FANUC Robot series

R-30*i*B CONTROLLER

*i*RDiagnostics

OPERATIONS MANUAL

Version 8.20 and later

MAROBDG8204121E REV B

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

Copyrights and Trademarks

The descriptions and specifications contained in this manual were in effect at the time this manual was approved for printing. FANUC America Corporation, hereinafter referred to as FANUC, reserves the right to discontinue models at any time or to change specifications or design without notice and without incurring obligations.

FANUC manuals present descriptions, specifications, drawings, schematics, bills of material, parts, connections and/or procedures for installing, disassembling, connecting, operating and programming FANUC products and/or systems. Such systems consist of robots, extended axes, robot controllers, application software, the KAREL® programming language, INSIGHT® vision equipment, and special tools.

FANUC recommends that only persons who have been trained in one or more approved FANUC Training Course(s) be permitted to install, operate, use, perform procedures on, repair, and/or maintain FANUC products and/or systems and their respective components. Approved training necessitates that the courses selected be relevant to the type of system installed and application performed at the customer site.

WARNING

This equipment generates, uses, and can radiate radiofrequency energy and if not installed and used in accordance with the instruction manual, may cause interference to radio communications. As temporarily permitted by regulation, it has not been tested for compliance with the limits for Class A computing devices pursuant to subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference. Operation of the equipment in a residential area is likely to cause interference, in which case the user, at his own expense, will be required to take whatever measure may be required to correct the interference.

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

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:
product.documentation@fanucrobotics.com

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

4,630,567 4,639,878 4,707,647 4,708,175 4,708,580 4,942,539 4,984,745 5,238,029 5,239,739 5,272,805 5,293,107 5,293,911 5,331,264 5,367,944 5,373,221 5,421,218 5,434,489 5,644,898 5,670,202 5,696,687 5,737,218 5,823,389 5,853,027 5,887,800 5,941,679 5,959,425 5,987,726 6,059,092 6,064,168 6,070,109 6,086,294 6,122,062 6,147,323 6,204,620 6,243,621 6,253,799 6,285,920 6,313,595 6,325,302 6,345,818 6,356,807 6,360,143 6,378,190 6,385,508 6,425,177 6,477,913 6,490,369 6,518,980 6,540,104 6,541,757 6,560,513 6,569,258 6,612,449 6,703,079 6,705,361 6,726,773 6,768,078 6,845,295 6,945,483 7,149,606 7,149,606 7,211,978 7,266,422 7,399,363

