration is managed locally (generally through the robot teach pendant). This is different from a safety I/O block, for example, that is configured by a Safety Network Configuration Tool (SNCT). If a SNCT configures a device it generates a Safety Configuration Identifier (SCID) which can be used to verify device configuration. A SNCT (eg. RS-Logix5000, Omron Network Configurator safety plc configuration programs) does not configure the robot controller safety behavior. The robot controller safety configuration can be monitored using the following tools :

- DCS Signature Number screen found under DCS Menus
- Configuration Change Latch and Reset bits (CCL, CCR bits)

In the context of the robot acting as a CIP-Safety slave to a safety plc the CCL/CCR bits can be included in the safety I/O exchanged with the safety plc (see section 5.1 in this manual) to detect any change in the robot safety configuration.

The robot's Total Signature Number (shown in the DCS Signature Number screen) can optionally be manually entered into the SNCT as the Configuration Signature. If configured in the SNCT, the robot's signature must match what is entered into the SNCT before a safety connection can be established. The associated Date/Time stamp can be configured in the robot as ACTUAL (default) or FIXED. A setting of ACTUAL means the Date/Time stamp used in the Configuration Signature check when a safety connection is being established will be what is shown on the DCS Signature Number screen under Total Signature (offset in the SNCT by the timezone used by the SNCT). A setting of FIXED means the Configuration Signature Date/Time used in the Configuration Signature check when a safety connection is being established will always be 1/1/2009 at 6:00:00.0 am (offset in the SNCT by the timezone used by the SNCT).

Please consider the following points :

- The replacement of safety devices requires that the replacement device be configured properly and operation of the replacement device shall be user verified.

- The user should assign SNN numbers for each safety network or safety sub-net that are unique system-wide.
- If you choose to configure safety connections with an SCID=0, you are responsible for ensuring that originators and targets have the correct configurations. The robot does not get safety configuration from the safety plc or SNCT, as such, the SNCT has no basis to generate an SCID itself. The robot safety configuration can be managed using the "Signature Number" details screen (under DCS menu on the robot teach pendant) and/or using the "Configuration Change Latch" and "Configuration Change Reset" bits available within the Safety I/O Connect feature (see section 5.1) to detect any changes in robot configuration from the safety plc. If you manually enter the robot's Total Signature Number (including time/date stamp) into the SNCT as the Configuration Signature then this will be checked before a connection can be established.
- Please test safety connection configurations after they are applied in an originator to confirm the target connection is operating as intended.
- Please clear any pre-existing configuration from any safety device before installing it onto a safety network.
- Please commission all safety devices with MacId (and Baud Rate if necessary) prior to installing it onto a safety network.

- Please note that originators that have an "automatic" SNN setting feature should only use that feature when the safety system is not being relied upon.
- Please note that LEDs are NOT reliable indicators and cannot be guaranteed to provide accurate information. They should ONLY be used for general diagnostics during commissioning or troubleshooting. Do not attempt to use LEDs as operational indicators.

The following points are included for informational purposes, and apply to safety targets which contain SNCT-configurable data (i.e. a safety I/O block). Since the robot controller does not contain any such configuration, these rules have no real application in its use or setup:

- Please completely test a device's operation before setting the Lock Attribute. Since the robot safety configuration is not configured by the safety plc configuration tool the optional Lock attribute is not supported in the robot. Any changes to the robot safety configuration require applying the DCS code number on the robot teach pendant and will result in a change to the configuration signature and state of the appropriate configuration change latch bit.
- Please upload and compare the configuration from each affected safety devices to that which was sent by the SNCT before setting the Lock Attribute in those devices. This does not apply to the robot since the safety configuration is not set by the SNCT (Safety Network Configuration Tool).
- Please visually verify that all configuration data was downloaded correctly.
- Please note that user testing is the means by which all downloads are validated.
- Please note that the signature should only be considered "verified" after user testing.
- Please note that configuring an originator with connection data and/or target configuration data must be downloaded to the target so it can be tested and verified. Only then can SCIDs from the target be confirmed.

6.2 INTEGRATED DEVICENET SAFETY (IDNS)

6.2.1 Overview

In order to use Integrated DeviceNet Safety please be sure the following software options are loaded :
- DeviceNet (A05B-2600-J753 or J754)
- Integrated DeviceNet Safety (A05B-2600-J974)

The IDNS options requires the devicenet hardware to include the "DN4" daughterboard. Please see appendix A in the DeviceNet Setup & Operations manual for a list of assemblies that include the DN4 daughterboard.

Please review the CIP-Safety requirements section in this manual (section 6.1.2) for important general guidelines in setting up the network.

A DeviceNet channel in the robot can be used for both safety slave and normal slave DeviceNet connections. The channel cannot be a CIP-Safety slave and a DeviceNet master at the same time. If this is needed please use a second devicenet channel so that one channel can be configured as a safety slave, and the second channel can be configured as a master for normal I/O.

Note that the DCS Safe I/O Connect option (A05B-2600-J568) is automatically loaded when IDNS is loaded. Please see the chapter on DCS Safe I/O Connect for details in using this option.

IDNS supports up to 8 bytes in, and 8 bytes out, across the safety connection. The size is configurable. Use the DCS Safe I/O Connect option to map this safe I/O to particular safety signals within the robot.

It is important to note that the DeviceNet card labeling shows “HLTH” and “COMM”. The HLTH LED is synonymous with MS (module status). The COMM LED is synonymous with NS (Network Status).

The CIP-Safety settings (Safety I/O size, Enable/Bypass setting, which board number is configured for CIP-Safety) are saved in syscips.sv. The basic devicenet settings (mac address, baud rate) are saved as part of sysdnet.sv. See section 1.5 on backup/restore for more information.

Configuring a Safety Slave connection involves the following steps :
- Configure the robot (safety slave) for proper baud rate, mac address, and safety slave I/O size – see section 6.2.2.
- Configure the Safety PLC to exchange I/O with the robot – see section 6.2.3.

6.2.2 Robot Configuration

Robot configuration begins with configuring the mac address, baud rate, and enabling the channel for CIP-Safety. This is done within the normal devicenet screens and described in procedure 6-2-1. Following this the CIP Safety I/O sizes and Enable/Bypass settings can be reviewed/changed as needed in Procedure 6-2-2.

Procedure 6-2-1

Conditions :
- You have installed the DeviceNet DN4 hardware in the controller – see procedure 2-1 in the DeviceNet manual for details. Appendix A in the devicenet manual includes assembly part numbers and hardware information on the DN4 daughterboard.
- You have installed the DeviceNet Interface (A05B-2600-J753 or J754) and Integrated DeviceNet Safety (A05B-2600-J974) software options - see procedure 2-1 in the DeviceNet manual for details

Steps :
- Follow steps 1-8 in procedure 3-1 in the DeviceNet manual to configure the mac address and baud rate for the appropriate channel. Auto-restart is normally set to TRUE for a slave channel. Table 3-2 in the DeviceNet manual explains the board detail screen items if additional information is needed.
- Set “Integrated CIP-Safety” from False to True while in the board detail screen as shown in the following example. Note that “size of output from master” and “size of input to master” are for the normal (non-safe) slave connection. The channel can be configured to support both safe and normal I/O connections. The safety slave I/O size is set in the DCS menus and is covered later in this procedure.

```
Board Detail
Board: 1                Status:  OFFLINE
Scanner type:  SST 5136-DN4-104
Motherboard:  Full-slot
1  MAC-ID:                    5
2  Baud-rate:                 125 KB
3  Board auto-restart:         ON
4  Input resume state (rack 81): ZERO
Slave Operation:
   Slave Status:              OFFLINE
5  SLAVE Error Severity:       WARN
6  Size of output from master:   0 bytes
7  Size of input to master:     0 bytes
8 Integrated CIP-Safety :      True
```

- Cycle power and verify that there is an “S” next to the board configured for CIP-Safety as shown below.

```
Board List                              1/4
 Board   Comment          Rack  Status
S  1    [            ]    81  OFFLINE
   2    [            ]    82  OFFLINE
   3    [            ]    83  OFFLINE
   4    [            ]    84  OFFLINE
```

- Put the board Online by pressing Next and the F4 (Online).

Procedure 6-2-2 Setting the CIP-Safety I/O size, and/or setting the CIP-Safety connection to Enable/Bypass

Conditions :

- You have installed the DeviceNet DN4 hardware in the controller – see procedure 2-1 in the DeviceNet manual for details. Appendix A in the devicenet manual includes assembly part numbers and hardware information on the DN4 daughterboard.
- You have installed the DeviceNet Interface (A05B-2600-J753 or J754) and Integrated DeviceNet Safety (A05B-2600-J974) software options - see procedure 2-1 in the DeviceNet manual for details
- You have followed procedure 6-2-1 in this manual to configure the devicenet board in your system.

Steps :

Setting the CIP-Safety I/O size, or setting the connection to bypass is done within the DCS Safety screens.

- MENU -> SYSTEM -> Type (F1) -> DCS

```
   1 Safe I/O Status:
   2 Safe I/O connect:          OK
   3 CIP Safety:               CHGD
   4 Signature number:
   5 Change code number:
```

- Cursor to CIP Safety and press enter to see the following screen. Note that the TP must be enabled before any changes are allowed in this screen. The default safety I/O size is 2 bytes in and 2 bytes out. The Enable/Bypass setting is normally Enabled meaning the CIP-Safety connection must be operating before faults can be cleared in the robot. Bypass may be used during initial integration when a safety plc is not available. See the Safety I/O Connect chapter for how to detect BYPASS mode. The Config Signature Date/Time setting defaults to ACTUAL which is applicable if the

safety plc is configured to include a Configuration Signature check as part of connection establishment. Press PREV when any changes to CIP-Safety configuration are complete.

```
CIP Safety                          1/4
    Status:                        CHGD
  1 Enable/Bypass:                ENABLE
  2 CIP Safety input size(byte)      2
  3 CIP Safety output size(byte)     2
  4 Config Signature Date/Time: ACTUAL
```

- Use the F2 (APPLY) button while in the DCS Setup screen to complete changes. You will be prompted for the code number.
  If the clock setting is not valid and the "Config Signature Date/Time" is ACTUAL, the message "Reset system clock or Not use ACTUAL" is displayed and cannot APPLY to DCS parameter.

```
DCS
  1 Safe I/O Status:
  2 Safe I/O connect:              OK
  3 CIP Safety:                   CHGD
  4 Signature number:
  5 Change code number:

[TYPE]  APPLY   DETAIL          UNDO
```

- You will then be shown a screen detailing the differences for review (press OK after review).

```
DCS
Verify (diff)                       1/12
F Number: F00000
VERSION : HandlingTool
$VERSION: V7.4307     01/05/2009
DATE:    01-FEB-09 14:59


--- CIP safety -------------------------
   Status:                       CHGD
 1 Enable/Bypass:               ENABLE
 2 CIP Safety input size(byte)     4

                ALL    OK     QUIT
```

- A power cycle is required to make changes active.

6.2.3 Safety PLC Configuration

Please see the appropriate section depending on which safety plc is being used :
- Rockwell GuardLogix plc : section 6.2.3.1
- Omron Safety Controller : section 6.2.3.2

6.2.3.1 GuardLogix safety PLC example configuration

Please follow documentation provided with Rockwell Guardlogix PLC. The following procedure should be used for reference when configuring the robot as a DeviceNet Safety slave connected to a GuardLogix plc.

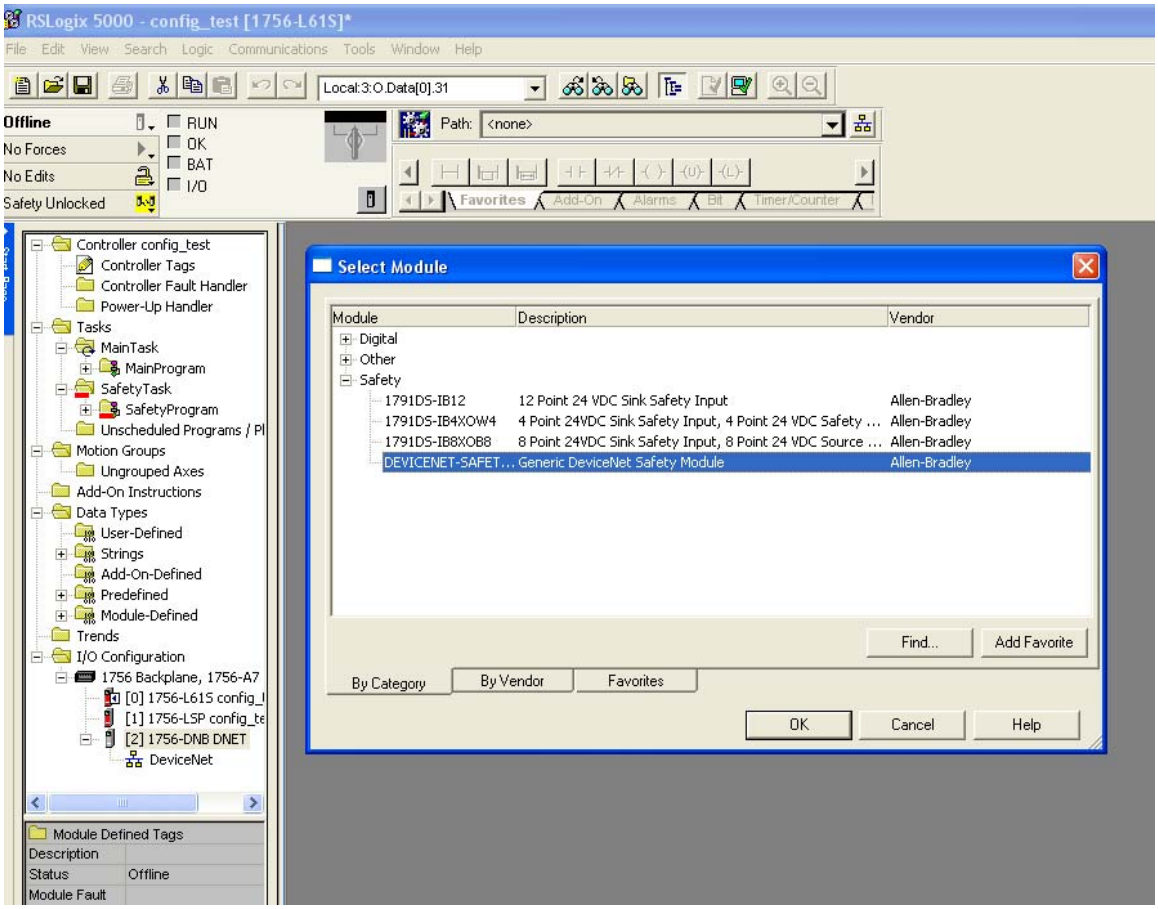
Procedure

Follow the procedure below after DeviceNet Safety Setting of robot controller is completed.

> **⚠WARNING**
> The procedure written in the document focuses on the way of setting, and it does not include any safety precaution. The operator must read manuals provided by Rockwell, and examine them carefully and sufficiently before using the procedure, and take any precaution, if required, in using the procedure.

To add a robot devicenet safety slave connection to GuardLogix :

- Install Rockwell PLC hardware and software
- Launch the RSLogix5000
- In the IO Configuration tree add applicable backplane and modules to configure the system (eg. 1756-DNB devicenet scanner module)
- Right click on the appropriate DeviceNet scanner and choose “New Module” (you must be offline to add a module).
- Under Safety choose the “Generic DeviceNet Safety Module”

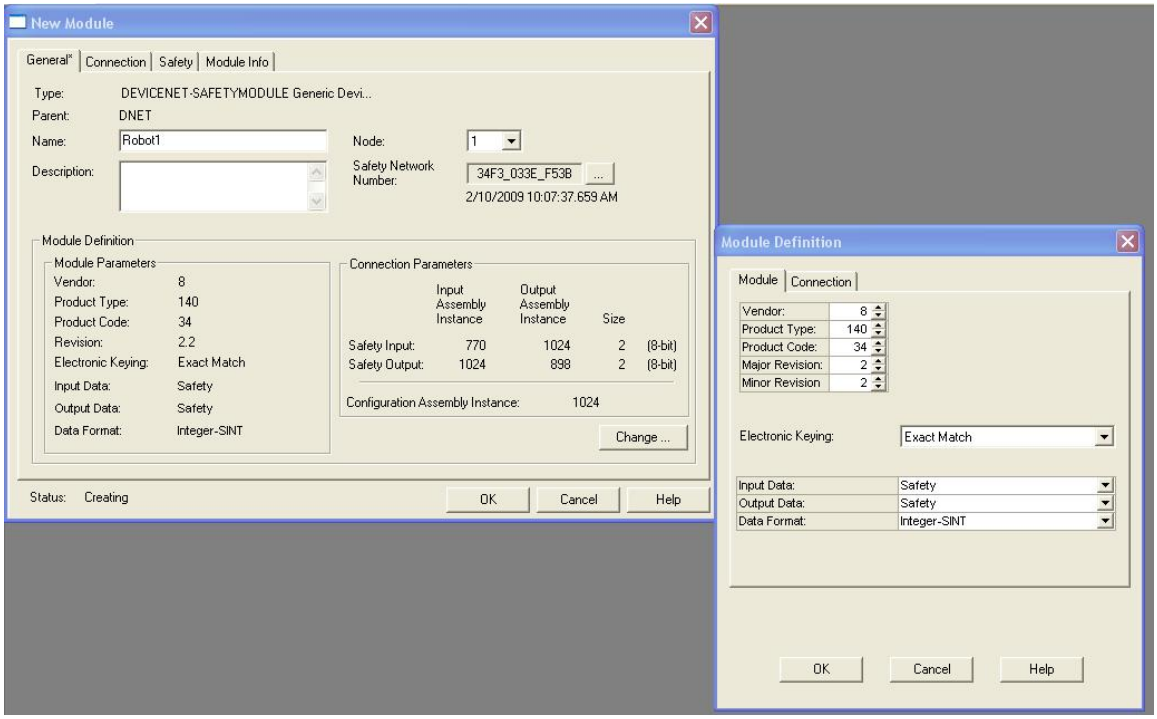


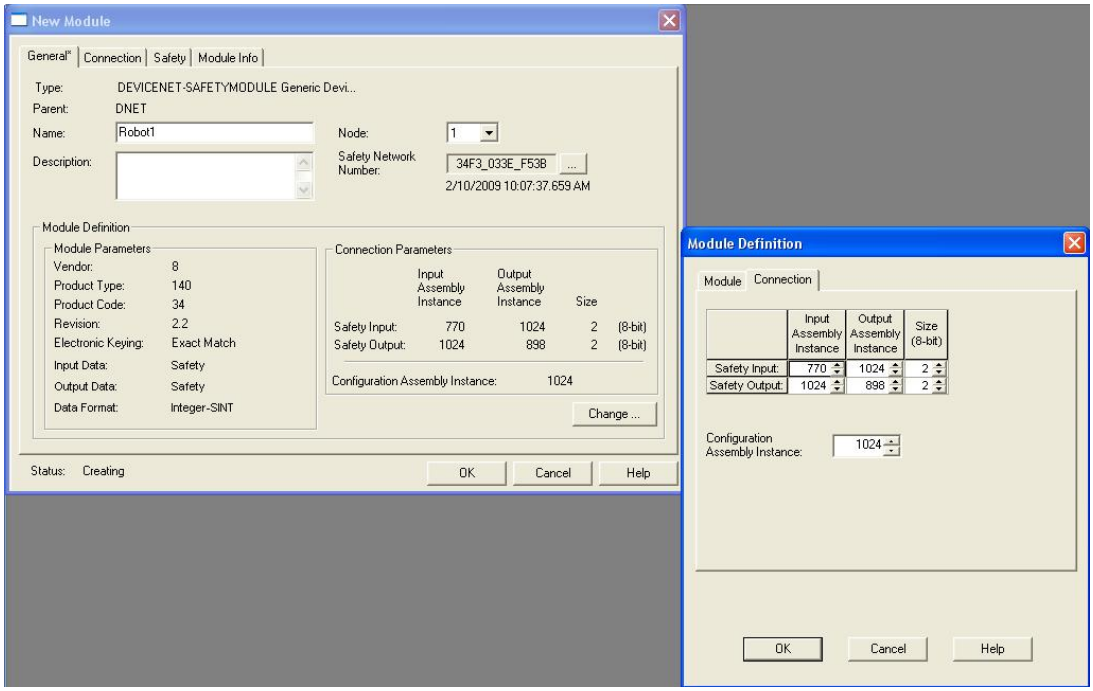
Configure the DN Safety Slave in Module Properties under the General Tab (use ‘Change …’ button):

- Name’ and ‘Description’ is user defined (can be anything).
- Set ‘Node’ to correct MAC_ID.
- Set ‘Vendor’ to 8, ‘Product Type’ to 140 and ‘Product Code’ to 34.
- Set ‘Major’ and ‘Minor Revision’ to match stack version. See EDS file. Currently major revision is 2 and minor revision is 2.

- Set ‘Electronic Keying’ to Exact Match.
- Set ‘Output’ and ‘Input Data’ to Safety. Set ‘Data Format’ to Integer-SINT.
- Set ‘Configuration Instance’ to 1024.
- Set ‘Safety Input -> Output Assembly’ to 1024.
- Set ‘Safety Output -> Input Assembly’ to 1024.
- Set ‘Safety Input -> Input Assembly’ to 768 + size in bytes of robot safety I/O. (i.e. default size of 2 bytes = 770).
- Set ‘Safety Output -> Output Assembly’ to 896 + size in bytes of robot safety I/O. (i.e. default size of 2 bytes = 898)
- Set 8-bit sizes accordingly (2 bytes if using default safety I/O sizes).

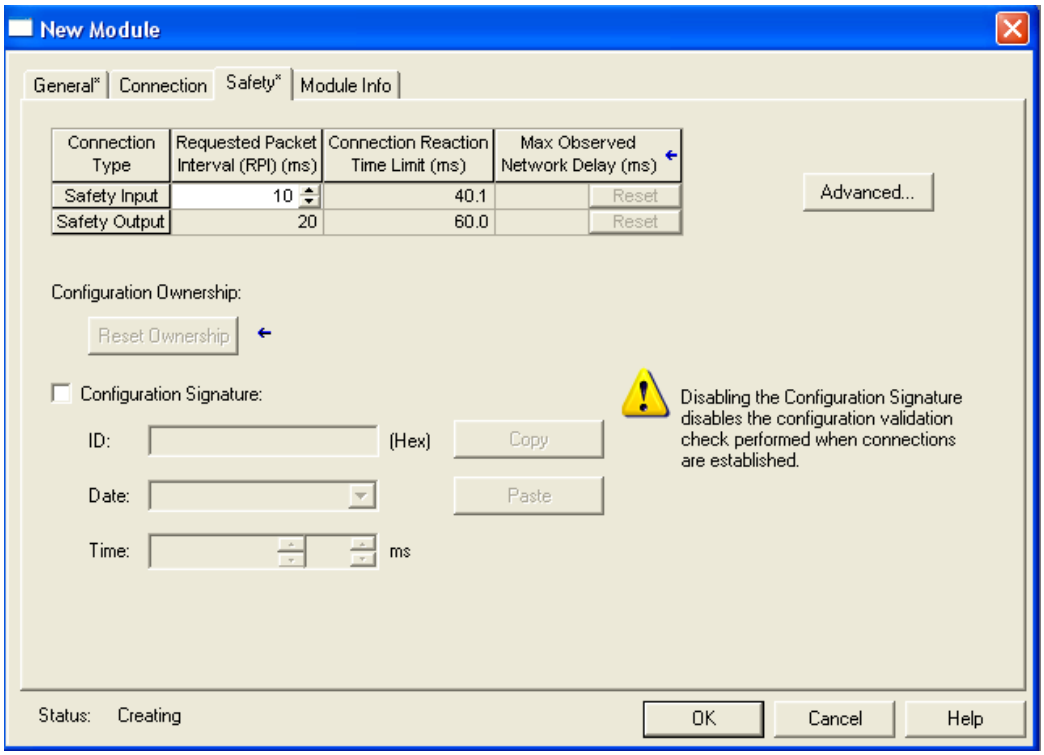
The following screen shots are for a safety connection to the robot using the default safety I/O size of 2 bytes in and 2 bytes out. Changing robot safety I/O size is described ion section 6.2.2.





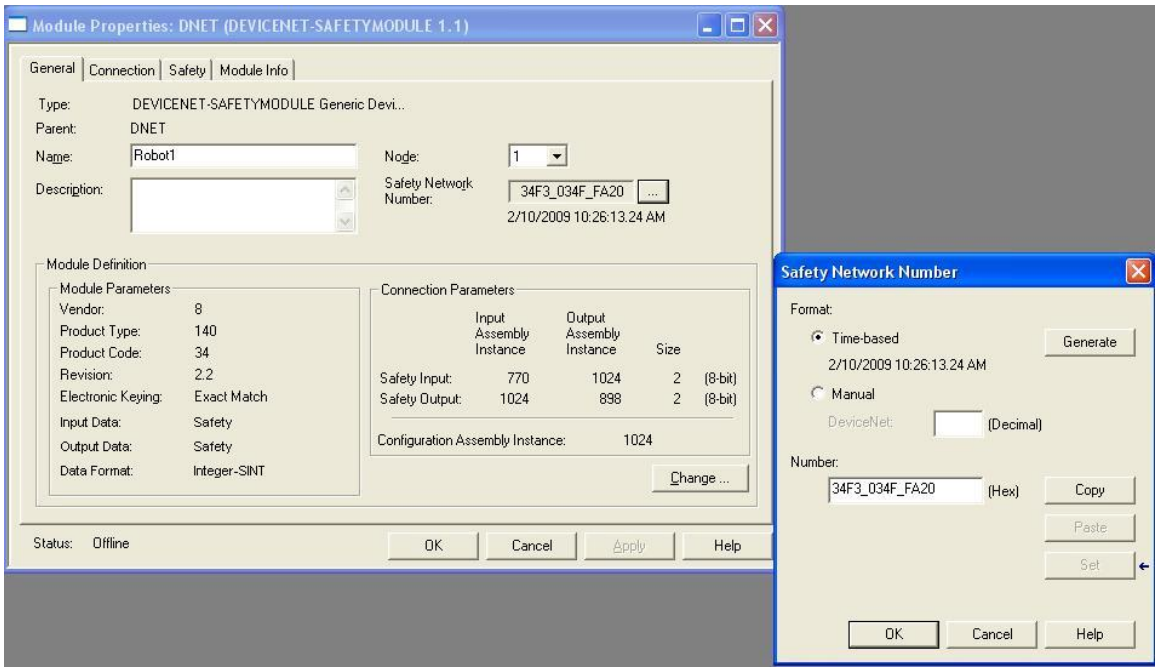
Under the Safety Tab Configuration Signature setting you can choose to :

- Disable checking of configuration signature to skip comparing Configuration Signature during connection establishment
- Enable checking of configuration signature. You must manually enter the robot's Total Signature Number (shown on DCS Signature Number screen) in Hex. The Date/Time stamp will be the ACTUAL Date/Time stamp shown on the DCS Signature screen (offset in the SNCT by the timezone) or 1/1/2009 at 6:00:00.000 (offset in the SNCT by the timezone) if FIXED is set for Config Signature Date/Time in the CIP Safety setup screen. The timezone offset in the SNCT can be seen by double clicking on the time in the task bar and looking at the local timezone. As an example if FIXED date/time is used and the SNCT shows GMT-05:00 then instead of 6am the time would be entered as 1am.



Press OK to add the robot safety slave connection to the safety plc configuration. Download the new configuration to the Safety plc and go online. The new safety connection will fail until the Safety Network Number (SNN) is set. Use the "…" button on the General tab of the robot safety slave module properties to set the SNN. The "SET" button will be active when the safety plc configuration software is online with the safety plc and the robot is on the devicenet network configured for a safety connection.

Note that the slave only accepts a new SNN when it currently has no SNN (reset back to factory default). The "Reset Ownership" button under the safety tab can be used to reset the SNN if required.



The current SNN set in the robot can be viewed on the CIP-Safety Status screen. See section 6.2.4.1 for details on this screen,

6.2.3.2 Omron safety PLC example configuration

This section does not replace any part of manuals provided by OMRON. It is based on using the following controller :

- OMRON safety controller: NE1A-SCPU01-V1, NE1A-SCPU02

Required configuration software (provided by OMRON):
- Network Configurator for DeviceNet Safety

Related manuals (provided by OMRON):
- DeviceNet Safety System Configuration Manual (Z905)
- DeviceNet Safety Network Controller Operation Manual (Z906)
- DeviceNet Safety I/O Terminal Operation Manual (Z904)

Procedure

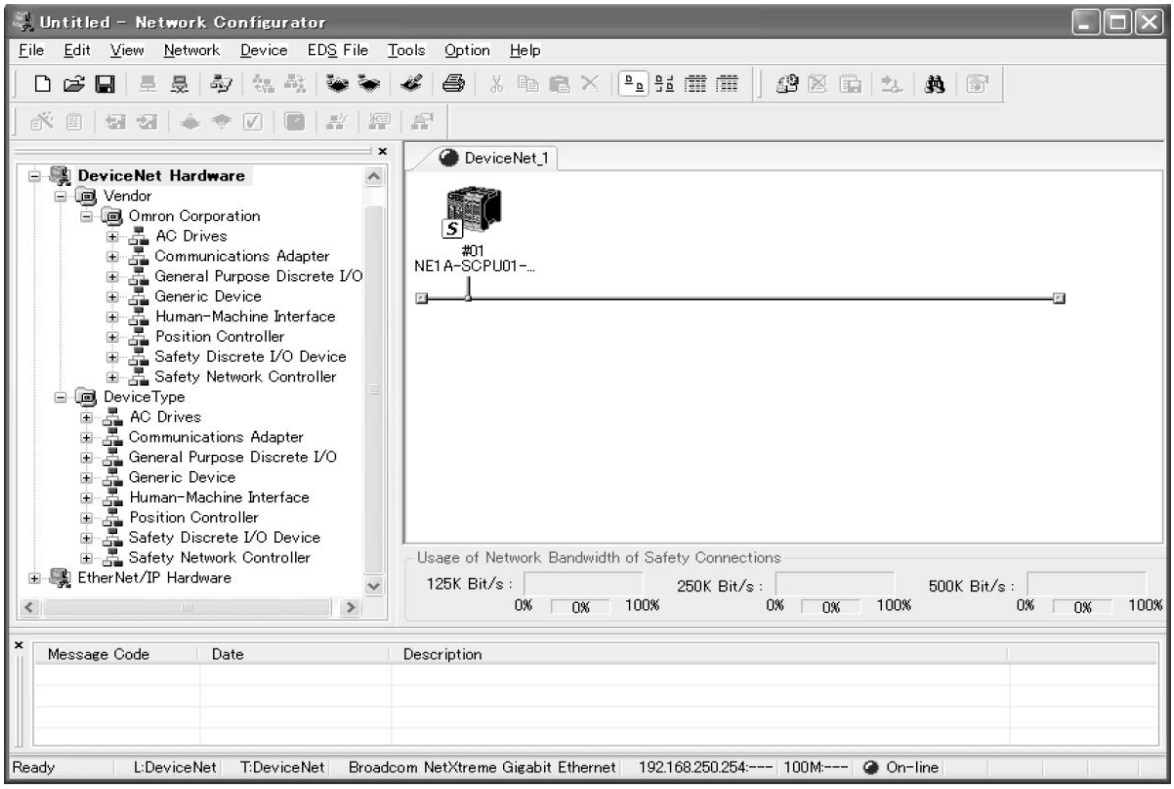
Follow the procedure below after DeviceNet Safety Setting of robot controller is completed.

Please set $DN_BD_INFO[X].$DN_OPTIONS (where X is board number 1-4 used as safety interface) system variable in the robot from 0 to 2. The Omron Configuration Tool does not support a Configuration Signature Check with the robot and this setting is needed to disable the check. If this check

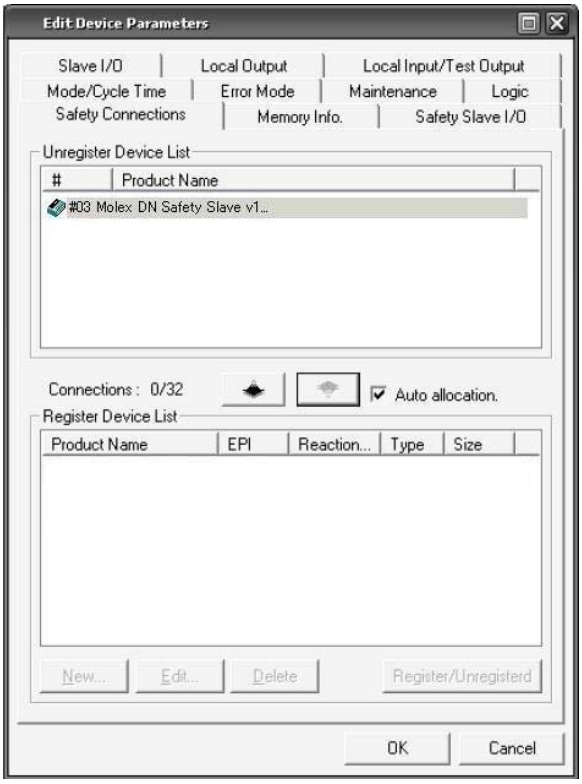
is not disabled by the above setting, the project file of the omron configuration tool can't be opened again when the project file is saved after uploading from robot or from network.

> **⚠WARNING**
> The procedure written in the document focuses on the way of setting, and it does not include any safety precaution. The operator must read manuals provided by OMRON, and examine them carefully and sufficiently before using the procedure, and take any precaution, if required, in using the procedure.

1. In Network Configurator, create a project for DeviceNet Safety network. Add a OMRON safety controller to the virtual network.

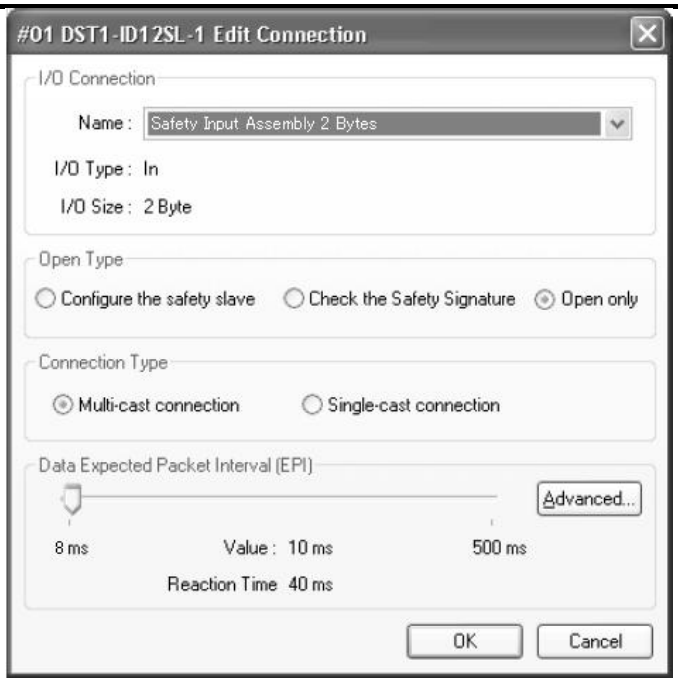


2. Select EDS file – Install. Select the EDS file of Molex DN Safety Slave, and press open. The EDS file will be registered.
3. Look for Molex DN Safety Slave in Hardware List Window. Molex DN Safety Slave is under the following location in the list.
   DeviceNet Hardware->Vendor->Woodhead Software & Electronics(SST)
   ->Safety Communications Adapter
4. Double click Molex DN Safety Slave in Hardware List to add it to the virtual network.
5. Select Molex DN Safety Slave in the Network Configuration pane, and right-click it and select Change Node Address. Then dialog box will show up. Change the node address and click OK button.
6. Double click OMRON safety controller in the Network Configuration pane to open safety connection setting window.



7. Molex DN Safety Slave is listed in Unregistered Device List(upper pane). Click  button.
8. Molex DN Safety Slave is moved to Registered Device List(lower pane).
9. Double click Molex DN Safety Slave in Registered Device List to open the screen for setting safety connection parameters.
10. Choose Safety Input Assembly with the data size configured as output size in DCS screen of robot controller. Select "Open only" as Open type. Change other settings as required, and press OK.

NOTE
The input in the setting means input to PLC. The size of input must be equal to the size of CSO.



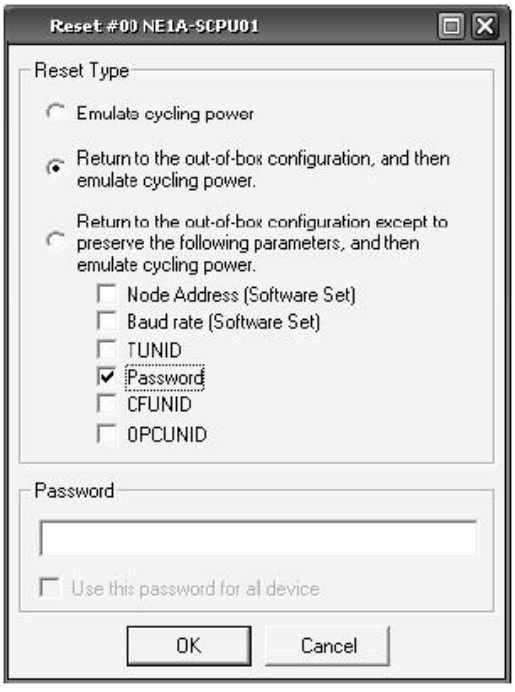
11. Double click Molex DN Safety Slave in Registered Device List again.
12. Choose Safety Output Assembly with the data size configured as input size in DCS screen of robot controller. Select "Open only" as Open type. Change other settings as required, and press OK.

NOTE
The output in the setting means output from PLC. The size of output must be equal to the size of CSI.

13. The parameters required for safety connection with Molex DN Safety Slave have been configured. The input/output of the connection have become available in the program of OMRON safety controller.
14. Edit the program of the OMRON safety controller.
15. Complete the project for DeviceNet Safety, and save it.
16. Connect the PC to the OMRON safety controller.
17. Select the OMRON safety controller in the Network Configuration pane. Press the right click the safety controller, and select Parameter – Download. Enter the password, and complete downloading.

NOTE
Don't select Molex DN Safety Slave because download to the device is not needed.
Don't use Downloading to All Device if Molex DN Safety Slave is present.

18. After the downloading finishes, select Molex DN Safety Slave in the network configuration pane, and select Device-Reset from the menu bar.
19. Choose "Return to the out-of-box configuration, and then emulate cycling power", and press OK.



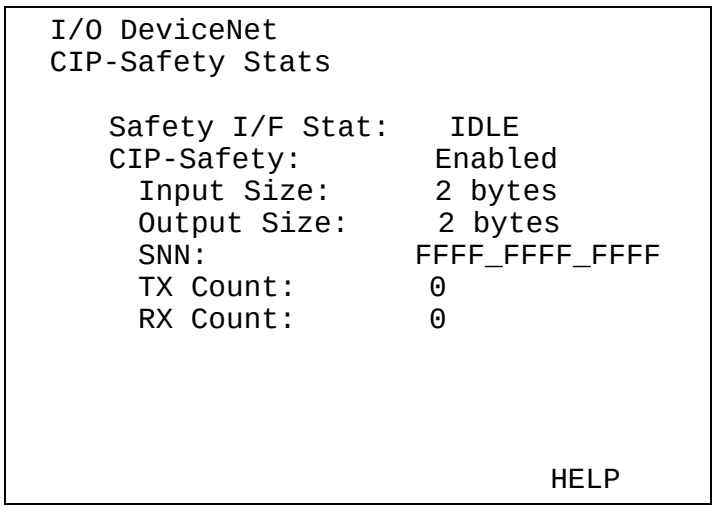
20. Cycle power the robot controller.
21. After the robot controller starts up and TP screen is available, select the OMRON safety controller in the Network Configuration pane, and select Device – Change Mode. Select "Run". The safety connection will be established.
22. Open CIP-Safety Status screen (described in section 6.2.4.1) in the DeviceNet screen of robot controller, and verify SNN is set, and the status becomes ONLINE.

6.2.4 Troubleshooting

6.2.4.1 CIP-safety status screen

The CIP-Safety Status screen is available under DeviceNet board detail (MENU -> I/O -> Type (F1) -> DeviceNet -> Cursor to correct board -> Detail (F4) -> CIP-Stat (F2). This screen is only available if "Integrated CIP Safety" is set to TRUE in the board detail screen. This screen is read-only and includes :

- Safety I/F Stat : Idle, Running. Idle implies the Safety PLC did not or could not make a safety I/O connection to the robot. Running means there is an active safety I/O connection.
- CIP-Safety : Enabled, Bypassed. This is set in DCS menu.
- Input Size : 1-8 bytes. This is set in DCS menu.
- Output Size : 1-8 bytes. This is set in DCS menu.
- SNN : Safety Network Number. This is set from safety plc configuration software.
- TX Count : Transmit Count (packets sent to plc). This count is dynamically updated so can be observed to increment when connection is active.
- RX Count : Receive Count (packets received from plc). This count is dynamically updated so can be observed to increment when connection is active.



Please note that when SNN shows FFFF_FFFF_FFFF it means the SNN has not been set from the Safety PLC configuration software. Please follow the information in section 6.2.3.1 or 6.2.3.2 to set the SNN.

6.2.4.2 Troubleshooting using LEDs

Table 6.2.4.2 Troubleshooting using LEDs

Safety Supervisor Status	Module LED(HLTH)	Network LED(COMM)	Causes
Not initialized	Amber	Off	Board has not been initialized. Check dip switches on devicenet daughterboard (see appendix A in Devicenet manual).
Self-Test	Flash Red/Green	Off	Normal behavior during powerup and if board is offline.
Wait for TUNID	Flash Red/Green	No Override *	SNN is not set from Safety PLC configuration software
Wait for TUNID (propose_TUNID service accepted)	Flash Red/Green	Flash Red/Green Fast **	Safety PLC configuration software in the process of setting SNN

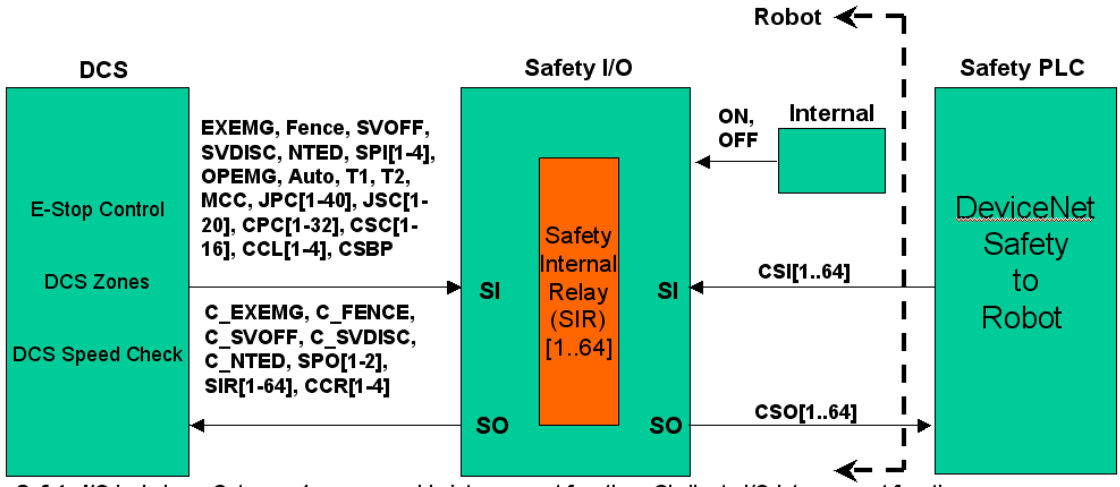
Safety Supervisor Status	Module LED(HLTH)	Network LED(COMM)	Causes
Critical Fault	Red – OR - Flash Red/Off	No Override *	If mac address has been changed since SNN was set please update SNN from Safety plc configuration software. Otherwise please contact Technical Support for assistance.
Idle (no safety connection)	Flash Green/Off	No Override *	Normal condition waiting for connection from Safety PLC
Executing (safety connection active)	Green	Green	Normal condition. Active connection from Safety PLC.

