GE Fanuc Automation

Programmable Control Products

PACSystems® RX3i

Serial Communications Modules

User's Manual, GFK-2460A

March 2007

GFL-002

Warnings, Cautions, and Notes as Used in this Publication

Warning

Warning notices are used in this publication to emphasize that hazardous voltages, currents, temperatures, or other conditions that could cause personal injury exist in this equipment or may be associated with its use.

In situations where inattention could cause either personal injury or damage to equipment, a Warning notice is used.

Caution

Caution notices are used where equipment might be damaged if care is not taken.

Note

Notes merely call attention to information that is especially significant to understanding and operating the equipment.

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Contents

Chapter 1 Introduction

This chapter is an introduction to the PACSystems RX3i Serial Communications modules:

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  - Module Specifications
  - Communications Standards
- **Introduction to Installing Serial Communications Modules**
- **Introduction to Serial Communications Module Configuration**
- **Introduction to Serial Communications Module Data**
  - Status and Control Data
  - Serial Communications Data
- **Introduction to MODBUS Communications**
  - Supported MODBUS Functions
  - Supported Transmission Mode
- **Introduction to Serial I/O Communications**
- **Introduction to CCM Slave Communications**

Additional Documentation

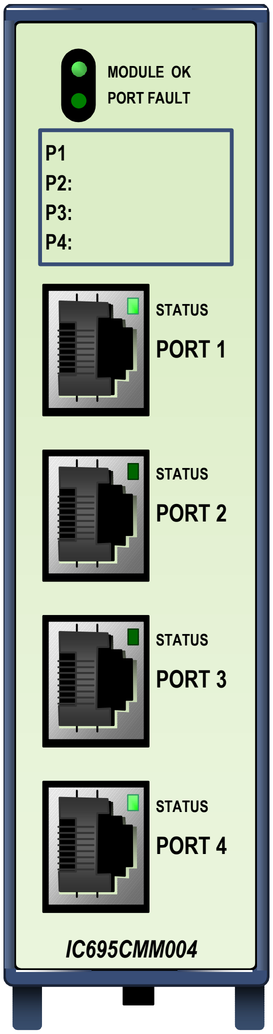
PACSystems Serial Communications Modules IC695CMM002 and IC695CMM004, GFK-2461. This datasheet-type document contains the same module descriptions and specifications found in this user manual, plus the most up-to-date release information for these two modules.

PACSystems RX3i System Manual, GFK-2314. This manual details system and module installation procedures, and includes descriptions and specifications of PACSystems RX3i I/O and option modules.

PACSystems RX3i user manuals, module datasheets, and other important product documents are available online at www.gefanuc.com. They are also included in the *Infolink for PLC* documentation library on CDs, catalog number IC690CDR002.

RX3i Serial Communications modules function as part of a larger control system. Additional documentation may be needed to complete the system installation and configuration.

Introduction to PACSystems RX3i Serial Communications Modules



PACSystems RX3i Serial Communications modules expand the serial communications capabilities of an RX3i system.

Serial Communications module IC695CMM002 provides two independent, isolated serial ports. Serial Communications module IC695CMM004, illustrated at right, provides four independent, isolated serial ports. Up to six Serial Communications modules can be located in the main PACSystems RX3i backplane.

Each port can be configured for MODBUS Master, MODBUS Slave, Serial I/O protocol. In addition, for modules that are version 1.02 or later, each port can be configured for CCM Slave protocol.

Additional module features include:

- Port-to-port isolation and port-to-backplane isolation.
- RS-232, RS-485/422 communication, software-selected
- Hardware handshake: RTS/CTS for RS-232
- Selectable Baud Rates: 1200, 2400, 4800, 9600, 19.2K, 38.4K, 57.6K, 115.2K
- Module fault status reporting (Watchdog, Ram Fail, Flash Fail)
- Module identity and status reporting, including LED status indicators
- Meets CE, UL/CUL 508 and 1604, and ATEX requirements
- Flash memory for future upgrades

These modules must be located in an RX3i Universal Backplane. An RX3i CPU with firmware version 3.83 or later is required. Machine Edition 5.5 with Service Pack 2 SIM 4 or later is required for configuration. Machine Edition 5.6 SIM 6 or later is required for CCM Slave protocol. RX3i Serial Communications Modules can be hot-inserted and removed following the instructions in the *PACSystems RX3i System Manual*, GFK-2314.

