FANUC Robotics SYSTEM R-30*i*A and R-30*i*B Controller Modbus TCP Interface Setup and Operations Manual

MAROCMODB06071E REV B

Version 7.30 or later

About This Manual

This manual can be used with controllers labeled R-30*i*A or R-J3*i*C. If you have a controller labeled R-J3*i*C, you should read R-30*i*A as R-J3*i*C throughout this manual.

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Patents

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FRA Patent List

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

FANUC LTD Patent List

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

VersaBell, ServoBell and SpeedDock Patents Pending.

Conventions

This manual includes information essential to the safety of personnel, equipment, software, and data. This information is indicated by headings and boxes in the text.

Warning

Information appearing under WARNING concerns the protection of personnel. It is boxed and in bold type to set it apart from other text.

Caution

Information appearing under **CAUTION** concerns the protection of equipment, software, and data. It is boxed to set it apart from other text.

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

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Safety

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

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

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

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

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

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

CONSIDERING SAFETY FOR YOUR ROBOT INSTALLATION

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

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

Keeping People Safe

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

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

Using Safety Enhancing Devices

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

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

Setting Up a Safe Workcell

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

- Sponsor your personnel for training in approved FANUC Robotics training course(s) related to your application. Never permit untrained personnel to operate the robots.
- Install a lockout device that uses an access code to prevent unauthorized persons from operating the robot.
- Use anti-tie-down logic to prevent the operator from bypassing safety measures.
- Arrange the workcell so the operator faces the workcell and can see what is going on inside the cell.

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

Staying Safe While Teaching or Manually Operating the Robot

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

- Never wear watches, rings, neckties, scarves, or loose clothing that could get caught in moving machinery.
- Know whether or not you are using an intrinsically safe teach pendant if you are working in a hazardous environment.
- Before teaching, visually inspect the robot and *work envelope* to make sure that no potentially hazardous conditions exist. The work envelope is the area defined by the maximum motion range of the robot. These include tooling attached to the wrist flange that extends this range.
- The area near the robot must be clean and free of oil, water, or debris. Immediately report unsafe working conditions to the supervisor or safety department.
- FANUC Robotics recommends that no one enter the work envelope of a robot that is on, except for robot teaching operations. However, if you must enter the work envelope, be sure all safeguards are in place, check the teach pendant DEADMAN switch for proper operation, and place the robot in teach mode. Take the teach pendant with you, turn it on, and be prepared to release the DEADMAN switch. Only the person with the teach pendant should be in the work envelope.

Warning

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

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

Warning

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

— Using a low motion speed, single step the program for at least one full cycle.

— Using a low motion speed, test run the program continuously for at least one full cycle.

— Using the programmed speed, test run the program continuously for at least one full cycle.

- Make sure all personnel are outside the work envelope before running production.

Staying Safe During Automatic Operation

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

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

Staying Safe During Inspection

When inspecting the robot, be sure to

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

Staying Safe During Maintenance

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

- Never enter the work envelope while the robot or a program is in operation.
- Before entering the work envelope, visually inspect the workcell to make sure no potentially hazardous conditions exist.
- Never wear watches, rings, neckties, scarves, or loose clothing that could get caught in moving machinery.
- Consider all or any overlapping work envelopes of adjoining robots when standing in a work envelope.
- Test the teach pendant for proper operation before entering the work envelope.
- If it is necessary for you to enter the robot work envelope while power is turned on, you must be sure that you are in control of the robot. Be sure to take the teach pendant with you, press the DEADMAN switch, and turn the teach pendant on. Be prepared to release the DEADMAN switch to turn off servo power to the robot immediately.
- Whenever possible, perform maintenance with the power turned off. Before you open the controller front panel or enter the work envelope, turn off and lock out the 3-phase power source at the controller.
- Be aware that an applicator bell cup can continue to spin at a very high speed even if the robot is idle. Use protective gloves or disable bearing air and turbine air before servicing these items.
- Be aware that when you remove a servomotor or brake, the associated robot arm will fall if it is not supported or resting on a hard stop. Support the arm on a solid support before you release the brake.

Warning

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

- Release or block all stored energy. Before working on the pneumatic system, shut off the system air supply and purge the air lines.
- Isolate the robot from all remote control signals. If maintenance must be done when the power is on, make sure the person inside the work envelope has sole control of the robot. The teach pendant must be held by this person.

- Make sure personnel cannot get trapped between the moving robot and other equipment. Know the path that can be used to escape from a moving robot. Make sure the escape route is never blocked.
- Use blocks, mechanical stops, and pins to prevent hazardous movement by the robot. Make sure that such devices do not create pinch points that could trap personnel.

Warning

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

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

KEEPING MACHINE TOOLS AND EXTERNAL DEVICES SAFE

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

Programming Safety Precautions

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

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

Mechanical Safety Precautions

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

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

KEEPING THE ROBOT SAFE

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

Operating Safety Precautions

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

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

Programming Safety Precautions

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

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

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

Chapter 1

INTRODUCTION

Contents

The Modbus TCP interface supports an I/O exchange with other Modbus TCP enabled devices over an Ethernet network. The Modbus TCP option on the robot only acts as a server (slave), and therefore will only exchange I/O with client (master) devices. Modbus TCP uses TCP/IP and is based on a Client-Server model. Modbus TCP can be configured to exchange up to the full amount of I/O supported on the robot. The Modbus TCP specification is managed by the Modbus-IDA.

Ethernet is nondeterministic and Modbus TCP does not guarantee any timing. The robot Modbus TCP server will time-out and post an error if an I/O exchange is not received within the configured time limit, unless time-outs are disabled. Good network design and topology is very critical for successful deployment of Modbus TCP for fast and reliable communications between any two devices.

Chapter 2

SYSTEM OVERVIEW

Contents

2.1 MODBUS OVERVIEW

The robot Modbus TCP server supports up to 4 simultaneous Modbus TCP connections. These connections are classified into two connection pools: the Priority connection pool, and the Non-Priority connection pool. By default, all connections are Non-Priority.

Up to two connections might be marked as Priority Connections by specifying the Modbus TCP clients' IP address. This means no other Modbus TCP client device can connect to the robot and use a Priority connection except the device with the corresponding IP address.

Any Modbus TCP client device can connect to a Non-Priority connection, unless the robot is configured with a Non-Priority connection pool of size 0. If all available non-priority connections are used, and another Modbus TCP client attempts to make a connection to the Non-Priority pool, the oldest existing Non-Priority connection will be closed, and the new connection request will be honored.

The Modbus TCP interface corresponds to Rack 96 Slot 1 in the robot for I/O mapping. Any amount of I/O can be mapped with Modbus TCP, up to the maximum supported on the robot.

Good network design is critical to having reliable communications. Excessive traffic and collisions must be avoided or managed.

2.2 I/O TABLES

2.2.1 Overview

Modbus bases its data model on a series of tables:

Table 2–1. Maximum I/O Supported per Connection

Item	Max Limit
Max number of digital inputs per connection	64 Words (16 bits each) or 128 Bytes or 1024 I/O Points
Max number of digital outputs per connection	64 Words (16 bits each) or 128 Bytes or 1024 I/O Points

Table 2–2. Modbus Data Model

Table	Object Type	Type of	Robot Mapping
Discrete inputs	Single bit	Read-Only	Digital Output (DO)
Coils	Single bit	Read-Write	Digital Input (DI)
Input Registers	16–bit word	Read-Only	Digital Output (DO)
Holding Registers	16–bit word	Read-Write*	Digital Input (DI) and Digital Output (DO)

* Even though Robot Digital Outputs (DO) can be accessed as Modbus Holding Registers, Robot Digital Outputs are still Read-Only. A Modbus Illegal Address error code will be returned if Robot Digital Outputs are written to as Holding Registers.

The Modbus Discrete Inputs and Input Register tables are overlaid and mapped to robot Digital Outputs (DO) on the robot. Likewise, the Coils and Holding Register tables are overlaid and mapped to Digital Inputs (DI).

Table 2–3 is a quick reference for the Modbus to Robot address map.

Note In all examples throughout this documentation, DO[1] refers to the first Digital Output point allocated to Modbus Rack 96, slot 1 on the robot. Likewise, DI[1] refers to the first Digital Input point allocated to Modbus Rack 96, slot 1 on the robot

Note All registers are returned by the robot in big-endian format

Table 2–3. Modbus to Robot Address Mapping (Quick Reference)

Modbus Address	Robot I/O
Discrete input 0 Discrete input 1 Discrete input 2 ...	Digital Output : DO[1] Digital Output : DO[2] Digital Output : DO[3] ...
Coils 0 Coils 1 Coils 2 ...	Digital Input : DI[1] Digital Input : DI[2] Digital Input : DI[3] ...
Input Register 0 Input Register 1 Input Register 2 ...	Digital Outputs (DO[1] — DO[16]) Digital Outputs (DO[17] — DO[32]) Digital Outputs (DO[33] — DO[48]) ...

Table 2–3. Modbus to Robot Address Mapping (Quick Reference) (Cont'd)

Modbus Address	Robot I/O
Holding Registers 0 Holding Registers 1 Holding Registers 2 ...	Digital Inputs (DI[1] — DI[16]) Digital Inputs (DI[17] — DI[32]) Digital Inputs (DI[33] — DI[48]) ...
Holding Registers 10000 *(read-only)* Holding Registers 10001 *(read-only)* Holding Registers 10002 *(read-only)* ...	Digital Outputs (DI[1] — DI[16]) Digital Outputs (DI[17] — DI[32]) Digital Outputs (DI[33] — DI[48]) ...

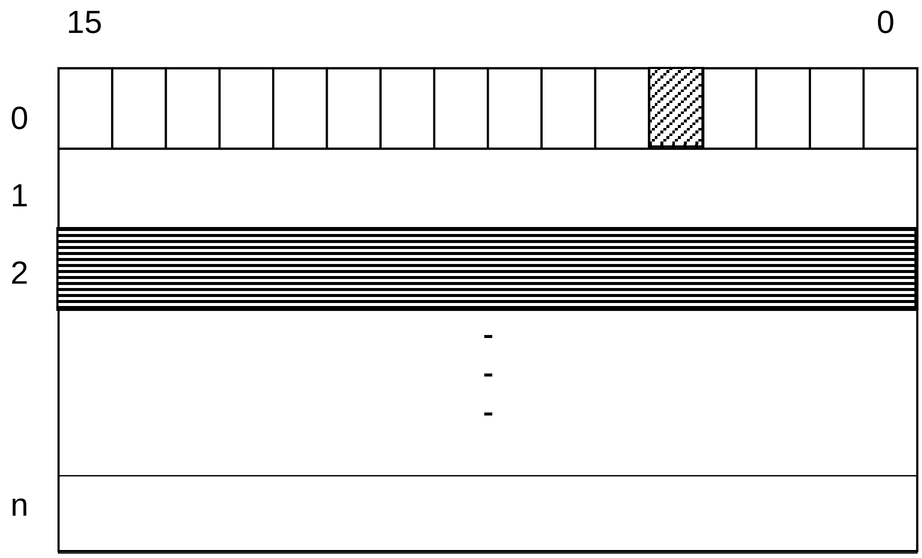
2.2.2 Discrete Inputs and Input Registers

Discrete Inputs are accessible starting at address 0. For example, "read input discrete 4" would access the fifth Robot Digital Output point (DO[5]), as seen by the diagonal-striped area shown in Figure 2–1 .

Input Registers are also accessible starting at address 0. For example, "read input register 2" would access the third set of 16 Digital Output points (DO[33]-DO[48]) as a register, as seen in the horizontally-striped area Figure 2–1 . Note that when reading Modbus Registers, robot data is returned in big-endian format with the output points numbered from the least significant bit (right hand side) to the most significant bit (left hand side), also shown in Figure 2–1 .

Having these two tables overlaid means that reading discrete inputs 0 through 15 would effectively be the same as reading input register 0. And reading discrete inputs 16 through 31 would effectively be the same as reading input register 1, and so on.

Figure 2–1. Robot Digital Outputs (Rack 96 Slot 1)



In Figure 2–1 , the diagonally-striped output point represents the output returns from a Read Input Discrete 4 request. The horizontal-striped portion of the data map represents the 16-point register that would be returned on a Read Input Register 2 request.