FANUC CORPORATION Patent List

4,571,694 4,626,756 4,700,118 4,706,001 4,728,872 4,732,526 4,742,207 4,835,362 4,894,596 4,899,095 4,920,248 4,931,617 4,934,504 4,956,594 4,967,125 4,969,109 4,970,370 4,970,448 4,979,127 5,004,968 5,006,035 5,008,834 5,063,281 5,066,847 5,066,902 5,093,552 5,107,716 5,111,019 5,130,515 5,136,223 5,151,608 5,170,109 5,189,351 5,267,483 5,274,360 5,292,066 5,300,868 5,304,906 5,313,563 5,319,443 5,325,467 5,327,057 5,329,469 5,333,242 5,337,148 5,371,452 5,375,480 5,418,441 5,432,316 5,440,213 5,442,155 5,444,612 5,449,875 5,451,850 5,461,478 5,463,297 5,467,003 5,471,312 5,479,078 5,485,389 5,485,552 5,486,679 5,489,758 5,493,192 5,504,766 5,511,007 5,520,062 5,528,013 5,532,924 5,548,194 5,552,687 5,558,196 5,561,742 5,570,187 5,570,190 5,572,103 5,581,167 5,582,750 5,587,635 5,600,759 5,608,299 5,608,618 5,624,588 5,630,955 5,637,969 5,639,204 5,641,415 5,650,078 5,658,121 5,668,628 5,687,295 5,691,615 5,698,121 5,708,342 5,715,375 5,719,479 5,727,132 5,742,138 5,742,144 5,748,854 5,749,058 5,760,560 5,773,950 5,783,922 5,799,135 5,812,408 5,841,257 5,845,053 5,872,894 5,887,122 5,911,892 5,912,540 5,920,678 5,937,143 5,980,082 5,983,744 5,987,591 5,988,850 6,023,044 6,032,086 6,040,554 6,059,169 6,088,628 6,097,169 6,114,824 6,124,693 6,140,788 6,141,863 6,157,155 6,160,324 6,163,124 6,177,650 6,180,898 6,181,096 6,188,194 6,208,105 6,212,444 6,219,583 6,226,181 6,236,011 6,236,896 6,250,174 6,278,902 6,279,413 6,285,921 6,298,283 6,321,139 6,324,443 6,328,523 6,330,493 6,340,875 6,356,671 6,377,869 6,382,012 6,384,371 6,396,030 6,414,711 6,424,883 6,431,018 6,434,448 6,445,979 6,459,958 6,463,358 6,484,067 6,486,629 6,507,165 6,654,666 6,665,588 6,680,461 6,696,810 6,728,417 6,763,284 6,772,493 6,845,296 6,853,881 6,888,089 6,898,486 6,917,837 6,928,337 6,965,091 6,970,802 7,038,165 7,069,808 7,084,900 7,092,791 7,133,747 7,143,100 7,149,602 7,131,848 7,161,321 7,171,041 7,174,234 7,173,213 7,177,722 7,177,439 7,181,294 7,181,313 7,280,687 7,283,661 7,291,806 7,299,713 7,315,650 7,324,873 7,328,083 7,330,777 7,333,879 7,355,725 7,359,817 7,373,220 7,376,488 7,386,367 7,464,623 7,447,615 7,445,260 7,474,939 7,486,816 7,495,192 7,501,778 7,502,504 7,508,155 7,512,459 7,525,273 7,526,121

Conventions

WARNING

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

CAUTION

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

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

Safety

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

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

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

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

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

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

CONSIDERING SAFETY FOR YOUR ROBOT INSTALLATION

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

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

Keeping People Safe

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

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

Using Safety Enhancing Devices

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

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

Setting Up a Safe Workcell

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

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

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

Staying Safe While Teaching or Manually Operating the Robot

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

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

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

WARNING

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

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

WARNING

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

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

Staying Safe During Automatic Operation

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

- Make sure all safety provisions are present and active.

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

Staying Safe During Inspection

When inspecting the robot, be sure to

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

Staying Safe During Maintenance

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

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

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

⚠WARNING

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

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

⚠WARNING

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

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

KEEPING MACHINE TOOLS AND EXTERNAL DEVICES SAFE

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

Programming Safety Precautions

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

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

Mechanical Safety Precautions

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

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

KEEPING THE ROBOT SAFE

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

Operating Safety Precautions

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

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

Programming Safety Precautions

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

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

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

ADDITIONAL SAFETY CONSIDERATIONS FOR PAINT ROBOT INSTALLATIONS

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

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

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

CAUTION

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

Paint robots are operated in three modes:

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

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

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

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

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

Paint System Safety Features

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

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

The paint system includes the following safety features:

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

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

WARNING

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

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

Staying Safe While Operating the Paint Robot

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

WARNING

Observe all safety rules and guidelines to avoid injury.

WARNING

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

WARNING

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

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

Special Precautions for Combustible Dusts (Powder Paint)

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

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

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

Staying Safe While Operating Paint Application Equipment

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

⚠ WARNING

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

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

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

Staying Safe During Maintenance

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

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

Table of Contents

1 OVERVIEW

1 OVERVIEW

The *i*RDiagnostics function consists of following three functions:

Function	Description
Robot Condition Detection	Warn the users when abnormalities are detected in the reducers.
Servo Diagnosis	Diagnose servo alarms to show possible causes of alarms.
Motion Profiler	Show motion data (OVC, overheat, power consumption) of each program.