NOTE
* No Override means normal network behavior (i.e. Off = Offline, Flash green = Online and not connected, Green = connected)
** All flashing means alternating color every 500ms, except for 'fast' which means alternating every 250ms

6.3 SAFETY I/O CONNECT IN CIP-SAFETY SYSTEM

The Safety I/O Connect feature provides a means to tie the CIP-Safety I/O to particular safety signals in the controller. See chapter 5 for detailed information about Safety I/O Connect.

The following figure provides a visual representation of Safety I/O and the overall system. Safety I/O Connect logic runs within the Safety I/O area.



• **Safety I/O** includes a Category 4 programmable interconnect function. Similar to I/O Interconnect function.
• Only safety I/O can be specified. Logic Operators are limited to AND/OR/NOT.
• A maximum of two safety I/O can be specified on input side of expression.
• A maximum of 64 expressions can be defined at 2ms scan rate.

The safety I/O Connect setup is saved in DCSIOC.SV. See section 1.5 on backup/restore for more information.

6.4 BACKUP/RESTORE OF CIP-SAFETY SETTINGS

CIP-Safety settings are included within the following system files during an application backup :

- SYSCIPS.SV – this file includes the Safety I/O size, Enable/Bypass setting, and which Interface is configured for CIP-Safety.
- DCSIOC.SV – this file includes the Safety I/O Connect configuration

These files are included under a “Backup – All of the Above” and “Backup – System Files”. These are found on the File Menu under the Backup function key.

These files can only be restored at CTRL start.

NOTE
The Safety PLC data set in the robot (eg. SNN) is not included in any application backup. It must be explicitly set on a robot from the Safety PLC configuration software.

NOTE
Basic devicenet settings (such as mac address, baud rate) are held in SYSDNET.SV.
Backup/restore SYSDNET.SV with SYSCIPS.SV if needed.

Please see section 1.5 on backup/restore for more information.

6.5 EDS FILE

Please contact your FANUC representative for Information on obtaining the robot CIP-Safety slave EDS file.
In North America: Call 1-800-47ROBOT for Information on obtaining the robot CIP-Safety slave EDS file.

7 ETHERNET/IP SAFETY

7.1 INTRODUCTION

7.1.1 Overview

CIP-Safety is part of a suite of protocols specified by the Open DeviceNet Vendors Association (www.odva.org). This chapter covers the EtherNet/IP Safety option that is based on the CIP-Safety protocol.

This option allows the robot to act as a slave to a safety PLC (such as Rockwell GuardLogix) exchanging I/O using the CIP-Safety protocol.

> ⚠ **WARNING**
> At the initial start-up, the operation check and validation of the wiring for safety signals should be carried out, and then the wiring should be protected by the cable duct.

7.1.2 CIP Safety Requirements

This product has been designed to be a part of larger safety devices/systems, each one having different properties.

The robot controller safety configuration is managed locally (generally through the robot teach pendant). This is different from a safety I/O block, for example, that is configured by a Safety Network Configuration Tool (SNCT). If a SNCT configures a device it generates a Safety Configuration Identifier (SCID), which can be used to verify device configuration. A SNCT (eg. RS-Logix5000) does not configure the robot controller safety behavior. The robot controller safety configuration can be monitored using the following tools :

- DCS Signature Number screen found under DCS Menus
- Configuration Change Latch and Reset bits (CCL, CCR bits)

In the context of the robot acting as a CIP-Safety slave to a safety PLC the CCL/CCR bits can be included in the safety I/O exchanged with the safety PLC (see section 5.1 in this manual) to detect any change in the robot safety configuration.

The robot's Total Signature Number (shown in the DCS Signature Number screen) can optionally be manually entered into the SNCT as the Configuration Signature. If configured in the SNCT, the robot's signature must match what is entered into the SNCT before a safety connection can be established. The associated Date/Time stamp can be configured in the robot as ACTUAL (default) or FIXED. A setting of ACTUAL means the Date/Time stamp used in the Configuration Signature check when a safety connection is being established will be what is shown on the DCS Signature Number screen under Total Signature (offset in the SNCT by the timezone used by the SNCT). A setting of FIXED means the Configuration Signature Date/Time used in the Configuration Signature check when a safety connection is being established will always be 1/1/2009 at 6:00:00.0 am (offset in the SNCT by the timezone used by the SNCT).

Please consider the following points :

- The replacement of safety devices requires that the replacement device be configured properly and operation of the replacement device shall be user verified.

- The user should assign SNN numbers for each safety network or safety sub-net that are unique system-wide.
- If you choose to configure safety connections with an SCID=0, you are responsible for ensuring that originators and targets have the correct configurations. The robot does not get safety configuration from the safety PLC or SNCT, as such, the SNCT has no basis to generate an SCID itself. The robot safety configuration can be managed using the "Signature Number" details screen (under DCS menu on the robot teach pendant) and/or using the "Configuration Change Latch" and "Configuration Change Reset" bits available within the Safety I/O Connect feature (see section 5.1) to detect any changes in robot configuration from the safety PLC. If you manually enter the robot's Total Signature Number (including time/date stamp) into the SNCT as the Configuration Signature then this will be checked before a connection can be established.
- Please test safety connection configurations after they are applied in an originator to confirm the target connection is operating as intended.
- Please clear any pre-existing configuration from any safety device before installing it onto a safety network.
- Please commission all safety devices with an IP address unique to the subnet on which it will be installed prior to installing it onto a safety network.
- Please note that originators that have an "automatic" SNN setting feature should only use that feature when the safety system is not being relied upon.
- Please note that LEDs are NOT reliable indicators and cannot be guaranteed to provide accurate information. They should ONLY be used for general diagnostics during commissioning or troubleshooting. Do not attempt to use LEDs as operational indicators.

The following points are included for informational purposes, and apply to safety targets that contain SNCT-configurable data (i.e. a safety I/O block). Since the robot controller does not contain any such configuration, these rules have no real application in its use or setup:

- Please completely test a device's operation before setting the Lock Attribute. Since the robot safety configuration is not configured by the safety PLC configuration tool the optional Lock attribute is not supported in the robot. Any changes to the robot safety configuration require applying the DCS code number on the robot teach pendant and will result in a change to the configuration signature and state of the appropriate configuration change latch bit.
- Please upload and compare the configuration from each affected safety devices to that which was sent by the SNCT before setting the Lock Attribute in those devices. This does not apply to the robot since the safety configuration is not set by the SNCT (Safety Network Configuration Tool).
- Please visually verify that all configuration data was downloaded correctly.
- Please note that user testing is the means by which all downloads are validated.
- Please note that the signature should only be considered "verified" after user testing.
- Please note that configuring an originator with connection data and/or target configuration data must be downloaded to the target so it can be tested and verified. Only then can SCIDs from the target be confirmed.

7.2 ETHERNET/IP SAFETY (EIP-SAFE)

7.2.1 Overview

In order to use EtherNet/IP Safety please be sure the following software options are loaded:
- EtherNet/IP Adapter (A05B-2600-R784)
- EtherNet/IP Safety (A05B-2600-R713)

Note that the EtherNet/IP Scanner option (A05B-2600-R785 or R785) includes the EtherNet/IP Adapter option.

The EtherNet/IP Safety option requires no additional hardware installed to the robot controller. Note that the Ethernet/IP Safety option can be used with internal port (CD38A or CD38B) on the main board. The Ethernet/IP Safety option can NOT be used with internal port CD38C.

Please review the CIP-Safety requirements section in this manual (section 7.1.2) for important general guidelines in setting up the network.

An Ethernet port in the robot can be used for both safety slave and normal EtherNet/IP connections. The Ethernet port can be used for safe and non-safe EtherNet/IP connections at the same time.

Note that the DCS Safe I/O Connect option (A05B-2600-J568) is automatically loaded when EIP-Safe is loaded. Please see the chapter on DCS Safe I/O Connect for details in using this option.

Note that the EtherNet/IP Safety option cannot be loaded with the Integrated DeviceNet Safety (IDNS) (A05B-2600-J974) option. These two options are mutually exclusive.

EIP-Safe supports up to 8 bytes in, and 8 bytes out, across the safety connection. The size is configurable. Use the DCS Safe I/O Connect option to map this safe I/O to particular safety signals within the robot.

The CIP-Safety settings (Safety I/O size, Enable/Bypass setting, which Ethernet interface is configured for CIP-Safety) are saved in syscips.sv.

Configuring a Safety Slave connection involves the following steps :
- Configure the robot (safety slave) with an IP address and subnet mask on the safety network. Details on the Ethernet interface and TCP/IP configuration can be found in the *Internet Options Setup and Operations Manual*.
- Configure the robot (safety slave) with a safety Ethernet interface, and safety slave I/O size – see section 7.2.2.
- Configure the Safety PLC to exchange I/O with the robot – see section 7.2.3.

7.2.2 Robot Configuration

Robot configuration begins with configuring the IP address, Subnet mask, and enabling the Ethernet interface for CIP-Safety. Details on the Ethernet interface and TCP/IP configuration can be found in the *Internet Options Setup and Operations Manual*. Configuring the Ethernet interface for CIP-Safety is done within the normal EtherNet/IP screens and described in procedure 7-2-1. Following this the CIP Safety I/O sizes and Enable/Bypass settings can be reviewed/changed as needed in Procedure 7-2-2.

Procedure 7-2-1

Conditions :
- The robot controller is properly configured with an IP address and Subnet mask for the safety network. Details on the Ethernet interface and TCP/IP configuration can be found in the *Internet Options Setup and Operations Manual*.
- You have installed the EtherNet/IP Adapter (A05B-2600-R784 or R784) software option.
- You have installed the EtherNet/IP Safety (A05B-2600-R713 or R713) software option.

Steps :
- From the EtherNet/IP I/O screen, press F3 [SAFETY].
- Set “Ethernet Interface” from “Undefined” to either “Port 1” or “Port 2” using the F4 [CHOICE] key. This selection will depend on which Ethernet interface has been configured to be on the safety network. The following example assumes “Port 2” is selected. Note that the “Ethernet Interface” is the only modifiable field in this screen. All other fields are informational only (see section 7.2.4.1). The safety slave I/O size is set in the DCS menus and is covered later in this procedure.

```
I/O EtherNet/IP
  EIP CIP-Safety Operation          1/2

   Ethernet Interface:    Port 2
   Safety I/F Status:     PENDING

   CIP-Safety Operation:
     DCS:                Enable
     Input Size:          2
     Output Size:         2
     SNN:                          ???
     TX Count:           0
     RX Count:           0
```

- A power cycle is required to make changes active.

Procedure 7-2-2 Setting the CIP-Safety I/O size, and/or setting the CIP-Safety connection to Enable/Bypass

Conditions :

- You have installed the EtherNet/IP Adapter (A05B-2600-R784 or R784) software option.
- You have installed the EtherNet/IP Safety (A05B-2600-R713 or R713) software option.
- You have followed procedure 7-2-1 in this manual to specify the EtherNet/IP Safety Ethernet Interface in your system.

Steps :

Setting the CIP-Safety I/O size, or setting the connection to bypass is done within the DCS Safety screens.

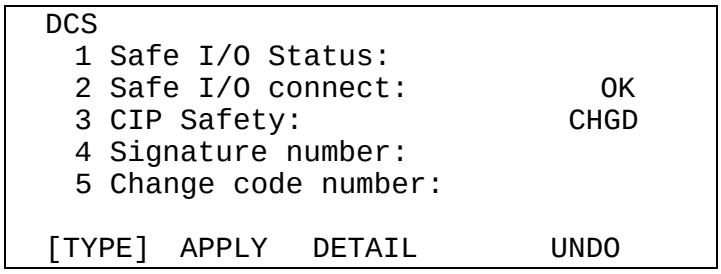
- MENU -> SYSTEM -> Type (F1) -> DCS

```
    1 Safe I/O Status:
    2 Safe I/O connect:            OK
    3 CIP Safety:                CHGD
    4 Signature number:
    5 Change code number:
```

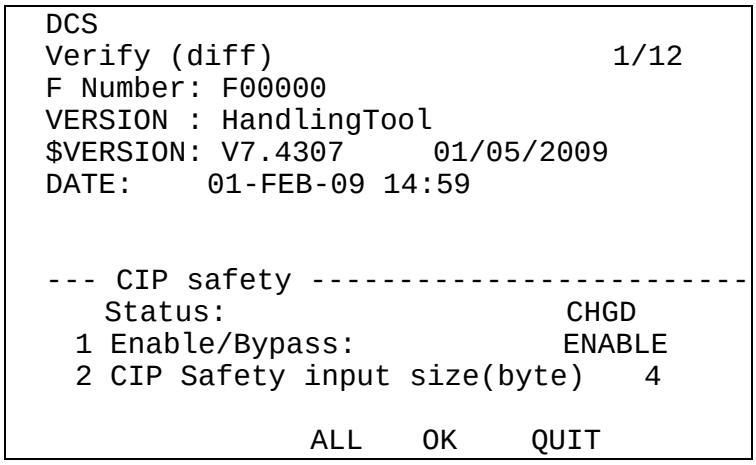
- Cursor to CIP Safety and press enter to see the following screen. Note that the TP must be enabled before any changes are allowed in this screen. The default safety I/O size is 2 bytes in and 2 bytes out. The Enable/Bypass setting is normally Enabled meaning the CIP-Safety connection must be operating before faults can be cleared in the robot. Bypass may be used during initial integration when a safety PLC is not available. See the Safety I/O Connect chapter for how to detect BYPASS mode. The Config Signature Date/Time setting defaults to ACTUAL which is applicable if the safety PLC is configured to include a Configuration Signature check as part of connection establishment. Press PREV when any changes to CIP-Safety configuration are complete.

```
  CIP Safety                        1/4
     Status:                      CHGD
    1 Enable/Bypass:              ENABLE
    2 CIP Safety input size(byte)    2
    3 CIP Safety output size(byte)   2
    4 Config Signature Date/Time: ACTUAL
```

- Use the F2 (APPLY) button while in the DCS Setup screen to complete changes. You will be prompted for the code number.
  If the clock setting is not valid and the "Config Signature Date/Time" is ACTUAL, the message "Reset system clock or Not use ACTUAL" is displayed and cannot APPLY to DCS parameter.



- You will then be shown a screen detailing the differences for review (press OK after review).



- A power cycle is required to make changes active.

7.2.3 Safety PLC Configuration

Please see the appropriate section depending on which safety PLC is being used :
- Rockwell GuardLogix PLC : section 7.2.3.1

7.2.3.1 GuardLogix safety PLC example configuration

Please follow documentation provided with Rockwell Guardlogix PLC. The following procedure should be used for reference when configuring the robot as an EtherNet/IP Safety slave connected to a GuardLogix PLC.

There is currently a limitation when using both safe and standard Ethernet/IP connections with the GuardLogix PLC and the robot. The robot uses the Generic Ethernet/IP Module profile for the standard connection, and the Generic Ethernet/IP Safety Module for the safety connection in RS-Logix5000 configuration software. RS-Logix5000 currently does not support two connections to the same IP address under a single Ethernet Bridge module. If both connections are required it can be dealt with in one of the following ways :
- Use a separate Ethernet Bridge module (ENBT) for standard and safety connections. Both ENBT modules should be configured on the same subnet as the robot port being used.
- If a DNS server is available on the network the standard connection can be configured using HOSTNAME instead of IP address in RS-Logix5000 Generic Ethernet/IP profile. The ENBT in the PLC must be configured with the DNS Server's IP address so that it can resolve the name into an

IP address (the PLC and robot have no problem using the same IP address for both connections, only RS-Logix5000 has this limitation). To configure the ENBT DNS client go to ENBT properties and choose the “Internet Protocol” tab in RS-Logix5000.

- A simple DNS server can be configured in the robot if required for this purpose. There is a system variable called $DNSS_CFG with following fields :
  - $ENABLED : default false, set true to enable
  - $IFACE_NUM : defines DNS server function to run on port 0 (upper RJ45) or port 1 (lower RJ45)
  - $DOM_NAME : can be left blank. If used must match domain used on ENBT card under DNS setup.
  - Changes take effect at powerup. You can add robot names under local or shared host table so plc can resolve those names with robot. The hostname of the robot acting as DNS server does not need an additional entry in the table. The ENBT card can have primary and secondary DNS server so a second robot can act as backup.

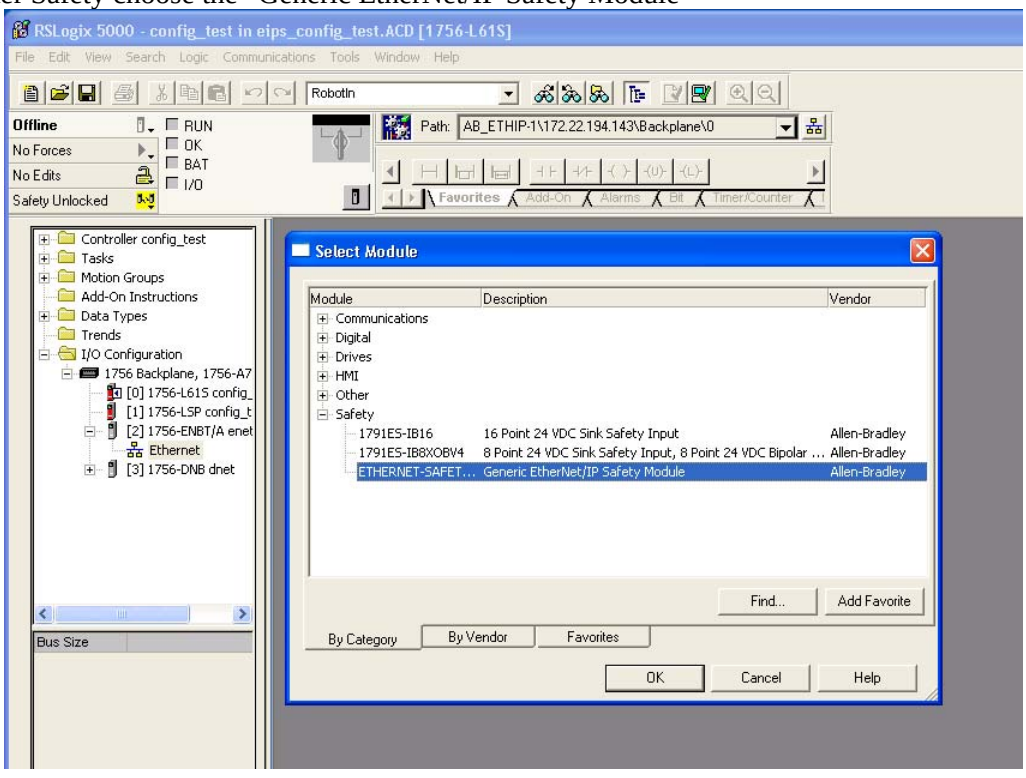
Procedure

Follow the procedure below after the EtherNet/IP Safety Setting of robot controller is completed.

> **⚠WARNING**
> The procedure written in the document focuses on the way of setting, and it does not include any safety precaution. The operator must read manuals provided by Rockwell, and examine them carefully and sufficiently before using the procedure, and take any precaution, if required, in using the procedure.

To add a robot EtherNet/IP safety slave connection to GuardLogix :

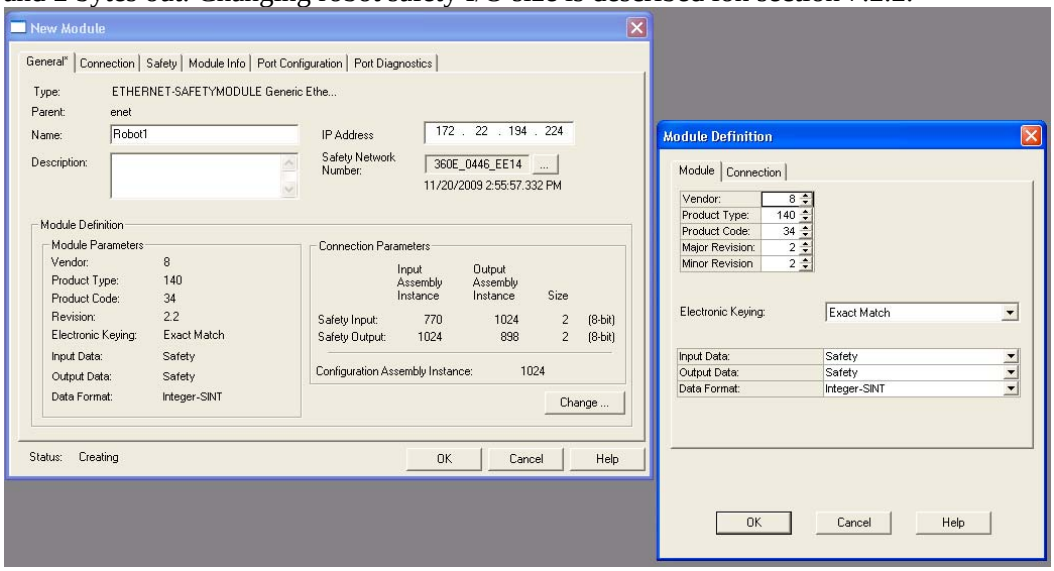
- Install Rockwell PLC hardware and software
- Launch the RSLogix5000
- In the IO Configuration tree add applicable backplane and modules to configure the system (eg. 1756-ENBT/A module)
- Right click on the appropriate EtherNet/IP scanner and choose “New Module” (you must be offline to add a module).
- Under Safety choose the “Generic EtherNet/IP Safety Module”

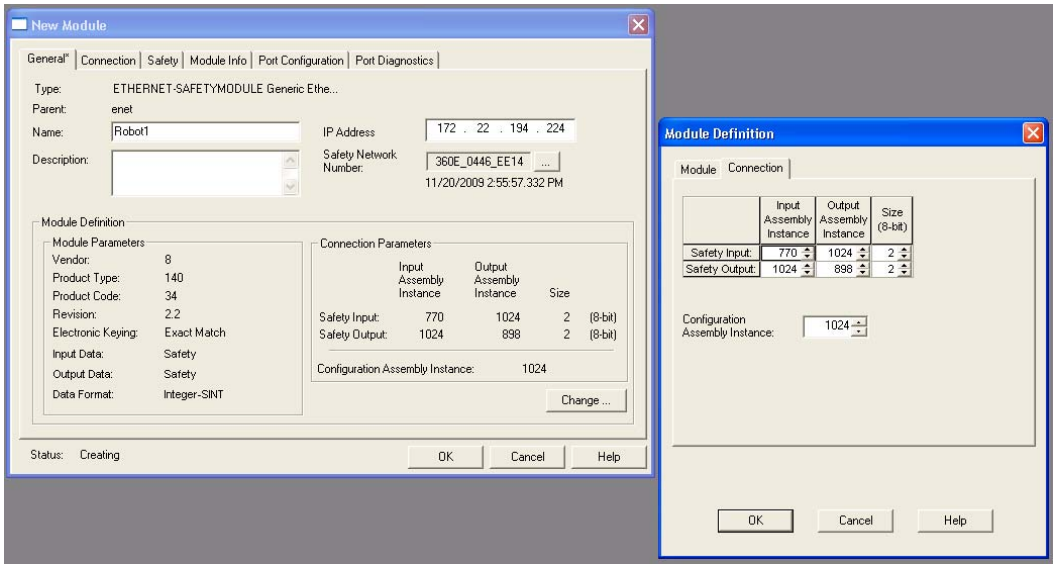


Configure the EtherNet/IP Safety Slave in Module Properties under the General Tab (use ‘Change …’ button):

- Name’ and ‘Description’ is user defined (can be anything).
- Set ‘IP Address’ to the IP address of the robot’s interface configured for EtherNet/IP Safety.
- Set ‘Vendor’ to 8, ‘Product Type’ to 140 and ‘Product Code’ to 34.
- Set ‘Major’ and ‘Minor Revision’ to match stack version. See EDS file. Currently major revision is 2 and minor revision is 2.
- Set ‘Electronic Keying’ to Exact Match.
- Set ‘Output’ and ‘Input Data’ to Safety. Set ‘Data Format’ to Integer-SINT.
- Set ‘Configuration Instance’ to 1024.
- Set ‘Safety Input -> Output Assembly’ to 1024.
- Set ‘Safety Output -> Input Assembly’ to 1024.
- Set ‘Safety Input -> Input Assembly’ to 768 + size in bytes of robot safety I/O. (i.e. default size of 2 bytes = 770).
- Set ‘Safety Output -> Output Assembly’ to 896 + size in bytes of robot safety I/O. (i.e. default size of 2 bytes = 898)
- Set 8-bit sizes accordingly (2 bytes if using default safety I/O sizes).

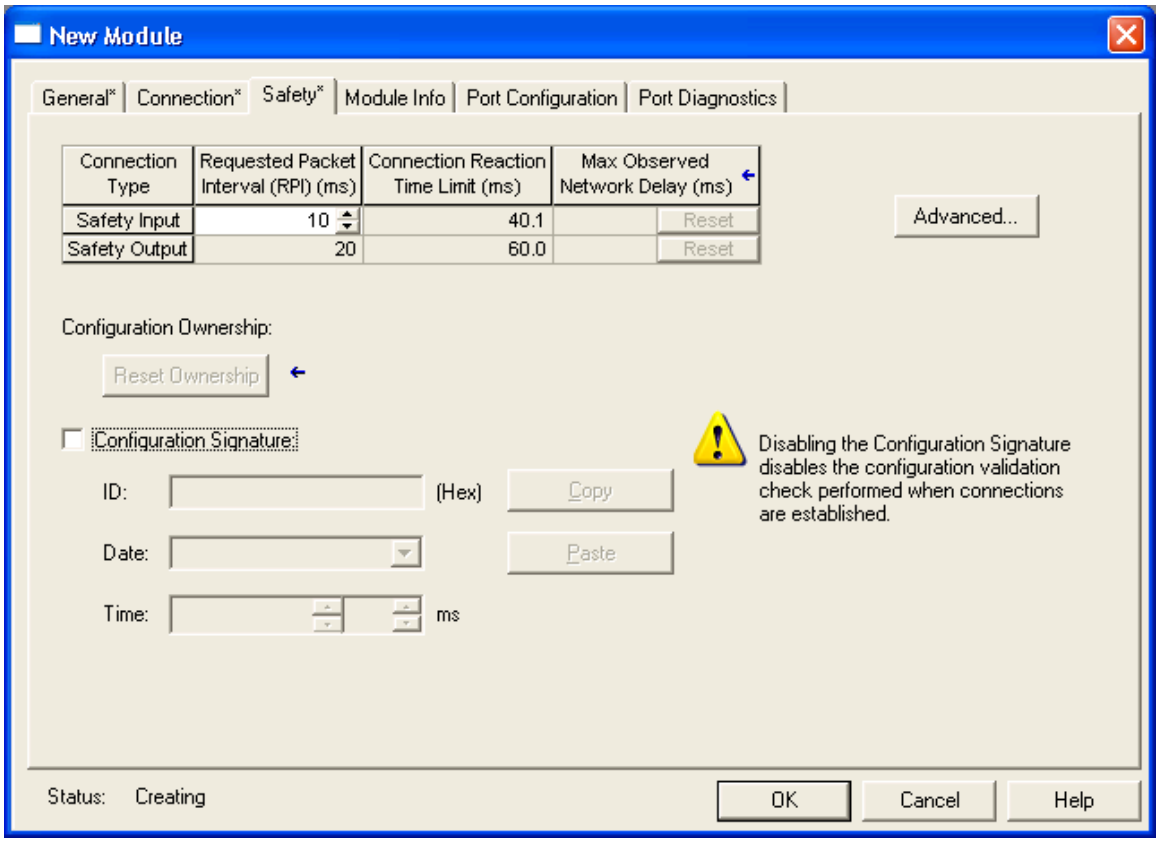
The following screen shots are for a safety connection to the robot using the default safety I/O size of 2 bytes in and 2 bytes out. Changing robot safety I/O size is described ion section 7.2.2.





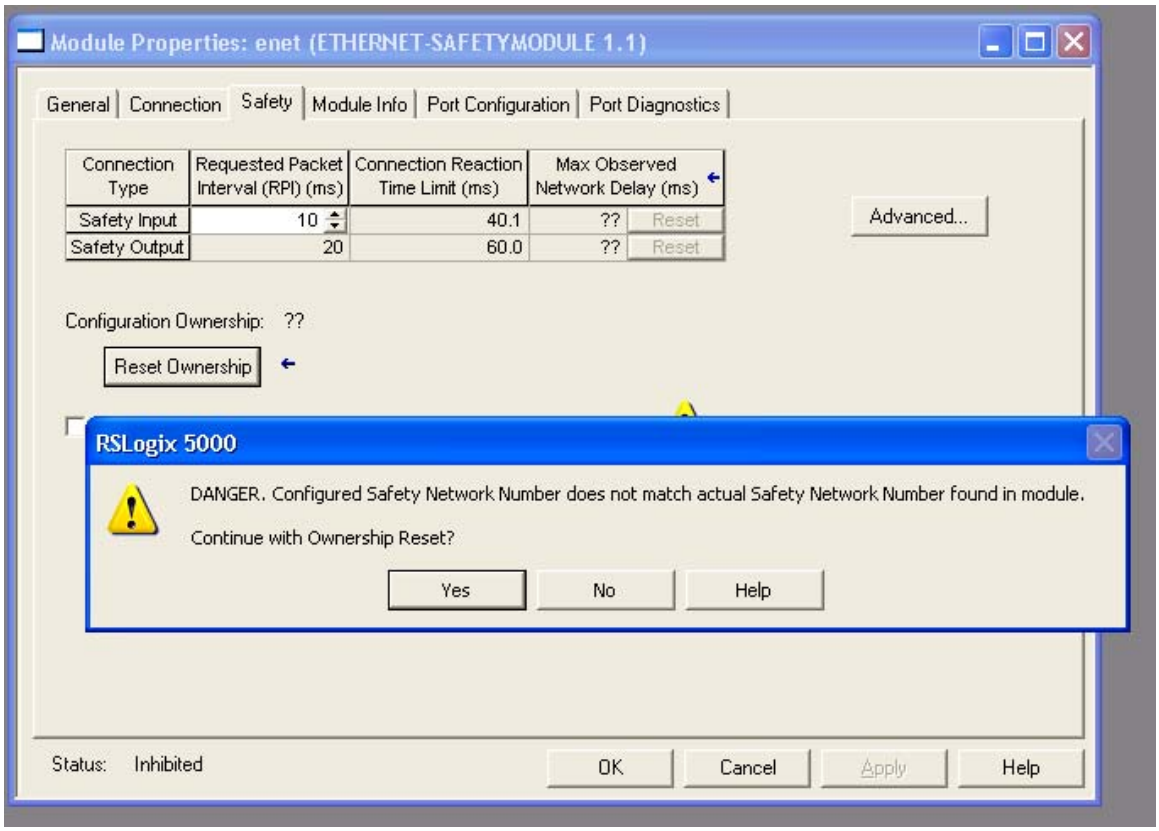
Under the Safety Tab Configuration Signature setting you can choose to :

- Disable checking of configuration signature to skip comparing Configuration Signature during connection establishment.
- Enable checking of configuration signature. You must manually enter the robot's Total Signature Number (shown on DCS Signature Number screen) in Hex. The Date/Time stamp will be the ACTUAL Date/Time stamp shown on the DCS Signature screen (offset in the SNCT by the timezone), or 1/1/2009 at 6:00:00.000 (offset in the SNCT by the timezone) if FIXED is set for Config Signature Date/Time in the CIP Safety setup screen. The timezone offset in the SNCT can be seen by double clicking on the time in the task bar and looking at the local timezone. As an example if FIXED date/time is used and the SNCT shows GMT-05:00 then instead of 6am the time would be entered as 1am.

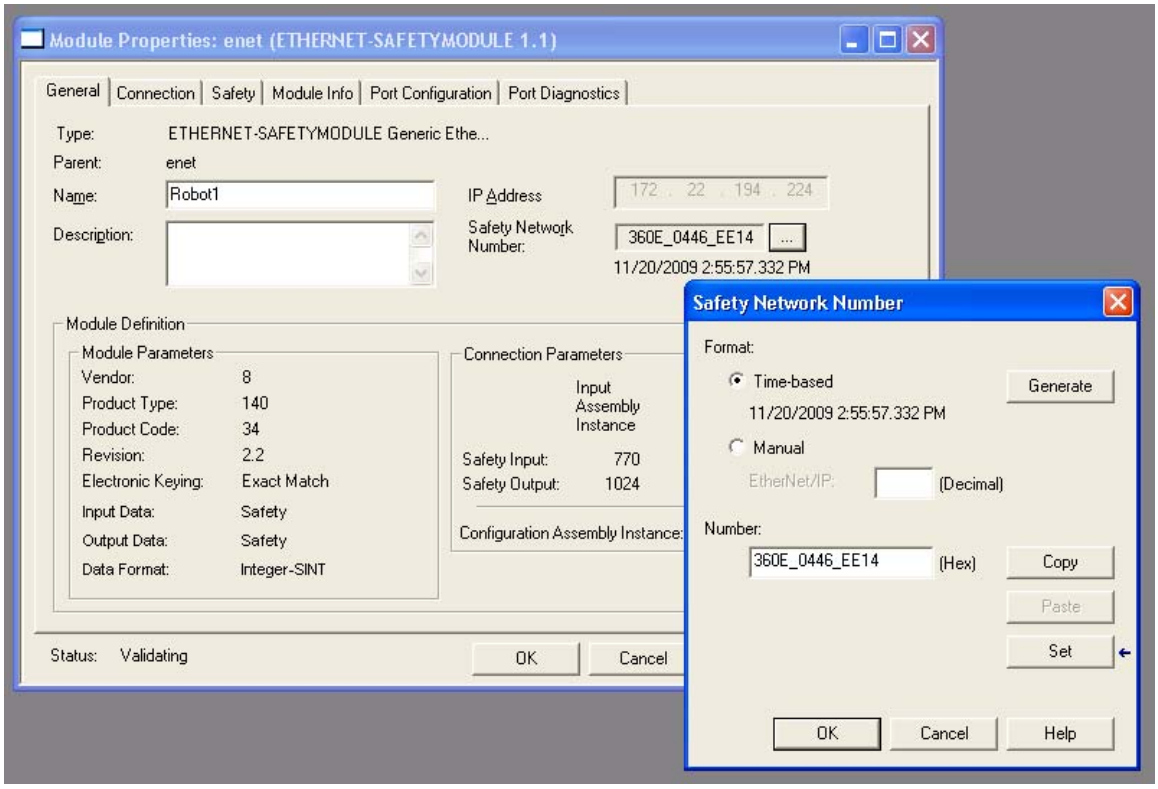


Press OK to add the robot safety slave connection to the safety PLC configuration. Download the new configuration to the Safety PLC and go online.

Note that the robot slave will only accept a new SNN when it currently has no SNN (reset back to factory default). The "Reset Ownership" button under the safety tab can be used to reset the SNN if required. This reset ownership must be performed at least once after software load before the robot can be configured with an SSN number.



The new safety connection will fail until the Safety Network Number (SNN) is set. Use the "…" button on the General tab of the robot safety slave module properties to set the SNN. The "SET" button will be active when the safety PLC configuration software is online with the safety PLC (the PLC connection must not be inhibited), and the robot is on the network.



The current SNN set in the robot can be viewed on the CIP-Safety Status screen. See section 7.2.4.1 for details on this screen,

7.2.4 Troubleshooting

7.2.4.1 CIP-safety status screen

The CIP-Safety Status screen is available under I/O Ethernet/IP (MENU -> I/O -> F1 [Type] -> EtherNet/IP -> F3 [Safety]. Most of this screen is read-only and includes :

- Safety I/F Status : Pending, Idle, Running. Pending implies the configuration steps have not yet been completed. Idle implies the Safety PLC did not or could not make a safety I/O connection to the robot. Running means there is an active safety I/O connection.
- DCS : Enabled, Bypassed. This is set in DCS menu.
- Input Size : 1-8 bytes. This is set in DCS menu.
- Output Size : 1-8 bytes. This is set in DCS menu.
- SNN : Safety Network Number. This is set from safety PLC configuration software.
- TX Count : Transmit Count (packets sent to PLC). This count is dynamically updated so can be observed to increment when connection is active.
- RX Count : Receive Count (packets received from PLC). This count is dynamically updated so can be observed to increment when connection is active.

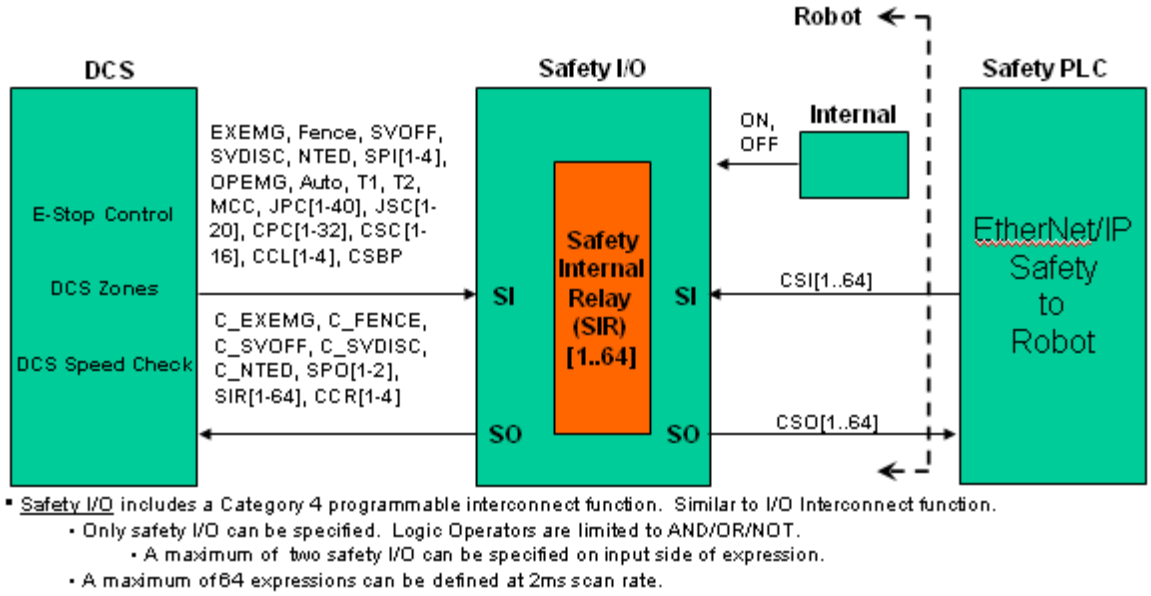
```
I/O EtherNet/IP
  EIP CIP-Safety Operation          1/2

   Ethernet Interface:    Port 2
   Safety I/F Status:     IDLE

   CIP-Safety Operation:
     DCS:                Enable
     Input Size:          2
     Output Size:         2
     SNN:                FFFF_FFFF_FFFF
     TX Count:            0
     RX Count:            0
```

Please note that when SNN shows “FFFF_FFFF_FFFF” or “???” it means the SNN has not been set from the Safety PLC configuration software. If the SSN shows “???”, a “Reset Ownership” must be performed before the SNN can be set. Please follow the information in section 7.2.3.1 or 7.2.3.2 to perform a reset ownership and/or set the SNN.

7.3 SAFETY I/O CONNECT IN CIP-SAFETY SYSTEM

The Safety I/O Connect feature provides a means to tie the CIP-Safety I/O to particular safety signals in the controller. See chapter 5 for detailed information about Safety I/O Connect.

The following figure provides a visual representation of Safety I/O and the overall system. Safety I/O Connect logic runs within the Safety I/O area.



- Safety I/O includes a Category 4 programmable interconnect function. Similar to I/O Interconnect function.
  - Only safety I/O can be specified. Logic Operators are limited to AND/OR/NOT.
    - A maximum of two safety I/O can be specified on input side of expression.
  - A maximum of 64 expressions can be defined at 2ms scan rate.

The safety I/O Connect setup is saved in DCSIOC.SV. See section 1.5 on backup/restore for more information.

7.4 BACKUP/RESTORE OF CIP-SAFETY SETTINGS

CIP-Safety settings are included within the following system files during an application backup :

- SYSCIPS.SV – this file includes the Safety I/O size, Enable/Bypass setting, and which Interface is configured for CIP-Safety.
- DCSIOC.SV – this file includes the Safety I/O Connect configuration

These files are included under a “Backup – All of the Above” and “Backup – System Files”. These are found on the File Menu under the Backup function key.

These files can only be restored at CTRL start.

NOTE
The Safety PLC data set in the robot (eg. SNN) is not included in any application backup. It must be explicitly set on a robot from the Safety PLC configuration software.

NOTE
The basic Ethernet settings, such as IP address and subnet mask, are stored to SYSHOST.SV. As necessary, backup and restore SYSHOST.SV in addition to SYSCIPS.SV.

Please see section 1.5 on backup/restore for more information.

7.5 EDS FILE

Please contact your FANUC representative for Information on obtaining the robot CIP-Safety slave EDS file. In North America: Call 1-800-47ROBOT for Information on obtaining the robot CIP-Safety slave EDS file.

8 PROFINET SAFETY

8.1 INTRODUCTION

PROFINET Safety function is an option software that provides the functionality of F-Device function of PROFIsafe V2 to FANUC robot.

The robot controller works as an F-device of PROFIsafe and communicates safety signals with an external F-Host.

> ⚠**WARNING**
> At the initial start-up, the operation check and validation of the wiring for safety signals should be carried out, and then the wiring should be protected by the cable duct.

8.2 PROFINET SAFETY FUNCTION

8.2.1 Overview

In order to use the PROFINET Safety, please be sure the following software options are loaded :
- PROFINET I/O function (A05B-2600-J930) or Dual-Channel PROFINET (A05B-2600-R834)
- PROFINET Safety function (A05B-2600-J931)

A05B-2600-J930 needs the software version 7DC1/06 or later. A05B-2600-R834 needs 7DC3 series.

For R-30*i*B controller, order either A05B-2600-J930 or A05B-2600-R834. These options are exclusive.

For R-30*i*B Mate controller, 7DC3 series is required for PROFINET Safety function. Order A05B-2600-J930 for open air type controller. Order A05B-2600-R834 if it is not open air type controller.

The PROFINET Safety option requires the PROFINET hardware including PROFINET board.

Table 8.2.1 Hardware for PROFINET Safety

Option	Description
A05B-2600-J930	CP1604 must be used for PROFINET board. Please see the section 1.2 in the *PROFINET I/O operator's manual* for the order list. Open air type controller is required for R-30*i*B Mate controller. As for the firmware versioin of PROFINET board, it must be V2.5.2.2(1) in 7DC0 series, 7DC1 series and 7DC2 series. In 7DC3 series, use V2.6.0.3.
A05B-2600-R834	The firmware version must be V1.3.1.0. Open air type conttoller hasn't been supported at the time of creating this manual.

The GSDML file for robot is required to configure robot controller as an F-Device. Please contact FANUC for the GSDML file for robot. There are 8 safety modules of different safety I/O size in the GSDML.

PROFINET I/O Device function must be enabled in order to use PROFINET Safety function because PROFINET I/O Device function manages a safety module together with standard I/O modules. A safety module must be added in the module list of the PROFINET I/O Device function for safety data exchange. Only one safety module can be used, and it can be added in the first slot. The safety data is not exchanged when there is no safety module in the module list.
PROFINET I/O Controller function can be enabled, but it exchanges only standard I/O data.

Note that the DCS Safe I/O Connect option (A05B-2600-J568) is automatically loaded when PROFINET Safety is loaded. Please see the chapter on the DCS Safe I/O Connect for details in using this option.

PROFINET Safety supports up to 8 bytes input, and 8 bytes output, across the safety connection. Use the DCS Safe I/O Connect option to map this safe I/O to particular safety signals within the robot.

