## **FANUC** Robot series

## R-30*i*B/R-30*i*B Mate CONTROLLER EtherCAT Function **OPERATOR'S MANUAL**

MAROBECAT06141E REV. A

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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.fanucrobotics.com

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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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#### **FANUC CORPORATION Patent List**

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#### **Conventions**

### AWARNING

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

#### **A**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

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

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Should you wish to export or re-export these products, please contact FANUC for advice.

In this manual we have tried as much as possible to describe all the various matters.

However, we cannot describe all the matters which must not be done, or which cannot be done, because there are so many possibilities.

Therefore, matters which are not especially described as possible in this manual should be regarded as "impossible".

# **Safety**

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.

## AWARNING

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:

#### **A**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.

#### **A**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.

### AWARNING

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.

#### A 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.



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.



Observe all safety rules and guidelines to avoid injury.

#### **A**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.

#### **A** 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
- 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.



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**

Thank you for purchasing FANUC Robot.

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 WORKING PERSON

The personnel can be classified as follows.

#### Operator:

- Turns robot controller power ON/OFF
- Starts robot program from operator's panel

Programmer or teaching operator:

- Operates the robot
- Teaches robot inside the safety fence

#### Maintenance engineer:

- Operates the robot
- Teaches robot inside the safety fence
- Maintenance (adjustment, replacement)
- An operator cannot work inside the safety fence.
- A 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 fence, the person must be trained on proper robot operation.

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

- Use adequate clothing or uniforms during system operation
- Wear safety shoes
- Use helmet

# 2 DEFINITION OF WARNING, CAUTION AND NOTE

To ensure the safety of working persons and prevent damage to the machine, this manual indicates each precaution on safety with "Warning" or "Caution" according to its severity. Supplementary information is indicated by "Note". Read the contents of each "Warning", "Caution" and "Note" before attempting to use the robots.

#### **⚠ WARNING**

Applied when there is a danger of the working person being injured or when there is a danger of both the working person being injured and the equipment being damaged if the approved procedure is not observed.

#### **ACAUTION**

Applied when there is a danger of the equipment being damaged, if the approved procedure is not observed.

#### NOTE

Notes are used to indicate supplementary information other than Warnings and Cautions.

• Read this manual carefully, and store it in a sales place.

## **3** WORKING PERSON SAFETY

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

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

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

- (2) Even when the robot is stationary, it is possible that the robot is still in a ready to move state, and is waiting for a signal. In this state, the robot is regarded as still in motion. To ensure working person 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 working person can enter the work area without passing through the gate. Install an interlocking device, a safety plug, and so forth in the safety gate so that the robot is stopped as the safety gate is opened.

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

(4) Provide the peripheral devices with appropriate grounding (Class A, Class B, Class C, and Class D).

- (5) Try to install the peripheral devices outside the work area.
- (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 working person enters the work area.
- (8) If necessary, install a safety lock so that no one except the working person in charge can turn on the power of the robot.

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

- (9) When adjusting each peripheral device independently, be sure to turn off the power of the robot.
- (10) Operators should be ungloved while manipulating the operator's panel or teach pendant. Operation with gloved fingers could cause an operation error.
- (11) Programs, system variables, and other information can be saved on memory card or USB memories. Be sure to save the data periodically in case the data is lost in an accident.
- (12) The robot should be transported and installed by accurately following the procedures recommended by FANUC. Wrong transportation or installation may cause the robot to fall, resulting in severe injury to workers.
- (13) In the first operation of the robot after installation, the operation should be restricted to low speeds. Then, the speed should be gradually increased to check the operation of the robot.
- (14) Before the robot is started, it should be checked that no one is 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) When the robot is used, the following precautions should be taken. Otherwise, the robot and peripheral equipment can be adversely affected, or workers can be severely injured.
  - Avoid using the robot in a flammable environment.
  - Avoid using the robot in an explosive environment.
  - Avoid using the robot in an environment full of radiation.
  - Avoid using the robot under water or at high humidity.
  - Avoid using the robot to carry a person or animal.
  - Avoid using the robot as a stepladder. (Never climb up on or hang from the robot.)
- (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) When preparing trestle, please consider security for installation and maintenance work in high place according to Fig.3 (c). Please consider footstep and safety bolt mounting position.

