

FANUC Robot **series**

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

EtherNet/IP

OPERATOR'S MANUAL

B-82854EN/02

- **Original Instructions**

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

- No part of this manual may be reproduced in any form.
- All specifications and designs are subject to change without notice.

The products in this manual are controlled based on Japan's "Foreign Exchange and Foreign Trade Law". The export from Japan may be subject to an export license by the government of Japan.

Further, re-export to another country may be subject to the license of the government of the country from where the product is re-exported. Furthermore, the product may also be controlled by re-export regulations of the United States government.

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

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

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

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

SAFETY PRECAUTIONS

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.

If any description in this chapter differs from that in the other part of this manual, the description given in this chapter shall take precedence.

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 user 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 oscillator.

WARNING

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

CAUTION

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.

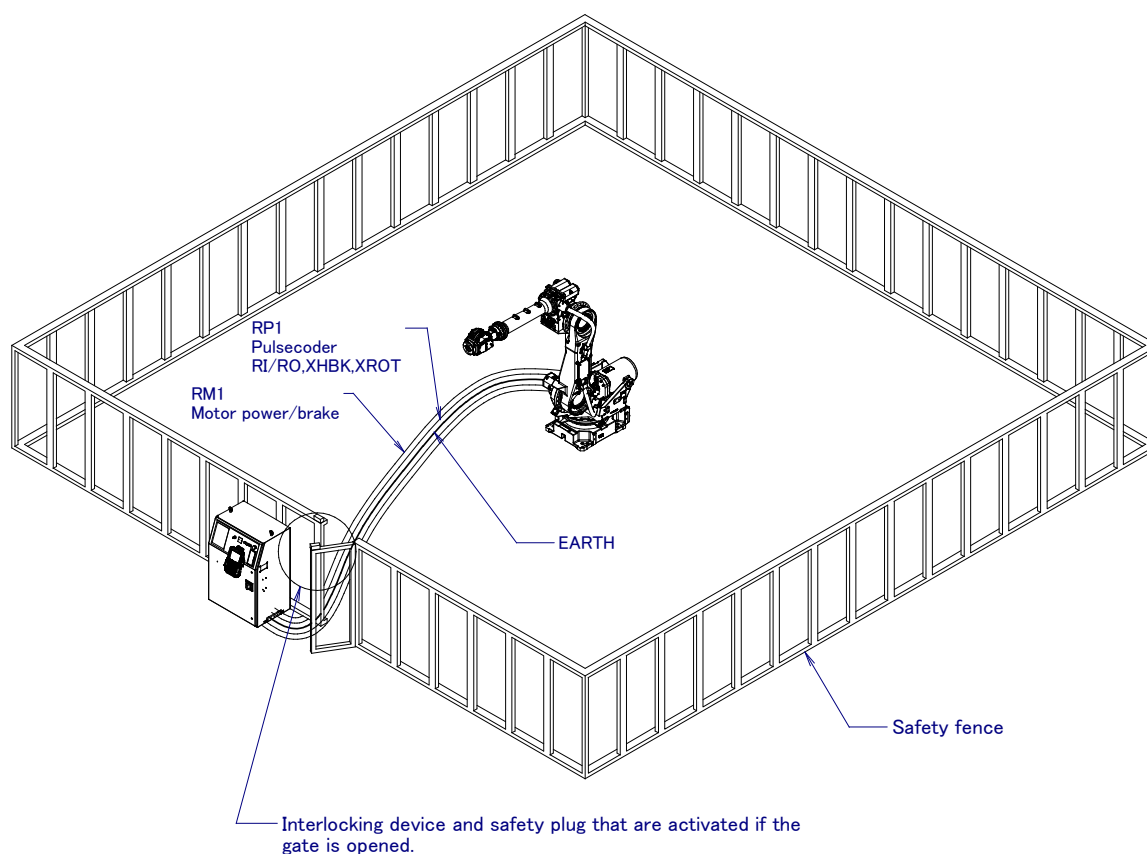


Fig. 3 (a) Safety fence and safety gate

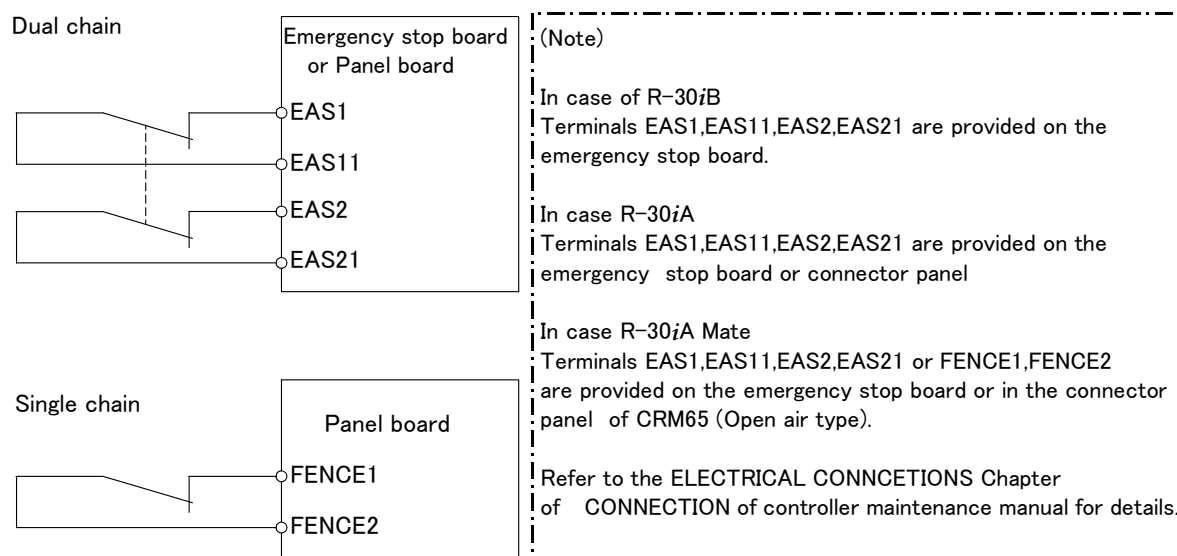


Fig. 3 (b) Limit switch circuit diagram of the safety fence

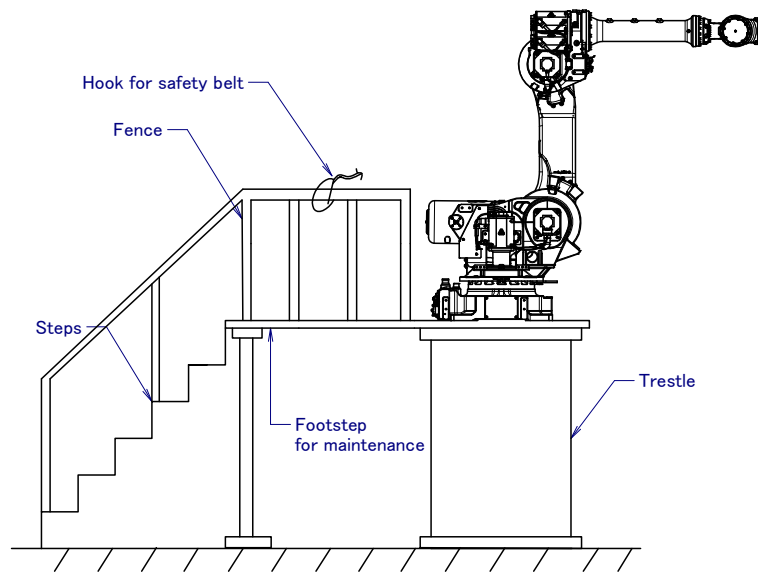


Fig.3 (c) Footstep for maintenance

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.

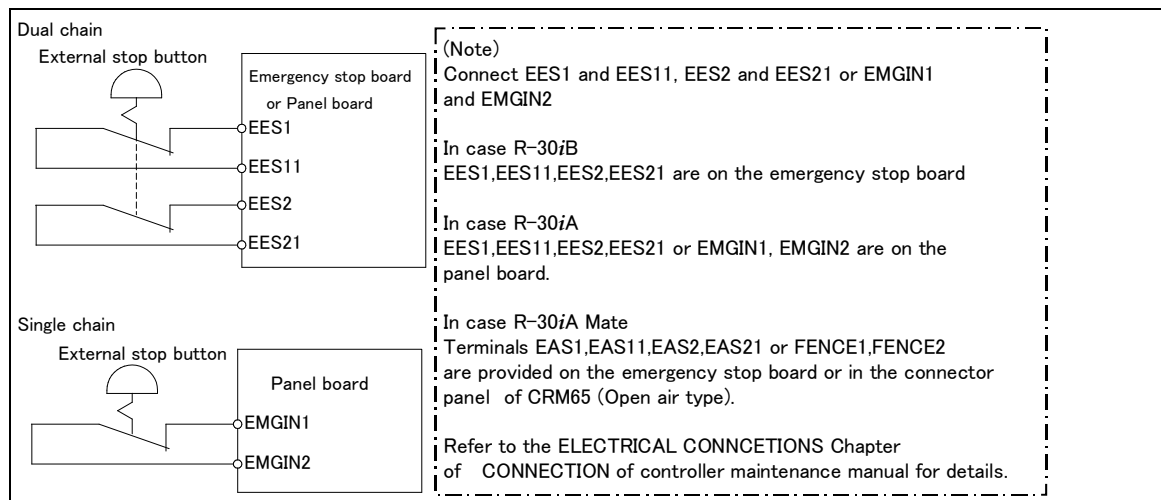


Fig.3.1 Connection diagram for external emergency stop button

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 user.

Our operator panel is provided with an emergency stop button and a key switch (mode switch) for selecting the automatic operation mode (AUTO) and the teach modes (T1 and T2). Before entering the inside of the safety fence for the purpose of teaching, set the switch to a teach mode, remove the key from the mode switch to prevent other people from changing the operation mode carelessly, then open the safety gate. If the safety gate is opened with the automatic operation mode set, the robot stops (Please refer to "STOP TYPE OF ROBOT" in SAFETY PRECAUTIONS for detail of stop type). After the switch is set to a teach mode, the safety gate is disabled. The programmer should understand that the safety gate is disabled and is responsible for keeping other people from entering the inside of the safety fence. (In case of R-30iA Mate Controller standard specification, there is no mode switch. The automatic operation mode and the teach mode is selected by teach pendant enable switch.)

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 an emergency stop (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-30iB/R-30iA/ R-30iA 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.

In case of R-30iB/R-30iA controller or CE or RIA specification of R-30iA Mate controller

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

T1,T2 mode: DEADMAN switch is effective.

In case of standard specification of R-30iA Mate controller

Teach pendant enable switch	Software remote condition	Teach pendant	Peripheral device
On	Ignored	Allowed to start	Not allowed
Off	Local	Not allowed	Not allowed
	Remote	Not allowed	Allowed to start

- (6) (Only when R-30iB/R-30iA Controller or CE or RIA specification of R-30iA Mate controller is selected.) 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 "Controller operator's manual".) 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. When these attentions are not kept, unexpected troubles might occur.
 - 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.
 - Please do not interfere with the other parts of mechanical unit when install equipments in the robot.
- (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.
 - 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) Robot stops urgently when collision detection alarm (SRVO-050) etc. occurs. The frequent urgent stop by alarm causes 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 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.

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
A	AUTO	P-Stop	P-Stop	C-Stop	C-Stop	P-Stop
	T1	P-Stop	P-Stop	-	C-Stop	P-Stop
	T2	P-Stop	P-Stop	-	C-Stop	P-Stop
B	AUTO	P-Stop	P-Stop	P-Stop	P-Stop	P-Stop
	T1	P-Stop	P-Stop	-	P-Stop	P-Stop
	T2	P-Stop	P-Stop	-	P-Stop	P-Stop
C	AUTO	C-Stop	C-Stop	C-Stop	C-Stop	C-Stop
	T1	P-Stop	P-Stop	-	C-Stop	P-Stop
	T2	P-Stop	P-Stop	-	C-Stop	P-Stop

P-Stop: Power-Off stop

C-Stop: Controlled stop

-: Disable

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

Option	R-30iB
Standard	A (*)
Controlled stop by E-Stop (A05B-2600-J570)	C (*)

(*) R-30iB does not have servo disconnect.

Option	R-30iA				R-30iA Mate		
	Standard (Single)	Standard (Dual)	RIA type	CE type	Standard	RIA type	CE type
Standard	B (*)	A	A	A	A (**)	A	A
Stop type set (Stop pattern C) (A05B-2500-J570)	N/A	N/A	C	C	N/A	C	C

(*) R-30iA standard (single) does not have servo disconnect.

(**) R-30iA Mate Standard does not have servo disconnect, and the stop type of SVOFF input is Power-Off stop.

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 (In case of R-30iA/R-30iA Mate, it is Stop type set (Stop pattern C) (A05B-2500-J570)) 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. (R-30iA/R-30iB controller)
SRVO-194 Servo disconnect	Servo disconnect input (SD4-SD41, SD5-SD51) is open. (R-30iA controller)
SRVO-218 Ext.E-stop/Servo Disconnect	External emergency stop input (EES1-EES11, EES2-EES21) is open. (R-30iA Mate/R-30iB controller)
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.

In case of R-30*i*A or R-30*i*A Mate, this function is available only in CE or RIA type hardware.

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 INTRODUCTION

The EtherNet/IP interface supports an I/O exchange with other EtherNet/IP enabled devices over an Ethernet network. The EtherNet/IP specification is managed by the Open DeviceNet Vendors Association (www.odva.org).

From the EtherNet/IP Specification (Release 1.0) Overview :

EtherNet/IP (Ethernet/Industrial Protocol) is a communication system suitable for use in industrial environments. EtherNet/IP allows industrial devices to exchange time-critical application information. These devices include simple I/O devices such as sensors/actuators, as well as complex control devices such as robots, programmable logic controllers, welders, and process controllers.

EtherNet/IP uses CIP (Control and Information Protocol), the common network, transport and application layers also shared by ControlNet and DeviceNet. EtherNet/IP then makes use of standard Ethernet and TCP/IP technology to transport CIP communications packets. The result is a common, open application layer on top of open and highly popular Ethernet and TCP/IP protocols.

EtherNet/IP provides a producer/consumer model for the exchange of time-critical control data. The producer/consumer model allows the exchange of application information between a sending device (e.g., the producer) and many receiving devices (e.g., the consumers) without the need to send the data multiple times to multiple destinations. For EtherNet/IP, this is accomplished by making use of the CIP network and transport layers along with IP Multicast technology. Many EtherNet/IP devices can receive the same produced piece of application information from a single producing device.

EtherNet/IP makes use of standard IEEE 802.3 technology; there are no non-standard additions that attempt to improve determinism. Rather, EtherNet/IP recommends the use of commercial switch technology, with 100 Mbps bandwidth and full-duplex operation, to provide for more deterministic performance.

The terms adapter and scanner are used throughout this manual. Although EtherNet/IP is a producer/consumer network, these terms are still appropriate to describe a device which creates the I/O connection (the scanner), and a device which responds to connection requests (the adapter). The scanner can also be called the connection originator. The adapter can also be called the connection target.

The following steps are necessary to configure EtherNet/IP with the robot as the adapter:

1. **Design and install the network.** It is critical to follow good network design and installation practices for a reliable network. Refer to Section 8.1 .
2. **Set the IP addresses.** All devices on the network require a valid IP address. Refer to Section 2.3 for additional information for the robot.
3. **Configure the adapter devices.** Adapter devices might require configuration such as setting I/O sizes. Refer to Section 3.2.1 to configure the robot as an adapter.
4. **Configure the scanner devices.** Scanners must be configured with a list of devices (adapters) to connect to along with parameters for each connection. Refer to Section 3.2.2 to configure an Allen Bradley ControlLogix PLC to connect to the robot.
5. **Map EtherNet/IP I/O to digital, group, or UOP I/O points within the robot.** Refer to Section 6.2 for more information. Scanner connections can also be mapped to analog. Refer to Section 4.2.5 .
6. **Backup the configuration.** Refer to Section 6.3 for details on doing this for the robot.

NOTE

If you need to perform diagnostics or troubleshooting, refer to Chapter 9 .

NOTE

For EtherNet/IP Safety function that exchanges safety signals on EtherNet/IP, please read “R-30iA/R-30iA Mate controller Dual Check Safety Function (ISO 13849-1:2006 compliant) operator’s manual (B-83104EN)” or “R-30iB controller Dual Check Safety Function operator’s manual (B-83184EN) in addition to this manual.

2 SYSTEM OVERVIEW

2.1 OVERVIEW

The robot supports 32 connections. Each connection can be configured as either a Scanner connection, or as an Adapter connection. Adapter connections are normally to a cell controller or PLC to exchange cell interface I/O data. The EtherNet/IP Adapter option must be loaded to support this functionality.

Each Scanner connection can be configured to exchange I/O with a remote device capable of acting as an adapter on an EtherNet/IP network. The EtherNet/IP Scanner option must be loaded to support this functionality (the EtherNet/IP Scanner option includes the adapter functionality as well).

The EtherNet/IP interface corresponds to Rack 89 in the robot for I/O mapping. The slot number reflects the connection number from the EtherNet/IP interface user interface screen. Any amount of I/O can be mapped within EtherNet/IP, up to the maximum supported on the robot. Analog I/O is supported on scanner connections.

Good network design is critical to having reliable communications. Excessive traffic and collisions must be avoided or managed. Refer to Section 8.1 for details.

2.2 SPECIFICATION OVERVIEW

Table 2.2(a) and table 2.2(b) provides an overview of specifications for EtherNet/IP.

Table 2.2(a) R-30iA/R-30iA Mate specification overview

Item	Specification
Number Adapter Connections	0–32
Number Scanner Connections	32 minus the number of adapter connections
Minimum RPI	8 msec
Maximum Number of Input bytes per connection (combination of Digital and Analog)	64 Words (1Word = 16 bits) or 128 Bytes (1Bytes = 8bits)
Maximum Number of Output bytes per connection (combination of Digital and Analog)	64 Words (1Word = 16 bits) or 128 Bytes (1Bytes = 8bits)
Supported Signal Types	Digital, Group, UOP, Analog (for scanner connections only)

Table 2.2(b) R-30iB specification overview

Item	Specification
Number Adapter Connections	0–32
Number Scanner Connections	32 minus the number of adapter connections
Minimum RPI	8 msec

Item	Specification
Maximum Number of Input bytes per connection (combination of Digital and Analog)	248 Words (1Word = 16 bits) or 496 Bytes (1Bytes = 8bits)
Maximum Number of Output bytes per connection (combination of Digital and Analog)	248 Words (1Word = 16 bits) or 496 Bytes (1Bytes = 8bits)
Supported Signal Types	Digital, Group, UOP, Analog (for scanner connections only)

NOTE

The maximum number of Input/Output bytes per connection in table 2.2(a) and table 2.2(b) is the range of value that can be set as the data size of EtherNet/IP connection. On the other hand, the maximum number of I/O that can be used in a robot controller differs according to the application software and other option software configuration.

NOTE

In order for the scanner to work, the EtherNet/IP Scanner option must be loaded.

NOTE

For EtherNet/IP Safety function that exchanges safety signals on EtherNet/IP, please read “R-30iA/R-30iA Mate controller Dual Check Safety Function (ISO 13849-1:2006 compliant) operator’s manual (B-83104EN)” or “R-30iB controller Dual Check Safety Function operator’s manual (B-83184EN) in addition to this manual.

2.3 ETHERNET CONNECTION AND IP ADDRESS ASSIGNMENT

The robot must have a valid IP (Internet protocol) address and subnet mask to operate as an EtherNet/IP node.

The Ethernet interface supports 10Mbps and 100Mbps baud rates, along with half and full duplex communication. By default both interfaces will auto-negotiate and should be connected to a switch which supports 100Mbps full duplex connections. The LEDs located near the RJ45 connectors on the main CPU board are useful in confirming link establishment.

The IP address(es) can be configured in the following ways :

- Manually configured on the robot teach pendant
- DHCP (Dynamic Host Configuration Protocol)

NOTE

DHCP is an optional software component. It is important to utilize static or infinite lease IP addresses when using EtherNet/IP.

Either one or both Ethernet ports can be configured for use with EtherNet/IP. Note that in order to use both ports at the same time they must be properly configured on separate subnets. Also note that port 2 (CD38B) is optimized for Ethernet I/O protocols such as EtherNet/IP. The preferred setup is to connect

port 1 (CD38A) to your building network to access the robot through HTTP, FTP, and so forth , and to connect port 2 (CD38B) to an isolated network for use by EtherNet/IP.

NOTE

Be sure that all EtherNet/IP node IP addresses are configured properly before you perform the functions in this manual. The PING utility can be used to verify basic communications. Refer to Chapter 9 for more information.

2.4 ADAPTER MODE CONFIGURATION OUTLINE

Perform the following steps to configure the adapter connection on the robot:

- Configure the I/O size on the robot. Refer to Section 3.2.1 .
- Map the physical EtherNet/IP I/O to logical I/O points (digital, group, or UOP) on the robot. Refer to Section 6.2 .
- Configure the remote scanner (for example, ControlLogix PLC). Refer to Section 3.2.2 .

Table 2.4 provides a summary of the adapter configuration. This information is used in the scanner device (for example, PLC) configured to communicate with the robot EtherNet/IP Adapter interface.

Table 2.4 Adapter configuration summary

ITEM	DESCRIPTION
Vendor ID	356
Product Code	2
Device Type	12
Communication Format	Data – INT
Input Assembly Instance	101–132
Input Size	User Configurable, Set in 16-bit Words
Output Assembly Instance	151–182
Output Size	User Configurable, Set in 16-bit Words
Configuration Instance	100
Configuration Size	0

The default I/O size for the adapter connection is four words for both inputs and outputs. This corresponds to 64 I/O points based on a 16-bit word. This size must be configured on the robot teach pendant, as well as on the remote scanner (for example, PLC).

Refer to Chapter 3 for details.

2.5 SCANNER MODE CONFIGURATION OUTLINE

The robot must be configured to initiate EtherNet/IP connections. Up to 32 scanner connections are supported. Perform the following steps to configure the scanner connection on the robot :

- Configure the robot scan list on the teach pendant. Refer to Section 4.2.3 .
- Map the physical EtherNet/IP I/O to logical I/O points (for example, digital, group, analog, or UOP) on the robot. Refer to Section 6.2 .

For each connection the following data must be provided on the robot teach pendant. (Refer to the manual that applies to the adapter device being configured for more information.)

- Name/IP address
- Vendor ID
- DeviceType
- Product Code
- Input Size (16-bit words or 8-bit bytes)
- Output Size (16-bit words or 8-bit bytes)
- RPI (ms)
- Input assembly instance
- Output assembly instance
- Configuration instance

NOTE

The robot currently cannot be configured for devices with a non-zero configuration size from the teach pendant. Refer to Appendix A for information on third party configuration tools.

3 ADAPTER CONFIGURATION

3.1 OVERVIEW

The robot supports up to 32 adapter connections. These connections are normally to a cell controller or PLC to exchange cell interface I/O data. The EtherNet/IP Adapter Option must be loaded to support this functionality.

The following steps are required to configure the adapter connection on the robot :

- Configure I/O size on the robot. Refer to Section 3.2.1 .
- Map the physical EtherNet/IP I/O to logical I/O points (digital, group, or UOP) on the robot. Refer to Section 6.2 .
- Configure the remote scanner (for example, ControlLogix PLC). Refer to Section 3.2.2 .

3.2 SETTING UP YOUR ROBOT

3.2.1 Configuring the Robot I/O Size

The Input size and Output size are set in 16-bit word sizes. This means if 32 bits of input and 32 bits of output are needed then the Input size and Output Size would be set to 2 words each. The default size of the adapter connection is 4 words (64 bits) of input and 4 words (64 bits) of output. Changes in I/O size require you to turn off and turn on the robot to take effect.

Refer to Procedure 3-1 to configure I/O size on the robot.

Table 3.2.1(a) describes the items displayed on the EtherNet/IP Status screen.

Table 3.2.1(b) describes the items on the EtherNet/IP Configuration screen.

Table 3.2.1(a) EtherNet/IP status screen descriptions

ITEM	DESCRIPTION
Description Default: ConnectionX where X is the slot number of the Adapter.	This item is the description of the adapter or scanner. This can be set as desired to coordinate with your equipment.
TYP Default: ADP	This item indicates whether the connection is configured as an Adapter, or as a Scanner.
Enable Default: TRUE (for Adapter 1, FALSE for Adapters 2–32)	This item indicates whether the adapter or scanner is enabled (TRUE) or disabled (FALSE).
Status	<p>The Status field can have the following values :</p> <ul style="list-style-type: none"> ● OFFLINE– the connection is disabled. ● ONLINE – the connection is enabled but is not active (for example, waiting for a connection). ● RUNNING - the connection is enabled and active (I/O is being exchanged). ● <RUNNING> - the connection is enabled and active (I/O is being exchanged), and auto-reconnect is enabled. See Table 4.2.4 for more information on the auto-reconnect setting. ● PENDING – changes have taken place in configuration. You must turn off the robot, then turn it on again.

ITEM	DESCRIPTION
Slot	This item is the value used when mapping EtherNet/IP I/O to digital, group, or UOP I/O signals.

Table 3.2.1(b) EtherNet/IP configuration screen descriptions

ITEM	DESCRIPTION
Description	This item is the comment that shows up on the Status screen. It is set on the Status screen as well.
Input size (words) Default:	This item is the number of 16 bit words configured for input.
Output size (words) Default:	This item is the number of 16 bit words configured for output.
Alarm Severity Default: WARN	This item indicates the severity of alarm that will be posted by the adapter connection. The valid choices are STOP, WARN, and PAUSE.
Scanner IP	The IP address of the connected scanner.
API 0 => T	Actual Packet Interval at which the scanner/originator is producing.
API T => 0	Actual Packet Interval at which the adapter/target is producing.

Procedure 3-1 Configuring I/O Size on the Robot

Steps

1. Press MENUS.
2. Select I/O.
3. Press F1, [TYPE], and select EtherNet/IP. You will see a screen similar to the following.

I/O EtherNet/IP				JOINT	10 %
EtherNet/IP List (Rack 89)					1/8
Description	TYP	Enable	Status	Slot	
Connection1	ADP	TRUE	ONLINE	1	
Connection2	ADP	FALSE	OFFLINE	2	
Connection3	ADP	FALSE	OFFLINE	3	
Connection4	ADP	FALSE	OFFLINE	4	
Connection5	ADP	FALSE	OFFLINE	5	
Connection6	ADP	FALSE	OFFLINE	6	
Connection7	ADP	FALSE	OFFLINE	7	
Connection8	ADP	FALSE	OFFLINE	8	

Refer to Table 3.2.1(a) for descriptions of these screen items.