2 ROBOT CONDITION DETECTION

2 ROBOT CONDITION DETECTION

2.1 Overview

- This function detects abnormalities of reducers to help users decide time for preventive replacement in order to minimize down time due to a problem in reducers.
- By posting a warning, it warns the users of reducer abnormalities detected by periodically analyzing motion data.
- It requires creation of a diagnostic program, registration of initial data, and periodical execution of the diagnostic program.
- The diagnostic program is created by giving a base position and allowable motion range.
- This function supports R-2000*i*B and R-1000*i*A Series robots.
- If enough motion range is not given, motion data cannot be analyzed.
- In case of impulsion-induced rapid degradation, or failure in certain parts, reducer failure may not be detected beforehand as abnormality.
- A failure due to aging may also progress rapidly in a few days before failure. Run the diagnostic program periodically or around once a day.

2.2 Setup

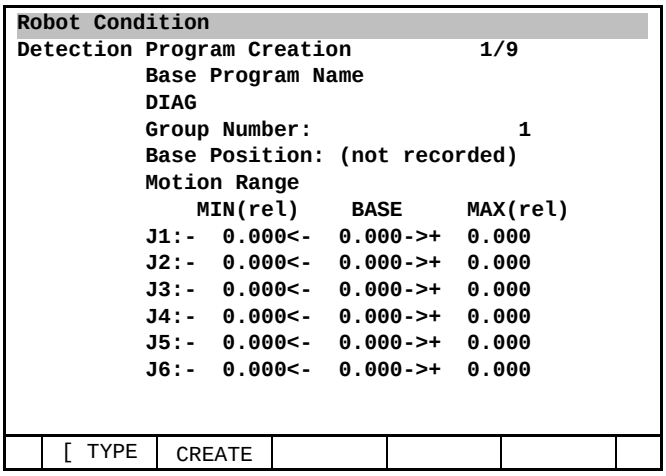
2.2.1 CREATE

This function requires creation of diagnostic program. Create the diagnostic program with following procedure.

Procedure 2-1 Creating the Diagnostic Program

Step

1. Jog the robot to the base position, where diagnostic program starts and ends.
2. Press MENU.
3. Select UTILITIES.
4. Press F1, [TYPE].
5. Select Robot Condition. You will see a screen similar to the following.



6 Move the cursor to Base Program Name, and type the name of the diagnostic program to be created. The group number will be added to the base name to create program name. The base program name should not be more than 34 letters.

7 Move the cursor to Group Number, and type the number of the group for analysis.

8 Move the cursor over Base Position, and press SHIFT and F4, RECORD at the same time.

9 Enter allowable motion range of each axis in degrees.

For each axis, enter the allowable motion range relative to the base position, both MIN and MAX.

The robot will move axis by axis, one axis at a time.

The axis without wide enough motion range cannot be analyzed.

10 Set to AUTO mode and disable the teach pendant.

11 Set the override to 100%.

Press SHIFT and F2, CREATE. A program will be created with group number added to the Base Program Name.

Note: Run the program with a low override to assure safety of the program.

2.2.2 MASTER

Procedure 2-2 Registration of the Initial Data

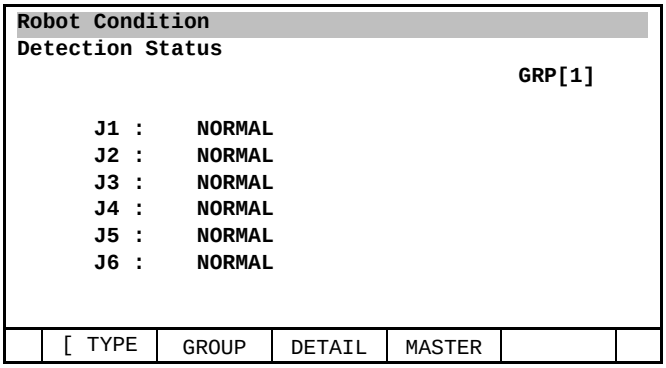
1 Run the created program with 100% override (run with low override beforehand to assure safety).