The PROFINET Safety settings (Safety I/O size, Enable/Bypass setting, and F-Address) are saved in syspnsf.sv. The basic PROFINET settings are saved in pnio.sv or pmio.sv. See section 1.5 on backup/restore for more information.

Configuring F-Device involves the following steps :
- Configure the robot (F-Device) with a safety module – see section 8.2.2.
- Configure the Safety PLC to exchange safety I/O with the robot – see section 8.2.3.

8.2.2 Robot Configuration

Robot configuration begins with configuring the PROFINET I/O Device function and adding a safety module to the module list. This is done within the normal PROFINET I/O screens and described in procedure 8-2-1 for A05B-2600-J930, or in procedure 8-2-2 for A05B-2600-R834. Next the PROFINET Safety I/O sizes, Enable/Bypass settings and F-Address can be reviewed/changed as needed in procedure 8-2-3.

Procedure 8-2-1 Setting in Setup PROFINET I/O Device module screen

Please refer to *PROFINET I/O operator's manual* for the details of PROFINET I/O Device module list/detail screen.

Steps :

- Open the setup PROFINET I/O Device module list screen (MENU->6. Setup, F1 (TYPE)->PROFINET, F3 (Other)->I/O Device, move cursor on <Detail>, press Enter).
- Add the Data Access Point (DAP) as the first module (slot=0, subslot=1, or if the firmware version is V2.6 or later, slot=1, subslot=1).
- Move to the next module, set slot=1, subslot=1, or if the firmware version is V2.6 or later, slot=2, subslot=1.
- Refer to the GSDML for robot to choose a safety module according to the safety slave I/O size.
- Set its Module ID and Subslot ID to add the safety module.
- If necessary, continue adding standard modules.
- A power cycle is required to make changes active.

Example : Module ID=0x1008 (The safety slave I/O size = 8 bytes)

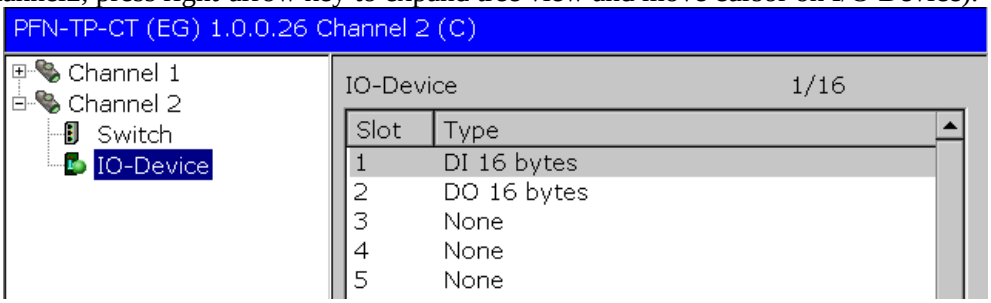
```
Setup PROFINET I/O
  I/O Device : Module 1             1/6
1  Slot :                          1
2  Subslot :                       1
   Comment :
3           [                     ]
4  ModId(hex)             0x00001008
5  SubslotId(hex)         0x00000001
     Module I/O type              NONE
6  Data size :                [     ]
7  Data type :                [Digital]

[TYPE]   list     prev    next
```

Procedure 8-2-2 Adding Safety module to I/O Device channel

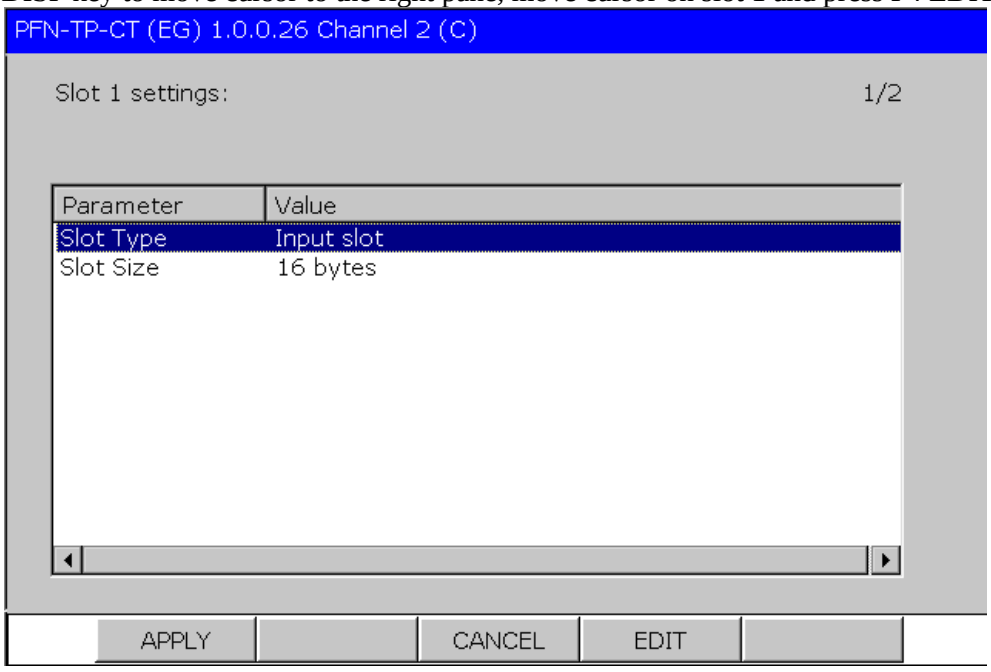
Please refer to *PROFINET I/O operator's manual* for the details of PROFINET I/O Device function.

Steps :

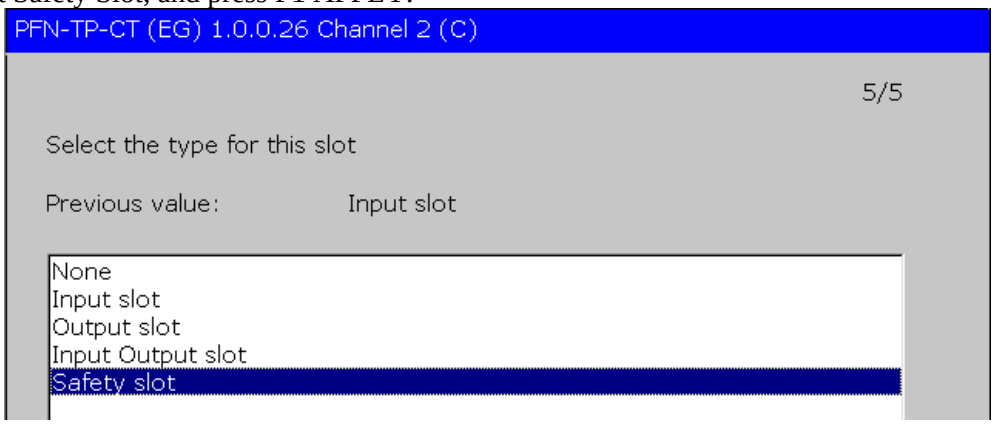
- Open the module list of I/O Device (MENU->6. Setup, F1 (TYPE)->PROFINET(M), move cursor on Channel2, press right-arrow key to expand tree view and move cursor on I/O Device).



- Press DISP key to move cursor to the right pane, move cursor on slot 1 and press F4 EDIT.



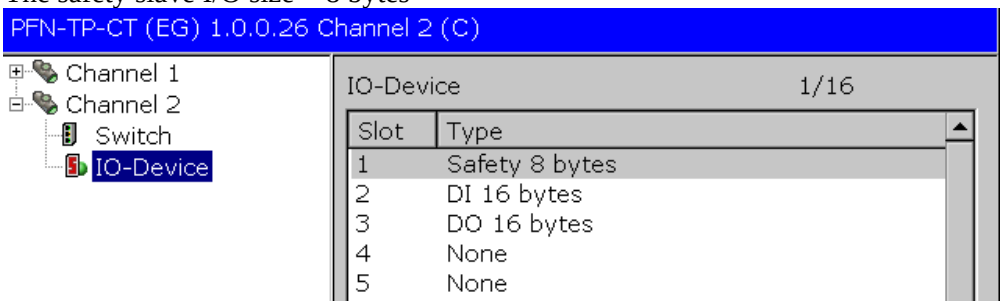
- Move cursor on Slot Type and press F4 EDIT.
- Select Safety Slot, and press F1 APPLY.



- Move cursor on Slot Size, and press F4 EDIT.
- Select appropriate Safety I/O size, and press F1 APPLY.

- Press F1 APPLY to complete the slot1, the cursor moves to the left pane.
- If required, continue adding standard modules by similar operation.
- Press F1 SAVE to save current configuration when the cursor is on the left pane.
- A power cycle is required to make changes active.

Example : The safety slave I/O size = 8 bytes



Procedure 8-2-3 Setting the PROIFNET Safety I/O size, Enable/Bypass, and F-Address

Steps :

Setting the PROFINET Safety I/O size, or setting the connection to bypass is done within the DCS Safety screens.

- MENU -> SYSTEM -> Type (F1) -> DCS

```
   1 Safe I/O Status:
   2 Safe I/O connect:          OK
   3 PROFINET Safety:           CHGD
   4 Signature number:
   5 Change code number:
```

- Cursor to PROFINET Safety and press enter to see the following screen. Note that the TP must be enabled before any changes are allowed in this screen. The default safety I/O size is 8 bytes in and 8 bytes out. The Enable/Bypass setting is normally Enabled meaning the PROFIsafe connection must be operating before faults can be cleared in the robot. Bypass may be used during initial integration when a safety PLC is not available. See the Safety I/O Connect chapter for how to detect BYPASS mode. Press PREV when any changes to PROFINET Safety configuration are complete.

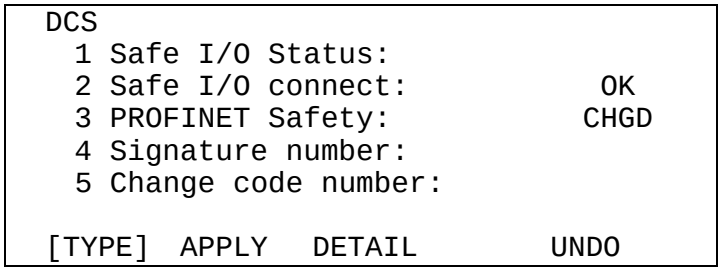
```
PROFINET Safety                      1/4
   Status:                    CHGD
 1 Enable/Bypass:             ENABLE
 2 Safety input size(byte)        8
 3 Safety output size(byte)       8
 4 F-Address                    200
```

Table 8.2.2 The parameters in the DCS PROFINET safety screen

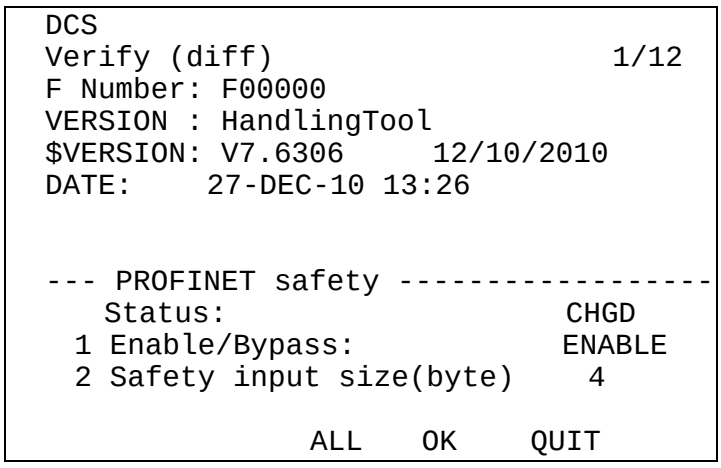
Item	Description
Enable/Bypass	The mode of safety network. Enable : Safety communication must be operating before robot alarm status can be cleared. Bypass : Bypass may be used during initial integration when a safety PLC is not available. There is no safety communication error and robot can move in standalone mode, but all CSI from the safety PLC are ignored. Bypass mode is indicated by SSI[11], which can be interconnected to any CSO to the safety PLC. Refer to 8.2.4 Operation without Safety PLC (bypass mode) when Bypass is used.

Item	Description
Input/Output size	The number of safety input/output that is to be allocated in the robot controller. The default value is 8 bytes. This setting must be equal to the number of input/output specified in the configuration of safety PLC, otherwise the system becomes error status (PRIO-604 will show up with PRIO-603 “PROFIsafe hard fail”).
F-Address	Logical address designation of F-Device that can be assigned freely but unambiguously (from 1 to 65534). The default value is 200. This setting must be equal to the F-Destination-Address specified in the configuration of safety PLC.

- Use the F2 (APPLY) button while in the DCS Setup screen to complete changes. You will be prompted for the code number.



- You will then be shown a screen detailing the differences for review (press OK after review).



- A power cycle is required to make changes active.

8.2.3 Safety PLC Configuration

This section provides information for setting up robot as an F-Device of PROFIsafe by using configuration software, such as STEP7.

First of all, please follow the manuals provided by the manufacturer of the safety PLC. For example, safety engineering system manual and safety programming manual.

Please install the GSDML file for robot in the configuration software. The GSDML file has the information of robot as an F-Device. There are 8 safety modules of different safety I/O size in the GSDML. Only one safety module can be configured, and it can be inserted in only the first slot. The minimum watchdog time of robot as an F-Device is 40ms. The watchdog time may need to be increased depending to the network option software configuration in the robot controller. The process time of the

safety PLC should be considered in deciding the watchdog time. Please set the I/O device update time in the PROFINET-I/O system property equal to, or less than 4ms for safety data exchange.

The safety parameters (F-Parameter) for an F-Device, for example safety I/O size, are supposed to be configured in configuration software. The value must be equal to that set in procedure 8-2-3, otherwise safety communication can't be started. Please see also 8.2.5.3.

> **⚠WARNING**
> The information written in the document does not include any safety precaution. The operator must read manuals provided by the manufacturer of the safety PLC, and examine them carefully and sufficiently before using the information, and take any precaution, if required, in using the information.

8.2.4 Operation without Safety PLC (bypass mode)

In bypass mode, there is no safety communication error and robot can move in standalone mode, but all CSI from the safety PLC are ignored. Bypass mode is indicated by SSI[11], which can be interconnected to any CSO to the safety PLC.

In bypass mode, the following events bring the robot to alarm status to prevent the robot from moving. Operation is required to recover from the alarm status. This feature is only for PROFINET Safety.

Table 8.2.4 (a) Events that bring the robot to alarm status in bypass mode

Item	Description
Hot/Cold start	When the robot controller is turned off in bypass mode, SYST-212 "Need to apply to DCS param" shows up at HOT start or Cold start. The mode of safety network is changed to "Enable", but it has not been applied yet (The actual mode is bypass). The operator should apply the change in the DCS screen by entering the password and cycling power the robot controller. Instead, the operator may use bypass mode by changing the mode back to bypass. The password is not necessary for this operation, and the alarm can be reset without cycling power
Safety communication gets established to F-Host	Once the safety PLC establishes communication in bypass mode, SYST-212 "Need to apply to DCS param" shows up. The mode of safety network is changed to "Enable" but it has not been applied yet (The actual mode is bypass). The alarm status prevents the operator from continuing on using bypass mode to move the robot. It cannot be cleared until the change is applied and power is cycled. The operator should apply the change in the DCS screen by entering the password and cycling power to the robot controller.
The mode switch is changed to T2 or AUTO	SYST-212 "Need to apply to DCS param" shows up when the mode switch is changed to T2 or AUTO in bypass mode. The alarm status prohibits the robot from moving in T2 or AUTO in bypass mode. It cannot be cleared until the mode switch is back to T1 and the reset button is pressed.

The following system variables specify which of the events are monitored. The change takes effect immediately (no need to cycle power to apply the change).

Table 8.2.4 (b) System variables to specify which of the events are monitored

Item	Description
$PNSF_SET.$BY_PWFAIL	If the value is not 0, the bypass mode is disabled at "Hot/Cold start". The default value is 1.
$PNSF_SET.$BY_PLCCON	If the value is not 0, the bypass mode is disabled when Safety communication gets established to F-Host. The default value is 1.

Item	Description
$PNSF_SET.$BY_PLCRUN	This variable is only used when $PNSF_SET.$BY_PLCCON is not 0. If the value is not 0, the bypass mode is disabled when F-Host is connected and F-Device has received valid F-Parameter. The default value is 1.
$PNSF_SET.$BY_T1ONLY	If this value is not 0, the bypass mode is disabled when the mode is changed to T2 or AUTO. The default value is 1.

8.2.5 Troubleshooting

8.2.5.1 PROFINET safety status screen

In A05B-2600-J930, the PROFINET Safety Status screen is available under PROFINET Status screen (MENU -> 0. Next page -> 4. Status -> F1 (TYPE) -> PROFINET -> F3 (Other) -> Safety. This screen can be opened when the PROFINET Safety function is installed. This screen is read-only. This screen is not a part of safety functions, and the output of this screen is non-safe.

```
PROFINET Status
  PROFINET Safety Operation          1/1

   Safety I/F Status:    INIT

   PROFIsafe Operation:
     DCS:               Enable
     Input Size:         8
     Output Size:        8
     Frame Count:        0

[TYPE]             [Other]
```

Table 8.2.5.1 The items in the PROFINET safety status screen

Item	Description
Safety I/F Status	INIT : The configuration steps have not yet been completed. IDLE : The safety PLC does not or cannot start the safety I/O communication with the robot. RUNNING : The safety I/O communication is active.
DCS	This item shows if PROFINET Safety connection is enabled or bypassed.
Input/Output size	Current setting of input/output size.
Frame Count	Local counter of PROFIsafe safety process data unit (PDU) in the robot controller. Only exchange with valid data is counted.

8.2.5.2 DIAGSAFETY screen

In A05B-2600-R834, the DIAGSAFETY screen is available under I/O Device.

- MENU -> 6. Setup -> F1 (TYPE) -> PROFINET(M), move cursor on Channel2, press right-arrow key to expand tree view and move cursor on I/O Device.
- Press F3 DIAGSAFETY.

This screen can be opened when the PROFINET Safety function is installed. This screen is read-only. This screen is not a part of safety functions, and the output of this screen is non-safe.

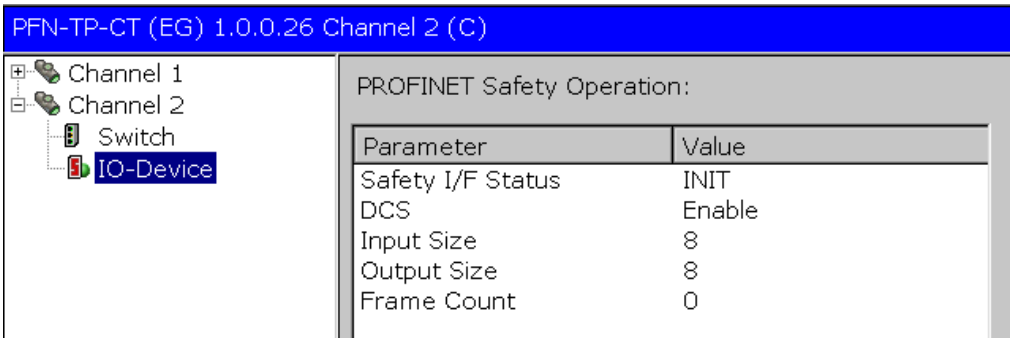


Table 8.2.5.2 The items in the DIAGSAFETY screen

Item	Description
Safety I/F Status	INIT : The configuration steps have not yet been completed. IDLE : The safety PLC does not or cannot start the safety I/O communication with the robot. RUNNING : The safety I/O communication is active.
DCS	This item shows if PROFINET Safety connection is enabled or bypassed.
Input/Output size	Current setting of input/output size.
Frame Count	Local counter of PROFIsafe safety process data unit (PDU) in the robot controller. Only exchange with valid data is counted.

8.2.5.3 Error indication

There are alarms that indicates error state in PROFINET Safety.

- In A05B-2600-J930, PRIO-604 shows up with PRIO-603 “PROFIsafe hard fail”, “CRC check error” or “status check error” (the string data in English is displayed as PRIO-603 message).
- In A05B-2600-R834, PRIO-380 shows up.

If such alarm shows up, first of all, check whether the configuration of safety PLC and the setting of robot controller matches. Check the size of safety input/output in DCS PROFINET Safety screen, configure the safety PLC again, and cycle power to the controller. If the problem persists, the error is probably due to a hardware problem. Please contact FANUC.

8.3 BACKUP/RESTORE OF PROFINET SAFETY SETTINGS

PROFINET Safety settings are included within the following system files during an application backup :

- SYSPNSF.SV – this file includes the Safety I/O size, Enable/Bypass setting, and F-Address of PROFINET Safety
- PNIO.SV – In A05B-2600-J930, this file includes the setting of the safety module together with the standard PROFINET I/O function settings
- PMIO.SV – In A05B-2600-R834, this file includes the setting of the safety module together with the standard PROFINET I/O function settings
- DCSIOC.SV – this file includes the Safety I/O Connect configuration

These files are included under a “Backup – All of the Above” and “Backup – System Files”. These are found on the File Menu under the Backup function key. These files can only be restored at CTRL start.

NOTE
When PROFINET Safety function is used, basic PROFINET settings (such as I/O Device configuration) are held in PNIO.SV in A05B-2600-J930, or in PMIO.SV in A05B-2600-R834. Backup/restore PNIO.SV or PMIO.SV with SYSPNSF.SV if required.

NOTE
In PROFIsafe, F-Host is supposed to send F-Parameter to F-Device.
F-Parameter is not stored in any application backup.

Please see section 1.5 on backup/restore for more information.

8.4 GSDML FILE

Please contact FANUC for the GSDML file for robot. Please inform the type of robot controller (R-30*i*B, R-30*i*B Mate), the software version and the order number of PROFINET option (J930 or R834).

9 SAFETY FUNCTION BY FL-NET

9.1 INTRODUCTION

Safety function by FL-net is option software that provides an ability to exchange safety signals between a robot and other robots or CNCs by FL-net.

> **⚠WARNING**
> At the initial start-up, the operation check and validation of the wiring for safety signals should be carried out, and then the wiring should be protected by the cable duct.

9.2 SAFETY FUNCTION BY FL-NET

9.2.1 Overview

In order to use Safety function by FL-net, please be sure the following software options are loaded.

- FL-net Interface (A05B-2600-J759)
- Safety function by FL-net (A05B-2600-J586)

DCS Safe I/O Connect option (A05B-2600-J568) is automatically loaded when Safety function by FL-net is loaded. Please see the chapter on the Safe I/O Connect for details in using this option.

Safety function by FL-net can be used with internal port (CD38A or CD38B) on main board. FL-net board (A05B-2600-J105) can't be used for Safety function by FL-net.

Safety function by FL-net has 3 modes for selecting behavior when attending node changed to power OFF.
In mode 1, when 1 or more nodes, which attend to Safety function by FL-net, is cycle powered, alarm happens in all nodes, which attend the same Safety function by FL-net network. For resetting this alarm, change power OFF for all nodes. After power off the all nodes, power ON all nodes.
In mode 2, alarm doesn't happen even when power offed node exists. When Mode 2 is used, a risk assessment for the whole system is necessary, including that alarm doesn't happen even when disconnected node by power off etc. exists.
In mode 3, alarm happens when power offed node exists, but the alarm can be reset after all node is connected.
Mode of all nodes should be same.

Safety function by FL-net supports up to 203 safety inputs, and 70 safety outputs for 1 node,. But the number of input + the number of output must be equal or less than 210. Use the DCS Safe I/O Connect function to map this safe I/O to particular safety signals within the robot.

Each Safety function by FL-net node has some IDs. 1 ID has 7 safety signals for user and 1 signal reserved for system (total 8 signals). The user can’t use the reserved signal. The range of the ID is 1 to 30. 1 node can have maximum 10 consecutive IDs. The number is called as “IDnum.”. Node having ID is consecutive starting from same ID with own node number and the number of ID is "IDnum.". Output data is comprised of all IDs of the node having ID. . For example, if node number is 11 and IDnum is 5 then the node has ID 11 to 15 which has 35 signals for user and 5 system signals. In this case, node 12 to 15 can not be used in Safety function by FL-net. Maximum 30 nodes, which are Robots and CNCs, can be connected to the network of the Safety function by FL-net, if all nodes occupy only 1 ID (IDnum. = 1).

CNC doesn't have IDnum. Setting but it is assumed as IDnum. = 1. IDnum. for CNCs should be set as 1 in robot. CNC (18***i***-LNB) can't participate to the network of Safety function by FL-net, to which Robot participating, because safety specification is different.

The Safety function by FL-net uses first 6 words * IDnum. of the node's common memory area 1, which is allocated to the node exclusively, to send the safety data. Therefore, the allocation size of common memory area 1 of the node that composes the network of the Safety function by FL-net should be larger than 6 words * IDnum. Common memory area 1 other than the above-mentioned words and common memory area 2 can be used as a normal data area. So, even when Safety function by FL-net is enabled, standard FL-net data can be exchanged.

Safety function by FL-net can use FL-net multicast.

Safety function by FL-net settings (Enable/Disable, Own node number, Node, Timer for receive data, Start timer after Power ON) are saved in sysflsf.sv.

9.2.2 Safety Signal

This section explains the safety signals that are the interface of the DCS Safe I/O connection function and the Safety function by FL-net. OFF should be safety side in safety signals.

9.2.2.1 Sending safety signal area

The signal data, which is sent from the DCS Safe I/O connection function to other nodes via Safety function by FL-net, is FSO composed of the 7 safety signals and 1 system signal per ID.
There are signal data for 10 IDs in FSO. FSO number is summarized in Table 9.2.2.2 (a). In this table, if node number is 11 and IDnum. = 10, 1st ID is 11 and 10th ID is 20.

9.2.2.2 Receiving safety signal area

The signal data ,which is received from other nodes via Safety function by FL-net and passed to the DCS Safe I/O connection function, is FSI, which is composed of 7 safety signals and 1 system signal per ID. There are signal data for 30 IDs in FSI. FSI number is summarized in Table 9.2.2.2 (b).
Moreover, the safety function target ID information area (32signals) is allocated after the receiving safety signal area. The 1st signal of the safety function target ID information area is the own node safety effective notification area. Please see Table 9.2.2.2(c).

System signal

In mode 1, for example when an error is first detected by the Safety function by FL-net from the data of ID 1, the System signal of the ID 1 is set to ON. If the error is detected from the data of another ID 2 after the first error detected from the data of ID 1, the System signal of the ID 2 is NOT set to ON. System signal of only first error detected ID changes to ON.
In mode 2 and 3, when counter error, which happens when other node is disconnected by power off etc., detected after first error is detected from other ID data, this system signal becomes ON. In other error, specification is same with mode1.
When other DCS functions detect error, system signal is set to ON for the 1st ID of the node and other FSI for the ID is set to OFF, in all modes. In this case, like mode 1, system signal of 1st ID of only 1st error detected node becomes ON.

Safety function target node information area

The safety function target node information area (found after the receiving safety signal area) represents the target node of communication by using the Safety function by FL-net. Each signal from node 1 to node 30 in Table 9.2.2.2 (c) shows status of each node. The logical add of safety parameter

ENABLE(**0**)/DISABLE(**1**) and safety parameter ENTRY(**0**)/SEPARATE(**1**) is reflected to this area. Pay attention ENABLE = 0, DISABLE = 1, ENTRY = 0 and SEPARATE = 1. If the signal is OFF, the communication to that node is executed and if the signal is ON, the communication to that node is NOT executed. The signal that corresponds to the own node becomes ON. Moreover, FSI[241] of the safety function target node information area is the own node safety effective notification area. This signal shows whether the safety function of own node is effective or not. After the validity of the safety parameter is confirmed when the power supply is turned on, safety parameter ENABLE/DISABLE of own node is reflected to this area. OFF shows the safety function is not effective, and ON shows effective.

Table 9.2.2.2 (a) FSO number

Safety Signal / ID	1st	2nd	3rd	4th	5th	6th	7th	System signal
1st	1	2	3	4	5	6	7	8
2nd	9	10	11	12	13	14	15	16
3rd	17	18	19	20	21	22	23	24
4th	25	26	27	28	29	30	31	32
5th	33	34	35	36	37	38	39	40
6th	41	42	43	44	45	46	47	48
7th	49	50	51	52	53	54	55	56
8th	57	58	59	60	61	62	63	64
9th	65	66	67	68	69	70	71	72
10th	73	74	75	76	77	78	79	80

Table 9.2.2.2 (b) FSI number

Safety Signal / ID	1st	2nd	3rd	4th	5th	6th	7th	System signal
1	1	2	3	4	5	6	7	8
2	9	10	11	12	13	14	15	16
3	17	18	19	20	21	22	23	24
4	25	26	27	28	29	30	31	32
5	33	34	35	36	37	38	39	40
6	41	42	43	44	45	46	47	48
7	49	50	51	52	53	54	55	56
8	57	58	59	60	61	62	63	64
9	65	66	67	68	69	70	71	72
10	73	74	75	76	77	78	79	80
11	81	82	83	84	85	86	87	88
12	89	90	91	92	93	94	95	96
13	97	98	99	100	101	102	103	104
14	105	106	107	108	109	110	111	112
15	113	114	115	116	117	118	119	120
16	121	122	123	124	125	126	127	128
17	129	130	131	132	133	134	135	136
18	137	138	139	140	141	142	143	144
19	145	146	147	148	149	150	151	152
20	153	154	155	156	157	158	159	160
21	161	162	163	164	165	166	167	168
22	169	170	171	172	173	174	175	176
23	177	178	179	180	181	182	183	184
24	185	186	187	188	189	190	191	192
25	193	194	195	196	197	198	199	200
26	201	202	203	204	205	206	207	208
27	209	210	211	212	213	214	215	216

Safety Signal / ID	1st	2nd	3rd	4th	5th	6th	7th	System signal
28	217	218	219	220	221	222	223	224
29	225	226	227	228	229	230	231	232
30	233	234	235	236	237	238	239	240

Table 9.2.2.2 (c) Safety function target node information area (FSI[241] is the own node safety effective notification area)

FSI[241]	Own node
FSI[242]	NODE 1
FSI[243]	NODE 2
FSI[244]	NODE 3
FSI[245]	NODE 4
FSI[246]	NODE 5
FSI[247]	NODE 6
FSI[248]	NODE 7
FSI[249]	NODE 8
FSI[250]	NODE 9
FSI[251]	NODE 10
FSI[252]	NODE 11
FSI[253]	NODE 12
FSI[254]	NODE 13
FSI[255]	NODE 14
FSI[256]	NODE 15
FSI[257]	NODE 16
FSI[258]	NODE 17
FSI[259]	NODE 18
FSI[260]	NODE 19
FSI[261]	NODE 20
FSI[262]	NODE 21
FSI[263]	NODE 22
FSI[264]	NODE 23
FSI[265]	NODE 24
FSI[266]	NODE 25
FSI[267]	NODE 26
FSI[268]	NODE 27
FSI[269]	NODE 28
FSI[270]	NODE 29
FSI[271]	NODE 30
FSI[272]	(Reserved)

9.2.3 Robot Configuration

Robot configuration begins with configuring the FL-net function. This is done within the normal FL-net screens. Procedure 9-2-1 describes settings relate to safety function in normal FL-net screen. Parameters for Safety function by FL-net can be reviewed/changed in procedure 9-2-2.

Procedure 9-2-1 Setting in SETUP FL-NET screen

Please refer to FL-net operator's manual (B-82674) for the normal settings of FL-net.

Steps:

- Open the FL-NET OWN NODE SETUP screen (MENU -> 6. Setup -> F1 (TYPE) -> FL-NET -> F3 (OTHER) -> OWN NODE)

```
SETUP FL-NET
 FL-NET OWN NODE SETUP                1/29
  1 ERROR ONE SHOT          :     DISABLE
  2 MAX DIGITAL PORT NUM    :        1024
  3 USING PORT              :INTERNAL2
    IP ADDRESS       :[192.168.250.21 ]
  4 MULTICAST               :   DISABLE
  5 MULTICAST ADDRESS:[239.255.0  .0  ]
  6 NODE NAME              :[ROBOT     ]
  7 TOKEN WATCH TIME(msec) :          30
  8 FRAME INTERVAL(0.1msec):           0
  9 UOP ASSIGNMENT          :     DISABLE
 10 UI ALLOCATION NODE      :           2
    AREA1 SETUP             :
 11 AREA1 WORD OFFSET       :           0
 12 AREA1 WORD SIZE         :          60
 13 DO BYTE OFFSET1         :           0
 14 DO BYTE SIZE1           :           0
 15 DO BYTE OFFSET2         :           0
 16 DO BYTE SIZE2           :           0
 17 WO BYTE OFFSET          :           0
 18 WO BYTE SIZE            :           0
 19 WSTK OUT BYTE OFFSET    :           0
 20 WSTK OUT BYTE SIZE      :           0
    AREA2 SETUP             :
 21 AREA2 WORD OFFSET       :           0
 22 AREA2 WORD SIZE         :           0
 23 AO BYTE OFFSET          :           0
 24 AO CHANNEL NUMBER       :           0
 25 AO SHIFT LEFT           :           0
 26 AO RANGE                :          16
 27 REGISTER BYTE OFFSET    :           0
 28 REGISTER START          :           1
 29 REGISTER NUMBER         :           0
```

- Other node settings can be changed from F3 (OTHER) -> NODE LIST -> Move cursor to setting changing node -> F2 “DETAIL”.
- The following items should be set to use Safety function by FL-net.

Table9.2.3 (a) Basic parameters

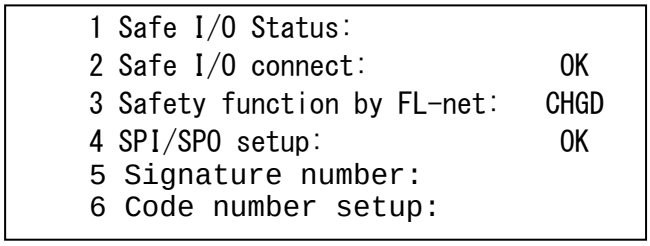
Parameter name	Description
USING PORT	BOARD : Using port on FL-net board(Can't use Safety function by FL-net). Use one of following internal port. INTERNAL1 : Using internal Ethernet port1 (CD38A). INTERNAL2 : Using internal Ethernet port2 (CD38B).
IP ADDRESS	IP address of the local node. The host address section (the last numeric value) of this IP address is the node number of the local node. Only an IP address in class C can be specified. If INTERNAL port is selected as USING PORT, set IP address from [MENU] -> "6.SETUP." -> F1 key [TYPE] -> Host Comm -> TCP/IP. Change the IP address setting port by F3 key "PORT". If the Safety function by FL-net is enabled, the value of "Own node number" in safety parameter should be same with the host address section (the last numeric value) of this IP ADDRESS.
AREA 1 WORD OFFSET	Start address of common memory area 1 of the local node. A value from 0 to 511 can be set. See "III-2.3 SAMPLE NODE SETTINGS" in FL-net operator's manual (B-82674) for detail.
AREA 1 WORD SIZE	Data size of common memory area 1 of the local node. A value from 0 to 512 can be set. AREA1 WORD SIZE should be equal or more than (IDnum. * 6). First (IDnum. * 6) word, (IDnum. * 12) byte in other words, is used by Safety function by FL-net. DO/WO/WSTK BYTE OFFSET should be equal or more than (IDnum. * 12). Example: If IDnum. = 10 (The safety I/O size = 80 points), AREA 1 WORD SIZE should be equal or more than 60 and DO/WO/WSTK BYTE OFFSET should be equal or more than 120.

Procedure 9-2-2 Setting the Safety function by FL-net

Steps :

Setting the Safety function by FL-net is done within the DCS Safety screens.

- MENU -> 0 -- NEXT -- -> 6 SYSTEM -> F1 (TYPE) -> DCS



- Cursor to Safety function by FL-net and press enter to see the following screen. Note that the TP must be enabled before any changes are allowed in this screen. Press PREV when any changes to Safety function by FL-net configuration are completed.

```
Safety function by FL-net
  1 Enable/Disable:      ENABLE    OK
  2 Own node number:            1   OK
  3 Node:(Set DISABLE for own node)
         ENB/DIS ENT/DET   IDnum.
       1 ENABLE  ENTRY         1   OK
       2 ENABLE  ENTRY         1   OK
       3 ENABLE  ENTRY         1   OK
              ...
      29 ENABLE  ENTRY         1   OK
      30 ENABLE  ENTRY         1   OK
  4 Timer for receive data:     0  OK
  5 Start timer after PowerON:  0  OK
  6 Mode:                       1  OK
```

Table9.2.3 (b) Parameters in Safety function by FL-net screen

Item	Description
Enable/Disable	The mode of safety network. ENABLE : Safety function by FL-net is enabled in this robot. DISABLE: Safety function by FL-net is disabled in this robot.
Own node number	[Valid data range] 1 to 30. Set the local node number on FL-net.
Node:ENB/DIS	Left hand number 1 to 30 represents a node number. Specify nodes with which safety data communication is to be performed using the Safety function by FL-net. It is necessary for nodes that communicate with each other to mutually set the node parameters. Be sure to set DISABLE to the local node.
Node: ENT/DET	ENTRY : Participates in the network of Safety function by FL-net. DETACH : Temporarily detached from the network of Safety function by FL-net. A group of nodes that communicate safety data using the Safety function by FL-net are defined with “Other node: Enable/Disable” parameters. Use ENT/DET if one of the nodes of the Safety function by FL-net is to be temporarily disabled and detached from the group in the process of starting up facilities. For details, please refer to section 9.2.5 " Temporarily detaching some nodes from the Safety function by FL-net". Set DETACH in the place corresponding to the node that is to be temporarily detached from the network of the Safety function by FL-net. If DETACH is set for one or more nodes, alarm “SRVO-468 TmpDetachedNode exists in FLSF" is issued when the power is turned on.
Node: IDnum.	[Valid data range] 1 to 10. Set the occupation Data ID number. 1 Data ID has 8 safety signals (7 for user, 1 for system). Max Data ID is 30. If IDnum. in node x is n (n>=2), node x + 1 to node x + n – 1 can’t be used in the Safety function by FL-net network.

Item	Description
Timer for receive data	[Unit of data] millisecond [Valid data range] 0 to 500 The FL-net safety function transfers data of independent two safety circuits from the sending node to receiving node. On the receiving node, 2 CPU mutually monitor the data of these two paths. If an inconsistency or no-update is present for more than this parameter-set time, safety alarm (SRVO-420 Safety FL-net comm. error i,j) is issued. If this value is too small, error happens after power-on or after signal changing. This value is recommended to set equal or larger than the following formula (1). **“MAX RCM * 3 + 16”** - - - formula (1). You can check MAX RCM in FL-net status screen (MENU -> STATUS -> FL-NET -> F3”OTHER” -> NETWORK). You may have to set “Timer for receive data” larger than aforementioned formula because MAX RCM will change by the load of node. An Error is less likely to occur if “Timer for receive data” is larger. But, larger this parameter, larger the time to set safety signal OFF and system signal ON when trouble happens on Safety function by FL-net. This time is maximum "Timer for receive data + 4". Signal duration is recommended to be kept larger than formula (1) millisecond, in other words, if the signal is changed, the signal is recommended not to be changed in formula (1) millisecond. Keep signal as large as possible.
Start timer after powerON	[Unit of data] second [Valid data range] 0 to 255 When this parameter-set time has passed since start of safety function, the Safety function by FL-net starts checking received data. However, when all nodes that participate in the Safety function by FL-net participate in the network, the confirmation of the received data is begun even if the time set to this parameter doesn't pass. The value to be set in this parameter must be longer than the time required for all nodes using the Safety function by FL-net to start up and start FL-net communication. If the setting value is from 0 to 60, 60 seconds are adopted as the start timer.

Item	Description
Mode	Default setting of mode is 1. Mode1: When error happens in Safety function by FL-net, alarm happens. All signal of Safety function by FL-net (FSI [1~240]) becomes OFF. But most significant bit of safety signal of 1st error detected data ID becomes ON. Alarm can be reset only after removing the error cause and cycle-power of all nodes. Mode2: Alarm doesn't happen even when disconnected node by power off etc. exists. Safety signal can be exchanged between rests of nodes even after disconnected node exists. Alarm doesn't happen even after counter no update error happens by disconnected node. The counter error doesn't display in the diagnostic screen of Safety function by FL-net. Safety signal from disconnected ID looks like system signal is ON, others are OFF. Node can always attend the safety network. "Start timer after power ON" is ignored and safety function starts just after power ON. Safety signals of data ID, which is set as ENABLE and ENTRY, are followings just after power ON. System signal is ON, others are OFF. Servo can become ON even when no attending node exists just after power ON or after that. Safety signals of the node are recovered automatically when the node attends safety network. When Mode 2 is used, a risk assessment for the whole system is necessary, including that alarm doesn't happen even when disconnected node by power off etc. exists. Mode3: Alarm happens and servo becomes OFF by counter error by power OFF or disconnection etc. in this mode. Alarm reset and servo ON is enabled after resolving the counter error by connecting the node etc. If disconnected node exists, all signals including from power ON node are looked like OFF. System signal of power OFF ID is looked like ON. Safety signals of all nodes are recovered automatically without reset when all nodes attend network. Alarm can't be reset when power off node, which is set as entry, exists. Alarm can be reset by reset after all nodes become ON. Alarm doesn't reset without reset. To reset alarms of all nodes, do reset on all nodes. Node can always attend safety network. "Start timer after power ON" is ignored, and safety function starts just after power up. Alarm (counter alarm) happens just after power up.

⚠WARNING
In Mode 2, alarm doesn't happen even when disconnected node by power off etc. exists. In this case, a risk assessment for the whole system is necessary, including that alarm doesn't happen even when disconnected node by power off etc. exists.

- Use the F2 (APPLY) button while in the DCS Setup screen to complete changes. You will be prompted for the code number.

```
    1 Safe I/O Status:
    2 Safe I/O connect:              OK
    3 Safety function by FL-net:   CHGD
    4 SPI/SPO setup:                 OK
    5 Signature number:
    6 Code number setup:

  [TYPE] APPLY  DETAIL        UNDO
```

- You will then be shown a screen detailing the differences for review (press OK after review).

```
DCS
Verify (diff)                          1/18
F Number: F00000
VERSION : HandlingTool
$VERSION: V8.10P10     12/10/2012
DATE:     27-DEC-12 13:26


--- Safety function by FL-net ------------------
    Status:                          CHGD
  1 Enable/Disable:                ENABLE
  2 Own node number                  21

                     ALL    OK     QUIT
```

- A power cycle is required to make changes active.

> **⚠WARNING**
> If a parameter of the Safety function by FL-net is set incorrectly, the safety function will not work, and serious personal injury could result. When a parameter of Safety function by FL-net is changed, the values must be verified and the function must be tested again.

9.2.4 Alarm

When 1 or more nodes are cycle powered, all nodes should be cycle powered when mode 1 or reset when mode 2 because of the following reasons.
Data transferred to other nodes by the Safety function by FL-net includes the value of a counter that counts up at certain intervals. The receiving node checks the value of the counter. If the value of the counter does not change during the period of time, set in the safety parameter (Timer for receive data), error happens in all nodes when mode 1 or mode 3 because a node is powered off and the counter isn't updated.

The alarm generated by the temporary detachment setting can be released by the reset in all modes.

Table 9.2.4 Alarm

Number	Message	Description
SRVO-420	Safety FL-net comm. error i,j	Safety function by FL-net detected the abnormality of the safety data. Please confirm the content of the alarm on the diagnosis screen of the Safety function by FL-net.
SRVO-468	TmpDetachedNode exists in FLSF	Temporary detaching parameter of Safety function by FL-net is set to DETACH.