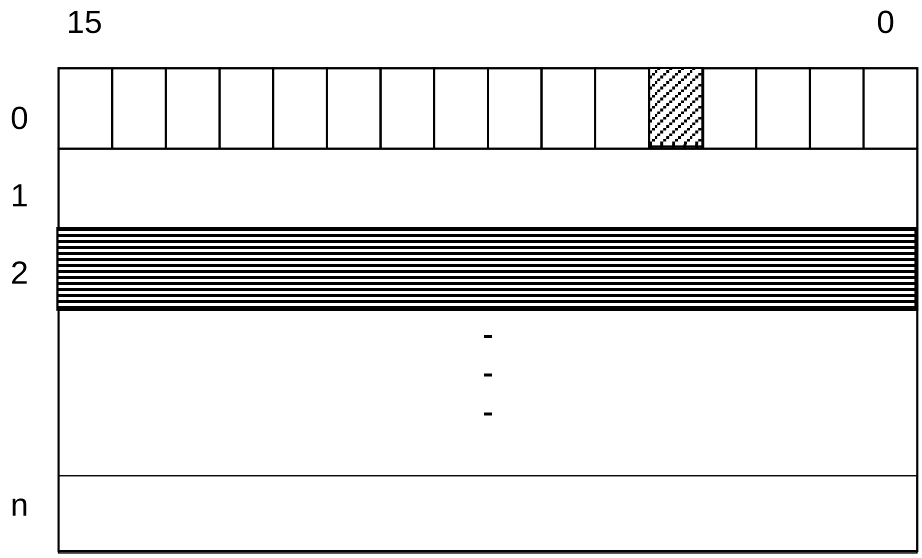
2.2.3 Coils and Holding Registers

Coils are accessible starting at address 0. For example, “write coil 4” would access the fifth Robot Digital Input point, as seen in the diagonally-striped area shown in Figure 2–2 .

Holding Registers are also accessible starting at address 0. For example, “write register 2” would access the third set of 16 Digital Input points (DI[33]-DI[48]), as seen in the horizontally-striped area shown in Figure 2–2 . When writing Holding Registers, Coils are written in big-endian format with the Input points numbered from the least significant bit (right hand side) to the most significant bit (left hand side), also shown in Figure 2–2 .

Having these two tables overlaid means that writing coils 0 through 15 would effectively be the same as writing holding register 0. And writing coils 16 through 31 would effectively be the same as writing input register 1, and so on.

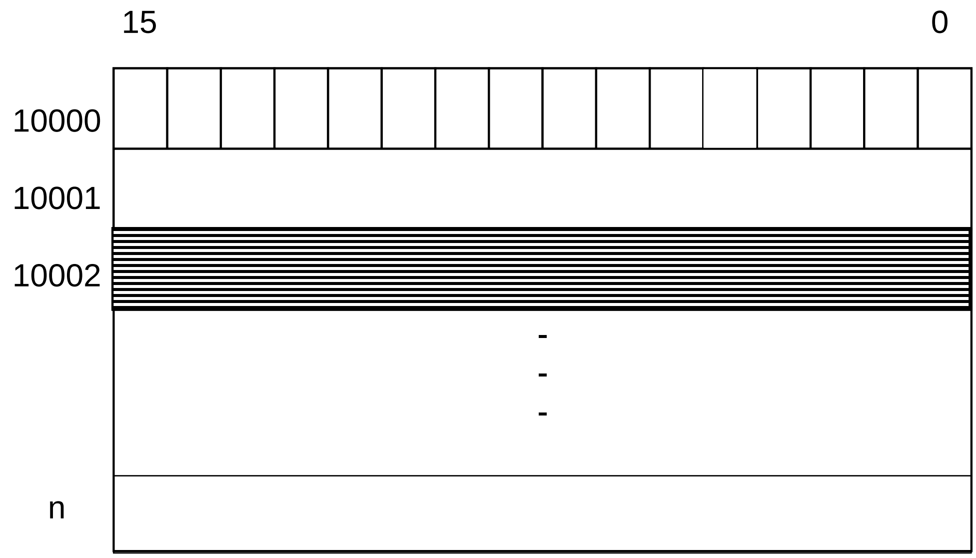
Figure 2–2. Robot Digital Inputs (Rack 96 Slot 1)



In Figure 2–2 , the diagonal-striped input point represents the input written in a Write Coil 4 request. The horizontal-striped portion of the data map represents the 16-point register that would be written on a Write Register 2 request.

Robot Digital Outputs are also accessible as read-only Modbus Holding Registers, starting at address 10000. For example, “read register 10002” would access the third set of 16 Digital Output points (DO[33]-DO[48]), as seen in the horizontally-striped area shown in Figure 2–2 . When reading Holding Registers, Coils are written in big-endian format with the Output points numbered from the least significant bit (right hand side) to the most significant bit (left hand side), also shown in Figure 2–3 . Starting point for holding registers for digital outputs can be changed from default 10000 using $MODBUSTCP.$OUTPUTBASE.

Figure 2–3. Robot Digital Outputs (Rack 96 Slot 1) as Holding Registers



In Figure 2–3 , the horizontally-striped portion of the data map represents the 16-point register that would be returned on a Read Input Register 2 request.

Accessing both Robot Digital Inputs and Digital Output through Holding Registers allows you to take advantage of Modbus function 23: ReadWrite Registers. Through a single Modbus request, a Modbus client can read and write robot digital I/O.

2.2.4 Zero-based Versus One-based Addressing

Modbus addressing is zero-based, and robot addressing is one-based. This can be confusing to some users. For example, when accessing Robot Digital Input 1 (DI[1]), the Modbus client should be configured to access Coil 0.

However, the robot Modbus software also offers a feature to support one-based addressing at the Modbus level. When the system variable $MODBUSTCP.$BASEZERO is set to FALSE, one-based addressing is enforced, in which case the Modbus client should write to Coil 1 to set DI[1] on the robot. Writing to Coil 0 would result in a Modbus Illegal Address error.

All examples in this documentation assume zero-based addressing is being used.

2.3 SUPPORTED MODBUS FUNCTIONS

The robot Modbus TCP server support the following Modbus functions as shown in Table 2–4 .

Table 2–4. Modbus Functions

Decimal Code	Hexadecimal Code	Function
01	0x01	Read Coils
02	0x02	Read Discrete Inputs
03	0x03	Read Holding Registers
04	0x04	Read Input Registers
05	0x05	Write Single Coil
06	0x06	Write Single Register
16	0x10	Write Multiple Registers
23	0x17	Read/Write Multiple Registers

2.4 ETHERNET CONNECTION AND IP ADDRESS ASSIGNMENT

The robot must have a valid IP (Internet protocol) address and subnet mask to operate as a Modbus TCP node. Details on the Ethernet interface and TCP/IP configuration can be found in the *Internet Options Setup and Operations Manual*.

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 that supports 100Mbps full duplex connections. If auto-negotiation is configured only on one side (the robot or the switch) and not on the other side, a duplex mismatch is likely to occur causing serious problems.

The LEDs located near the RJ45 connectors on the main CPU board are useful in confirming link establishment (for details on the LEDs, refer to appendix “Diagnostic Information” in the *Internet Options Setup and Operations Manual*).

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

- Manually configured on the robot teach pendant – Refer to the "Setting Up TCP/IP" chapter in the *Internet Options Setup and Operations Manual*.
- DHCP (Dynamic Host Configuration Protocol) – Refer to the “Dynamic Host Configuration Protocol” chapter in the *Internet Options Setup and Operations Manual*.

Note DHCP is an optional software component. It is important to utilize static or infinite lease IP addresses when using Modbus TCP.

Either one or both Ethernet ports can be configured for use with Modbus TCP. Note that in order to use both ports at the same time they must be properly configured on separate subnets. Refer to the “Setting Up TCP/IP” chapter in the *Internet Options Setup and Operations Manual*.

Note Be sure that all Modbus TCP 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 Section 6.3 for more information.

Chapter 3

MODBUS TCP SERVER CONFIGURATION

Contents

3.1 OVERVIEW

The robot supports up to four Modbus TCP connections. These connections are normally to a cell controller or PLC to exchange cell interface I/O data. The Modbus TCP Option must be loaded to support this functionality.

3.2 CONFIGURATION

The Modbus TCP screen is split into two sections: Status and configuration. The Status section includes one field: Slave Status, which is read-only. The Configuration section has six user configurable fields. A power-cycle is required for any changes made to the configuration fields to take effect. Table 3–1 describes all the Modbus TCP screen items. Use Procedure 3-1 to set up a Modbus TCP slave.

Table 3–1. Modbus Screen Items

Field Name	Description
Slave Status	The Slave Status field will be either RUNNING or IDLE. RUNNING indicates that I/O is being exchanged with a Modbus TCP Master, whereas IDLE indicates I/O is currently not being exchanged.
Number of Connections	The Number of Connections field allows you to specify how many Modbus TCP connections the slave can have at one time. This can be set to 0 to completely disable the robot Modbus slave, up to a maximum of 4 connections. Per the Modbus TCP protocol specification, when a new connection request arrives and no unused connections remain, the oldest connection will be closed, and the new connection request will be accepted. The first time this happens after a power-cycle, a PRIO-494 warning alarm will be posted.
Timeout	The Timeout field defines the time for an idle Modbus TCP connection to expire (in milliseconds). If no message is received from any master for this timeout value, the slave device will assume that the network connection has been lost or terminated, will close all connections, and will post a Timeout alarm. Setting this field to 0 disables timeouts.
Error Severity	The Error Severity field defines the severity of Modbus TCP alarms. You can set this to STOP, WARN, or PAUSE by using the F4, [CHOICE] key.
Keep Input on Timeout	The Keep Input on Timeout field specifies how to handle Inputs in the case of a timeout. When set to FALSE, all Modbus Inputs will be set to zero when a timeout occurs. Otherwise, inputs will be left in their last state.

Table 3–1. Modbus Screen Items (Cont'd)

Field Name	Description
Input Words	The Input Words field specifies how much Digital Input to allocate. In this context a word would be 16-bits. So if 4 words were configured, 64 points of Digital Input would be allocated to Rack 96, Slot 1. All master devices connected to the robot Modbus slave would have read-write access to this Digital Input data.
Output Words	The Output Words field specifies how much Digital Output to allocate. In this context a word would be 16-bits. So if 4 words were configured, 64 points of Digital Output would be allocated to Rack 96, Slot 1. All master devices connected to the robot Modbus slave would have read access to this Digital Output data.

Procedure 3-1 Setting Up a Modbus TCP Slave

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

```
Modbus TCP Slave Rack 96
  Status
   Slave Status:        IDLE
  Configuration
   Number of Connections:    1
   Timeout (0 = None):     300
   Error Severity:        STOP
   Keep Input on Timeout: FALSE
   Input Words:              4
   Output Words:             4
```

4. Select each of the following and set them as desired (refer to Table 3–1 .
   - Number of Connections
   - Timeout
   - Error Severity
   - Keep Input on Timeout
   - Input Words
   - Output Words

5. Turn off the controller, then turn it on again.

3.3 PRIORITY CONNECTIONS

The Modbus TCP server supports Priority connections. Up to two connections can be marked as Priority Connections by specifying the Modbus TCP clients' IP address. This means no other Modbus TCP client device can connect to the robot and use a Priority connection except the device with the corresponding IP address. Moreover, the robot Modbus TCP server will never close a Priority connection unless the connection is first closed by the Modbus TCP client, or in the case of a time-out.

Any Modbus TCP client device can connect to a Non-Priority connection--a connection not marked as a priority connection. If all available non-priority connections are used, and another Modbus TCP client attempts to make a connection to the Non-Priority pool, the oldest existing Non-Priority connection will be closed, and the new connection attempt will be honored. The first time this happens after a power-cycle, a PRIO-494 warning alarm will be posted.

By default, all connections are Non-Priority. Priority connections can be configured by setting one or both of the following system variables with either a valid IP address or hostname:

- $MODBUSTCP.$PRIO1
- $MODBUSTCP.$PRIO2

For example, suppose we had a PLC with an IP address of 192.168.1.11, and a HMI device at 192.168.1.22. We might want the PLC connection to be marked as a priority connection, while the HMI device can connect using a non-priority connection. We would set the "Number of Connections" field to be 2. We would also set $MODBUSTCP.$PRIO1 = "192.168.1.11". Lastly, we would set the "Timeout" field as appropriate based on the faster scan rate of either the PLC or HMI device.