4. Move the cursor to select a connection. If the connection is configured as a scanner, move the cursor to the TYP column and press F5. This configures the connection as an adapter.
5. Move the cursor to select the desired adapter. If you plan to make changes to the adapter configuration, you must first disable the connections. Otherwise, the configuration screen is read-only.

NOTE

If the adapter connection is Enabled, the first line of the adapter configuration screen will display "Adapter config (Read-only)" and the items on the screen cannot be modified. To make changes to the adapter configuration screen, you must disable the adapter connection on the EtherNet/IP Status screen.

6. To change adapter status:

- a. Move the cursor to highlight the field in the Enable column for the adapter.
- b. To disable the adapter and change the status to OFFLINE, press F5, FALSE.
To enable the adapter and change the status to ONLINE, press F4, TRUE.
7. Move the cursor to the Description column. Press F4, CONFIG. You will see a screen similar to the following.

```

Adapter configuration :
  Description :      Connection1
  Input size (words) : 4
  Output size(words) : 4
  Alarm Severity : WARN

  Scanner IP : *****
  API O=>T :      0
  API T=>O :      0

```

Refer to Table 3.2.1(b) for descriptions of these screen items.

8. To change the I/O size:
 - a. Move the cursor to select "Input size (words)."
 - b. Type the value you want and press Enter.
 - c. Move the cursor to select "Output size (words)."
 - d. Type the value you want and press Enter.
 - e. Move the cursor to select the alarm severity.
 - f. Press F4, [CHOICE], and select the desired severity.
 - g. To return to the previous screen, press F3, [PREV].
9. After modifying the adapter configuration, you must enable the connection on the EtherNet/IP status screen. If any changes were made, the status will show as "PENDING". This indicates that you must cycle power in order for the changes to take effect.

NOTE

To map EtherNet/IP I/O to digital, group, or UP I/O, refer to Section 6.2 .

3.2.2 Configuring the Remote Scanner

The EtherNet/IP Interface status screen should show that the adapter connection is ONLINE. This means it is available and waiting for a request from a scanner (for example, PLC) to exchange I/O. If the adapter status is not ONLINE, refer to Procedure 3-1 , Step 6 .

Table 3.2.2(a) provides a summary of the adapter configuration. This information is used to configure the remote scanner (for example, PLC).

Table 3.2.2(a) Adapter configuration summary

ITEM	DESCRIPTION
Vendor ID	356
Product Code	2
Device Type	12
Communication Format	Data – INT
Input Assembly Instance	101–132
Input Size	User Configurable, Set in 16-bit Words
Output Assembly Instance	151–182
Output Size	User Configurable, Set in 16-bit Words
Configuration Instance	100
Configuration Size	0

Table 3.2.2(b) Connection points

Slot Number	Input Assembly Instance	Output Assembly Instance
1	101	151
2	102	152
3	103	153
4	104	154
5	105	155
6	106	156
7	107	157
8	108	158
9	109	159
10	110	160
11	111	161
12	112	162
13	113	163
14	114	164
15	115	165
16	116	166
17	117	167
18	118	168
19	119	169
20	120	170
21	121	171
22	122	172
23	123	173
24	124	174
25	125	175
26	126	176
27	127	177
28	128	178
29	129	179
30	130	180
31	131	181
32	132	182

Use Procedure 3-2 to configure the Allen Bradley ControlLogix PLC. for other scanners, refer to their configuration software in conjunction with Table 3.2.2(a) .

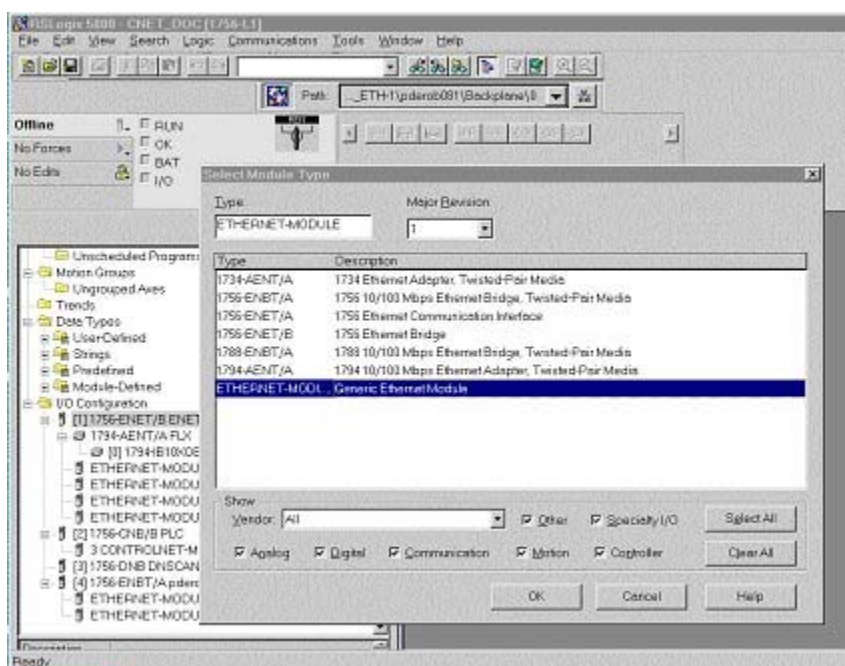
Procedure 3-2 Configuring the Scanner Using RS-Logix5000 Software

Steps

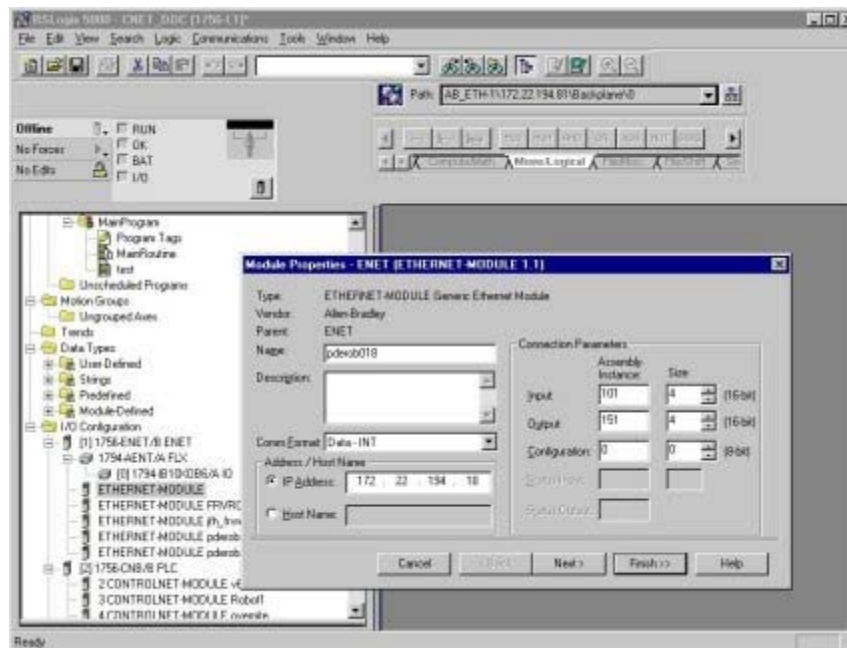
NOTE

The following screens show how to configure the scanner using RS-Logix5000 software, which is used with the Allen Bradley ControlLogix PLC. This example assumes that an EtherNet/IP Bridge module has been added to the configuration in the ControlLogix PLC.

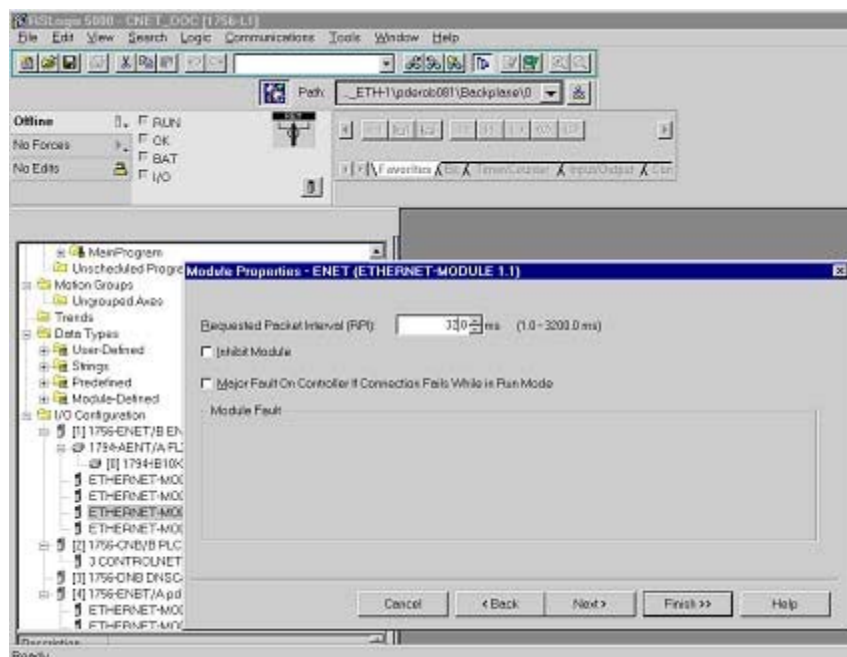
1. To add the robot adapter connection to the configuration, right-click the EtherNet/IP Bridge module in the PLC, and select “New Module”.
2. Select “Generic Ethernet Module,” and click OK. You will see a screen similar to the following.



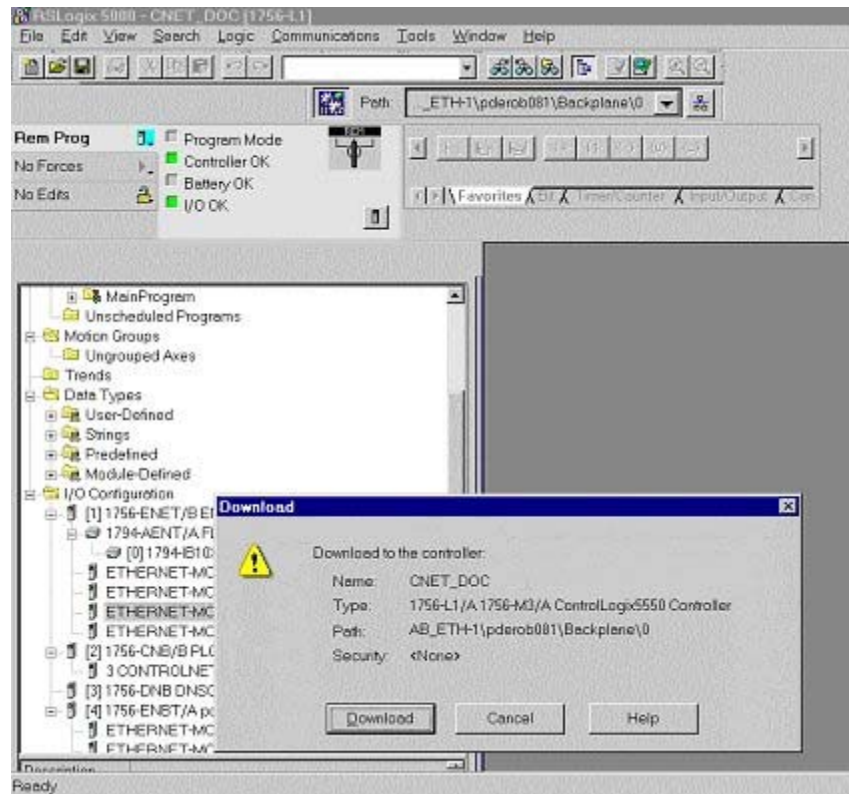
3. In the next screen, RSLogix will ask for information regarding the communication to the robot. Type a name for the robot adapter connection.
In the example below we call the module “Example_Robot”. This name will create a tag in RSLogix, which can be used to access the memory location in the PLCs memory where the data for the Example_Robot will be stored. A description can also be added if desired (optional).
4. Select the “Comm_Format,” which tells RSLogix the format of the data.
In this example we select Data-INT, which will represent the data in the robot as a field of 16-bit words.
5. Set connection parameters as follows:
Each of the 32 Connections have different Connection parameters, which are based on the slot number. Refer to Table 3.2.2(b) to determine the correct parameters. The size of the input connection and the output connection must correspond to the size that we have configured for the robot. In this example we configured the robot for 4 (16 bit) words of input data and output data. The configuration instance should be set to 100 and size of the configuration instance is set to 0.
In the following example, we will be setting up connection parameters corresponding to the adapter in slot 1.
6. Type the IP address that we have configured for the module.
This could be the Host Name if the DNS (Domain Name Service) is configured and available for the PLC to resolve names to IP addresses (if names are used be sure the DNS server is very reliable and always available to the PLC during operation). You will see a screen similar to the following.



7. The RPI (requested packet interval) is set on the next screen. This sets the rate for I/O updates. In the following example the RPI is set to 32ms. This means the PLC will send its outputs to the robot every 32ms, and the robot will send its inputs to the PLC every 32ms. You will see a screen similar to the following.



8. Press Finish to complete this step.
9. To download the new configuration to the ControlLogix PLC, select Download from the Communications menu. You will see a screen similar to the following.



10. If there are any errors, a warning triangle will be present on the Example_Robot in the I/O configuration listing. Double click the module to view any error that is reported.

3.2.3 Common Errors

The robot will post an alarm indicating that the adapter connection is idle if it is enabled but no scanner has connected to it. This is an informational alarm (warning level) by default. This message is reposted whenever the robot RESET button is pressed and the adapter connection is idle. If desired, the error severity level of EtherNet/IP adapter alarms can be increased. See Step 8 of Procedure 3-1 for more details.

If the adapter connection is lost the values of any mapped inputs will be zeroed out (by default). The last state behavior can be changed by setting the following system variable : \$EIP_CFG.\$KEEP_IO_ADP. The values are :

- FALSE : The last state values of the adapter inputs will be zero (default)
- TRUE : The last state values of the adapter inputs will be their last value

NOTE

If some of the EtherNet/IP adapter I/O signals are configured as UOP HOLD/IMSTP signals and communication is interrupted, then the default behavior will cause the robot to stop. This is due to the UOP inputs going to zero (last state behavior) and causing UOP HOLD and IMSTP alarms to be posted. It is typical for the adapter connection to be configured so that alarms are of "WARNING" severity and the "Last State" is set to FALSE (default behavior), which allows UOP in/out signals to stop the robot operation.

4 SCANNER CONFIGURATION

4.1 OVERVIEW

The robot supports up to 32 scanner connections. Each connection can be configured to exchange I/O with a remote device capable of acting as an adapter on an EtherNet/IP network. The EtherNet/IP Scanner option must be loaded to support this functionality. The EtherNet/IP Scanner option includes the adapter functionality as well. An example of an EtherNet/IP adapter device that the robot would connect to might be an I/O block.

The robot must be configured to initiate EtherNet/IP connections. Up to 32 scanner connections are supported. Perform the following steps to configure the scanner connection on the robot :

- Configure the adapter device if required. Refer to Section 4.2.2 .
- Configure the robot scan list on the teach pendant. Refer to Section 4.2.3 or configure the robot scan list from RSNetWorx for EtherNet/IP (Refer to Appendix A).
- Map the physical EtherNet/IP I/O to logical I/O points (digital, group, analog, or UOP) on the robot. Refer to Section 6.2 .

NOTE

All scanlist configurations must either be done entirely from the teach pendant, or be done entirely from a third-party configuration tool such as RSNetWorx for EtherNet/IP.

4.2 SETTING UP YOUR ROBOT

4.2.1 Overview

For each connection, the following data must be provided on the robot teach pendant (see documentation for the adapter device being configured for more information) :

- Name/IP address
- Vendor ID
- Device Type
- Product Code
- Input Size (16-bit words or 8-bit bytes)
- Output Size (16-bit words or 8-bit bytes)
- RPI (ms)
- Input assembly instance
- Output assembly instance
- Configuration instance

NOTE

The robot currently cannot be configured for devices with a non-zero configuration size from the teach pendant. Refer to Appendix A for information on third party configuration tools.

4.2.2 Configure the Adapter Device

See the documentation for the adapter device being configured. Configuring the adapter is typically a matter of connecting the device to the network and setting the IP address. The device should successfully respond to a PING request before proceeding. Refer to Chapter 9 for details on using PING.

NOTE

The number of scanner connections equals 32 minus the number of adapter connections.

4.2.3 Configure the Robot Scan List

Use Procedure 4-1 to configure the robot scan list from the teach pendant.

Table 4.2.3(a) describes the items displayed on the EtherNet/IP Status screen. Table 4.2.3(b) describes the items displayed on the EtherNet/IP scanner configuration screen. Table 4.2.3(c) lists RPI minimum values.

NOTE

When the scanner connection type is other than Exclusive-Owner, set O=>T format and T=>O format by selecting the connection type in Advanced EtherNet/IP Scanner Configuration screen. Refer to 4.2.4 for more detail.

Table 4.2.3(a) EtherNet/IP status screen item descriptions

ITEM	DESCRIPTION
Description Default: ConnectionX where X is the slot number of the Adapter.	This item is the description of the adapter or scanner. This can be set as desired to coordinate with your equipment.
TYP Default: ADP	This item indicates whether the connection is configured as an Adapter, or as a Scanner.
Enable Default: TRUE (for Adapter 1, FALSE for Adapters 2–32)	This item indicates whether the adapter or scanner is enabled (TRUE) or disabled (FALSE).
Status	<p>The Status field can have the following values :</p> <ul style="list-style-type: none"> ● OFFLINE– the connection is disabled. ● ONLINE – the connection is enabled but is not active (for example, waiting for a connection). ● RUNNING - the connection is enabled and active (I/O is being exchanged). ● <RUNNING> - the connection is enabled and active (I/O is being exchanged), and auto-reconnect is enabled. See Table 4.2.4 for more information on the auto-reconnect setting. ● PENDING – changes have taken place in configuration. You must turn off the robot, then turn it on again.
Slot	This item is the value used when mapping EtherNet/IP I/O to digital, group, or UOP I/O signals.

Table 4.2.3(b) Scanner configuration screen item descriptions

ITEM	DESCRIPTION
Description	This item is the comment that shows up on the Status screen.
Name/IP address	This item is the hostname or IP address of the device to which you are connecting. If a hostname is used, it must be in the local host table or available through DNS.
Vendor ID	This item is the vendor ID of the device to which you are connecting. Refer to the adapter (target) device's documentation of EDS files for assigned value. The vendor ID, Device Type, and Product Code can be entered if electronic keying is needed (this information must match the device in order to make a successful connection). If the fields are left at 0 then the keying is ignored.
Device Type	This item is the Device Type of the device to which you are connecting. Refer to the adapter (target) device's documentation or EDS file for assigned value. The vendor ID, Device Type, and Product Code can be entered if electronic keying is needed (this information must match the device in order to make a successful connection). If the fields are left at 0 then the keying is ignored.
Product code	This item is the product code of the device to which you are connecting. Refer to the adapter (target) device's documentation or EDS file for assigned value. The vendor ID, Device Type, and Product Code can be entered if electronic keying is needed (this information must match the device in order to make a successful connection). If the fields are left at 0 then the keying is ignored.
Input size Range: 0 – 64 (R-30iA/R-30iA Mate), 0-248 (R-30iB) Default: 0	This item is the number of words or bytes configured for input. The default data type is 16-bit words, but can be configured as 8-bit bytes. To change the data type, modify the I/O Data Type field in the EtherNet/IP Advanced Scanner Configuration Screen (See Table 4.2.4). The Input size and Output size need to match the adapter device to which the robot will connect.
Output size Range: 0 – 64 (R-30iA/R-30iA Mate), 0-248 (R-30iB) Default: 0	This item is the number of words or bytes configured for output. The default data type is 16-bit words, but can be configured as 8-bit bytes. To change the data type, modify the I/O Data Type field in the EtherNet/IP Advanced Scanner Configuration Screen (See Table 4.2.4). The Input size and Output size need to match the adapter device to which the robot will connect.
RPI (ms) Min: 8 ms Max: 5000 Default: 32	This item is the requested packet interval. This defines how often I/O updates are done. The minimum value allowed is 8 ms, however this value should be set based on application requirements. Be aware that fast I/O updates cause excessive network traffic. Refer to Table 4.2.3(c) for a guide to minimum RPI values within the robot. As a rule of thumb, the robot controller can support a maximum of 1250 packet per second. Both Originator-to-Target and Target-to-Originator packets must be factored into this calculation.
Assembly instance (input)	The Input, Output, and Configuration instance values need to be set based on the adapter device to which the robot will connect.
Assembly instance (output)	The Input, Output, and Configuration instance values need to be set based on the adapter device to which the robot will connect.
Configuration instance	The Input, Output, and Configuration instance values need to be set based on the adapter device to which the robot will connect.

Table 4.2.3(c) Requested packet interval (RPI) minimum values

Number of Connections	Minimum RPI for any connection (ms)
1	8
2	8
3	8
4	8
5	8
6	12
7	12
8	16
9	16
10	16
11	20
12	20
13	24
14	24
15	24
16	28
17	28
18	32
19	32
20	32
21	36
22	36
23	36
24	40
25	40
26	44
27	44
28	44
29	48
30	48
31	48
32	52

Procedure 4-1 Configuring the Robot Scan List

Steps

1. Press MENUS.

2. Select I/O.
3. Press F1, [TYPE], and select EtherNet/IP. You will see a screen similar to the following.

I/O EtherNet/IP				JOINT	10 %
EtherNet/IP List (Rack 89)					1/8
Description	TYP	Enable	Status	Slot	
Connection1	ADP	TRUE	ONLINE	1	
Connection2	ADP	FALSE	OFFLINE	2	
Connection3	ADP	FALSE	OFFLINE	3	
Connection4	SCN	FALSE	OFFLINE	4	
Connection5	SCN	FALSE	OFFLINE	5	
Connection6	SCN	FALSE	OFFLINE	6	
Connection7	SCN	FALSE	OFFLINE	7	
Connection8	SCN	FALSE	OFFLINE	8	

4. Move the cursor to the connection you want to set. If the connection is configured as an adaptor, move the cursor to the TYP column, and press F4. This configures the connection as a scanner.

NOTE

If the scanner connection is enabled, the first line of the scanner configuration screen will display "Scanner config (Read-only)" and the items on the screen cannot be modified. To make changes to the read-only scanner configuration screen, you must disable the scanner connection on the EtherNet/IP status screen.

5. To change scanner status:
 - a. Move the cursor to highlight the field in the Enable column for the scanner you want to modify.
 - b. To disable the scanner and change the status to OFFLINE, press F5, [FALSE].
To enable the scanner and change the status to RUNNING, press F4, [TRUE].

NOTE

The status will not change until the connection has been established and I/O is being exchanged.

6. Press F4, CONFIG. You will see a screen similar to the following.

```

I/O EtherNet/IP          JOINT 10 %
Scanner configuration :   1/10
Description : Connection1
Name/IP address : 192.168.0.12
Vendor Id : 0
Device Type : 0
Product code : 0
Input size (words): 1
Output size (words): 1
RPI (ms) : 32
Assembly instance(input) : 1
Assembly instance(output) : 2
Configuration instance : 4
  
```

7. Move the cursor to select each item and set the appropriate value.

NOTE

If you make changes to I/O size, you must turn off then turn on the controller in order for the changes to take effect. Other changes in the configuration do not require you to turn off then turn on the controller to take effect.

8. Press the PREV key to return to the EtherNet/IP Status screen. You can enable the connection. If the status is PENDING then you must turn off then turn on the controller in order for the changes to take effect.

NOTE

Any enabled scanner connections which are not RUNNING or PENDING will be retried each time the robot is RESET.

NOTE

To map EtherNet/IP to digital, group, analog, or UOP I/O, refer to Section 6.2 .

4.2.4 Advanced EtherNet/IP Scanner Configuration

An advanced EtherNet/IP configuration screen is provided to allow you to access advanced scanner configuration options. Table 4.2.4 describes the items displayed on the Advanced Scanner Configuration Screen. The advance screen can be accessed and configured by using Procedure 4-2 .

NOTE

Part of items, such as Quick connect, can be used only in system software V8.10 or above.

Table 4.2.4 EtherNet/IP advanced scanner configuration screen item descriptions

ITEM	DESCRIPTION
I/O Data Type Default: 16-bit words	This item allows changing the data type to 16-bit words or 8-bit bytes.
Timeout Multiplier Default: DEFAULT	This item allows changing the timeout multiplier. When set to DEFAULT, the controller will intelligently choose an appropriate multiplier based on the RPI value.
Reconnect Default: FALSE	<p>If this item is set to TRUE, the scanner will attempt to re-establish the connection when the connection is enabled and in an OFFLINE state.</p> <div style="border: 1px solid black; padding: 10px; margin-top: 10px;"> <p>NOTE</p> <p>The reconnect parameter was designed for tool changing applications. Enabling reconnect has the following side effect. While enabled, all EtherNet/IP alarms relating to connection establishment and connection time-outs for the corresponding connection will be masked (will not be posted). See Appendix B in the manual for more details. As such, it is recommended that non-tool changing applications do not enable this parameter in a production environment.</p> </div>
Major Revision Default: 0	This item indicates the major revision number of the device being scanned. Is sometimes required by third-party configuration devices.
Minor Revision Default: 0	The minor revision number of the device being scanned. Is sometimes required by third-party configuration devices.
Alarm Severity	This item indicates the severity of alarm that will be posted by the scanner connection. The valid choices are STOP, WARN, and PAUSE.

ITEM	DESCRIPTION
Quick Connect Default: FALSE	<p>If this item is set to TRUE, the scanner will attempt to establish the connection in quick connect mode if connection is started using KAREL macro. See Appendix B for details.</p> <div style="border: 1px solid black; padding: 10px;"> <p>NOTE</p> <p>The quick connect parameter was designed for tool changing applications. Enabling connection using KAREL macro forces scanner to wait for gratuitous ARP from adapter device before initiating the connection. As such, it is recommended that non-tool changing applications do not enable this parameter in a production environment.</p> </div>
Originator To Target RPI(ms) Default: 32	This item indicates the Requested Packet Interval for the scanner to produce at in milliseconds. This field allows for the scanner to have different RPIs for producing and consuming data.
Transport Type Default: UNICAST	This item allows the scanner to request that the adapter send data using a point-to-point/unicast connection, or to multicast data. If multicasting is not required, we strongly recommend setting this value to UNICAST. However, a small number of adapter devices only support the MULTICAST setting.
Target To Originator RPI(ms) Default: 32	This item indicates the Requested Packet Interval for the scanner to consume at in milliseconds. This field allows for the scanner to have different RPIs for producing and consuming data.
Connection Type Default: (blank)	This item allows the user to set up a scanner connection of type Exclusive-Owner, Input-Only, or Listen-Only. When a connection type is selected, the O=>T Format and T=>O Format fields will automatically be modified to correspond with the selected Connection Type. This field will be blank after each power-cycle, as this field is only an aid in selecting the proper O=>T and T=>O formats. Exclusive-Owner is the most common connection type.
O=>T Format Default: Run/Idle Header	The format of the producer's data packet. By default this is set to Run/Idle Header, consistent with an Exclusive-Owner Connection Type.
T=>O Format Default: Modeless	The format of the consumer's data packet. By default this is set to Modeless, consistent with an Exclusive-Owner Connection Type.
Configuration String Status Size(bytes)	Some EtherNet/IP adapters accept or require a non-zero length configuration string. This configuration data can only be configured on the robot using a third party configuration tool such as RSNetWorx for EtherNet/IP (Refer to Appendix A in the manual). This status item displays how much configuration data is currently configured for the connection. If no third party configuration tool is used, this item will always be 0.