Module Specifications

Number of Serial Ports	IC695CMM002: two independent serial ports IC695CMM004: four independent serial ports	
Connectors	RJ-45	
Number of Serial Communications Modules per CPU	Six in the main CPU backplane	
Backplane power requirements	IC695CMM002	0.7 Amps maximum @ 3.3 VDC 0.115 Amps maximum @ 5.0 VDC
	IC695CMM004	0.7 Amps maximum @ 3.3 VDC 0.150 Amps maximum @ 5.0 VDC
LEDs	Module OK, Port Fault, Port Status (2 or 4)	
Port Type	RS-232 or RS-485/22, 4-wire (full duplex) or 2-wire (half-duplex) operation for RS-485/422	
Flow Control for R-232	Selectable: Hardware (CTS/RTS) or none	
Turnaround Delay	6mS minimum enforced by module. External devices must hold off response for at least 6ms after the last character received.	
Baud rates	1200, 2400, 4800, 9600, 19.2K, 38.4K, 57.6K, 115.2K	
Parity	Even, odd, none	
Data bits	7, 8	
Stop bits	1, 2	
Operating Temperature	0°C to + 60°C	
Input Impedance	Zin > 96 kOhm for RS-485/422 3 kOhm < Zin < 7 kOhm for RS-232	
Max Overvoltage	+/- 25V	
Channel-Channel Crosstalk	-55 dB minimum	
Isolation	Port to Backplane and to frame ground: 250 VAC continuous; 1500 VAC for 1 minute, 2550VDC for one second. Port to port: 500VDC continuous, 710VDC for one minute.	

In order to meet emission and immunity requirements for the EMC directive (CE mark), shielded cable must be used with this module.

Communications Standards

Each port on an RX3i Serial Communications module supports the RS-232, RS-422, and RS-485 standards for asynchronous serial communications. RS-485 has largely replaced RS-422, because it guarantees multidrop capability.

RS-232

In RS-232 mode, a port transmits and receives data and control signals on unbalanced circuits, with one Signal Common (or Signal Ground) wire serving as the return path for all the data and control circuits. RS-232 is suitable for point-to-point connections up to about 25 meters in length. It is not suitable for longer lines or multidrop connections. The RS-232 specification recommends limiting the data rate to 19,200 bits per second (bps) or less, but rates up 115,200 bps are sometimes used with short cables (typically about 2 meters).

RS-485

In RS-485 mode, line drivers in the data circuits are required to switch to a high-impedance state except when transmitting, and the control and status circuits are rarely connected through the cable in multidrop applications. Consequently, multiple data line drivers can be connected in parallel to each data circuit. The port firmware guarantees only one port at a time will attempt to transmit on each circuit.

RS-485 uses 120-ohm cable and terminating resistors. Because transmitters are not always connected to the line, terminating resistors must be used at both ends of each circuit.

Some RS-485 serial devices require pull-up and pull-down resistors to polarize (bias) receive-data circuits to the mark state when all transmitters are in the high-impedance state. The ports on RX3i Serial Communications modules do not require pull-up and pull-down resistors.

In a multidrop network, slave devices must all use RS-485-compatible serial ports so that their transmitters are disabled except when transmitting. The master may use either RS-422 or RS-485 because it is the only transmitter on that pair.

Introduction to Installing Serial Communications Modules

Up to six RX3i Serial Communications modules can be installed in the PACSystems Universal Backplane. Modules are installed following the general installation instructions in the *PACSystems RX3i System Manual*, GFK-2314.

Chapter 2 of this manual, *Installation and Wiring*, describes the module LEDs and communications ports, and gives port pin assignments. Note that RX3i Serial Communications modules require custom cables for MODBUS communications; their port pin assignments do not match the MODBUS specification.

RX3i Serial Communications modules can be connected to one serial device for either RS-232 or RS-422/485 communications. Connections to multiple devices require RS-422 or RS-485 communications. Each port is easily set up for either RS-232 or RS-485 communications in the module configuration.

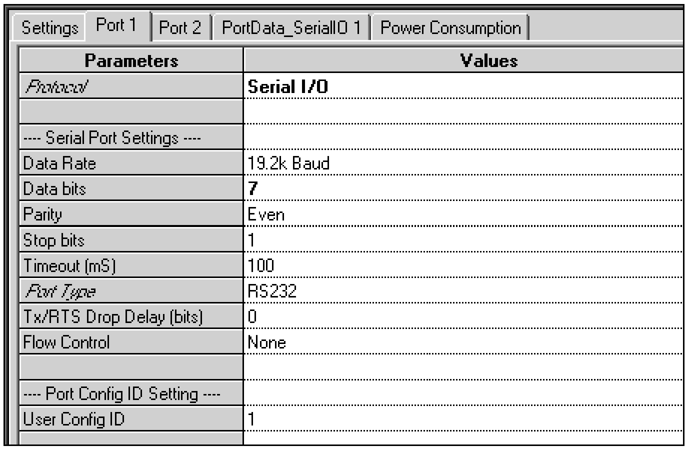
MODBUS Multidrop RS-485

For multidrop MODBUS connections in an RS-485 system, either two-wire or four-wire:

- At least 32 devices can be connected to an RS-485 network without a repeater. Repeaters can be used if more devices are required.
- An RS-485 MODBUS serial line without a repeater has one trunk cable. Devices can be either connected directly, or using short branch cables (up to 20 meters).
- In multidrop mode, MODBUS slave devices must all use RS-485-compatible serial ports so that their transmitters are disabled except when transmitting. Although some RS-422 devices disable outputs when not transmitting, the RS-422 specification does not require it. The master may use either RS-422 or RS-485 because it is the only transmitter on that pair.
- If a multi-port tap is used, each branch has a maximum length of 40 meters divided by the number of branches fed by that tap.
- Two-wire devices can be connected to a four-wire network and vice-versa, following the instructions in chapter 2.