In the example above, two Modbus TCP connections were configured. One of the two was marked as a Priority connection for the PLC. Since only one Priority connection was configured, the second connection defaulted to a Non-Priority connection and can be used by any Modbus TCP client, including the HMI device.

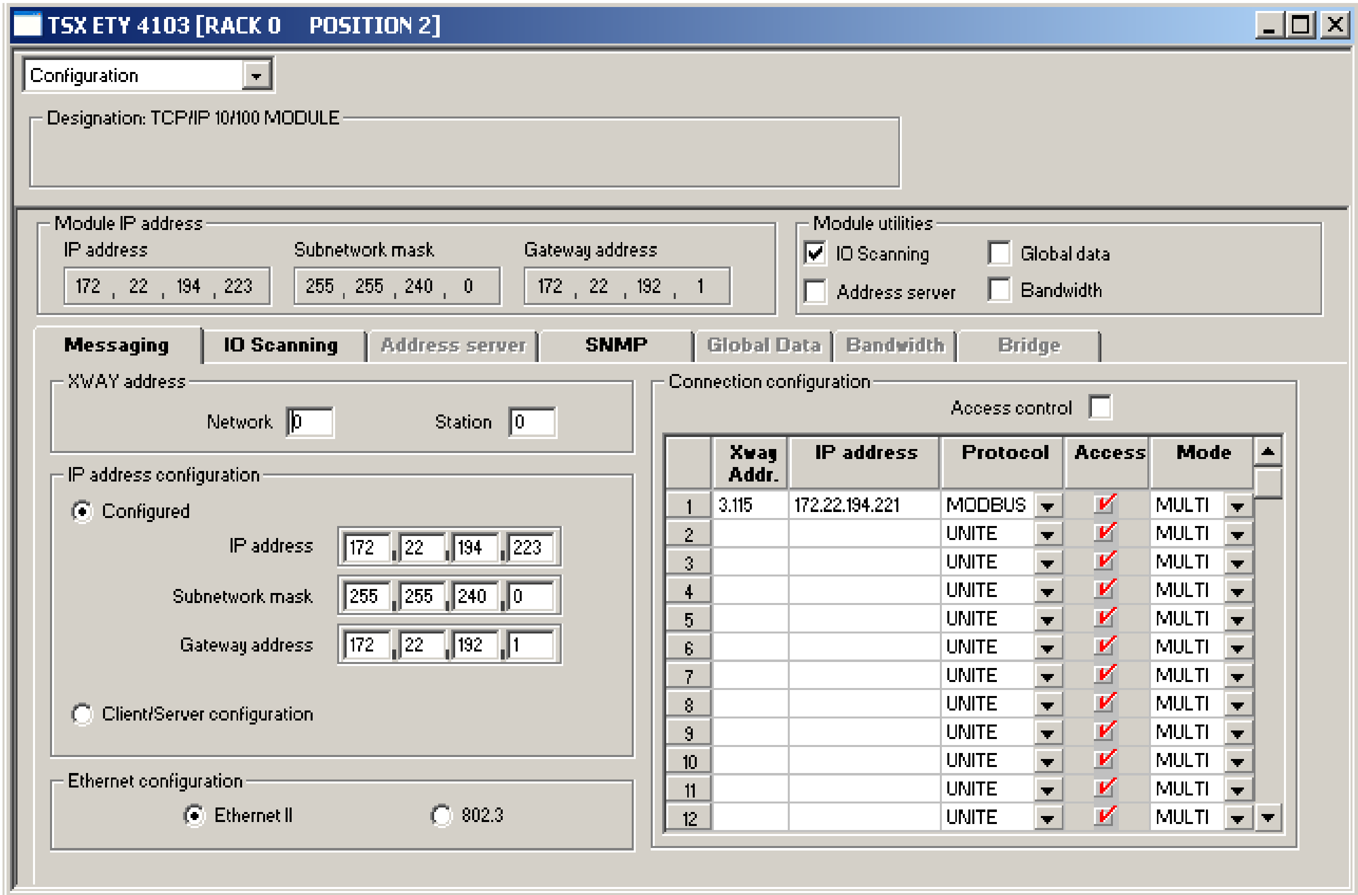
3.4 CONFIGURING THE REMOTE MODBUS TCP CLIENT

The robot will be ready to accept Modbus TCP client connections when the Number of Connections field on the Modbus TCP screen is set to a value of 1 or greater. Use Procedure 3-2 to configure the Schneider Premium PLC. For other Modbus TCP clients, refer to their configuration software documentation.

Procedure 3-2 Configuring the Modbus TCP Client Using PL7 PRO

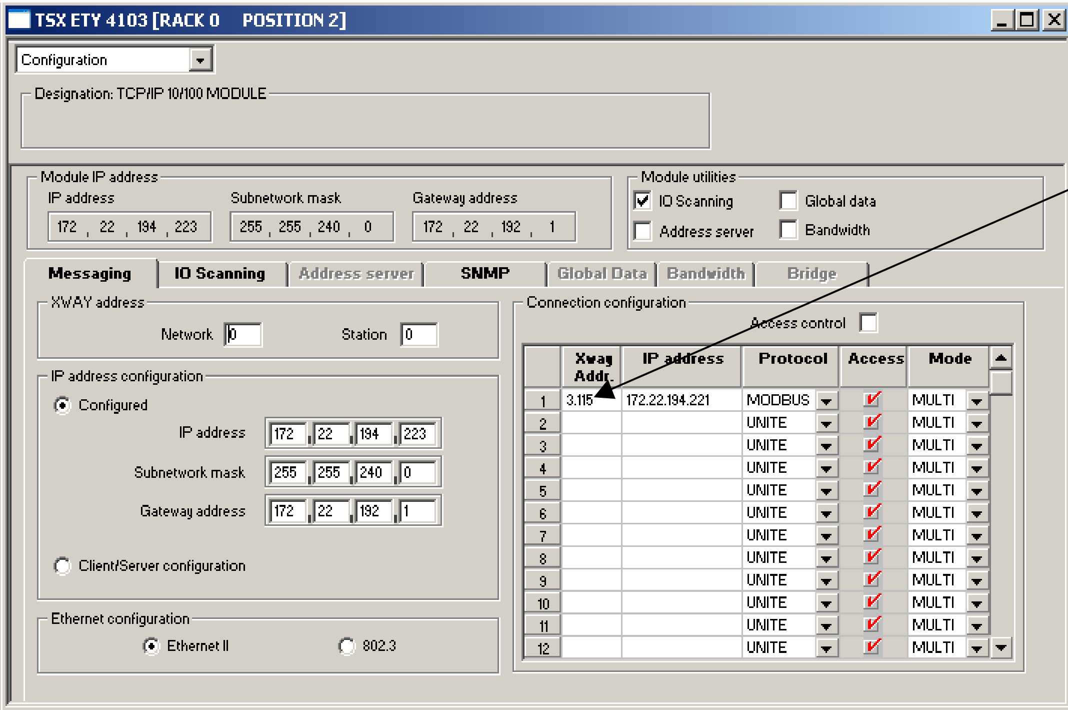
1. Double-click on the Ethernet module in the Hardware Configuration and display the Messaging tab. See Figure 3–1 .

Figure 3–1. Ethernet Module



2. Configure the Xway address for your connection in the Connection Configuration section. See Figure 3–2 .

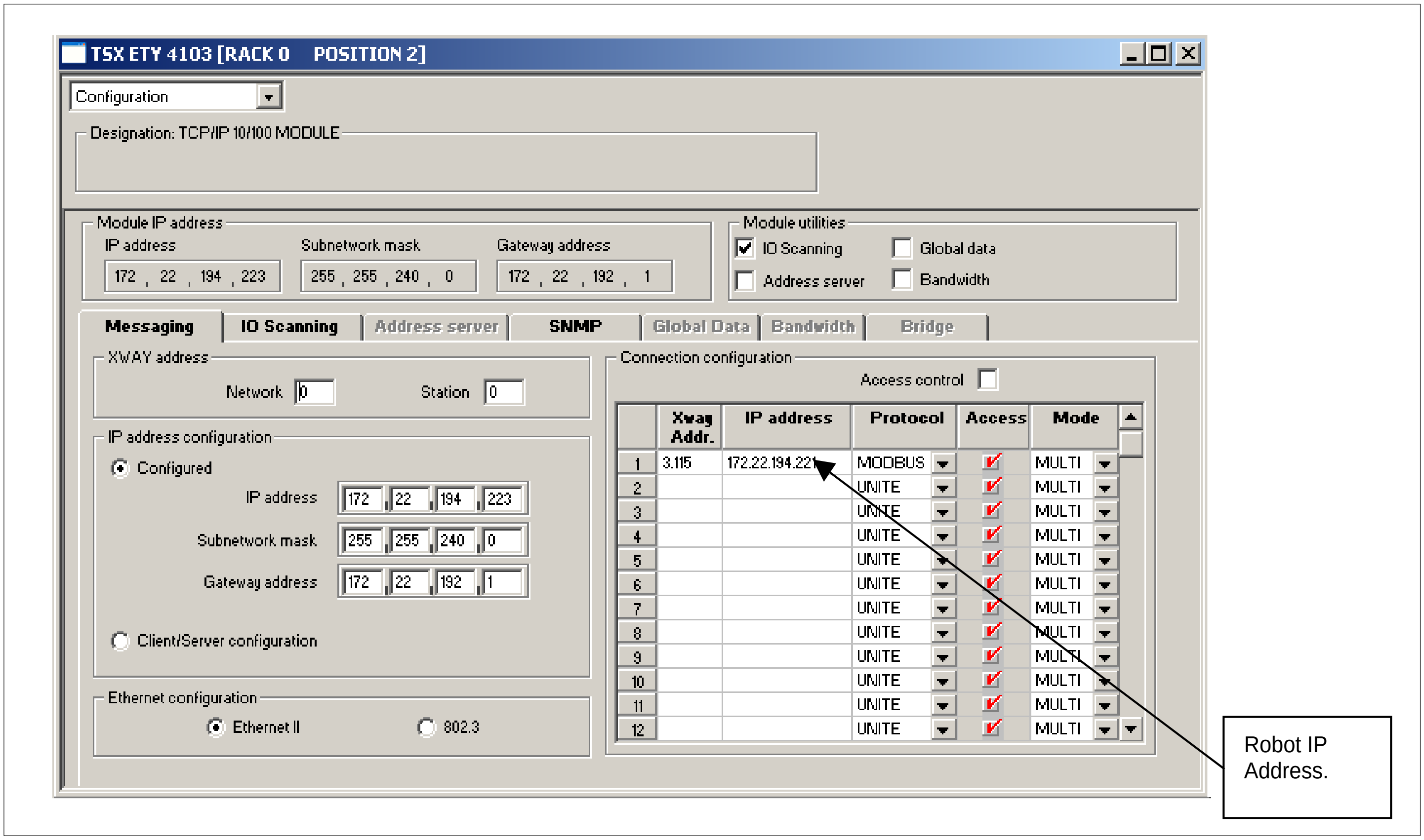
Figure 3–2. Xway address



The Xway address is another form of communication. Parts of this address are used to identify the Modbus TCP node address. In this example, the 3 is the Xway network number and is irrelevant to Modbus TCP. The second number is the Modbus node address and must be between 100 and 163. In this case, 115 is node 15. Add additional lines in this format to talk to multiple robots.