2 Press MENU.

3 Select, STATUS.

4 Press F1, [TYPE].

5 Select Robot Condition. You will see a screen similar to the following.



6 If the upper right display of GRP[] does not show the group for analysis, press F2 GROUP and enter the group number.

7 Press F4, MASTER.

8 Enter –1 (all axes) when prompted to enter the axis number.

9 A message will ask to confirm removal of previous data and use of current data as base data.

10 Select [YES] when the following prompt is displayed: "Please confirm to use current data as baseline data? Please note previous history will be removed after master."

The latest analysis data is registered as base line data.
The axis not registered, shown with *s, was not given enough motion range to analyze the condition.

NOTE:

Please note the following items may prevent this function from working properly.

- Do not edit the created program.
- Creating the program with the same name will overwrite the old program. If overwritten after "MASTER", this function will not work properly. If the program needs to be changed during setup, go through both "CREATE" and "MASTER".
- Different programs may be created with arbitrary base positions. However, an axis can be analyzed with only one program. With different programs analyzing the same axis, this function will not work properly because of different characteristics of the data collected. When tried to analyze an axis with a program different from the one used for "MASTER", a warning will be posted (different axes can be analyzed with different programs).
- Basically, go through "MASTER" only with initial setup and when replacing reducer.
- If it becomes impossible to use the program for some reason, such as moving the robot to different location, it would be necessary to go through "CREATE" and "MASTER". However, if there is a reducer already reaching an end of its operating life, then go through these steps may cause this function not work properly

.

2.3 Execute the Program

After the base line data is registered, the latest data is analyzed every time a diagnostic program is executed with 100% override, and check if there are any abnormalities.
Run the program periodically to detect abnormality: for example, once a day.
Make sure that the program is run under the same condition as the time the baseline data was recorded, such as load.

If an abnormality is detected, the following warning will be posted, “SRVO-394 Reducer Abnormal (Gg, Aa)” where g is the group number and a is the axis number.
An abnormality is detected in corresponding axis. Please plan for a replacement.

2.4 Robot Condition Detection Status

Current condition can be viewed at Robot Condition Detection Status.
To view Robot Condition Detection Status,

1. Press MENU.
2. Select STATUS.
3. Press F1, [TYPE].
4. Select Robot Condition. The Robot Condition Detection Status shows the condition of each axis.

Moving the cursor over an axis and pressing F3, DETAIL will show the time of registration of the base line data and time of analysis of the latest data.

2.4.1 After Replacement

When the reducer is replaced, the corresponding base line data needs to be re-registered.

Procedure 2-3 Re-Registering the Data

Step

1 Run the diagnostic program with 100% override. (Run with low override beforehand to assure safety.)

2 Press MENU.

3 Select STATUS.

4 Press F1, [TYPE].

5 Select Robot Condition.

6 If the upper right display of GRP[] does not show the group for analysis, press F2 GROUP and enter the group number.

7 Move the cursor over the axis of replacement, and press F3 DETAIL.

8 Check that the time of the Latest is the time diagnostic program was run in step 1.

9 Press F4 MASTER

10 Enter the axis of replacement when prompted to enter the axis number.

11 A message will ask to confirm removal of previous data and use of current data as base data.
“Please confirm to use current data as baseline data? Please note previous history will be removed after master.”
Select [YES]