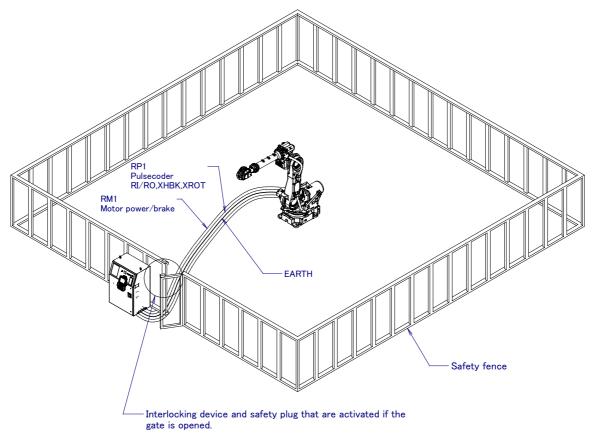


Fig. 3 (a) Safety fence and safety gate

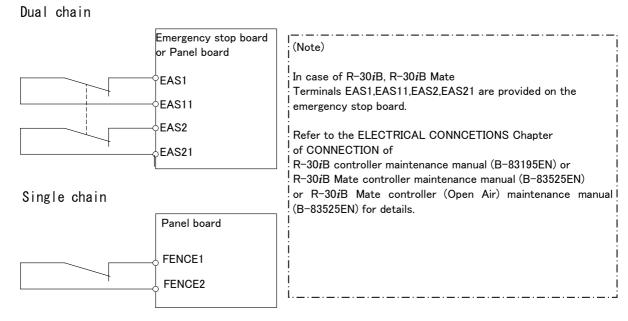


Fig. 3 (b) Limit switch circuit diagram of the safety fence

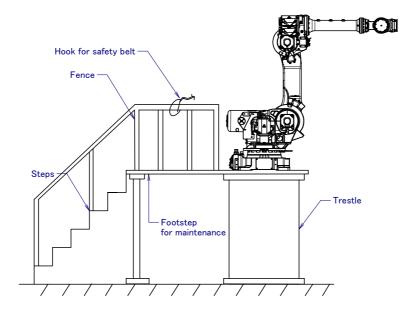


Fig.3 (c) Footstep for maintenance

### 3.1 OPERATOR SAFETY

The operator is a person who operates the robot system. In this sense, a worker who operates the teach pendant is also an operator. However, this section does not apply to teach pendant operators.

- (1) If you do not have to operate the robot, turn off the power of the robot controller or press the EMERGENCY STOP button, and then proceed with necessary work.
- (2) Operate the robot system at a location outside of the safety fence
- (3) Install a safety fence with a safety gate to prevent any worker other than the operator from entering the work area unexpectedly and to prevent the worker from entering a dangerous area.
- (4) Install an EMERGENCY STOP button within the operator's reach.

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.

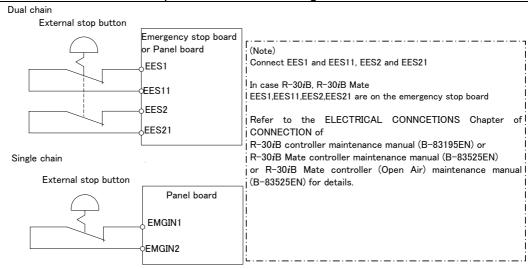


Fig.3.1 Connection diagram for external emergency stop button

## 3.2 SAFETY OF THE PROGRAMMER

While teaching the robot, the operator must enter the work area of the robot. The operator must ensure the safety of the teach pendant operator especially.

- (1) Unless it is specifically necessary to enter the robot work area, 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 operating condition.
- (3) If it is inevitable to enter the robot work area 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 work area.
- (5) Programming should be done outside the area of the safety fence as far as possible. If programming needs to be done in the area of the safety fence, the programmer should take the following precautions:
  - Before entering the area of the safety fence, ensure that there is no risk of dangerous situations in the area.
  - Be prepared to press the emergency stop button whenever necessary.
  - Robot motions should be made at low speeds.
  - Before starting programming, check the entire system status to ensure that no remote instruction to the peripheral equipment or motion would be dangerous to the working person.

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.

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

- (1) Emergency stop button: Causes the stop of the robot (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type) when pressed.
- (2) DEADMAN switch: Functions differently depending on the teach pendant enable/disable switch setting status.
  - (a) Disable: The DEADMAN switch is disabled.
  - (b) Enable: Servo power is turned off when the operator releases the DEADMAN switch or when the operator presses the switch strongly.
  - 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 SW 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
	On	Local	Not allowed	Not allowed	Not allowed
AUTO	Oli	Remote	Not allowed	Not allowed	Not allowed
mode	Off	Local	Not allowed	Allowed to start	Not allowed
		Remote	Not allowed	Not allowed	Allowed to start
	On	Local	Allowed to start	Not allowed	Not allowed
T1, T2 mode		Remote	Allowed to start	Not allowed	Not allowed
		Local	Not allowed	Not allowed	Not allowed
	Off	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 the robot work area and that there are no abnormal conditions in the robot work area.
- (7) When a program is completed, be sure to carry out a test operation according to the procedure below.
  - (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 should leave the robot work area.

#### 3.3 SAFETY OF THE MAINTENANCE ENGINEER

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

- (1) During operation, never enter the robot work area.
- (2) A hazardous situation may arise when the robot or the system, are kept with their power-on during maintenance operations. Therefore, for any maintenance operation, the robot and the system should be put into the power-off state. If necessary, a lock should be in place in order to prevent any other person from turning on the robot and/or the system. In case maintenance needs to be executed in the power-on state, the emergency stop button must be pressed.
- (3) If it becomes necessary to enter the robot operation range while the power is on, press the emergency stop button on the operator panel, or the teach pendant before entering the range. 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 worker must check the entire system in order to make sure no dangerous situations exist. In case the worker needs to enter the safety area whilst a dangerous situation exists, extreme care must be taken, and 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 teaching, check that the robot and its peripheral devices are all in the normal operating condition.
- (7) Do not operate the robot in the automatic mode while anybody is in the robot work area.
- (8) When you maintain the robot alongside 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 when any moving device other than the robot is installed, such as belt conveyor, pay careful attention to its motion.
- (10) If necessary, have a worker who is familiar with the robot system stand beside the operator panel and observe the work being performed. If any danger arises, the worker should be ready to press the EMERGENCY STOP button at any time.
- (11) When replacing a part, please contact FANUC service center. If a wrong procedure is followed, an accident may occur, causing damage to the robot and injury to the worker.
- (12) When replacing or reinstalling components, take care to prevent foreign material from entering the system.
- (13) When handling each unit or printed circuit board in the controller during inspection, turn off the circuit breaker to protect against electric shock.