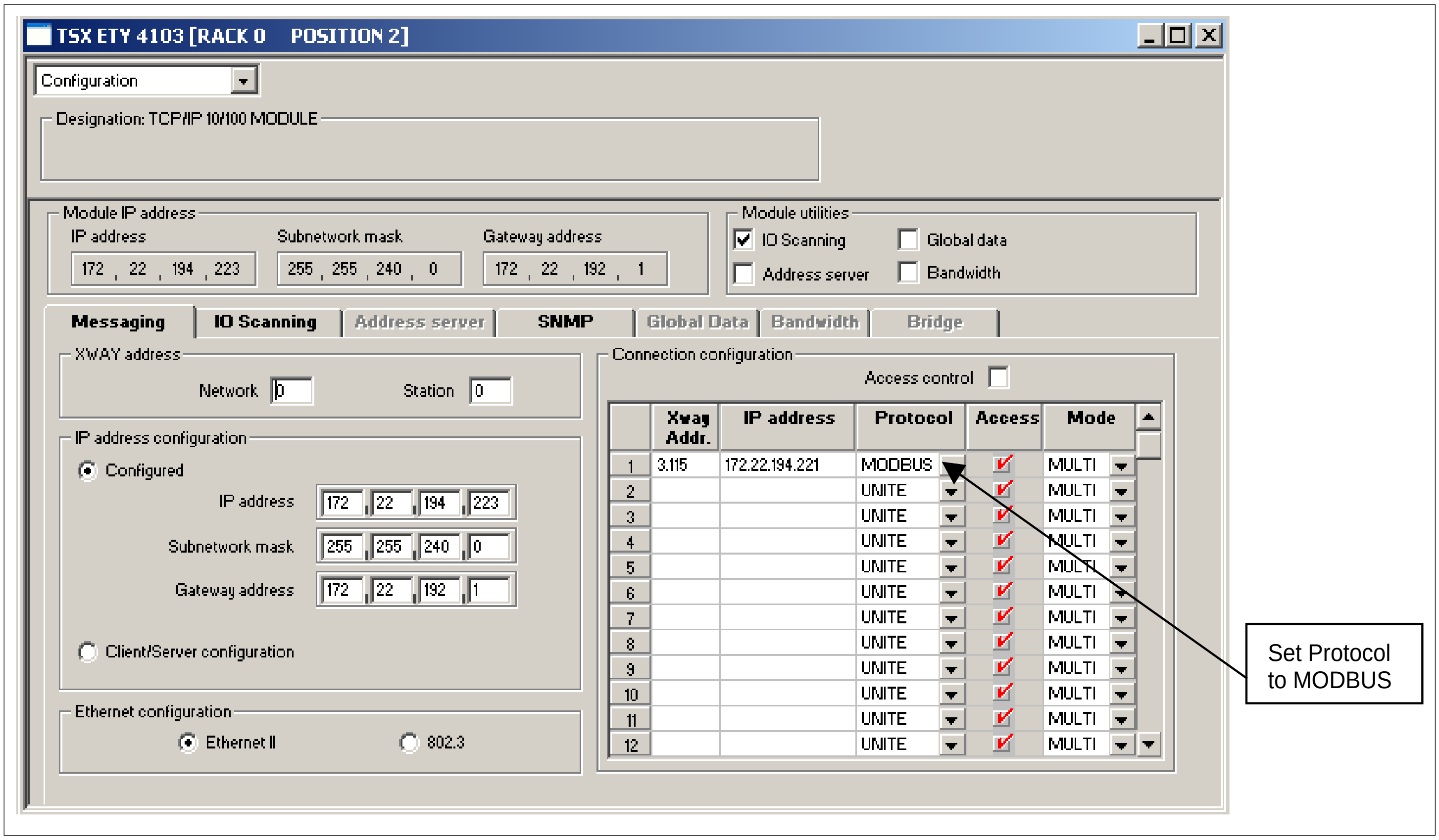
3. Enter the IP address of the robot in the IP address field in the Connection Configuration section. See Figure 3–3 .

Figure 3–3. I/P Address



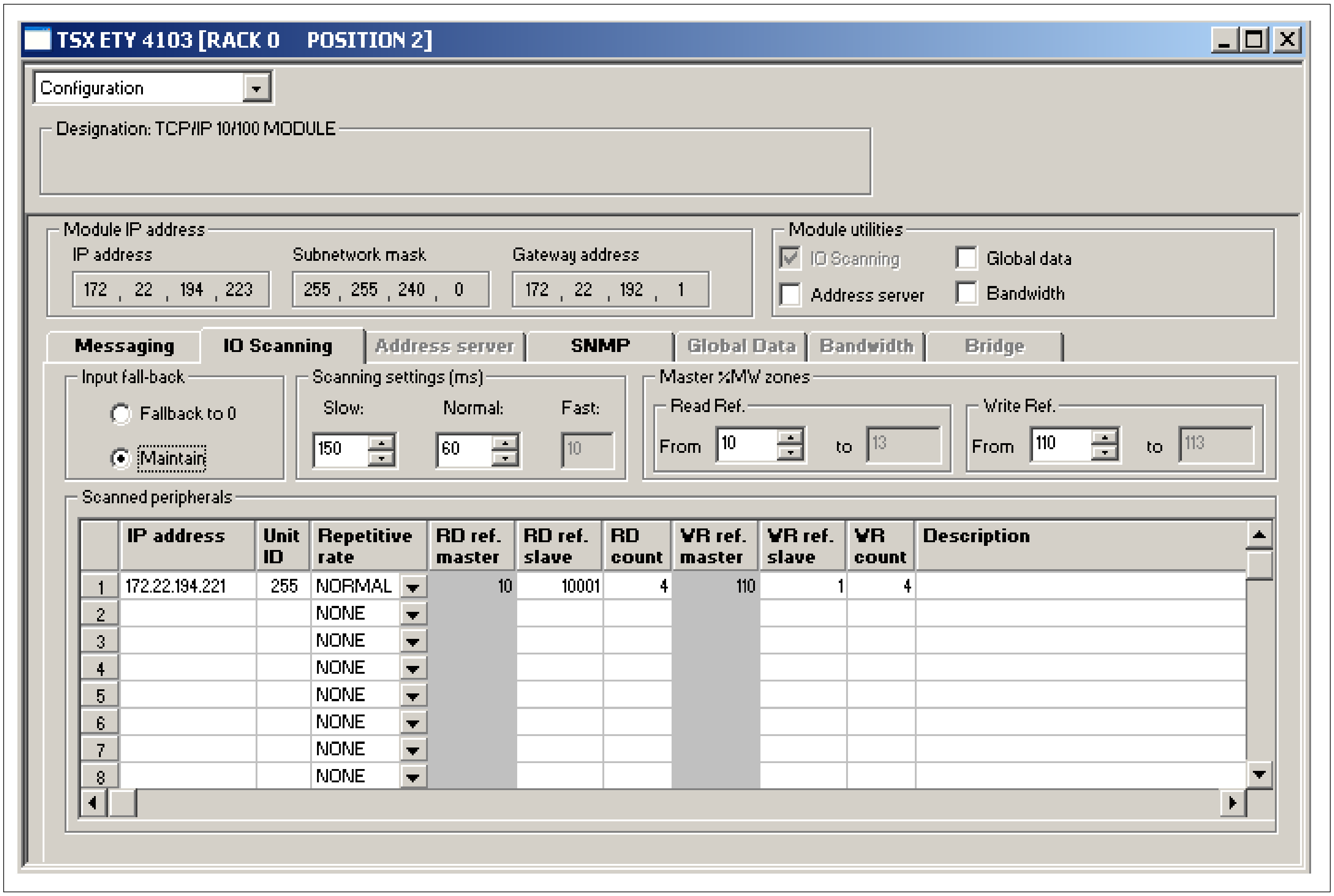
4. Set the protocol to MODBUS in the Protocol field in the Connection Configuration section. See Figure 3–4 .

Figure 3–4. Protocol



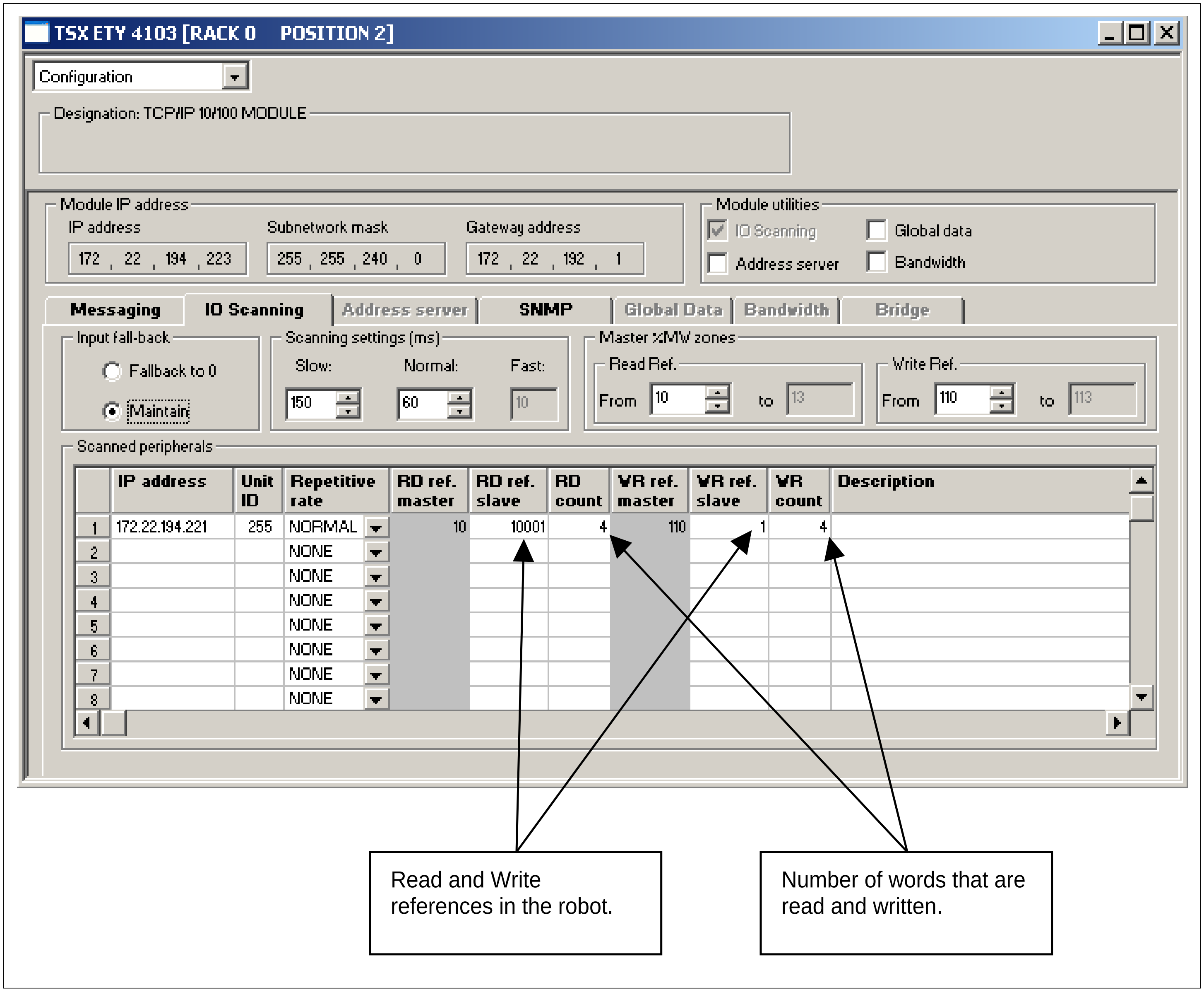
5. Go to the IO Scanning Tab. See Figure 3–5 .