9.2.5 Temporarily Detaching Some Nodes from the Safety Function by FL-net

In the process of starting up facilities with CNCs, needs may arise to configure the system and operate it with some of the nodes being removed. For example, such needs arise if an FL-net network is configured with some nodes disconnected completely from the network and using the remaining nodes only, and if only Safety function by FL-net is to be disabled even if nodes are connected to the network.
In such cases in CNC, if the safety parameters in CNC are changed, it is not possible to communicate normal data (not safety data) unless the other values of the FL-net parameters of CNC nodes are adjusted accordingly. (Because differences are generated in the positions of normal data in the PMC area.)
To avoid such an inconvenience and temporarily detach some CNC nodes from the Safety function by FL-net, use the temporary detachment settings.

Using the temporary detachment parameters

In accordance with the final system configuration planned, set the FL-net safety parameters and FL-net parameters of all nodes, referring to section 9.2.3 “Robot Configuration”.

Afterwards, in each node, set the temporarily detaching setting of the corresponding node to DETACH. In the temporarily detaching node, set the temporarily detaching parameter to DETACH of own node and of all nodes composing Safety function by FL-net.

This makes it possible to detach the specific node from the network of the Safety function by FL-net without changing the values of other parameters in CNC.

The signal of the safety function target node information area that corresponds to the node for which ON is set if the temporary detachment setting is DETACH. Please program the safety logic to ignore the signals transmitted from the node where the safety function target node information is ON.

If DETACH is set in any of the temporary detachment settings, “SRVO-468 TmpDetachedNode exists in FLSF” is issued when the power is turned on. To operate the robot, the alarm must be cleared with the reset button.

Safety signal from the temporary detaching node is kept to OFF.
If sending node is set as temporary detaching but receiving node is NOT set as temporary detaching for sending node, or if sending node is NOT set as temporary detaching but receiving node is set as temporary detaching for sending node, “SRVO-420 Safety FL-net comm. error %x,%x “ is issued.

9.2.6 Troubleshooting

The Safety function by FL-net Status screen is available under FL-net Status screen (Menu -> 0 -- NEXT -- -> 4 STATUS -> F1 (TYPE) -> FL-NET -> F3 (OTHER) -> 5 SAFETY). This screen can be opened when the Safety function by FL-net is installed. This screen is read-only. This screen is not a part of safety functions, and the output of this screen is non-safe.
If IDnum. of node x is set as n, ID x to ID x + n - 1 is used by node x.

```
STATUS FL-NET
 SAFETY FUNCTION BY FL-NET PAGE1

  1 ALARM INFORMATION
       SAFETY FUNCTION BY FL-net ERROR
       (MAIN/COMM.)
                                    MAIN COMM.
  2 PARAM TRANS COMPLETE      :     1    1
  3 FL-net SAFETY START       :     1    1
  4 FL-net PARAM ERROR        :     0    0
  5 FL-net START TIMEUP       :     0    0
  6 SEND ERR ID               :    02   02
  7 DETECT ERR ID             :    21   21

  [ TYPE ]    PAGE2    [OTHER ]
```

Table9.2.6 (a) The items in the SAFETY FUNCTION BY FL-NET PAGE1 screen.

Item	Description
ALARM INFORMATION	NO ALARM : Alarm doesn't happen. SAFETY FUNCTION BY FL-net ERROR: Error happened.
PARAM TRANS COMPLETE	When the power is turned on, the parameters related to the Safety function by FL-net are transferred from FROM to DRAM. After completion of transfer, the value is changed from 0 to 1.
FL-net SAFETY START	On mode 1, when all nodes that use the Safety function by FL-net participate in the network after the power is turned on, the FL-net safety checking function starts operation. At this time, this value changes from 0 to 1. On mode 2 and 3, this parameter is always 1.
FL-net PARAM ERROR	When the value of a parameter related to the Safety function by FL-net is abnormal, the value changes from 0 to 1.
FL-net START TIMEUP	On mode 1, when the time set in the safety parameter (Start timer after power ON) has elapsed, the FL-net safety checking function starts operation, regardless of whether all nodes are participating in the network. At this time, the value changes from 0 to 1.
SEND ERR ID	The ID number that sent the error is displayed in two digits. "--" is displayed when it is normal.
DETECT ERR ID	The ID number that detected the error is displayed in two digits. "--" is displayed when it is normal.

You can change pages between PAGE1 and PAGE2 by F2 key.

In the following screen ID with * is my ID.

```
STATUS FL-NET
 SAFETY FUNCTION BY FL-NET PAGE2  1/30

        MAIN          COMM
 ID  EI UMSITRCP  EI UMSITRCP P:PARAM
*01  00 00000000  00 00000000 C:CROSS
*02  00 00000000  00 00000000 R:CORRUPT
*03  00 00000000  00 00000000 T:COUNTER
 04  00 00000000  00 00000000 I:ID NUM
 05  00 00000000  00 00000000 S:SYS BIT
 06  00 00000000  00 00000000 M:RAM CHK
 07  00 00000000  00 00000000 U:CPU CHK
 08  00 00000000  00 00000000 EI:ERR ID
 09  00 00000000  00 00000000
 10  00 00000000  00 00000000
                :
 30  00 00000000  00 00000000

[ TYPE ]  PAGE1  [OTHER ]
```

Table9.2.6 (b) The meaning of EI

EI	Description
00	No error is detected.
nn	ID xx detected the alarm at the received data from node nn. (On the screen of the id xx, nn is displayed as 00.)

Table9.2.6 (c) The descriptions of errors.

Symbol	Name	Description
P	Parameter error	The safety parameters of Safety function by FL-net are periodically checked. If parameter error is detected, this error bit is set to 1.
C	Cross-check error	The receiving node cross-checks dual safety data. If a mismatch lasts longer than the period of time set in safety parameter (Timer for receive data), this error bit is set to 1.
R	Corruption error	When the safety signal is transmitted to other nodes, the Safety function by FL-net forwards the CRC calculated from safety data together. The receiving node calculates the CRC from the safety data and collates it with received CRC. When abnormality is found, this error bit is set to 1.
T	Counter error	Data transferred to another node by the Safety function by FL-net includes the value of a counter that counts up at certain intervals. The receiving node monitors the value of the counter. If the value of the counter does not change during the period of time set in the safety parameter (Timer for receive data), this error bit is set to 1.
I	ID number error	When transferring safety data to another node, the Safety function by FL-net transfers the local node number together with the safety signal data. The receiving node checks the node number. If an error is detected, this error bit is set to 1.
S	System bit error	8^{th} safety signal of the FL-net safety DO data (FSO) in each ID is used by the system. If this bit is set to ON inadvertently, this error bit is set to 1.
M	RAM check error	If an error is detected in the RAM area, when the Safety function checks the RAM area related to the safety function, this error bit is set to 1. Other error is detected by the safety function, this error bit is set to 1.
U	CPU Self check error	The Safety function performs the CPU self test. If this test shows an abnormality, this error bit is set to 1.

9.3 BACKUP/RESTORE OF SAFETY FUNCTION BY FL-NET

Settings for Safety function by FL-net are included within the following system files.

- SYSFLSF.SV – this file includes the settings in Safety function by FL-net screen.
- FLNET.SV – this file includes the setting of the FL-net.
- DCSIOC.SV – this file includes the Safety I/O Connect configuration

These files are included under “All of above” and “System Files”. These are found on the Backup function key in File Menu.

These files can only be restored at CTRL start.

Please see section 1.5 on backup/restore for more information.

10 SAFETY PMC FUNCTION

Safety PMC function (A05B-2600-J764) is the function to control the sequence of safe I/O by executing sequence program of ladder language.

To use Safety PMC function, "Integrated PMC function (A05B-2600-J760)" option and "Safety PMC function (A05B-2600-J764)" option are needed.

PMC display menu on teach pendant can display ladder diagram and the sequence program can be changed on teach pendant if "PMC change mode(A05B-2600-R652)" is ordered.

To create Safety PMC sequence program, FANUC LADDER-III for Robot is needed.

To use safety PMC function in R-30*i*B Mate controller, the main board that has PMC function is necessary.

10.1 OVERVIEW

Safety PMC function can process the Safe I/O instead of Safe I/O connect function.
The following is the feature of Safety PMC function comparison with Safe I/O connect function.

- Sequence program of ladder language is used.
- Maximum 3000 steps sequence program can be executed.
- The 1st level and the 2nd level sequence programs are executed. The 1st level sequence program is executed every 2ms, but the maximum size is 180 steps. The scan time of 2nd level sequence program is increased according to the size of the sequence program. As the same as Integrated PMC function, the 2nd level sequence program uses the 2nd level synchronous input memory for X and F address.
- Fixed timer (TMRB/TMRBF) and Rising/Falling edge detection (DIFU/DIFD) are available.
- The 1500 bytes internal relay (R0 - R1499) is available.

Only one sequence program is used for Safety PMC, because the Safety PMC function executes the sequence program as dual channel process internally.

To use Safety PMC function, set "Safe I/O process" item to "Safety PMC" in DCS Safe I/O device menu. By this setting, Safe I/O connect function is disabled.
To disable Safety PMC, set "Safe I/O process" item to "I/O connect" in DCS Safe I/O device menu.

The specification of the sequence program and the operation of DCS PMC function are common with Integrated PMC function. This manual describes only the different part from Integrated PMC function. Please refer to " FANUC Robot Series R-30*i*B Controller Integrated PMC OPERATOR'S MANUAL" (B-83254EN) about the common part with Integrated PMC function.

The following is the significant differences of Safety PMC function from Integrated PMC function.

- Safety PMC function is the safety function as Category 4, PL e, SIL 3.
- Safety PMC function can output to Safe I/O.
- The available signals of Safety PMC program is only Safe I/O and internal relay(R). Safety PMC function cannot use the normal I/O such as DI/DO.
- The meaning of PMC address of Safety PMC is fixed. PMC external assignment and PMC internal assignment are not available.
- Basic instructions that require the extended PMC ladder instruction function are not available.

- The available functional instructions are only Fixed timer (TMRB/TMRBF) and Rising/Falling edge detection (DIFU/DIFD).
- Nonvolatile memory is not available.
- The 3rd level sequence program is not available.
- Override function is not available.
- To change Safety PMC program, apply to DCS parameter is needed.
- The execution of Safety PMC program cannot be stopped.

⚠WARNING
If Safety PMC program is incorrect, the safety function will not work, and serious personal injury could result. When Safety PMC program is changed, the Safety PMC program must be verified and the all functions of the Safety PMC program must be tested.

⚠WARNING
If Safety PMC feature is used, safety signal status that is output by the Level 1 sequence program could be delayed by a maximum of 2ms. And safety signal status that is output by the Level 2 sequence program could be delayed by a maximum of the execution period of Level 2. The execution period of Level 2 is displayed in DCS Safety PMC menu. In this case, a risk assessment for the whole robot system is necessary, including the additional signal status delay.

⚠WARNING
If the safety output signals such as SPO, CSO, FSO or SLO is used, the robot system should be designed as that the robot system becomes Safe (Stop) State when these safety output signals are OFF. These safety output signals are forced to OFF when internal fault is detected in robot controller.
If the robot system does not become Safe State when these safety output signals are OFF, the safety function will not work, and serious personal injury could result.

10.2 BASIC SPECIFICATION

Function	Safety PMC
Programming language	Ladder
Number of ladder levels	2
Level 1 execution period	2ms
Processing power - Basic instruction processing speed	 500 ns/step
Program capacity - Ladder - Symbol & Comment - Message	 Up to about 3000 steps (1st level is 180 steps) At least 1KB At least 8KB
Instructions - Basic instructions - Functional instructions	 14 6
Internal I/O interface - Inputs (F) - Outputs (G)	 768 bytes 768 bytes
External I/O interface - Inputs (X) - Outputs (Y)	 128 bytes 128 bytes

Function	Safety PMC
Symbol & Comment	
- Number of symbol characters	40
- Number of comment characters	255
Program storage area (Flash ROM)	128KB
PMC Memory	
- Internal relay (R)	1500 bytes
- System Relay (R9000)	(None)
- Extra relay (E)	(None)
- Message display (A)	
Display requests	(None)
Status displays	(None)
Nonvolatile memory	
- Timer (T)	
Variable timer	(None)
Variable timer precision	(None)
- Counter (C)	
Variable counter	(None)
Fixed counter	(None)
- Keep relay (K)	
User area	(None)
System area	(None)
- Data table (D)	(None)
- Step sequence	
Step number (S)	(None)
Functional instructions	
- Variable timers (TMR)	(None)
- Fixed timers (TMRB/TMRBF)	100 pieces
- Variable counters (CTR)	(None)
- Fixed counters (CTRB)	(None)
- Rising/Falling edge detection (DIFU/DIFD)	256 pieces
- Labels (LBL)	(None)
- Subprograms (SP)	(None)

10.3 PMC ADDRESSES

The available addresses in Safety PMC sequence program are the following. Safe I/O is assigned to X, Y, F and G area. This assignment cannot be changed. The addresses that are not specified in this table are not available in Safety PMC sequence program. The name of Safe I/O assigned to each address is displayed in Bit menu of PMC menu.

Letter	Type of signal	Address range	Corresponded Safe I/O
X	Input to Safety PMC	X0.0 - X7.7	SPI[1-64]
		X40.0 - X47.7	CSI[1-64]
		X60.0 - X67.7	SLI[1-64]
		X80.0 - X113.7	FSI[1-272]
Y	Output from Safety PMC	Y0.0 - Y7.7	SPO[1-64]
		Y40.0 - Y47.7	CSO[1-64]
		Y60.0 - Y67.7	SLO[1-64]
		Y80.0 – Y89.7	FSO[1-80]

Letter	Type of signal	Address range	Corresponded Safe I/O
F	Input to Safety PMC	F0.0 - F1.2	SSI[1-11]
		F40.0 - F40.3	CCL[1-4]
		F60.0 - F60.3	RPI[1-4]
		F80.0 - F83.7	NSI[1-32]
		F100.0 - F103.7	CPC[1-32]
		F120.0 - F121.7	CSC[1-16]
		F140.0 - F144.7	JPC[1-40]
		F160.0 - F164.7	JSC[1-40]
G	Output from Safety PMC	G0.0 - G0.6	SSO[1-7]
		G40.0 - G40.3	CCR[1-4]
		G60.0 - G60.3	RPO[1-4]
		G80.0 - G87.7	SIR[1-64]
R	Internal relay	R0.0 - R1499.7	

In PMC menu and FANUC LADDER-III for Robot, the following addresses are available. Some addresses that are not available for Safety PMC sequence program are also available because of the compatibility with Integrated PMC function.

Address	PMC menu and FANUC LADDER-III for Robot
X0 - X128	Read only.
Y0 - Y128	Read only.
F0 - F767	Read only.
G0 - G767	Read only.
R0 - R1499	Read only.
R9000 - R9499	Read only.
A0 - A249	Read only.
A9000 - A9249	Read only.
T0 - T79	Read only.
T9000 - T9079	Read only.
C0 - C79	Read only.
C9000 - C9039	Read only.
K0 - K19	Read only.
K900 - K999	K900.0, K900.1, K900.4 and K900.7 can be changed. The other address are read only.
D0 - D2999	Read only.

10.4 BASIC INSTRUCTIONS

The following is the available functional instructions for Safety PMC program.
The instructions that require the extended PMC ladder instruction function are not available.
The specification of each instruction is the same as Integrated PMC.

Instruction name	Required memory size
RD	4 bytes
RD.NOT	4 bytes
WRT	4 bytes
WRT.NOT	4 bytes
AND	4 bytes
AND.NOT	4 bytes
OR	4 bytes
OR.NOT	4 bytes
RD.STK	4 bytes
RD.NOT.STK	4 bytes

Instruction name	Required memory size
AND.STK	4 bytes
OR.STK	4 bytes
SET	4 bytes
RST	4 bytes

10.5 FUNCTIONAL INSTRUCTIONS

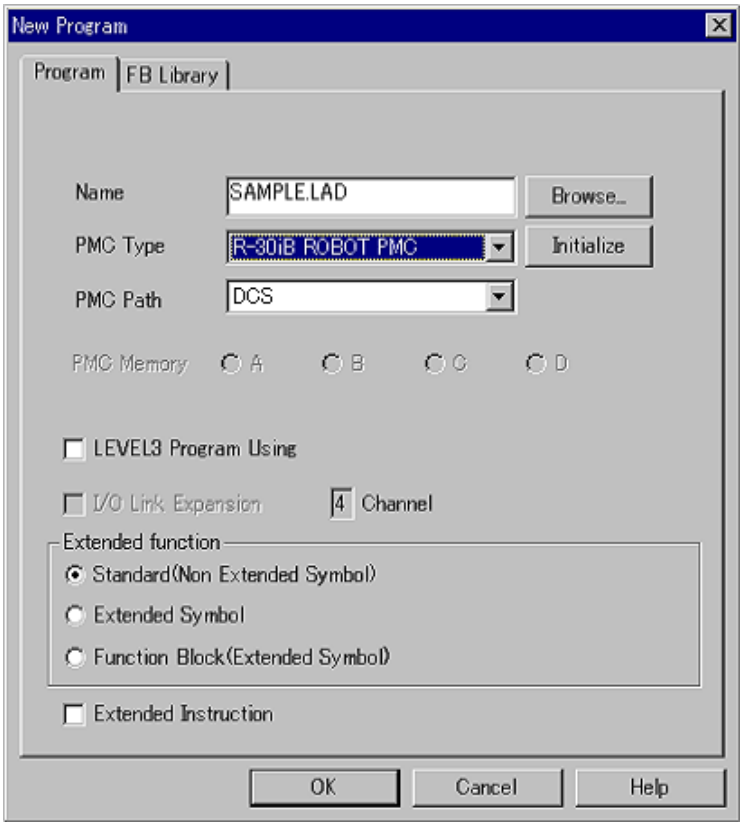
The following is the available functional instructions for Safety PMC program.
The specification of each instruction is the same as Integrated PMC.

Instruction name	SUB No.	Processing	Required memory size (byte)
TMRB	24	Fixed on-delay timer	12
TMRBF	77	Fixed off-delay timer	12
DIFU	57	Rising-edge detection	8
DIFD	58	Falling-edge detection	8
END1	1	End of first-level program	4
END2	2	End of second-level program	4

10.6 FANUC LADDER-III FOR ROBOT PROGRAMMING

Sequence program of Safety PMC is created by FANUC LADDER-III for Robot. The operation to create the sequence program is the same as Integrated PMC function, but the following is different.

- Set "PMC type" to "R-30iB ROBOT PMC".
- Set "PMC path" to "DCS".
- Remove the check of "LEVEL 3 program using".
- Remove the check of "Extended Instruction".



The operation to edit, transfer and so on is the same as Integrated PMC function, but the following are different.

- Run/Stop of Safety PMC program cannot be controlled. To execute the new transferred Safety PMC program, please apply to DCS parameter.
- When the new Safety PMC program is transferred from FANUC LADDER-III for Robot and the Safety PMC program is not written to F-ROM (Back Up is not done), the Safety PMC program is written to F-ROM automatically by apply to DCS parameter.
- The file name of Safety PMC program is LADDERS.PMC for store and load.
- In signal status screen, the data can be displayed, but the data cannot be changed.
- In PMC setting parameters screen, only "HIDE PMC PROGRAM" (K900.0), "PROGRAMMER ENABLE" (K900.1), "RAM WRITE ENABLE" (K900.4) and "HIDE DATA TBL CNTL SCREEN" (K900.7) can be changed. The other items cannot be changed.

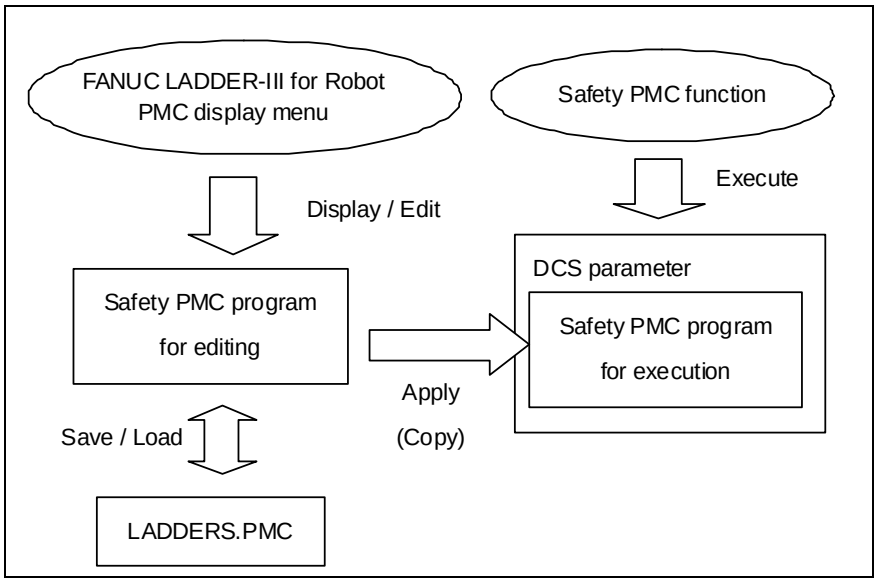
10.7 TEACH PENDANT OPERATION

The teach pendant operation for Safety PMC function is the same as Integrated PMC function, but the following is different.

- To select Safety PMC path in PMC menu, enter 0 in "Change Path" of F3[FUNC] menu in PMC menu. When Safety PMC path is selected, "PMCS" is displayed in the title line of PMC menu.
- When Safety PMC path is selected in PMC menu, the execution status is displayed in title line. When "Safe I/O process" item in DCS Safe I/O device menu is "Safety PMC", "<RUNNING>" is displayed as the execution status. When "I/O connect" is selected, "<STOP>" is displayed.
- When Safety PMC path is selected in PMC menu, "Run/Stop PMC" in F3[FUNC] of PMC menu is not available.
- To execute the changed Safety PMC program, please apply to DCS parameter.
- The sequence program of Safety PMC path is saved/loaded as LADDERS.PMC. The parameter of Safety PMC path is saved/loaded as PARAMS.PMC.
- When Safety PMC path is selected in PMC menu, the data can be displayed but cannot be changed in Bit menu and Byte menu.
- When Safety PMC path is selected in PMC menu, only "Forbid program disp. K900.0", "Use Programmer K900.1", "Change address value K900.4" and "Protect data tbl ctl K900.7" can be changed in Parameter menu. The other items cannot be changed.
- In PMC setting menu, there is no setting item about Safety PMC path.

10.8 SAFETY PMC EXECUTION (APPLY TO DCS PARAMETER)

To execute Safety PMC program, apply to DCS parameter is needed. Please refer to "1.3APPLY TO DCS PARAMETER" about the operation of apply to DCS parameter.



The sequence program of Safety PMC function can be displayed/edited by FANUC LADDER-III for Robot or PMC menu as the same as the sequence program of Integrated PMC function. At this time, the Safety PMC program for editing is displayed/edited.
The Safety PMC program for execution in DCS parameter is executed by Safety PMC function.
By apply to DCS parameter, the Safety PMC program for editing is copied to the Safety PMC program for execution in DCS parameter, and the Safety PMC program for execution is executed after cycle power of the robot controller.
When the Safety PMC program uses invalid instruction or invalid address, the Safety PMC program cannot be applied to DCS parameter. In this case, please check the occurred warnings in alarm history menu, and correct the Safety PMC program.

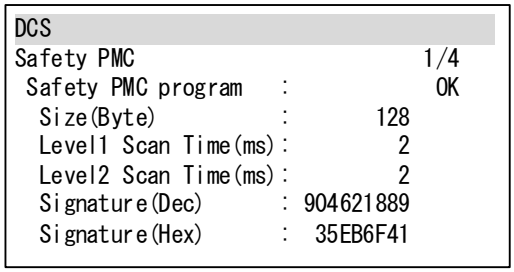
When the Safety PMC program for editing and the Safety PMC program for execution are different, "SYST-212 Need to apply to DCS param" occurs. This alarm cannot be reset until the "Apply to DCS parameter" procedure is done. In this case, the Safety DCS program displayed in PMC display menu or FANUC LADDER-III for Robot is the Safety PMC program for editing, and it is different from the executing Safety PMC program.

When Safety PMC program is changed and applied to DCS parameter, the Safety PMC program must be verified and the all functions of the Safety PMC program must be tested.

> **⚠WARNING**
> If Safety PMC program is incorrect, the safety function will not work, and serious personal injury could result. When Safety PMC program is changed, the Safety PMC program must be verified and the all functions of the Safety PMC program must be tested.

10.9 DCS SAFETY PMC MENU

The DCS Safety PMC menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "Safety PMC" item in the DCS Top menu.
In this menu, status, size, scan time and signature of the Safety PMC program is displayed.



Items in DCS Safety PMC menu

Item	Description
Safety PMC program	The status of Safety PMC program is displayed. OK: The Safety PMC program for editing and the Safety PMC program for execution are the same. CHGD: The Safety PMC program for editing is changed, but not applied to the Safety PMC program for execution in DCS parameter. PEND: The Safety PMC program for editing is changed and applied to the Safety PMC program for execution in DCS parameter, but controller power has not been cycled.
Size(Byte)	Size of the Safety PMC program for editing.
Level1 Scan Time(ms)	Scan Time of Level1.
Level2 Scan Time(ms)	Scan Time of Level2.
Signature(Dec)	Signature of the Safety PMC program for editing as decimal value.
Signature(Hex)	Size of the Safety PMC program for editing as hexadecimal value.

Operation in DCS Safety PMC menu

Operation	Description
PREV	The DCS Top menu is displayed.

11 AUXILIARY AXIS SERVO OFF (LOCAL STOP) FUNCTION

Auxiliary axis servo off (local stop) function (A05B-2600-J806) is the function to prevent the unexpected motion of auxiliary axis by cutting off the servo power of the auxiliary axis.

This function needs the special hardware.

This manual describes the operation of DCS local stop menu.
Please refer to "R-30*i*B Local Stop function with STO Maintenance and Order Manual" (A-95028E) about the hardware of Auxiliary axis servo off (local stop) function and the setting value of DCS local stop menu according to the hardware configuration.
Please refer to chapter "AUXILIARY AXIS SERVO OFF (LOCAL STOP) FUNCTION" in "FANUC Robot Series R-30*i*B CONTROLLER Option Function OPERATOR'S MANUAL" (B-83284EN-2) about the software except DCS local stop menu.

Maximum 8 local stop can be defined in DCS local stop menu. The following items should be setup for each local stop.

STO-OUT
: Set the safety output signal that commands auxiliary axis servo off. The signal is OFF when auxiliary axis servo off is requested. Set the index of SPO. When the index is set to 0, this local stop is disabled.

STO-FB
: Set the input signal to monitor the auxiliary axis servo off status. This signal is ON when auxiliary axis servo is off. The monitoring signal is single channel input, and one channel of the dual channel safety input (SFDI) is used. Set the channel to use as -1 or -2.
The SPI that is used for STO-FB cannot be used for the other safety functions such as Safe I/O connect, Safety PMC and Position/Speed check function. And the status of the SPI is always OFF in Safe I/O status menu and so on.

Fence
: Set the safety input signal that connected to the safety device that detects an operator is in the working space near the auxiliary axis such as light curtain. Set the Safe I/O type and index. Normally SPI is used as Safe I/O type, but the other Safe I/O type can be used.

The following alarm occurs according to the status of these signals.

When auxiliary axis is not servo off and the Safe I/O of Fence is OFF, the alarm "SRVO-446 DCS LS Fence open" occurs and the servo power of all axes are turned off.
When auxiliary axis is servo off, the alarm does not occur even though the Safe I/O of Fence is OFF.

The stop type of the alarm "SRVO-446 DCS LS Fence open" is selected as "Power-of stop" or "Controlled stop". And the alarm can be ignored in T1/T2 mode by setting.

When STO-OUT is turned OFF, the auxiliary axis servo off is commended, then STO-FB is turned ON when the auxiliary axis servo is turned OFF. The alarm "SRVO-447 DCS LS STO-FB alarm" occurs when STO-FB is not turned ON for 1 second or more.

When STO-OUT is turned ON, the auxiliary axis servo on is commended, then STO-FB is turned OFF when the auxiliary axis servo is turned ON. The alarm "SRVO-447 DCS LS STO-FB alarm" occurs when STO-FB is not turned OFF for 1 second or more.

When the alarm "SRVO-447 DCS LS STO-FB alarm" occurs, please check the hardware connection and the setting of DCS local stop menu. The this alarm occurs, all safety outputs are turned OFF.

> **⚠WARNING**
> At the initial start-up, the operation check and validation of the wiring for safety signals should be carried out, and then the wiring should be protected by the cable duct.

> **⚠WARNING**
> If local stop setting is set incorrectly, the safety function will not work, and serious personal injury could result. When local stop settings are changed, the values must be verified and the function must be tested again.

11.1 DCS LOCAL STOP MENU

The DCS local stop menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "Local stop setup" item in the DCS Top menu.

```
DCS
Local Stop                              1/10
  Stop Type : Controlled stop            OK
  Fence in T1/T2 mode : ENABLE           OK
No.  STO-OUT    STO-FB      Fence     Status
1  @SPO[  1]  SPI[  2]-1 @SPI[  1]   OK
2   SPO[  0]  SPI[  0]-1  SPI[  0]   OK
3   SPO[  0]  SPI[  0]-1  SPI[  0]   OK
4   SPO[  0]  SPI[  0]-1  SPI[  0]   OK
5   SPO[  0]  SPI[  0]-1  SPI[  0]   OK
6   SPO[  0]  SPI[  0]-1  SPI[  0]   OK
7   SPO[  0]  SPI[  0]-1  SPI[  0]   OK
8   SPO[  0]  SPI[  0]-1  SPI[  0]   OK

[ TYPE ]                               UNDO
```

Items in DCS Local stop menu

Item	Description
Stop type	Used to select the stop type to be performed when the Safe I/O of Fence is OFF in case of the auxiliary axis is not servo off. Power-off stop: Motor power is shut down immediately. Control stop: Deceleration stop, then motor power is shut down. (Motor power shutdown is delayed for a maximum of 2 seconds.)
Fence in T1/T2 mode	ENABLE: The alarm occurs regardless of mode when the Safe I/O of Fence is OFF in case of the auxiliary axis is not servo off. DISABLE: The alarm always occurs in AUTO mode when the Safe I/O of Fence is OFF in case of the auxiliary axis is not servo off, but the alarm does not occur in T1 nor T2 mode.
STO-OUT	Set the safety output signal that commands auxiliary axis servo off. The signal is OFF when auxiliary axis servo off is requested. When the specified Safe I/O is ON, "@" is displayed on the left side of the Safe I/O name.

Item	Description
STO-FB	Set the input signal to monitor the auxiliary axis servo off status. This signal is ON when auxiliary axis servo is off. The monitoring signal is single channel input, and one channel of the dual channel safety input (SFDI) is used. Set the channel to use as -1 or -2. When the specified Safe I/O is ON, "@" is displayed on the left side of the Safe I/O name.
Fence	Set the safety input signal that connected to the safety device that detects an operator is in the working space near the auxiliary axis such as light curtain. When the specified Safe I/O is ON, "@" is displayed on the left side of the Safe I/O name.
Status	The status of each line is displayed. OK: Setting parameter and DCS parameter are the same. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.

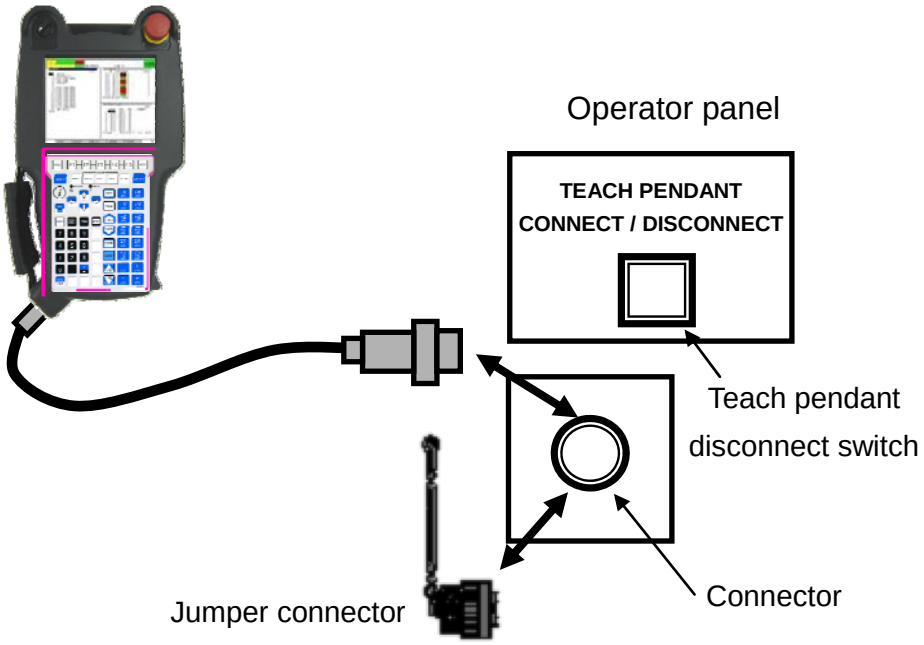
Operation in DCS Local stop menu

Operation	Description
F5(UNDO)	UNDO the items in this menu. The setting parameters become the same as the current DCS parameters.
PREV	The DCS Top menu is displayed.

12 TEACH PENDANT HOT SWAP

Teach pendant hot swap function (A05B-2600-J647) allows to connect / disconnect teach pendant without Emergency Stop alarm. Existing Teach pendant disconnect (with E-stop) function causes Emergency stop when teach pendant is connected or disconnected.

⚠CAUTION
- A special hardware for hot swap function is needed to use this function. An alarm occurs when the hardware is not used.
- This function uses safety I/O SFDI1 and SFDI2 on the emergency stop board. These safety I/O cannot be used for other functions or purposes.
- This function cannot be used on R-30iB Mate controller.
- This option is not needed to user the existing Teach Pendant Disconnect function (with E-stop). Do not order this option to use it.



Disconnect Teach pendant

- Select AUTO mode.
- Press Teach pendant disconnect switch (hold the switch during the disconnect operation). The power of the teach pendant is turned off, and the LED on the Teach pendant disconnect switch starts blinking.
- Disconnect the teach pendant while the LED is blinking.
- Connect the jumper connector, and release the teach pendant disconnect switch. The LED on the teach pendant disconnect switch is turned off.

Connect Teach pendant

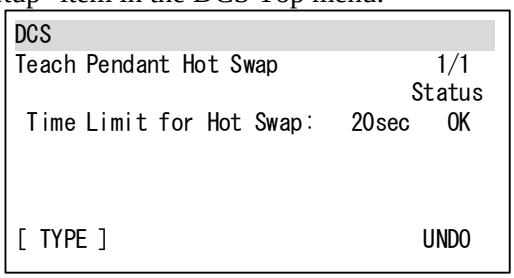
- Select AUTO mode.
- Release the Emergency stop bottom on the teach pendant.
- Press Teach pendant disconnect switch (hold the switch during the connect operation). The LED on the Teach pendant disconnect switch starts blinking.
- Disconnect the jumper connector.

- Connect the teach pendant, then the LED on the teach pendant disconnect switch is turned off. Release the teach pendant disconnect switch, then the power of the teach pendant is turned on, and the communication is started.

⚠CAUTION
- Connect / disconnect teach pendant in AUTO mode. If the teach pendant is disconnected in T1/T2 mode, Emergency stop occurs.
- Complete the connect / disconnect operation within the time limit (default: 20 seconds). When the time limit is passed, the LED of the tech pendant disconnect switch is turned off. If the teach pendant is disconnected after the time limit, Emergency stop occurs.
- While the teach pendant is connected, the Emergency stop button on the teach pendant is active.
- Connect jumper connector when teach pendant is not connected. If the jumper connector is not connected, Emergency stop occurs. The jumper connecter is equipped on the operator panel.
- When teach pendant is connected / disconnected without pushing disconnect switch, chain alarm of SFDI1 could occur. Connect / disconnect teach pendant with pushing the switch.
- When teach pendant is connected/ disconnected in T1/T2 mode, chain alarm of SFDI1 could occur. Connect / disconnect teach pendant in AUTO mode.

12.1 DCS TEACH PENDANT HOT SWAP MENU

The DCS Teach Pendant Hot Swap menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "Local stop setup" item in the DCS Top menu.



Items in DCS Teach Pendant Hot Swap menu

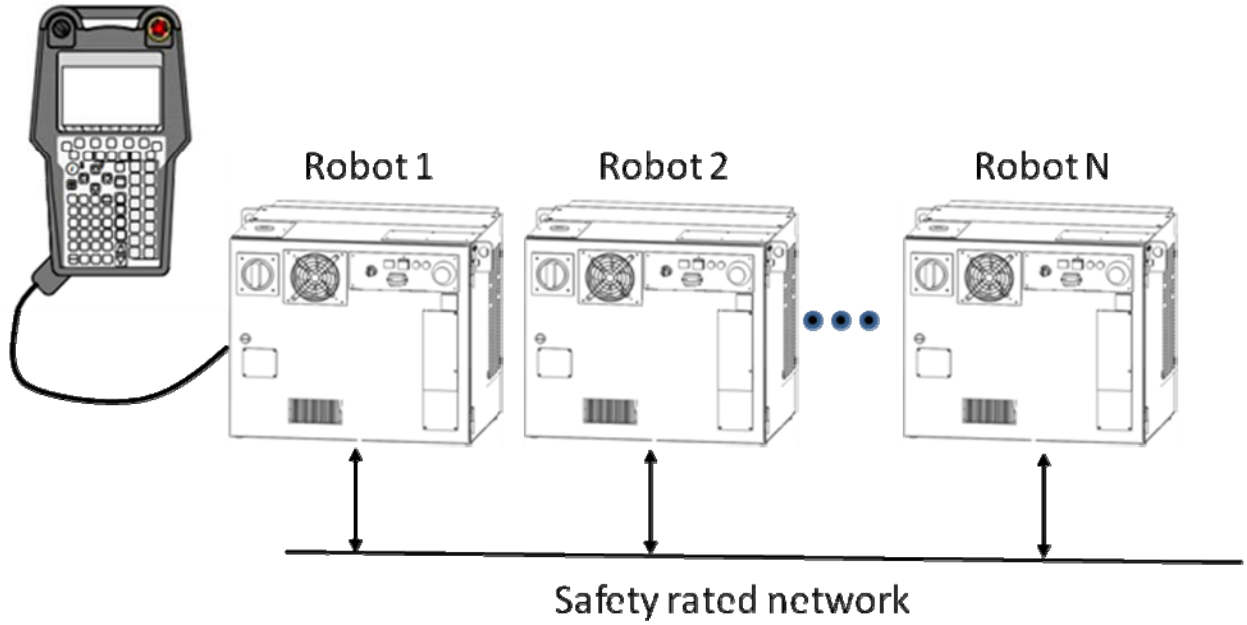
Item	Description
Time Limit for Hot Swap	Time limit of Teach pendant hot swap operation from the Teach pendant disconnect switch is pressed. When the specified time is passed, the LED of the Teach pendant disconnect switch is turned off, and Emergency stop occurs when the Teach pendant is disconnected. The range is 0 - 60 seconds. Default is 20 seconds.
Status	The status of each line is displayed. OK: Setting parameter and DCS parameter are the same. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.

Operation in DCS Teach Pendant Hot Swap menu

Operation	Description
F5(UNDO)	UNDO the items in this menu. The setting parameters become the same as the current DCS parameters.
PREV	The DCS Top menu is displayed.

13 SHARED TEACH PENDANT

The Shared Teach Pendant option (A05B-2600-R844) provides the capability use a single pendant among multiple robot controllers connected via Ethernet without having to change where it is physically attached. You select and log in to a controller, then operate the teach pendant as if it was physically attached to that controller.
The robot controllers are interconnected via Ethernet and configured as a shared Teach Pendant group. Shared Teach Pendant group is defined in all controllers. Up to 16 controllers can be included in a shared Teach Pendant group.



The Shared Teach Pendant option (A05B-2600-R844) is required. It includes the following other robot software options:

- DCS Safe I/O connect (J568)
- FL-net interface (J759)
- Internet Conn/Custo (R558)
- Safety func by FL-net (J586)

> **⚠CAUTION**
> A Teach Pendant disconnect hardware is needed to use this function.

Status of emergency stop, deadman switch and mode are sent and shared in Shared Teach Pendant group via Safety function by FL-net. Each controller handles them and inhibits to operate robot depending on these status.

Emergency Stop

Emergency stop are shared in the Shared Teach Pendant group. Teach Pendant emergency stop, Operator Panel emergency stop and External emergency stop effect to all controllers in the group. Emergency stop occurs in all controllers in the group when Emergency stop occurs in either controller in the group. When Emergency stop occurs by a factor of other controllers in the shared Teach Pendant group, “SRVO-422 Shared TP E-stop” occurs.

Mode

Mode is notified to all controllers in Shared Teach Pendant group. Robot operation is inhibited in following case.

- To start production running in Auto mode, modes of all controllers in the Shared Teach Pendant group must be Auto. “SRVO-423 Shared TP: Disconnected state” occurs when any other controllers is not AUTO.
- A robot on T1 mode cannot move if there is T2 mode controller in the Shared Teach Pendant group. “SRVO-424 Shared TP: Mode mismatch” occurs. To move a robot in T1 mode, the modes of other controllers in the group have to be T1 or AUTO.
- A robot on T2 mode cannot move if there is T1 mode controller in the Shared Teach Pendant group. “SRVO-424 Shared TP: Mode mismatch” occurs. To move a robot in T2 mode, the modes of other controllers in the group have to be T2 or AUTO.

Deadman Switch

The Teach Pendant Deadman switch applies to all robot controllers in Shared Teach Pendant group. When Deadman switches are griped in controllers in the group, Deadman switch status in other all controllers is also change to griped status even if Teach Pendant is not wired.

Connection of Teach Pendant

If more than one Teach Pendant in the shared Teach Pendant group are wired, the alarm “SYST-311 Shared TP: Multiple TP connection” is raised on all controllers prohibiting any motion. Please disconnect extra Teach Pendant to reset the alarm.

⚠WARNING
Confirm that operated robot is certainly selected by Teach pendant.
Ensure that you are able to view all robots in Shared Teach Pendant group, and that there are no personnel and obstructions when you start operating a robot.
Otherwise, you could injure personnel or damage equipment.

⚠CAUTION
The system designer is responsible for designing the robot system to comply with the requirement of the control of multiple robots in ISO 10218.

13.1 CONFIGURATION

The robots need to be connected via Ethernet. If the Shared Teach Pendant group contains only two robot controllers, then a direct cable can be used between the two ports. When the shared Teach Pendant group contains more than two robots, a high quality Ethernet switch must be used.

The emergency stop status is shared with all controllers in the Shared Teach Pendant group via the Safety function by FL-net. The external emergency stop signal must be wired to all controllers in the group. When some controllers are power down temporary while system-up, these controllers have to be removed from the Shared Teach Pendant group. External E-stop signals that wired to removed controllers do not work for controllers in other Shared Teach Pendant group then.

Fence signal is not shred by Shared Teach Pendant function. The fence signal must be wired to all controllers in the group.

⚠WARNING
When external emergency stop signal and fence signal is not wired to all controllers in the Shared Teach Pendant group, external emergency stop and fence will not work, and serious personal injury could result. When system is set up, external E-stop signal and fence signal must be tested to ensure works in all cases.

You can configure the Shared Teach Pendant option to turn on a digital output when the Teach Pendant is logged into it. Connecting this output to a beacon on the robot arm will help to identify the robot that is being controlled.

> **⚠CAUTION**
> When a single teach pendant controls two or more robots, an indication, clearly visible from within the safeguarded space, shall be provided of those robot(s) that have been activated. For this purpose, the digital output signal that is turned on when the Teach Pendant is logged into this controller can be used to comply with the requirements of Clause 5.9.2 of EN ISO 10218-1.

Following settings are needed to use Shared Teach Pendant function.

- Assignment IP address
- Configuration for Shared Teach Pendant group and RIPE
- Configuration to connect via Safety function by FL-net
- Configuration of Safety Shared Teach Pendant group for DCS safety function and assignment of FL-net ID.

To setup Shared Teach Pendant, Teach Pendants that wired each controller are needed. Please wire Teach Pendant to controller directly to setup it.