12 Press F3 DETAIL and check that time of the Base is updated.

The new base line data is now registered

3 SERVO DIAGNOSIS

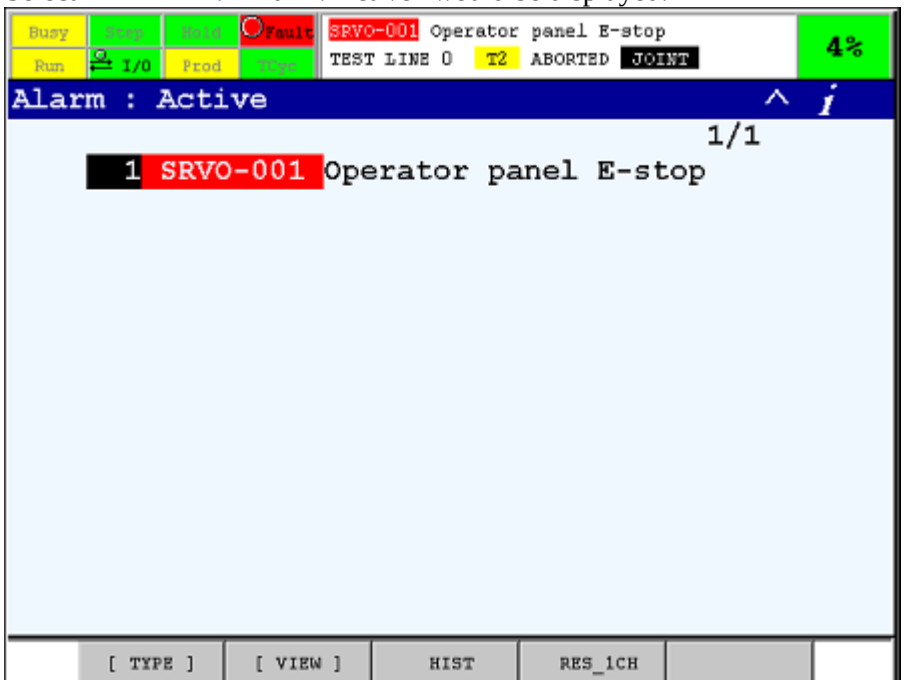
3 SERVO DIAGNOSIS

3.1 Overview

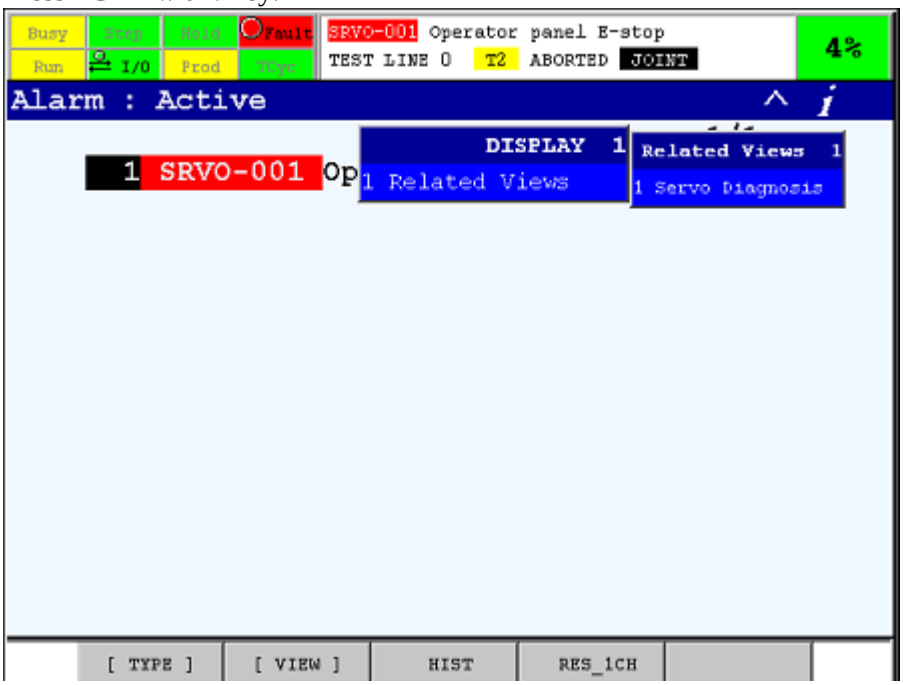
- This function diagnoses alarms posted, and list probable causes, aiming to decrease down time before resetting alarm.
  - ➢ This function estimates where the problem is, based on the alarm posted and internal information acquirable by software. However, it may not be able to estimate the problem in some cases such as if problem rises where software cannot acquire information. Please use it to help solve problem when alarm is posted.
- When servo alarm is posted, follow the procedure to perform Servo Diagnosis.

(Alarm Posted.)