  If there are two cabinets, turn off the both circuit breaker.
- (14) A part should be replaced with a part recommended by FANUC. If other parts are used, malfunction or damage would occur. Especially, a fuse that is not recommended by FANUC should not be used. Such a fuse may cause a fire.
- (15) When restarting the robot system after completing maintenance work, make sure in advance that there is no person in the work area and that the robot and the peripheral devices are not abnormal.
- (16) When a motor or brake is removed, the robot arm should be supported with a crane or other equipment beforehand so that the arm would not fall during the removal.
- (17) Whenever grease is spilled on the floor, it should be removed as quickly as possible to prevent dangerous falls.
- (18) The following parts are heated. If a maintenance worker 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 the controller
  - Reducer
  - Gearbox
  - Wrist unit
- (19) Maintenance should be done under suitable light. Care must be taken that the light would not cause any danger.
- (20) When a motor, reducer, or other heavy load is handled, a crane or other equipment should be used to protect maintenance workers from excessive load. Otherwise, the maintenance workers would be severely injured.
- (21) The robot should not be stepped on or climbed up during maintenance. If it is attempted, the robot would be adversely affected. In addition, a misstep can cause injury to the worker.
- (22) When performing maintenance work in high place, secure a footstep and wear safety belt.
- (23) After the maintenance is completed, spilled oil or water and metal chips should be removed from the floor around the robot and within the safety fence.
- (24) When a part is replaced, all bolts and other related components should put back into their original places. A careful check must be given to ensure that no components are missing or left not mounted.
- (25) In case robot motion is required during maintenance, the following precautions should be taken:
  - Foresee an escape route. And during the maintenance motion itself, monitor continuously the whole system so that your escape route will not become blocked by the robot, or by peripheral equipment.
  - Always pay attention to potentially dangerous situations, and be prepared to press the emergency stop button whenever necessary.
- (26) The robot should be periodically inspected. (Refer to the robot mechanical manual and controller maintenance manual.) A failure to do the periodical inspection can adversely affect the performance or service life of the robot and may cause an accident

(27) After a part is replaced, a test operation should be given for the robot according to a predetermined method. (See TESTING section of "R-30iB/R-30iB Mate Controller operator's manual (Basic Operation)".) During the test operation, the maintenance staff should work outside the safety fence.

# 4 SAFETY OF THE TOOLS AND PERIPHERAL DEVICES

## 4.1 PRECAUTIONS IN PROGRAMMING

- (1) Use a limit switch or other sensor to detect a dangerous condition and, if necessary, design the program to stop the robot when the sensor signal is received.
- (2) Design the program to stop the robot when an 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 so that they do not 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, and operate the robot in an environment free of grease, water, and dust.
- (2) Don't use unconfirmed liquid for cutting fluid and cleaning fluid.
- (3) Employ a limit switch or mechanical stopper to limit the robot motion so that the robot or cable does not strike against its 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.
  - Don't add user cable or hose to inside of mechanical unit.
  - Please do not obstruct the movement of the mechanical unit cable 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 execute 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 executed.
  - When alteration was necessary, safety switch is operated by opening safety fence and power-off stop is executed 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 operate routinely and power-off stop is executed for the robot.

(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 MECHANISM

## **5.1** PRECAUTIONS IN OPERATION

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

### **5.2** PRECAUTIONS IN PROGRAMMING

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

### 5.3 PRECAUTIONS FOR MECHANISMS

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

7

## STOP TYPE OF ROBOT

The following three robot stop types exist:

#### 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.

The following processing is performed at Power-Off stop.

- An alarm is generated and servo power is turned off.
- The robot operation is stopped immediately. 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.

The following processing is performed at Controlled stop.

- The alarm "SRVO-199 Controlled stop" occurs along with a decelerated stop. Execution of the program is paused.
- An alarm is generated and servo power is turned off.

#### Hold (Category 2 following IEC 60204-1)

The robot is decelerated until it stops, and servo power remains on.

The following processing is performed at Hold.

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

#### **⚠ WARNING**

The stopping distance and stopping time of Controlled stop are longer than the stopping distance and stopping time 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
	AUTO	P-Stop	P-Stop	C-Stop	C-Stop	P-Stop
Α	T1	P-Stop	P-Stop	-	C-Stop	P-Stop
	T2	P-Stop	P-Stop	-	C-Stop	P-Stop
	AUTO	P-Stop	P-Stop	P-Stop	P-Stop	P-Stop
В	T1	P-Stop	P-Stop	-	P-Stop	P-Stop
	T2	P-Stop	P-Stop	-	P-Stop	P-Stop
	AUTO	C-Stop	C-Stop	C-Stop	C-Stop	C-Stop
С	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-30iB/ R-30iB Mate
Standard	A (*)
Controlled stop by E-Stop (A05B-2600-J570)	C (*)

R-30iB / R-30iB Mate does not have servo disconnect. R-30iB 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 stopping time of Controlled stop is longer than the stopping distance and stopping time 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 stopping 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 stopping time of Controlled stop are longer than the stopping distance and stopping time 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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1 SPECIFICATION

Item	Description	
Data size	128,256,512,1024,2048,4096 points for each of input and output	
Synchronous mode	nous mode Free Run mode (asynchronous) only. DC mode isn't supported.	
Communication	PDO communication only	

- Protocol "CAN application protocol over EtherCAT(CoE)" is supported.
- Maximum number of slaves depends on EtherCAT master's performance. The greater of the input data size and the output data size is used for calculation of maximum number of slaves. For example, the combination of input 1024 / output 128 is equal to that of input 1024 / output 1024.
- To use this function, "EtherCAT slave board" is necessary. Only 1 board can be installed to the robot controller.
- To use this function, "EtherCAT slave (J743)" should be ordered.
- To use this function, the system software version should be 7DC2/P11 or later. R-30*i*B Mate is supported by 7DC3 or later.
- DI/DO, GI/GO, UI/UO can be exchanged. Update unit is 16 points and each 16 points from start point 1 is updated by one update. Please take care of data tearing caused when 1 GI/GO is updated by more than one update.
- Acyclic communication (SDO communication), which communicates only when requested, is not supported.
- I/O update interval in robot is 8ms by default and it isn't synchronized to EtherCAT communication.
- ESI file for robot is available from FANUC. Except for 7DC2 series, ESI file can be output to any device from setup screen.