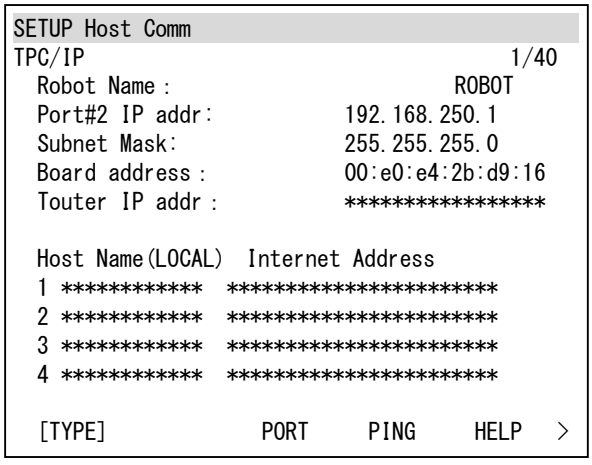
13.1.1 ASSIGNMENT OF IP ADDRESS

All robots must be assigned an IP Address and be active on the Ethernet network. We recommend using Ethernet port 2 for the shared Teach Pendant group and FL-net, and dedicate it to the Shared Teach Pendant function.
The Safety function by FL-net uses host address, the last number of the IP address, as the node number. If possible, assign IP addresses sequentially from XXX.XXX.XXX.1 to reduce complexity. They must be used IP address in class C.

Procedure 13-1 Assign IP Address

Steps

1. Press ‘MENU’.
2. Move the cursor to ‘SETUP’, and select ‘HOST COMM’ from the fly-out menus.
3. Move the cursor to ‘TCP/IP’, then press F3 ‘DETAIL’. TCP/IP detail screen is displayed.
4. Press F3 ‘PORT’ to select the port being assigned.
5. Specify the IP address. Only an IP address in class C can be specified for FL-net function.
6. Enter 255.255.255.0 as the subnet mask.



13.1.2 CONFIGURATION OF SHARED TEACH PENDANT GROUP

You have to also create a text file named ROSIPCFG.XML to be loaded on all controllers in Shared Teach Pendant group. This file identifies all the controllers that are in the shared Teach Pendant group. Below is an example of the contents of a ROSIPCFG.XML file that defines a Shared Teach Pendant group containing four controllers. We recommend using this example, modifying the count and <MEMBER/> elements to match your configuration.

Example: ROSIPCFG.XML

```
<?xml version="1.0"?>
<ROSIPCFG>

   <ROBOTRING count="4" timeslot="400">
      <MEMBER name="RC_1" ipadd="192.168.250.1"/>
      <MEMBER name="RC_2" ipadd="192.168.250.2"/>
      <MEMBER name="RC_3" ipadd="192.168.250.3"/>
      <MEMBER name="RC_4" ipadd="192.168.250.4"/>
   </ROBOTRING>

   <IPENDANTRING count="4">
      <MEMBER name="RC_1" ipadd="192.168.250.1" focusbg="128"
       port_type="2" port_num ="30"/>
      <MEMBER name="RC_2" ipadd="192.168.250.2" focusbg="32768"
       port_type="2" port_num ="30"/>
      <MEMBER name="RC_3" ipadd="192.168.250.3" focusbg="8388736"
       port_type="2" port_num ="30"/>
      <MEMBER name="RC_4" ipadd="192.168.250.4" focusbg="14423100"
       port_type="2" port_num ="30"/>
  </IPENDANTRING>

</ROSIPCFG>
```

The ROBOTRING element provides information to the ROS Interface Packets over Ethernet (RIPE) feature. RIPE is used by the Shard Teach Pendant feature for maintaining network status and sharing information between controllers. MEMBER tag is used to define each controller. The attribute name must be lower case. Its numeric value must be enclosed within quotes.

Items of ROBOTRING tag

Item	Description
count	This is the number controller that is the RIPE network. This must always equal the number of MEMBER elements enclosed within the ROBOTRING element.
timeslot	This controls how often the system polls a robot to see if it is still on line. This is typically in the range of 100 to 400ms.

Items of MEMBER tag for ROBOTRING

Item	Description
name	This can be any 1 to 10 characters string of your choosing to identify the controller. RIPE allows names longer than 10 characters but FL-net is limited to 10 and it is less confusing to use the same name for all aspects of the Shared Teach Pendant feature.
ipadd	This is the IP Address by which RIPE accesses this controller. It uses the XXX.XXX.XXX.XXX string format.

IPENDNTRING element is use to define a Shared Teach pendant group. MEMBER tag is used to define each controller. Items in below list can be used. The attribute name must be lower case. Its numeric value must be enclosed within quotes.

Items of IPENDANTRING tag

Item	Description
count	This is the number controller that is in the Shared Teach Pendant group. This must always equal the number of MEMBER elements enclosed within the IPENDANTRING element.

Items of MEMBER tag for IPENDNATRING

Item	Description
name	This name identifies the robot controller in the shared TP group. It must be from 1 to 10 characters long. It can be different than the RIPE name but it is less confusing to use the same name for all aspects of the Shared Teach Pendant feature. This name will also be displayed to the left of the menu title on the focus bar on the TP screen, Therefore, it is best to keep it as shorts as possible.
ipadd	This is the IP Address by which the controller is accessed within the Shared TP group. It uses the XXX.XXX.XXX.XXX string format.
focusbg	This I s the decimal value of the color of the focus bar when logged into this member controller. It is defined as the intensity (0 to 255) of each of the primary colors red, green and blue. Use the following formula to combine the color intensities into a decimal number. focusbg = Red + Green*256 + Blue*65536
port_type	This is optional and if set it identifies an I/O output type to be set ON when the Teach Pendant is logged into this controller. Valid values for this are: IO type / Value DO / 2 F / 35 GO / 19 RO / 9
port_num	This Is index of an above I/O output.

Procedure 13-2 Define the Shared Teach Pendant Group

Steps

1. Create ROSIPCFG.XML and save to any device. Please refer the above example.
2. Press ‘MENU’ and select ‘FILE’. File screen is displayed.
3. Select the device that ROSIPCFG.XML is saved. Move the cursor to ROSIPCFG.XMO and push F3 ‘LOAD’.
4. Cycle power.
5. Load ROSIPCFG.XML to all controllers in Shared Teach Pendant group by these steps.

13.1.3 CONFIGURATION OF SAFETY FUNCTIONT BY FL-NET

For safety operation, safety signals, emergency stop, Deadman switch and mode have to be signify to controllers in the Shared Teach Pendant group. To signify them, Safety function by FL-net must be established to communicate between all controllers in the group.

Refer to the following manuals for additional details:

- R-30*i*A/R-30*i*A Mate/R-30*i*B/R-30*i*B Mate CONTROLLER FL-net Interface OPERATOR’S MANUAL (B-82674)
- Section “#9 Safety Function by FL-net” in this manual (B83184)

> **⚠WARNING**
> When setting of Safety function by FL-net is changed, other applications that using safety function by FL-net are affected. When setting is changed, the values must be verified and these functions and Shared Teach Pendant function must be tested again. Otherwise, serious personal injury could result.

Procedure 13-3 Define Fl-net

Steps

1. Press ‘MENU’.
2. Move the cursor to ‘SETUP’, and select ‘FL-NET’ from the fly-out menus. FL-net own node setup screen is displayed.
3. Set ‘USING PORT’ to ‘INTERNAL2’.
4. Set ‘NODE NAME’ to match the one used in the shared TP group setup for this controller
5. Set ‘AREA1 WORK OFFSET’ and ‘AREA1 WORD SIZE’. ‘AREA1 WORD SIZE’ should be equal or more than (IDnum. * 6). Shared Teach Pendant function needed to 1 output of Safety function of FL-net. It should be set 6, if Safety function by FL-net is not used for other applications.
6. Set other items if they are needed, See “III. OPERATION” in “FL-net operator’s manual (B-82674)” for detail.

```
SETUP FL-NET
FL-NET OWN NODE SETUP                1/31
1 DISPLAY VARIETY          :           1
2 TOTAL VARIETY            :           2
3 ERROR NOE SHOT           : ENABLE
4 MAX DIGITAL PORT NUM     :    1024
5 USING PORT               : INTERNAL2
   IP ADDRESS      :[192.168.250.1]
6 MULTICAST                :DISABLE
7 NODE NAME                :[ROBOT    ]
            …
13 AREA1 WOR OFFSET        :           0
14 AREA1 WORD SIZE         :           6
15 DO BYTE OFFSET1         :           0
16 DO BYTE SIZE1           :           0
            …
  [TYPE]          [OTHER]
```

7. Press F3 [OTHER], and select ‘NODE LIST’ form the fly-out menu.
8. Move cursor to another node in the shared TP group and press F2 ‘DETAIL’. FL-net node detail screen is displayed.
9. Set ‘AREA1 WORK OFFSET’ and ‘AREA1 WORD SIZE’. ‘AREA1 WORD SIZE’ should be equal or more than (IDnum. * 6). Shared Teach Pendant function needed to 1 output ID of Safety function by FL-net. It should be set 6, if Safety function by FL-net is not used for other applications.
10. Set other items if they are needed, See “III. OPERATION” in “FL-net operator’s manual (B-82674)” for detail.

```
SETUP FL-NET
FL-NET NODE 2 DETAIL SET             1/25
1 NODE NO.                 :           2
2 DISCONNECTION ALRM       :[STOP     ]
3 I/O SAFETY VALUE         :[CLEAR    ]
4 AREA1 ALLOCATION         :ENABLE
5 AREA1 WORD OFFSET        :           6
6 AREA1 WORD SIZE          :           6
7 DI BYTE OFFSET1          :           0
8 DO BYTE SIZE             :           0
            …
  [TYPE]   PREV   NEXT
```

11. Press the ‘PREV’ hard key to move back to the Node List screen.
12. Repeat steps 5. 6 and 7, for all other nodes in the shared TP group.
13. In Node List screen, set ‘AREA1’ to ‘ENABLE’ for all nodes that you have configured above.

```
SETUP FL-NET
FL-NET NODE LIST                    1/254
NO   AREA1   AREA2      Comment
  1  ENABLE   DISABLE [                  ]
  2  ENABLE   DISABLE [                  ]
  3  ENABLE   DISABLE [                  ]
  4  DISABLE  DISABLE [                  ]
  5  DISABLE  DISABLE [                  ]
  6  DISABLE  DISABLE [                  ]
          …

  [TYPE]  DETAIL  [OTHER] ENABLE DISALBE
```

Procedure 13-4 Define the Safety Function by FL-net

Steps

1. Press ‘MENU’.
2. Move the cursor to ‘SYSTEM’, and select ‘DCS’ from the fly-out menus.
3. Select ‘Safety function by FL-net’. The Safety function by FL-net setup screen is displayed.
4. Set ‘Enable/Disable’ to ‘ENABLE’.
5. Set ‘own node number’ to the numeric value of the last octet in the IP address string.
6. Set ‘ENB/DIS’ of each node in the share Teach Pendant group to ‘ENABLE’. Set all other nodes to ‘DISABLE’.
7. Leave IDnum: at 1 if Safety function by FL-net is not used for other applications.
8. Set ‘Timer of receive data’, ‘Start timer after PowerON’ and ‘Mode’ as needed. Mode 2 has to be selected if this controller can be placed in bypass.

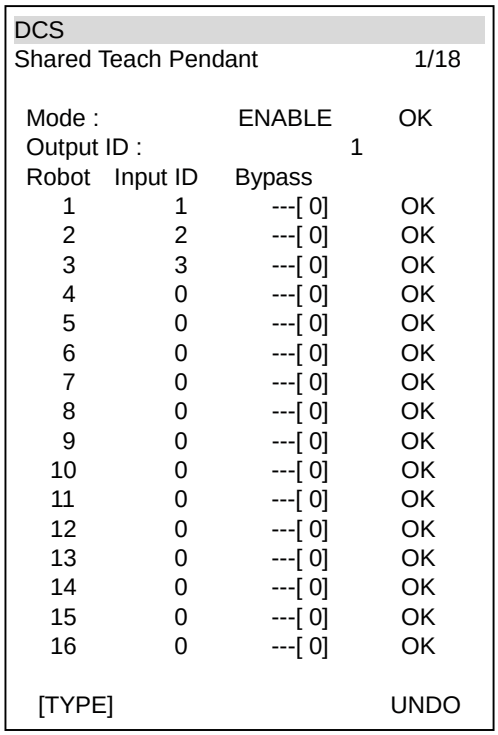
```
DCS
Safety function by FL-net                1/35

1 Enable/Disable:              ENABLE  OK
2 Own node number:             1       OK
3 Node: (Set DISABLE for own node)
          ENB/DIS   ENT/DST   IDnum.
     1    DISABLE   ENTRY          1    OK
     2    ENABLE    ENTRY          1    OK
     3    ENABLE    ENTRY          1    OK
                    …
    29    DISABLE   ENTRY          1    OK
    30    DISABLE   ENTRY          1    OK
4 Timer for receive data:            0    OK
5 Start timer after Power ON:        0    OK
6 Mode:                              2    OK

  [TYPE]                                 UNDO
```

13.1.4 DCS CONFIGURATION OF SHARED TEACH PENDANT

Setting of connection between ID of FL-net and shared controllers has to be defined in DCS Shared Teach Pendant screen.

DCS screen for Shared Teach Pendant function

Shared Teach Pendant screen is displayed when cursor is moved on ‘Shared Teach Pendant’ and Enter key of F3 [DETAIL] is pushed on DCS top screen.



Items in DCS Shared Teach Pendant screen

Item	Description
Mode	The mode of Shared Teach Pendant function. ENABLE: Shared Teach Pendant function is enabled in this robot. DISABLE: Shared Teach Pendant function disabled in this robot.
Output ID	Safety function by FL-net is a general function and other applications can use it even if it was also used for the Shared Teach Pendant function. Each application is assigned an Output ID. If Safety function by FL-net is used only by the Shared Teach Pendant application, output ID should be set to 1.
Input ID	Input ID of Safety function of FL-net. If Safety function by FL-net is not used for other applications, output ID should be as flowing. Input ID = node number + (output ID – 1) Note: Node number and output ID are defined on each controller. Please check each controller's screen to know node number and output ID.
Bypass	ON, OFF or safety I/O can be set. If this signal is ON, this robot is removed from the shared TP group temporally. Bypass signal is not used, set to ---. This setting is used when any robot power is down. When ON is specified or the status of the specified safety I/O is ON, it is possible to turn off the power of the robot, and the other robots can be operated.

Operation in DCS Shared Teach Pendant screen

Operation	Description
F5 UNDO	UNDO the items in this menu. The setting parameters become the same as the current DCS parameters.
PREV	The DCS Top menu is displayed.

⚠WARNING

If setting of safety function is set incorrectly, the safety function will not work, and serious personal injury could result. When setting of Shared Teach Pendant function is changed, the values must be verified. And Shared Teach pendant function and other applications that using safety function by FL-net must be tested again.

⚠WARNING
When bypass setting is incorrect, safety function will not work, and serious personal injury could result. When bypass setting is changed, the setting must be verified and Shared TP system must be tested

⚠CAUTION
- Safety function by FL-net has 3 modes, MODE1, MODE2 and MODE3. To use Bypass, MODE2 must be used.
- To remove a controller from shared Teach Pendant group, bypass setting of all controllers in the group have to be changed.

Procedure 13-5 Define the DCS for Shared Teach Pendant

Steps

1. Press ‘MENU’.
2. Move the cursor to ‘SYSTEM’, and select ‘DCS’ from the fly-out menus.
3. Select ‘Shared Teach Pendant’. The Shared Teach Pendant setup screen is displayed.
4. Set ‘Mode’ to ‘ENABLE’.
5. Set ‘Output ID’. It should be set to 1, if only Shared Teach Pendant function uses Safety function by FL-net.
6. Set ‘Input ID’ of each controller to its FL-net node number
7. If safety signal is used for bypass control, set the safety signal as bypass and set up the relationships.
8. Press ‘PREV’ to move back to the DCS top screen
9. Press F2 [APPLY] to apply DCS parameters
10. Re-power the controller.

13.1.5 CREATING WEB PAGE TO SWITCH ROBOTS

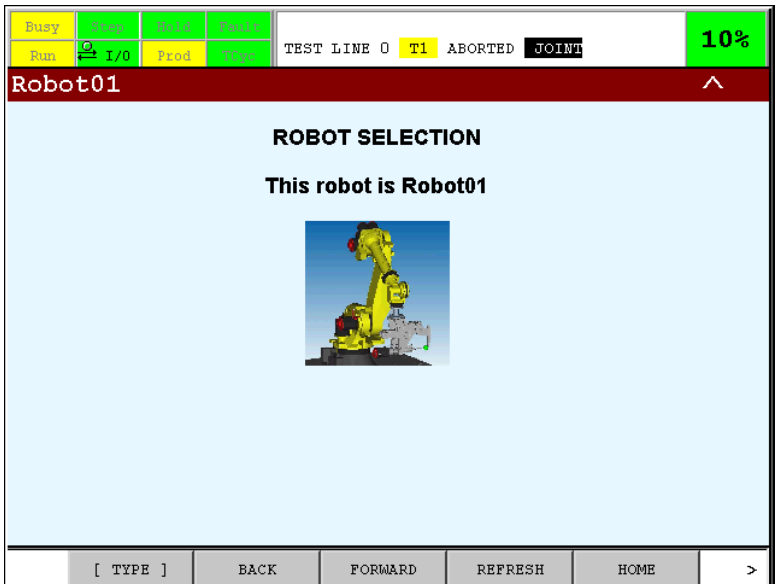
Web pages can be defined containing the remote robots that the iPendant can connect to. This is not required but you may prefer a graphical picture of the robots in the work cell instead of selecting from the Change Robot list.

You need a web page to logout. We page is written by HTML format.
By specifying target=”_top”, you will log out of the connected robot.

Example: logout.htm

```
<html>
<body bgcolor="#E0F0FF">
<strong>
<center>
<font size=3 face="Arial, Helvetica, sans-serif">
<br>
<h3>ROBOT SELECTION</h3>
<h3>This is Robot01</h3>
<p>
</font>
<a href="http://1.1.0.10/fr/selrobot.htm" target="_top">
   <img border="0" src="robot1.jpg" width="120" height="120">
</a>
</center>
</strong>
</body>
```

```
</html>
```



You can access your logout web page from the BROWSER menu by setting the appropriate system variables. Notice the web page took over the entire screen. This is because you are now logged out of all robots. While you are logged out, RESET, jog keys, and other menu keys are not active.

Example:

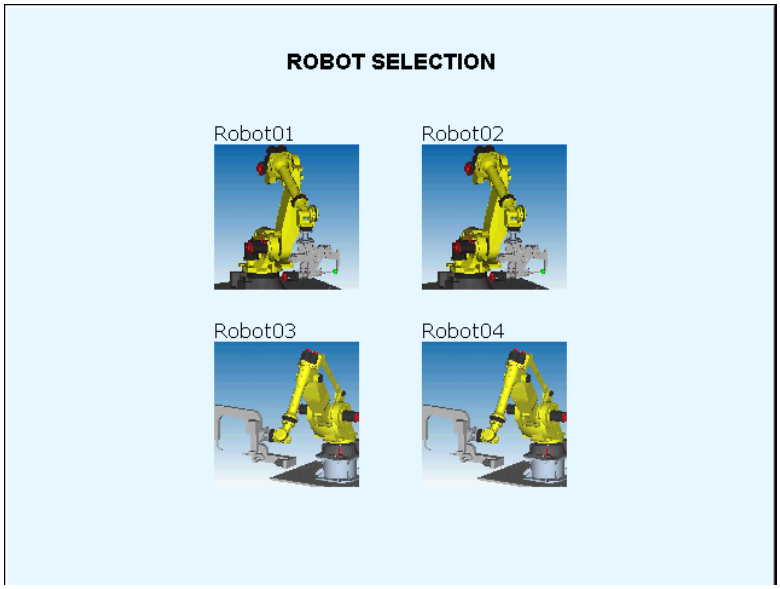
```
$tx_screen[1].$destination = '/fr/logout.htm'
$tx_screen[1].$screen_name = 'Change Robot'
```

You need a web page to select a different robot. Typically this needs on the controllers that Teach Pendants are wired.

Example: selrobot.htm

```
<HTML>
<BODY bgColor=#E0F0FF>
<center>
<strong>
<font size=3 face="Arial, Helvetica, sans-serif">
<br>
<h3>ROBOT SELECTION</h3>
<p>
</font>
</strong>
<table border="0" cellspacing="20">
  <tr>
    <td width="150" height="130">
      Robot01<BR/>
      <a href="http://1.1.0.10:3080/frh/cgtp/cgtp.htm">
        <img border="0" src="robot1.jpg" width="120" height="120">
      </a>
    </td>
    <td width="120" height="130">
      Robot02 <BR/>
```

```
          <a href="http://192.168.0.2:3080/frh/cgtp/cgtp.htm">
            <img border="0" src="robot1.jpg" width="120" height="120">
          </a>
        </td>
      </tr>
      <tr>
        <td width="120" height="130">
          Robot03<BR/>
          <a href="http://1.1.0.10:3080/frh/cgtp/cgtp.htm">
            <img border="0" src="robot3.jpg" width="120" height="120">
          </a>
        </td>
        <td width="120" height="130">
          Robot04 <BR/>
          <a href="http://192.168.0.2:3080/frh/cgtp/cgtp.htm">
            <img border="0" src="robot4.jpg" width="120" height="120">
          </a>
        </td>
      </tr>
</table>
</center>
</BODY>
</HTML>
```



13.2 OPERATION

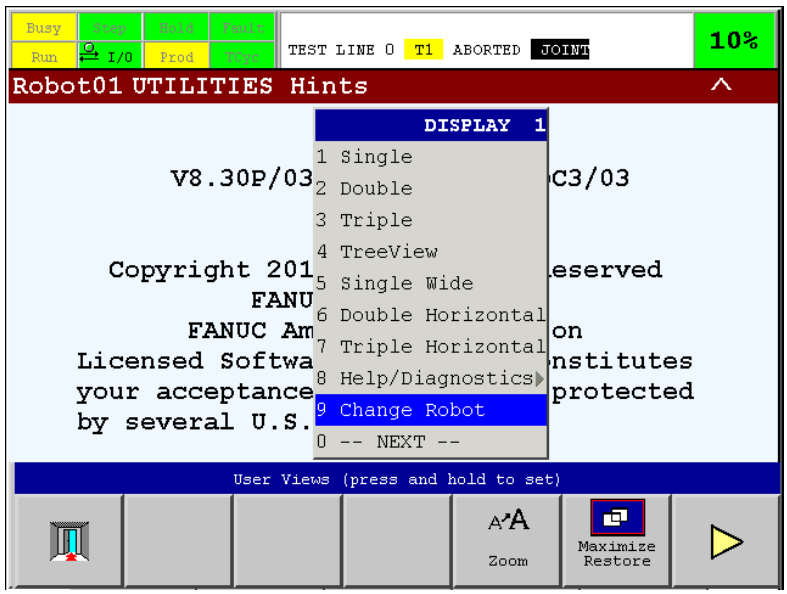
13.2.1 LOG INTO A ROBOT

You must log into a robot controller in order for the teach pendant to control it.
When the teach pendant is first turned on, it automatically logs into the controller to which it is physically connected. When setting of Shred Teach Pendant function is completed, ‘Change Robot’ is displayed in view menu and Teach Pendant can log in to other controllers.

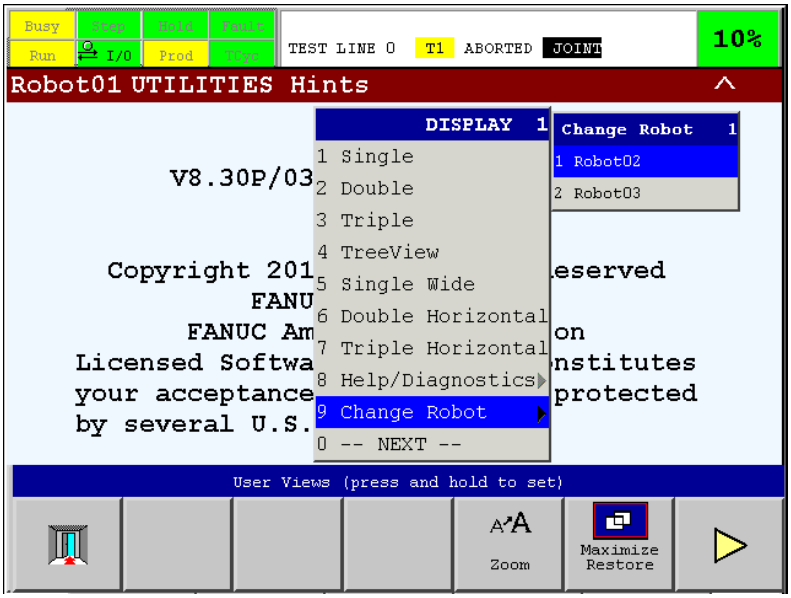
Procedure 13-6 Log into a robot

Steps

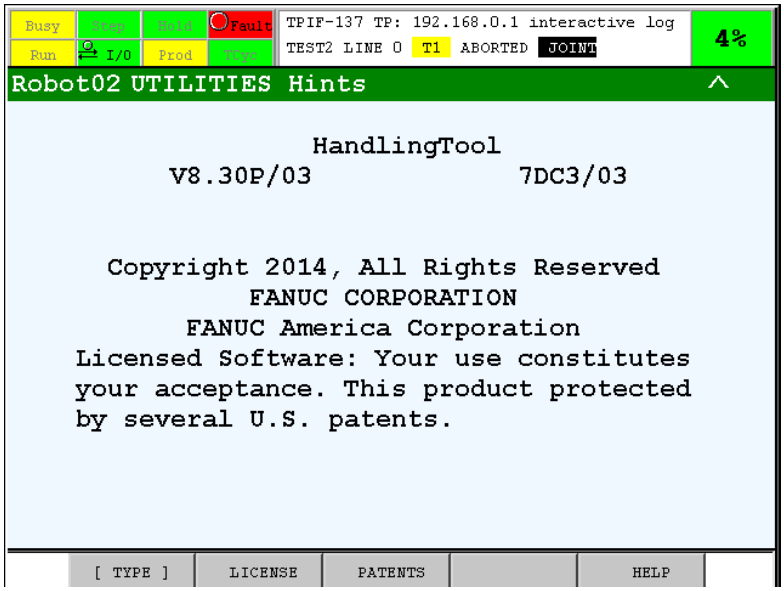
1. Connect Teach Pendant cable to outlet on controllers in the Shared Teach Pendant group. Teach Pendant log in to the controller. Color of title bar is set as you defined and robot name is displayed on it.
2. Hold ‘SHIFT’ and press ‘DISP’. View menu is displayed.



If there are more than two robots in the shared Teach Pendant group, select the robot you want to log in to from the fly-out menu provided.



3. Select ‘Change Robot’ or required robot name from the drop-down menu. The Teach Pendant logs into the selected controller and screen of the controller is display. You can check which robot does Teach Pendant long in by color of title bar and the robot name on the title bar.

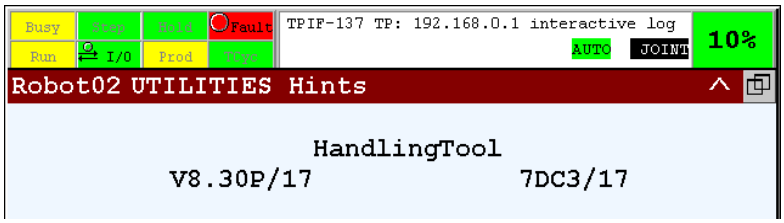


In below cases, Teach Pendant cannot change connected controller.

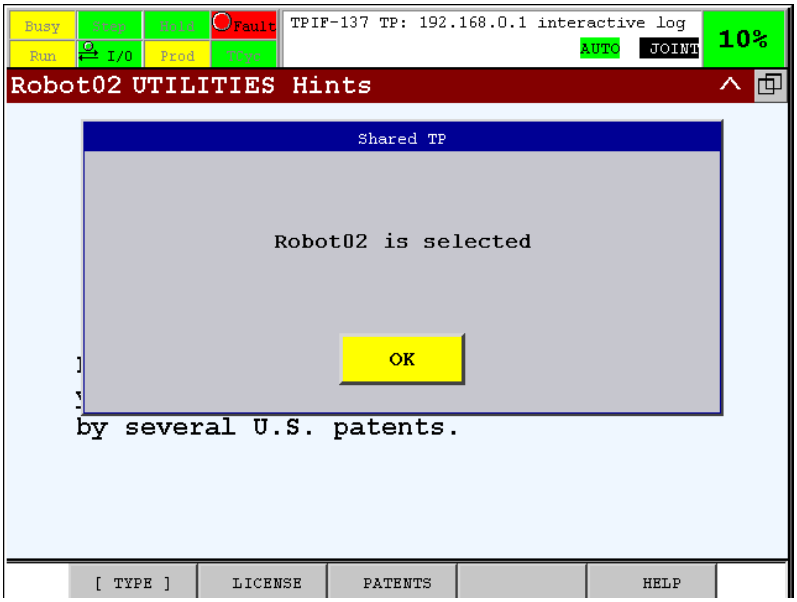
- 'Change Robot' item is not displayed on the menu if these are some mistakes in ROSIFCFG.XML.
- Teach Pendant cannot change robot with some warnings if there are some mistakes of Shared Teach Pendant settings in the controller that Teach Pendant is wired physically.
- Teach Pendant cannot log in remote controller if there are some mistakes of Shared Teach Pendant settings in the remote controller. In this case, the Teach Pendant is disconnected from any controllers and only error message is displayed. Please press MEMU key to log back to the controller that Teach Pendant is wired.
- Teach Pendant cannot log in remote controller if bypass setting for the remote controller is ON. "SYST-315 Shared TP: bypassed setting" occurs.
- Teach Pendant cannot log in remote controller if bypass setting for controller that Teach Pendant is wired is ON in the remote controller.

13.2.2 CONFIRMATION OF SELECTED ROBOT

Selected robot by Shared Teach Pendant can be confirmed on Teach Pendant screen. Selected robot name is displayed on title bar in Teach Pendant screen and specified color is used for title bar. Please refer "13.1.2 CONFIGURATION OF SHARED TEACH PENDANT GROUP" to specify displayed robot name and color of title bar.



When any key on Teach Pendant is pushed after power-on robot or changing robot, confirmation of selected robot is displayed on Teach Pendant screen. Please confirm if displayed name is indicated a robot that you would like to operate and push OK button or ENTER key.
When any key on the Teach Pendant is pushed after the Teach Pendant is not operated while specified time, the confirmation is displayed. The default time is 10 minutes and it can be modified by $STP_CFG.$NOOPE_TIME.



⚠WARNING
Confirm that operated robot is certainly selected by Teach pendant.
Ensure that you are able to view all robots in Shared Teach Pendant group, and that there are no personnel and obstructions when you start operating a robot.
Otherwise, you could injure personnel or damage equipment.

13.2.3 OPERATION OF ROBOT

Teach Pendant can operate robot that is logged in by the Teach Pendant like it normally operate. Teach Pendant provide Teaching, JOG operation, Start programs or etc on T1/T2 mode.

USB memory on Teach Pendant appears as UT1: on the Teach Pendant even if the Teach Pendant login other controllers. Controller that Teach Pendant login can use USB memory on the operated Teach Pendant as UT1:. For example, when backup is executed to UT1; backup data of the controller that Teach Pendant login is saved to USB memory on the Teach Pendant.
UD1: and MC: show devices on controller that Teach Pendant login, not controller that the Teach Pendant is physically wired.

Limitation:
Following operations cannot be performed by shared Teach Pendant that be wired other controllers. Wire Teach Pendant directly to target controllers to perform these operations.
- Display Boot monitor screen and operations in the screen
- Display Configuration menu and operations in the menu.

Controlled start on controller that TP is not wired can be performed from Function menu. Selection menu of start mode is displayed on Teach Pendant, when FCTN key is pushed and ‘CYCLE POWER’ is selected in the function menu. When select ‘CONTROLLED’, the controller is repowered with controlled start.

⚠CAUTION
- The TP ENABLE switch and HOLD key affect to only the robot controller which the teach pendant is logged in.
- Teach pendant cannot operate a robot when multiple Teach Pendants are connected to controllers in Shared Teach Pendant group.

13.2.4 BYPASSING DOWN ROBOT

When a robot is down, it needs to be bypassed through the safety network to enable the other robots to operate. To operate robots when the controller in shared Teach Pendant group is down, the DCS bypass setting of that robot in all controllers must be changed to ON. When it is ON, the controller is removed from shared Teach Pendant group.
Safety I/O can be set as bypass and it can change status of bypass without changing configuration and re-power. Please refer procedure 13-5 to set Safety I/O.

Procedure 13-7 Manually Setting a Robot in Bypass

Steps

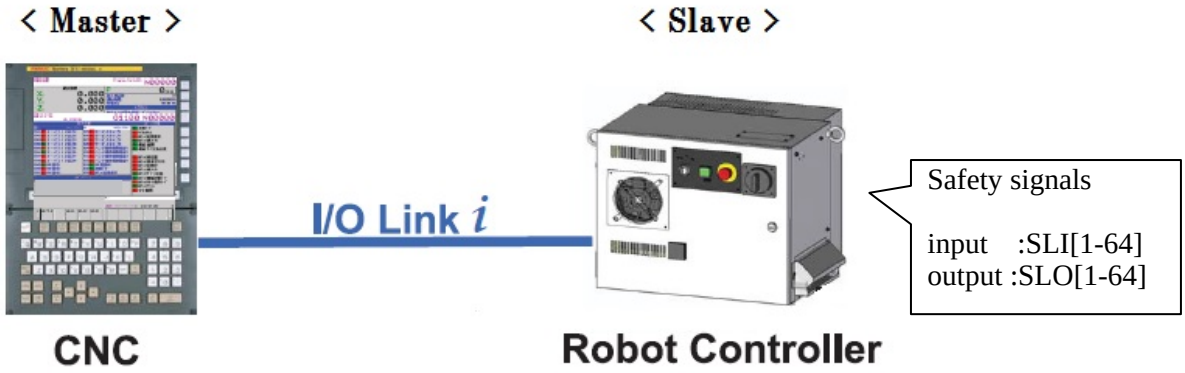
1. Press 'MENU'
2. Move the cursor to 'SYSTEM' and select 'DCS' from the fly-out menus
3. Select 'Shared Teach Pendant'. The Share Teach Pendant screen is displayed.
4. Cursor to the robot to be bypassed and select ON.
5. Press the 'PREV' key to back to the DCS top screen
6. F2 [APPLY] to apply DCS parameters.
7. Re-power the controller.
8. Set bypass ON on other controllers.

⚠WARNING
When bypass setting is incorrect, safety function will not work, and serious personal injury could result. When bypass setting is changed, the setting must be verified and Shared TP system must be tested

⚠CAUTION
- Safety function by FL-net has 3 modes, MODE1, MODE2 and MODE3. To use Bypass, MODE2 must be used.
- To the controller is removed from shared Teach Pendant group, bypass setting of all controllers in the group have to be changed. When bypass statuses are not matched between controllers in shared Teach Pendant group, "SYST-338 Shared TP: bypass status mismatch" occurs.

14 I/O LINK *i* SLAVE FUNCTION

The I/O link *i* Slave is the function that communicates safety I/O with CNC controller via I/O link *i*. The CNC is the master device, and the robot is the slave device of I/O link *i*.



- Maximum 64 safety input and 64 safety output are available.
- Safety input signals from CNC are accessed as SLI[1-64] by Safety I/O connect or Safety PMC function.
- Safety output signals to CNC are accessed as SLO[1-64] by Safety I/O connect or Safety PMC function.
- When the I/O link *i* communication with CNC is not established such as the power of CNC does not turn on, all input signals from master are OFF because the input signals are not updated. Therefore, SLI[1-64] are OFF.
- When the I/O link *i* communication with CNC is lost such as the power of CNC is turned off after the communication is established, all input signals from master are read as OFF. Therefore, SLI[1-64] are turned OFF. User application such as Safety PMC should be designed as that system will be safe state when SLI signals are OFF.

⚠WARNING
If I/O Link *i* Slave setting is set incorrectly, the safety function will not work, and serious personal injury could result. When I/O Link *i* Slave settings are changed, the values must be verified and the function must be tested again.

⚠WARNING
If I/O Link *i* Slave is used, safety signal status could be delayed by a maximum of 2 ms. In this case, a risk assessment for the whole robot system is necessary, including the additional 2 ms delay.

⚠WARNING
If the safety output signal SLO is used, the robot system should be designed as that the robot system becomes Safe (Stop) State when SLO output signals are OFF. This safety output signals are forced to OFF when internal fault is detected in robot controller.
If the robot system does not become Safe State when SLO signals are OFF, the safety function will not work, and serious personal injury could result.

⚠WARNING
If the safety input signal SLI is used, the robot system should be designed as that the robot system becomes Safe (Stop) State when SLI input signals are OFF. These safety input signals are forced to OFF when I/O link *i* communication does not work correctly.
If the robot system does not become Safe State when SLI signals are OFF, the safety function will not work, and serious personal injury could result.

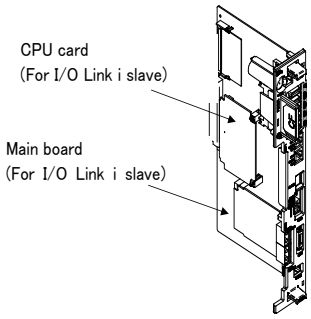
If you use I/O Link *i* Slave function, you need to use hardware that I/O Link *i* Slave function is supported. Software has been supported since 7DC3/14. Software option is not needed, so you can use this function as standard if you use supported hardware.

14.1 NEEDED HARDWARE CONSTRUCTION

14.1.1 In Case of using R-30*i*B

To use the function of I/O Link *i* slave, both of the Main board and the CPU card must support I/O Link *i* slave. The software version must be 7DC3/14 or later.

Name	Ordering Specification	Board Specification	Note
Main board **(For I/O Link *i* slave)**	A05B-2600-H004	A16B-3200-0800	Standard
	A05B-2600-H005	A16B-3200-0801	With Force sensor
	A05B-2600-H006	A16B-3200-0802	With Force sensor, High speed
CPU card **(For I/O Link *i* slave)**	A05B-2600-H026	A17B-3301-0109	Standard / SDRAM 32Mbyte
	A05B-2600-H027	A17B-3301-0110	Standard / SDRAM 64Mbyte
	A05B-2600-H028	A17B-3301-0111	Standard / SDRAM 128Mbyte
	A05B-2600-H029	A17B-3301-0112	High speed / SDRAM 32Mbyte
	A05B-2600-H030	A17B-3301-0113	High speed / SDRAM 64Mbyte
	A05B-2600-H031	A17B-3301-0114	High speed / SDRAM 32Mbyte



NOTE

The combination of the specification of the mainboard, the CPU card and the software is limited as below.

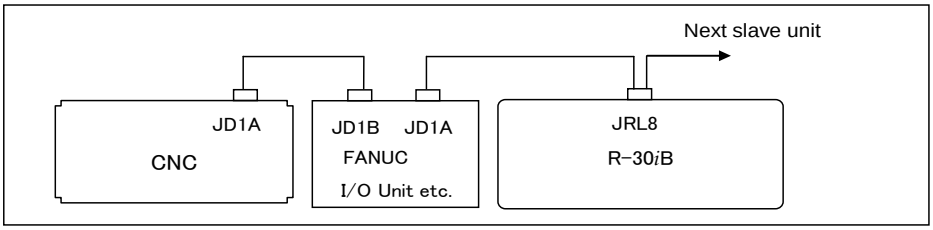
[Main board (For I/O Link *i* slave)] + [CPU card (For I/O Link *i* slave)]
+ [Software (7DC3/14 or later)]

Except for the above condition, the system does not work correctly as followings.

a) [Main board (Non-compliant)] + [CPU card (For I/O Link *i* slave)]
Neither the function of I/O Link slave nor I/O Link *i* slave work correctly. So the alarm regarding I/O Link or I/O Link *i* occur on the master side.
And in case the software version is not correct, system does not work correctly.

b) [Main board (For I/O Link *i* slave)] + [CPU card (Non-compliant)]
Neither the function of I/O Link slave nor I/O Link *i* slave work correctly, so the alarm regarding I/O Link or I/O Link *i* occurs on the master side.

The connection of I/O link *i* in the R-30*i*B is shown below.



Connection of I/O Link *i*

Please check it in the following about a connection of the I/O Link cable.

1. Connect the cable according to the system. Be sure to perform shielding.
Shield the cable collectively and ground the shield on the CNC side.
2. Before connection turn off the power.

NOTE

For connection with the CNC with I/O link *i* , turn on or off the power of the CNC and the robot controller at the following timing.

a) Slave units and the master must be powered on at the same time.
b) If the CNC or robot controller is powered off after startup of the system, an I/O link *i* error occurs. To successfully make connection with I/O links again, power off all of the units and then power them on at the timing indicated in a).

JRL8

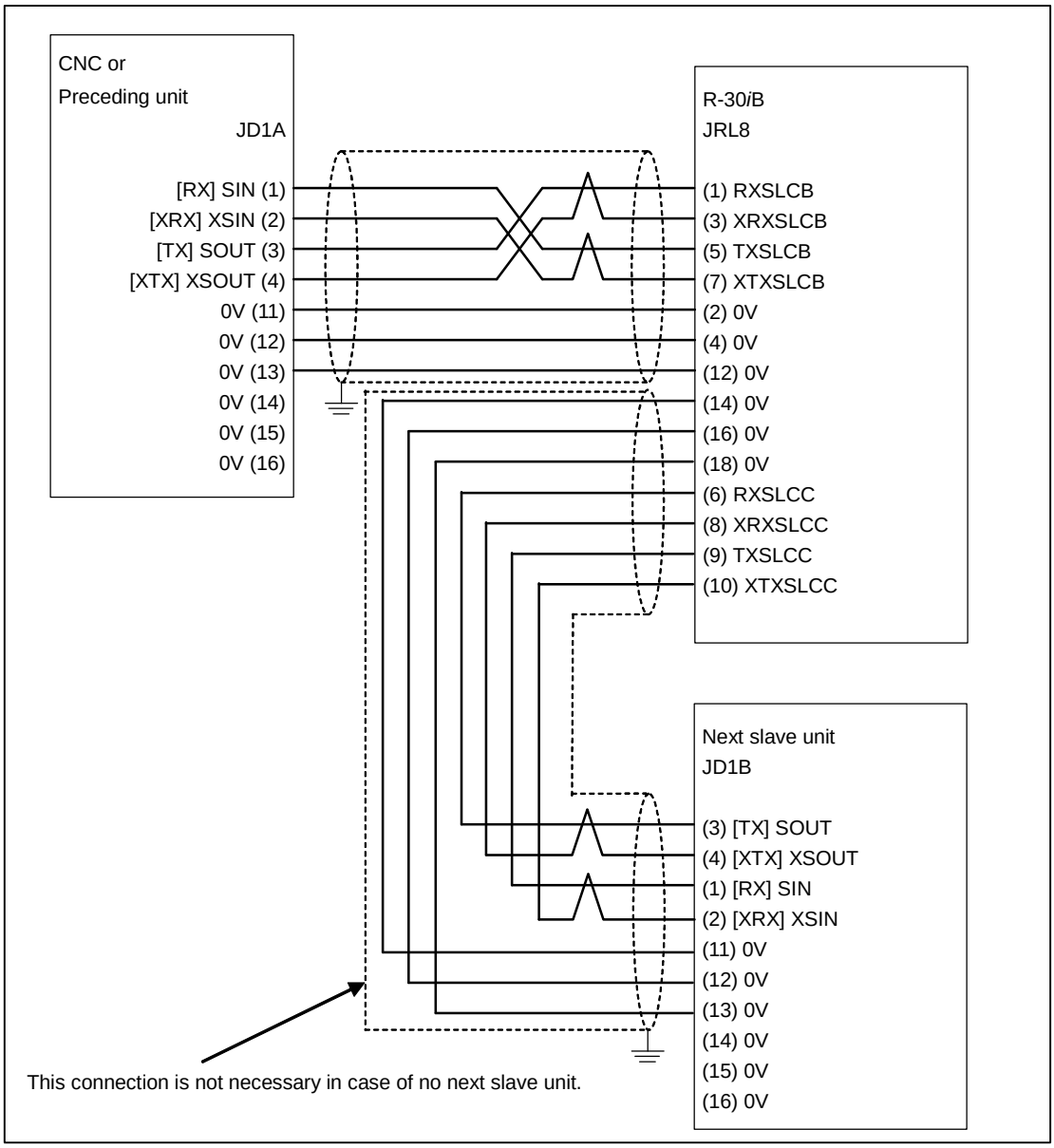
1	RXSLCB	11	*HDI0
2	0V	12	0V
3	*RXSLCB	13	*HDI1
4	0V	14	0V
5	TXSLCB	15	*HDI2
6	RXSLCC	16	0V
7	*TXSLCB	17	*HDI3
8	*RXSLCC	18	0V
9	TXSLCC	19	*HDI4
10	*TXSLCC	20	0V

JRL8 Interface

3 When the R-30*i*B controller is connected to CNC or preceding I/O link *i* slave unit, use a twisted-pair cable in which wires RXSLCB (Pin No.1 of JRL8) and *RXSLCB (Pin No.3 of JRL8) are paired and wires TXSLCB (Pin No.5 of JRL8) and *TXSLCB (Pin No.7 of JRL8) are paired.