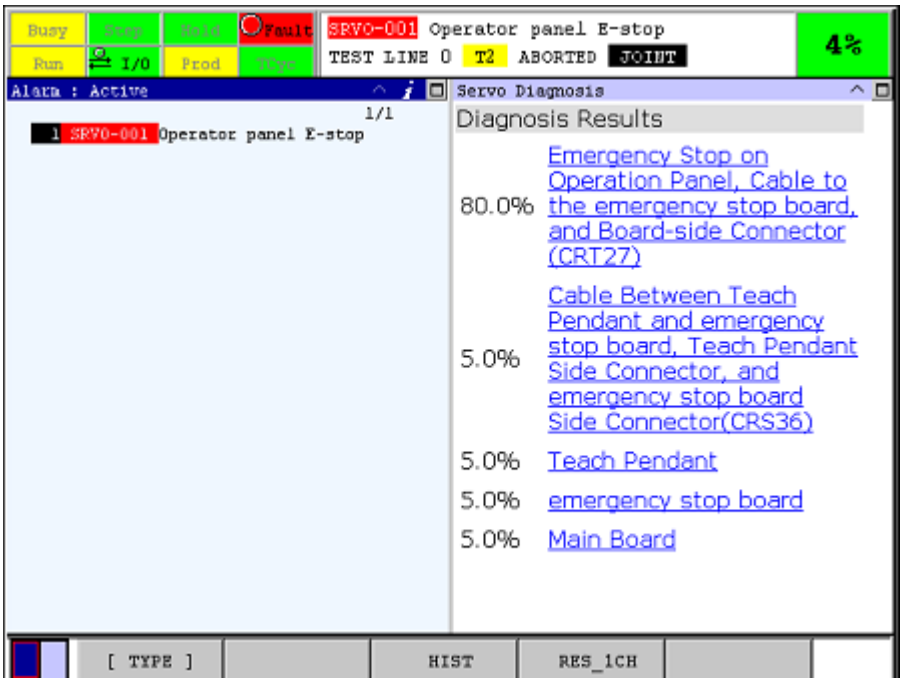
1. Press MENU.
   Select “ALARM”. “Alarm: Active” would be displayed.



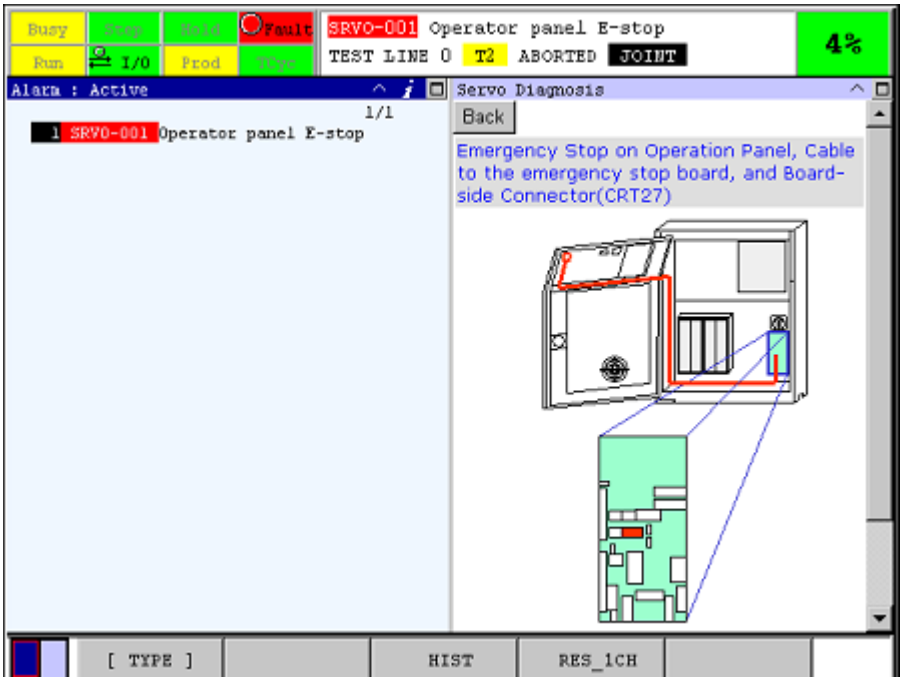
2. Press FCTN with *i* key.