Introduction to Serial Communications Module Configuration

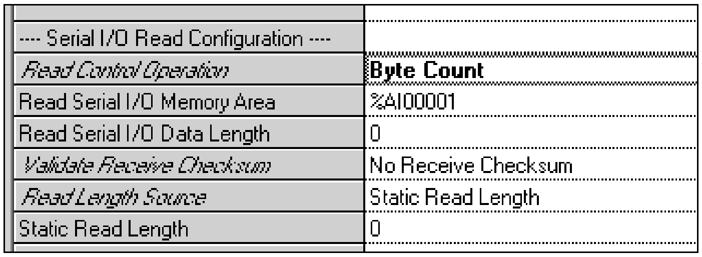
Chapter 3, *Configuration,* describes the configurable parameters of PACSystems RX3i Serial Communications modules. Configuration with Proficy® Machine Edition software is an important part of setting up module communications, because RX3i Serial Communications modules do not use COMMREQs for communications between the CPU and the module. A module's configuration determines all of its communications capabilities, from the basic setup of each port:



Settings | Port 1 | Port 2 | PortData_SerialIO 1 | Power Consumption

Parameters	Values
Protocol	**Serial I/O**
---- Serial Port Settings ----	
Data Rate	19.2k Baud
Data bits	**7**
Parity	Even
Stop bits	1
Timeout (mS)	100
Port Type	RS232
Tx/RTS Drop Delay (bits)	0
Flow Control	None
---- Port Config ID Setting ----	
User Config ID	1

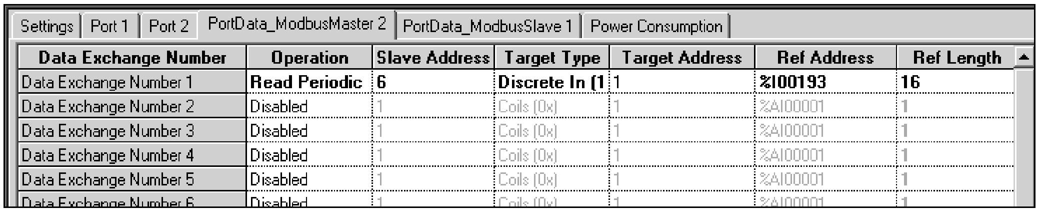
To the details of reading and writing data:



---- Serial I/O Read Configuration ----	
Read Control Operation	**Byte Count**
Read Serial I/O Memory Area	%AI00001
Read Serial I/O Data Length	0
Validate Receive Checksum	No Receive Checksum
Read Length Source	Static Read Length
Static Read Length	0

For some slave protocols, pre-configured default data exchanges are provided that can be used as-is or customized for the application..

For other protocols, such as MODBUS master, the configuration of a port includes defining all of the data exchanges that will be read or written by the port. Up to 64 exchanges can be defined.



Settings | Port 1 | Port 2 | PortData_ModbusMaster 2 | PortData_ModbusSlave 1 | Power Consumption

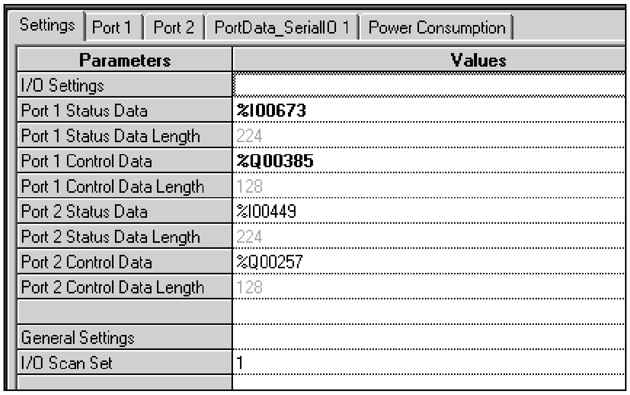
Data Exchange Number	Operation	Slave Address	Target Type	Target Address	Ref Address	Ref Length
Data Exchange Number 1	**Read Periodic**	**6**	**Discrete In (1**	1	**%I00193**	**16**
Data Exchange Number 2	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 3	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 4	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 5	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 6	Disabled	1	Coils (0x)	1	%AI00001	1

Introduction to Serial Communications Module Data

During system operation, an RX3i Serial Communications module exchanges two basic types of data with the system CPU: Status and Control data, and Serial Communications data. Data formats are detailed in chapter 4, *Port Status and Control Data.*

Status and Control Data

The module exchanges status (input) and control (output) data for each port with the CPU during the CPU's I/O Scan. Transfer of this data is controlled by the CPU. Status and control data for each port uses reference addresses that are assigned during module configuration:

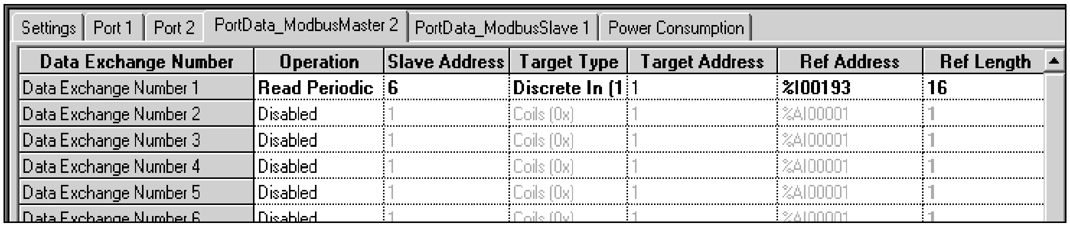


Parameters	Values
I/O Settings	
Port 1 Status Data	**%I00673**
Port 1 Status Data Length	224
Port 1 Control Data	**%Q00385**
Port 1 Control Data Length	128
Port 2 Status Data	%I00449
Port 2 Status Data Length	224
Port 2 Control Data	%Q00257
Port 2 Control Data Length	128
General Settings	
I/O Scan Set	1

The application logic monitors the status data for each port in the input references, and sends commands to the port in the output references. Those commands control the port's communications, which result in the communications data described below. While the CPU is stopped, it does not read Port Status (input) data from the module. When the CPU goes back into Run mode, it starts reading the Status data again.

Serial Communications Data

Serial communications data is exchanged separately and stored separately from the Port Status and Port Control Data. Transfer of this data to and from the RX3i CPU is controlled by the module and is not synchronized with the I/O Scan. When the CPU is stopped or outputs are disabled, the module continues exchanging serial communications data with the CPU. Communications data uses another set of CPU reference addresses that are assigned during port configuration, as shown below for a port in MODBUS Master mode:



Data Exchange Number	Operation	Slave Address	Target Type	Target Address	Ref Address	Ref Length
Data Exchange Number 1	**Read Periodic**	**6**	**Discrete In (1**	1	**%I00193**	**16**
Data Exchange Number 2	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 3	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 4	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 5	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 6	Disabled	1	Coils (0x)	1	%AI00001	1

Introduction to MODBUS Communications

Each port on an RX3i Serial Communications module can be set up for either MODBUS Master or MODBUS Slave operation.

RX3i Serial Communications modules handle MODBUS master or slave communications without the need for COMMREQ commands in the application program. Chapter 5, *MODBUS Communications,* explains how RX3i Serial Communications modules handle each supported MODBUS function, in master or slave mode. The following MODBUS functions are supported:

Supported MODBUS Functions

Function Code	***Function***	***MODBUS Master***	***MODBUS Slave***
01	Read Coil Status (Read Output Table)	Yes	Yes
02	Read Input Status (Read Input Table)	Yes	Yes
03	Read Holding Registers	Yes	Yes
04	Read Input Registers (Read Registers)	Yes	Yes
05	Force Single Coil (Force Single Output)	Yes	Yes
06	Preset/Write Single Register	Yes	Yes
07	Read Exception Status	No	Yes
08	Diagnostics (Loopback Maintenance)	Yes	Yes
	Diagnostic Code 00: Return Query Data: Reads query data from one slave.	Yes	Yes
15	Write Multiple Coils (Force Multiple Outputs)	Yes	Yes
16	Preset/Write Multiple Registers Presets a group of contiguous registers to a specified value.	Yes	Yes
17	Report Slave ID(Report Device Type).	No	Yes
20	Mask 4x Registers	No	Yes
23	Read/Write 4x Registers	No	Yes

Supported Transmission Mode

RX3i Serial Communications modules execute MODBUS communications in RTU (Remote Terminal Unit) transmission mode. The entire message is transmitted as a continuous stream of characters. Between characters, the line is held in the 1 state. In RTU transmission mode, gaps of silence are used to frame a message. Because message frames must be separated by the intervals of silence, MODBUS RTU is not recommended for use with modems, which can compress or change the gaps between frames and interfere with message timing.

Introduction to Serial I/O Communications

Each port on an RX3i Serial Communications module can be set up for Serial I/O protocol. In Serial I/O mode, the port can exchange up to 2K bytes of data with an individual serial device, such as a modem.

RX3i Serial Communications modules support the same Serial I/O protocol features as the RX3i CPU. Chapter 6, *Serial I/O Communications,* compares the Serial I/O functions implemented using COMMREQs in an RX3i CPU with the same functions for an RX3i Serial Communications module.

The basic setup for read and write operations is done in the port configuration.

The port can be configured to read:

- A data string of variable length, up to a specified termination character.
- A predetermined length of data. When the specified number of bytes have been read, the read operation stops.
- A changeable length of data, with the length supplied by the application in the port's output data. When the specified number of bytes have been read, the read operation stops.
- The entire contents of the ports 2K bytes input buffer.

The port can be configured to write:

- A predetermined length of data. When the specified number of bytes have been written, the write operation stops.
- A changeable length of data, with the length supplied by the application in the port's output data. When the specified number of bytes have been written, the write operation stops.

Monitoring and Controlling Serial I/O Communications

Instead of using COMMREQ commands in the application program, RX3i Serial Communications modules use the port's status and control data to monitor and control serial communications. Chapter 4, *Status and Control Data,* describes all of the input and output data that is automatically exchanged between the CPU and a Serial Communications module. The application uses this data to start and stop communications, to monitor communications status, to clear errors, to reset the port, and to implement hardware flow control.