4 When the R-30*i*B controller is connected to next I/O link *i* slave unit, use a twisted-pair cable in which wires RXSLCC (Pin No.6 of JRL8) and *RXSLCC (Pin No.8 of JRL8) are paired and wires TXSLCC (Pin No.9 of JRL8) and *TXSLCC (Pin No.10 of JRL8) are paired.

The connection of I/O link *i* in the R-30*i*B is shown below.

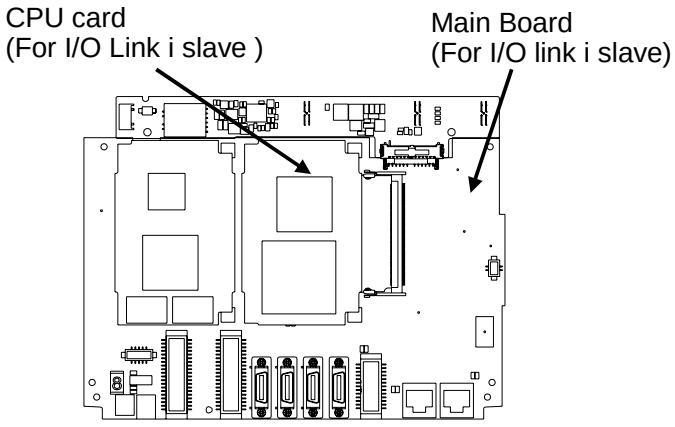


14.1.2 In Case of using R-30*i*B Mate

To use the function of I/O Link *i* slave, both of the Main board and the CPU card must support I/O Link *i* slave.

The software version must be 7DC3/14 or later.

Name	Ordering Specification	Board Specification	Note
Main board **(For I/O Link *i* slave)**	A05B-2650-H004	A20B-8201-0420	Standard Ethernet:1ch
	A05B-2650-H005	A20B-8201-0421	Ethernet:2ch with Vision I/F, Force sensor I/F
	A05B-2650-H006	A20B-8201-0422	Ethernet:2ch with VisionI/F, Force sensor I/F, PMC, HDI
CPU card **(For I/O Link *i*)**	A05B-2600-H026	A17B-3301-0109	Standard / SDRAM 32Mbyte
	A05B-2600-H027	A17B-3301-0110	Standard / SDRAM 64Mbyte
	A05B-2600-H028	A17B-3301-0111	Standard / SDRAM 128Mbyte
	A05B-2600-H029	A17B-3301-0112	High speed / SDRAM 32Mbyte
	A05B-2600-H030	A17B-3301-0113	High speed / SDRAM 64Mbyte
	A05B-2600-H031	A17B-3301-0114	High speed / SDRAM 128Mbyte



NOTE

The combination of the specification of the mainboard, the CPU card and the software is limited as below.

[Main board (For I/O Link *i* slave)] + [CPU card (For I/O Link *i* slave)]
+ [Software (7DC3/14 or later)]

Except for the above condition, the system does not work correctly as followings.

c) [Main board (Non-compliant)] + [CPU card (For I/O Link *i* slave)]
Neither the function of I/O Link slave nor I/O Link *i* slave work correctly. So the alarm regarding I/O Link or I/O Link *i* occur on the master side.
And in case the software version is not correct, system does not work correctly.

d) [Main board (For I/O Link *i* slave)] + [CPU card (Non-compliant)]
The system does not work correctly.

The connection of I/O link *i* in the R-30*i*B Mate is shown below.

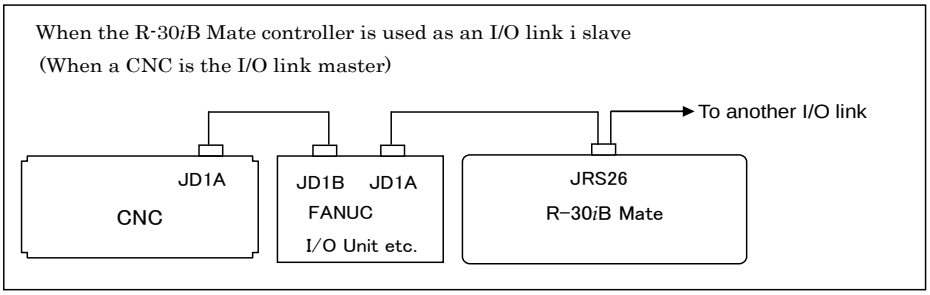


Fig. M.2 Connection of I/O Link *i*

Please check it in the following about a connection of the I/O Link cable.

1. Connect the cable according to the system. Be sure to perform shielding.
2. Before connection turn off the power.

NOTE
For connection with the CNC with I/O link *i*, turn on or off the power of the CNC and the robot controller at the following timing.

a) Slave units and the master must be powered on at the same time.
b) If the CNC or robot controller is powered off after startup of the system, an I/O link *i* error occurs. To successfully make connection with I/O links again, power off all of the units and then power them on at the timing indicated in a).

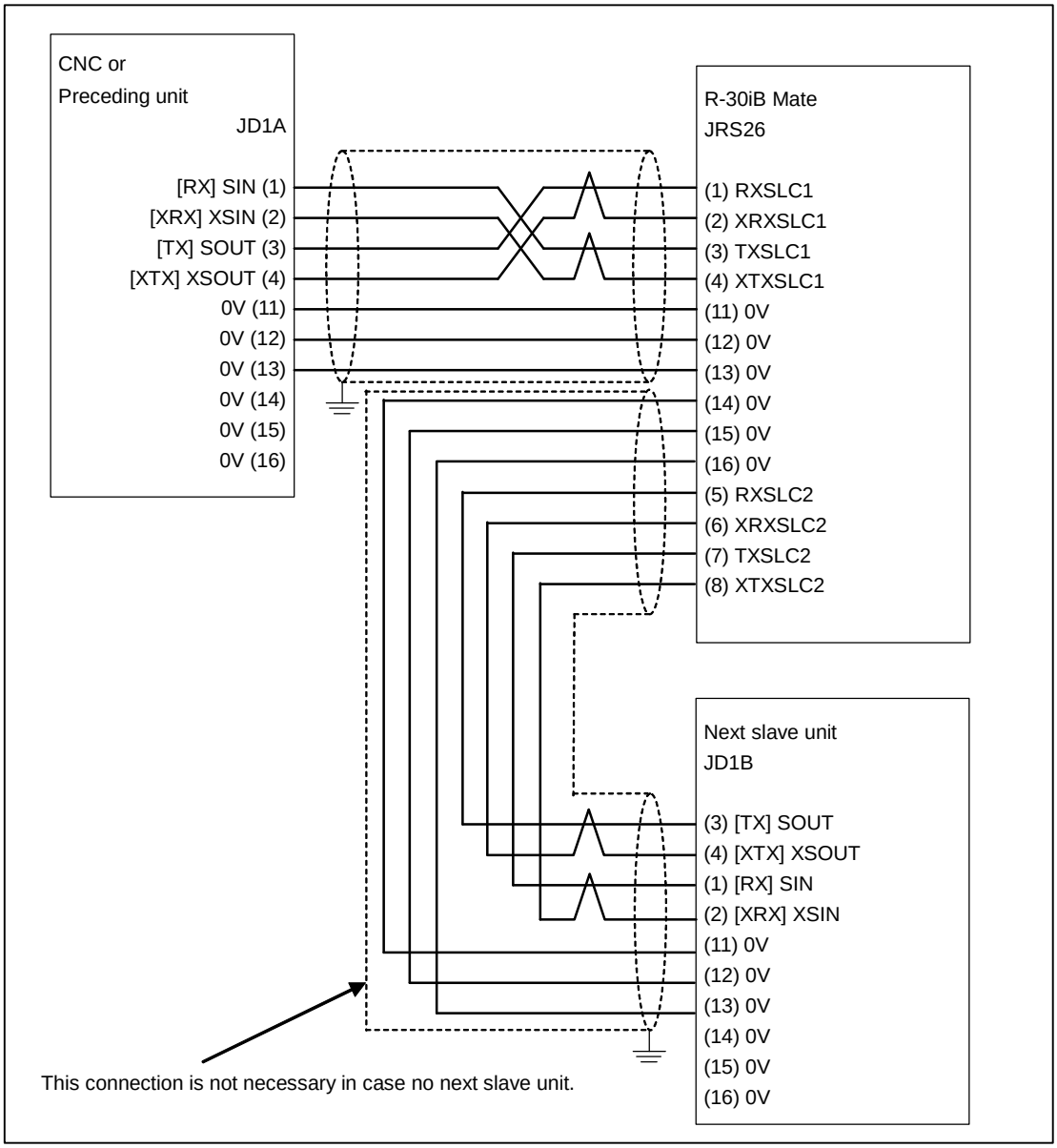
JRS26 Interface

11	0V	01	RXSLC1
12	0V	02	*RXSLC1
13	0V	03	TXSLC1
14	0V	04	*TXSLC1
15	0V	05	RXSLC2
16	0V	06	*RXSLC2
17		07	TXSLC2
18	(+5V)	08	*TXSLC2
19	(24V)	09	(+5V)
20	(+5V)	10	(24V)

3 When the R-30*i*B Mate controller is connected to preceding I/O link *i* slave unit, use a twisted-pair cable in which wires RXSLC1 (Pin No.1 of JRS26) and *RXSLC1 (Pin No.2 of JRS26) are paired and wires TXSLC1 (Pin No.3 of JRS26) and *TXSLC1 (Pin No.4 of JRS26) are paired.

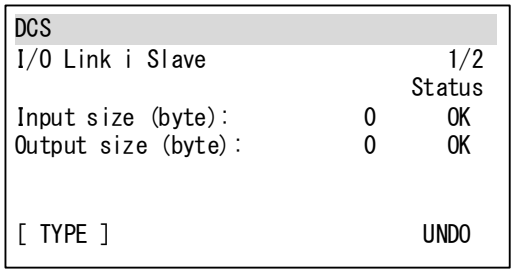
4 When the R-30*i*B Mate controller is connected to next I/O link *i* slave unit, use a twisted-pair cable in which wires RXSLC2 (Pin No.5 of JRS26) and *RXSLC2 (Pin No.6 of JRS26) are paired and wires TXSLC2 (Pin No.7 of JRS26) and *TXSLC2 (Pin No.8 of JRS26) are paired.

The connection of I/O link *i* in the R-30*i*B Mate is shown below.



14.2 DCS I/O LINK *i* SLAVE MENU

The DCS I/O Link *i* Slave menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the " I/O Link *i* Slave" item in the DCS Top menu.



Items in I/O Link *i* Slave menu

Item	Description
Input size (byte) Output size (byte)	The number of safety signals as byte. Maximum value is 8 byte, in this case, 64 safety signals are available. When both input size and output size are 0, safety signal of I/O link *i* slave function is disable. The range is 0 - 8 byte. Default is 0.
Status	The status of each line is displayed. OK: Setting parameter and DCS parameter are the same. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.

Operation in I/O Link *i* Slave menu

Operation	Description
F5(UNDO)	UNDO the items in this menu. The setting parameters become the same as the current DCS parameters.
PREV	The DCS Top menu is displayed.

14.3 NUMBER OF SAFETY AND NON-SAFETY SIGNALS

14.3.1 Case with Safety Signals

The number of usable safety signals for I/O Link *i* Slave function is up to 64 points. The sum of safety and non-safety signals for I/O Link *i* Slave function is up to 224 points. In other words, if used safety signals are few, usable non-safety signals increase by the amount.

The default number of non-safety signal is as the following:
- R-30*i*B : Input is 0 point. Output is 0 point
- R-30*i*B Mate : Input is 72 points. Output is 68 points.

The number of non-safety signals is set by the following system variables:
- Input : $IOSLAVE.$INPUT_N
- Output : $IOSLAVE.$OUTPUT_N

If the value of the system variable is over the maximum, error occurs and non-safety signal is not assigned.

14.3.2 Case without Safety Signals

If you don't use safety signals, it is possible for I/O Link *i* to use 512 points per a group. And Robot Controller has two groups to treat dual signal for safety signals, so 1024 points is usable totally.

However, CNC software keeps 16 points (2bytes) out of 512 points for other purpose. So you can use up to 496 points per a group for CNC actually, and 992 points are usable totally.

Assignment is as follows if you use two groups for non-safety signals:
- 1st group : rack 32, slot 1
- 2nd group : rack 32, slot 2

The system variables to set the number of non-safety signal are as follows:
- 1st group : (Input) $IOSLAVE.$INPUT_N, (Output) $IOSLAVE.$OUTPUT_N
- 2nd group : (Input) $IOSLAVE.$INPUT_N2, (Output) $IOSLAVE.$OUTPUT_N2

In addition, I/O Unit ID codes for the two groups of Robot Controller are displayed on the I/O DEVICE MONITOR screen of CNC as follows:

- 1st group : 56 (R-30*i*B) or 57 (R-30*i*B Mate)
- 2nd group : 3F

14.4 MAPPING OF SAFETY AND NON-SAFETY SIGNALS

When Robot Controller (R-30*i*B or R-30*i*B Mate) is connected to CNC by I/O Link *i* as slave, safety signals for Robot Controller are assigned to start address. And non-safety signals are assigned following those. You have to consider this mapping if you set cross check for CNC.

Example)
The case that CNC uses safety signals (Input/Output: 16/8 points) and non-safety signals (Input/Output: 32/24 points) with PMC1 and DCSPMC.

Assignment of signal (PMC1)

Physical number	Address of CNC	Assignment of safety and non-safety signal for Robot Controller
In 1- 8	Yn	SLI[1- 8]
in 9-16	Yn+1	SLI[9-16]
in 17-24	Yn+2	DI[1- 8]
in 25-32	Yn+3	DI[9-16]
in 33-40	Yn+4	DI[17-24]
in 41-48	Yn+5	DI[25-32]
out 1- 8	Xm	SLO[1- 8]
out 9-16	Xm+1	DO[1- 8]
out 17-24	Xm+2	DO[9-16]
out 25-32	Xm+3	DO[17-24]

NOTE: You can change used index of DI/DO as non-safety signal by manual assignment.
(as DO[1-8] -> DO[101-108])
Non-safety signals are assigned as rack 32, slot 1.

Assignment of signal (DCSPMC)

Physical number	Address of CNC	Assignment of safety and non-safety signal for Robot Controller
in 1- 8	Yp	SLI[1- 8]
in 9-16	Yp+1	SLI[9-16]
out 1- 8	Xq	SLO[1- 8]

In this case, you need to set cross check Yn, Yn+1 and Xm for PMC1, and Yp, Yp+1 and Xq for DCSPMC.

14.5 LOADING OF UNSUPPORTED VERSION BACKUP

14.5.1 Loading of Backup to Unsupported Hardware

When image backup that safety signals for I/O Link *i* Slave function is used or $IOSLAVE.$INPUT_N2 or $IOSLAVE.$OUTPUT_N2 for non-safety signals has the value other than 0 is loaded to unsupported hardware, the alarm "PRIO-052 I/O Link *i* slave hardware mismatch" occurs.

When not image backup but normal backup is loaded to unsupported hardware, if the hardware uses the old software (before 7DC3/14), it makes no affect. The loading of new system variable, $IOSLAVE.$INPUT_N2 and $OUTPUT_N2 will fail.

But if unsupported hardware uses the new software (7DC3/14 or later) and $IOSLAVE.$INPUT_N2 or $IOSLAVE.$OUTPUT_N2 for non-safety signals has the value other than 0 in normal backup, the alarm "PRIO-052 I/O Link *i* slave hardware mismatch" occurs.

14.5.2 Loading of Backup that is Unsupported Software

When image backup of unsupported software (before 7DC3/14) is loaded to the hardware that I/O Link *i* Slave function is supported, the following behaviors will appear:

- Master (CNC) fails to initialize I/O Link *i* connection to slave (Robot controller).
- Slave (Robot controller) is unable to update I/O.
- Unsupported software can't recognize the capacity of new CPU card that I/O Link *i* Slave function is supported. If CPU card has 64MB or more, unsupported software treats it as 32MB, and unexpected problems can occur.
- For R-30*i*B Mate Robot controller, the software will not come up.

When not image backup but normal backup of unsupported software (before 7DC3/14) is loaded to the hardware that I/O Link *i* Slave function is supported, it makes no effect.

15 SAFE I/O CONSISTENCY CHECK FUNCTION

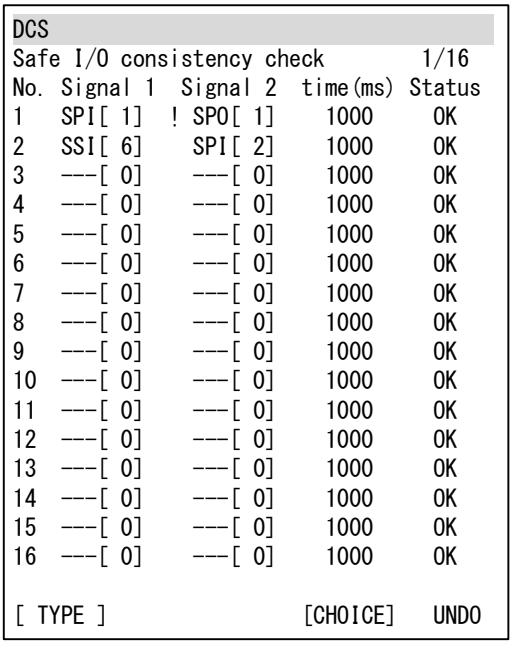
The Safe I/O consistency check is the function to check the consistency of a pair of safe I/O. If the pair of Safe I/O status is not consistent for the specified time, servo power is turned off immediately. The servo power cannot be turned on until the pair of Safe I/O status becomes consistent.
Maximum 16 pairs of Safe I/O can be checked.

The consistent situation is the status of the Safe I/O pair are the same, such as both are ON or both are OFF. When the operator "!" specified, the consistent situation is the status of the Safe I/O pare are different, such as ON and OFF, OFF and ON.
In the inconsistency situation, "SRVO-484 Safe I/O consistency alarm %x, %x" occurs. When this alarm occurs, please check the connection of Safe I/O, the setting of "Safe I/O consistency check" menu and failure of hardware that the Safe I/O is connected. To reset the alarm, please remove the factors and cycle power.

> **⚠WARNING**
> If Safe I/O consistency check setting is set incorrectly, the safety function will not work, and serious personal injury could result. When settings are changed, the values must be verified and the function must be tested.

15.1 DCS SAFE I/O CONSISTENCY CHECK MENU

The DCS Safe/IO consistency check menu is displayed by pressing the ENTER key or the F3(DETAIL) key while on the "Safe I/O consistency check" item in the DCS Top menu.



```
DCS
Safe I/O consistency check          1/16
No.  Signal 1   Signal 2   time(ms) Status
1    SPI[ 1]  ! SPO[ 1]     1000     OK
2    SSI[ 6]    SPI[ 2]     1000     OK
3    ---[ 0]    ---[ 0]     1000     OK
4    ---[ 0]    ---[ 0]     1000     OK
5    ---[ 0]    ---[ 0]     1000     OK
6    ---[ 0]    ---[ 0]     1000     OK
7    ---[ 0]    ---[ 0]     1000     OK
8    ---[ 0]    ---[ 0]     1000     OK
9    ---[ 0]    ---[ 0]     1000     OK
10   ---[ 0]    ---[ 0]     1000     OK
11   ---[ 0]    ---[ 0]     1000     OK
12   ---[ 0]    ---[ 0]     1000     OK
13   ---[ 0]    ---[ 0]     1000     OK
14   ---[ 0]    ---[ 0]     1000     OK
15   ---[ 0]    ---[ 0]     1000     OK
16   ---[ 0]    ---[ 0]     1000     OK

[ TYPE ]                  [CHOICE]   UNDO
```

Items in DCS Safe I/O consistency check menu

Item	Description
Signal 1	Used to set the first Safe I/O to check consistency.
Signal 2	Used to set the second Safe I/O to check consistency. You can specify "!" on the signal 2 of the Safe I/O name, this means the inverse value (NOT) is compared. When the operator “!” specified, the consistent situation is the status of the Safe I/O pare are different, such as ON and OFF, OFF and ON.
Time	The time limit is set in safety parameter for each pair. The default is 1000ms, and the maximum value is 2000ms.
Stats	The status of each line is displayed. OK: Setting parameter and DCS parameter are the same. CHGD: Setting parameter is changed, but not applied to DCS parameter. PEND: Setting parameter is changed and applied to DCS parameter, but controller power has not been cycled.

Operation in DCS Safe I/O consistency check menu

Operation	Description
F5(UNDO)	UNDO the items in this menu. The setting parameters become the same as the current DCS parameters.
PREV	The DCS Top menu is displayed.

16 SAFETY SIGNALS

In the R-30*i*B controller, safety signal interface depends on the type of cabinet.
The detail of interface is shown in Table 11.

Table 16 Safety signal interface

	Cabinet	Number of I/O points		Remarks
		SFDI (Note1)	SFDO (Note2)	
1	R-30*i*B A-cabinet	2 pair（POS / NEG type）	2 pair (POS / POS type)	Standard
2	R-30*i*B B-cabinet	8 pair（POS / NEG type）	8 pair (POS / POS type)	Option (Note3) (Ordering Specification: A05B-2600-J130)

The following options are able to add the safety I/O signals.

	Option	Number of I/O points		Remarks
		SFDI (Note1)	SFDO (Note2)	
3	Additional safety I/O board (R-30*i*B A-cabinet, B-cabinet, R-30*i*B Mate common)	8 pair（POS / NEG type）	8 pair (POS / POS type)	(Ordering Specification: A05B-2600-J131) Category 4
4	I/O Unit-MODEL A	(Note4)	(Note4)	Category 3

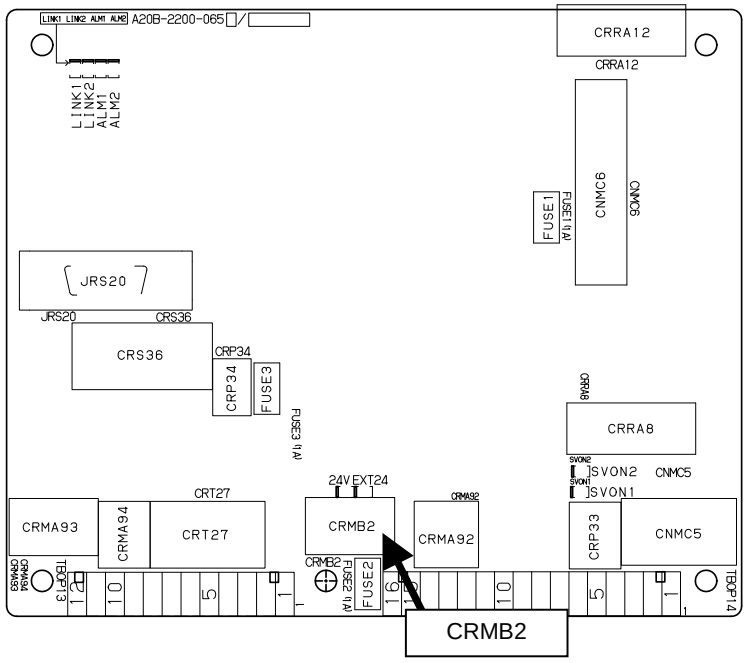
NOTE
1 Polarity of SFDI
NEGative : (Current source type, source type, or Nch)
Regard to be ON when input is at Low level.
POSitive : (Current sink type, sink type, or Pch)
Regard to be ON when input is at High level.
2 Polarity of SFDO
NEGative : (Current sink type) Output is at Low level when ON.
POSative : (Current source type) Output is at High level when ON.
3 If A05B-2600-J130 is not ordered, safety signals (SFDI, SFDO) can not be used in R-30*i*B B-cabinet.
4 Regarding the number of I/O points and polarity, please refer to the connection and maintenance manual of I/O Unit-MODEL A (B-61813).

⚠WARNING
At the initial start-up, the operation check and validation of the wiring for safety signals should be carried out, and then the wiring should be protected by the cable duct.

16.1 SAFETY SIGNAL INTERFACE

16.1.1 In Case of A-cabinet

In the A-cabinet of R-30*i*B, safety signals (SFDI, SFDO) are included in CRMB2 connector on the emergency stop board.



Emergency stop board (A-cabinet)

CRMB2 Connector

A1	24E	B1	0V
A2	24E	B2	0V
A3	SFDI11	B3	SFDI21
A4	SFDI12	B4	SFDI22
A5	SFDO11	B5	SFDO21
A6	SFDO12	B6	SFDO22

The specification of the connectors for cable side is shown below.

Manufacturer : TE Connectivity
Housing : 2-1827864-6
Contact : 1939991-2

Safety Inputs (SFDI)

SFDI11 - SFDI21
SFDI12 - SFDI22

Connect duplicitously as in the above combination.

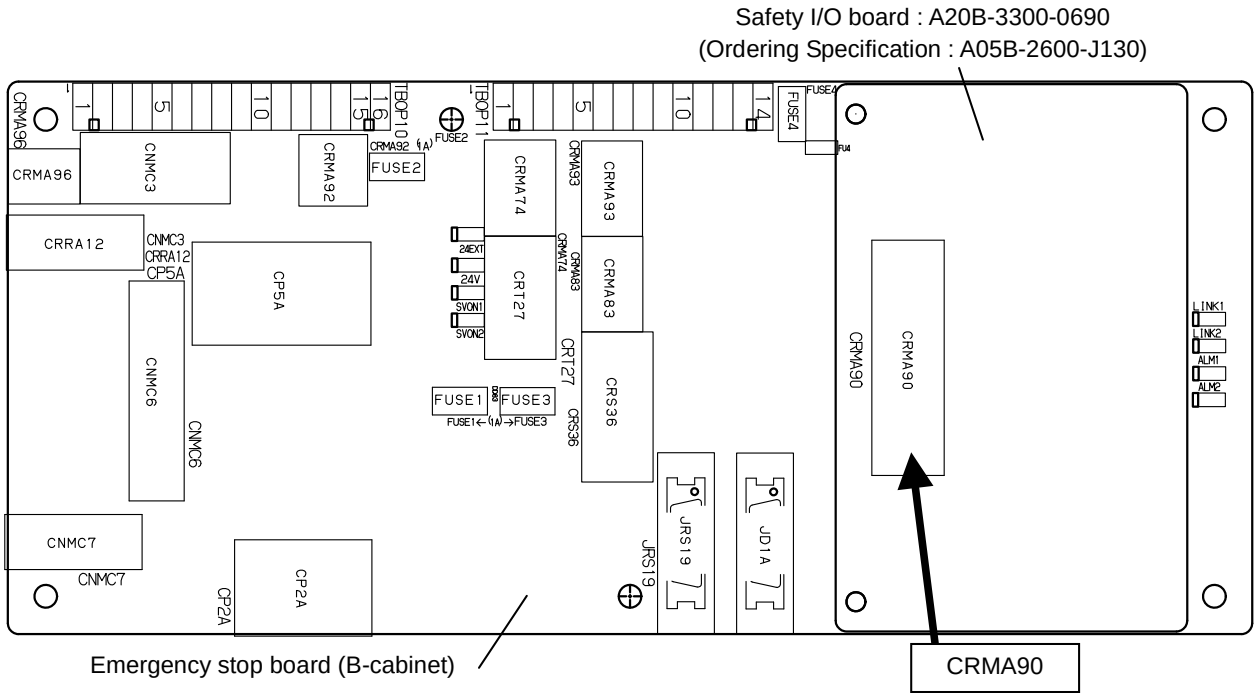
Safety Outputs (SFDO)

SFDO11 - SFDO21
SFDO12 - SFDO22

Connect duplicitously as in the above combination.

16.1.2 In Case of B-cabinet

In the B-cabinet of R-30*i*B, safety signals (SFDI, SFDO) are included in CRMA90 connector on the safety I/O board (option).



Emergency stop board (B-cabinet) and Safety I/O board (Option)

CRMA90 Connector

A1	24E	B1	0V
A2	SFDI11	B2	SFDI21
A3	SFDI12	B3	SFDI22
A4	SFDI13	B4	SFDI23
A5	SFDI14	B5	SFDI24
A6	SFDI15	B6	SFDI25
A7	SFDI16	B7	SFDI26
A8	SFDI17	B8	SFDI27
A9	SFDI18	B9	SFDI28
A10		B10	
A11	SFDO11	B11	SFDO21
A12	SFDO12	B12	SFDO22
A13	SFDO13	B13	SFDO23
A14	SFDO14	B14	SFDO24
A15	SFDO15	B15	SFDO25
A16	SFDO16	B16	SFDO26
A17	SFDO17	B17	SFDO27
A18	SFDO18	B18	SFDO28
A19	0V	B19	0V
A20	0V	B20	0V

The specification of the connectors for cable side is shown below.

Manufacturer : TE Connectivity
Housing : 1-1827863-0
Contact : 1939991-2

Safety Inputs (SFDI)

SFDI11 - SFDI21
SFDI12 - SFDI22
SFDI13 - SFDI23
SFDI14 - SFDI24
SFDI15 - SFDI25
SFDI16 - SFDI26
SFDI17 - SFDI27
SFDI18 - SFDI28

Connect duplicitously as in the above combination.

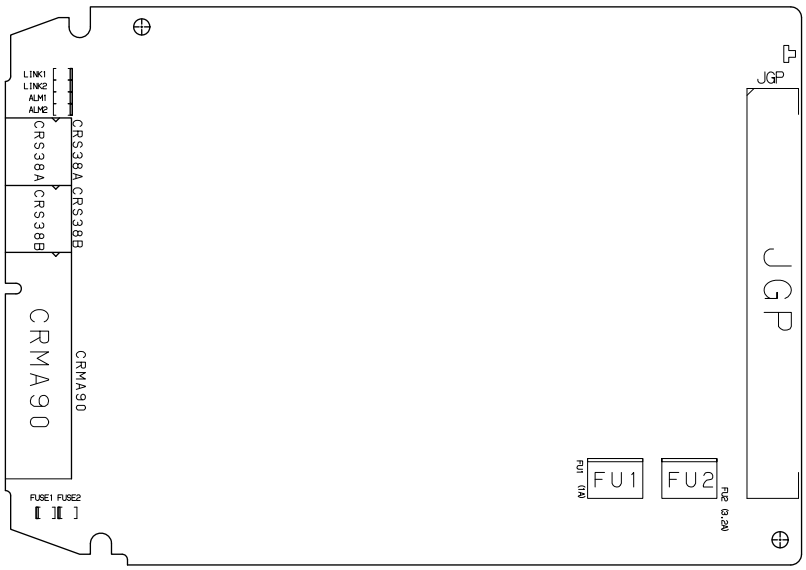
Safety Outputs (SFDO)

SFDO11 - SFDO21
SFDO12 - SFDO22
SFDO13 - SFDO23
SFDO14 - SFDO24
SFDO15 - SFDO25
SFDO16 - SFDO26
SFDO17 - SFDO27
SFDO18 - SFDO28

Connect duplicitously as in the above combination.

16.1.3 In Case of Additional Safety I/O Board (mini-slot)

In the additional safety I/O board, safety signals (SFDI, SFDO) are included in CRMA90 connector on the additional safety I/O board (mini-slot).



Additional safety I/O board (Option)

CRMA90 Connector

A1	24E	B1	0V
A2	SFDI11	B2	SFDI21
A3	SFDI12	B3	SFDI22
A4	SFDI13	B4	SFDI23
A5	SFDI14	B5	SFDI24
A6	SFDI15	B6	SFDI25
A7	SFDI16	B7	SFDI26
A8	SFDI17	B8	SFDI27
A9	SFDI18	B9	SFDI28
A10		B10	
A11	SFDO11	B11	SFDO21
A12	SFDO12	B12	SFDO22
A13	SFDO13	B13	SFDO23
A14	SFDO14	B14	SFDO24
A15	SFDO15	B15	SFDO25
A16	SFDO16	B16	SFDO26
A17	SFDO17	B17	SFDO27
A18	SFDO18	B18	SFDO28
A19	0V	B19	0V
A20	0V	B20	0V

The specification of the connectors for cable side is shown below.
Manufacturer : TE Connectivity
Housing : 1-1827863-0
Contact : 1939991-2

Safety Inputs (SFDI)
SFDI11 - SFDI21
SFDI12 - SFDI22
SFDI13 - SFDI23
SFDI14 - SFDI24
SFDI15 - SFDI25
SFDI16 - SFDI26
SFDI17 - SFDI27
SFDI18 - SFDI28

Connect duplicitously as in the above combination.

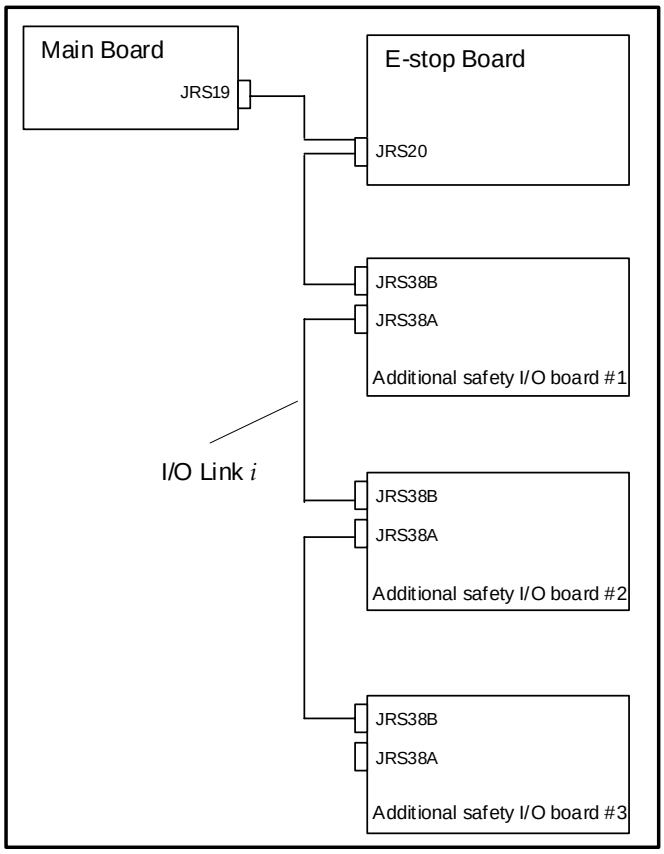
Safety Outputs (SFDO)
SFDO11 - SFDO21
SFDO12 - SFDO22
SFDO13 - SFDO23
SFDO14 - SFDO24
SFDO15 - SFDO25
SFDO16 - SFDO26
SFDO17 - SFDO27
SFDO18 - SFDO28

Connect duplicitously as in the above combination.

General connection diagram

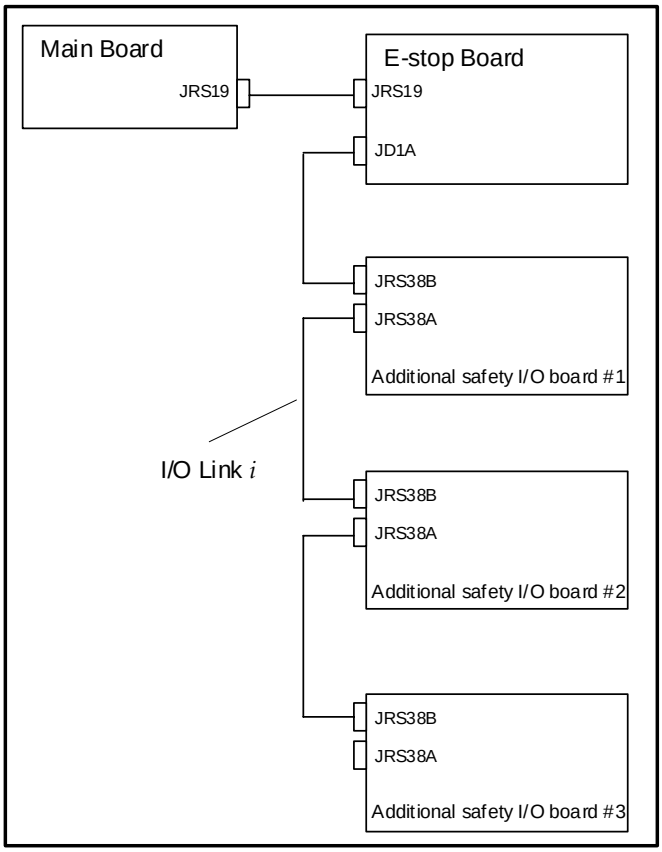
In case of A-cabinet

Additional safety I/O board is connected with I/O Link *i* as shown in the figure below.
E-stop board and additional safety I/O board are defined as “Group” of the I/O Link *i*. I/O Link *i* can connect up to 4 Groups.



In case of B-cabinet

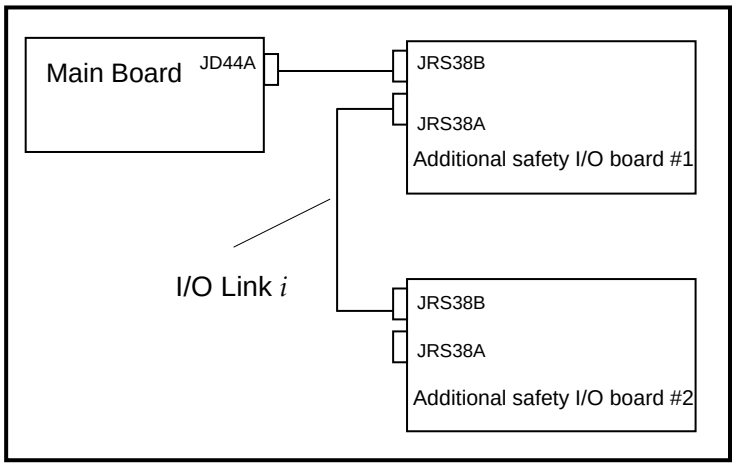
Additional safety I/O board is connected with I/O Link *i* as shown in the figure below.
E-stop board and additional safety I/O board are defined as "Group" of the I/O Link *i*. I/O Link *i* can connect up to 4 Groups.



In case of R-30*i*B Mate

Additional safety I/O board is connected with I/O Link *i* as shown in the figure below.
Additional safety I/O board is defined as "Group" of the I/O Link *i*. I/O Link *i* can connect up to 4 Groups.
The maximum number of safety I/O boards in the controller is 2 because the number of mini-slot is 2.

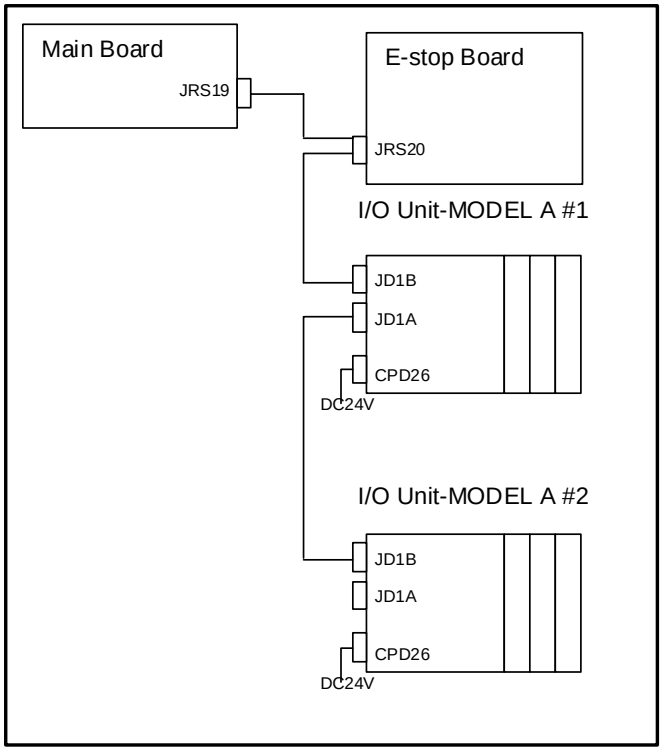
To use aadditional safety I/O board in R-30*i*B Mate controller, the main board that has PMC function is necessary.



16.1.4 In case of I/O Unit-MODEL A

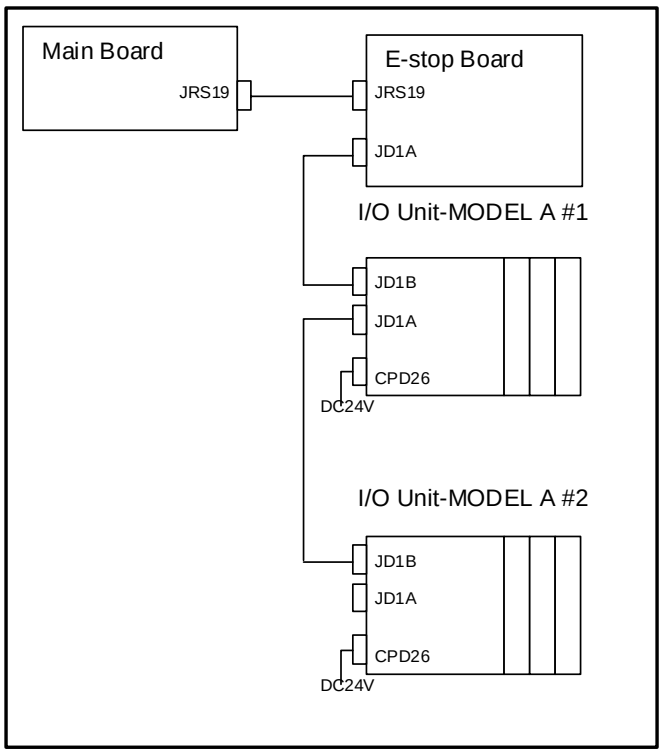
General connection diagram

In case of A-cabinet



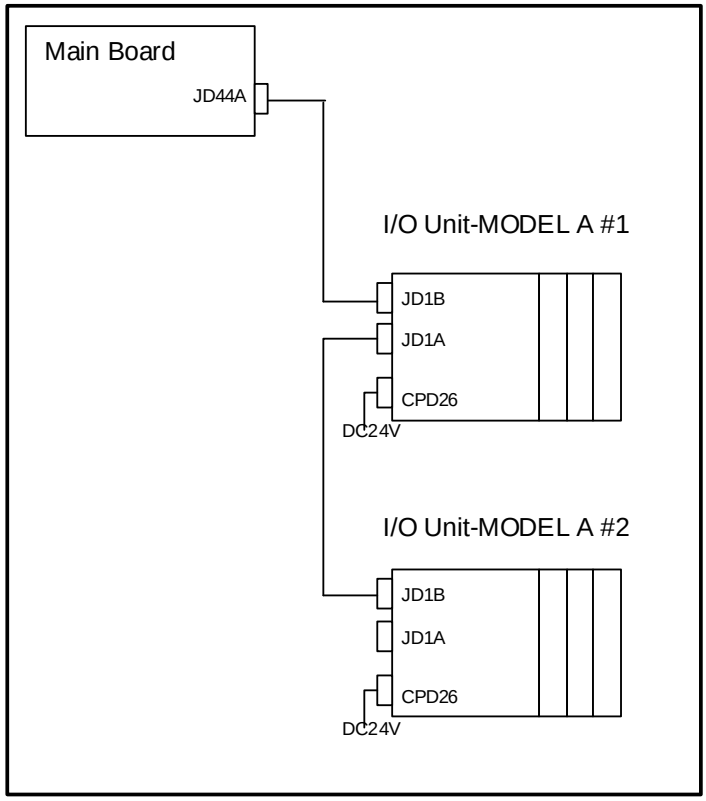
About the detail of connection, please refer to the connection and maintenance manual of I/O Unit-MODEL A (B-61813).