Procedure 4-2 Configuring Advanced Scanner Options

1. Press MENUS.
2. Select I/O.
3. Press F1, [TYPE], and select EtherNet/IP.
4. Move the cursor to a Scanner connection.
5. Press F4, [CONFIG].
6. Press F2, [ADV]. You will see a screen similar to the following:


```

I/O EtherNet/IP          JOINT 100 %
Advanced configuration :   1/12
General
  I/O Data Type :        16-BIT WORDS
  Timeout Multiplier :DEFAULT
  Reconnect :           FALSE
  Major Revision :       0
  Minor Revision :       0
  Alarm Severity :       STOP
  Quick Connect :        FALSE
Originator To Target
  RPI :                  32
Target To Originator
  Transport Type :       UNICAST
  RPI :                  32
Connection Type
  Type :                 Exclusive-Owner
  O=>T Format :           Run/Idle Header
  T=>O Format :           Modeless
Configuration String Status
  Size(bytes) :          0

```

7. Move the cursor to select each item and set the appropriate value.
8. Press the PREV key to return to the EtherNet/IP Scanner configuration screen.
9. Press the PREV key to return to the EtherNet/IP Status screen. You can enable the connection. If the status is PENDING then you must turn off then turn on the controller in order for the changes to take effect.

4.2.4.1 Quick connect feature

CAUTION

Please note that this feature is available only to software version V810 or above.

To make using EtherNet/IP feasible for changes in robot end-of-arm tooling, especially when frequent changes are involved, a methodology for EtherNet/IP “Quick Connect” must be established. This means that the robot scanner should establish an EtherNet/IP implicit connection and begin exchanging I/O with a new end-of-arm adapter device “within 150 ms after receiving gratuitous ARP from the adapter device”. As per spec EIP Vol 2 V1.11 adapter device shall power-up within 300 ms. Altogether power-up and first IO data exchange shall not exceed 500ms.

NOTE

Please note that Quick Connect feature is disabled by factory default setting.

Enable Quick Connect Feature in FANUC's Scanner

Quick Connect feature can be turned on by setting 'Quick Connect' parameter to TRUE. Quick Connect feature is only effective when it is started using KAREL macros(EN_ONLN). See Appendix B for more details.

NOTE

Please note that FANUC's adapter does not support quick connect feature.

Enable Quick Connect Feature in Adapter (not FANUC robot's)

Follow : Menu >> I/O >> EthernetI/P >> NEXT >> F2 (EXP_MSG) >> Input Mode >> F4 (Q-Conn).
You will see a screen similar to Figure 4.2.4.1(a) .


I/O EtherNet/IP		2/3
Explicit Message Query		
Input Mode:	Q-Conn	
IP Addr:	<div style="background-color: black; color: black;">XXXXXXXXXX</div>	
Class:	245	
Instance:	1	
Attribute:	12	
Service:	Get Att	
Value Size:	Byte(1)	
Value:	0	
<div style="display: flex; justify-content: space-between; padding: 5px;"> [TYPE] EXEC  HELP </div>		

Fig. 4.2.4.1(a) Enabling quick connect using explicit messaging

Fill-in IP address of target device and cursor down to Service. You will see a screen similar to Figure 4.2.4.1(b) . Now you can choose the service you want to perform. To check current status of quick connect feature on target device leave default i.e. 'Get Att' or press F2 to select. Now cursor up or down to see 'EXEC' on F3 and press F3 to execute selected service.


I/O EtherNet/IP		3/3
Explicit Message Query		
Input Mode:	Q-Conn	
IP Addr:	172.22.200.167	
Class:	245	
Instance:	1	
Attribute:	12	
Service:	<div style="background-color: black; color: black;">Get Att</div>	
Value Size:	Byte(1)	
Value:	0	
<div style="display: flex; justify-content: space-between; padding: 5px;"> [TYPE] Get Att QC_ON QC_OFF  HELP </div>		

Fig. 4.2.4.1(b) Fill-in IP address and select service


I/O EtherNet/IP		2/3
Explicit Message Query		
Input Mode:	Q-Conn	
IP Addr:	<div style="background-color: black; color: black;">172.22.200.167</div>	
Class:	245	
Instance:	1	
Attribute:	12	
Service:	QC_ON	
Value Size:	Byte(1)	
Value:	1	
<div style="display: flex; justify-content: space-between; padding: 5px;"> [TYPE] EXEC  HELP </div>		

Fig. 4.2.4.1(c) Select quick connect service

To turn on quick connect feature press F3 (QC_ON) or press F4 (QC_OFF) to turn off quick connect feature on target device. Now cursor up or down (Figure 4.2.4.1(c)) to see 'EXEC' on F3 and press F3 to execute selected service.

Quick Connection Time

The scanner connection is estimated as follows after device powers up and sends gratuitous ARP indicating that it is ready to communicate. This time may vary due to network load along with switch and adapter device behavior. Figure 4.2.4.1(d) shows general quick connect setup.

Connection Time = $60 + 10 \times (\text{no of devices} - 3)$ milliseconds
--

Table 4.2.4.1 Connection time

No of Devices	Connection Time
3	$60 + 10 \times (3-3) = 60$ ms
7	$60 + 10 \times (7-3) = 100$ ms

All devices are set for static IP addressing, no MDIX, no auto negotiate, etc.

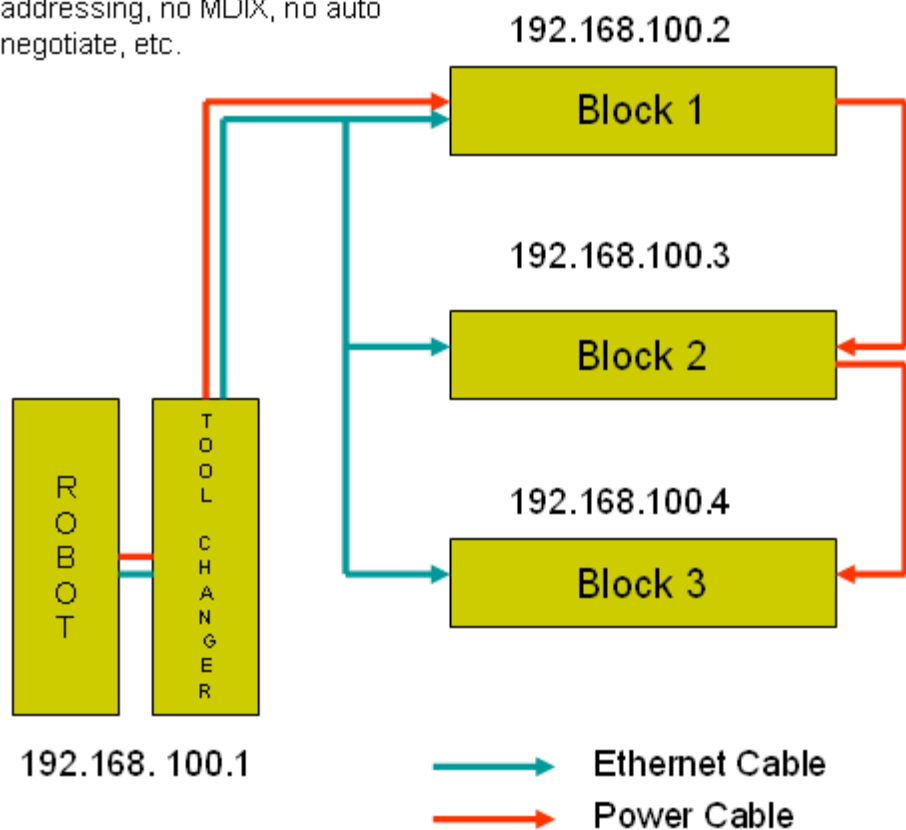


Fig. 4.2.4.1(d) Quick connection setup

4.2.5 Analog I/O

4.2.5.1 Overview

I/O for EtherNet/IP Scanner connections can be mapped to analog. Analog and digital I/O can be intermixed—for example a device may produce sixteen points of Digital Inputs and two words of Analog Inputs on the same connection to the robot controller.

Table 4.2.5.1 describes the items displayed on the Scanner Analog Configuration Screen. The analog screen can be accessed and configured by using Procedure 4-3 .

Table 4.2.5.1 Scanner analog configuration screen setup items

ITEM	DESCRIPTION
RANGE Default: 1 – maximum allocated I/O	The Range of I/O points to be mapped to an analog channel, or a digital start point.
TYPE Default: Digital	The type of I/O being mapped: Analog or Digital.
START PT/CHNL Default: 1	The analog channel or the digital start point.

Procedure 4-3 Configuring Scanner Analog I/O

1. Press **MENUS**.
2. Select **I/O**.
3. Press **F1**, **[TYPE]**, and select **EtherNet/IP**.
4. Move the cursor to a Scanner connection.
5. Press **F4**, **[CONFIG]**.
6. Type the correct input and output sizes.
7. Press **F4**, **[ANALOG]**. You will see a screen similar to the following.

I/O EtherNet/IP	JOINT 100 %
Map Inputs:	1/1
# RANGE TYPE START PT/CHNL	
1 [1- 128] Digital 1	

8. Move the cursor to the **RANGE** column and select the range of the first collection of Inputs. If you do not want to intermix Analog and Digital Inputs, do not modify this column.
9. Select the type of Inputs, Analog or Digital, in the **TYPE** column.
10. Select the channel for Analog Input, or the point for Digital Input in the **START PT/CHNL** column.
11. Repeat as necessary as additional rows are automatically created.
12. Press **F2** **[IN/OUT]**. You will see a screen similar to the following.

I/O EtherNet/IP	JOINT 100 %
Map Outputs:	1/1
# RANGE TYPE START PT/CHNL	
1 [1- 128] Digital 1	

13. Repeat Step 8 through Step 11 as necessary for Outputs.
14. Press the **PREV** key to return to the EtherNet/IP Scanner configuration screen.
15. Press the **PREV** key to return to the EtherNet/IP Status screen. You can enable the connection. If the status is **PENDING** then you must turn off then turn on the controller in order for the changes to take effect.

NOTE

The 16-bits of each analog I/O channel can be byte-swapped (toggled from big-endian to little-endian) on a per connection basis by toggling the system variable \$EIP_SC[].\$ANALOGFMT. When the system variable is set to 0, the data will be produced and consumed in big-endian format. When set to 1, little-endian format will be used.

4.2.5.2 Examples

Suppose a device produces sixteen consecutive points of digital input followed by two words of analog input. A properly configured EtherNet/IP Analog In screen would look like the following:

I/O EtherNet/IP					JOINT 100 %
Map Inputs:					1/2
#	RANGE	TYPE	START	PT/CHNL	
1	[1- 16]	Digital	1		
2	[17- 48]	Analog	1		

Suppose a device produces sixteen consecutive points of digital input followed by two words of analog input followed by eight more consecutive points of digital input. A properly configured EtherNet/IP Analog In screen would look like the following. Note that the 49th connection input point will be mapped as the 17th digital input point.

I/O EtherNet/IP					JOINT 100 %
Map Inputs:					1/3
#	RANGE	TYPE	START	PT/CHNL	
1	[1- 16]	Digital	1		
2	[17- 48]	Analog	1		
3	[49- 56]	Digital	17		

4.2.6 Common Errors

If the connection is lost, the values of any mapped inputs will be zeroed out. The last state behavior can be changed by setting the following system variable : \$EIP_CFG.\$KEEP_IO_SCN. The values are :

- FALSE : The last state values of the adapter inputs will be zero (default)
- TRUE : The last state values of the adapter inputs will be their last value

This setting applies to all the scanner connections.

Any enabled scanner connections which are not RUNNING or PENDING will be retried each time the robot is RESET.

5 ETHERNET/IP TO DEVICENET ROUTING

5.1 OVERVIEW

EtherNet/IP and DeviceNet are both based on the Common and Industrial Protocol (CIP) which was initially defined by Rockwell with specifications managed by ODVA (www.odva.org). The robot can have connections to both Ethernet and DeviceNet networks and this feature provides the capability to route messages between two networks for configuration and diagnostics purposes.

This feature allows you to configure and manage the local robot DeviceNet network from personal computers (PCs) connected to their plant's Ethernet network. This eliminates someone having to connect a laptop PC to the physical robot in the DeviceNet network for certain third party device configuration and diagnostics functions. The PC software used is typically a tool such as RS-Networx for DeviceNet, which supports the following features:

- CIP routing
- Functions such as remotely configuring a device attached to the local DeviceNet network
- Network “who” of the local robot in the DeviceNet network from the PC connected to Ethernet.
- Explicit Messaging Connections to the devices in DeviceNet via “Class Instance Editor”

For more detailed technical information on EtherNet/IP to DeviceNet routing, refer to Chapter 10, Bridging and Routing, in *The CIP Common specification (EtherNet/IP specification volume 1)*.

NOTE

The following option hardware is required:

- DeviceNet Interface board with SST DN3 or DN4 daughter board.

The following option software is required:

- EtherNet/IP Router (R-30iA/R-30iA Mate) (R539)
- EtherNet/IP DN Router (R-30iB) (R804)
- DeviceNet Interface (Master, Slave) (J753)

5.2 GUIDELINES

Review the following guidelines before you use routing:

- Any errors returned from devices in DeviceNet are posted in the third party application software. (e.g. RSNetworx for DeviceNet)
- The G3_ONLY feature is supported on SST DN3 or DN4 cards only
- Routing is limited to explicit messages directed to the connection manager object using the unconnected send service. Routing of I/O is not supported.
- Do not change the status of the devices while Routing is performed. This disrupts the connection between the master (robot in the DeviceNet network) and slave (device in DeviceNet network).

5.3 SETTING UP ETHERNET/IP TO DEVICENET ROUTING

EtherNet/IP to DeviceNet Routing is installed with the EthernetIP (DN) Router option. The default method for using Routing is to have it configured to start when the controller is turned on. Even though the EtherNet/IP to DeviceNet Routing interface screen is available, some features can only be configured by setting system variables.

NOTE

\$EIP_RTR.\$G3_ONLY is added to protect I/O performance. Group 2 devices need to set up Predefined Master/Slave connections to exchange Explicit Messaging packets and I/O packets. The priorities of Group 2 messages are predefined by ODVA. For example, Explicit Message request and response have higher priority than the Master's I/O poll request. Thus, there is a chance that an Explicit Message request and response will win over a Master's I/O poll request. This could affect I/O performance. When \$EIP_RTR.\$G3_ONLY is enabled, routing to Group 2 devices are not allowed.

\$EIP_RTR.\$DIN_NUM is added to enable/disable routing dynamically based on a digital input. For example, this feature can be useful for I/O sensitive processes such as dispensing around a windshield. When the corresponding DIN is ON, the routing is disabled. Refer to Table 5.3 for information on the system variables used in routing.

Table 5.3 EtherNet/IP to devicenet routing system variables

System Variable	Default Value	Description
\$EIP_RTR.\$ENABLE	TRUE	Enable EIP Router*
\$EIP_RTR.\$BOARD_1	FALSE	When this is enabled, DeviceNet Board 1 routes packets from EtherNet to DeviceNet.
\$EIP_RTR.\$BOARD_2	TRUE	When this is enabled, DeviceNet Board 2 routes packets from EtherNet to DeviceNet.
\$EIP_RTR.\$BOARD_3	FALSE	When this is enabled, DeviceNet Board 3 routes packets from EtherNet to DeviceNet.
\$EIP_RTR.\$BOARD_4	FALSE	When this is enabled, DeviceNet Board 4 routes packets from EtherNet to DeviceNet.
\$EIP_RTR.\$G3_ONLY	FALSE	When this is enabled, CIP packets are only routed to Group 3 only (UCMM capable) devices.
\$EIP_RTR.\$DIN_NUM	0	When DIN input port is specified and input port is ON, no packets are routed to DeviceNet network.*

* \$ENABLE and \$DIN_NUM can be set via user interface screen.

5.4 USING ETHERNET/IP TO DEVICENET ROUTING

After system variables are configured, enabling and disabling Router and Setting DIN[] can be done using the EtherNet/IP Configuration screen. Refer to Procedure 5-1 to set up EtherNet/IP to DeviceNet Routing. Refer to Procedure 5-2 for information on Routing using RSNetworx for DeviceNet.

Procedure 5-1 Setting Up EtherNet/IP to DeviceNet Routing

Conditions

- The controller is turned on.

Steps

1. Press MENUS.
2. Select I/O.
3. Press F1, [TYPE].
4. Select EtherNet/IP. You will see a screen similar to the following.

I/O EtherNet/IP				JOINT	10 %
EtherNet/IP List (Rack 89)					1/8
	Description	TYP	Enable	Status	Slot
1	Conn1	ADP	TRUE	ONLINE	1
2	Conn2	ADP	FALSE	OFFLINE	2
3	Conn3	ADP	FALSE	OFFLINE	3
4	Conn4	ADP	FALSE	OFFLINE	4
5	Conn5	ADP	FALSE	OFFLINE	5
6	Conn6	ADP	FALSE	OFFLINE	6
7	Conn7	ADP	FALSE	OFFLINE	7
8	Conn8	ADP	FALSE	OFFLINE	8

5. Press NEXT and then press F3 [RTR]. You will see a screen similar to the following.

I/O EtherNet/IP				JOINT	10 %
Router configuration :					1/2
Enable : TRUE					
Disable when DIN[0] is ON					

6. Make sure Enable is set TRUE. If it is not, move the cursor to Enable, and press F4, TRUE.
7. If you want to disable routing when a particular DIN is ON, move the cursor to DIN[], and type the port number. Note that DIN[] port 0 does not exist in the robot I/O. Thus, DIN[0] would not disable Routing unless the port number is changed.

NOTE

This feature is optional and can be useful for I/O sensitive processes such as dispensing around a windshield.

Procedure 5-2 Routing using RSNetworkx for DeviceNet**Conditions**

- \$EIP_RTR.\$BOARD_2 is set TRUE.
- Board 2 in DeviceNet is ONLINE.
- You are using a personal computer (PC), and have installed RSNetworkx for DeviceNet.

Steps

1. Launch RSNetworkx for DeviceNet. For example on your PC, select Start, Programs, Rockwell software, RSNetworkx, and then RSNetworkx for DeviceNet. You will see a screen similar to the following.

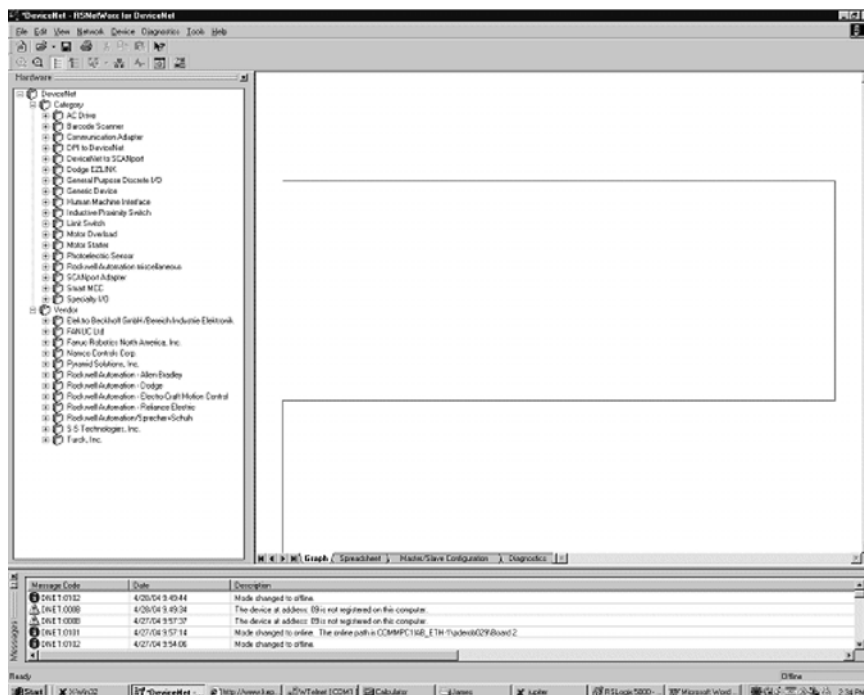


Fig. 5.4(a) RSNetworx for DeviceNet first screen

2. Select Properties under Network tab. You will see a screen similar to the following.

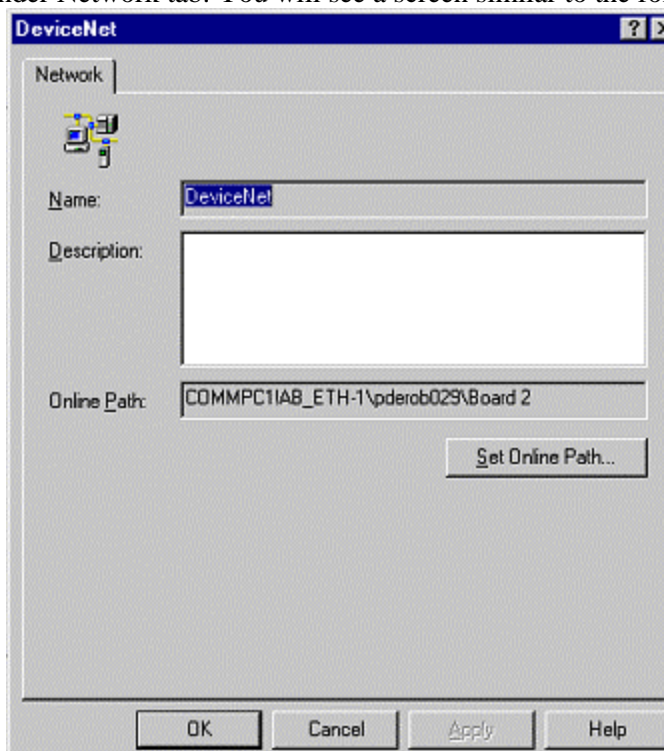


Fig. 5.4(b) DeviceNet network screen

3. Click Set Online Path. You will see a screen similar to the following.

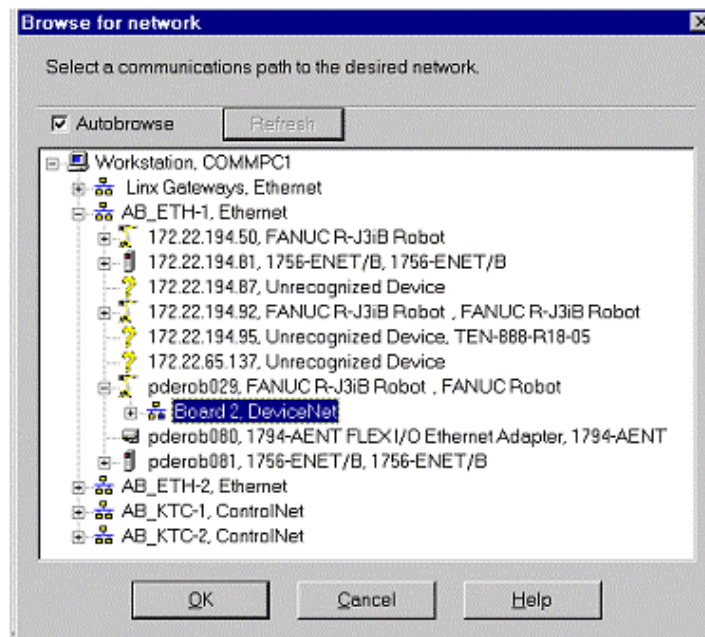


Fig. 5.4(c) Set online path.. screen

4. Find the robot under Ethernet channel. In this example, the robot named pderob029 is under AB-ETH1, EtherNet.
5. Select Board 2, DeviceNet under the robot (pderob029), and click OK. You should see new path in Online Path text box. This is shown as COMMP1AB_ETH-1pderob029Board 2 in this example.
6. Click Apply, and then click OK. After the path is set, you are ready to browse the devices in DeviceNet.
7. Select Online under the Network tab.
8. Click OK to begin browsing the network. After this is done, you will see the screen similar to the following.

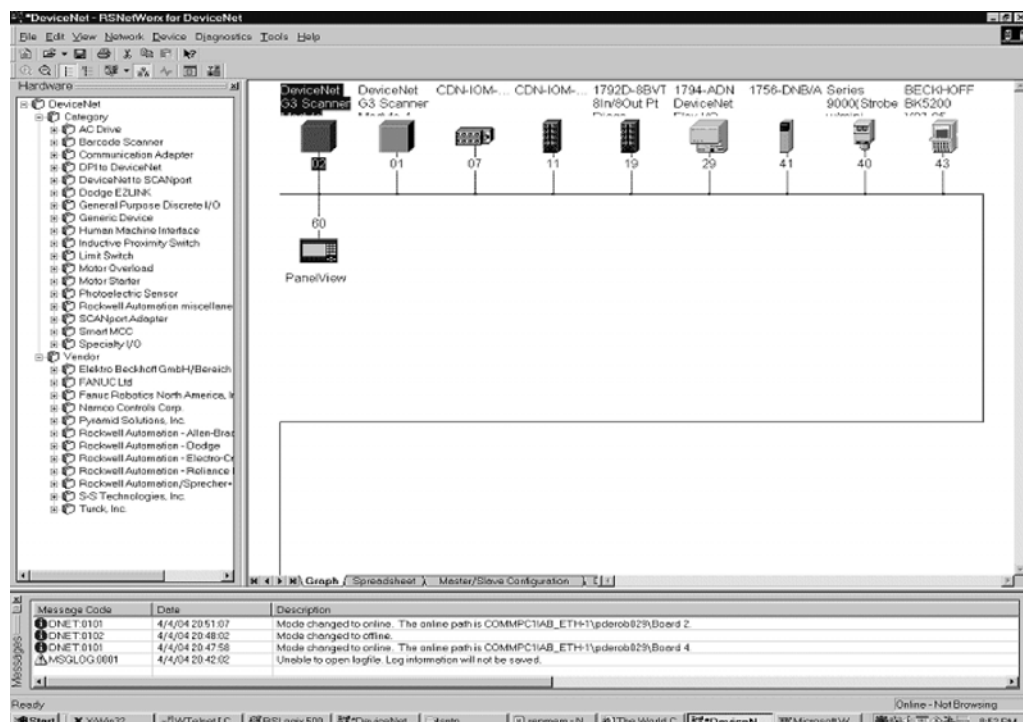


Fig. 5.4(d) Local DeviceNet

9. At this point you can use the Class Instance Editor to get or set device parameters. For more information on how to use RSNetworkx for DeviceNet, refer to the RSNetworkx for DeviceNet Manual .