Figure 3–5. I/O Scanning



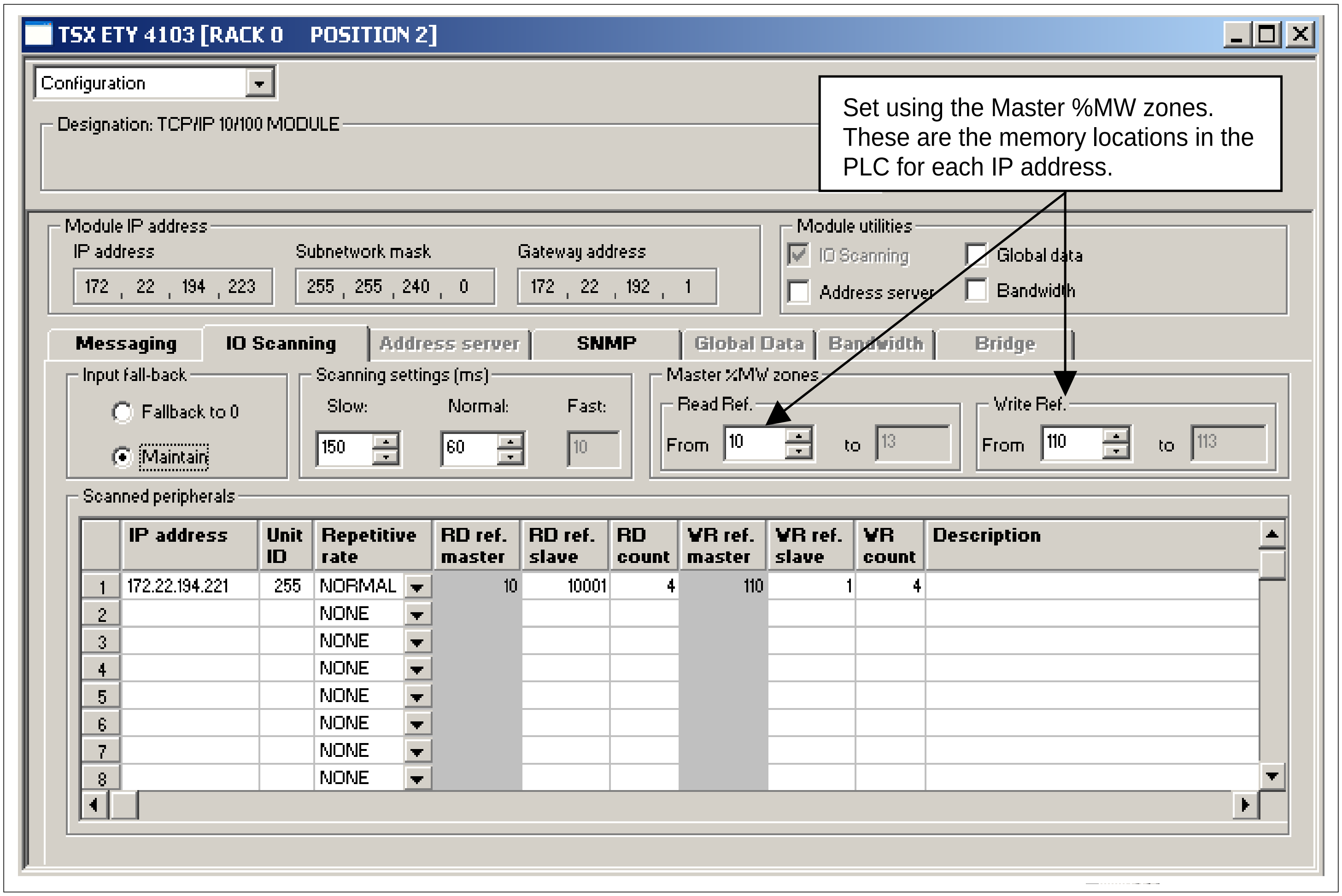
6. Set the RD ref slave to the first Holding Registers address of robot Digital Output (DO[1]). This will be 10000 if zero-based addressing is used, or 10001 for one-based addressing. This number should correspond with the configuration of Output Words on the robot Modbus TCP screen. See Figure 3–6 .

Figure 3–6. RD Slave



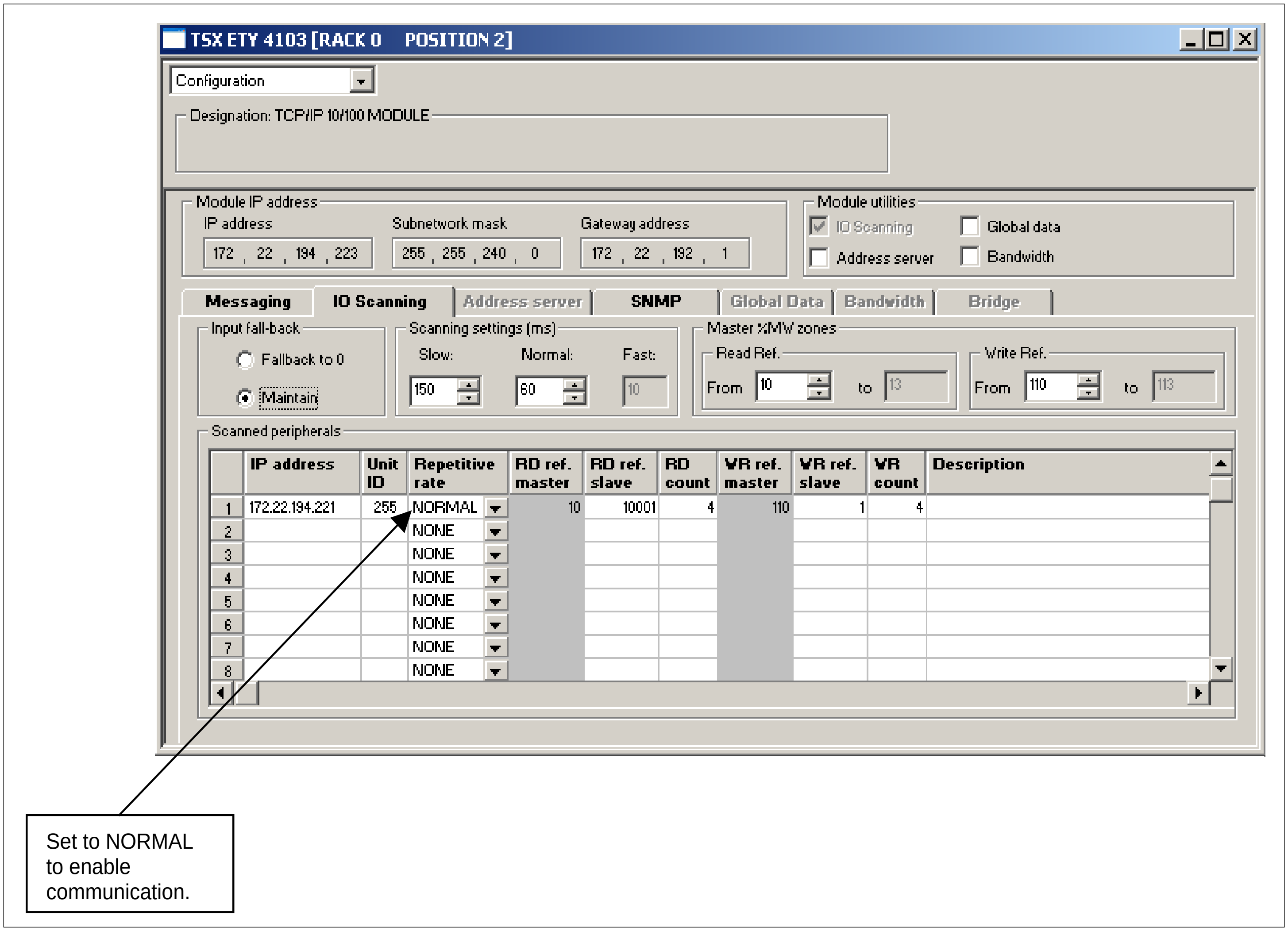
7. Set the RD count to the number Holding Registers to be read off the robot.
8. Set the WR ref slave to the first Holding Registers address of robot Digital Input (DI[1]). This will be 0 if zero-based addressing is used, or 1 for one-based addressing.
9. Set the RD count to the number Holding Registers to be written to the robot. This number should correspond with the configuration of Input Words on the robot Modbus TCP screen.
10. Set the Master %MW zones as appropriate for you PLC configuration. See Figure 3–7 .

Figure 3–7. Master %MW Zones



11. Set the Repetitive rate to NORMAL to enable communication. See Figure 3–8 .

Figure 3–8. Repetitive Rate



I/O CONFIGURATION

Contents

4.1 OVERVIEW

This chapter describes how to make Modbus TCP I/O available within the robot by mapping it to digital, and group. It also describes procedures for backing up and restoring the Modbus TCP and I/O configurations.

4.2 MAPPING I/O ON THE ROBOT

The Modbus TCP I/O can be mapped to digital, or group I/O. 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. Modbus TCP I/O uses rack 96, Slot 1.

Use Procedure 4-1 to Map I/O on the Robot.

Procedure 4-1 Mapping I/O on the Robot

1. Press MENUS.
2. Select I/O.
3. Press F1, [TYPE], and select Digital, or Group.
4. Press F2, CONFIG.
5. Set the Range to the appropriate value.
6. Set the Rack to 96, set the slot number to 1, and set the 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.

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) 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 re-map all the I/O. This is done by clearing assignments (CLR_ASG). Use Procedure 4-2 to clear I/O assignments.

Procedure 4-2 Clearing I/O Assignments

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

4.3 BACKING UP AND RESTORING MODBUS TCP

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

DIOCFGSV.IO contains general I/O configuration and all I/O mappings (for example, mappings between Modbus TCP and digital, and group).

SYSMBUS.SV contains Modbus TCP specific configuration.

Use Procedure 4-3 to back up files manually.

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

Procedure 4-3 Backing Up Files Manually

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 SYSMBUS.SV:
   a. Press MENUS.
   b. Select I/O.
   c. Press F1, [TYPE], and choose Modbus TCP.
   d. Press FCTN.
   e. Select Save to save SYSMBUS.SV to the default device.

Procedure 4-4 Performing a Full Application Backup

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”.

Chapter 5

MODBUS TCP GUIDELINES

Contents

5.1 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 (refer to the chapter titled “Setting Up TCP/IP” in the *Internet Options Setup and Operations Manual*). 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 (refer to the appendix titled “Diagnostic Information” in the *Internet Options Setup and Operations Manual* for details on the LEDs). Link State can be confirmed using the TCP/IP status Host Comm screen by following Procedure 5-1 .

Procedure 5-1 Verifying Link State

1. Press MENUS.
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. FANUC Robotics recommends limiting 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. EtherN et/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
- Hischmann 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

Chapter 6

DIAGNOSTICS AND TROUBLESHOOTING

Contents

6.1 OVERVIEW

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 6.2 for more information about Ethernet status LEDs. Refer to Section 6.3 for more information about the PING utility.

6.2 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. For more information about the Ethernet status LEDs, refer to the appendix titled “Diagnostic Information” in the *Internet Options Setup and Operations Manual*. Details on auto-negotiating and manually setting speed and duplex level can be found in the chapter titled “Setting Up TCP/IP” in the of the *Internet Options Setup and Operations Manual*. The robot will auto-negotiate by default and should not be changed in most cases.

6.3 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 Linux, Unix, and Windows and is also supported on the robot. Even devices that do not support generating PING requests (for example, a Modbus TCP block with no user interface) will respond to the PING request.

The PING utility is also available on the robot to PING any name or IP address. Use Procedure 6-1 .

The PING utility is also available from any Windows PC. Use Procedure 6-2 .

Procedure 6-1 Using PING on the Robot

1. Press MENUS.
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.

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

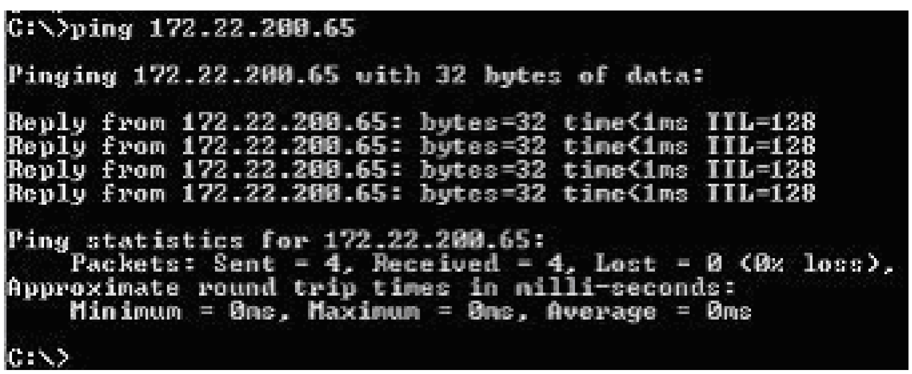
Procedure 6-2 Using PING on a Windows PC

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. See the following screen for an example.

```
PING 192.168.0.10
```

The following image shows a successful PING.

Figure 6–1. Successful PING



The following image shows an unsuccessful PING.