## 2 SETUP

### 2.1 SETUP SCREEN

SETUP EtherCAT

1/10

1 Error one shot : DISABLE

2 I/O safety value : CLEAR

Process data size

3 The number of input : [1024] points

4 The number of output : [1024] points

5 Output ESI file : <Execute>

Item	Description
Error one shot default: DISABLE	ENABLE: Pressing reset can release "PRIO-801 EtherCAT off line" regardless of EtherCAT communication status. This is used when robot should be moved even when EtherCAT communication is offline etc. Please use ENABLE only when robot is under setup because robot may move even when this function is in error status (e.g. EtherCAT communication is offline etc.). Use DISABLE normally.  DISABLE: Pressing reset cannot release "PRIO-801 EtherCAT off line" until the cause of the error is solved.
I/O safety value default: CLEAR	This item decides if DI, GI, UI assigned to EtherCAT are kept or cleared when EtherCAT communication is offline.
The number of input/output default: 512 points	Process data size of EtherCAT communication. Select from 128,256,512,1024,2048,4096 points.
Output ESI file (Except for 7DC2)	ESI file is output to the selected folder in selected device in the FILE screen, which is displayed from MENU key -> FILE.

To initialize the setting, set default value above to each items.

## 2.2 DETAIL OF THE SETTING

- In DI/DO config screen, rack 106, slot 1(fixed) is for EtherCAT.
- To use more DI/DO than default, change \$MAX\_DIG\_PRT to the number of DI/DO and cycle power.
- Settings in this screen are saved to "ETHERCAT.SV".
- In EtherCAT setup screen, press [NEXT] key and [F1] CLR\_ASG, "Clear ALL I/O assignments?" is displayed and press [F4] "YES" then all I/O assignment are cleared.

# 3 STATUS SCREEN

### 3.1 STATUS SCREEN

```
STATUS EtherCAT
                                        1/36
 1 Communication status
                               : 0P
 2 AL Status : 0x8
 3 AL Status Code : 0x0
 4 Port1 Invalid frame counter: 0
 5 Port1 Rx Error counter
 6 Port2 Invalid frame counter : 0
 7 Port2 Rx Error counter
 8 Forwarded Rx Error Counter
     Port1: 0
     Port2: 0
 9 ECAT Processing Unit Error Counter
10 PDI Error Counter : 0
11 Lost Link Counter
     Port1: 0
     Port2: 0
12 Vendor ID : 0x0
13 Product code : 0x0
14 Revision : 0x 0
15 Node address: 1
16 RxPDO 1st index
                     : 0x1602
17 TxPDO 1st index
                     : 0x1A02
[ TYPE ]
                           UPDATE
```

Pressing F4 UPDATE button updates the screen.

item	Description	
Communication	INIT : During communication initialization. No data communication is available.	
status	PREOP : Pre operational. No data communication is available.	
	BOOTSTRAP: Firmware update. No data communication is available.	
	SAFEOP : Safe operational. Only sending data is available.	
	OP : Operational. Sending and receiving data are available. Normal communication status.	
AL Status	When bit 4(0x10) is on, error is present.	

## **EtherCAT COMMUNICATION SOFT UPDATE**

This chapter explains how to update EtherCAT communication software and EEPROM image on EtherCAT board.

#### **Procedure except for 7DC2**

- 1 Turn off the robot controller.
- 2 Set SMODE switch on EtherCAT board to C.
- 3 Turn on the robot controller.
- After robot controller starts up, check "PRIO-804 EtherCAT Com Soft Update Mode" and "PRIO-807 EtherCAT Update finished" in alarm history.
- 5 Turn off the robot controller.
- Set SMODE switch on EtherCAT board to E. 6
- 7 Turn on the robot controller.
- After robot controller starts up, check "PRIO-805 EtherCAT EEPROM Update Mode" and 8 "PRIO-807 EtherCAT Update finished" in alarm history.
- Set SMODE switch on EtherCAT board to 0.

#### **Procedure for 7DC2**

- Get EtherCAT communication software and EEPROM image from FANUC.
- Copy the software and image to USB memory, memory card, or the directory which can be accessed 2 from robot controller FTP.
- Set the location of EtherCAT communication software to \$ECAT.\$ECAT\_SOFT. 3
- 4 Set the location of EEPROM image to \$ECAT.\$EEPROM\_IMG.
- Go to "Procedure except for 7DC2".

## 5 SYSTEM VARIABLES

In this chapter, change of system variable is valid after cycle power unless otherwise described.

\$MAX\_DIG\_PRT

The number of DI/DO.

## **5.1** SYSTEM VARIABLES UNDER \$ECAT

\$ASGUOP default 1

0: EtherCAT isn't assigned to UOP automatically.

1: EtherCAT is assigned to UOP automatically.

\$SCAN\_TIME default 4 (8ms)

Scan interval between EtherCAT slave board and I/O of robot. Unit is 2ms.

\$WARNINGENB default 1

0: "PRIO-800 EtherCAT Board not installed" doesn't show up.

1: The alarm above shows up.

\$DEAD\_BAND default 0

During this time from specific timing in power-on, "PRIO-801 EtherCAT off line" doesn't show up. Unit is 2ms.

\$ECAT\_SOFT default except for 7DC2 series FRS:\(\frac{1}{2}\)ecat.\(\text{bin}\) 7DC2 series UD1:\(\frac{1}{2}\)ecat.\(\text{bin}\) Set the location of EtherCAT communication software.