6 I/O CONFIGURATION

6.1 OVERVIEW

This chapter describes how to make EtherNet/IP I/O available within the robot by mapping it to digital, group, and UOP I/O points. Scanner connection I/O can also map to analog. Refer to Section 4.2.5 .

This chapter also describes procedures for backing up and restoring the EtherNet/IP and I/O configurations.

6.1.1 I/O Size of Each Connection and I/O Configuration

Each connection (adapter or scanner) has input/output size setting, which determines the amount of I/O of each connection that can be assigned to I/O of the robot.

In some application software, the I/O is automatically configured when you turn on the controller.

The system variable \$IO_AUTO_CFG (for digital I/O) and \$IO_AUTO_UOP (for UOP I/O) controls this behavior.

If I/O is automatically configured, I/O configuration of each connection is made according to the input/output size of each connection.

If a connection was once configured and it is no longer used, please set its input/output size to 0 in addition to setting its ENABLE to FALSE, and removing its I/O assignment.

If input/output size is not 0, I/O assignment is made again by next power on.

6.2 MAPPING I/O ON THE ROBOT

The EtherNet/IP I/O can be mapped to digital, group, or UOP I/O points within the robot scanner connection. I/O can also map to analog (for scanner connections only). This is similar to mapping other I/O points on the robot where the rack, slot, and starting point number are used to map physical I/O to logical I/O within the I/O map.

All EtherNet/IP I/O uses rack 89. The slot number for each connection is shown in the EtherNet/IP Status screen. Use Procedure 6-1 to map I/O on the robot.

Procedure 6-1 Mapping I/O on the Robot

Steps

1. Press MENU.
2. Select I/O.
3. Press F1, [TYPE], and select Digital, Group, UOP, or analog (analog is supported on scanner connections).
4. Press F2, CONFIG.
5. Set the Range to the appropriate value. For analog, set the channel to the appropriate value.
6. Set the Rack to 89 and set the appropriate slot number and starting point as required.

NOTE

Refer to the Input/Output (I/O) Setup chapter in the application-specific *Setup and Operations Manual* for additional information on I/O configuration.

NOTE

See Procedure 4-3 for additional information on configuring Analog I/O on the controller.

In some application software the I/O is automatically configured when you turn on the controller. The system variable \$IO_AUTO_CFG (for digital I/O) and \$IO_AUTO_UOP (for UOP I/O) controls this behavior. If the system has already automatically configured the I/O, and sizes are changed, the I/O assignments can be cleared to force the system to remap all the I/O. This is done by clearing assignments (CLR_ASG). Use Procedure 6-2 to clear I/O assignments.

Procedure 6-2 Clearing I/O Assignments

Steps

1. Press MENUS.
2. Select I/O.
3. Press F1, [TYPE].
4. Select Link Device.
5. Press F5, CLR_ASG.
6. To remap all I/O, turn the controller off and back on.

NOTE

This clears all I/O assignments. The I/O will be remapped when you turn off then turn on the controller based on the settings of \$IO_AUTO_CFG (for digital I/O) and \$IO_AUTO_UOP (for UOP I/O).

6.3 BACKING UP AND RESTORING ETHERNET/IP AND I/O CONFIGURATION

There are two files which contain information on the configuration of EtherNet/IP and I/O mappings :

- DIOCFGSV.IO contains general I/O configuration and all I/O mappings (for example, mappings between EtherNet/IP and digital, group, and UOP I/O).
- SYSEIP.SV contains EtherNet/IP specific configuration including all adapter and scanner settings.

Use Procedure 6-3 to back up files manually.

Use Procedure 6-4 to do a full application backup, which includes DIOCFGSV.IO and SYSEIP.SV.

Procedure 6-3 Backing Up Files Manually

Steps

1. Select the default file device where files will be saved:
 - a. Press MENUS.
 - b. Select File.
 - c. Press F5, [UTIL], and choose SET DEVICE.
 - d. Select the device to which you want to save the files.
2. Save DIOCFGSV.IO:
 - a. Press MENUS.
 - b. Select I/O.
 - c. Press F1, [TYPE], and choose DIGITAL.
 - d. Press FCTN.
 - e. Select Save to save DIOCFGSV.IO to the default device.
3. Save SYSEIP.SV:
 - a. Press MENUS.
 - b. Select I/O.
 - c. Press F1, [TYPE], and choose EtherNet/IP.
 - d. Press FCTN.
 - e. Select Save to save SYSEIP.SV to the default device.

Procedure 6-4 Performing a Full Application Backup

Steps

1. Select the default file device (where files will be saved):
 - a. Press **MENUS**.
 - b. Select **File**.
 - c. Press **F5**, [**UTIL**], and choose **SET DEVICE**.
 - d. Select the device to which you want to save the files.
2. Press **F4**, [**BACKUP**], and choose “All of above”.

7 EXPLICIT MESSAGING

7.1 OVERVIEW

The robot controller is an explicit message server and supports connected and unconnected explicit messaging. Up to six explicit message connections are supported. The EtherNet/IP Adapter option must be loaded to support this functionality. The following objects are supported by the controller:

- Identity Object (0x01)
- Message Router Object (0x02)
- Assembly Object (0x04)
- Connection Manager Object (0x06)
- Vendor Specific Register Object--Integers (0x6B)
- Vendor Specific Register Object--Reals (0x6C)
- Vendor Specific Register Object--Strings (0x6D)
- Vendor Specific Register Object--Position Registers: Cartesian (0x7B)
- Vendor Specific Register Object--Position Registers: Joint (0x7C)
- Vendor Specific Active Alarm Object (0xA0)
- Vendor Specific Alarm History Object (0xA1)
- Vendor Specific Motion Alarm Object (0xA2)
- Vendor Specific System Alarm Object (0xA3)
- Vendor Specific Application Alarm Object (0xA4)
- Vendor Specific Recovery Alarm Object (0xA5)
- Vendor Specific Communications Alarm Object (0xA6)
- Connection Configuration Object (0xF3)
- Port Object (0xF4)
- TCP/IP Object (0xF5)
- Ethernet Link Object (0xF6)

This chapter does not go into the details of the standard CIP objects defined by ODVA. This chapter will instead document FANUC's Vendor Specific Alarm and Register objects, and the Assembly Object instances numbers for accessing I/O on the robot controller.

In general, no configuration is required on the robot controller to use explicit messaging. I/O must be configured on the robot if it is to be accessed through the Assembly Object.

NOTE

Writing to a register is only supported by V7.20P11 or later.

NOTE

Vendor Specific Register Object--Reals (0x6C) is only supported by V7.40 or later. Only Vendor Specific Register Object--Integers (0x6B) can be used before V7.40P.

NOTE

Vendor Specific Register Object--Strings (0x6D) is only supported by V7.70P27 or later.

NOTE

Vendor Specific Register Object--Position Registers can be used in V8.10P or later.

7.2 ROBOT EXPLICIT MESSAGING CLIENT

7.2.1 Overview

NOTE

Robot Explicit Message Client is only supported by V7.40P or later.

The Robot Explicit Messaging Client allows you to send simple EtherNet/IP explicit messages to other EtherNet/IP enabled devices on the network. You can access this option from the main EtherNet/IP screen and execute queries from the teach pendant.

The explicit messaging feature implements the Get Attribute Single, and Set Attribute Single services. Explicit messaging clients require up to five values for configuration. These values are usually described in hexadecimal notation, with the exception of the IP address. These values are shown in Table 7.2.1 .

Table 7.2.1 Explicit messaging configuration values

ITEM	DESCRIPTION
IP Address	The address of the remote device to be queried.
Class	The class of Object to which the explicit message is being sent.
Instance	The instance number defines which instance of the class will receive the message.
Attribute	Defines which attribute of the instance is being accessed.
Service	The action to be performed. The robot explicit messaging client only supports the Get Attribute Single, and Set Attribute Single services.

An explicit message configuration file can also be created that performs a batch of commands. (Refer to Procedure 7-3). Normally this is used with the Set Attributes Single service to configure a remote device. Procedure 7-1 describes how to use the Get Attribute Single service. Procedure 7-2 describes how to use the Set Attribute Single service.

Procedure 7-1 Get Attribute Single Service

1. Press MENUS.
2. Select I/O.
3. Press F1, [TYPE].
4. Select EtherNet I/P.
5. Press NEXT and then press F2 [EXP-MSG]. (If you scrolled to an active connection, that connection's IP address will be used as the default IP address). You will see a screen similar to the following.

```

I/O EtherNet/IP      JOINT 10 %
Explicit Message Query      1/8
  Input Mode:         Manual
    IP Addr:
    Class:            1
    Instance:         1
    Attribute:        1
    Service:          Get Att
    Value Size:       Byte(1)
    Value:            0

```

6. Select Input Mode, and choose Manual (the default).
7. Set the IP Addr field to the address of the remote device.

8. Set the Class, Instance, and Attribute fields. This information should either describe standard CIP objects, or be provided by the vendor of the remote device.
9. Select Service field and choose Get Att (the default).
10. Press F3 [EXEC] (you will have to cursor to a field other then Services and Value Size to see the F3 [EXEC] function). The robot will attempt to send the Explicit Message query to the device. A valid response or any errors will be displayed at the bottom of the screen.

Procedure 7-2 Set Attribute Single Service

1. Press MENUS.
2. Select I/O.
3. Press F1, [TYPE].
4. Select EtherNet I/P.
5. Press NEXT and then press F2 [EXP-MSG]. (If you scrolled to an active connection, that connection's IP address will be used as the default IP address). You will see a screen similar to the following.

I/O EtherNet/IP	JOINT 10 %
Explicit Message Query	1/8
Input Mode:	Manual
IP Addr:	
Class:	1
Instance:	1
Attribute:	1
Service:	Get Att
Value Size:	Byte(1)
Value:	0

6. Select Input Mode, and choose Manual (the default).
7. Set the IP Addr field to the address of the remote device.
8. Set the Class, Instance, and Attribute fields. This information should either describe standard CIP objects, or be provided by the vendor of the remote device.
9. Select Service field and choose Set Att.
10. Set the Value Size, and Value fields. The supported Value Size fields are Byte, Word, and Long.
11. Press F3, [EXEC] (you will have to cursor to a field other then Services and Value Size to see the F3 [EXEC] function). The robot will attempt to send the Explicit Message query to the device. The result of the query or any errors will be displayed at the bottom of the screen.

Procedure 7-3 Explicit Messaging Batch File Method

1. Press MENUS.
2. Select I/O.
3. Press F1, [TYPE].
4. Select EtherNet I/P.
5. Press NEXT and then press F2 [EXP-MSG]. You will see a screen similar to the following.

I/O EtherNet/IP	JOINT 10 %
Explicit Message Query	1/8
Input Mode:	Manual
IP Addr:	
Class:	1
Instance:	1
Attribute:	1
Service:	Get Att
Value Size:	Byte(1)
Value:	0

6. Move the cursor to Input Mode, and choose File. You will see a screen similar to the following.

```

I/O EtherNet/IP      JOINT 10 %
Explicit Message Query      1/2
Device:   MC:¥
Input Mode:      File
Config File Name:  None

```

7. Move the cursor to the Config File Name field. Press F2, [DEVICE] to select the device where the explicit message config file is located.
8. Press F4, [CHOICE] to select the config file. (Only files with a .EM extension can be selected.)
9. Press F3, [EXEC] to execute the config file. The robot will attempt to send the Explicit Message query to the device. The result of the query or any errors will be displayed at the bottom of the screen.

7.2.2 Creating a Configuration File for the Batch File Method

The configuration file format is documented in this section. All files must be name with the .EM file extension (for example, MYCONFIG.EM). Lines beginning with '*' are comments. Comments and blank lines are ignored. See Example 7.1 .

The following seven (7) lines **MUST** exist for each query followed by a space and corresponding value:

```

QUERY:
IPADDR:
CLASS:
INSTANCE:
ATTRIBUTE:
SIZE:
VALUE:

```

There can be multiple queries within a file. The Set Attribute Single service is assumed in all cases. Each Query begins with a query number, which is unique and generally sequential.

The Size field refers to the Data Size of the parameter (Value), the following three are supported.

- 1 (BYTE or 1 byte)
- 2 (WORD or 2 bytes)
- 4 (LONG or 4 bytes)

Example 7.2.2 Batch file example

```

* File Name: EMCFG.EM
* Author: Joe User
* Date: 03/15/2004
* File must be saved with an .EM extension
* Lines beginning with '*' are comments.
* Comments and blank lines are ignored.
* Following 7 lines MUST exist for each query.
* There can be multiple queries within a file.
* The "SET ATT" service is assumed in all cases.
* Each Query begins with a query number, which is
* unique and generally sequential.
* Size field refers to the Data Size of the
* parameter, the following three are supported
* 1 (BYTE or 1 byte), 2 (WORD or 2 bytes), 4 (LONG or 4 bytes)
QUERY: 1
IPADDR: 172.22.200.147
CLASS: 15
INSTANCE: 2
ATTRIBUTE: 1
SIZE: 1
VALUE: 4
QUERY: 2
IPADDR: 172.22.200.147
CLASS: 15
INSTANCE: 3
ATTRIBUTE: 1
SIZE: 2
VALUE: 300

```

7.3 REMOTE EXPLICIT MESSAGING CLIENT CONFIGURATION

Explicit messaging clients require up to four values for configuration. These values are usually described in hexadecimal notation. These values are shown in Table 7.3 .

Table 7.3 Configuration values

ITEM	DESCRIPTION
Class	The class of Object to which the explicit message is being sent.
Instance	The instance number defines which instance of the class will receive the message.
Attribute	Defines which attribute of the instance is being accessed.
Service	The action to be performed.

These values are documented in this manual for all FANUC's Vendor Specific Objects. Here is an example of configuring an Explicit Message in RSLogix5000. Note the Service Code, Class, Instance and Attribute fields.

Fig. 7.3 Message configuration

7.4 VENDOR SPECIFIC REGISTER OBJECTS

NOTE

Writing to a register is only supported by V7.20P11 or later.

Table 7.4 shows the brief description of FANUC register object model.

Table 7.4 FANUC register object model

Register Type	Service	Class	Instance	Attribute
NUMREG (Int)	Get_Attr_Single	0x6B	1 (8 bits)	reg #
NUMREG (Int)	Get_Attr_All	0x6B	1 (8 bits)	N/A

Register Type	Service	Class	Instance	Attribute
NUMREG (Int)	Get_Attr_Block	0x6B	blk_size, 1 (16 bits)	start reg #
NUMREG (Int)	Set_Attr_Single	0x6B	1 (8 bits)	reg #
NUMREG (Int)	Set_Attr_All	0x6B	1 (8 bits)	N/A
NUMREG (Int)	Set_Attr_Block	0x6B	blk_size, 1 (16 bits)	start reg #
NUMREG (Real)	Get_Attr_Single	0x6C	1 (8 bits)	reg #
NUMREG (Real)	Get_Attr_All	0x6C	1 (8 bits)	N/A
NUMREG (Real)	Get_Attr_Block	0x6C	blk_size, 1 (16 bits)	start reg #
NUMREG (Real)	Set_Attr_Single	0x6C	1 (8 bits)	reg #
NUMREG (Real)	Set_Attr_All	0x6C	1 (8 bits)	N/A
NUMREG (Real)	Set_Attr_Block	0x6C	blk_size, 1 (16 bits)	start reg #
STRREG	Get_Attr_Single	0x6D	1 (8 bits)	reg #
STRREG	Get_Attr_All	0x6D	1 (8 bits)	N/A
STRREG	Get_Attr_Block	0x6D	blk_size, 1 (16 bits)	start reg #
STRREG	Set_Attr_Single	0x6D	1 (8 bits)	reg #
STRREG	Set_Attr_All	0x6D	1 (8 bits)	N/A
STRREG	Set_Attr_Block	0x6D	blk_size, 1 (16 bits)	start reg #
POSREG (CRT)	Get_Attr_Single	0x7B	group # (8 bits)	reg #
POSREG (CRT)	Get_Attr_All	0x7B	group # (8 bits)	N/A
POSREG (CRT)	Get_Attr_Block	0x7B	blk_size, group # (16 bits)	start reg #
POSREG (CRT)	Set_Attr_Single	0x7B	group # (8 bits)	reg #
POSREG (CRT)	Set_Attr_All	0x7B	group # (8 bits)	N/A
POSREG (CRT)	Set_Attr_Block	0x7B	blk_size, group # (16 bits)	start reg #
POSREG (JNT)	Get_Attr_Single	0x7C	group # (8 bits)	reg #
POSREG (JNT)	Get_Attr_All	0x7C	group # (8 bits)	N/A
POSREG (JNT)	Get_Attr_Block	0x7C	blk_size, group # (16 bits)	start reg #
POSREG (JNT)	Set_Attr_Single	0x7C	group # (8 bits)	reg #
POSREG (JNT)	Set_Attr_All	0x7C	group # (8 bits)	N/A
POSREG (JNT)	Set_Attr_Block	0x7C	blk_size, group # (16 bits)	start reg #
CURPOS (CRT)	Get_Attr_Single	0x7D	group # (8 bits)	1
CURJPOS (JNT)	Get_Attr_Single	0x7E	group # (8 bits)	1

7.4.1 Numeric Register Objects (0x6B and 0x6C)

NOTE

Vendor Specific Register Object--Reals (0x6C) is only supported by V7.40 or later. Only Vendor Specific Register Object--Integers (0x6B) can be used before V7.40P.

Numeric registers can be read and written through FANUC's Registers Object. These registers on the robot controller can be one of two types: Integer type, or Real type. Normally, the type is transparent to the user. For example, if R[1] is set to a value of 49 (R[1] = 49), the numeric register will automatically be configured as an Integer type. However, if R[2] is set to a value of 1.61803 (R[2] = 1.61803), the numeric register will be automatically configured as a Real type.

Because of the format of the data transfer through explicit messaging, this automatic configuration cannot be done. Therefore, two Register Objects have been created: Register Object--Integers (0x6B), and Register Object--Reals (0x6C). To read or write a numeric register as an Integer value, the Register Object--Integers (0x6B) should be accessed. To read or write a numeric register as a Real value, the Register Object--Real (0x6C) should be accessed.

Note that when writing to the Register Object--Integers, the numeric register will be changed to the Integer type. Likewise, when writing to the Register Object--Reals, the numeric register will be changed to the Real type.

However, when reading a numeric register using the Register Object--Integers, if the numeric register is configured as a Real type, an "Undefined Attribute" (0x14) error will be returned. Likewise, when reading a numeric register using the Register Object--Real, if the numeric register is configured as an Integer type, an "Undefined Attribute" (0x14) error will be returned.

NOTE

FANUC's Register objects also allow reading and writing of the registers in blocks. The Get_Attribute_All service allows reading of up to the first 124 registers starting from first register. The Set_Attribute_All service allows writing of up to the first 115 registers starting from first register. The Get_Attribute_Block allows up to 124 registers for Reading and Set_Attribute_Block allows writing up to 115 registers at a time starting from any register number.

7.4.1.1 Instance attributes

FANUC's Register Objects support a single instance: instance 1. Each attribute in the instance corresponds to a register. For example, attribute 1 corresponds to R[1] and attribute 5 corresponds to R[5]. Refer to Table 7.4.1.1 .

Table 7.4.1.1 Instance attributes

Attribute ID	Name	Data Type	Description of Attribute
1	R[1]	32-bit integer	Register 1
2	R[2]	32-bit integer	Register 2
...			
n-1	R[n-1]	32-bit integer	Register n-1
n*	R[n]	32-bit integer	Register n

*Where n is the total number of registers on the controller.

7.4.1.2 Common services

FANUC's Register Objects provide the Common Services at the Instance level shown in Table 7.4.1.2(a). No Class level services are provided.

Table 7.4.1.2(a) Common services

Service Code	Service Name	Description of Service
0E hex	Get_Attribute_Single	Returns the content of the specified attribute.
01 hex	Get_Attribute_All	Returns a listing of the object's attributes (See the Get_Attribute_All definition below).
32 hex	Get_Attribute_Block	Returns specified block o registers values
10 hex	Set_Attribute_Single	Sets the specified attribute to the specified value.
02 hex	Set_Attribute_All	Sets all attributes starting from Attribute 1 to 115 or MAX registers on controller whichever is smaller.
33 hex	Set_Attribute_Block	Sets values to the specified block of registers up to 115 or MAX registestr on controllor whichever is smaller.

At the Instance level, the attributes are returned in the order shown in Table 7.4.1.2(b) using little-endian byte-swapping.

Table 7.4.1.2(b) Get_Attribute_All response

32-bit integer	Byte 0	Byte 1	Byte 2	Byte 3
1	Register 1 (R[1])			
2	Register 2 (R[2])			
...				
n-1	Register n-1 (R[n-1])			
n*	Register n (R[n])			

*Where n is the total number of registers on the controller or 124, whichever is smaller.

7.4.1.3 Errors

FANUC's Vendor Specific Register Objects will return the errors shown in Table 7.4.1.3 .

Table 7.4.1.3 FANUC's vendor specific register object errors

Error Status	Error Description
Undefined Attribute (0x14)	Returned when the Register requested does not exist.
Unsupported Service (0x08)	Returned when the requested service is unsupported.
Undefined Class Instance (0x05)	Returned when the requested instance number is unsupported.

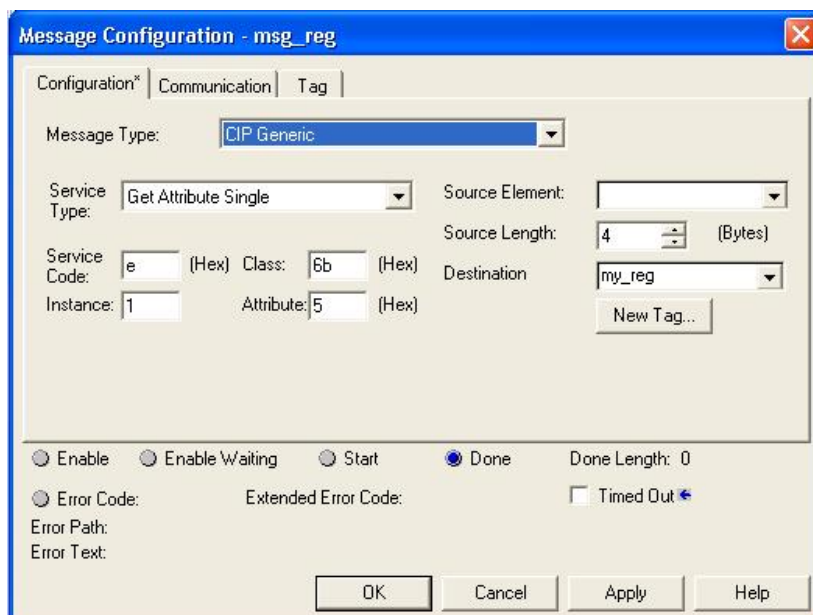
7.4.1.4 Read single register

The examples below assume the numeric register(s) have type integer, and use object 0x6B. The same examples can be used for numeric registers of type Real by using Class 0x6C, instead of Class 0x6B. To read R[5] from the controller, assuming R[5]'s type is an integer, the explicit message client would be configured with the values shown in Table 7.4.1.4 .

Table 7.4.1.4 Read register R[5]

Class	0x6B
Instance	0x01
Attribute	0x05
Service	0x0E

Figure 7.4.1.4 shows message block configuration in RSLogix5000 where my_reg is a 32-bits integer variable. The explicit message server on the robot controller would return R[5] to the client as a 32-bit integer.

**Fig. 7.4.1.4 Read register R[5]**

7.4.1.5 Read all registers

To read up to the first 124 Registers from the controller, and assuming all these registers are configured as type integer, the explicit message client would be configured with the values shown in Table 7.4.1.5 .

Table 7.4.1.5 Read all registers

Class	0x6B
Instance	0x01
Attribute	0x0
Service	0x01

Figure 7.4.1.5 is snapshot of RSLogix5000 message block configuration to read all registers where my_regall is an array of 124 integers. The explicit message server on the robot controller would return up to the first 124 Registers as an array of integers as described in Section 7.4.1.2 .

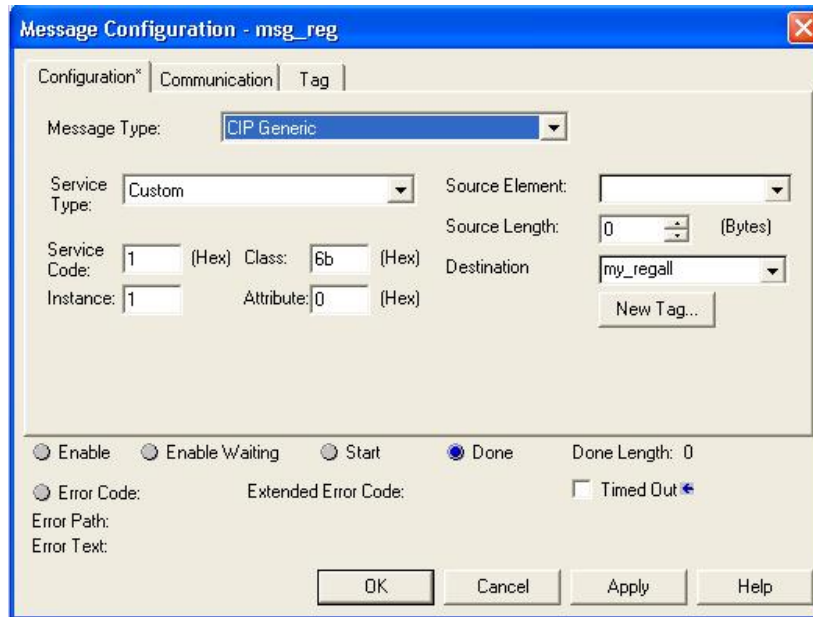


Fig. 7.4.1.5 Read all registers

7.4.1.6 Read a block of registers

Register objects also provide the functionality to read or write a block of registers. Common services used for read a block is Get_Attribute_Block (0x32). In order to use this functionality Instance and attributes are used as follows.

Instance is 2 byte. It is divided into two pieces. First (lower) 8 bits carry instance number which could be maximum 255 (for now it is just place holder because FANUC's register supports only single class instance). Second (higher) 8 bits carry the number of registers to be read so maximum 255 but FANUC's register object allows 124 for reading at time. Please refer to Table 7.4.1.6(a) for instance number calculation. For example, to read 10 registers starting from register number 6 in integer format see Table 7.4.1.6(b) and Figure 7.4.1.6 for configuration details. Messaging server would return values of registers 6 to 15.