Introduction to CCM Slave Communications

Each port on an RX3i Serial Communications module (revision 1.10 or later, and Proficy™ Machine Edition 5.6 SIM 6 or later) can be set up for CCM Slave protocol. CCM Slave protocol makes RX3i CPU data accessible to a variety of GE Fanuc devices, such as Series 90-30 and Series 90-30 CCM and PCM modules. RX3i Serial Communications modules do not support CCM Master or peer-to-peer operation.

CCM Networks use the RS-232 / RS-422 communication standards. RS-422 is necessary for a multi-drop Master-Slave network. Communication is asynchronous, half-duplex at speeds up to 115.2K baud.

As a CCM Slave, an RX3i Serial Communications Module will respond to the CCM Master commands listed below. The Command Numbers listed in the left column are used in the Master's application program to identify the command to be executed; they are not part of the CCM communication itself, and they are not relevant to the RX3i Serial Communications Module.

Master Command Number	***Command Description***
6101	Read from target to source register table
6102	Read from target to source input table
6103	Read from target to source output table
6109	Read Q-Response to source register table
6110	Single bit write.
6111	Write to target from source register table
6112	Write to target from source input table
6113	Writeto target from source Output Table

CCM Protocol defines additional commands that can be used by Masters or by other CCM devices. However, any CCM command that is not listed above cannot be processed by an RX3i Serial Communications module. That includes Local CCM commands that might be sent in COMMREQs by the RX3i CPU. The functions performed using Local CCM commands for other types of CCM modules are not used for RX3i Serial Communications Modules.

Implementation of CCM functions for an RX3i Serial Communications module is different from the implementation for other CCM devices. Chapter 7, *CCM Communications,* describes CCM for an RX3i Serial Communications module.

Chapter 2 Installation and Wiring

This chapter provides installation information for RX3i Serial Communications modules.

- **LEDs**
  - Module LEDs
  - Port LEDs
- **Serial Ports**
  - Port Pin Assignments
  - Built-in Termination
- **Point to Point Serial Connections**
  - RS-232 MODBUS
- **MODBUS Multidrop Connections**
  - Grounding and Ground Loops
  - Multidrop Connections for Four-Wire MODBUS
  - Multidrop Connections for Two-Wire MODBUS

For additional module installation and system installation information, please refer to the *PACSystems RX3i System Manual*, GFK-2314.

Installation in Hazardous Locations

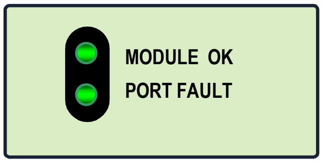
The information below applies to modules that are installed in hazardous locations. For more information about standards compliance, please refer to Appendix A of the *PACSystems RX3i System Manual,* GFK-2314.

- EQUIPMENT LABELED WITH REFERENCE TO CLASS I, GROUPS A, B, C & D, DIV. 2 HAZARDOUS LOCATIONS IS SUITABLE FOR USE IN CLASS I, DIVISION 2, GROUPS A, B, C, D OR NON-HAZARDOUS LOCATIONS ONLY
- WARNING - EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2;
- WARNING - EXPLOSION HAZARD - WHEN IN HAZARDOUS LOCATIONS, TURN OFF POWER BEFORE REPLACING OR WIRING MODULES; AND
- WARNING - EXPLOSION HAZARD - DO NOT CONNECT OR DISCONNECT EQUIPMENT UNLESS POWER HAS BEEN SWITCHED OFF OR THE AREA IS KNOWN TO BE NONHAZARDOUS.

LEDs

RX3i Serial Communications provide visual indication of module and port status with the LEDs described below.

Module LEDs



The Module OK LED indicates the status of the module. Solid green indicates that the module has been configured.

The Module OK LED is off if the module is not receiving power from the RX3i backplane or if a serious module fault exists.

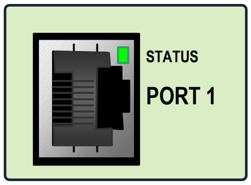
At powerup, the Module OK LED flashes green/off while the module is executing powerup diagnostics. It then flashes more slowly as the module receives its configuration from the CPU.

If a problem occurs, the Module OK LED blinks amber to indicate the cause of the error.

1 = watchdog expired
2 = RAM error
6 = Invalid CPU Master Interface version
7 = CPU heartbeat failure
8 = Failed to get semaphore

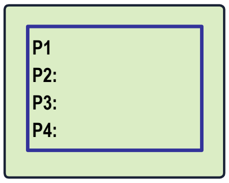
The Port Fault LED indicates the status of all ports. The Port Fault LED is green when there are no faults present on any enabled port. If this LED turns amber, there is a fault on at least one port.

Port LEDs



Each port has a Status LED that flashes green when there is activity on the port.

Recording Port Assignments



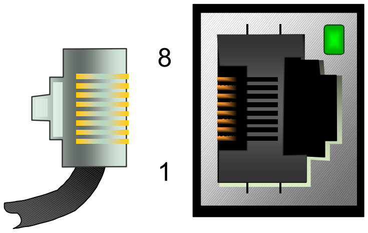
The front of the module has an area where identifying information about each port should be written.