\$EEPROM\_IMG default except for 7DC2 series FRS:\(\frac{1}{2}\)ecat\_epr.bin 7DC2 series

UD1:\(\text{Yecat\_epr.bin}\)

Set the location of EEPROM image.

## 6 ALARM

### **6.1** ALARM IN ROBOT CONTROLLER

PRIO-800 WARN EtherCAT Board not installed

Cause: No EtherCAT PCB is installed. Remedy: Install EtherCAT PCB.

PRIO-801 STOP EtherCAT off line

Cause: EtherCAT becomes off line.

Remedy: Check EtherCAT settings and cable.

PRIO-802 STOP EtherCAT input size different

Cause: EtherCAT input size is different from master.

Remedy: Check EtherCAT settings.

PRIO-803 STOP EtherCAT output size different

Cause: EtherCAT output size is different from master.

Remedy: Check EtherCAT settings.

PRIO-804 STOP EtherCAT Com Soft Update Mode

Cause: Mode switch on EtherCAT board is communication software update mode.

Remedy: Change mode switch on EtherCAT board to 0 to change normal mode and cycle power.

PRIO-805 STOP EtherCAT EEPROM Update Mode

Cause: Mode switch on EtherCAT board is EEPROM update mode.

Remedy: Change mode switch on EtherCAT board to 0 to change normal mode and cycle power.

PRIO-806 STOP EtherCAT Update file not found

Cause: EtherCAT update file is not found.

Remedy: Check system variables \$BOOT2 \$BOOT3 \$ECAT\_SOFT \$EEPROM\_IMG under \$ECAT and check the file.

PRIO-807 STOP EtherCAT Update finished

Cause: Update for EtherCAT communication software or EEPROM is finished.

Remedy: Change mode switch on EtherCAT board to 0 to change normal mode and cycle power.

PRIO-808 STOP EtherCAT comm. error %x

Cause: EtherCAT communication error occurs.

Remedy: Please contact FANUC. Report the number displayed.

PRIO-809 STOP EtherCAT system error %x

Cause: EtherCAT system error occurs.

Remedy: Please contact FANUC. Report the number displayed.

PRIO-810 WARN %s

Cause: See the message displayed.

Remedy: This alarm displays the detail of alarm.

PRIO-811 STOP EtherCAT Com Soft mismatch

Cause: EtherCAT communication software on EtherCAT slave board is older or newer than the robot software.

Remedy: Update EtherCAT communication software and EEPROM image by the procedure written in EtherCAT operation

manual.

PRIO-812 WARN Required %s, Current %s

Cause: This message shows up together with PRIO-811 to inform the required and the current version of EtherCAT

communication software.

Remedy: Update EtherCAT communication software and EEPROM image by the procedure written in EtherCAT operation manual

## 6.2 ALARM IN MASTER

- When process data size in robot controller and master are different Slave application abnormal (error code 0x0020) is reported to master. Correct the process data size and cycle power.
- Input or output size is changed by master
  Robot should be cycle powered when EtherCAT communication data size is changed after
  communication is once established.
  In this case, slave application abnormal (error code 0x0020) is reported to master.
- When watch dog error occurs When a fault, such as communication CPU failure, occurs in robot controller, slave application abnormal (error code 0x0020) is reported to master.

## 7 INSTALLATION

This chapter provides information required for installation of the EtherCAT slave board.

## 7.1 SPECIFICATIONS

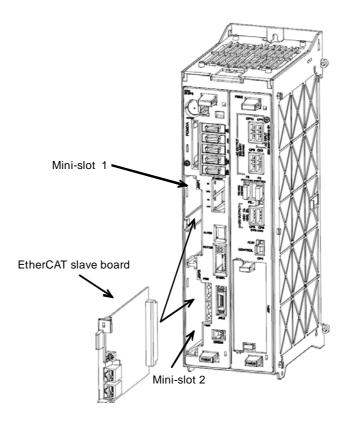
The specifications of the EtherCAT slave board are described below.

Name	EtherCAT slave board
Ordering code	A05B-2600-J120(R-30 <i>i</i> B, R-30 <i>i</i> B Mate)
Board drawing number	A20B-8101-0821

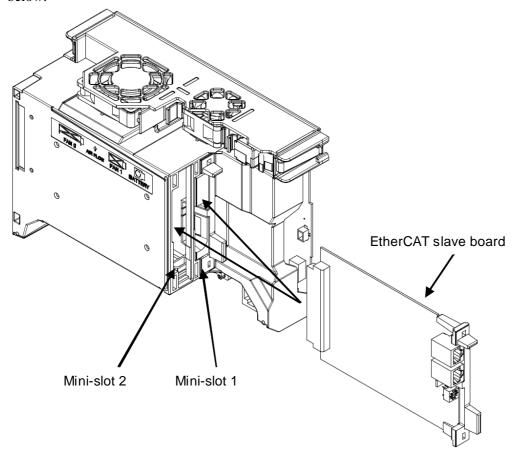
## 7.2 INSTALLATION

This section describes information about the installation of the EtherCAT slave board. The maximum number of EtherCAT slave board in the controller is 1.

In the R-30*i*B controller, an EtherCAT slave board can be installed to an option slot like the figure below.



In the R-30*i*B Mate controller, an EtherCAT slave board can be installed to an option slot like the figure below.