Table 7.4.1.6(a) Instance numbers for block access

Block Size Decimal (HEX)	Instance (HEX)	Instance (Decimal)
1 (0x01)	0x0101	257
2 (0x02)	0x0201	513
3 (0x03)	0x0301	769
4 (0x04)	0x0401	1025
5 (0x05)	0x0501	1281

Table 7.4.1.6(b) Read 10 registers from R[6]-R[15]

Class	0x6B
Instance	0x0A01
Attribute	0x06
Service	0x01

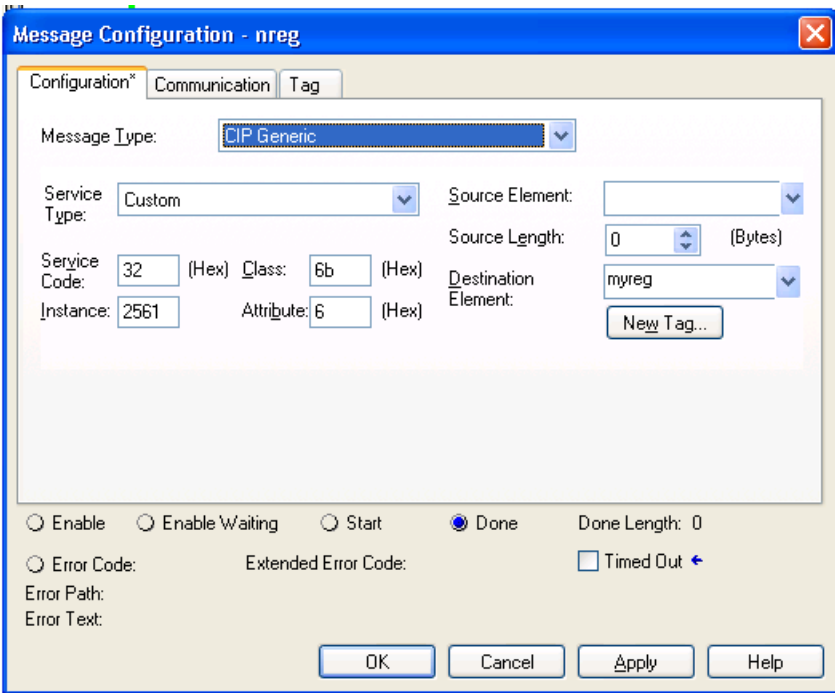


Fig. 7.4.1.6 Read 10 registers from R[6]-R[15]

7.4.1.7 Write single register

To write the integer value 49 to R[5], the explicit message client would be configured with the values shown in Table 7.4.1.7 .

Table 7.4.1.7 Write value to R[5]

Class	0x6B
Instance	0x01
Attribute	0x05
Service	0x10
Value	49

Figure 7.4.1.7 is an snapshot of RSLogix5000 message block configuration. my_reg is 32-bits integer which has value 49. The explicit message server on the robot controller would write the value 49 to R[5] as a 32-bit integer.

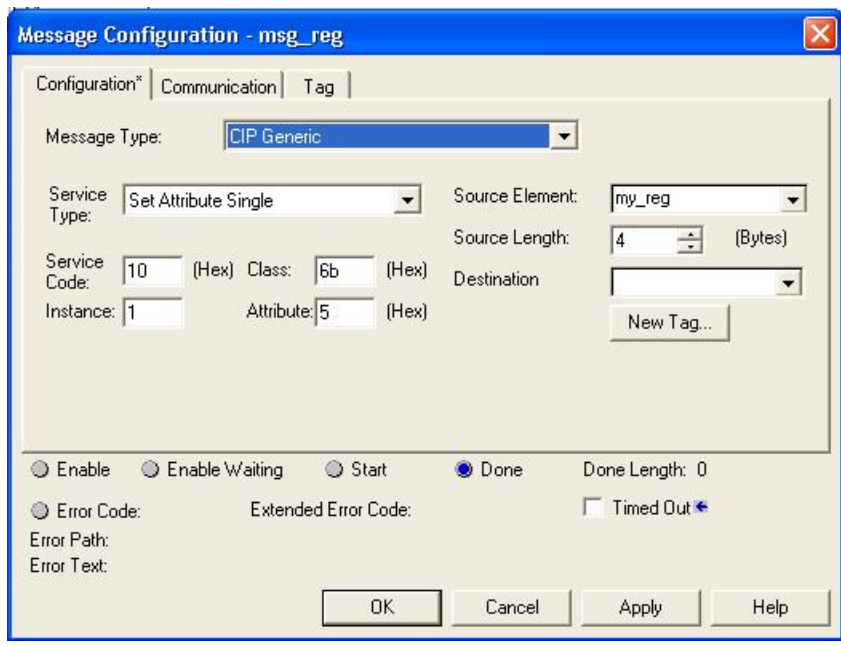


Fig. 7.4.1.7 Write value to R[5]

7.4.1.8 Write all registers

Similarly, all register can be written at once. Only 115 or total number of registers on controller (whichever is less) can be written, configuration parameters shown in Table 7.4.1.8 . Explicit message client (e.g. PLC) would carry an array of 115 integers or real (460 bytes total) along with this configuration.

Table 7.4.1.8 Write all registers

Class	0x6B
Instance	0x01
Attribute	0x0
Service	0x02

Figure 7.4.1.8 is taken from RSLogix5000 to write all registers to controllers. Source element is my_regall[115] which is an array of 115 DINT. Source length is data size to be written. Service code is 0x02, class 0x6B for Integer, Instance is 1 and attribute has to be zero.

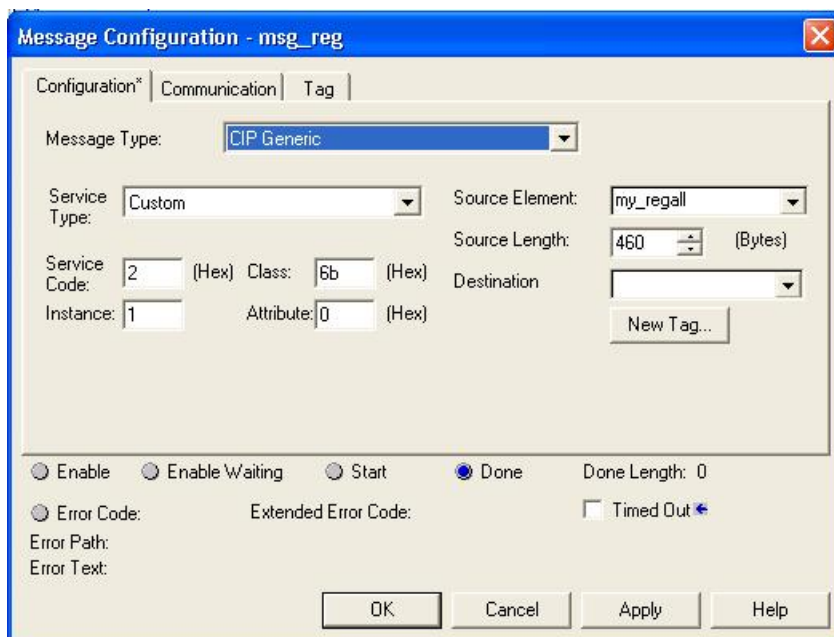


Fig. 7.4.1.8 Write all registers

7.4.1.9 Write a block of registers

Similarly, a block of registers can be written to robot using this functionality. Service used for function is Set_Attribute_Block (0x33). Maximum 115 or maximum available registers in controller whichever is less can be written at a time. For example, to write 5 registers (integer) starting from 11 (0xB) following configuration is needed, see Table 7.4.1.9 .

Table 7.4.1.9 Write 5 registers from R[11]-R[15]

Class	0x6C
Instance	0x501
Attributes	0xB
Service	0x02

Please refer to Figure 7.4.1.9 for message block configuration to write registers in RSLogix5000.

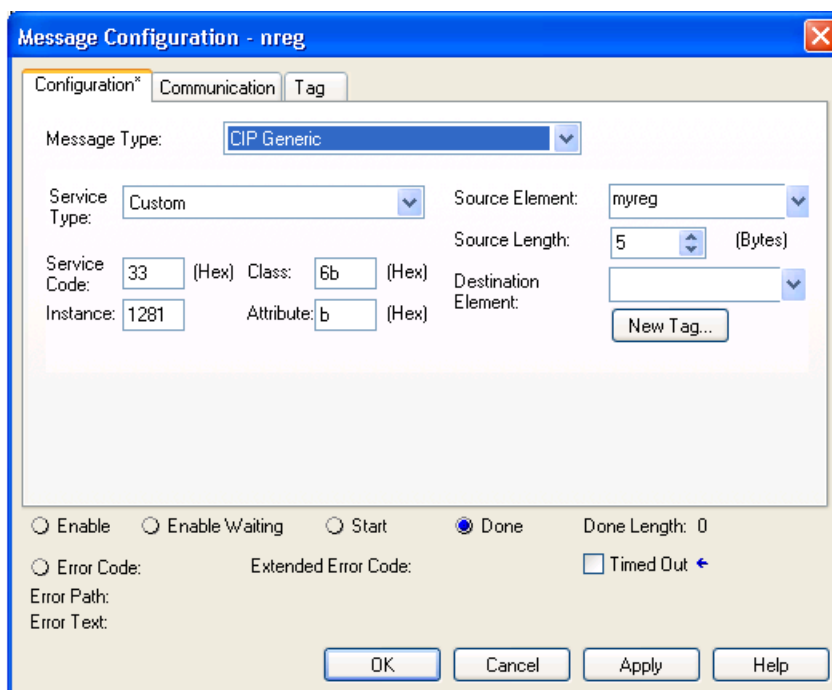


Fig. 7.4.1.9 Write registers from R[11]-R[15]

7.4.2 String Register Object (0x6D)

NOTE

Vendor Specific Register Object--Strings (0x6D) is only supported by V7.70P27 or later.

String register object will provide similar functionality as numeric register objects. It provides the ability to read string data as well as write string data via Ethernet/IP explicit messaging.

7.4.2.1 Instance attributes

FANUC's string register object provides single class instance i.e. 1. Instance attributes supported are maximum string registers supported on controller. String register is of STRING or STRING2 or STRINGN type. The declaration of a variable of type STRING, STRING2, or STRINGN is equivalent to declaring a structured data type for the variable which allocates a UINT variable (first 4 bytes) containing the current size of the string in characters and an array of declared character size elements. String register object is composed of first 4 bytes string length, 82 bytes long string and 2 bytes padding which totals to 88 bytes in single string register, refer to Table 7.4.2.1(a) and Figure 7.4.2.1 . So on reading single register, it returns 88 bytes of data which contains maximum 82 byte long string. This is done to be compatible with RockWell PLC string structure (RSLogix5000) as shown in Figure 7.4.2.1 .

Table 7.4.2.1(a) String format

0-3 Byte	4-85 Bytes	86-87 bytes
String Length	String Register n (SR[n])	Padding

Name:

Description:

Maximum Characters:

Members: Data Type Size: 88 byte(s)

	Name	Data Type	Style	Description
	LEN	DINT	Decimal	
	DATA	SINT[82]	ASCII	

Fig. 7.4.2.1 String structure RSLogix5000

Please note that size of string shown in Figure 7.4.2.1 also includes 2 byte padding.

Table 7.4.2.1(b) Instance attributes

Attribute ID	Name	Data Type	Description of Attribute
1	SR[1]	Structure containing unsigned integer and char array of 82 bytes and last 2 bytes is padding Array	String Register 1
2	SR[2]	Structure containing unsigned integer and char array of 82 bytes and last 2 bytes is padding Array	String Register 2
...			
n-1	SR[n-1]	Structure containing unsigned integer and char array of 82 bytes and last 2 bytes is padding Array	String Register n-1
n*	SR[n]	Structure containing unsigned integer and char array of 82 bytes and last 2 bytes is padding Array	String Register n

*Where n is the total number of registers on the controller.

7.4.2.2 Common services

FANUC's Register Objects provide the Common Services at the Instance level shown in Table 7.4.2.2 . No Class level services are provided.

Table 7.4.2.2 Common services

Service Code	Service Name	Description
0E hex	Get_Attribute_Single	Returns the content of the specified attribute i.e. 88 byte char array.
01 hex	Get_Attribute_All	Returns an array of 88 bytes char arrays. Maximum register returned are 5 or string registers supported on controller whichever is smaller.
32 hex	Get_Attribute_Block	Returns block of string registers starting from any register up to next 5 registers or maximum string registers supported on controller whichever is smaller.
10 hex	Set_Attribute_Single	Sets the specified attribute to the specified value.

Service Code	Service Name	Description
02 hex	Set_Attribute_All	Sets all attributes starting from Attribute 1 to 5 or maximum string registers supported on controller whichever is smaller.
33 hex	Set_Attribute_Block	Sets values to block of string registers starting from any register up to next 5 registers or maximum string registers supported on controller whichever is smaller.

7.4.2.3 Errors

Refer to Section 7.4.1.3

7.4.2.4 Read single register

Figure 7.4.2.4 shows message block configuration to read single string registers. Example screen shots are taken from RSLogix5000. To read string register 8, a string type variable “my_string_in” needs to be created to read the string. Please note that Instance value in Figure 7.4.2.4 is decimal number and all others are hexadecimal numbers. Table 7.4.2.4 lists the all configuration parameters to read SR[8].

Fig. 7.4.2.4 Read string register SR[8]

Table 7.4.2.4 Read register SR[8]

Class	0x6D
Instance	0x01
Attribute	0x08
Service	0x0E

7.4.2.5 Read all register

Reading all registers is also supported for string registers. Reading all register allows to read first 5 string registers. This limitation is posed due to maintain compatibility with RSLogix5000. Figure 7.4.2.5 shows the message block configuration to read all string registers where 'mystr' is an array of 5 STRING variables.

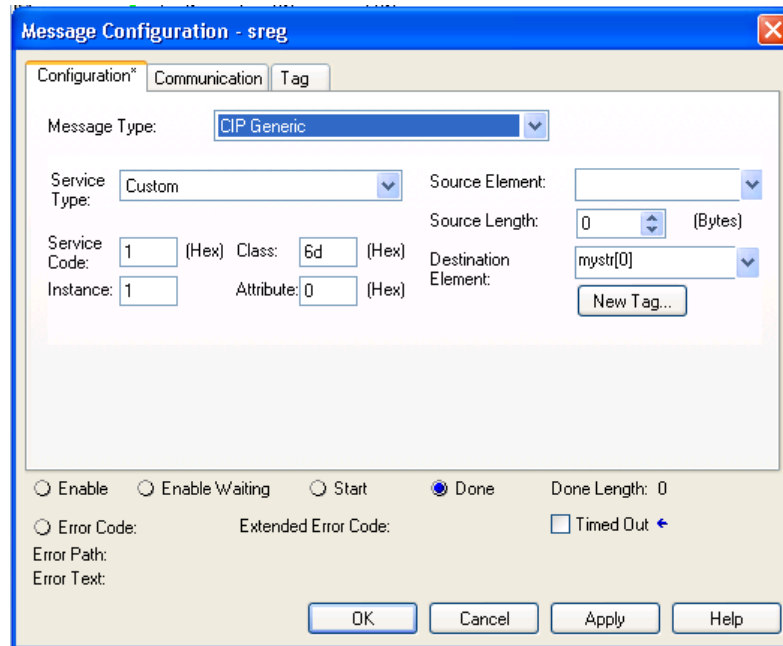


Fig. 7.4.2.5 Read all register

7.4.2.6 Read a block of register

String registers also can be read in blocks. The block size limitation is 5 registers at a time. The advantage over read all register is that it allows to read from any register index to next 5 registers. Please refer to Figure 7.4.2.6 for configuration details to read 5 registers starting from register number 5.

NOTE

Please note that the data returned/consumed as a result of block read/write operation is always multiple of 88 which is 88 times block size. In case of read/write all data size is 440 bytes, if total string registers available on controller are 5 or more.

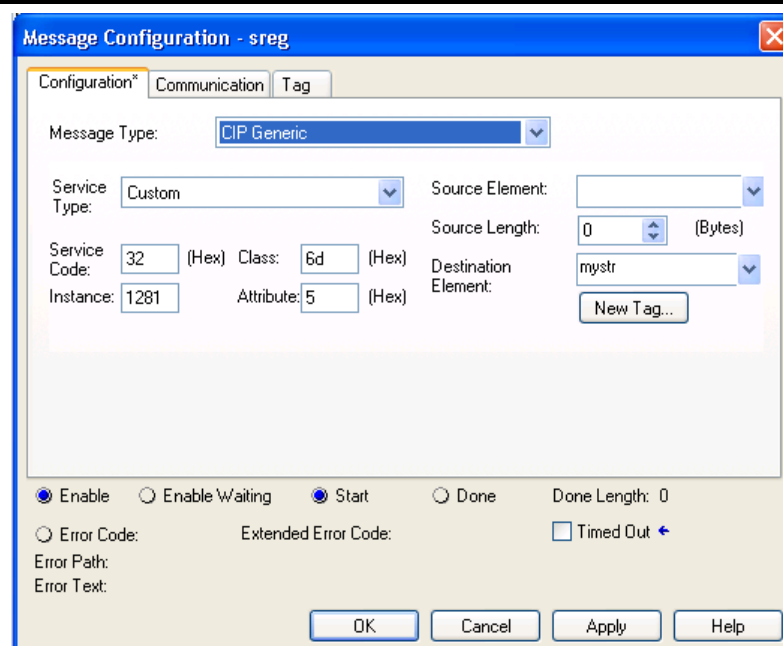


Fig. 7.4.2.6 Read a block of register

7.4.2.7 Write single register

For writing string to any specified string register, a variable of STRING (RSLogix5000) type or a structure as described in Section 7.4.2.1 needs to be created which carries string data. Please refer to Figure 7.4.2.7 .

Fig. 7.4.2.7 Write string to SR[5]

Table 7.4.2.7 Write string to SR[5]

Class	0x6D
Instance	0x01
Attribute	0x05
Service	0x10

7.4.2.8 Write all registers

This service allows to write strings to first 5 string registers. Each string data could be 82 bytes long. Figure 7.4.2.8 shows the message block configuration where 'mystr' is an array of 5 STRING data type. Please refer to Figure 7.4.2.1 for STRING data type definition.

The dialog box 'Message Configuration - sreg' has three tabs: 'Configuration*', 'Communication', and 'Tag'. The 'Configuration*' tab is active. It contains the following fields and controls:

- Message Type:** A dropdown menu set to 'CIP Generic'.
- Service Type:** A dropdown menu set to 'Custom'.
- Source Element:** A dropdown menu set to 'mystr'.
- Source Length:** A numeric input set to '440' with '(Bytes)' to its right.
- Service Code:** A numeric input set to '2' with '(Hex)' to its right.
- Class:** A numeric input set to '6d' with '(Hex)' to its right.
- Destination Element:** A dropdown menu.
- Instance:** A numeric input set to '1'.
- Attribute:** A numeric input set to '0' with '(Hex)' to its right.
- Buttons:** 'New Tag...' (disabled), 'OK', 'Cancel', 'Apply', and 'Help'.
- Options:**
 - ☒ Enable
 - ☐ Enable Waiting
 - ☒ Start
 - ☐ Done
 - Done Length: 0
 - ☐ Error Code:
 - Extended Error Code:
 - ☐ Timed Out
 - Error Path:
 - Error Text:

Fig. 7.4.2.8 Write all registers

7.4.2.9 Write a block of registers

This service is similar to write all except it allows to write string data starting from any registers to next 5 registers. Please refer to Figure 7.4.2.9 for message configuration details.

The dialog box 'Message Configuration - sreg' has three tabs: 'Configuration*', 'Communication', and 'Tag'. The 'Configuration*' tab is active. It contains the following fields and controls:

- Message Type:** A dropdown menu set to 'CIP Generic'.
- Service Type:** A dropdown menu set to 'Custom'.
- Source Element:** A dropdown menu set to 'mystr'.
- Source Length:** A numeric input set to '440' with '(Bytes)' to its right.
- Service Code:** A numeric input set to '33' with '(Hex)' to its right.
- Class:** A numeric input set to '6d' with '(Hex)' to its right.
- Destination Element:** A dropdown menu.
- Instance:** A numeric input set to '1281'.
- Attribute:** A numeric input set to '5' with '(Hex)' to its right.
- Buttons:** 'New Tag...' (disabled), 'OK', 'Cancel', 'Apply', and 'Help'.
- Options:**
 - ☒ Enable
 - ☐ Enable Waiting
 - ☒ Start
 - ☐ Done
 - Done Length: 0
 - ☐ Error Code:
 - Extended Error Code:
 - ☐ Timed Out
 - Error Path:
 - Error Text:

Fig. 7.4.2.9 Write a block of registers

7.4.3 Position Register Object (0x7B, 0x7C, 0x7D, 0x7E)

⚠ CAUTION

Please note that Position Register object is only applicable to software version v810 or above.

Position register object provides similar functionality as numeric register objects. It provides the ability to read position data as well as writing the position data. This also has flexibility to read/write data in two representations Cartesian and Joint.

7.4.3.1 Instance attributes

FANUC's position register object provides single class instance i.e. 1. Instance attributes supported are maximum position registers supported in controller. Position register is an structure shown in Figure 7.4.3.1(a) and Figure 7.4.3.1(b) for joint and cartesian representations respectively. Joint representation can be accommodated in an structure consisting an unsigned 32–bits integer and 9 real which supports up to 9 axes . If robot axes are less than 9 then remaining axes returned are zeros. The explicit messaging server returns 40 bytes data for joint position representation on reading and consumes 40 bytes position data on writing. On the other hand, cartesian position representation is 44 byte. The explicit messaging server returns 44 bytes of data on reading and consumes 44 bytes of data on writing.

Table 7.4.3.1(a) Structure definition for joint position representation

Structure Name: PRJNT9 (User defined)			
Member Names	Data Size	Data Type	Description
UT	1 Byte	Decimal	User Tool Number
UF	1 Byte	Decimal	User Frame Number
Dummy	2 Bytes	Decimal	Reserved
JNT_ANGLE[9]	36 Bytes	Float	Robot Axes: An array of 9 Real

Table 7.4.3.1(b) Instance number calculation

Block Size Decimal (HEX)	Instance (HEX) Group #1	Instance (Decimal) Group #1	Instance (HEX) Group #2	Instance (Decimal) Group #2
1 (0x01)	0x0101	257	0x0102	258
2 (0x02)	0x0201	513	0x0202	514
3 (0x03)	0x0301	769	0x0302	770
4 (0x04)	0x0401	1025	0x0402	1026
5 (0x05)	0x0501	1281	0x0502	1282

Table 7.4.3.1(c) Structure definition for cartesian position representation

Structure Name: PRCRT (user defined)			
Member Names	Data Size	Data Type	Description
UT	1 Byte	Decimal	User Tool Number
UF	1 Byte	Decimal	User Frame Number
Dummy	2 Bytes	Decimal	Reserved
X	4 Bytes	Float	X mm

Structure Name: PRCRT (user defined)			
Member Names	Data Size	Data Type	Description
Y	4 Bytes	Float	Y mm
Z	4 Bytes	Float	Z mm
W	4 Bytes	Float	W Degree
P	4 Bytes	Float	P Degree
R	4 Bytes	Float	R Degree
Turn4	1 Byte	Decimal	Turn4
Turn5	1 Byte	Decimal	Turn5
Turn6	1 Byte	Decimal	Turn6
Reserved1-4	4-Bits	Bool	Reserved
Front	1 Bit	Bool	Front
Up	1 Bit	Bool	Up
Left	1 Bit	Bool	Left
Flip	1 Bit	Bool	flip
EXT[3]	12 Bytes	Float	Extended Axes

Name:

Description:

Members: Data Type Size: 40 byte(s)

	Name	Data Type	Style	Description
<input type="checkbox"/>	UT	SINT	Decimal	
<input type="checkbox"/>	UF	SINT	Decimal	
<input type="checkbox"/>	DUMMY	INT	Decimal	
<input type="checkbox"/>	JNT_ANGLE	REAL[9]	Float	

Fig. 7.4.3.1(a) Position register joint mode

Name:

Description:

Members: Data Type Size: 44 byte(s)

Name	Data Type	Style	Description
UT	SINT	Decimal	
UF	SINT	Decimal	
DUMMY	INT	Decimal	
LOC	PRLOC		
X	REAL	Float	
Y	REAL	Float	
Z	REAL	Float	
ORNT	PRORNT		
W	REAL	Float	
P	REAL	Float	
R	REAL	Float	
CFG	PRCFG		
TURN4	SINT	Decimal	
TURN5	SINT	Decimal	
TURN6	SINT	Decimal	
RESERVED1	BOOL	Decimal	
RESERVED2	BOOL	Decimal	
RESERVED3	BOOL	Decimal	
RESERVED4	BOOL	Decimal	
FRONT	BOOL	Decimal	
UP	BOOL	Decimal	
LEFT	BOOL	Decimal	
FLIP	BOOL	Decimal	
EXT	DINT[3]	Decimal	

Fig. 7.4.3.1(b) Position register cartesian mode

7.4.3.2 Common services

FANUC's Register Objects provide the Common Services at the Instance level shown in Table 7.4.3.2 . No Class level services are provided.

Table 7.4.3.2 Common services

Service Code	Service Name	Description
0E hex	Get_Attribute_Single	Returns the content of the specified attribute i.e. 40 or 44 bytes for Joint or Cartesian representation respectively.
01 hex	Get_Attribute_All	Returns an array of position registers. Maximum register returned are 10 or position registers supported on controller whichever is smaller.
32 hex	Get_Attribute_Block	Returns block of position registers starting from any register up to next 10 registers or maximum position registers supported on controller whichever is smaller.
10 hex	Set_Attribute_Single	Sets the specified attribute to the specified value.

Service Code	Service Name	Description
02 hex	Set_Attribute_All	Sets all attributes starting from Attribute 1 to 10 or maximum position registers supported on controller whichever is smaller.
33 hex	Set_Attribute_Block	Sets values to block of position registers starting from any register up to next 10 registers or maximum position registers supported on controller whichever is smaller.

NOTE

Please note that reading or writing of position registers in any representation i.e. joint or cartesian, would NOT affect controller's current position register representation.

7.4.3.3 Errors

Refer to Section 7.4.1.3.

7.4.3.4 Read single register

Reading position register is similar to numeric or string registers except instance number represents the group number of the robot having multiple groups so instance number is always nonzero positive integer. This object allows to read registers from multiple groups of the robot. Table 7.4.3.4(a) and Figure 7.4.3.4(a) show the configuration details to read position register 3 in joint representation.