3. Select "Servo Diagnosis" in the "Related Views" menu.
The causes of the alarm would be listed. Please check the items to see if there is any trouble.



4. Some of the causes text have a hyperlink. As the hyperlink is tapped, the diagram about the cause is shown.



Click “Back” button to return back to the cause list view.

3.2 Alarms

- The alarms covered by this function are following:
  - SRVO-001 Operator panel E-Stop
  - SRVO-005 Robot overtravel
  - SRVO-006 Hand broken
  - SRVO-009 Pneumatic pressure alarm
  - SRVO-018 Brake abnormal (G:%d A:%d)
  - SRVO-021 SRDY off (Group:%d Axis:%d)
  - SRVO-022 SRDY on (Group:%d Axis:%d)
  - SRVO-023 Stop error excess (G:%d A:%d)
  - SRVO-024 Move error excess (G:%d A:%d)
  - SRVO-036 Inpos time over (G:%d A:%d)
  - SRVO-038 Pulse mismatch (G:%d A:%d)
  - SRVO-043 DCAL alarm (Group:%d Axis:%d)
  - SRVO-044 DCHVAL alarm (PS) (Group:%d Axis:%d)
  - SRVO-045 HCAL alarm(Group:%d Axis:%d)
  - SRVO-046 OVC alarm (Group:%d Axis:%d)
  - SRVO-047 LVAL alarm(Group:%d Axis:%d)
  - SRVO-049 OHAL1 alarm (Grp:%d Ax:%d)
  - SRVO-050 Collision Detect alarm (G:%d A:%d)
  - SRVO-051 CUER alarm(Group:%d Axis:%d)
  - SRVO-055 FSSB com error 1 (G:%d A:%d)
  - SRVO-056 FSSB com error 2 (G:%d A:%d)
  - SRVO-057 FSSB disconnect (G:%d A:%d)
  - SRVO-062 BZAL alarm(Group:%d Axis:%d)

- SRVO-064 PHAL alarm(Group:%d Axis:%d)
- SRVO-067 OHAL2 alarm (Grp:%d Ax:%d)
- SRVO-068 DTERR alarm (Grp:%d Ax:%d)
- SRVO-069 CRCERR alarm (Grp:%d Ax:%d)
- SRVO-070 STBERR alarm (Grp:%d Ax:%d)
- SRVO-071 SPHAL alarm (Grp:%d Ax:%d)
- SRVO-072 PMAL alarm(Group:%d Axis:%d)
- SRVO-073 CMAL alarm(Group:%d Axis:%d)
- SRVO-074 LDAL alarm(Group:%d Axis:%d)
- SRVO-076 Tip Stick Detection(G:%d A:%d)
- SRVO-105 Door open or E.Stop
- SRVO-136 DCLVAL alarm (G:%d A:%d)
- SRVO-156 IPMAL alarm (G:%d A:%d)
- SRVO-157 CHGAL(PS) alarm (G:%d A:%d)
- SRVO-204 External(SVEMG abnormal) E-stop
- SRVO-205 Fence open(SVEMG abnormal)
- SRVO-206 Deadman switch (SVEMG abnormal)
- SRVO-213 E-STOP Board FUSE2 blown
- SRVO-214 6ch amplifier fuse blown(R:%d)
- SRVO-215 Brake Unit fuse blown(R:%d)
- SRVO-216 OVC(total) (%d)
- SRVO-233 TP OFF in T1,T2/Door open
- SRVO-235 Short term Chain abnormal
- SRVO-251 DB relay abnormal(G:%d A:%d)
- SRVO-252 Current detect abnl(G:%d A:%d)
- SRVO-253 Amp internal over heat(G:%d A:%d)
- SRVO-277 Panel E-stop(SVEMG abnormal)
- SRVO-278 TP E-stop(SVEMG abnormal)
- SRVO-290 Dclink HC alarm(G:%d A:%d)
- SRVO-291 IPM over heat (G:%d A:%d)
- SRVO-292 EXT.FAN alarm (G:%d A:%d)
- SRVO-349 DCS MCC ON alarm %x,%x

4 MOTION PROFILER

4 MOTION PROFILER

4.1 Overview

Motion Profiler is a motion option provides important motion information for either total execution cycle or each executed program line. This option enables the easy diagnosis of program performance for selected program. The exact motion lines can be indentified and then adjusted easily using this option so the desired performance can be achieved.