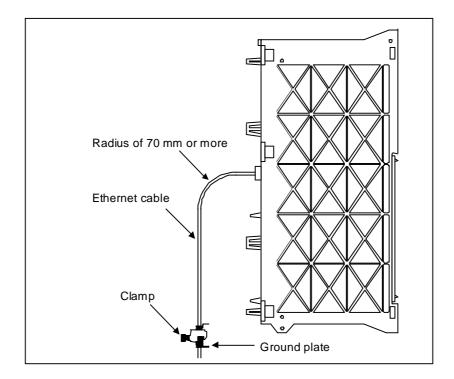


## 8 CONNECTION

This chapter provides information required for Ethernet connection of the EtherCAT slave board.

### **8.1** ROUTING OF THE ETHERNET CABLE

The Ethernet cable can be routed only from the front of the control unit. For connector location information, see the layout of components of EtherCAT slave board.



The Ethernet cable needs to be secured with a clamp so that no tension is applied to the connector (RJ-45) installed at the end of the cable even if the cable is pulled. This clamping also serves as the grounding of the cable shield.

#### **NOTE**

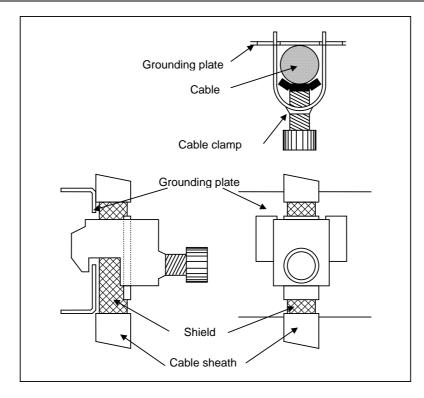
In EtherCAT communication, be sure to use twisted pair cables with a common shield in category 5 or more (STP cables).

## 8.2 ANTI-NOISE MEASURES

## 8.2.1 Clamping and Shielding of Cables

The Ethernet twisted pair cable needs to be clamped in the same way as the cables need to be shielded, as shown below. The clamping is required to shield and fix the cable. Be sure to perform the clamping to ensure the stable operation of the system.

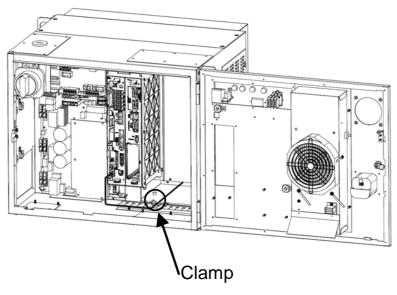
As shown in the figure, strip a part of the cable sheath to expose the metal shield and push the shield against the grounding plate with the clamping hardware.



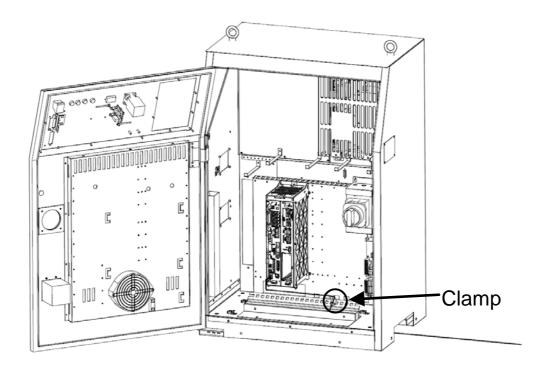
#### **NOTE**

- 1 Be sure to clamp and shield the cable to ensure the stable operation of the system.
- 2 Refer to the specification of master for master's shielding.
- 3 Unlike general Ethernet communication, EtherCAT communication does not perform retransmission at intervals of several seconds to achieve high responsibility. Accordingly, severer anti-noise measures must be taken as compared with general Ethernet wiring.
- 4 Upon completion of cabling, perform a communication test sufficiently not only before but also after system operation to ensure anti-noise measures.

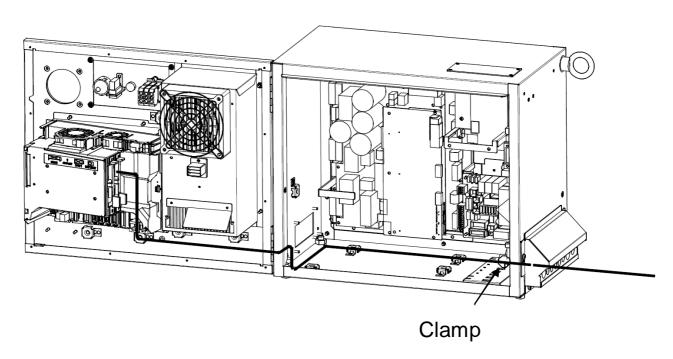
The following figure is how to lead the cable into the R-30*i*B controller.



A-cabinet



**B-cabinet**The following figure is how to lead the cable into the R-30*i*B Mate controller.

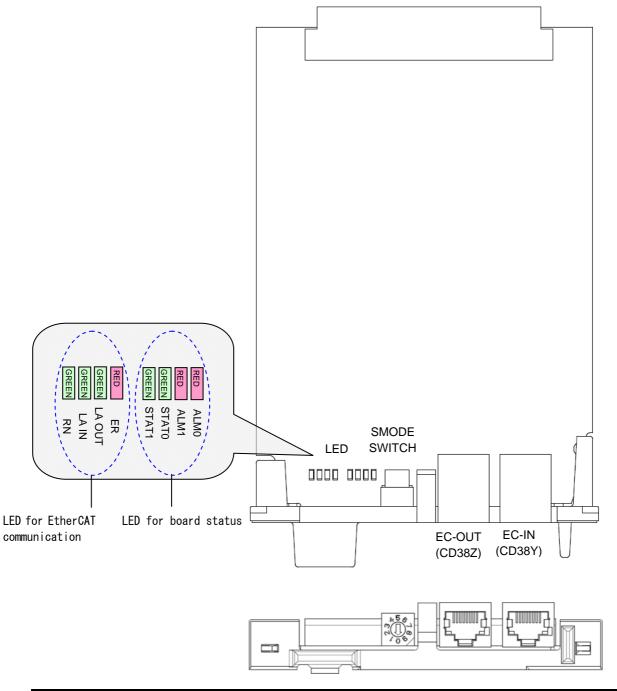


## 9 HARDWARE

This chapter provides hardware information required for the maintenance of the EtherCAT slave board.