Table 7.4.3.4(a) Read position register 3 in joint mode

Class	0x7C
Instance	0x01
Attribute	0x03
Service	0x0E

Message Configuration - posreg2

Configuration* Communication Tag

Message Type: CIP Generic

Service Type: Get Attribute Single

Service Code: e (Hex) Class: 7c (Hex) Instance: 1 Attribute: 3 (Hex)

Source Element: Source Length: 0 (Bytes) Destination Element: prd

Done Length: 0

☐ Enable ☐ Enable Waiting ☐ Start ☒ Done

☐ Error Code: Extended Error Code: ☐ Timed Out

Error Path: Error Text:

OK Cancel Apply Help

Fig. 7.4.3.4(a) Read single register in joint mode

Similarly Table 7.4.3.4(b) and Figure 7.4.3.4(b) show the configuration for read position register 8 in cartesian mode. Please remember that Joint representation is a 40 bytes and Cartesian representation is 44 byte data.

Table 7.4.3.4(b) Read position register 8 in cartesian mode

Class	0x7B
Instance	0x01
Attribute	0x08
Service	0x0E

Fig. 7.4.3.4(b) Read single register in cartesian mode

7.4.3.5 Read all registers

Reading all registers is also supported for position registers. Reading procedure is similar to Numeric or String Registers except class and data type. Reading all position registers is limited to maximum of 10 or number of registers on controller whichever is SMALLER starting from register 1. Please refer to Table 7.4.3.5 and Figure 7.4.3.5 for configuration details. prrd is an array of structures PRCRT a user define data type shown in Figure 7.4.3.1(b) for cartesian representation.

Table 7.4.3.5 Read all registers

Class	0x7B
Instance	0x01
Attribute	0x00
Service	0x01

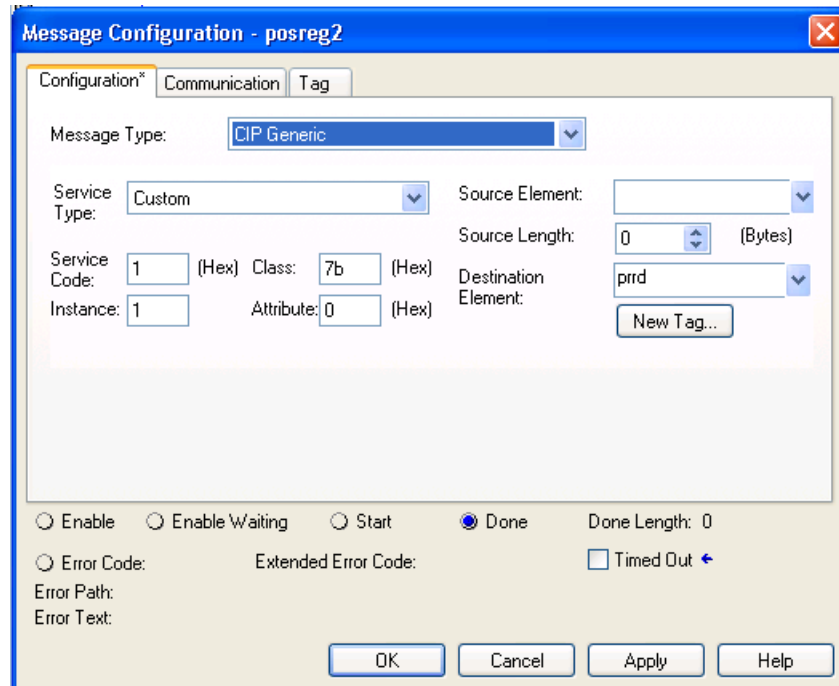


Fig. 7.4.3.5 Read all registers

7.4.3.6 Read a block of registers

Position registers also can read or written in blocks. The block size limitation is 10 registers at a time. This functionality provides the flexibility to set start register index of the block of registers i.e. read 23 to 32 or 50 to 59, etc.

NOTE

Please note that the data returned/consumed as a result of block read/write operation is always multiple of 40 (joint) or 44 (cartesian) which is 40 or 44 times block size for joint and cartesian respectively. In case of read/write all data size is 400 (joint) or 440 (cartesian) bytes, if total position registers available on controller are 10 or more.

For example, message block configuration is shown in Figure 7.4.3.6 for reading 8 position registers of group 1 starting from register number 10 in cartesian mode. Instance 2049 is decimal equivalent of 0x0801 and 'prrd' is an array of structure defined in Figure 7.4.3.1(b) to hold position data in cartesian mode.

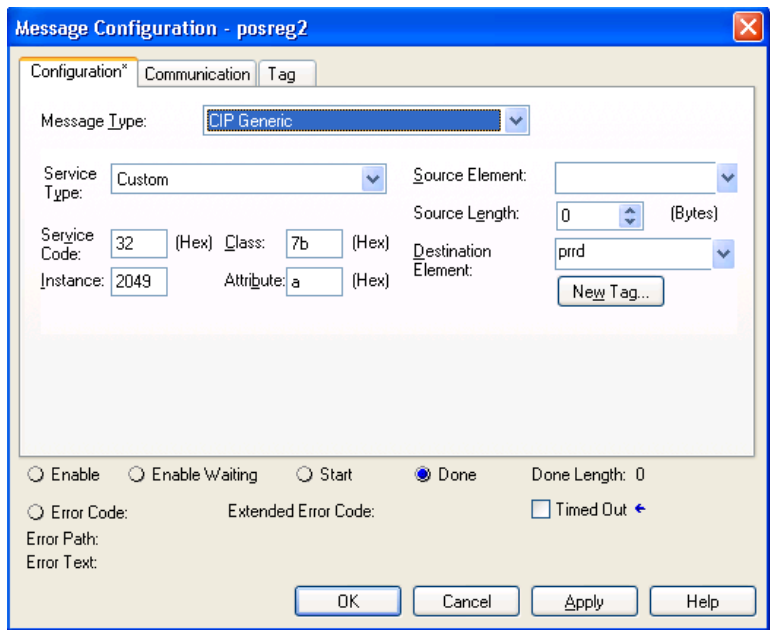


Fig. 7.4.3.6 Read a block of registers

7.4.3.7 Read current position (CURPOS or CURJPOS)

This functionality also allows to read current position of robot in two modes: joint and cartesian. Configuration is same as reading a single position register with index 1 except class 0x7D is used for cartesian and 0x7E is used for joint. Please refer to Figure 7.4.3.7(a) for cartesian mode and Figure 7.4.3.7(b) for joint mode in RSLogix5000 message block configuration. Table 7.4.3.7(a) and Table 7.4.3.7(b) show the configuration parameters for cartesian and joint mode respectively.

Table 7.4.3.7(a) Read current position in cartesian mode

Class	0x7D
Instance	0x01
Attribute	0x01
Service	0x0E

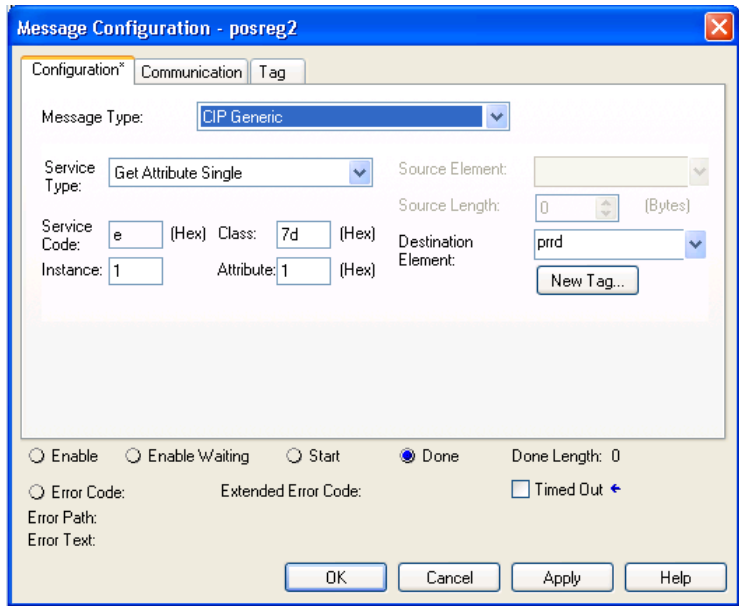


Fig. 7.4.3.7(a) Read CURPOS

Table 7.4.3.7(b) Read current position in joint mode

Class	0x7E
Instance	0x01
Attribute	0x01
Service	0x0E

Fig. 7.4.3.7(b) Read CURJPOS

7.4.3.8 Write single register

This service provides the flexibility to write position data to position registers in two modes cartesian and joint. Figure 7.4.3.8 shows the configuration parameters. Here prwr is a user defined data structure as shown in Figure 7.4.3.1(a) to hold the position data for joint representation.

Fig. 7.4.3.8 Write single register in joint mode

7.4.3.9 Write all registers

This service allows to write position data to first 10 position registers. Position data for each register is 44 or 40 bytes long for cartesian and joint representation respectively. Figure 7.4.3.9 shows the message block configuration where 'prwr' is an array of 10 data structures to hold cartesian position data. Please refer to Figure 7.4.3.1(b) for cartesian position data structure.

Message Configuration - posreg2

Configuration* Communication Tag

Message Type: CIP Generic

Service Type: Custom

Source Element: prwr

Source Length: 440 (Bytes)

Service Code: 2 (Hex) Class: 7b (Hex)

Instance: 1 Attribute: 0 (Hex)

Destination Element:

New Tag...

☐ Enable
 ☐ Enable Waiting
 ☐ Start
 ☒ Done
 Done Length: 0

☐ Error Code:
 Extended Error Code:
 ☐ Timed Out

Error Path:

Error Text:

OK Cancel Apply Help

Fig. 7.4.3.9 Write all registers

7.4.3.10 Write a block of registers

Figure 7.4.3.10(a) is message block configuration for writing 8 position registers of group 1 starting from register index 32 (0x20) in cartesian mode where “prwr” is an array of structure defined in Figure 7.4.3.1(b) to carry position data.

Message Configuration - posreg2

Configuration* Communication Tag

Message Type: CIP Generic

Service Type: Custom

Source Element: prwr

Source Length: 352 (Bytes)

Service Code: 33 (Hex) Class: 7b (Hex)

Instance: 2049 Attribute: 20 (Hex)

Destination Element:

New Tag...

☐ Enable
 ☐ Enable Waiting
 ☐ Start
 ☒ Done
 Done Length: 0

☐ Error Code:
 Extended Error Code:
 ☐ Timed Out

Error Path:

Error Text:

OK Cancel Apply Help

Fig. 7.4.3.10(a) Write a block of registers

Similarly a block of registers can be written to group #2 of robot. Figure 7.4.3.10(b) shows the message block configuration for writing 5 position registers of group #2 starting from register index 5 in joint mode. Instance 1282 is decimal equivalent of 0x0502, see Table 7.4.3.1(b) . Variable “prwr” is an array of structure defined in Figure 7.4.3.1(a) .

Fig. 7.4.3.10(b) Write a block of registers to group #2

7.5 VENDOR SPECIFIC ACTIVE ALARM OBJECT (0xA0)

Information about Active Alarms can be read through FANUC’s Active Alarm Object. Each instance of the object corresponds to an active alarm. For example, instance 1 corresponds to the most recent Active Alarm, and instance 5 corresponds to the 5th most recent Active Alarm.

7.5.1 Instance Attributes

Table 7.5.1 Instance attributes

Attribute ID	Name	Data Type	Description of Attribute
1	Alarm ID	16-bit integer	The Alarm ID, or Alarm Code.
2	Alarm Number	16-bit integer	The Alarm Number
3	Alarm ID Cause Code	16-bit integer	The Cause Code of the Alarm ID.
4	Alarm Num Cause Code	16-bit integer	The Cause Code of the Alarm Number.
5	Alarm Severity	16-bit integer	The Alarm Severity.
6	Time Stamp	32-bit integer	The Alarm Time Stamp in 32-bit MS-DOS format.
7	Date/Time String	24 character string	The Alarm Time Stamp in a human readable string.
8	Alarm Message	80 character string	The Alarm Message in a human readable string.
9	Cause Code Message	80 character string	The Alarm Cause Code Message in a human readable string.

Attribute ID	Name	Data Type	Description of Attribute
10	Alarm Severity String	24 character string	The Alarm Severity in a human readable string.

7.5.2 Common Services

FANUC's Active Alarm Object provides the following Common Services at the Instance level. No Class level services are provided. Refer to Table 7.5.2 .

Table 7.5.2 Common services

Service Code	Service Name	Description of Service
0E hex	Get_Attribute_Single	Returns the content of the specified attribute.
01 hex	Get_Attribute_All	Returns a listing of the object's attributes (See the Get_Attribute_All definition below).

7.5.2.1 Get_Attribute_All Response

At the Instance level, the attributes are returned in the order shown in Table 7.5.2.1 using little-endian byte-swapping for 16-bit and 32-bit integers.

Table 7.5.2.1 Get_Attribute_All responses

32-bit integer	Byte 0	Byte 1	Byte 2	Byte 3
1	Alarm ID		Alarm Number	
2	Alarm ID Cause Code		Alarm Num Cause Code	
3	Alarm Severity		PAD (All Zeros)	
4	Time Stamp			
5	Date/Time String (24 bytes)			
...	...			
11	Alarm Message (80 bytes)			
...	...			
31	Cause Code Message (80 bytes)			
...	...			
51	Alarm Severity String (24 bytes)			
...	...			

7.5.3 Errors

FANUC's Vendor Specific Active Alarm Object will return the errors shown in Table 7.5.3 .

Table 7.5.3 Errors

Error Status	Error Description
Undefined Attribute (0x14)	Returned when the Alarm Attribute requested does not exist.
Unsupported Service (0x08)	Returned when the requested service is unsupported.
Undefined Class Instance (0x05)	Returned when the requested instance number does not exist. For example, if there is only 1 single active alarm, requesting the Active Alarm Object instance 2 will cause this error to be returned.

7.5.4 Examples

7.5.4.1 Read most recent active alarm cause code

To read the most recent active alarm's cause code from the controller, the explicit message client would be configured with the values shown in Table 7.5.4.1 .

Table 7.5.4.1 Read most recent active alarm cause code

Class	0xA0
Instance	0x01
Attribute	0x03
Service	0x0E

The explicit message server on the robot controller would return the cause code to the client as a 16-bit integer.

7.5.4.2 Read all alarm information from the second most recent active alarm

To read all alarm information about the second most recent active alarm from the controller, the explicit message client would be configured with the values shown in Table 7.5.4.2 .

Table 7.5.4.2 Read all alarm information from the second most recent active alarm

Class	0xA0
Instance	0x02
Attribute	Not Required
Service	0x01

The explicit message server on the robot controller would return all Registers as described in Section 7.5.2.1 .

7.6 VENDOC SPECIFIC ALARM HISTORY OBJECT (0xA1)

Information about the Alarm History can be read through FANUC's Alarm History Object. Each instance of the object corresponds to an alarm in the history. For example, instance 1 corresponds to the most recent Alarm in the alarm history, and instance 5 corresponds to the 5th most recent Alarm.

7.6.1 Instance Attributes

The instance attributes are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.1 .

7.6.2 Common Services

The common services are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.2 .

7.6.3 Errors

The errors are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.3 .

7.6.4 Examples

7.6.4.1 Read most recent alarm cause code

To read the most recent alarm's cause code from the controller, the explicit message client would be configured with the values shown in Table 7.6.4.1 .

Table 7.6.4.1 Read most recent alarm cause code

Class	0xA1
Instance	0x01
Attribute	0x03
Service	0x0E

The explicit message server on the robot controller would return the cause code to the client as a 16-bit integer.

7.6.4.2 Real all alarm information from the second most recent alarm

To read all alarm information about the second most recent alarm from the controller, the explicit message client would be configured with the values shown in Table 7.6.4.2 .

Table 7.6.4.2 Real all alarm information from the second most recent alarm

Class	0xA1
Instance	0x02
Attribute	Not Required
Service	0x01

The explicit message server on the robot controller would return all Registers as described in Section 7.5.2.1 .

7.7 VENDOR SPECIFIC MOTION ALARM OBJECT (0xA2)

Information about Motion Alarms can be read through FANUC's Motion Alarm Object. Each instance of the object corresponds to a motion alarm. For example, instance 1 corresponds to the most recent motion alarm, and instance 5 corresponds to the 5th most recent motion alarm.

7.7.1 Instance Attributes

The instance attributes are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.1 .

7.7.2 Common Services

The common services are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in section Section 7.5.2 .

7.7.3 Errors

The errors are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.3 .

7.7.4 Examples

7.7.4.1 Read most recent motion alarm cause code

To read the most recent motion alarm's cause code from the controller, the explicit message client would be configured with the values shown in Table 7.7.4.1 .

Table 7.7.4.1 Read most recent motion alarm cause code

Class	0xA2
Instance	0x01
Attribute	0x03
Service	0x0E

The explicit message server on the robot controller would return the cause code to the client as a 16-bit integer.

7.7.4.2 Read all alarm information from the second most recent motion alarm

To read all alarm information about the second most recent motion alarm from the controller, the explicit message client would be configured with the values shown in Table 7.7.4.2 .

Table 7.7.4.2 Read all alarm information from the second most recent motion alarm

Class	0xA2
Instance	0x02
Attribute	Not Required
Service	0x01

The explicit message server on the robot controller would return all Registers as described in Section 7.5.2.1 .

7.8 VENDOR SPECIFIC SYSTEM ALARM OBJECT (0xA3)

Information about System Alarms can be read through FANUC's System Alarm Object. Each instance of the object corresponds to a system alarm. For example, instance 1 corresponds to the most recent system alarm, and instance 5 corresponds to the 5th most recent system alarm.

7.8.1 Instance Attributes

The instance attributes are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.1 .

7.8.2 Common Services

The common services are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.2 .

7.8.3 Errors

The errors are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.3 .

7.8.4 Examples

7.8.4.1 Read most recent system alarm cause code

To read the most recent system alarm's cause code from the controller, the explicit message client would be configured with the following values:

Table 7.8.4.1 Read most recent system alarm cause code

Class	0xA3
Instance	0x01
Attribute	0x03
Service	0x0E

The explicit message server on the robot controller would return the cause code to the client as a 16-bit integer.

7.8.4.2 Read all alarm information from the second most recent system alarm

To read all alarm information about the second most recent system alarm from the controller, the explicit message client would be configured with the following values:

Table 7.8.4.2 Read all alarm information from the second most recent system alarm

Class	0xA3
Instance	0x02
Attribute	Not Required
Service	0x01

The explicit message server on the robot controller would return all Registers as described in Section 7.5.2.1 .

7.9 VENDOR SPECIFIC APPLICATION ALARM OBJECT (0xA4)

Information about Application Alarms can be read through FANUC's Application Alarm Object. Each instance of the object corresponds to an application alarm. For example, instance 1 corresponds to the most recent application alarm, and instance 5 corresponds to the 5th most recent application alarm.

7.9.1 Instance Attributes

The instance attributes are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.1 .

7.9.2 Common Services

The common services are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.2 .

7.9.3 Errors

The errors are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.3 .

7.9.4 Examples

7.9.4.1 Read most recent application alarm cause code

To read the most recent alarm's cause code from the controller, the explicit message client would be configured with the values shown in Table 7.9.4.1 .

Table 7.9.4.1 Read most recent application alarm cause code

Class	0xA4
Instance	0x01
Attribute	0x03
Service	0x0E

The explicit message server on the robot controller would return the cause code to the client as a 16-bit integer.

7.9.4.2 Read all alarm information from the second most recent application alarm

To read all alarm information about the second most recent application alarm from the controller, the explicit message client would be configured with the values shown in Table 7.9.4.2 .

Table 7.9.4.2 Read all alarm information from the second most recent application alarm

Class	0xA4
Instance	0x02
Attribute	Not Required
Service	0x01

The explicit message server on the robot controller would return all Registers as described in Section 7.5.2.1 .

7.10 VENDOR SPECIFIC RECOVERY ALARM OBJECT (0xA5)

Information about Recovery Alarms can be read through FANUC's Recovery Alarm Object. Each instance of the object corresponds to a recovery alarm. For example, instance 1 corresponds to the most recent recovery alarm, and instance 5 corresponds to the 5th most recent recovery alarm.

7.10.1 Instance Attributes

The instance attributes are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.1 .

7.10.2 Common Services

The common services are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.2 .

7.10.3 Errors

The errors are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.3 .

7.10.4 Examples

7.10.4.1 Read most recent recovery alarm cause code

To read the most recent recovery alarm's cause code from the controller, the explicit message client would be configured with the values shown in Table 7.10.4.1 .

Table 7.10.4.1 Read most recent recovery alarm cause code

Class	0xA5
Instance	0x01
Attribute	0x03
Service	0x0E

The explicit message server on the robot controller would return the cause code to the client as a 16-bit integer.

7.10.4.2 Read all alarm information from the second most recent recovery alarm

To read all alarm information about the second most recent recovery alarm from the controller, the explicit message client would be configured with the values shown in Table 7.10.4.2 .

Table 7.10.4.2 Read all alarm information from the second most recent recovery alarm

Class	0xA5
Instance	0x02
Attribute	Not Required
Service	0x01

The explicit message server on the robot controller would return all Registers as described in Section 7.5.2.1 .

7.11 VENDOR SPECIFIC COMMUNICATIONS ALARM OBJECT (0xA6)

Information about Communications Alarms can be read through FANUC's Communications Alarm Object. Each instance of the object corresponds to a communications alarm. For example, instance 1 corresponds to the most recent communications alarm and instance 5 corresponds to the 5th most recent communications alarm.

7.11.1 Instance Attributes

The instance attributes are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.1 .

7.11.2 Common Services

The common services are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.2 .

7.11.3 Errors

The errors are identical to those of FANUC's Active Alarm Object (0xA0) and are documented in Section 7.5.3 .

7.11.4 Examples

7.11.4.1 Read most recent communication alarm cause code

To read the most recent alarm's cause code from the controller, the explicit message client would be configured with the values shown in Table 7.11.4.1 .

Table 7.11.4.1 Read most recent communication alarm cause code

Class	0xA6
Instance	0x01
Attribute	0x03
Service	0x0E

The explicit message server on the robot controller would return the cause code to the client as a 16-bit integer.

7.11.4.2 Read all alarm information from the second most recent communications alarm

To read the second most recent alarm's cause code from the controller, the explicit message client would be configured with the values shown in Table 7.11.4.2 .

Table 7.11.4.2 Read all alarm information from the second most recent communications alarm

Class	0xA6
Instance	0x02
Attribute	Not Required
Service	0x0E

The explicit message server on the robot controller would return all Registers as described in Section 7.5.2.1 .

7.12 ACCESSING I/O USING EXPLICIT MESSAGING

7.12.1 Accessing I/O Specific to an Implicit EtherNet/IP Connection

I/O can be accessed through ODVA's standard Assembly Object. Table 7.12.1(a) describes the Assembly Instance numbers that can be used to read or write I/O specific to an Implicit EtherNet/IP connection configured on a FANUC robot controller.

NOTE

I/O can not be written to the writable assembly instances using explicit messaging while an active implicit connection to the instance is running.

Detailed instructions for mapping I/O on the robot controller can be found in Section 6.2 of this manual.

Table 7.12.1(a) Accessing I/O

Instance Number	Read/Write	Input/Output	Slot
101	r	output	1
102	r	output	2
103	r	output	3
104	r	output	4
105	r	output	5
106	r	output	6
107	r	output	7
108	r	output	8
109	r	output	9
110	r	output	10
111	r	output	11
112	r	output	12
113	r	output	13
114	r	output	14
115	r	output	15
116	r	output	16
117	r	output	17
118	r	output	18
119	r	output	19
120	r	output	20
121	r	output	21
122	r	output	22
123	r	output	23
124	r	output	24
125	r	output	25
126	r	output	26
127	r	output	27
128	r	output	28
129	r	output	29
130	r	output	30
131	r	output	31

Instance Number	Read/Write	Input/Output	Slot
132	r	output	32
151	r/w*	input	1
152	r/w*	input	2
153	r/w*	input	3
154	r/w*	input	4
155	r/w*	input	5
156	r/w*	input	6
157	r/w*	input	7
158	r/w*	input	8
159	r/w*	input	9
160	r/w*	input	10
161	r/w*	input	11
162	r/w*	input	12
163	r/w*	input	13
164	r/w*	input	14
165	r/w*	input	15
166	r/w*	input	16
167	r/w*	input	17
168	r/w*	input	18
169	r/w*	input	19
170	r/w*	input	20
171	r/w*	input	21
172	r/w*	input	22
173	r/w*	input	23
174	r/w*	input	24
175	r/w*	input	25
176	r/w*	input	26
177	r/w*	input	27
178	r/w*	input	28
179	r/w*	input	29
180	r/w*	input	30
181	r/w*	input	31
182	r/w*	input	32

* Only instances corresponding to Adapter connections are writable using Explicit Messaging; however, these instances will not be writable while an active implicit connection to the instance is running. If the corresponding connection is a Scanner connection, then the instance will be read-only.

For example, suppose the controller is configured with one Adapter connection on slot 1 with a 16-bit word of input and a 16-bit word of output, which are mapped to DI[1-16] and to DO[1-16] respectively.

Once an implicit connection is established to the adapter, the output values in DO[1-16] can be accessed through explicit messaging with the values shown in Table 7.12.1(b) .

Table 7.12.1(b) Output values

Class	0x04
Instance	0x65
Attribute	0x03
Service	0x0E

And the input values in DI[1-16] can be accessed through explicit messaging with the values Table 7.12.1(c) .

Table 7.12.1(c) Input values

Class	0x04
Instance	0x97
Attribute	0x03
Service	0x0E

7.12.2 Accessing General I/O

In addition to I/O mapped from EtherNet/IP connections, other types of I/O can be read with explicit messaging using the following Assembly Object Instance numbers.

Table 7.12.2(a) Accessing general I/O

I/O Type	Instance Number (hexadecimal)
Digital input	0x320
Digital output	0x321
Analog input	0x322
Analog output	0x323
Tool output	0x324
PLC input	0x325
PLC output	0x326
Robot digital input	0x327
Robot digital output	0x328
Brake output	0x329
Operator panel input	0x32a
Operator panel output	0x32b
Teach pendant digital input	0x32d
Teach pendant digital output	0x32e
Weld input	0x32f
Weld output	0x330
Group input	0x331
Group output	0x332

I/O Type	Instance Number (hexadecimal)
User operator panel input	0x333
User operator panel output	0x334
Laser DIN	0x335
Laser DOUT	0x336
Laser AIN	0x337
Laser AOUT	0x338
Weld stick input	0x339
Weld stick output	0x33a
Memory image boolean	0x33b
Memory image DIN	0x33c
Dummy boolean port type	0x33d
Dummy numeric port type	0x33e
Process axes (ISDT)	0x33f
Internal operator panel input	0x340
Internal operator panel output	0x341
Flag (F[])	0x342
Marker (M[])	0x343

For example, the values shown in Table 7.12.2(b) would access all Digital Outputs (DOs) with explicit messaging.