In case of B-cabinet



About the detail of connection, please refer to the connection and maintenance manual of I/O Unit-MODEL A (B-61813).

In case of R-30*i*B Mate



About the detail of connection, please refer to the connection and maintenance manual of I/O Unit-MODEL A (B-61813).
To use safety signals by I/O Unit-MODEL A, the main board that has PMC function is necessary.

Available module

Table 16.1.4(a), Table 16.1.4(b) and Table 16.1.4(c) shows the details of the available interface safety I/O board of category 3.

Table 16.1.4(a) Detail of available digital input modules of I/O Unit-MODEL A

Module name	Option	Points	Input type
AID16C	A05B-2450-J402	16	Insulation type DC input
AID16K	A05B-2450-J410		
AID16D	A05B-2450-J403		
AID16L	A05B-2450-J411		
AID32E1	A05B-2450-J404	32	
AID32E2	A05B-2450-J405		
AID32F1	A05B-2450-J406		
AID32F2	A05B-2450-J407		

Table 16.1.4(b) Detail of available digital output modules of I/O Unit-MODEL A

Module name	Option	Points	Output type
AOD08D	A05B-2450-J432	8	Insulation type DC output
AOD16D	A05B-2450-J434	16	
AOD16DP	A05B-2450-J444		
AOD32D1	A05B-2450-J436	32	
AOD32D2	A05B-2450-J437		

Module name	Option	Points	Output type
AOR08G	A05B-2450-J441	8	RELAY output
AOR16G	A05B-2450-J442	16	
AOR16H2	A05B-2450-J443		

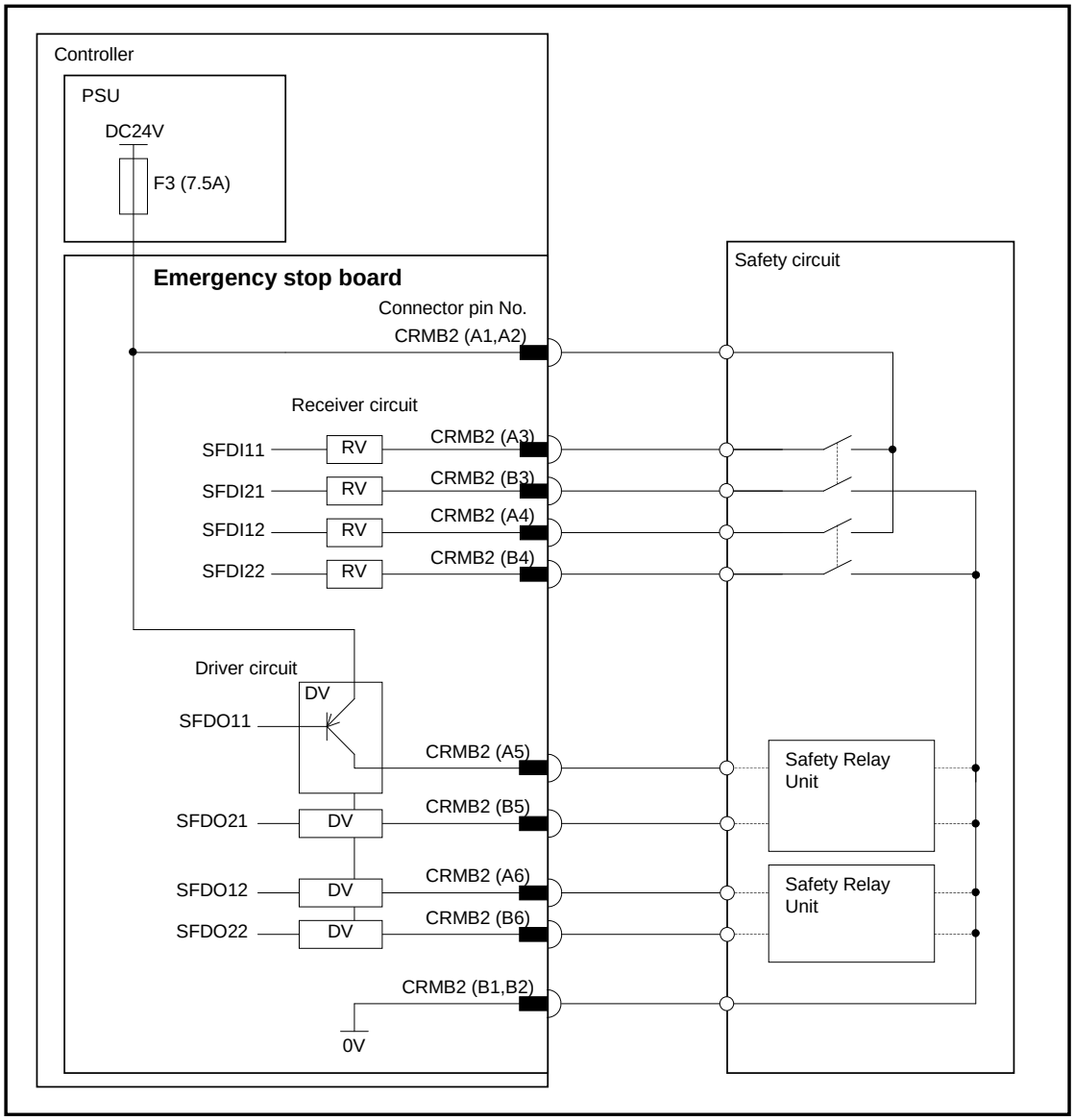
Table 16.1.4(c) Detail of available interface modules of I/O Unit-MODEL A

Module name	Option
AIF01E	A03B-0826-J016

16.2 PERIPHERAL DEVICE AND SAFETY SIGNALS CONNECTION

16.2.1 In Case of A-cabinet

Example of the Connection diagram



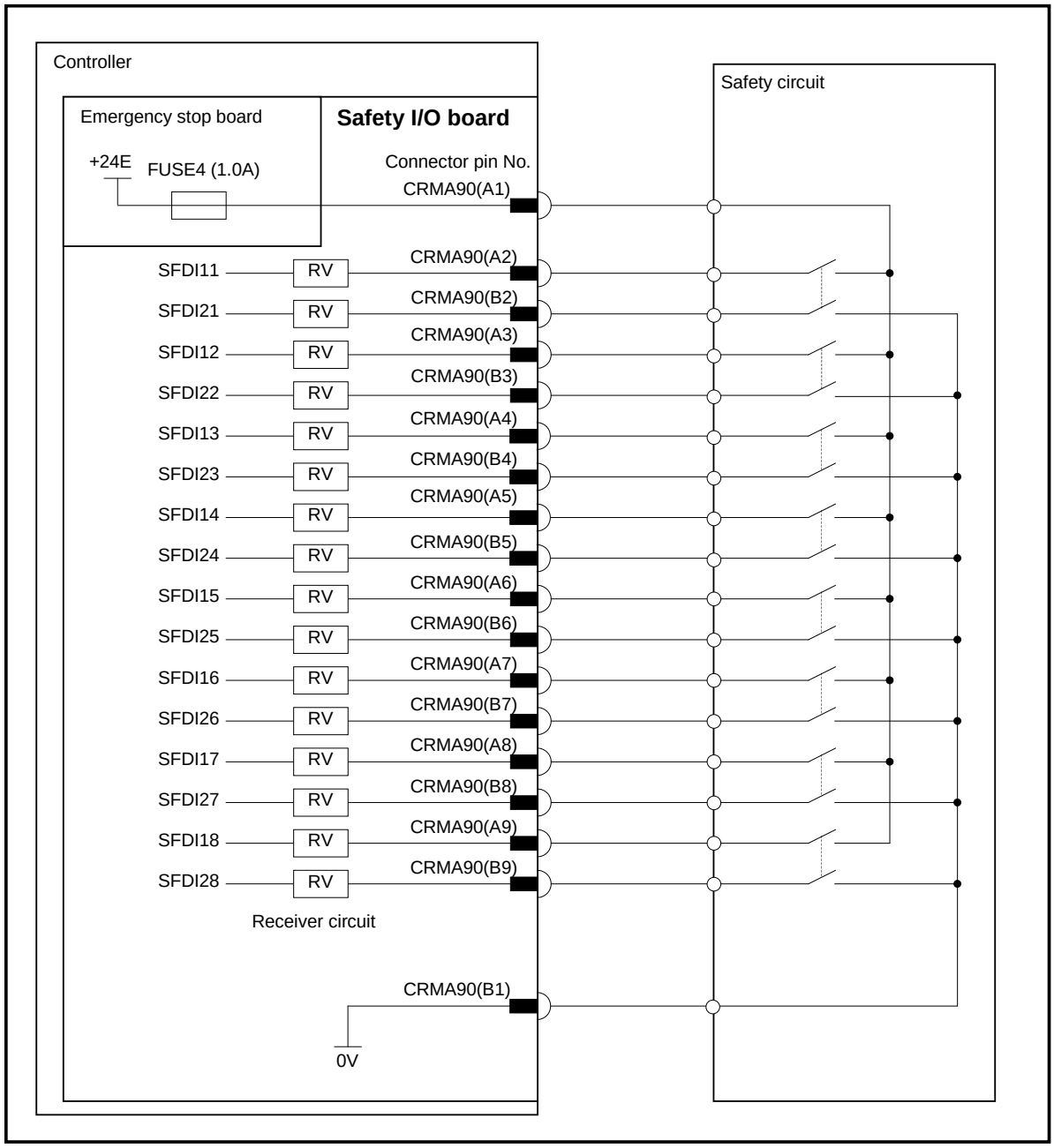
Signals	Description	Remarks
SFDI11 - SFDI21 SFDI12 - SFDI22	Safety Inputs: Connect redundant contacts to the pair of SFDI.	See section 16.3.1 for detailed information about Safety Input Specifications.
SFDO11 - SFDO21 SFDO12 - SFDO22	Safety Outputs: Connect redundant circuits (e.g. safety relay unit) to the pair of SFDO.	See section 16.3.2 for detailed information about Safety Output Specifications.

⚠WARNING
1 Be sure to use the pair of SFDI11 with SFDI21, and SFDI12 with SFDI22.
2 Be sure to use the pair of SFDO11 with SFDO21, and SFDO12 with SFDO22.

- To use SFDO as safety function of Cat. 4, PL e, SIL 3, SFDO pulse check must be enable to avoid the fault accumulation. See section 5.1.1 for detailed information about SFDO Pulse Check.

16.2.2 In Case of B-cabinet

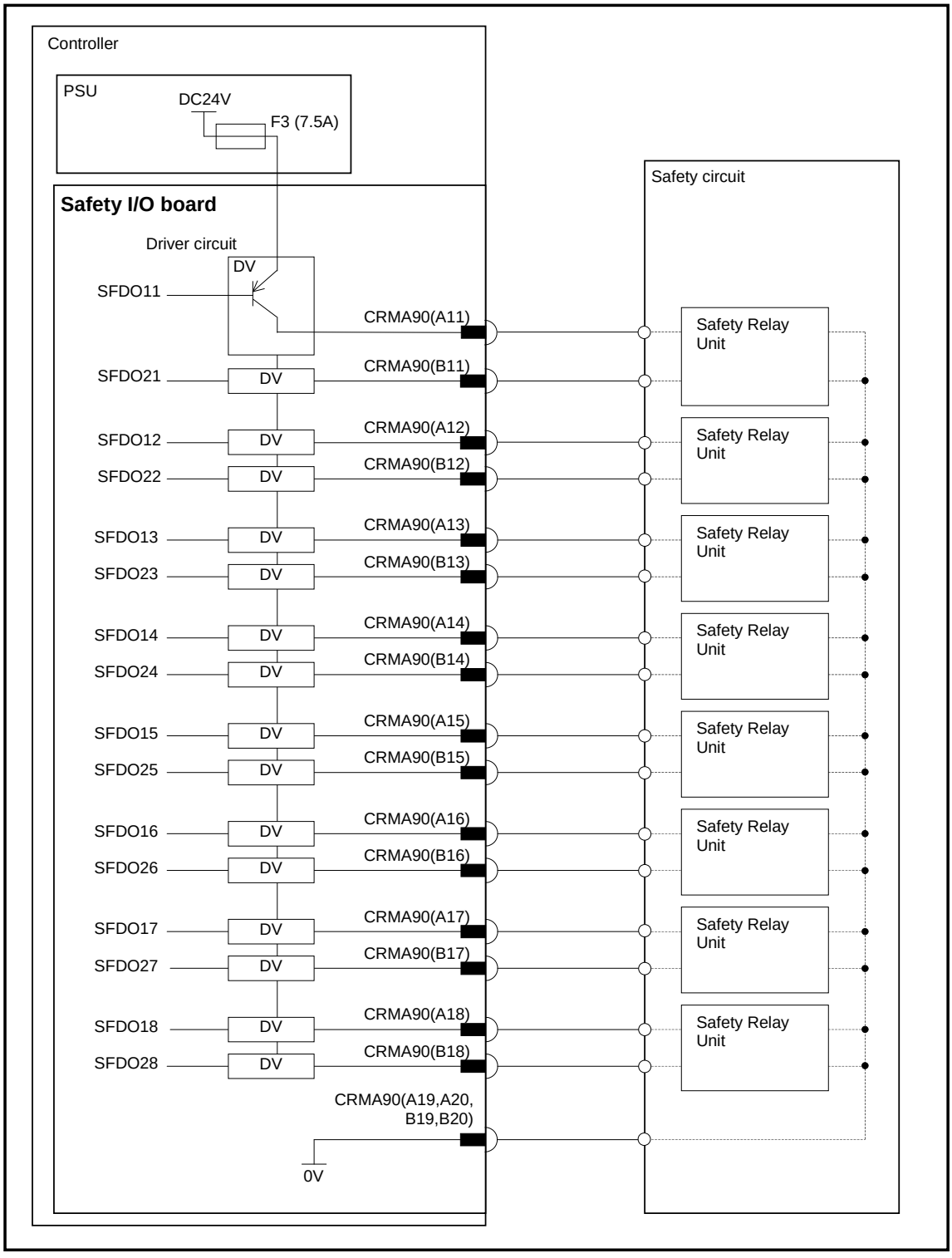
Example of the Connection diagram



Signals	Description	Remarks
SFDI11 - SFDI21 SFDI12 - SFDI22 SFDI13 - SFDI23 SFDI14 - SFDI24 SFDI15 - SFDI25 SFDI16 - SFDI26 SFDI17 - SFDI27 SFDI18 - SFDI28	Safety Inputs: Connect redundant contacts to the pair of SFDI.	See section 16.3.1 for detailed information about Safety Input Specifications.

⚠WARNING
Be sure to use the pair of
SFDI 11 with SFDI 21, SFDI 12 with SFDI 22,
SFDI 13 with SFDI 23, SFDI 14 with SFDI 24,
SFDI 15 with SFDI 25, SFDI 16 with SFDI 26,
SFDI 17 with SFDI 27, and SFDI 18 with SFDI 28.

Example of the Connection diagram



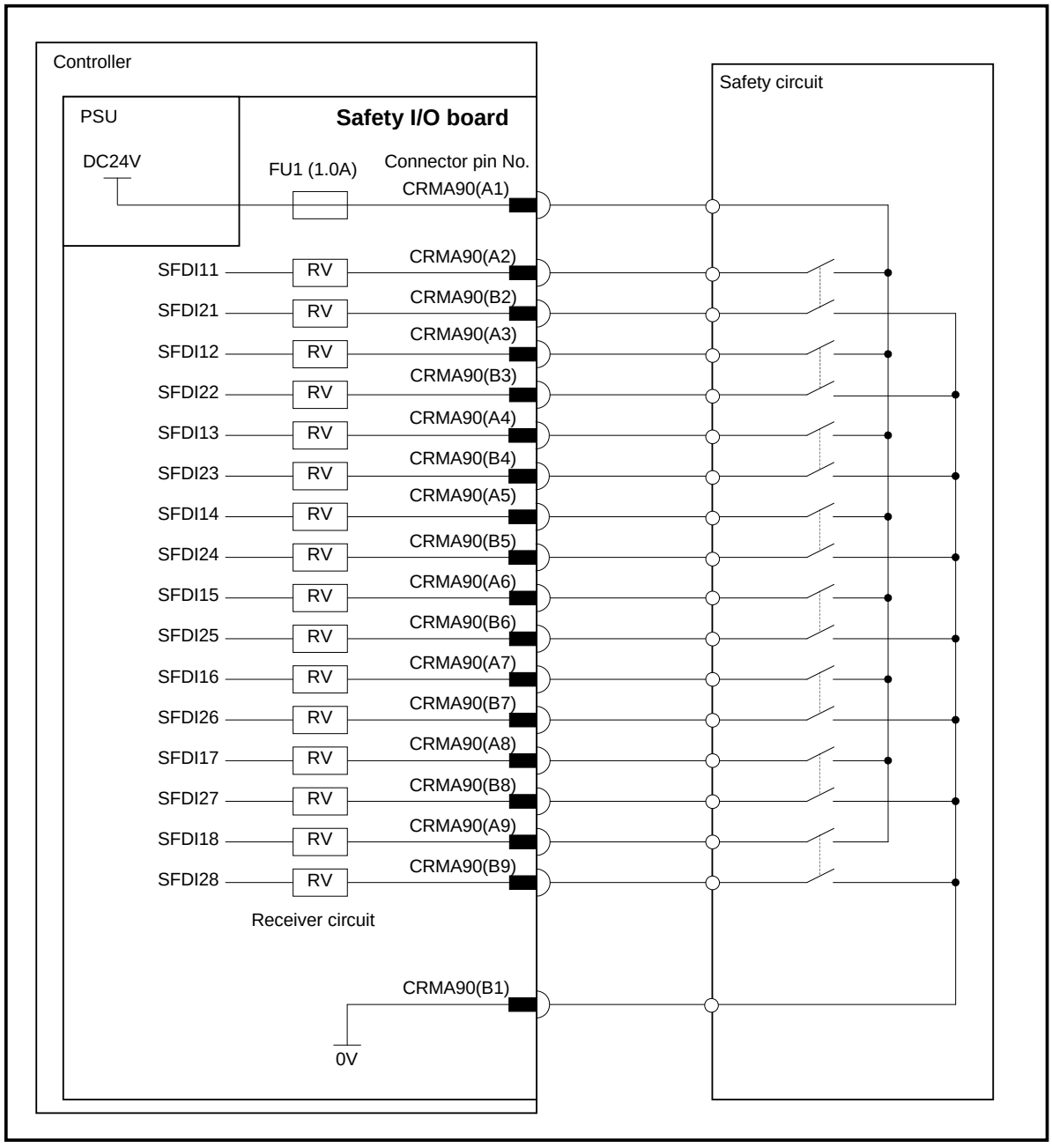
Signals	Description	Remarks
SFDO11 － SFDO21 SFDO12 － SFDO22 SFDO13 － SFDO23 SFDO14 － SFDO24 SFDO15 － SFDO25 SFDO16 － SFDO26 SFDO17 － SFDO27 SFDO18 － SFDO28	Safety Outputs: Connect redundant circuits (e.g. safety relay unit) to the pair of SFDO.	See section 16.3.2 for detailed information about Safety Output Specifications.

⚠WARNING
Be sure to use the pair of
SFDO11 with SFDO21, SFDO12 with SFDO22,
SFDO13 with SFDO23, SFDO14 with SFDO24,
SFDO15 with SFDO25, SFDO16 with SFDO26,
SFDO17 with SFDO27, and SFDO18 with SFDO28.

- To use SFDO as safety function of Cat. 4, PL e, SIL 3, SFDO pulse check must be enable to avoid the fault accumulation. See section 5.1.1 for detailed information about SFDO Pulse Check.

16.2.3 In Case of Additional Safety I/O Board (mini-slot)

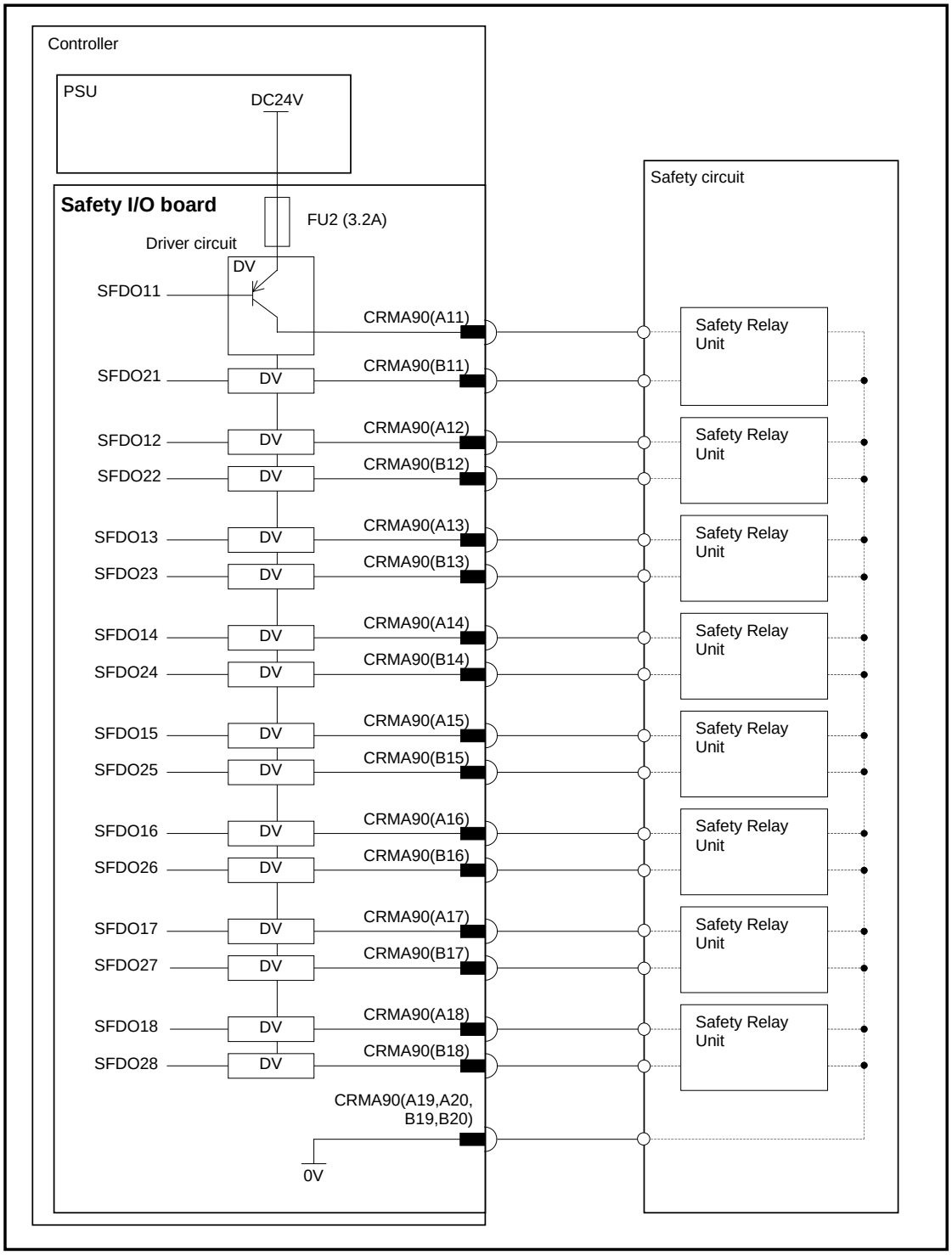
Example of the Connection diagram



Signals	Description	Remarks
SFDI11 - SFDI21 SFDI12 - SFDI22 SFDI13 - SFDI23 SFDI14 - SFDI24 SFDI15 - SFDI25 SFDI16 - SFDI26 SFDI17 - SFDI27 SFDI18 - SFDI28	Safety Inputs: Connect redundant contacts to the pair of SFDI.	See section 16.3.1 for detailed information about Safety Input Specifications.

⚠WARNING
Be sure to use the pair of
SFDI 11 with SFDI 21, SFDI 12 with SFDI 22,
SFDI 13 with SFDI 23, SFDI 14 with SFDI 24,
SFDI 15 with SFDI 25, SFDI 16 with SFDI 26,
SFDI 17 with SFDI 27, and SFDI 18 with SFDI 28.

Example of the Connection diagram



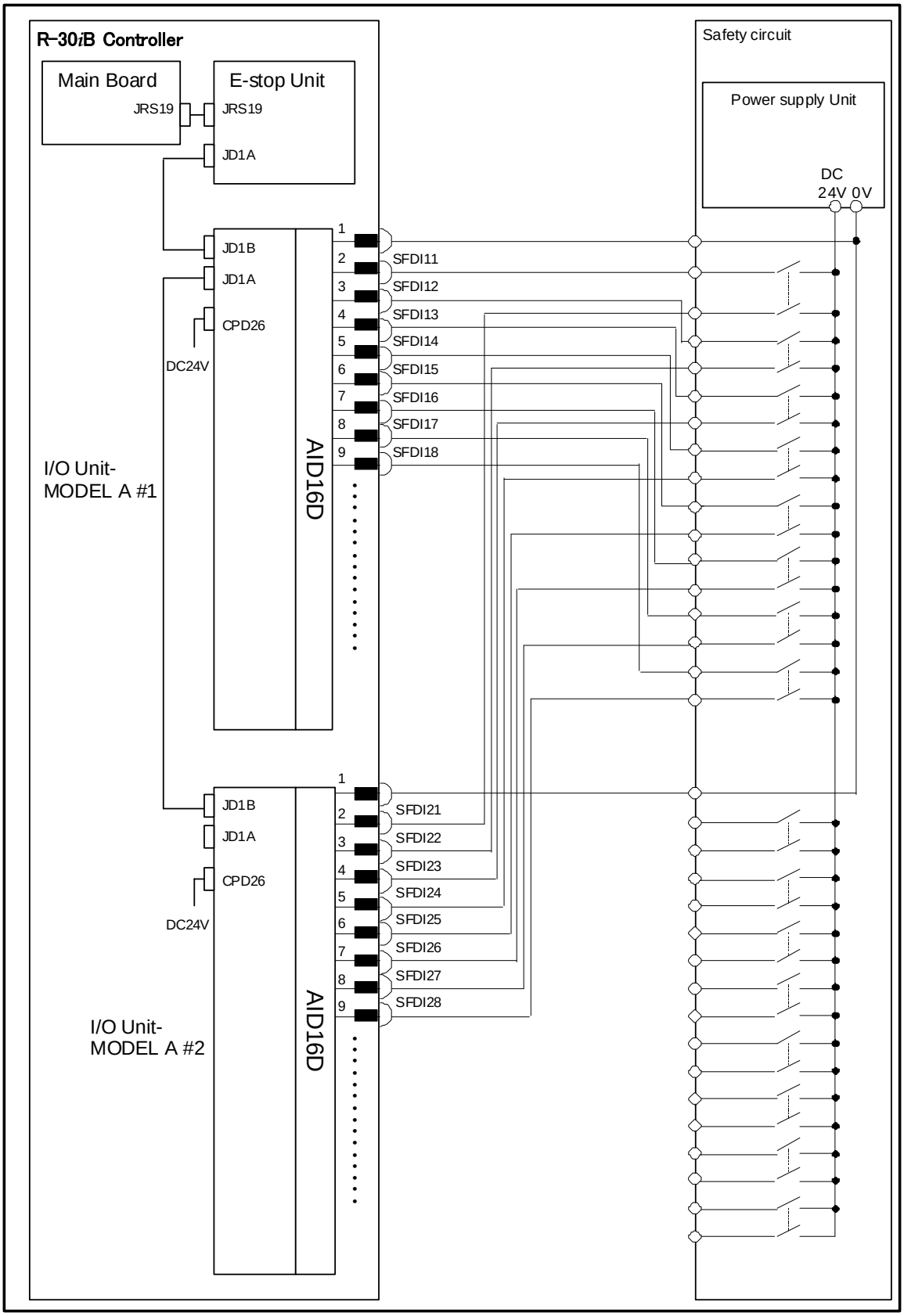
Signals	Description	Remarks
SFDO11 － SFDO21 SFDO12 － SFDO22 SFDO13 － SFDO23 SFDO14 － SFDO24 SFDO15 － SFDO25 SFDO16 － SFDO26 SFDO17 － SFDO27 SFDO18 － SFDO28	Safety Outputs: Connect redundant circuits (e.g. safety relay unit) to the pair of SFDO.	See section 16.3.2 for detailed information about Safety Output Specifications.

⚠WARNING
Be sure to use the pair of
SFDO11 with SFDO21, SFDO12 with SFDO22,
SFDO13 with SFDO23, SFDO14 with SFDO24,
SFDO15 with SFDO25, SFDO16 with SFDO26,
SFDO17 with SFDO27, and SFDO18 with SFDO28.

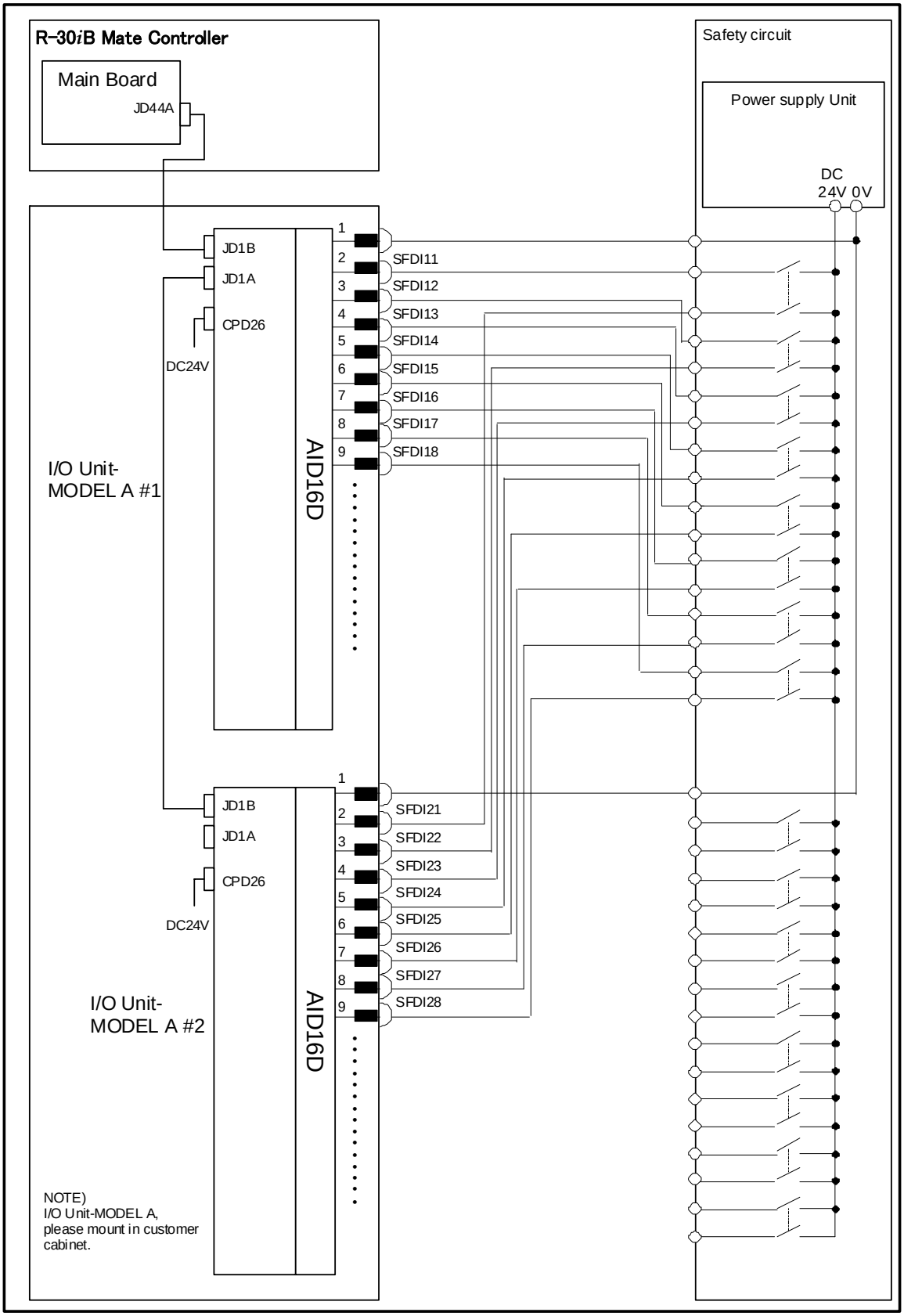
- To use SFDO as safety function of Cat. 4, PL e, SIL 3, SFDO pulse check must be enable to avoid the fault accumulation. See section 5.1.1 for detailed information about SFDO Pulse Check.

16.2.4 In Case of I/O Unit-MODEL A

In case of using the input module of AID16D (Example 1)



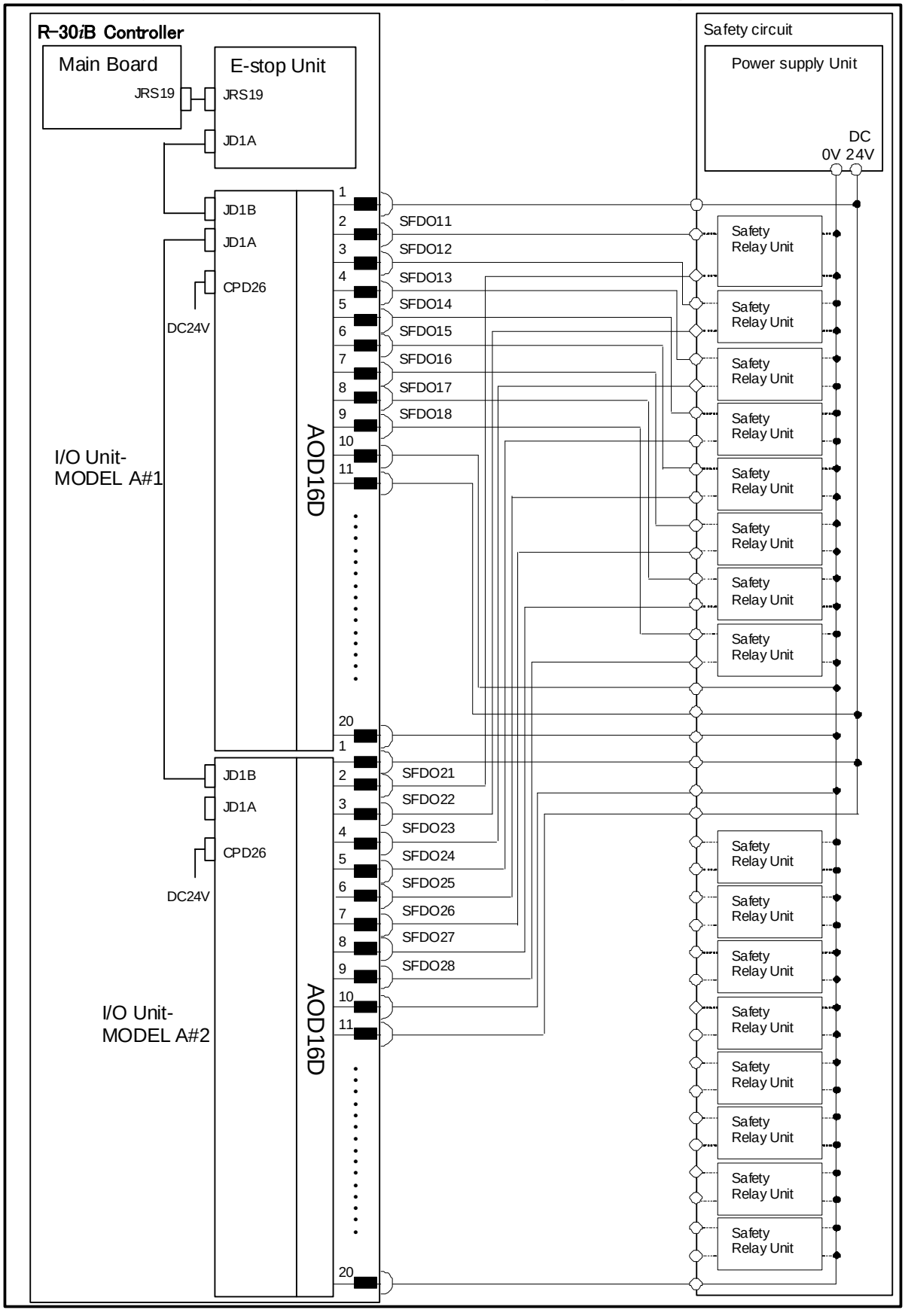
In case of using the input module of AID16D (Example 2)



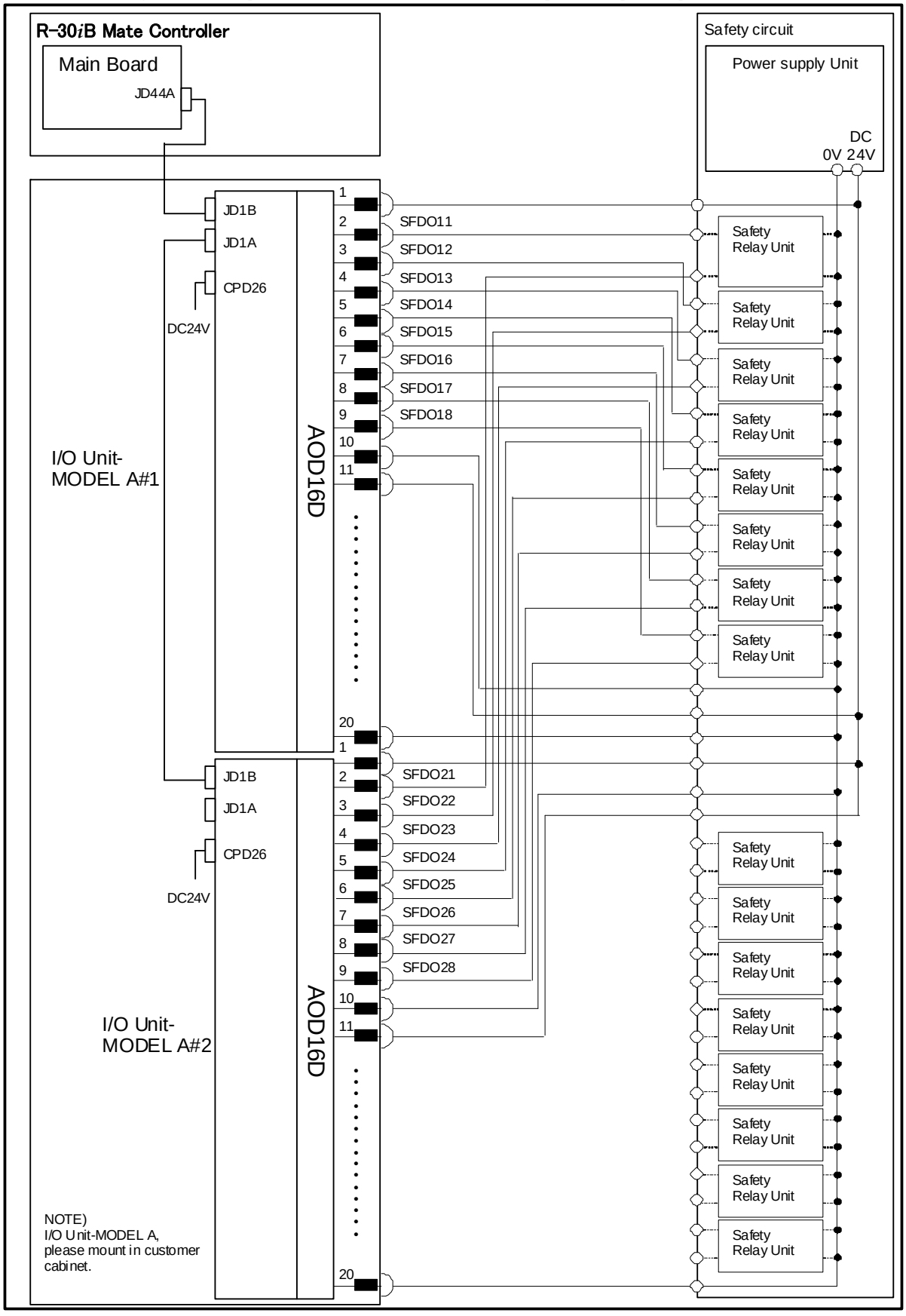
Signals	Description	Remarks
SFDI11 - SFDI21 SFDI12 - SFDI22 SFDI13 - SFDI23 SFDI14 - SFDI24 SFDI15 - SFDI25 SFDI16 - SFDI26 SFDI17 - SFDI27 SFDI18 - SFDI28 SFDI19 - SFDI29 SFDI110 - SFDI210 SFDI111 - SFDI211 SFDI112 - SFDI212 SFDI113 - SFDI213 SFDI114 - SFDI214 SFDI115 - SFDI215 SFDI116 - SFDI216	Safety Inputs: Connect redundant contacts to the pair of SFDI.	See the connection and maintenance manual of I / O Unit-MODEL A(B-61813) for detailed information about Safety Input Specifications.

⚠WARNING
Be sure to use the pair of
SFDI 11 with SFDI 21, SFDI 12 with SFDI 22,
SFDI 13 with SFDI 23, SFDI 14 with SFDI 24,
SFDI 15 with SFDI 25, SFDI 16 with SFDI 26,
SFDI 17 with SFDI 27, SFDI 18 with SFDI 28,
SFDI 19 with SFDI 29, SFDI 110 with SFDI 210,
SFDI 111 with SFDI 211, SFDI 112 with SFDI 212,
SFDI 113 with SFDI 213, SFDI 114 with SFDI 214,
SFDI 115 with SFDI 215, and SFDI 116 with SFDI 216.

In case of using the output module of AOD16D (Example 1)



In case of using the output module of AOD16D (Example 2)



Signals	Description	Remarks
SFDO11 － SFDO21 SFDO12 － SFDO22 SFDO13 － SFDO23 SFDO14 － SFDO24 SFDO15 － SFDO25 SFDO16 － SFDO26 SFDO17 － SFDO27 SFDO18 － SFDO28 SFDO19 － SFDO29 SFDO110 － SFDO210 SFDO111 － SFDO211 SFDO112 － SFDO212 SFDO113 － SFDO213 SFDO114 － SFDO214 SFDO115 － SFDO215 SFDO116 － SFDO216	Safety Outputs: Connect redundant circuits (e.g. safety relay unit) to the pair of SFDO.	See the connection and maintenance manual of I / O Unit-MODEL A (B-61813) for detailed information about Safety Output Specifications.