## 9.1 LAYOUT OF COMPONENTS

The EtherCAT slave board has LEDs as the following figure.

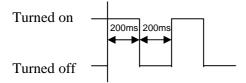


Name	PCB drawing number
EtherCAT slave board	A20B-8101-0821

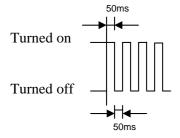
### 9.1.1 LED STATES

LED states have the following states in addition to turned on and turned off.

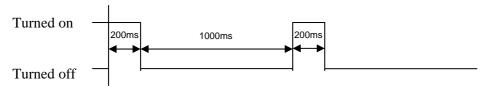
### **Blinking**



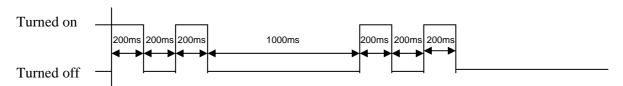
### **Flickering**



## Single flash



#### **Double flash**



## 9.1.2 LED INDICATION FOR EtherCAT COMMUNICATION

The following shows the LED indication for the EtherCAT communication.

### RN, ER

Name	Color	State	Description
		Turned Off	Initialization state
RN	Green	Blinking	PRE-OPERATIONAL state
KIN	Gleen	Single Flash	SAFE-OPERATIONAL state
		Turned On	OPERATIONAL state
		Turned Off	The EtherCAT communication of the device is in working condition
ER	Red	Blinking	General configuration error
EK	Reu	Single Flash	Slave device application has changed the EtherCAT state
			autonomously, due to local error.
		Double Flash	An application watchdog timeout has occurred.

#### LA IN. LA OUT

Name	Color	State	Description
		Turned Off	Port closed
LA IN	Green	Flickering	Port open
		Turned On	Port open, Not activity
		Turned Off	Port closed
LA OUT	Green Flickering Port open	Port open	
		Turned On	Port open, Not activity

### 9.1.3 LED INDICATION FOR BOARD STATUS

The following shows the LED indication for the board status.

In the description below, the following marks are used to represent the display states of each LED:

□ : Turned Off / ■ : Turned On / ☆ : Blinking / ★ : Flickering / △ : Single Flash / ー : Don't care

LED indication after completion of start-up for EtherCAT slave board

LED indication	
STAT1 (Green) STAT0 (Green) ALM1 (Red) ALM0 (Red)	Description
	Normal operation (communication mode)
<b>☆</b> ☆	The firmware of the EtherCAT slave board detected an abnormal.  The EtherCAT communication state is initialization (INIT).  The EtherCAT communication is not in working condition.
<b></b> ★★	The firmware of the EtherCAT slave board detected an abnormal.  The EtherCAT communication state is initialization (INIT).  The EtherCAT communication is not in working condition.  The seven segment LED indication of robot controller may be abnormal.

### LED indication before completion of start-up for EtherCAT slave board

LED Indication	
STAT1 (Green) STAT0 (Green) ALM1 (Red) ALM0 (Red)	Description
	The EtherCAT slave board is updating the software.
	The EtherCAT slave board completes software update. Set SMODE switch to normal mode "0".
	The EtherCAT slave board is updating the EEPROM data.
	The EtherCAT slave board completes EEPROM data update. Set SMODE switch to normal mode "0".

LED Indication	
STAT1 (Green) STAT0 (Green) ALM1 (Red) ALM0 (Red)	Description
	The SMODE switch is set to unsupported position.  Set SMODE switch to normal mode "0" normally.  Set SMODE switch to updating mode "C" when software of EtherCAT has to be updated.  Set SMODE switch to EEPROM updating mode "E" when EEPROM data has to be updated.
	The software version of EtherCAT slave board is old.  The software of EtherCAT has to be updated by setting SMODE switch to updating mode "C".  Set SMODE switch to updating mode "C" and update the software of EtherCAT (7DC3 or later).
	The software version of EtherCAT slave board is new.  The software of EtherCAT has to be updated by setting SMODE switch to updating mode "C".  Set SMODE switch to updating mode "C" and update the software of EtherCAT (7DC3 or later).
	The updating of software of EtherCAT slave board is failed or the updating of the EEPROM data of the EtherCAT slave board is failed.  Please try updating operation again after restarting the robot controller.  If the updating fails again, the EtherCAT slave board may have broken.  Replace the EtherCAT slave board.
••••	Initializing.  If the LED of the EtherCAT slave board does not change for a while, please restart the robot controller.  If a similar phenomenon occurs again, the EtherCAT slave board may have broken.  Replace the EtherCAT slave board.

#### **⚠** CAUTION

Please do not turn off the power during the software updating or the EEPROM data updating for the EtherCAT slave board.

If the power turned off during the software updating, the internal ROM or EEPROM data of EtherCAT slave board may have broken.

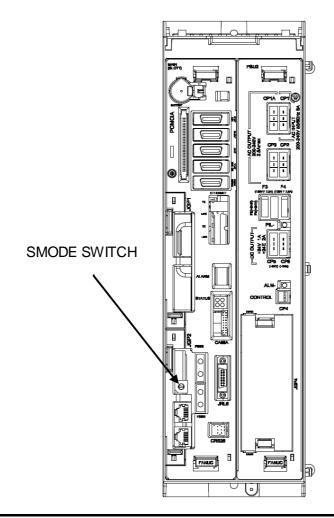
If the internal ROM or EEPROM data of EtherCAT slave board is broken, EtherCAT slave board can not communicate.