Figure 6–2. 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:\>
```

Glossary

A

abort

Abnormal termination of a computer program caused by hardware or software malfunction or operator cancellation.

absolute pulse code system

A positional information system for servomotors that relies on battery-backed RAM to store encoder pulse counts when the robot is turned off. This system is calibrated when it is turned on.

A/D value

An analog to digital-value. Converts a multilevel analog electrical system pattern into a digital bit.

AI

Analog input.

AO

Analog output.

alarm

The difference in value between actual response and desired response in the performance of a controlled machine, system or process. Alarm=Error.

algorithm

A fixed step-by-step procedure for accomplishing a given result.

alphanumeric

Data that are both alphabetical and numeric.

AMPS

Amperage amount.

analog

The representation of numerical quantities by measurable quantities such as length, voltage or resistance. Also refers to analog type I/O blocks and distinguishes them from discrete I/O blocks. Numerical data that can vary continuously, for example, voltage levels that can vary within the range of -10 to +10 volts.

AND

An operation that places two contacts or groups of contacts in series. All contacts in series control the resulting status and also mathematical operator.

ANSI

American National Standard Institute, the U.S. government organization with responsibility for the development and announcement of technical data standards.

APC

See absolute pulse code system.

APC motor

See servomotor.

application program

The set of instructions that defines the specific intended tasks of robots and robot systems to make them reprogrammable and multifunctional. You can initiate and change these programs.

arm

A robot component consisting of an interconnecting set of links and powered joints that move and support the wrist socket and end effector.

articulated arm

A robot arm constructed to simulate the human arm, consisting of a series of rotary motions and joints, each powered by a motor.

ASCII

Abbreviation for American Standard Code for Information Interchange. An 8-level code (7 bits plus 1 parity bit) commonly used for the exchange of data.

automatic mode

The robot state in which automatic operation can be initiated.

automatic operation

The time during which robots are performing programmed tasks through unattended program execution.

axis

1. A straight line about which a robot joint rotates or moves. 2. One of the reference lines or a coordinate system. 3. A single joint on the robot arm.

B

backplane

A group of connectors mounted at the back of a controller rack to which printed circuit boards are mated.

BAR

A unit of pressure equal to 100,000 pascals.

barrier

A means of physically separating persons from the restricted work envelope; any physical boundary to a hazard or electrical device/component.

battery low alarm

A programmable value (in engineering units) against which the analog input signal automatically is compared on Genius I/O blocks. A fault is indicated if the input value is equal to or less than the low alarm value.

baud

A unit of transmission speed equal to the number of code elements (bits) per second.

big-endian

The adjectives big-endian and little-endian refer to which bytes are most significant in multi-byte data types and describe the order in which a sequence of bytes is stored in a computer's memory. In a big-endian system, the most significant value in the sequence is stored at the lowest storage address (i.e., first). In a little-endian system, the least significant value in the sequence is stored first.

binary

A numbering system that uses only 0 and 1.

bit

Contraction of binary digit. 1. The smallest unit of information in the binary numbering system, represented by a 0 or 1. 2. The smallest division of a programmable controller word.

bps

Bits per second.

buffer

A storage area in the computer where data is held temporarily until the computer can process it.

bus

A channel along which data can be sent.

bus controller

A Genius bus interface board for a programmable controller.

bus scan

One complete communications cycle on the serial bus.

Bus Switching Module

A device that switches a block cluster to one bus or the other of a dual bus.

byte

A sequence of binary digits that can be used to store a value from 0 to 255 and usually operated upon as a unit. Consists of eight bits used to store two numeric or one alpha character.

C

calibration

The process whereby the joint angle of each axis is calculated from a known reference point.

Cartesian coordinate system

A coordinate system whose axes (x, y, and z) are three intersecting perpendicular straight lines. The origin is the intersection of the axes.

Cartesian coordinates

A set of three numbers that defines the location of a point within a rectilinear coordinate system and consisting of three perpendicular axes (x, y, z).

cathode ray tube

A device, like a television set, for displaying information.

central processing unit

The main computer component that is made up of a control section and an arithmetic-logic section. The other basic units of a computer system are input/output units and primary storage.

channel

The device along which data flow between the input/output units of a computer and primary storage.

character

One of a set of elements that can be arranged in ordered groups to express information. Each character has two forms: 1. a man-intelligible form, the graphic, including the decimal digits 0-9, the letters A-Z, punctuation marks, and other formatting and control symbols; 2. a computer intelligible form, the code, consisting of a group of binary digits (bits).

circular

A MOTYPE option in which the robot tool center point moves in an arc defined by three points. These points can be positions or path nodes.

clear

To replace information in a storage unit by zero (or blank, in some machines).

closed loop

A control system that uses feedback. An open loop control system does not use feedback.

C-MOS RAM

Complementary metal-oxide semiconductor random-access memory. A read/write memory in which the basic memory cell is a pair of MOS (metal-oxide semiconductor) transistors. It is an implementation of S-RAM that has very low power consumption, but might be less dense than other S-RAM implementations.

coaxial cable

A transmission line in which one conductor is centered inside and insulated from an outer metal tube that serves as the second conductor. Also known as coax, coaxial line, coaxial transmission line, concentric cable, concentric line, concentric transmission line.

component

An inclusive term used to identify a raw material, ingredient, part or subassembly that goes into a higher level of assembly, compound or other item.

computer

A device capable of accepting information, applying prescribed processes to the information, and supplying the results of these processes.

configuration

The joint positions of a robot and turn number of wrist that describe the robot at a specified position. Configuration is designated by a STRING value and is included in positional data.

continuous path

A trajectory control system that enables the robot arm to move at a constant tip velocity through a series of predefined locations. A rounding effect of the path is required as the tip tries to pass through these locations.

continuous process control

The use of transducers (sensors) to monitor a process and make automatic changes in operations through the design of appropriate feedback control loops. While such devices historically have been mechanical or electromechanical, microcomputers and centralized control is now used, as well.

continuous production

A production system in which the productive equipment is organized and sequenced according to the steps involved to produce the product. Denotes that material flow is continuous during the production process. The routing of the jobs is fixed and set-ups are seldom changed.

controlled stop

A controlled stop controls robot deceleration until it stops. When a safety stop input such as a safety fence signal is opened, the robot decelerates in a controlled manner and then stops. After the robot stops, the Motor Control Contactor opens and drive power is removed.

controller

A hardware unit that contains the power supply, operator controls, control circuitry, and memory that directs the operation and motion of the robot and communications with external devices. See control unit.

controller memory

A medium in which data are retained. Primary storage refers to the internal area where the data and program instructions are stored for active use, as opposed to auxiliary or external storage (magnetic tape, disk, diskette, and so forth.)

control, open-loop

An operation where the computer applies control directly to the process without manual intervention.

control unit

The portion of a computer that directs the automatic operation of the computer, interprets computer instructions, and initiates the proper signals to the other computer circuits to execute instructions.

coordinate system

See Cartesian coordinate system.

CPU

See central processing unit.

CRT

See cathode ray tube.

cps (viscosity)

Centipoises per second.

CRT/KB

Cathode ray tube/keyboard. An optional interface device for the robot system. The CRT/KB is used for some robot operations and for entering programs. It can be a remote device that attaches to the robot via a cable.

cycle

1. A sequence of operations that is repeated regularly. The time it takes for one such sequence to occur. 2. The interval of time during which a system or process, such as seasonal demand or a manufacturing operation, periodically returns to similar initial conditions. 3. The interval of time during which an event or set of events is completed. In production control, a cycle is the length of time between the release of a manufacturing order and shipment to the customer or inventory.

cycle time

1. In industrial engineering, the time between completion of two discrete units of production. 2. In materials management, the length of time from when material enters a production facility until it exits. See throughput.

cursor

An indicator on a teach pendant or CRT display screen at which command entry or editing occurs. The indicator can be a highlighted field or an arrow (> or ^).

cylindrical

Type of work envelope that has two linear major axes and one rotational major axis. Robotic device that has a predominantly cylindrical work envelope due to its design. Typically has fewer than 6 joints and typically has only 1 linear axis.

D

D/A converter

A digital-to-analog converter. A device that transforms digital data into analog data.

D/A value

A digital-to-analog value. Converts a digital bit pattern into a multilevel analog electrical system.

daisy chain

A means of connecting devices (readers, printers, etc.) to a central processor by party-line input/output buses that join these devices by male and female connectors. The last female connector is shorted by a suitable line termination.

daisy chain configuration

A communications link formed by daisy chain connection of twisted pair wire.

data

A collection of facts, numeric and alphabetical characters, or any representation of information that is suitable for communication and processing.

data base

A data file philosophy designed to establish the independence of computer program from data files. Redundancy is minimized and data elements can be added to, or deleted from, the file designs without changing the existing computer programs.

DC

Abbreviation for direct current.

DEADMAN switch

A control switch on the teach pendant that is used to enable servo power. Pressing the DEADMAN switch while the teach pendant is on activates servo power and releases the robot brakes; releasing the switch deactivates servo power and applies the robot brakes.

debugging

The process of detecting, locating and removing mistakes from a computer program, or manufacturing control system. See diagnostic routine.

deceleration tolerance

The specification of the percentage of deceleration that must be completed before a motion is considered finished and another motion can begin.

default

The value, display, function or program automatically selected if you have not specified a choice.

deviation

Usually, the absolute difference between a number and the mean of a set of numbers, or between a forecast value and the actual data.

device

Any type of control hardware, such as an emergency-stop button, selector switch, control pendant, relay, solenoid valve, or sensor.

diagnostic routine

A test program used to detect and identify hardware/software malfunctions in the controller and its associated I/O equipment. See debugging.

diagnostics

Information that permits the identification and evaluation of robot and peripheral device conditions.

digital

A description of any data that is expressed in numerical format. Also, having the states On and Off only.

digital control

The use of a digital computer to perform processing and control tasks in a manner that is more accurate and less expensive than an analog control system.

digital signal

A single point control signal sent to or from the controller. The signal represents one of two states: ON (TRUE, 1. or OFF (FALSE, 0).

directory

A listing of the files stored on a device.

discrete

Consisting of individual, distinct entities such as bits, characters, circuits, or circuit components. Also refers to ON/OFF type I/O blocks.

disk

A secondary memory device in which information is stored on a magnetically sensitive, rotating disk.

disk memory

A non-programmable, bulk-storage, random-access memory consisting of a magnetized coating on one or both sides of a rotating thin circular plate.

drive power

The energy source or sources for the robot servomotors that produce motion.

DRAM

Dynamic Random Access Memory. A read/write memory in which the basic memory cell is a capacitor. DRAM (or D-RAM) tends to have a higher density than SRAM (or S-RAM). Due to the support circuitry required, and power consumption needs, it is generally impractical to use. A battery can be used to retain the content upon loss of power.

E

edit

1. A software mode that allows creation or alteration of a program. 2. To modify the form or format of data, for example, to insert or delete characters.

emergency stop

The operation of a circuit using hardware-based components that overrides all other robot controls, removes drive power from the actuators, and causes all moving parts of to stop. The operator panel and teach pendant are each equipped with EMERGENCY STOP buttons.

enabling device

A manually operated device that, when continuously activated, permits motion. Releasing the device stops the motion of the robot and associated equipment that might present a hazard.

encoder

1. A device within the robot that sends the controller information about where the robot is. 2. A transducer used to convert position data into electrical signals. The robot system uses an incremental optical encoder to provide position feedback for each joint. Velocity data is computed from the encoder signals and used as an additional feedback signal to assure servo stability.

end effector

An accessory device or tool specifically designed for attachment to the robot wrist or tool mounting plate to enable the robot to perform its intended tasks. Examples include gripper, spot weld gun, arc weld gun, spray paint gun, etc.

end-of-arm tooling

Any of a number of tools, such as welding guns, torches, bells, paint spraying devices, attached to the faceplate of the robot wrist. Also called end effector or EOAT.

engineering units

Units of measure as applied to a process variable, for example, psi, Degrees F., etc.

envelope, maximum

The volume of space encompassing the maximum designed movements of all robot parts including the end effector, workpiece, and attachments.

EOAT

See end of arm tooling, tool.

EPROM

Erasable Programmable Read Only Memory. Semiconductor memory that can be erased and reprogrammed. A non-volatile storage memory.

error

The difference in value between actual response and desired response in the performance of a controlled machine, system or process. Alarm=Error.

error message

A numbered message, displayed on the CRT/KB and teach pendant, that indicates a system problem or warns of a potential problem.

Ethernet

A Local Area Network (LAN) bus-oriented, hardware technology that is used to connect computers, printers, terminal concentrators (servers), and many other devices together. It consists of a master cable and connection devices at each machine on the cable that allow the various devices to "talk" to each other. Software that can access the Ethernet and cooperate with machines connected to the cable is necessary. Ethernets come in varieties such as baseband and broadband and can run on different media, such as coax, twisted pair and fiber. Ethernet is a trademark of Xerox Corporation.