Serial Ports

RX3i Serial Communications modules provide either 2 or 4 identical serial ports that can be individually configured for RS-232 or RS-485 operation.

Port Pin Assignments

Each port is a standard RJ-45 female connector with the following pin assignments. For MODBUS applications, note that these pin assignments are different than the standard MODBUS pin assignments. If the port is configured for MODBUS master or slave operation, custom cables are needed.



RJ-45 Pin	***RS-232***	***RS-485/422 Half Duplex***	***RS-485/422 Full Duplex***
8	COM	GND	GND
7			Termination 2
6	CTS		R- (RxD0)
5	COM	GND	GND
4		Termination 1	
3	RxD		R+ (RxD1)
2	TxD	T- / R- (D0)	T- (TxD0
1	RTS	T+ / R+ (D1)	T+ (TxD1)

Note: There is no shield or frame ground pin on this connector.

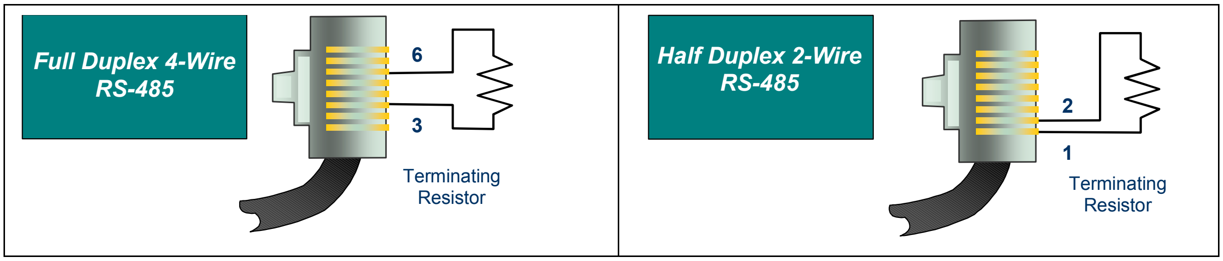
If the Serial Communications module is communicating with a Series 90-30 CPU363 or external PACSystems RX3i CPU, the connections are:

RX3i Serial Module		***CPU363/RX3i***
T+	To	RD('B')
T-	To	RD('A')
R+	To	SD('B')
R-	To	SD('A')

Termination

Termination is needed if the module is the first or last device on an RS-485 network, even if there is only one other device on the network. Termination can be provided using either an external resistor or the port's built-in 120-Ohm termination. If line termination other than 120 Ohms is required, an appropriate external resistor must be supplied. Termination using the built-in 120-Ohm resistor can be done by either setting the appropriate RS-485 termination jumper as shown at the bottom of the page, *OR* by installing shorting jumpers on the RS-485 cable connector that attaches to the serial port:

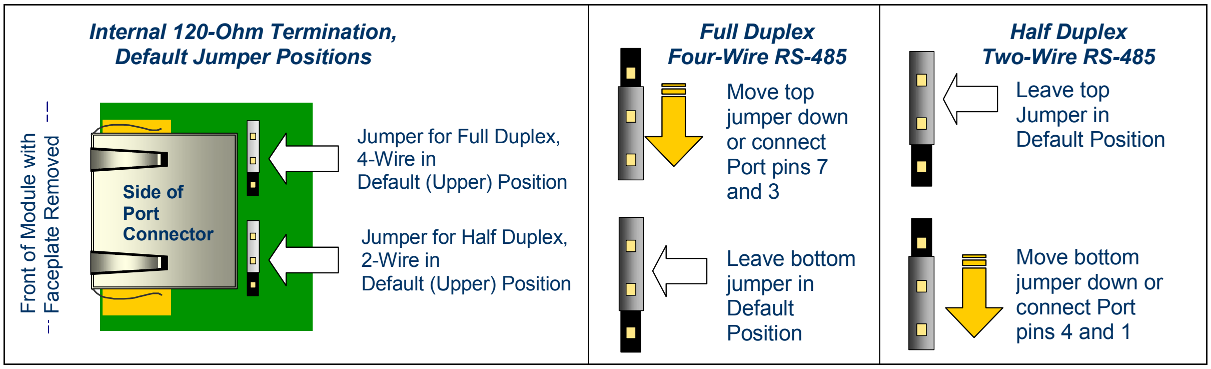
User-Supplied Termination for RS-485



Built-in Termination for RS-485

By default, each port is set for no termination. To set 120-Ohm termination internally:

1. Remove the module's faceplate by pressing in on the side tabs and pulling the faceplate away from the module.
2. With the module oriented as shown, move *either* the upper or lower jumper:


Internal 120-Ohm Termination, Default Jumper Positions
-- Front of Module with Faceplate Removed --
Side of Port Connector
Jumper for Full Duplex, 4-Wire in Default (Upper) Position
Jumper for Half Duplex, 2-Wire in Default (Upper) Position
Full Duplex Four-Wire RS-485
Move top jumper down or connect Port pins 7 and 3
Leave bottom jumper in Default Position
Half Duplex Two-Wire RS-485
Leave top Jumper in Default Position
Move bottom jumper down or connect Port pins 4 and 1

Point to Point Serial Connections

When the network has only one slave device, a point-to-point connection between the master and slave is used. The cable connection may be either RS-232 or RS-485.