In this case, replace the EtherCAT slave board.

After confirm that the LED state is normal or flashing (blinking, flickering, single flash, double flash), turn off the power.

## 9.2 SMODE SWITCH

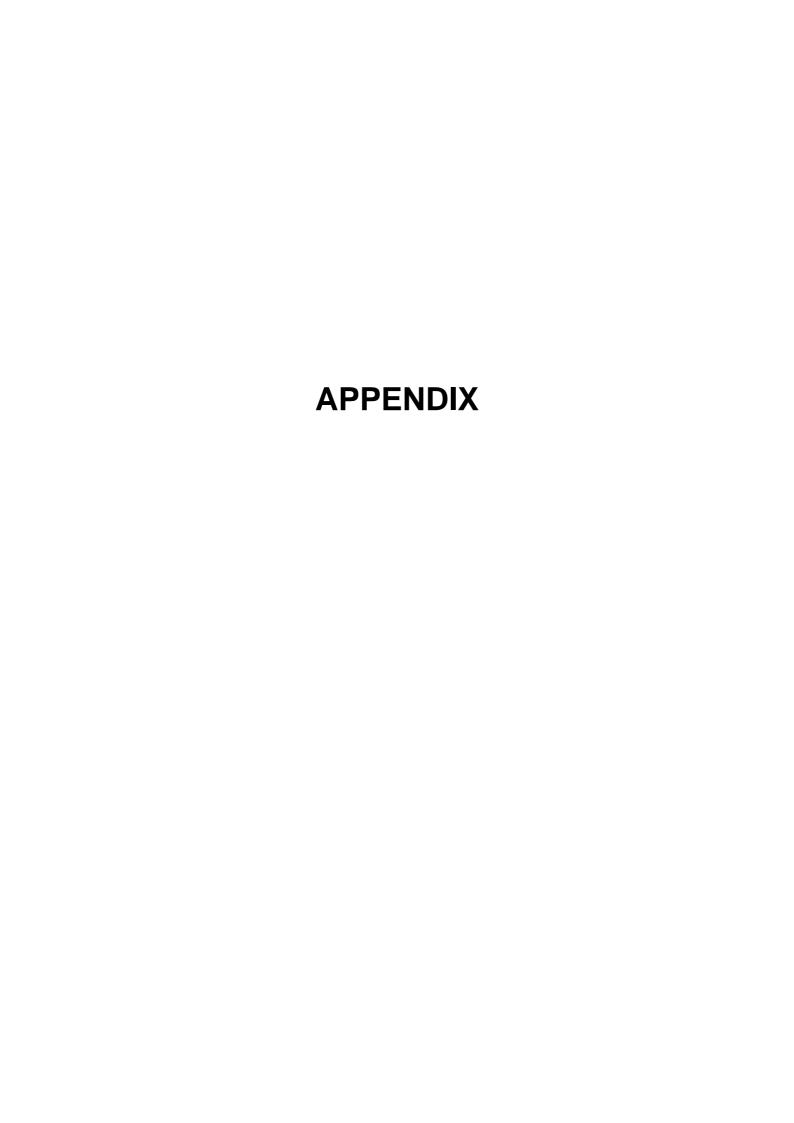
By setting the following switch, the communication software for the EtherCAT slave function can be updated.



### NOTE

The updating mode and EEPROM updating mode are not used normally.

SMODE Switch	Mode	Description
0	Normal mode	In this mode, EtherCAT communication is possible. The robot controller normally starts in this mode.
С	Updating mode	In this mode, updating communication software for EtherCAT slave function is possible.
E	EEPROM updating mode	In this mode, updating EEPROM data is possible





## **ETHERCAT I/O DATA**

M	Mapping object			Object dictionary			
Name	Index	Subindex	Index	Subindex	Direction	Data type	Robot assignment
OUT128	1600H	1	2100H	1	OUT	Bit array[128]	DI, UI, GI
OUT256	1601H	1-2	2101H	1-2	OUT	Bit array[128]	DI, UI, GI
OUT512	1602H	1-4	2102H	1-4	OUT	Bit array[128]	DI, UI, GI
OUT1024	1603H	1-8	2103H	1-8	OUT	Bit array[128]	DI, UI, GI
OUT2048	1604H	1-16	2104H	1-16	OUT	Bit array[128]	DI, UI, GI
OUT4096	1605H	1-32	2105H	1-32	OUT	Bit array[128]	DI, UI, GI
IN128	1A00H	1	3100H	1	IN	Bit array[128]	DO, UO, GO
IN256	1A01H	1-2	3101H	1-2	IN	Bit array[128]	DO, UO, GO
IN512	1A02H	1-4	3102H	1-4	IN	Bit array[128]	DO, UO, GO
IN1024	1A03H	1-8	3103H	1-8	IN	Bit array[128]	DO, UO, GO
IN2048	1A04H	1-16	3104H	1-16	IN	Bit array[128]	DO, UO, GO
IN4096	1A05H	1-32	3105H	1-32	IN	Bit array[128]	DO, UO, GO

- 1600H, 1601H, 1602H, 1603H, 1604H, 1605H are exclusive, only 1 item can be selected.
- 1A00H, 1A01H, 1A02H, 1A03H, 1A04H, 1A05H are exclusive, only 1 item can be selected.
- Bit array of 128bits are assigned for robot as 1bit = 1 point.

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REVISION RECORD

## **REVISION RECORD**

Edition	Date	Contents
01	Jun., 2014	

B-83704EN/01

\* B - 8 3 7 0 4 E N / 0 1 \*