execute

To perform a specific operation, such as one that would be accomplished through processing one statement or command, a series of statements or commands, or a complete program or command procedure.

extended axis

An optional, servo-controlled axis that provides extended reach capability for a robot, including in-booth rail, single- or double-link arm, also used to control motion of positioning devices.

F

faceplate

The tool mounting plate of the robot.

feedback

1. The signal or data fed back to a commanding unit from a controlled machine or process to denote its response to the command signal. The signal representing the difference between actual response and desired response that is used by the commanding unit to improve performance of the controlled machine or process. 2. The flow of information back into the control system so that actual performance can be compared with planned performance, for instance in a servo system.

field

A specified area of a record used for a particular category of data. 2. A group of related items that occupy the same space on a CRT/KB screen or teach pendant LCD screen. Field name is the name of the field; field items are the members of the group.

field devices

User-supplied devices that provide information to the PLC (inputs: push buttons, limit switches, relay contacts, an so forth) or perform PLC tasks (outputs: motor starters, solenoids, indicator lights, and so forth.)

file

1. An organized collection of records that can be stored or retrieved by name. 2. The storage device on which these records are kept, such as bubble memory or disk.

filter

A device to suppress interference that would appear as noise.

Flash File Storage

A portion of FROM memory that functions as a separate storage device. Any file can be stored on the FROM disk.

Flash ROM

Flash Read Only Memory. Flash ROM is not battery-backed memory but it is non-volatile. All data in Flash ROM is saved even after you turn off and turn on the robot.

flow chart

A systems analysis tool to graphically show a procedure in which symbols are used to represent operations, data, flow, and equipment. See block diagram, process chart.

flow control

A specific production control system that is based primarily on setting production rates and feeding work into production to meet the planned rates, then following it through production to make sure that it is moving. This concept is most successful in repetitive production.

format

To set up or prepare a memory card or floppy disk (not supported with version 7.20 and later) so it can be used to store data in a specific system.

FR

See Flash ROM.

F-ROM

See Flash ROM.

FROM disk

See Flash ROM.

G

general override stat

A percentage value that governs the maximum robot jog speed and program run speed.

Genius I/O bus

The serial bus that provides communications between blocks, controllers, and other devices in the system especially with respect to GE FANUC Genius I/O.

gripper

The "hand" of a robot that picks up, holds and releases the part or object being handled. Sometimes referred to as a manipulator. See EOAT, tool.

group signal

An input/output signal that has a variable number of digital signals, recognized and taken as a group.

gun

See applicator.

H

Hand Model.

Used in Interference Checking, the Hand Model is the set of virtual model elements (spheres and cylinders) that are used to represent the location and shape of the end of arm tooling with respect to the robot's faceplate.

hardware

1. In data processing, the mechanical, magnetic, electrical and electronic devices of which a computer, controller, robot, or panel is built. 2. In manufacturing, relatively standard items such as nuts, bolts, washers, clips, and so forth.

hard-wire

To connect electric components with solid metallic wires.

hard-wired

1. Having a fixed wired program or control system built in by the manufacturer and not subject to change by programming. 2. Interconnection of electrical and electronic devices directly through physical wiring.

hazardous motion

Unintended or unexpected robot motion that can cause injury.

hexadecimal

A numbering system having 16 as the base and represented by the digits 0 through 9, and A through F.

hold

A smoothly decelerated stopping of all robot movement and a pause of program execution. Power is maintained on the robot and program execution generally can be resumed from a hold.

HTML.

Hypertext Markup Language. A markup language that is used to create hypertext and hypermedia documents incorporating text, graphics, sound, video, and hyperlinks.

http.

Hypertext transfer protocol. The protocol used to transfer HTML files between web servers.

I

impedance

A measure of the total opposition to current flow in an electrical circuit.

incremental encoder system

A positional information system for servomotors that requires calibrating the robot by moving it to a known reference position (indicated by limit switches) each time the robot is turned on or calibration is lost due to an error condition.

index

An integer used to specify the location of information within a table or program.

index register

A memory device containing an index.

industrial robot

A reprogrammable multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions in order to perform a variety of tasks.

industrial robot system

A system that includes industrial robots, end effectors, any equipment devices and sensors required for the robot to perform its tasks, as well as communication interfaces for interlocking, sequencing, or monitoring the robot.

information

The meaning derived from data that have been arranged and displayed in a way that they relate to that which is already known. See data.

initialize

1. Setting all variable areas of a computer program or routine to their desired initial status, generally done the first time the code is executed during each run. 2. A program or hardware circuit that returns a program a system, or hardware device to an original state. See startup, initial.

input

The data supplied from an external device to a computer for processing. The device used to accomplish this transfer of data.

input device

A device such as a terminal keyboard that, through mechanical or electrical action, converts data from the form in which it has been received into electronic signals that can be interpreted by the CPU or programmable controller. Examples are limit switches, push buttons, pressure switches, digital encoders, and analog devices.

input processing time

The time required for input data to reach the microprocessor.

input/output

Information or signals transferred between devices, discreet electrical signals for external control.

input/output control

A technique for controlling capacity where the actual output from a work center is compared with the planned output developed by CRP. The input is also monitored to see if it corresponds with plans so that work centers will not be expected to generate output when jobs are not available to work on.

integrated circuit

A solid-state micro-circuit contained entirely within a chip of semiconductor material, generally silicon. Also called chip.

interactive

Refers to applications where you communicate with a computer program via a terminal by entering data and receiving responses from the computer.

interface

1. A concept that involves the specifications of the inter-connection between two equipments having different functions. 2. To connects a PLC with the application device, communications channel, and peripherals through various modules and cables. 3. The method or equipment used to communicate between devices.

interference zone

An area that falls within the work envelope of a robot, in which there is the potential for the robot motion to coincide with the motion of another robot or machine, and for a collision to occur.

interlock

An arrangement whereby the operation of one control or mechanism brings about, or prevents, the operations of another.

interrupt

A break in the normal flow of a system or program that occurs in a way that the flow can be resumed from that point at a later time. Interrupts are initiated by two types of signals: 1. signals originating within the computer system to synchronize the operation of the computer system with the outside world; 2. signals originating exterior to the computer system to synchronize the operation of the computer system with the outside world.

I/O

Abbreviation for input/output or input/output control.

I/O block

A microprocessor-based, configurable, rugged solid state device to which field I/O devices are attached.

I/O electrical isolation

A method of separating field wiring from logic level circuitry. This is typically done through optical isolation devices.

I/O module

A printed circuit assembly that is the interface between user devices and the Series Six PLC.

I/O scan

A method by which the CPU monitors all inputs and controls all outputs within a prescribed time. A period during which each device on the bus is given a turn to send information and listen to all of the broadcast data on the bus.

ISO

The International Standards Organization that establishes the ISO interface standards.

isolation

1. The ability of a logic circuit having more than one inputs to ensure that each input signal is not affected by any of the others. 2. A method of separating field wiring circuitry from logic level circuitry, typically done optically.

item

1. A category displayed on the teach pendant on a menu. 2. A set of adjacent digits, bits, or characters that is treated as a unit and conveys a single unit of information. 3. Any unique manufactured or purchased part or assembly: end product, assembly, subassembly, component, or raw material.

J

jog coordinate systems

Coordinate systems that help you to move the robot more effectively for a specific application. These systems include JOINT, WORLD, TOOL, and USER.

JOG FRAME

A jog coordinate system you define to make the robot jog the best way possible for a specific application. This can be different from world coordinate frame.

jogging

Pressing special keys on the teach pendant to move the robot.

jog speed

Is a percentage of the maximum speed at which you can jog the robot.

joint

1. A single axis of rotation. There are up to six joints in a robot arm (P-155 swing arm has 8). 2. A jog coordinate system in which one axis is moved at a time.

JOINT

A motion type in which the robot moves the appropriate combination of axes independently to reach a point most efficiently. (Point to point, non-linear motion).

joint interpolated motion

A method of coordinating the movement of the joints so all joints arrive at the desired location at the same time. This method of servo control produces a predictable path regardless of speed and results in the fastest cycle time for a particular move. Also called joint motion.

K

K

Abbreviation for kilo, or exactly 1024 in computer jargon. Related to 1024 words of memory.

KAREL

The programming language developed for robots by the FANUC Robotics America, Inc.

L

label

An ordered set of characters used to symbolically identify an instruction, a program, a quantity, or a data area.

LCD

See liquid crystal display.

lead time

The span of time needed to perform an activity. In the production and inventory control context, this activity is normally the procurement of materials and/or products either from an outside supplier or from one's own manufacturing facility. Components of lead time can include order preparation time, queue time, move or transportation time, receiving and inspection time.

LED

See Light Emitting Diode.

LED display

An alphanumeric display that consists of an array of LEDs.

Light Emitting Diode

A solid-state device that lights to indicate a signal on electronic equipment.

limiting device

A device that restricts the work envelope by stopping or causing to stop all robot motion and that is independent of the control program and the application programs.

limit switch

A switch that is actuated by some part or motion of a machine or equipment to alter the electrical circuit associated with it. It can be used for position detection.

linear

A motion type in which the appropriate combination of axes move in order to move the robot TCP in a straight line while maintaining tool center point orientation.

liquid crystal display

A digital display on the teach pendant that consists of two sheets of glass separated by a sealed-in, normally transparent, liquid crystal material. Abbreviated LCD.

little-endian

The adjectives big-endian and little-endian refer to which bytes are most significant in multi-byte data types and describe the order in which a sequence of bytes is stored in a computer's memory. In a big-endian system, the most significant value in the sequence is stored at the lowest storage address (i.e., first). In a little-endian system, the least significant value in the sequence is stored first.

load

1. The weight (force) applied to the end of the robot arm. 2. A device intentionally placed in a circuit or connected to a machine or apparatus to absorb power and convert it into the desired useful form. 3. To copy programs or data into memory storage.

location

1. A storage position in memory uniquely specified by an address. 2. The coordinates of an object used in describing its x, y, and z position in a Cartesian coordinate system.

lockout/tagout

The placement of a lock and/or tag on the energy isolating device (power disconnecting device) in the off or open position. This indicates that the energy isolating device or the equipment being controlled will not be operated until the lock/tag is removed.

log

A record of values and/or action for a given function.

logic

A fixed set of responses (outputs) to various external conditions (inputs). Also referred to as the program.

loop

The repeated execution of a series of instructions for a fixed number of times, or until interrupted by the operator.

M

mA

See milliampere.

machine language

A language written in a series of bits that are understandable by, and therefore instruct, a computer. This is a "first level" computer language, as compared to a "second level" assembly language, or a "third level" compiler language.

machine lock

A test run option that allows the operator to run a program without having the robot move.

macro

A source language instruction from which many machine-language instructions can be generated.

magnetic disk

A metal or plastic floppy disk (not supported on version 7.10 and later) that looks like a phonograph record whose surface can store data in the form of magnetized spots.

magnetic disk storage

A storage device or system consisting of magnetically coated metal disks.

magnetic tape

Plastic tape, like that used in tape recorder, on which data is stored in the form of magnetized spots.

maintenance

Keeping the robots and system in their proper operating condition.

MC

See memory card.

mechanical unit

The robot arm, including auxiliary axis, and hood/deck and door openers.

medium

plural **media** . The physical substance upon which data is recorded, such as a memory card (or floppy disk which is not supported on version 7.10 and later).

memory

A device or media used to store information in a form that can be retrieved and is understood by the computer or controller hardware. Memory on the controller includes C-MOS RAM, Flash ROM and D-RAM.

memory card

A C-MOS RAM memory card or a flash disk-based PC card.

menu

A list of options displayed on the teach pendant screen.

message

A group of words, variable in length, transporting an item of information.

microprocessor

A single integrated circuit that contains the arithmetic, logic, register, control and memory elements of a computer.

microsecond

One millionth (0.000001) of a second

milliampere

One one-thousandth of an ampere. Abbreviated mA.

millisecond

One thousandth of a second. Abbreviated msec.

module

A distinct and identifiable unit of computer program for such purposes as compiling, loading, and linkage editing. It is eventually combined with other units to form a complete program.

motion type

A feature that allows you to select how you want the robot to move from one point to the next. MOTYPES include joint, linear, and circular.

mode

1. One of several alternative conditions or methods of operation of a device. 2. The most common or frequent value in a group of values.

N

network

1. The interconnection of a number of devices by data communication facilities. "Local networking" is the communications network internal to a robot."Global networking" is the ability to provide communications connections outside of the robot's internal system. 2. Connection of geographically separated computers and/or terminals over communications lines. The control of transmission is managed by a standard protocol.