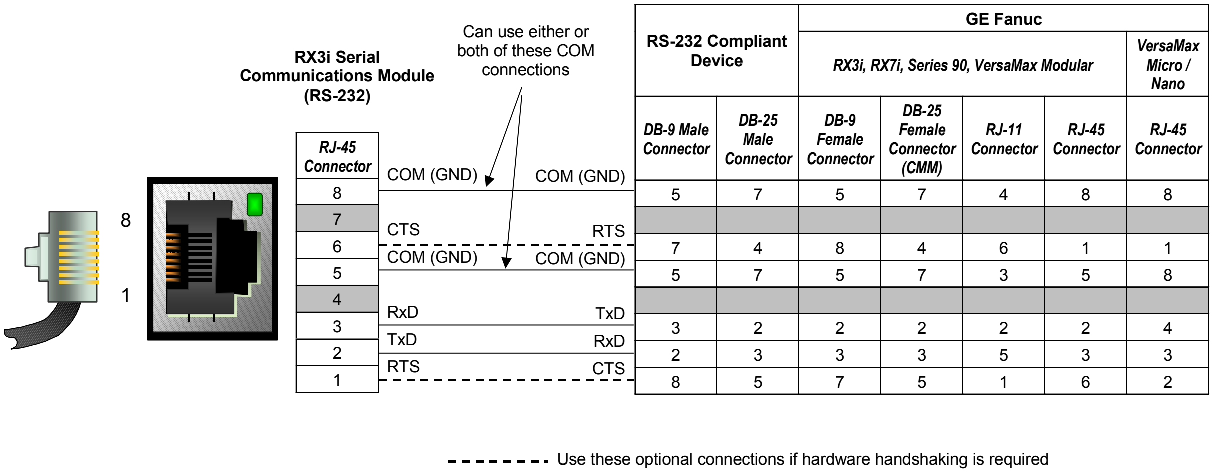
RS-232 MODBUS

RS-232 MODBUS should only be used for shorter distances, typically less than 20 meters. MODBUS Devices that use an RS-232 interface define the following connections:

Signal	*Description*	*For DCE*	*Required for MODBUS*
Common	Signal Common	--	yes
CTS	Clear to Send	In	
RTS	Request to Send	Out	
RxD	Received Data	In	yes
TxD	Transmitted Data	Out	yes

Each TxD must be wired with the RxD of the other device.

RS-232 bus cable should not be terminated.



RX3i Serial Communications Module (RS-232)			RS-232 Compliant Device		GE Fanuc				
					RX3i, RX7i, Series 90, VersaMax Modular				VersaMax Micro / Nano
RJ-45 Connector			DB-9 Male Connector	DB-25 Male Connector	DB-9 Female Connector	DB-25 Female Connector (CMM)	RJ-11 Connector	RJ-45 Connector	RJ-45 Connector
8	COM (GND)	COM (GND)	5	7	5	7	4	8	8
7									
6	CTS	RTS	7	4	8	4	6	1	1
5	COM (GND)	COM (GND)	5	7	5	7	3	5	8
4									
3	RxD	TxD	3	2	2	2	2	2	4
2	TxD	RxD	2	3	3	3	5	3	3
1	RTS	CTS	8	5	7	5	1	6	2

- - - - - - - - Use these optional connections if hardware handshaking is required

MODBUS Multidrop Connections

For a multidrop MODBUS connections in an RS-485 system, either two-wire or four-wire:

- At least 32 devices can be used without a repeater. Depending on the load and the line polarization (see below), more devices may be possible without a repeater. Repeaters can be used when more devices are required.
- An RS-485 MODBUS serial line without a repeater has one trunk table. Devices can be connected either directly or using short branch cables (up to 20 meters).
- If a multi-port tap is used, each branch has a maximum length of 40 meters divided by the number of branches fed by that tap.
- The length of the bus cable depends on the baud rate, the number of loads, the type of cable, and the network configuration. For a maximum 9600 baud rate and AWG28 or larger cable, the maximum length is 1000 meters. AWG24 is always sufficient for MODBUS data. Category 5 cables may be used up to a maximum length of 600 meters. In a system where four-wire cabling is used in a two-wire system as shown in this section, the maximum cable length must be divided by 2.
- For the balanced pairs in an RS-485 system, a characteristic impedance above 100 Ohms is preferred, especially for baud rates of 19200 and above.
- The line must be terminated near both ends of the bus trunk cable, between the D0 and D1 conductors of the balanced line. Termination must not be placed on a branch cable. 150 Ohm, 1/2W resistors can be used for termination. In a four-wire system, each pair must be terminated at each end of the bus.
- The signal and optional power supply common signal must be connected directly to protective ground, preferably at one point only. This is usually done at the master or its tap.