Table 7.12.2(b) Accessing digital outputs

Class	0x04
Instance	0x321
Attribute	0x03
Service	0x0E

7.13 USING EXPLICIT MESSAGING IN RSLogix 5000

This section steps through an example of how to configure an I/O read and write operation on a robot controller using RSLogix5000. In this example, an I/O read and write is done on Rack 89 Slot 1 of the robot controller every 1000ms.

Three rungs are created in our main program. The first rung is a timer rung. This timer, mtime, will trigger read and write messages to be sent to the robot controller every 1000ms. The next two rungs have MSG blocks, where the individual Explicit Messages will be defined. Figure 7.13(a) shows the three rungs.

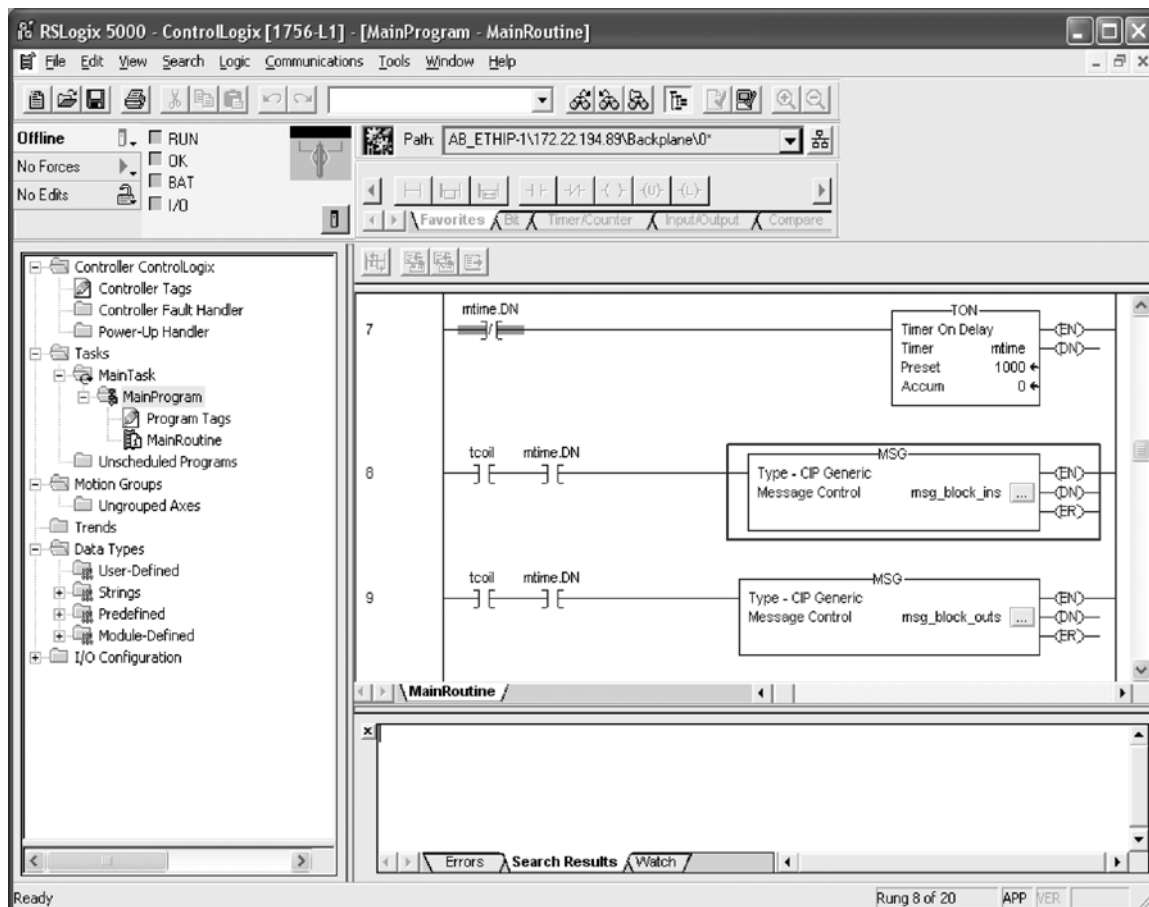


Fig. 7.13(a) RsLogix 5000 example rungs

NOTE

We have created the element tcoil to turn the sending of the two Explicit Messages on and off.

To add a message block, you will need to add a MSG ladder element. Figure 7.13(b) shows an example of adding a MSG ladder element.

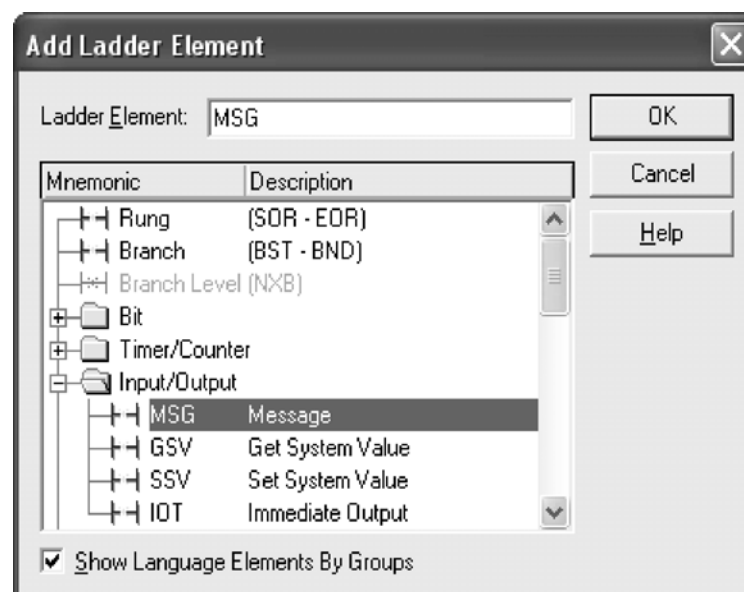


Fig. 7.13(b) RSLogix 5000 add MSG block

Configuration of the message block requires the Class, Instance, Attribute, and Service values as discussed in Section 7.3 of this manual. For example, to read the robot controller outputs at Rack 89 Slot 1, we would access the Assembly Class (0x04), Attribute 3 (0x03), Instance 101 (0x65), and Service Get_Attribute_Single (0x0e). See Section 7.12 for more details.

Thus, once configured, the MSG block should look similar to Figure 7.13(c) . You will need to create a destination for the robot controller outputs to be read into. In this example, we created an array named robot_douts.

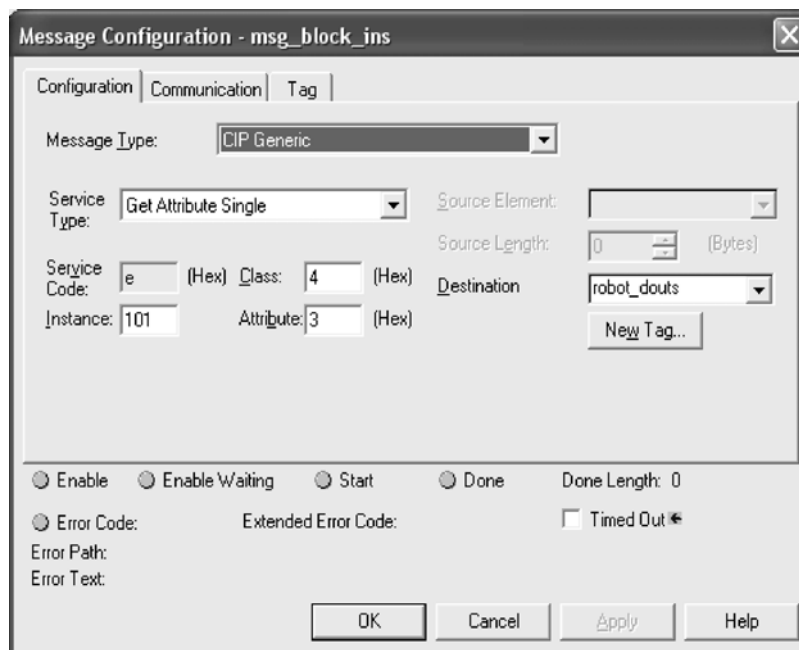


Fig. 7.13(c) MSG block: read robot DOUTs

Next, click on the Communications tab. From this tab you should be able to browse to the device to which you want to connect. In Figure 7.13(d) , we browsed to and are connecting to a device named pderob224. Note that the robot controller must already be configured in RSLogix5000's I/O Configuration for the Browse button to successfully find the robot.

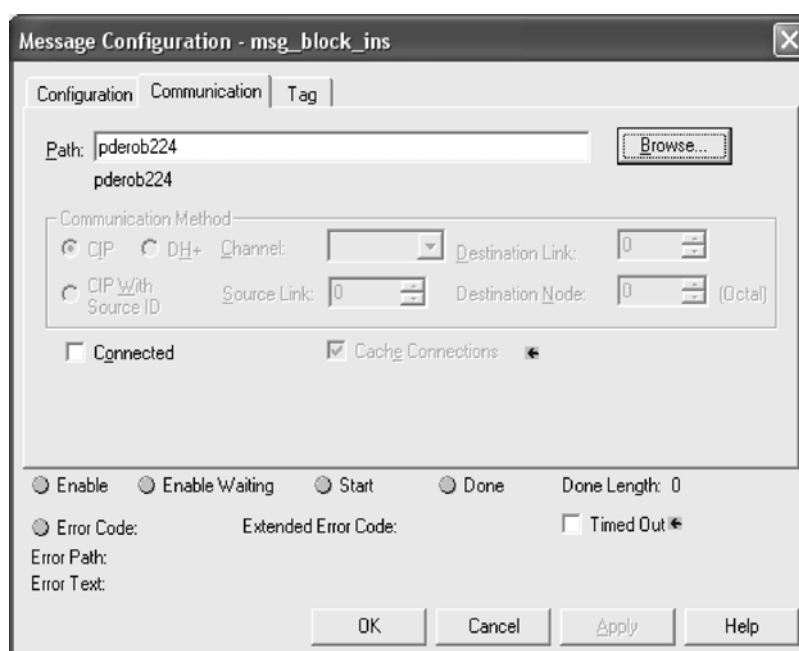


Fig. 7.13(d) MSG block communication tab

Documentation for RSLogix5000 also provides two additional ways of expressing the Path. First, the path can be an expression of comma-separated values that indicate the route for the MSG starting at the Ethernet module on the PLC and ending at the target device. For example “ENET,2,192.168.1.224” would be a path from the ENET module, port 2 on the ENET module (this value should always be 2), to the IP address of the robot controller.

Secondly, the same path could be expressed as “1,2,2,192.168.1.224”. Where the 1 represents the slot number of the processor in the rack, and the 2 in the second position represents the slot number of the ENET module. The 2 in the third position would represent port two on the ENET module, and the fourth position contains the IP address of the robot.

Figure 7.13(e) shows the MSG block used to write to the robot controller’s inputs. In this case we use Class 0x04, Instance 151 (0x97), Attribute 0x03, and Service Set_Attribute_Single (0x10). We also created the array robot_dins to write to the robot controller.

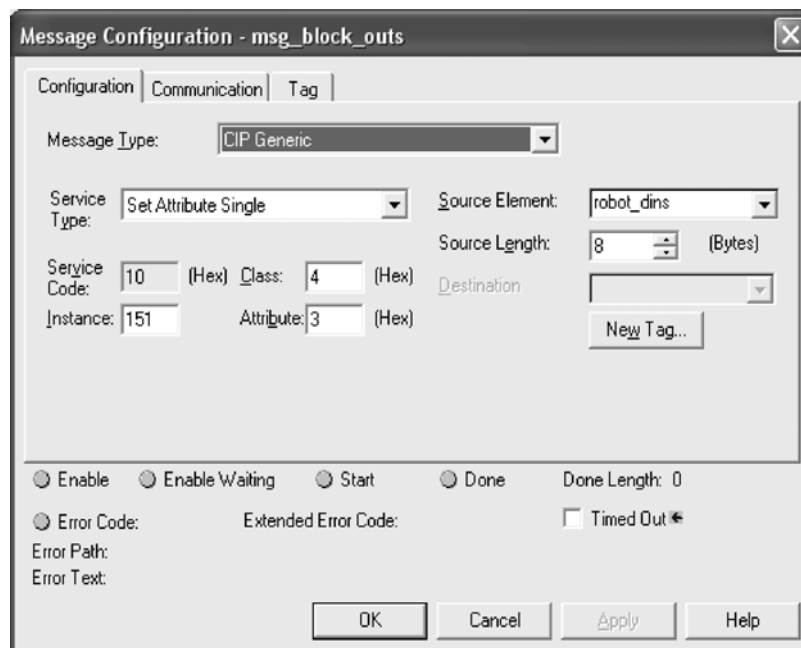


Fig. 7.13(e) MSG block: write robot DINs

8 NETWORK DESIGN AND PERFORMANCE

8.1 NETWORK DESIGN CONSIDERATIONS

Good network design is critical for reliable operation. It is important to pay special attention to wiring guidelines and environmental conditions affecting the cable system and equipment. It is also necessary to control network traffic to avoid wasted network bandwidth and device resources.

Keep in mind the following wiring guidelines and environmental considerations:

- Use category 5 twisted pair (or better) rated for 100-BaseTX Ethernet applications and the application environment. Consider shielded versus unshielded twisted pair cabling.
- Pay careful attention to wiring guidelines such as maximum length from the switch to the device (100 meters).
- Do not exceed recommended bending radius of specific cabling being used.
- Use connectors appropriate to the environment. There are various industrial Ethernet connectors in addition to the standard open RJ45 that should be used where applicable. For example, connectors are available with IP65 or IP67 ratings. M12 4-pin D-coded Connectors are included in the Ethernet/IP specification.
- Route the wire runs away from electrical or magnetic interference or cross at ninety degrees to minimize induced noise on the Ethernet network.

Keep the following in mind as you manage network traffic:

- Control or eliminate collisions by limiting the collision domain.
- Control broadcast traffic by limiting the broadcast domain.
- Control multicast traffic with multicast aware switches (support for IGMP snooping).
- Use QOS (Quality of Service) techniques in very demanding applications.

Collisions are a traditional concern on an Ethernet network but can be completely avoided by using switches—rather than hubs—and full duplex connections. It is critical to use switches and full duplex connections for any Ethernet I/O network, because it reduces the collision domain to only one device so that no collisions will occur. The robot interface will autonegotiate by default and use the fastest connection possible. Normally this is 100Mbps and full duplex. The robot can be set for a specific connection speed and duplex. However be very careful that both ends of the connection use the same speed and duplex mode. Be careful not to set one end of a connection for autonegotiate and set the other end to a specific speed duplex – both ends must autonegotiate, or both ends must be fixed to the same settings.

The LEDs near the RJ45 connector on the robot will confirm a connection link. Link State can be confirmed using the TCP/IP status Host Comm screen by following Procedure 8-1 .

Procedure 8-1 Verifying Link State

1. Press MENU.
2. Select Setup.
3. Press [F1] TYPE and select Host Comm.
4. Select TCP/IP.
5. Toggle to the correct port (port #1 or port #2) by pressing [F3] PORT.
6. Press NEXT, then [F2] STATUS.

Broadcast traffic is traffic that all nodes on the subnet must listen for and in some cases respond to. Excessive broadcast traffic wastes network bandwidth and wastes resources in all effected nodes. The broadcast domain is the range of devices (typically the entire subnet) that must listen to all broadcasts. It is recommended to limit the broadcast domain to only the control devices (for example, EtherNet/IP nodes) by using a separate subnet for the control equipment or by using VLANs (virtual LANs) supported

by some higher end switches. If the EtherNet/IP network is completely isolated as a separate control network this is not a concern. However, when connecting into larger networks this becomes important. Some network environments have a significant amount of multicast traffic. A basic layer 2 switch will treat multicast traffic like broadcast traffic and forward to all ports in the switch wasting network bandwidth and node resources on traffic which is ultimately dropped for the nodes that are not interested in the multicast traffic. Switches that support “IGMP snooping” will selectively send multicast traffic only to the nodes which have joined a particular group. EtherNet/IP UDP packet has a TTL (time to link) value of one. You will not be able to route I/O traffic across more than one switch.

Quality of Service (QOS) techniques provide mechanisms to prioritize network traffic. Generally on an Ethernet network all packets are equal. Packets can be dropped or delayed within network infrastructure equipment (for example, switches) in the presence of excessive traffic. Which packets are dropped or delayed is random.

QOS is a term covering several different approaches to prioritizing packets including:

- MAC layer (layer 2) prioritization (IEEE 802.1p).
- IP layer (layer 3) prioritization using source/destination IP addresses.
- Transport layer (layer 4) prioritization using source/destination ports.

These QOS mechanisms are generally implemented within the network infrastructure equipment and are beyond the scope of this manual. Some form of QOS should be considered on complex networks requiring the highest possible level of determinism in I/O exchanges within the control network.

It is important to select the proper switch in order for the network to function correctly. The switch should support :

- 100 Mbps baud rate
- Full duplex connections
- Port auto-negotiation
- Environmental specifications appropriate for the application (for example, temperature)
- Power supply requirements and redundancy (for example, support for 24vdc or 120vac and support for a second redundant power supply if warranted)

NOTE

If there is a significant amount of multicast traffic, the switch should support IGMP snooping (multicast aware). Please consider this when Ethernet/IP and/or RIPE (robot ring) traffic exists.

NOTE

If the control network will be part of a larger network, the control network should be on a separate VLAN or subnet. This can be done within the control switch or possibly based on how the larger network connects to the control switch.

Some examples of switch products are:

- Cisco 2955 (industrialized version of 2950) – www.cisco.com
- Hirschmann MICE (modular industrial switch) – www.hirschmann.de
- Phoenix Contact (managed/unmanaged industrial switch) – www.ethernetrail.com
- N-Tron 508TX-A, 8 port industrial switch with advanced firmware – www.n-tron.com

8.2 I/O RESPONSE TIME

The system response time is the amount of time it takes an I/O signal to propagate through the system to its destination and back again. For a Controller -to- PLC system this time would be from the time an output is sent to the time a modified input is read. The system response time depends on many factors including:

- The Actual Packet Interval (API is based on RPI)
- PLC Ladder Scan Time
- No lost or delayed packets due to excessive traffic or noise

To calculate the response time, keep in mind that the response time is asynchronous but has a deterministic upper limit. After a signal is set in the I/O Image, it will take a maximum of one API before it gets transmitted to any node on the network.

Figure 8.2 shows a case where a DO is transferred to a PLC and back as a DI. In this case, after the DO is set in the I/O Image, it will take a maximum of one API, $t(\text{api})$, to get the DO to the Ethernet transceiver. After the DO is in the Ethernet transceiver, it is sent to the destination (PLC) at wire speed, $t(\text{wire})$ (assumes full duplex link so no collisions).

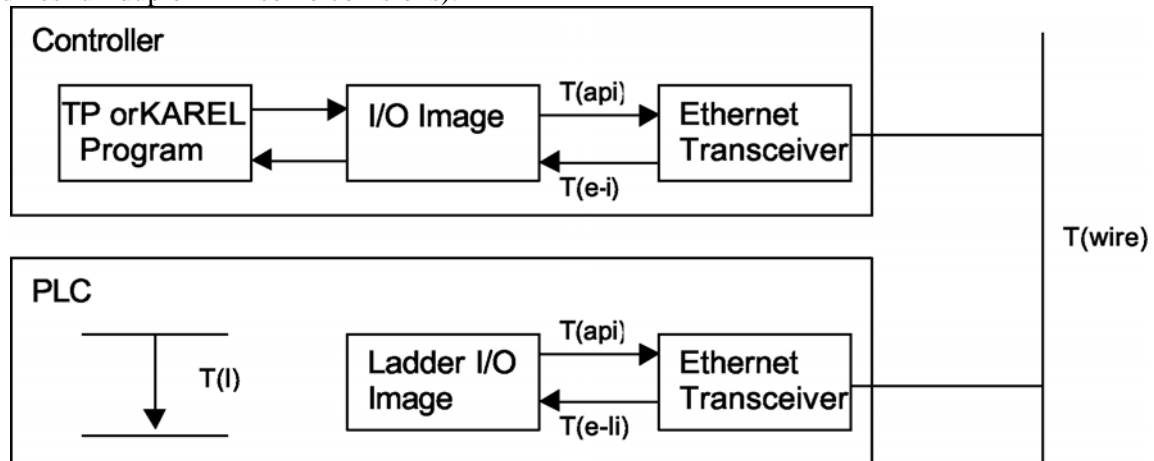


Fig. 8.2 EtherNet/IP response time diagram

In the PLC, the inputs are scanned into the Ladder I/O Image, which fixes them for the entire Ladder Scan, $t(\text{e-li})$. The inputs are processed during the ladder scan $t(\text{l})$ and then set back to the PLC's Ethernet transceiver at its API rate.

The PLC outputs are transferred at Ethernet wire speed back to the controller. They are then transferred to the I/O Image $t(\text{e-i})$ where they can be read by the KAREL or teach pendant program.

$$T(\text{Controller} \rightarrow \text{PLC} \rightarrow \text{Controller}) = t(\text{api}) + t(\text{wire}) + t(\text{e-li}) + t(\text{l}) + t(\text{api}) + t(\text{wire}) + t(\text{e-i})$$

- $t(\text{api})$ = KAREL or teach pendant outputs get immediately set in the I/O Image. The time necessary to get to them to Ethernet transceiver can be a maximum of one API. In this example it is assumed robot->plc API and plc->robot API values are the same.
- $t(\text{wire})$ = The time it takes for the packet to traverse the network including any switch delays due to queueing.
- $t(\text{e-l i})$ = After the signal is in the PLC Ethernet transceiver, it must get processed through the PLC network stack and placed in an appropriate ladder image data file to be accessed by the PLC Ladder.
- $t(\text{l})$ = The input value needs to be fixed for the entire scan in the ladder. The PLC Scan can usually be obtained by examining an appropriate status register in the PLC. After the signal has been processed, the reverse process must take place.
- $T(\text{e-i})$ = After the signal is in the robot Ethernet transceiver, it must get processed through the robot network stack and placed in I/O image area to be accessed by the TP or Karel program.

For example, using V7.10 or higher and a ControlLogix PLC over a simple network with a 20ms API, the following times were calculated. This example assumes wire time is negligible (100Mbps network, no switch delays), input packets are processed through the network stack and into image area within 1ms, and ladder scan time is 5ms.

$$T(\text{Controller} \rightarrow \text{PLC} \rightarrow \text{Controller}) = t(\text{api}) + t(\text{wire}) + t(\text{e-li}) + t(\text{l}) + t(\text{api}) + t(\text{wire}) + t(\text{e-i})$$

$T(\text{Controller} - \text{to} - \text{PLC} - \text{to} - \text{Controller}) = 20\text{ms} + 0\text{ms} + 1\text{ms} + 5\text{ms} + 20\text{ms} + 0\text{ms} + 1\text{ms}$
--

$T(\text{Controller} - \text{to} - \text{PLC} - \text{to} - \text{Controller}) = 47\text{ms} \quad ***$

*** This value assumes no delayed/lost packets due to excessive traffic or noise.

Your actual PLC ladder scan times might vary from the example. Most PLCs offer the capability to get the actual scan time from a programmer or monitor.

This example assumes the packet is not delayed or dropped in a network switch or at the source/destination node. Packets can be dropped due to the following reasons:

- Excessive traffic can cause queue delays or dropped packets in the switch or source/destination nodes depending on extent of traffic and queue sizes.
- Packet corruption due to noise can cause a bad CRC check on the packet (a packet with a bad CRC is dropped).

The maximum upper limit is based on EtherNet/IP timeout values. Timeouts will occur when a consumer does not receive data from a producer within a multiple of the API. Typically this timeout value is 3-4 times the API value. If a timeout occurs, an error is posted. The error severity and last state I/O behavior can be configured. Refer to Section 3.2.3 for adapter.

9 DIAGNOSTICS AND TROUBLESHOOTING

9.1 VERIFYING NETWORK CONNECTIONS

There are two basic tools for verifying network connections:

- Ethernet status LEDs
- PING

The LEDs and PING utility are basic tools but they give a good indication of whether or not devices are able to communicate on the network. If the LINK LED is off, or if PING times out, then no other network functionality will work for that device.

Refer to Section 9.1.1 for more information about Ethernet status LEDs.

Refer to Section 9.1.2 for more information about the PING utility.

9.1.1 Ethernet Status LEDs

The Ethernet status LEDs at the Ethernet RJ45 connector on the robot will indicate if the robot is connected. Most Ethernet switches and other equipment will have similar LEDs indicating a physical connection. If the LINK LED is off then there is no Ethernet connectivity at all. This generally implies a disconnected or bad cable or bad connections. The speed and duplex must match between the robot and the switch. The robot will auto-negotiate by default and should not be changed in most cases.

9.1.2 PING Utility

PING is a network utility that sends a request to a specific IP address and expects a response. The request is essentially "Can you hear me?" The destination node will send a response that it received the request. The requesting node will either receive the response or timeout. PING is a basic network utility that is included with most operating systems, such as Windows and Unix, and is also supported on the robot. Even devices that do not support generating PING requests (for example, an EtherNet/IP block with no user interface) will respond to the PING request.

The robot supports PING directly from the EtherNet/IP status screen. Use Procedure 9-1 .

The PING utility is also available on the robot to PING any name or IP address. Use Procedure 9-2 .

The PING utility is also available from any windows PC. Use Procedure 9-3 .

Procedure 9-1 Using PING from the EtherNet/IP Status Screen

Steps

1. Press MENU.
2. Select I/O.
3. Press F1, [TYPE].
4. Select EtherNet/IP.
5. Move the cursor to the connection with the device you want to PING.
6. Press F2, PING.

The prompt line on the teach pendant will indicate if the PING was successful or if the PING request timed out.

NOTE

This function only works on the adapter connection (connection #1) if there is a scanner connected.

Procedure 9-2 Using PING on the Robot

Steps

1. Press MENU.
2. Select Setup.
3. Press F1, [TYPE].
4. Select Host Comm.
5. Move the cursor to select PING in the Protocol List and press ENTER.
6. Enter the name or IP address of the node to PING.
7. Press F2, PING.
The prompt line on the teach pendant will indicate if the PING was successful or if the PING request timed out.