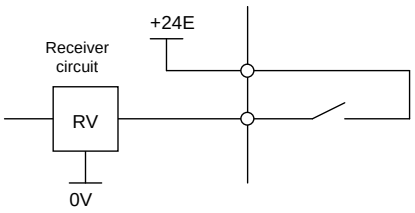
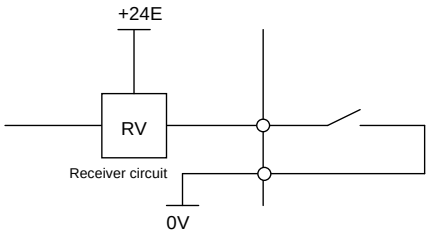
⚠WARNING

Be sure to use the pair of
SFDO11 with SFDO21, SFDO12 with SFDO22,
SFDO13 with SFDO23, SFDO14 with SFDO24,
SFDO15 with SFDO25, SFDO16 with SFDO26,
SFDO17 with SFDO27, SFDO18 with SFDO28,
SFDO19 with SFDO29, SFDO110 with SFDO210,
SFDO111 with SFDO211, SFDO112 with SFDO212,
SFDO113 with SFDO213, SFDO114 with SFDO214,
SFDO115 with SFDO215, and SFDO116 with SFDO216.

16.3 SAFETY SIGNAL SPECIFICATIONS

16.3.1 Safety Input Specifications

(a) Electrical specifications of the receiver

Polarity (Note 1)	POS	NEG
Applicable signals	SFDI11-18	SFDI21-28
Rated input voltage	Contact close +20V to +28V Contact open 0V to +4V	Contact close 0V to +4V Contact open +20V to +28V
Maximum applied input voltage	+28VDC	
Input impedance	3.0kΩ (approx.)	
Response Time	From SFDI input to software detection: 6ms(Max.) From software detection to SFDO output: 2ms(Max.)	
Example of connection		

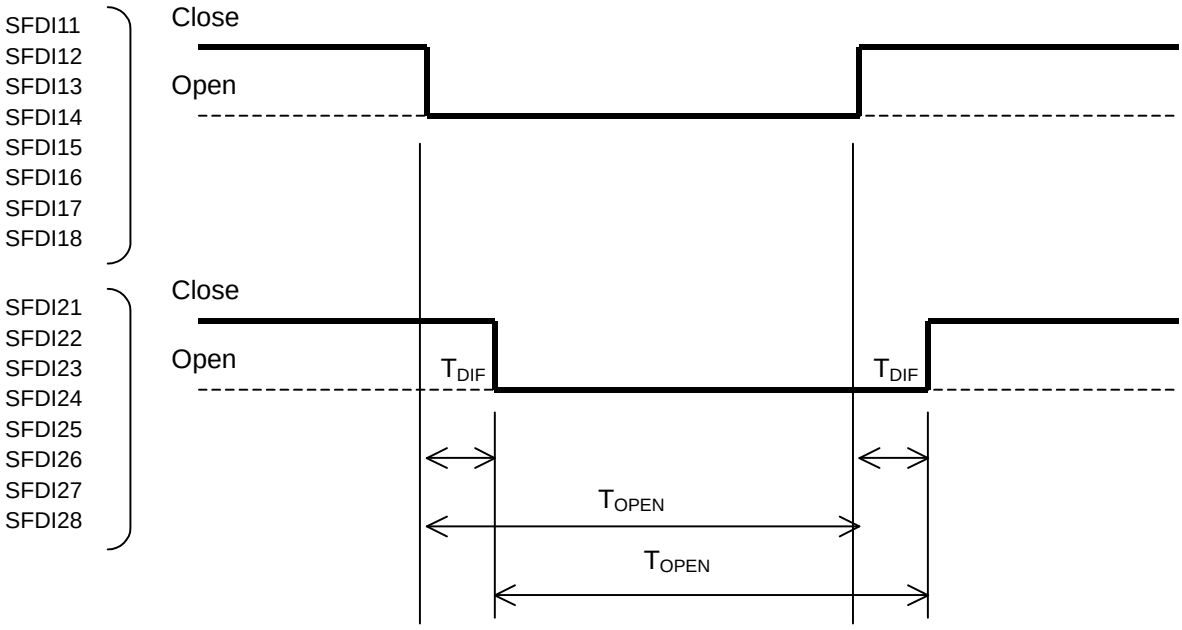
NOTE 1
Polarity of SFDI
NEGative : (Current source type, source type, or Nch)
Regard to be ON when input is at Low level.
POSitive : (Current sink type, sink type, or Pch)
Regard to be ON when input is at High level.

(b) Specifications of the peripheral device contact

Voltage and Current	Open and close of 24VDC 0.1A * Use a contact which minimum load is 5mA or less
Closed circuit resistance	100Ω or less
Opened circuit resistance	100kΩ or more

(c) Input timing

Duplicate inputs are used for the SFDI signal so that the safety function works correctly when a single failure occurs. The statuses of these duplicate input signals must always be changed at the same time according to the timing specifications provided in this section. The robot controller always checks that the statuses of the duplicate inputs are the same, and if controller finds a discrepancy, it issues an alarm. If the timing specifications are not satisfied, an alarm may be issued because of a signal discrepancy.

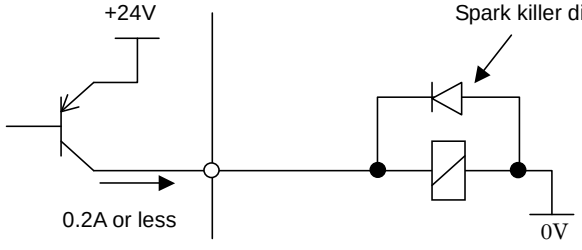


T_{DIF} (input time difference) < 200msec

T_{OPEN} (input hold period) > 2sec

16.3.2 Safety Output Specifications

(a) Electrical specifications

Polarity (Note 1)	POS
Applicable signals	SFDO11-18, SFDO21-28
Rated output voltage	24VDC (±10%)
Rated output current	200mA, including momentary variations
Maximum voltage decrease ON	28mV (output current is 200mA)
Maximum leakage current when OFF	5μA
Output protection function	Protection against overheat, over current, short-circuiting
Delay time	The driver delay time is 50μs (maximum) In addition, I/O Link *i* transfer time between Main board and Emergency stop board must be considered.
Example of connection	

NOTE 1
Polarity of SFDO
NEGative : (Current sink type) Output is at Low level when ON.
POSative : (Current source type) Output is at High level when ON.

⚠ **CAUTION**
1 The protection function is intended to protect the components internal rather than external units.
2 No protection function can protect their internal components in all cases. Once any protection function has worked, remove the cause promptly. If an absolute maximum rating is exceeded, for example, it is likely that protection functions may not work or an IC may break down before the related protection function works, depending on the way or situation in which the modules are used.
3 If an output protection function is defective, it is likely that, if the load current exceeds its rating continuously for a long time, smoke or ignition may occur.

(b) Power supply to output signals
The +24V power supply of R-30*i*B can be used if the total current of all SFDOs is 0.7A or less.

(c) Spark killer diode

Rated peak reverse voltage	:	100V or more
Rated effective forward current	:	1A or more

(d) Note on use
When adding a relay, solenoid, or the like directly to the circuit, connect a diode for counter electromotive voltage protection in parallel to the load.

17 ALARM CODES

SYST-212 Need to apply to DCS param

Cause: The setting parameter has been changed, and is now different from DCS parameter.
Remedy: Do an "APPLY" operation in DCS menu.

SYST-217 DCS is not available

Cause: DCS Function is not available in this hardware.
Remedy: 1. Delete DCS option.
2. Change the hardware to one that can be used for DCS function.

SYST-218 DCS Unavailable robot model G:%x Hex

Cause: "DCS Position/Speed Check Function" option is loaded, but this robot model is not supported. "i" is a hexadecimal value and each bit corresponds to a motion group.
Remedy: Delete DCS Position/Speed Check option.
This alarm can be cleared by setting $DCS_CFG.$EXCLUDE[motion group] to -1, but in this case, Position/Speed Check function cannot be used in this motion group.

SYST-219 Need to apply DCS param (%d)

Cause: 1 : An image backup has been loaded, and now the setting parameter and DCS parameter are different.
2 : F4"OK" has not been pressed in the DCS apply menu.
Remedy: Do an "APPLY" operation in DCS menu.

SYST-288 Failed to write DCS parameter(%x)

Cause: Failed to write the DCS parameters.
Remedy: 1. Check free size of FROM.
2. Change FROM/SRAM module.

SYST-289 Cannot apply to DCS parameter(%x)

Cause: Failed to apply DCS parameters.
Remedy: If a DCS apply is in progress in another screen, please wait, and try again.

SYST-290 Cycle power to use new DCS parameter

Cause: Controller power has not been cycled after doing an apply of the DCS parameters.
Remedy: Cycle controller power, and test DCS function with the new DCS parameter setting.

SYST-308 DCS SHIFT+RESET requires T1 mode

Cause: Shift Reset is pressed in T2 or AUTO mode.
Remedy: To reset DCS alarm, select T1 mode and press Shift Reset.

SYST-311 Shared TP: Multiple TP connection

Cause: Robot cannot be operated because multiple Teach Pendants are wired to controllers in Shared Teach Pendant group.
Remedy: Disconnect unnecessary Teach Pendant and wire only one Teach Pendant.

SYST-312 Shared TP: FL-net is disabled

Cause: Teach Pendant cannot log in to the controller, because Safety Function by FL-net is disabled.
Remedy: Check setting of Shared Teach Pendant function.

SYST-313 Shared TP: Shared TP is disabled

Cause: Teach Pendant cannot log in to the controller, because Shared Teach Pendant function is disabled.
Remedy: Check setting of FL-net function, Safety Function by FL-net and Shared Teach Pendant function.

SYST-314 Shared TP: shared group config error

Cause: Teach Pendant cannot log in to the controller, because this controller is not included to Shared Teach Pendant group.
Remedy: Refer section 13.1 and check setting Shared Teach Pendant function.

SYST-315 Shared TP: his robot is bypassed

Cause: Teach Pendant cannot log in to the controller, because this robot is bypassed.
Remedy: Change bypass setting of the controller to OFF.

SYST-331 Shared TP: config error (%s)

Cause: The controller is offline because Shared TP function or FL-net function is disabled on the controller.
Remedy: Refer section 13.1 and check setting Shared Teach Pendant function.

SYST-332 Shared TP: safety config mismatch (%s)

Cause: Safety configurations are not matched between the controller and own controller.
Remedy: Refer section 13.1 and check setting Shared Teach Pendant function.

SYST-333 Shared TP: bypass status mismatch (%s)

Cause: Bypass statuses are not matched between the controller and own controller. For example, Robot1 is bypassed Robot2 but Robot is contained Robot2 in Shared Teach Pendant group (not bypassed). Robot cannot be operated when each bypass statutes are consistency.
Remedy: Set the same bypass status on the both controllers.

SYST-334 Shared TP: address error (%s)

Cause: Different IP address is used between the controller and own controller (as setting of Ethernet port, ROSIPCFG.XML and FL-net).
Remedy: Refer section 13.1 and check setting Shared Teach Pendant function.

SYST-335 Shared TP: version mismatch (%s)

Cause: Software version is not matched between the controller and own controller. Shared Teach Pendant function cannot be used.
Remedy: Update software and use the same version software on controllers in Shared Teach Pendant group.

SYST-336 Shared TP: TP is already connected

Cause: Teach Pendant cannot log in to the controller, because other Teach Pendant already logs in this controller.
Remedy: Log out the controller by other Teach pendant witch log in the controller.

SYST-337 Shared TP: %s is offline

Cause: Robot cannot be operated the controller is offline.
Remedy:

1. Power up the controller.
2. Check if the controller is cabled by Ethernet.
3. Refer section 13.1 and check setting Shared Teach Pendant function.
4. Set Bypass signals of offline controllers to ON.

SYST-338 Shared TP: E-stop on %s

Cause: Emergency stop occurs on the controller.
Remedy: Release Teach Pendant, Operator Panel and External emergency stop on the controller.

SRVO-217 E-STOP Board not found %s

Cause: The emergency stop board or additional Safe I/O device is not found when the controller power is turned on.
When two or more Safe I/O devices are connected, the number of the safe I/O device that the alarm occurs is displayed in the end of the message such as (1). The safe I/O device number is displayed in DCS Safe I/O device menu.
Remedy:

1. Check whether fuse FUSE1 on the emergency stop board has blown. If the fuse has blown, check and correct the cause then replace the fuse.
2. Check the cable between emergency stop board and main board. Replace them if necessary.
3. Replace the E-Stop unit.
4. When the additional safety I/O board is connected, for the robot controller that the slave controller is connected such as M-2000iA, this alarm occurs. In this case, initialize the safety I/O device.
5. Check the cable between additional safe I/O device and emergency stop board. Replace them if necessary.
6. Replace the additional safe I/O device.

Before executing the remedy 7, perform a complete controller back up as image to save all your programs and settings.

7. Replace the main board, and restore the image backup.

Refer to the Controller Maintenance Manual for more information.

SRVO-219 Safety I/O brd fuse%d blown %s

Cause: A fuse on the additional Safe I/O board has blown.
The number of the safe I/O device that the alarm occurs is displayed in the end of the message such as (1). The safe I/O device number is displayed in DCS Safe I/O device menu.

Remedy: Replace the the fuse on the additional Safe I/O board or the additional Safe I/O board. Refer to the Controller Maintenance Manual for more information.

SRVO-230 Chain 1 abnormal %x,%x %s

Cause:

1. A failure occurred in chain 1 (+24V) / chain2 (0V) of emergency stop circuit.
   SRVO-230 is issued if such a mismatch that a contact connected on the chain 1 side is closed, and a contact on the chain 2 side is open occurs. SRVO-231 is issued if such a mismatch that a contact on the chain 1 side is open and a contact on the chain 2 side is closed occurs. If a chain error is detected, correct the cause of the alarm then reset the alarm according to the method described later.
2. There is a possibility that the specification of the teach pendant is incorrect when occurring immediately after turning on of the power supply. For instance, this might occur if the teach pendant of non-RIA/CE specification is connected with the controller of the RIA/CE specification.

There is a possibility that the specification of the teach pendant is incorrect when occurring immediately after turning on of the power supply. For instance, this might occur if the teach pendant of non-RIA/CE specification is connected with the controller of the RIA/CE specification.

Remedy:

1. In the above case 2, connect a correct teach pendant.
2. Confirm the history of the alarm on the Alarm Log screen [4 Alarm / HIST]. If occurring with either 'Operator panel E-stop', 'Teach pendant E-stop' or 'Deadman switch released', the emergency stop button is released, and it presses again. For deadman switch, the deadman switch is gripped once and it released again. Chain abnormal state was released if occurring SRVO-236 'Chain failure is repaired'. Release the emergency stop button, deadman and press RESET.
3. If this alarm cannot be reset, refer to the Controller Maintenance Manual for more information.

After these measures, the release operation of chain abnormal state is necessary.

a. Press the emergency stop button on the teach pendant or operator panel once and release it.
b. Press F4 'RES_1CH' on the Alarm Active screen [4 Alarm / ACTIVE].
c. Press RESET.

SRVO-231 Chain 2 abnormal %x,%x %s

Cause:

1. A failure occurred in chain 1 (+24V) / chain2 (0V) of emergency stop circuit.
   SRVO-230 is issued if such a mismatch that a contact connected on the chain 1 side is closed, and a contact on the chain 2 side is open occurs. SRVO-231 is issued if such a mismatch that a contact on the chain 1 side is open and a contact on the chain 2 side is closed occurs. If a chain error is detected, correct the cause of the alarm then reset the alarm according to the method described later.
2. There is a possibility that the specification of the teach pendant is incorrect when occurring immediately after turning on of the power supply. For instance, this might occur if the teach pendant of non-RIA/CE specification is connected with the controller of the RIA/CE specification.

There is a possibility that the specification of the teach pendant is incorrect when occurring immediately after turning on of the power supply. For instance, this might occur if the teach pendant of non-RIA/CE specification is connected with the controller of the RIA/CE specification.

Remedy: See the description for the SRVO-230 Chain 1 abnormal.

SRVO-335 DCS OFFCHK alarm %x,%x %s

Cause: A failure was detected in the safety signal input circuit.
When two or more Safe I/O devices are connected, the number of the safe I/O device that the alarm occurs is displayed in the end of the message such as (1). The safe I/O device number is displayed in DCS Safe I/O device menu.

Remedy:

1. Replace the emergency stop board.
2. In case of B-cabinet, replace the optional safety I/O board.

Note: You need to cycle power to release this alarm.

SRVO-336 DCS RAMCHK alarm %x,%x

Cause: DRAM failure is detected.

Remedy:

1. Check the other alarms for more information.
2. Replace the CPU card.

Before executing the remedy 3, perform a complete controller back up as image to save all your programs and settings.

3. Replace the main board, and restore the image backup.

Note: You need to cycle power to release this alarm.

SRVO-337 DCS PRMCHK alarm %x,%x

Cause: DCS parameter error is detected.

- When controller power is cycled without pressing F4"OK" in the DCS apply menu, this alarm occurs.
- When an image restore is done and 'Yes' is selected for initialize DCS parameter, this alarm occurs.
- When an image restore is done and 'No' is selected for initialize DCS parameter, if the previous DCS parameters are different from what is in the image file, this alarm occurs.
- When "SYST-289 Cannot apply to DCS parameter" occurs at APPLY of DCS parameter, this alarm may occur after cycle power.
- When auto software update is done as an item in a DCS menu is changed, the alarm "SYST-212 Need to apply to DCS param" occurs, and the "Apply to DCS parameter" procedure is not done, this alarm occurs.

Remedy:

1. Do an APPLY of the DCS parameters if an image restore was done.
2. Load backup files.
3. Replace the CPU card.

Before executing the remedy 4, 5, perform a complete controller back up as image to save all your programs and settings.

4. Replace the FROM/SRAM module, and restore the image backup.
5. Replace the main board, and restore the image backup.

Note: You need to cycle power to release this alarm.

SRVO-338 DCS FLOW alarm %x,%x

Cause: DCS process error is detected.

Remedy: Check the other alarms for more information.

Note: You need to cycle power to release this alarm.

SRVO-339 DCS MISC alarm %x,%x

Cause: DCS process error is detected.

Remedy: Check the other alarms for more information.

Note: You need to cycle power to release this alarm.

SRVO-340 DCS T1 TCP speed (G%d) %x,%x

Cause: The TCP speed exceeds 250mm/sec in T1 mode.

When robot is moved by Shift+Reset operation to recover from alarm of Position check function, this alarm may occur even though T1 mode speed check function is disabled.

Remedy: Make the override lower.

SRVO-341 DCS T1 flange speed (G%d) %x,%x

Cause: The flange speed exceeds 250mm/sec in T1 mode.

When robot is moved by Shift+Reset operation to recover from alarm of Position check function, this alarm may occur even though T1 mode speed check function is disabled.

Remedy: Make the override lower.

SRVO-344 DCS GRP alarm(G%d) %x,%x

Cause: A software internal error has occurred.

Remedy: Check the other alarms for more information.

Note: You need to cycle power to release this alarm.

SRVO-347 DCS AXS alarm(G%d,A%d) %x,%x

Cause: A software internal error has occurred.

Remedy: Check the other alarms for more information.
Note: You need to cycle power to release this alarm.

SRVO-348 DCS MCC OFF alarm %x,%x %s

Cause: A command was issued to turn off the magnetic contactor, but the magnetic contactor was not turned off.
When two or more Safe I/O devices are connected, the number of the safe I/O device that the alarm occurs is displayed in the end of the message such as (1). The safe I/O device number is displayed in DCS Safe I/O device menu.

Remedy:

1. If a signal is connected to the E-stop unit CRMA74, check whether there is a problem in the connection destination.
2. Check whether the FUSE4 on emergency stop board is blown.
3. Replace the E-stop unit.

Note: You need to cycle power to release this alarm.

SRVO-349 DCS MCC ON alarm %x,%x %s

Cause: A command was issued to turn on the magnetic contactor, but the magnetic contactor was not turned on.
When two or more Safe I/O devices are connected, the number of the safe I/O device that the alarm occurs is displayed in the end of the message such as (1). The safe I/O device number is displayed in DCS Safe I/O device menu.

Remedy:

1. Replace the E-Stop unit.
2. Replace the servo amplifier.

Note: You need to cycle power to release this alarm.

SRVO-350 DCS CPU alarm %x,%x

Cause: An error occurred in the RAM self test.

Remedy:

1. Replace the CPU card.

Before executing the remedy 2, perform a complete controller back up as image to save all your programs and settings.

2. Replace the main board, and restore the image backup.

Note: You need to cycle power to release this alarm.

SRVO-351 DCS CRC alarm %x,%x

Cause: An error occurred in the safety software CRC test.

Remedy:

Before executing the remedy 1, perform a complete controller back up as image to save all your programs and settings.

1. Replace the FROM/SRAM module, and restore the image backup.

Note: You need to cycle power to release this alarm.

SRVO-352 DCS COUNT1 alarm %x,%x

Cause: The safety software does not run with the proper timing.

Remedy: Check the other alarms for more information.
Note: You need to cycle power to release this alarm.

SRVO-353 DCS COUNT2 alarm %x,%x

Cause: The safety software does not run with the proper timing.

Remedy: Check the other alarms for more information.
Note: You need to cycle power to release this alarm.

SRVO-354 DCS DICHK alarm %x,%x

Cause: The safety software does not run with the proper timing.

Remedy: Check the other alarms for more information.
Note: You need to cycle power to release this alarm.

SRVO-355 DCS ITP_TIME alarm %x,%x

Cause: The safety software does not run with the proper timing.

Remedy: Check the other alarms for more information.

Note: You need to cycle power to release this alarm.

SRVO-356 DCS ITP_SCAN alarm %x,%x

Cause: The safety software does not run with the proper timing.

Remedy: Check the other alarms for more information.
Note: You need to cycle power to release this alarm.

SRVO-357 DCS ENABLED alarm %x,%x

Cause:

1. Cartesian Position Check, Cartesian Speed Check or T1 Mode Speed Check is enabled for a motion group that does not exist.
2. Joint Position Check or Joint Speed Check is enabled for an axis that does not exist.
3. Joint Position Check or Joint Speed Check is enabled for an axis that is excluded.
4. Cartesian Position Check, Cartesian Speed Check or T1 Mode Speed Check is enabled for a motion group that has an excluded axis that is not an auxiliary extended axis.
5. Joint Position Check is enabled for an axis that is speed only.
6. Cartesian Position Check or Cartesian Speed Check is enabled for a motion group that has an speed only axis that is not an auxiliary extended axis.

Remedy: Disable Joint Position Check, Joint Speed Check, Cartesian Position Check, Cartesian Speed Check or T1 Mode Speed Check.
Note: You need to cycle power to release this alarm.

SRVO-358 DCS INVPRM alarm %x,%x

Cause: Invalid data is set in the DCS parameters.

Remedy: Check DCS setting. Load backup files that were saved when the parameters were correct.
Note: You need to cycle power to release this alarm.

SRVO-359 DCS SYSTEM alarm %x,%x

Cause:

1. When config Signature Date/Time is ACTUAL in DCS CIP Safety menu, System clock setting is invalid. (Valid year is 2004-2150.)
2. Invalid data is set in the DCS parameters.

Remedy:

1. Set Config Signature Date/Time to FIXED, or set correct date/time to system clock.
2. Check DCS setting. Load backup files that were saved when the parameters were correct.

Note: You need to cycle power to release this alarm.

SRVO-360 DCS CC_TCP alarm(G%d) %x,%x

Cause: Results of 2 CPU are different.

Remedy: Check the other alarms for more information.
Note: You need to cycle power to release this alarm.

SRVO-361 DCS CC_FP alarm(G%d) %x,%x

Cause: Results of 2 CPU are different.

Remedy: Check the other alarms for more information.
Note: You need to cycle power to release this alarm.

SRVO-362 DCS CC_TCPS alarm(G%d) %x,%x

Cause: Results of 2 CPU are different.

Remedy: Check the other alarms for more information.
Note: You need to cycle power to release this alarm.

SRVO-363 DCS CC_FPS alarm(G%d) %x,%x

Cause: Results of 2 CPU are different.

Remedy: Check the other alarms for more information.
Note: You need to cycle power to release this alarm.

SRVO-364 DCS PRMCRC alarm(G%d) %x,%x

Cause: This robot model is not supported.
- When the positioner is not a Basic Positioner with Known Kinematics, this alarm occurs. To use Position/Speed Check function, the positioner must be a Basic Positioner with Known Kinematics.
- When a positioner axis of FANUC make is used with coordinated motion function, if "unknown point calibration for positioner" is used, this alarm occurs. To use Position/Speed Check function with the postioner of FANUC make, use "known four point calibration" or "known direct calibration".
- When mount angle 2 of Top Mount Robot is not 0, this alarm occurs. To use Position/Speed Check function, set mount angle 2 of Top Mount Robot to 0.

Remedy: Delete 'DCS Position/Speed Check function' option.
This alarm can be cleared by setting $DCS_CFG.$EXCLUDE[motion group] to -1, but in this case, Position/Speed Check function cannot be used in this motion group.
Note: You need to cycle power to release this alarm.

SRVO-365 DCS FB_CMP alarm(G%d,A%d) %x,%x

Cause: Difference between position command and position feedback exceeds position tolerance. The same cause as 'SRVO-023 Stop error excess' or 'SRVO-024 Move error excess' is expected.

Remedy: See the description for the SRVO-023.
Check the setting data displayed in the DCS robot setup menu.

SRVO-366 DCS FB_INFO alarm(G%d,A%d) %x,%x

Cause: Invalid data is set in DCS parameter for axis number.

Remedy: Check the setting data displayed in the DCS robot setup menu.
Note: You need to cycle power to release this alarm.

SRVO-367 DCS CC_JPOS alarm(G%d,A%d) %x,%x

Cause: Results of 2 CPU are different.

Remedy: Check the other alarms for more information.
Note: You need to cycle power to release this alarm.

SRVO-368 DCS CC_JSPD alarm(G%d,A%d) %x,%x

Cause: Results of 2 CPU are different.

Remedy: Check the other alarms for more information.
Note: You need to cycle power to release this alarm.

SRVO-370 SVON1 status abnormal %s

Cause: A chain alarm was detected with the emergency stop board internal signal (SVON).
When two or more Safe I/O devices are connected, the number of the safe I/O device that the alarm occurs is displayed in the end of the message such as (1). The safe I/O device number is displayed in DCS Safe I/O device menu.

Remedy: Replace the emergency stop board.
Note1: For the procedure of recovery from this alarm, see the descriptions for the SRVO-230 and SRVO-231.
Note2: If this alarm is issued, do not reset the chain error alarm until the failure is identified and repaired. If robot use is continued with one of the duplicate circuits being faulty, safety may not be guaranteed when the other circuit fails.

SRVO-371 SVON2 status abnormal %s

Cause: A chain alarm was detected with the emergency stop board internal signal (SVON).
When two or more Safe I/O devices are connected, the number of the safe I/O device that the alarm occurs is displayed in the end of the message such as (1). The safe I/O device number is displayed in DCS Safe I/O device menu.

Remedy: Replace the emergency stop board.
Note1: For the procedure of recovery from this alarm, see the descriptions for the SRVO-230 and SRVO-231.
Note2: If this alarm is issued, do not reset the chain error alarm until the failure is identified and repaired. If robot use is continued with one of the duplicate circuits being faulty, safety may not be guaranteed when the other circuit fails.

SRVO-372 OPEMG1 status abnormal

Cause: A chain alarm was detected with the emergency stop switch on the operator's panel.

Remedy:
1. Replace the emergency stop board.
2. Replace the teach pendant cable.

3. Replace the teach pendant.
4. Replace the emergency stop button on the operator's panel.

Note1: For the procedure of recovery from this alarm, see the descriptions for the SRVO-230 and SRVO-231.
Note2: If this alarm is issued, do not reset the chain error alarm until the failure is identified and repaired. If robot use is continued with one of the duplicate circuits being faulty, safety may not be guaranteed when the other circuit fails.

SRVO-373 OPEMG2 status abnormal

Cause: A chain alarm was detected with the emergency stop switch on the operator's panel.

Remedy:

1. Replace the emergency stop board.
2. Replace the teach pendant cable.
3. Replace the teach pendant.
4. Replace the emergency stop button on the operator's panel.

Note1: For the procedure of recovery from this alarm, see the descriptions for the SRVO-230 and SRVO-231.
Note2: If this alarm is issued, do not reset the chain error alarm until the failure is identified and repaired. If robot use is continued with one of the duplicate circuits being faulty, safety may not be guaranteed when the other circuit fails.

SRVO-374 MODE11 status abnormal

Cause: A chain alarm was detected with the mode switch signal.

Remedy:

1. Check the mode switch and its cable. Replace them if a defect is found.
2. Replace the emergency stop board.

Note1: For the procedure of recovery from this alarm, see the descriptions for the SRVO-230 and SRVO-231.
Note2: If this alarm is issued, do not reset the chain error alarm until the failure is identified and repaired. If robot use is continued with one of the duplicate circuits being faulty, safety may not be guaranteed when the other circuit fails.

SRVO-375 MODE12 status abnormal

Cause: A chain alarm was detected with the mode switch signal.

Remedy:

1. Check the mode switch and its cable. Replace them if a defect is found.
2. Replace the emergency stop board.

Note1: For the procedure of recovery from this alarm, see the descriptions for the SRVO-230 and SRVO-231.
Note2: If this alarm is issued, do not reset the chain error alarm until the failure is identified and repaired. If robot use is continued with one of the duplicate circuits being faulty, safety may not be guaranteed when the other circuit fails.

SRVO-376 MODE21 status abnormal

Cause: A chain alarm was detected with the mode switch signal.

Remedy:

1. Check the mode switch and its cable. Replace them if a defect is found.
2. Replace the emergency stop board.

Note1: For the procedure of recovery from this alarm, see the descriptions for the SRVO-230 and SRVO-231.
Note2: If this alarm is issued, do not reset the chain error alarm until the failure is identified and repaired. If robot use is continued with one of the duplicate circuits being faulty, safety may not be guaranteed when the other circuit fails.

SRVO-377 MODE22 status abnormal

Cause: A chain alarm was detected with the mode switch signal.

Remedy:

1. Check the mode switch and its cable. Replace them if a defect is found.
2. Replace the emergency stop board.

Note1: For the procedure of recovery from this alarm, see the descriptions for the SRVO-230 and SRVO-231.
Note2: If this alarm is issued, do not reset the chain error alarm until the failure is identified and repaired. If robot use is continued with one of the duplicate circuits being faulty, safety may not be guaranteed when the other circuit fails.

SRVO-378 SFDI xx status abnormal %s

Cause: A chain alarm was detected with the SFDI signal. The ‘xx’ in the alarm message shows signal name such as ‘SFDI11’. The detected status is that the displayed signal is open and the other signal for dual channel input is closed.
When two or more Safe I/O devices are connected, the number of the safe I/O device that the alarm occurs is displayed in the end of the message such as (1). The safe I/O device number is displayed in DCS Safe I/O device menu.

In the system that has robot disable switch, when the alarm of the following signals occurs in the emergency stop board of 1st slave controller, it means the status abnormal of the robot disable switch.

SFDI112 : Robot 1 disable switch chain 1 status abnormal.
SFDI212 : Robot 1 disable switch chain 2 status abnormal.
SFDI113 : Robot 2 disable switch chain 1 status abnormal.
SFDI213 : Robot 2 disable switch chain 2 status abnormal.
SFDI114 : Robot 3 disable switch chain 1 status abnormal.
SFDI214 : Robot 3 disable switch chain 2 status abnormal.
SFDI115 : Robot 4 disable switch chain 1 status abnormal.
SFDI215 : Robot 4 disable switch chain 2 status abnormal.

In the system with Teach Pendant Hot Swap function, the alarm of SFDI11 or SFDI21 can occur when Teach Pendant is connected / disconnected without pushing the disconnect switch, or in AUTO mode.

Remedy: In case that the SFDI that the alarm occurs is not robot disable switch:

1. Check whether the circuitry connected to the dual input signal (SFDI) is faulty.
2. Check whether the timing of the dual input signal (SFDI) satisfies the timing specification.
3. In case of B-cabinet, replace the optional safety I/O board.
4. Replace the emergency stop board.

In case that the SFDI that the alarm occurs is robot disable switch:

1. Replace robot disable switch.
2. Replace the cable between robot disable switch and emergency stop board.
3. Replace the emergency stop board.

In case that the alarm of SFDI11 or SFDI21 occurs in the system with Teach Pendant Hot Swap function:

1. If Teach Pendant is not connected / disconnected by the correct procedure of Teach Pendant Hot Swap function, recovery from this alarm by the procedure in the descriptions for the SRVO-230 and SRVO-231. Perform the correct procedure to connect /disconnect Teach Pendant.
2. If the alarm occurred even if Teach Pendant is connected /disconnected by the correct procedure, replace the emergency stop board and Teach Pendant Hot Swap hardware.

Note1: For the procedure of recovery from this alarm, see the descriptions for the SRVO-230 and SRVO-231.
Note2: If this alarm is issued, do not reset the chain error alarm until the failure is identified and repaired. If robot use is continued with one of the duplicate circuits being faulty, safety may not be guaranteed when the other circuit fails.

SRVO-401 CIP Safety comm. error %x,%x

Cause: CIP Safety communication error occurs.

Remedy: Check CIP Safety connection. This alarm doesn't show up when CIP Safety is in Bypass mode. Using bypass mode should be limited to during initial integration when it is required to move the robot without communication with Safety PLC. Refer to the chapter of DeviceNet Safety or EtherNet/IP Safety of the Dual Check Safety operator's manual.

SRVO-402 DCS Cart. pos. limit(%d,G%d,M%d) %02x

Cause: Cartesian Position Check function detected that a model is out of a safe zone.
The first value : Cartesian Position Check No.
G : Group number
M : User model number (0: Robot model)

Remedy: If the robot is actually out of thesafe zone, press SHIFT key and RESET key, and jog the robot to the safe zone.

SRVO-403 DCS Cart. speed limit(%d,G%d) %02x

Cause: Cartesian Speed Check function detected over speed.
The first value : Cartesian Speed Check No.
G : Group number

Remedy: Decrease robot speed.

SRVO-404 DCS Joint pos. limit(%d,G%d,A%d) %02x

Cause: Joint Position Check function detected that an axis is out of a safe zone.
The first value : Joint Position Check No.
G : Group number
A : Axis number

Remedy: If the robot is actually out of the safe zone, press SHIFT key and RESET key, and jog the robot to the safe zone.

SRVO-405 DCS Joint speed limit(%d,G%d,A%d) %02x

Cause: Joint Speed Check function detected over speed.
The first value : Joint Speed Check No.
G : Group number
A : Axis number

Remedy: Decrease Joint speed.

SRVO-406 DCS SSO SVOFF input %x,%x

Cause: SSO[1:C_SVOFF] is OFF.

Remedy: Check Safe I/O connect setting.

SRVO-407 DCS SSO Fence Open %x,%x

Cause: SSO[2:C_FENCE] is OFF.

Remedy: Check Safe I/O connect setting.

SRVO-408 DCS SSO Ext Emergency Stop %x,%x

Cause: SSO[3:C_EXEMG] is OFF.

Remedy: Check Safe I/O connect setting.

SRVO-409 DCS SSO Servo Disconnect %x,%x

Cause: SSO[4:C_SVOFF] is OFF.

Remedy: Check Safe I/O connect setting.

SRVO-410 DCS SSO NTED input %x,%x

Cause: SSO[5:C_NTED] is OFF.

Remedy: Check Safe I/O connect setting.

SRVO-411 DCS invalid mode %x,%x

Cause: Invalid mode.

Remedy: Select AUTO, T1 or T2.

SRVO-412 DCS COUNT3 alarm %x,%x

Cause: DCS servo on process is stopped.

Remedy: Check the other alarms for more information.
Note: You need to cycle power to release this alarm.

SRVO-413 DCS CC_SAFEIO alarm %x,%x

Cause: Results of Safe I/O process by 2 CPU are different.
This alarm sometimes occur when the safety input signals on the emergency stop board and Safe I/O board such as External E-STOP or SFDI is changed repeatedly in the very short time.

Remedy: Check the connection of the safety input signals on emergency stop board and Safe I/O board.
Check the other alarms for more information.
Note: You need to cycle power to release this alarm.

SRVO-414 DCS WORK CRC alarm %x,%x

Cause: DRAM failure is detected.

Remedy: Check the other alarms for more information.
Note: You need to cycle power to release this alarm.

SRVO-415 DCS Invalid tool (G%d) %x,%x

Cause:

1. Selected DCS tool frame number is not defined.
2. Verify I/O of DCS tool frame is not set in the selected DCS tool frame.

Remedy: Check DCS TCP setting.
Note: You need to cycle power to release this alarm.

SRVO-416 DCS Tool mismatch (G%d) %x,%x

Cause: All Verify I/O of DCS tool frame are OFF or two or more Verify I/O are ON for more than 1sec.

Remedy: Check Verify I/O status.

SRVO-417 DCS APSP_C alarm(G%d) %x,%x

Cause: Invalid DCS approach speed check parameter for Cartesian position check.
Remedy: Check DCS approach speed check parameter.
Note: You need to cycle power to release this alarm.

SRVO-418 DCS APSP_J alarm (G%d,A%d) %x,%x

Cause: Invalid DCS approach speed check parameter for Joint position check.
Remedy: Check DCS approach speed check parameter.
Note: You need to cycle power to release this alarm.

SRVO-419 DCS PROFIsafe comm. error %x,%x

Cause: PROFINET Safety communication error occurs.
Remedy: Check PROFINET Safety connection. This alarm doesn't show up when PROFINET Safety is in Bypass mode. Using bypass mode should be limited to during initial integration when it is required to move the robot without communication with Safety PLC. The mode is changed from Bypass to Enable at start up by default setting. Refer to the chapter of PROFINET Safety of the Dual Check Safety operator's manual.

SRVO-420 Safety FL-net comm. error %x,%x

Cause: Safety function by FL-net communication error occurs.
Remedy: Check Safety function by FL-net connection.

SRVO-422 Shared TP E-Stop

Cause: 1. Emergency stop occurs on either controller in Shared Teach Pendant group.
2. Emergency stop occurs, because either controller in Shared Teach Pendant group is powered off.
3. Emergency stop occurs, because Safety function by FL-net does not work.
4. Emergency stop occurs, because configurations of Shared Teach Pendant function are disabled.
Remedy: 1. Release Teach Pendant, Operator Panel and External emergency stop on controllers in Shared Teach Pendant group.
2. Power on all controllers in Shared Teach Pendant group.
3. Check setting of Safety function by FL-net and Shared Teach Pendant function.
4. Check configurations of Shared Teach Pendant function.

SRVO-423 Shared TP: T1/T2 on other robot

Cause: This controller is disconnected from Shared Teach Pendant group because mode of all controllers in Shared Teach Pendant group are not AUTO. This robot cannot be operated.
Remedy: Change modes of all controllers in Shared Teach Pendant group to AUTO.

SRVO-424 Shared TP: Mode mismatch

Cause: Modes of all controllers in Shared Teach Pendant group are not matched. This robot cannot be operated.
Remedy: Change modes of all controllers in Shared Teach Pendant group to match.

SRVO-425 Shared TP: Configuration mismatch

Cause: Configurations of Shared Teach Pendant function are not matched among controllers in Shared Teach Pendant group.
Remedy: Check and change configurations of Shared Teach Pendant function.

SRVO-446 DCS LS Fence open %x,%x

Cause: In Auxiliary axis servo off (Local stop) function, the safe I/O assigned to the fence input is OFF when the auxiliary axis is not servo off condition. The value displayed in the message shows the No. of local stop that the alarm occurs. The value is hexadecimal, and each bit is corresponded to each item in DCS local stop menu (1:No.1, 2:No.2, 4:No.3: 8:No.4, 10:No.5, 20:No.6, 40:No.7, 80:No.8).
Remedy: Set the safe I/O assigned to the fence input to ON, or set the auxiliary axis servo to off.

SRVO-447 DCS LS STO-FB alarm %x,%x

Cause: In Auxiliary axis servo off (Local stop) function, mismatch of STO-OUT and STO-FB is detected. The value displayed in the message shows the No. of local stop that the alarm occurs. The value is hexadecimal, and each bit is corresponded to each item in DCS local stop menu (1:No.1, 2:No.2, 4:No.3: 8:No.4, 10:No.5, 20:No.6, 40:No.7, 80:No.8).

Remedy:

1. Check the setting of DCS local stop menu.
2. Check the connection between emergency stop board and servo amplifier (α*i*SV).
3. Replace the cable between emergency stop board and servo amplifier (α*i*SV).
4. Replace the emergency stop board.
5. Replace the servo amplifier (α*i*SV).

Note: You need to cycle power to release this alarm.

SRVO-448 DCS PLSCHK alarm (SFDO%d) %s

Cause: The monitored signal of safety output is not OFF even though OFF pulse is output. The signal name that the trouble is detected is displayed after the alarm message.
When two or more Safe I/O devices are connected, the number of the safe I/O device that the alarm occurs is displayed in the end of the message such as (1). The safe I/O device number is displayed in DCS Safe I/O device menu.

Remedy:

1. Check the cabling of safety output circuit.
2. In case of B-cabinet, replace the optional safety I/O board.
3. Replace the emergency stop board.

Note: You need to cycle power to release this alarm.

SRVO-449 DCS DCS DOMON alarm (SFDO%d) %s

Cause: The monitored signal of safety ouput is different from the output command. The signal name that the trouble is detected is displayed after the alarm message.
When two or more Safe I/O devices are connected, the number of the safe I/O device that the alarm occurs is displayed in the end of the message such as (1). The safe I/O device number is displayed in DCS Safe I/O device menu.

Remedy:

1. Check the cabling of safety output circuit.
2. In case of B-cabinet, replace the optional safety I/O board.
3. Replace the emergency stop board.

Note: You need to cycle power to release this alarm.

SRVO-468 TmpDetachedNode exists in FLSF

Cause: Temporary detached node exists in Safety function by FL-net.

Remedy: Change the detached node to ENTRY.

SRVO-469 DCS Safety PMC alarm %x,%x

Cause: Safety PMC program has invalid instructions or address.

Remedy: Check Safety PMC program.
Note: You need to cycle power to release this alarm.

SRVO-471 I/O Link i slave(%d-%d) status abnormal

Cause: A mismatch of duplicate input signal for I/O Link i slave was detected over 1 second. Detected signal number is displayed by a range as (1-8). The range of detection is divided per 8 signals as (1-8), (9-16).

Remedy:

1. Check if a timing of duplicate output signal of master is matched.
2. Check if a connection of I/O Link cable is correct.
3. Replace the CPU card.
4. Replace the main board.

SRVO-484 Safe I/O consistency alarm %x,%x

Cause: **I**n Safe I/O consistency check function, consistency of Safe I/O is detected.

Remedy:

1. Check the setting of Safety I/O consistency check function.
2. Check the cabling of safety I/O circuit.
3. Check failure of the device that cabled to safety I/O.

Note: You need to cycle power to release this alarm.

DNET-138 IDNS unsupported H/W, Bd %d

Cause: A DevicNet channel has been configured for safety. A safety DeviceNet channel requires DN4 hardware. The detected hardware is not supported for a safety channel.

Remedy: Use DN4 DeviceNet hardware or disable safety on this channel.

PRIO-051 I/O Link i slave comm error %x, %x (hex)

Cause: Communication error for I/O Link i slave is detected.

Remedy: Check connection and reset alarm or cycle power.

PRIO-052 I/O Link i slave hardware mismatch %x, %x (hex)

Cause: Configuration is not for I/O Link i slave.

Remedy: Check whether CPU card and Main board are the hardware for I/O Link i slave.

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REVISION RECORD

Edition	Date	Contents
06	Oct., 2015	• Addition of I/O link *i* Slave function and Safe I/O Consistency Check function.
05	Nov., 2014	• Addition of Teach Pendant Hot Swap and Shared Teach Pendant, Revision of PROFINET Safety.
04	Apr., 2013	• Addition of Safety function by FL-net.
03	Jan., 2013	• Addition of R-30*i*B Mate.
02	Oct., 2012	• Addition of additional safety signals, safety PMC function and auxiliary axis servo off (local stop) function.
01	Apr., 2012	

B-83184EN/06