The summary data for execution cycle provided by this option includes:

- Total Cycle Time
- Power Consumption
- Regenerative Power (if hardware is available)
- Steady-State OVC (the prediction if the same path running non-stop continuously)
- Long term Overheat

The detailed data shown in bar charts per program execution line includes:

- Execution Time per line
- Power usage per line

Due to the memory constraints of controllers, the motion profiler data for the extreme long program may be overwritten and data may be missing. Please consider separating the very long program to reasonable program sizes.

4.2 Setup

Motion profiler function will be turned off automatically after the selected program is aborted. Please enable the function again if the program needs to be analyzed again.

It is important that ambient temperature, special hardware option, and robot connection cable (RCC) length for each robot group are entered correctly. The prediction and calculation result will be affected by these settings.

ITEM		**DESCRIPTION**
Status		Enable or disable Motion Profiler. This status will change to disable automatically after the main program is aborted.
Main Program		The main TP program to be used for Motion Profiler
Detail Settings	Group Number	Group number
	Ambient Temperature	The ambient temperature for this robot
	Robot Connection Cable Length	The length of robot connection cable (RCC) for this robot. This number may be printed on the robot connection cable
	Hardware Configuration	Any special hardware configuration for this robot. For example, motor fan, motor cover, etc.

4.3 Results

The results of Motion Profiler function can be reviewed in either Status menu or directly go to the "related view" from TP editor.

- Status screen
  1. Press MENU.
  2. Select STATUS.
  3. Press F1, [TYPE].
  4. Select Motion Profiler to show Main page.
  5. Move cursor to menu item and press F3 DETAIL to display the detail bar chart with program name: line number as horizontal axis, or data of each axis.

- Related view
  1. Press SELECT
  2. Select TP program that Motion Profiler was enabled and press Enter.
  3. In TP program editor, press *i* + FCTN key to display Related View menu.
  4. Select Motion Profiler to review triple pane with TP editor, Motion Profiler summary, and Motion Profiler detailed chart. Scrolling the cursor in the TP editor then Motion Profiler detailed chart will update to current line data automatically. This will work in the sub program as well.

4.3.1 Detail

Main page displays summarized data of analyzed program. With cursor over each item, pressing F3, DETAIL shows detailed data of each item (except regenerative power).

- Cycle Time
  Display execution time of the analyzed program. In DETAIL, bar chart shows execution time of each program line. The lines with very short execution time will not be shown, including some of command lines.

- Steady-State OVC
  Display the estimation of steady-state OVC value when analyzed program was run repeatedly. In Main page, the largest value among the axes is shown. In DETAIL pge, the values of each axis are shown. The values represent the ratio of calculated OVC against the thresholds. The value over 100% shows estimated result of OVC occurring.

- Overheat
  Actual Overheat alarm is triggered by sensor in the motor, but this function estimates if Overheat would occur, by comparing electric current data to experimental data. In Main page, the largest value among the axes is shown. In DETAIL page, the values of each axis are shown. The values represent the ratio of calculated value against the thresholds. The value over 100% shows the estimated result of Overheat occurring. The estimation is affected by Ambient Temperature and Hardware Configuration set in Detail Settings. Please set them accurately.

  Steady-State OVC and Overheat are results of estimation, and their accuracies are not guaranteed.

- Power Consumption
  Display power consumption while executing the analyzed program. In DETAIL page, power consumption per axis is shown. They are estimated results and not measured data. In cases such as unsupported group included in motion groups of the program, the results do not include their power consumption. The results are affected by Robot Connection Cable Length set in Detail Settings. Please set it accurately.

- Regenerative Power
  Display the estimation of regenerated energy while executing the analyzed program if the hardware option is installed. No detail data is recorded. The result is affected by Robot Connection Cable Length set in Detail Settings. Please set it accurately.