non-volatile memory

Memory capable of retaining its stored information when power is turned off.

O

Obstacle Model.
Used in Interference Checking, the Obstacle Model is the set of virtual model elements (spheres, cylinders, and planes) that are used to represent the shape and the location of a given obstacle in space.

off-line
Equipment or devices that are not directly connected to a communications line.

off-line operations
Data processing operations that are handled outside of the regular computer program. For example, the computer might generate a report off-line while the computer was doing another job.

off-line programming
The development of programs on a computer system that is independent of the "on-board" control of the robot. The resulting programs can be copied into the robot controller memory.

offset
The count value output from a A/D converter resulting from a zero input analog voltage. Used to correct subsequent non-zero measurements also incremental position or frame adjustment value.

on-line
A term to describe equipment or devices that are connected to the communications line.

on-line processing
A data processing approach where transactions are entered into the computer directly, as they occur.

operating system
Lowest level system monitor program.

operating work envelope
The portion of the restricted work envelope that is actually used by the robot while it is performing its programmed motion. This includes the maximum the end-effector, the workpiece, and the robot itself.

operator
A person designated to start, monitor, and stop the intended productive operation of a robot or robot system.

operator box
A control panel that is separate from the robot and is designed as part of the robot system. It consists of the buttons, switches, and indicator lights needed to operate the system.

operator panel
A control panel designed as part of the robot system and consisting of the buttons, switches, and indicator lights needed to operate the system.

optional features
Additional capabilities available at a cost above the base price.

OR

An operation that places two contacts or groups of contacts in parallel. Any of the contacts can control the resultant status, also a mathematical operation.

orientation

The attitude of an object in space. Commonly described by three angles: rotation about x (w), rotation about y (p), and rotation about z (r).

origin

The point in a Cartesian coordinate system where axes intersect; the reference point that defines the location of a frame.

OT

See overtravel.

output

Information that is transferred from the CPU for control of external devices or processes.

output device

A device, such as starter motors, solenoids, that receive data from the programmable controller.

output module

An I/O module that converts logic levels within the CPU to a usable output signal for controlling a machine or process .

outputs

Signals, typically on or off, that controls external devices based upon commands from the CPU.

override

See general override.

overtravel

A condition that occurs when the motion of a robot axis exceeds its prescribed limits.

overwrite

To replace the contents of one file with the contents of another file when copying.

P

parity

The anticipated state, odd or even, of a set of binary digits.

parity bit

A binary digit added to an array of bits to make the sum of all bits always odd or always even.

parity check

A check that tests whether the number of ones (or zeros) in an array of binary digits is odd or even.

parity error

A condition that occurs when a computed parity check does not agree with the parity bit.

part

A material item that is used as a component and is not an assembly or subassembly.

pascal

A unit of pressure in the meter-kilogram-second system equivalent to one newton per square meter.

path

1. A variable type available in the KAREL system that consists of a list of positions. Each node includes positional information and associated data. 2. The trajectory followed by the TCP in a move.

PCB

See printed circuit board.

PC Interface

The PC Interface software uses Ethernet connections to provide file transfer protocol (FTP) functions, PC send macros, telnet interface, TCP/IP interface web server functions, and host communications.

pendant

See teach pendant.

PLC

See programmable logic controller or cell controller.

PMC

The programmable machine controller (PMC) functions provide a ladder logic programming environment to create PMC functions. This provides the capability to use the robot I/O system to run PLC programs in the background of normal robot operations. This function can be used to control bulk supply systems, fixed automation that is part of the robot workcell, or other devices that would normally require basic PLC controls.

printed circuit board

A flat board whose front contains slots for integrated circuit chips and connections for a variety of electronic components, and whose back is printed with electrically conductive pathways between the components.

production mode

See automatic mode.

program

1. A plan for the solution of a problem. A complete program includes plans for the transcription of data, coding for the computer, and plans for the absorption of the results into the system. 2. A sequence of instructions to be executed by the computer or controller to control a robot/robot system. 3. To furnish a computer with a code of instructions. 4. To teach a robot system a specific set of movements and instructions to do a task.

programmable controller

See programmable logic controller or cell controller.

programmable logic controller

A solid-state industrial control device that receives inputs from user-supplied control devices, such as switches and sensors, implements them in a precise pattern determined by ladder diagram-based programs stored in the user memory, and provides outputs for control of processes or user-supplied devices such as relays and motor starters.

Program ToolBox

The Program ToolBox software provides programming utilities such as mirror image and flip wrist editing capabilities.

protocol

A set of hardware and software interfaces in a terminal or computer that allows it to transmit over a communications network, and that collectively forms a communications language.

psi

Pounds per square inch.

Q

queue.

1. Waiting lines resulting from temporary delays in providing service. 2. The amount of time a job waits at a work center before set-up or work is performed on the job. See also job queue.

R

RAM

See Random Access Memory.

random access

A term that describes files that do not have to be searched sequentially to find a particular record but can be addressed directly.

Random Access Memory

1. Volatile, solid-state memory used for storage of programs and locations; battery backup is required. 2. The working memory of the controller. Programs and variable data must be loaded into RAM before the program can execute or the data can be accessed by the program.

range

1. A characterization of a variable or function. All the values that a function can possess. 2. In statistics, the spread in a series of observations. 3. A programmable voltage or current spectrum of values to which input or output analog signals can be limited.

RI

Robot input.

RO

Robot output.

read

To copy, usually from one form of storage to another, particularly from external or secondary storage to internal storage. To sense the meaning of arrangements of hardware. To sense the presence of information on a recording medium.

Read Only Memory

A digital memory containing a fixed pattern of bits that you cannot alter.

record

To store the current set or sets of information on a storage device.

recovery

The restoration of normal processing after a hardware or software malfunction through detailed procedures for file backup, file restoration, and transaction logging.

register

1. A special section of primary storage in a computer where data is held while it is being worked on.
2. A memory device capable of containing one or more computer bits or words.

remote/local

A device connection to a given computer, with remote devices being attached over communications lines and local devices attached directly to a computer channel; in a network, the computer can be a remote device to the CPU controlling the network.

repair

To restore robots and robot systems to operating condition after damage, malfunction, or wear.

repeatability

The closeness of agreement among the number of consecutive movements made by the robot arm to a specific point.

reset

To return a register or storage location to zero or to a specified initial condition.

restricted work envelope

That portion of the work envelope to which a robot is restricted by limiting devices that establish limits that will not be exceeded in the event of any reasonably foreseeable failure of the robot or its controls. The maximum distance the robot can travel after the limited device is actuated defines the restricted work envelope of the robot.

RIA

Robotic Industries Association Subcommittee of the American National Standards Institute, Inc.

robot

A reprogrammable multifunctional manipulator designed to move material, parts, tools, or specialized devices, through variable programmed motions for the performance of a variety of tasks.

Robot Model.

Used in Interference Checking, the Robot Model is the set of virtual model elements (sphere and cylinders) that are used to represent the location and shape of the robot arm with respect to the robot's base. Generally, the structure of a six axes robot can be accurately modeled as a series of cylinders and spheres. Each model element represents a link or part of the robot arm.

ROM

See Read Only Memory.

routine

1. A list of coded instructions in a program. 2. A series of computer instructions that performs a specific task and can be executed as often as needed during program execution.

S

saving data.

Storing program data in Flash ROM, to a floppy disk (not supported on version 7.10 and later), or memory card.

scfm

Standard cubic feet per minute.

scratch start

Allows you to enable and disable the automatic recovery function.

sensor

A device that responds to physical stimuli, such as heat, light, sound pressure, magnetism, or motion, and transmits the resulting signal or data for providing a measurement, operating a control or both. Also a device that is used to measure or adjust differences in voltage in order to control sophisticated machinery dynamically.

serial communication

A method of data transfer within a PLC whereby the bits are handled sequentially rather than simultaneously as in parallel transmission.

serial interface

A method of data transmission that permits transmitting a single bit at a time through a single line. Used where high speed input is not necessary.

Server Side Include (SSI)

A method of calling or "including" code into a web page.

servomotor
An electric motor that is controlled to produce precision motion. Also called a "smart" motor.

SI
System input.

signal
The event, phenomenon, or electrical quantity that conveys information from one point to another.

significant bit
A bit that contributes to the precision of a number. These are counted starting with the bit that contributes the most value, of "most significant bit", and ending with the bit that contributes the least value, or "least significant bit".

singulating
Separating parts into a single layer.

slip sheet
A sheet of material placed between certain layers of a unit load. Also known as tier sheet.

SO
System output.

specific gravity
The ratio of a mass of solid or liquid to the mass of an equal volume of water at 45C. You must know the specific gravity of the dispensing material to perform volume signal calibration. The specific gravity of a dispensing material is listed on the MSDS for that material.

SRAM
A read/write memory in which the basic memory cell is a transistor. SRAM (or S-RAM) tends to have a lower density than DRAM. A battery can be used to retain the content upon loss of power.

slpm
Standard liters per minute.

Standard Operator Panel (SOP).
A panel that is made up of buttons, keyswitches, and connector ports.

state
The on or off condition of current to and from and input or output device.

statement
See instruction.

storage device
Any device that can accept, retain, and read back one or more times. The available storage devices are SRAM, Flash ROM (FROM or F-ROM), floppy disks (not available on version 7.10 and later), memory cards, or a USB memory stick.

system variable

An element that stores data used by the controller to indicate such things as robot specifications, application requirements, and the current status of the system.

T

Tare

The difference between the gross weight of an object and its contents, and the object itself. The weight of an object without its contents.

TCP

See tool center point.

teaching

Generating and storing a series of positional data points effected by moving the robot arm through a path of intended motions.

teach mode

1. The mode of operation in which a robot is instructed in its motions, usually by guiding it through these motions using a teach pendant. 2. The generation and storage of positional data. Positional data can be taught using the teach pendant to move the robot through a series of positions and recording those positions for use by an application program.

teach pendant

1. A hand-held device used to instruct a robot, specifying the character and types of motions it is to undertake. Also known as teach box, teach gun. 2. A portable device, consisting of an LCD display and a keypad, that serves as a user interface to the KAREL system and attaches to the operator box or operator panel via a cable. The teach pendant is used for robot operations such as jogging the robot, teaching and recording positions, and testing and debugging programs.

telemetry

The method of transmission of measurements made by an instrument or a sensor to a remote location.

termination type

Feature that controls the blending of robot motion between segments.

tool

A term used loosely to define something mounted on the end of the robot arm, for example, a hand, gripper, or an arc welding torch.

tool center point

1. The location on the end-effector or tool of a robot hand whose position and orientation define the coordinates of the controlled object. 2. Reference point for position control, that is, the point on the tool that is used to teach positions. Abbreviated TCP.

TOOL Frame

The Cartesian coordinate system that has the position of the TCP as its origin to stet. The z-axis of the tool frame indicates the approach vector for the tool.

TP.

See teach pendant.

transducer

A device for converting energy from one form to another.

U

UOP

See user operator panel.

URL

Universal Resource Locator. A standard addressing scheme used to locate or reference files on web servers.

USB memory stick

The controller USB memory stick interface supports a USB 1.1 interface. The USB Organization specifies standards for USB 1.1 and 2.0. Most memory stick devices conform to the USB 2.0 specification for operation and electrical standards. USB 2.0 devices as defined by the USB Specification must be backward compatible with USB 1.1 devices. However, FANUC Robotics does not support any security or encryption features on USB memory sticks. The controller supports most widely-available USB Flash memory sticks from 32MB up to 1GB in size.

USER Frame

The Cartesian coordinate system that you can define for a specific application. The default value of the User Frame is the World Frame. All positional data is recorded relative to User Frame.

User Operator Panel

User-supplied control device used in place of or in parallel with the operator panel or operator box supplied with the controller. Abbreviated UOP .

V

variable

A quantity that can assume any of a given set of values.

variance

The difference between the expected (or planned) and the actual, also statistics definitions.

vision system

A device that collects data and forms an image that can be interpreted by a robot computer to determine the position or to “see” an object.

volatile memory

Memory that will lose the information stored in it if power is removed from the memory circuit device.

W

web server

An application that allows you to access files on the robot using a standard web browser.

warning device

An audible or visible device used to alert personnel to potential safety hazards.

work envelope

The volume of space that encloses the maximum designed reach of the robot manipulator including the end effector, the workpiece, and the robot itself. The work envelope can be reduced or restricted by limiting devices. The maximum distance the robot can travel after the limit device is actuated is considered the basis for defining the restricted work envelope.

write

To deliver data to a medium such as storage.

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