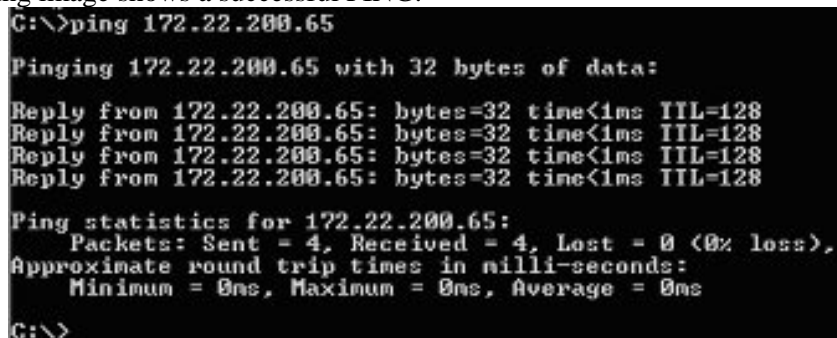
Procedure 9-3 Using PING on a Windows PC

Steps

1. Open a DOS command prompt.
2. Type the following command, replacing the IP address with the IP address you want to PING, and press ENTER.

```
PING 192.168.0.10
```

The following image shows a successful PING.



```
C:\>ping 172.22.200.65

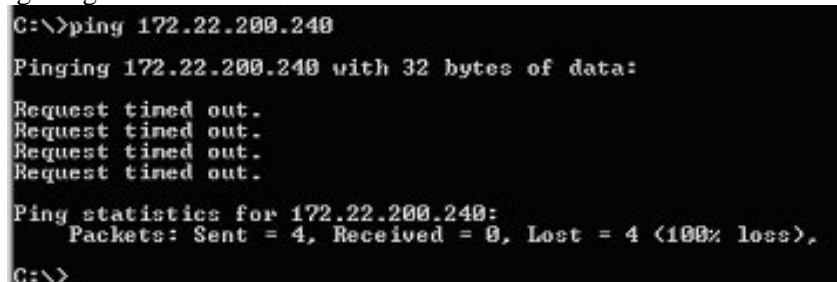
Pinging 172.22.200.65 with 32 bytes of data:

Reply from 172.22.200.65: bytes=32 time<1ms TTL=128
Reply from 172.22.200.65: bytes=32 time<1ms TTL=128
Reply from 172.22.200.65: bytes=32 time<1ms TTL=128
Reply from 172.22.200.65: bytes=32 time<1ms TTL=128

Ping statistics for 172.22.200.65:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>
```

The following image shows an unsuccessful PING.



```
C:\>ping 172.22.200.240

Pinging 172.22.200.240 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 172.22.200.240:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),

C:\>
```

If the LINK LED is on but a PING request fails it usually indicates a problem with IP address configuration. Either no IP address is configured, or the combination of IP address and subnet mask is inconsistent for the network.

9.2 ERROR CODES

The following error codes are defined by the EtherNet/IP January 2005 Specification. When a controller scanner connection fails when establishing a connection to a target device, the controller posts an error in the following format (PRIO-350 is the error code, and PRIO-358 is the cause code).

PRIO-350	EtherNet/IP Scanner Error (#)
PRIO-358	EtherNet/IP Fwd Open Fail (0x#)

The PRIO-350 code (#) specifies on which connection the error has occurred. The PRIO-358 code (0x#) specifies the **extended status** of the error returned by the target device (in hexadecimal format).

Table 9.2 lists the descriptions of the extended status error codes:

NOTE

EtherNet/IP alarms are documented in the R-30iA/R-30iA Mate controller ALARM CODE LIST operator's manual (B-83124EN-6) or R-30iB controller ALARM CODE LIST operator's manual (B-83284EN-1).

Table 9.2 Forward open failure error codes

GENERAL STATUS	EXTENDED STATUS	DESCRIPTION
0x01	0x0100	Connection in Use or Duplicate Forward Open
0x01	0x0103	Transport Class and Trigger combination not supported
0x01	0x0106	Ownership Conflict
0x01	0x0107	Connection not found at target application.
0x01	0x0108	Invalid Connection Type. Indicates a problem with either the Connection Type or Priority of the Connection
0x01	0x0109	Invalid Connection Size
0x01	0x0110	Device not configured
0x01	0x0111	RPI not supported. Might also indicate problem with connection timeout multiplier or production inhibit time.
0x01	0x0113	Connection Manager cannot support any more connections
0x01	0x0114	Either the Vendor Id or the Product Code in the key segment did not match the device
0x01	0x0115	Product Type in the key segment did not match the device
0x01	0x0116	Major or Minor Revision information in the key segment did not match the device
0x01	0x0117	Invalid Connection Point
0x01	0x0118	Invalid Configuration Format
0x01	0x0119	Connection request fails since there is no controlling connection currently open.
0x01	0x011A	Target Application cannot support any more connections

GENERAL STATUS	EXTENDED STATUS	DESCRIPTION
0x01	0x011B	RPI is smaller than the Production Inhibit Time.
0x01	0x0203	Connection cannot be closed since the connection has timed out
0x01	0x0204	Unconnected Send timed out waiting for a response.
0x01	0x0205	Parameter Error in Unconnected Send Service
0x01	0x0206	Message too large for Unconnected message service
0x01	0x0207	Unconnected acknowledge without reply
0x01	0x0301	No buffer memory available
0x01	0x0302	Network Bandwidth not available for data
0x01	0x0303	No screeners available
0x01	0x0304	Not Configured to send real-time data
0x01	0x0311	Port specified in Port Segment Not Available
0x01	0x0312	Link Address specified in Port Segment Not Available
0x01	0x0315	Invalid Segment Type or Segment Value in Path
0x01	0x0316	Error in close path
0x01	0x0317	Scheduling not specified
0x01	0x0318	Link Address to Self Invalid
0x01	0x0319	Resources on Secondary Unavailable
0x01	0x031A	Connection already established
0x01	0x031B	Direct connection already established
0x01	0x031C	Miscellaneous
0x01	0x031D	Redundant connection mismatch
0x01	0x031E	No more consumer resources available in the producing module
0x01	0x031F	No connection resources exist for target path
0x01	0x320 — 0x7FF	Vendor specific

APPENDIX

A THIRD-PARTY CONFIGURATION TOOLS

A.1 TOOLS OVERVIEW

Robot Scanner connections can be configured from the EtherNet/IP Interface screens, or from third party tools such as RSNetWorx for EtherNet/IP using the Connection Configuration Object (CCO). Certain devices require detailed configuration data, and can only be added to the robot scanlist by using offline tools such as an Allen Bradley Flex I/O block with attached modules. Other devices can be configured through both interfaces, such as another FANUC Robot, or an RJ-Lynx I/O block. To use the offline tools, an EDS file for each device is required.

It is recommended that either all scanlist configurations be done entirely from the teach pendant, or be done entirely from RSNetWorx for EtherNet/IP. In certain situations RSNetWorx for EtherNet/IP version 4.11 might delete scanlist entries configured through the teach pendant.

NOTE

TIP: Some third party tools cannot import scanlist configurations from the robot controller unless both the configured revision numbers (major and minor) exactly match the revision numbers in the EDS file that the third party tool had loaded for the corresponding device. To set the revision numbers, see Section 4.2.4 .

Procedure A-1 Configure the Robot Scanners Using RSNetworX for EtherNet/IP

Steps

1. From the EtherNet/IP Interface Status screen, create and configure the desired number of scanner connections. See Section 4.2.3 .
2. Perform a Controlled start.
3. Configure an AB_ETH driver in RSLinx. The configuration screen should be similar to the screen shown in Figure A.1(a) .

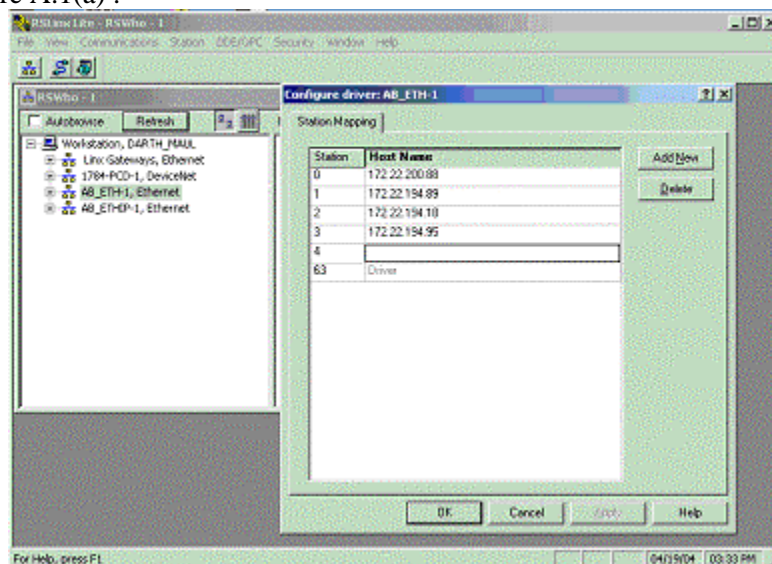


Fig. A.1(a) Configuring the driver

4. In RSNetWorx, under Tools, select the EDS Wizard and register the FANUC Robot EDS file.
5. Create an EtherNet/IP project in RSNetWorx that includes the devices configured in RSLinx.
6. Right click on the robot icon, and select Scanlist Configuration. You will see a screen similar to the one shown in Figure A.1(b)

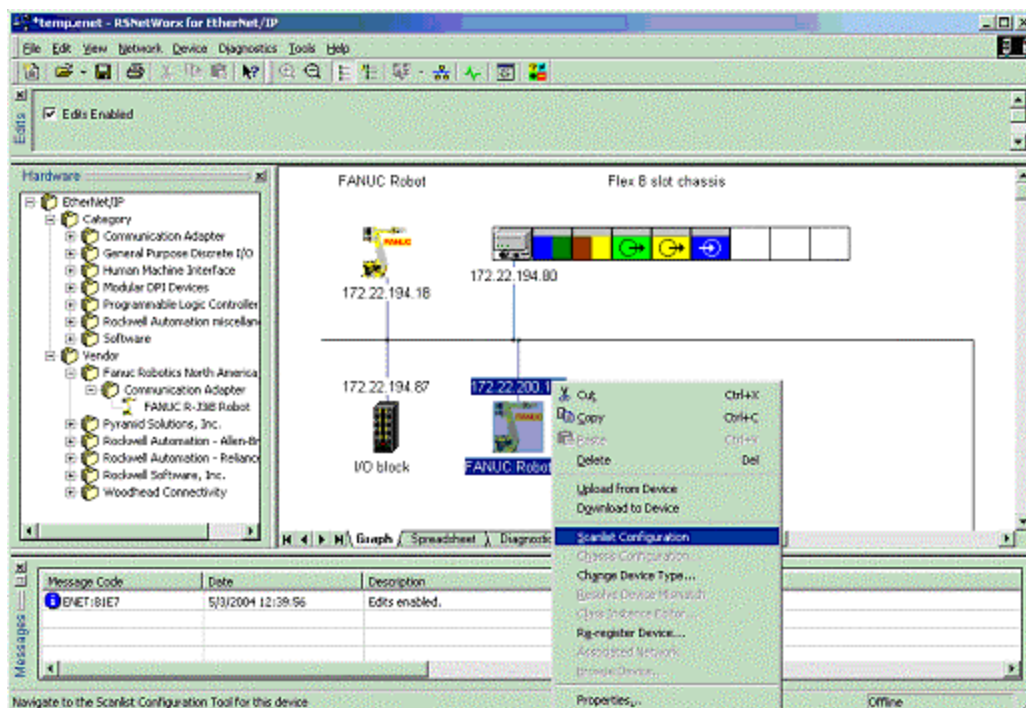


Fig. A.1(b) Scanlist configuration screen

7. A new window appears entitled "FANUC Robot – Scanlist Configuration". In this configuration window, right click over the device you want to add to the robot's scanlist, and select Insert Connection. See Figure A.1(c)

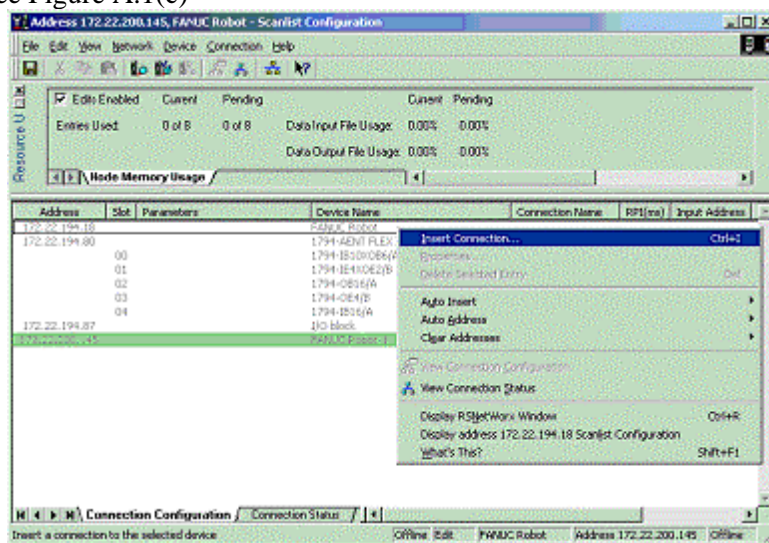


Fig. A.1(c) Insert connection screen

8. Configure the connection properties and click on OK. Pay specific attention to the selecting the appropriate Connection Name, Input Size, and Output Size. Other configurable values might include RPI, and Target to Scanner Transmission Mode. Note that the robot does not use values inserted for Input Address or Output Address. The screens below show a FANUC Robot being added to the scanlist of another FANUC Robot.

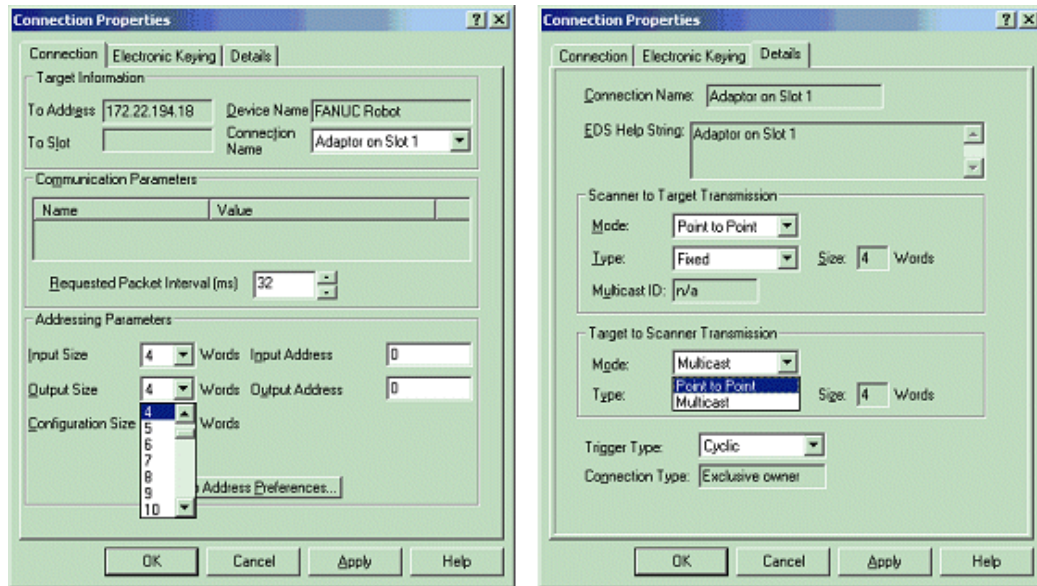


Fig. A.1(d) Adding a robot

9. In the Scanlist Configuration window, select Device/Download to Device.
10. When finished, Cold start the controller.

B KAREL PROGRAMS FOR ETHERNET/IP Scanner Quick Connect

B.1 OVERVIEW

The EtherNet/IP Scanner option installs the following KAREL programs:

- EN_OFFLN Allows a teach pendant program to turn an EtherNet/IP scanner connection off
- EN_ONLN Allows a teach pendant program to turn an EtherNet/IP scanner connection on
- EN_AROFF - Allows a teach pendant program to turn off auto-reconnect for an EtherNet/IP scanner connection.
- EN_ARON - Allows a teach pendant program to turn on auto-reconnect for an EtherNet/IP scanner connection.
- EN_STCHK - Allows a teach pendant program to check the status of an EtherNet/IP scanner connection.

B.2 KAREL PROGRAM DESCRIPTIONS AND PARAMETERS

The following are the KAREL program descriptions and parameters.

EN_OFFLN (INTEGER slot_number)

This program allows a teach pendant program to turn an EtherNet/IP scanner connection offline. This program takes the slot number as an argument. The valid values for a slot number are 1 through 32. For example, 1 corresponds to the EtherNet/IP Connection on slot 1, rack 89, or the first connection displayed on the EtherNet/IP Status Screen. There is no difference between this call and disabling the connection from the teach pendant.

EN_ONLN (INTEGER slot_number, INTEGER <wait_time>)

This program allows a teach pendant program to turn an EtherNet/IP scanner connection online. This program takes the slot number as an argument. The valid values for a slot number are 1 through 32. For example, 1 corresponds to the EtherNet/IP Connection on slot 1, rack 89, or the first connection displayed on the EtherNet/IP Status Screen. The optional argument, wait_time, is used as follows:

- **If wait_time is not used.** If wait_time is not explicitly specified (it is an optional argument), its value will be defaulted to 15 and EN_ONLN follows the: if wait_time is not 0 rule.
- **If wait_time is not 0.** The EtherNet/IP scanner connection will be enabled. Auto-reconnect will also be enabled, causing the scanner to attempt to make a connection to the adapter device every 2 seconds until successful. Note that EN_ONLN will block and will not return until a successful connection is made, or until the user aborts the teach pendant program. An alarm will be posted if wait_time seconds pass before a connection is established. After the alarm is posted and the robot faults, a reset/resume from either the PLC or teach pendant will restart/resume the program inside of the EN_ONLN call and the wait_time timer will be reset. Before EN_ONLN returns, auto-reconnect will set to its original state (its state before EN_ONLN was called).
- **If wait_time is used and set to 0.** Auto-reconnect will not be enabled--the user must explicitly enable Auto-reconnect if needed. The EtherNet/IP connection will be enabled and the call will return immediately (will not block). The application or user programs can then use EN_STCHK to check the status if it needs to confirm the status of the connection.

There is difference between this call and enabling the connection from the teach pendant. Call to this macro forces scanner device (if Quick Connect mode enabled) to wait for GRATUITOUS ARP packet from target device before starting the connection process.

EN_AROFF (INTEGER slot_number)

This program allows a teach pendant program to turn off auto-reconnect for an EtherNet/IP scanner connection. This program takes the slot number as an argument. The valid values for a slot number are 1 through 32. For example, 1 corresponds to the EtherNet/IP Connection on slot 1, rack 89, or the first connection displayed on the EtherNet/IP Status Screen.

There is no difference between this call and disabling auto-reconnect from the teach pendant.

EN_ARON (INTEGER slot_number)

This program allows a teach pendant program to turn on auto-reconnect for an EtherNet/IP scanner connection. This program takes the slot number as an argument. The valid values for a slot number are 1 through 32. For example, 1 corresponds to the EtherNet/IP Connection on slot 1, rack 89, or the first connection displayed on the EtherNet/IP Status Screen.

Enabling auto-reconnect has the following side effects. While enabled, all EtherNet/IP alarms relating to connection establishment and connection time-outs for this slot number will be masked (will not be posted). The EtherNet/IP scanner corresponding to the slot number will attempt to make a connection to the adapter device every 2 seconds until successful. Before each retry, the ARP cache in the TCP/IP stack will be flushed of the target IP address. Also, the status on the teach pendant will become encapsulated in < and > as in <STATUS>, for example.

There is no difference between this call and enabling auto-reconnect from the teach pendant.

EN_STCHK (INTEGER slot_number, INTEGER register_number)

This program allows a teach pendant program to check the status of an EtherNet/IP connection. This program takes the slot number, and register_number as arguments. The valid values for a slot number are 1 through 32. For example, 1 corresponds to the EtherNet/IP Connection on slot 1, rack 89, or the first connection displayed on the EtherNet/IP Status Screen. The possible status values returned in the register_number are:

- 0 Offline
- 1 Error
- 2 Pending
- 3 Enabled but not connected or trying to connection
- 4 Enabled but not connected. Is trying to connect.
- 5 Online and connected but I/O is not being received from adapter
- 6 Online and I/O is being exchanged

NOTE

When a connection is taken offline, if a background application were to access I/O belonging to that connection, an unassigned port alarm would be posted. This should be taken into consideration by the teach pendant programmer when using the EN_OFFLN program.

B.3 USING KAREL PROGRAMS IN TEACH PENDANT PROGRAMS

Procedure B-1 shows how to use the EN_STCHK KAREL program. The other programs listed in this section can be used in the same way.

Procedure B-1 Placing the Call to the KAREL Program in the Teach Pendant Program

1. Press SELECT.
2. Display the appropriate list of programs. If F1, [TYPE], is not displayed on the screen, press >, NEXT, until it is displayed.
 - a. Press F1, [TYPE].
 - b. Select the list you want:

3. Move the cursor to the name of the program you want to modify and press ENTER.
 4. Turn the teach pendant ON/OFF switch to ON.
 5. Select F4, [INST].
 6. Select Call from the list of options that appear at the top of the screen.
 7. Select Call Program and press ENTER.
 8. Press F3, [KAREL] to display the available KAREL programs at the top of the screen.
 9. Select EN_STCHK and press ENTER.
 10. Place the cursor to the right of the word EN_STCHK.
 11. Press F4, [CHOICE].
 12. Select Constant from the list at the top of the screen and press ENTER.
 13. Type the Slot Number and press ENTER.
 14. Press F4, [CHOICE].
 15. Select Constant from the list at the top of the screen and press ENTER.
 16. Type the Register Number for the result of the device status check and press ENTER.
- The finished line in the teach pendant program should look like the following:

```
CALL EN_STCHK ( 2 , 50 )
```

NOTE

50 is the register number for result (R[50]).

B.4 EXAMPLES USING ETHERNET/IP MACROS

B.4.1 Overview

Generally, EtherNet/IP macros are used to support tool change applications. The following examples demonstrate using Auto-Reconnect and connection Offline/Online macros in tool changing applications. The connection offline/online macros are similar to manually taking the connection offline or online in the teach pendant screens but are called programmatically through a teach pendant program.

A single EtherNet/IP scanner connection can be used to connect to different types of I/O blocks (different electronic keying) that may be used on the various tools if the I/O sizes for these blocks are the same. In these cases, the electronic keying parameters must be set to 0 in the corresponding scanner configuration screen.

Turning on Auto-Reconnect means that the robot will automatically try to reconnect to the target device if the connection is lost. Without Auto-Reconnect enabled, the robot will fault if an EtherNet/IP scanner connection is lost, and reset must be pressed to retry the connection. With auto-reconnect enabled, the robot will not fault and will continuously try to reconnect to the device. Auto-reconnect should be turned off if a tool change is not underway (when you do not expect the connection to be lost) so that unexpected connection problems are not masked.

B.4.2 Individual Examples

The example below turns on Auto-Reconnect for the second connection (the connection corresponding to EtherNet/IP slot 2). This call can be executed just before the tool is to be physically disconnected to prevent the robot from faulting once the disconnection occurs. Alternatively, call EN_OFFLN to disable the EtherNet/IP scanner connection before the tool is to be physically disconnected, and execute this call when the tool is physically reconnected, but before EN_ONLN is called.

```
1: CALL EN_ARON(2) ;
```

The next example enables, or brings online, the second connection (the connection corresponding to EtherNet/IP slot 2). This call should be executed when the tool is physically reconnected.

```
1: CALL EN_ONLN(2) ;
```

The example below checks the status of the second connection (the connection corresponding to EtherNet/IP slot 2). The status is placed in register 5, R[5]. The connection is not established and exchanging I/O until the status is equal to the value 6.

```
1: CALL EN_STCHK(2,5) ;
```

The next example turns off Auto-Reconnect for the second connection (the connection corresponding to EtherNet/IP slot 2). This call should be executed after an EtherNet/IP scanner connection has been established. Any problem with this EtherNet/IP connection at this point would be a valid error and will now fault the robot.

```
1: CALL EN_AROFF(2) ;
```

The example below disables, or takes offline, the second connection (the connection corresponding to EtherNet/IP slot 2). This call may be executed just before the tool is to be physically disconnected.

```
1: CALL EN_OFFLN(2) ;
```

B.4.3 Advanced Examples

It can take up to 300ms for an EtherNet/IP adapter device to power-up and become ready to exchange I/O. The following example can be done after moving away from the tool changer nest to help cycle time by allowing the device power-up and connection time to be done in parallel with the robot motion. The following logic will check for the device to go online for up to 15 seconds. If the device status becomes online in less than 15 seconds, the robot will resume immediately after the online status is obtained. If the device is still not online after 15 seconds a User Alarm is posted and the robot will fault. Note that in line #3, the option argument wait_time is set to 0 for EN_ONLN. Care must be used when setting a device online just after it is reconnected. If it is not fully powered up and available for reconnection by the scanner, an alarm might be generated. To avoid this problem, auto-reconnect is generally enabled while setting the device online, and then disabled once the device comes online. The following logic assumes auto-reconnect has already been enabled.

```
1: TIMER[1]=RESET ;
2: TIMER[1]=START ;
3: CALL EN_ONLN(2,0)
4: LBL[1] ;
5: WAIT .10(sec) ;
6: CALL EN_STCHK(2,50) ;
7: IF R[50]=6,JMP LBL[3] ;
8: IF (TIMER[1]<15),JMP LBL[1] ;
9: UALM[1] ;
10: JMP LBL[1] ;
11: LBL[3] ;
12: TIMER[1]=STOP ;
13: CALL EN_AROFF(2) ;
```

The same functionality of the above logic can also be achieved by setting the optional parameter wait_time of the EN_ONLN program to a non-zero value as seen in the logic below. When the wait_time parameter is not set, it will default to 15. In this case, EN_ONLN does not return until an EtherNet/IP scanner connection has been established.

```
1: CALL EN_ONLN(2,15)
2: CALL EN_AROFF(2) ;
```

OR

```
1: CALL EN_ONLN(2)
2: CALL EN_AROFF(2) ;
```

Below is an outline of how a tool change may occur and a recommended sequence of calls to programmatically handle the tool change.

* Tool is connected and exchanging I/O with EtherNet/IP scanner connection 2.

* A tool change is scheduled to occur.

```
CALL EN_OFFLN( 2 ) ;
```

* Physically disconnect the tool.

* Physically connect a new tool.

```
CALL EN_ARON( 2 ) ;
```

```
CALL EN_ONLN( 2 ) ;
```

* When EN_ONLN returns, tool is connected and exchanging I/O with EtherNet/IP scanner connection 2.

```
CALL EN_AROFF( 2 ) ;
```

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