Grounding and Ground Loops

Proper grounding of the cable shield requires careful planning of the network and its power wiring. To avoid data errors from intermittent electrical noise, the cable shield must be grounded to earth ground at every device on the network. Unfortunately, this introduces at least N-1 ground loops, where N is the number of devices on the network. Each ground loop path comprises the shield and drain wire on the cable segment between two devices and a ground return path. The return paths start at the frame ground point of one device, pass through its ground conductor to the common ground, and then pass through the ground conductor of the other device to its frame ground point.

Ground loop currents must be kept within acceptable limits by careful grounding. Otherwise, common-mode noise induced on the data pair by the ground loop currents can cause data errors.

When designing ground wiring, consider these requirements:

1. There must be one common ground point in the system with an extremely low impedance path to earth.
2. The conductor from the frame ground point of each device to the common ground must have extremely low impedance.
3. The recommended frame ground wire sizes, lengths and proper wiring practices must be observed in designing the connections between frame ground points and the common ground.
4. The data cable and ground wire routing must be physically isolated from other wiring that could couple noise onto the data cable or ground wiring.
5. If disconnecting the cable shield from earth ground at any device reduces data errors, the network has a ground loop issue. Connecting cable shields at one end only to eliminate ground loop currents is not recommended because it increases the network's susceptibility to intermittent data errors from electromagnetic interference (EMI). Such errors can be difficult to detect and costly to correct.

   If data errors caused by ground loops cannot be avoided (for example, because the cable run is too long for all devices to use a common ground point), add one or more optically isolated RS-485 repeaters to the network. Partition the network into segments so that each segment has a common ground. Isolate the segments with repeaters.

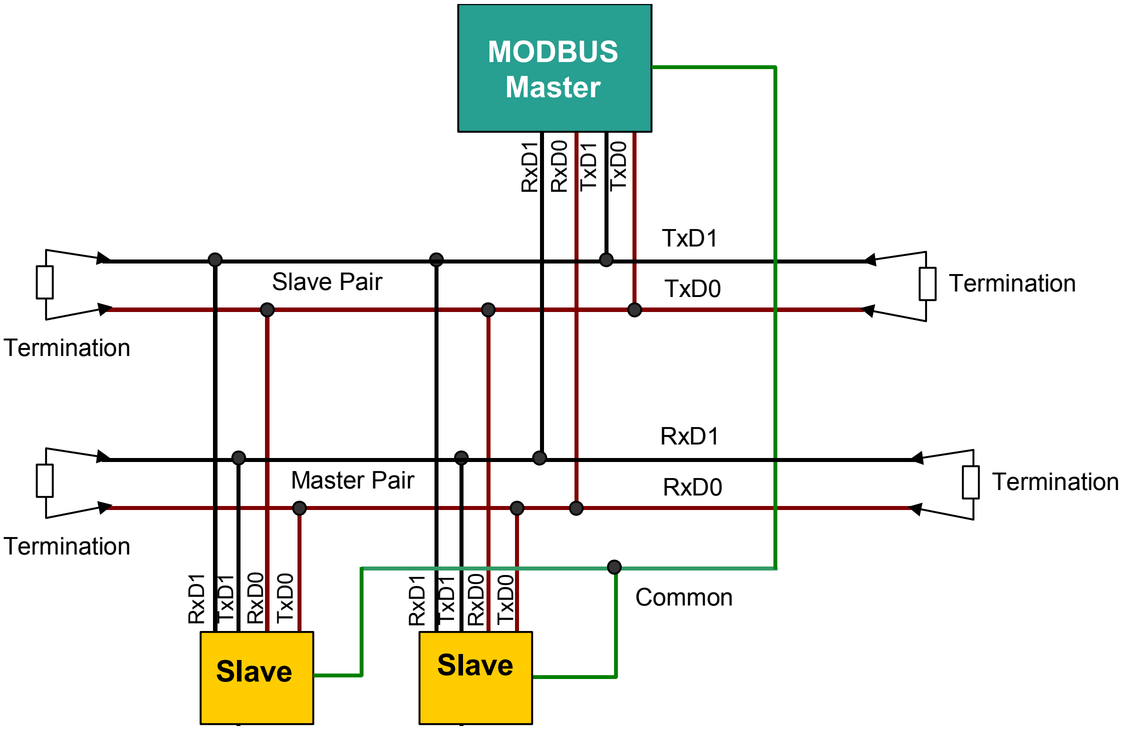
Multidrop Connections for Four-Wire MODBUS

Four-wire bus cable includes two pairs of communications lines and a common line. Data on the master pair (RxD1-RxD0) is received by only the master. Data on the slave pair (TxD1-TxD0) is received by only the slaves. Only one driver at a time has the right to transmit.

The MODBUS slave devices must all use RS-485-compatible serial ports so that their transmitters are disabled except when transmitting. Although some RS-422 devices disable outputs when not transmitting, the RS-422 specification does not require it. The master may use either RS-422 or RS-485 because it is the only transmitter on that pair.

Any high-quality shielded twisted-pair cable with two pairs is suitable for short cable runs (up to about 15 meters) without repeaters. Longer runs require a cable with a suggested nominal impedance of 120 ohms.

Both signal pairs must be terminated at both ends by a suggested 120-ohm, ¼ watt resistor across the RxD signal pair.



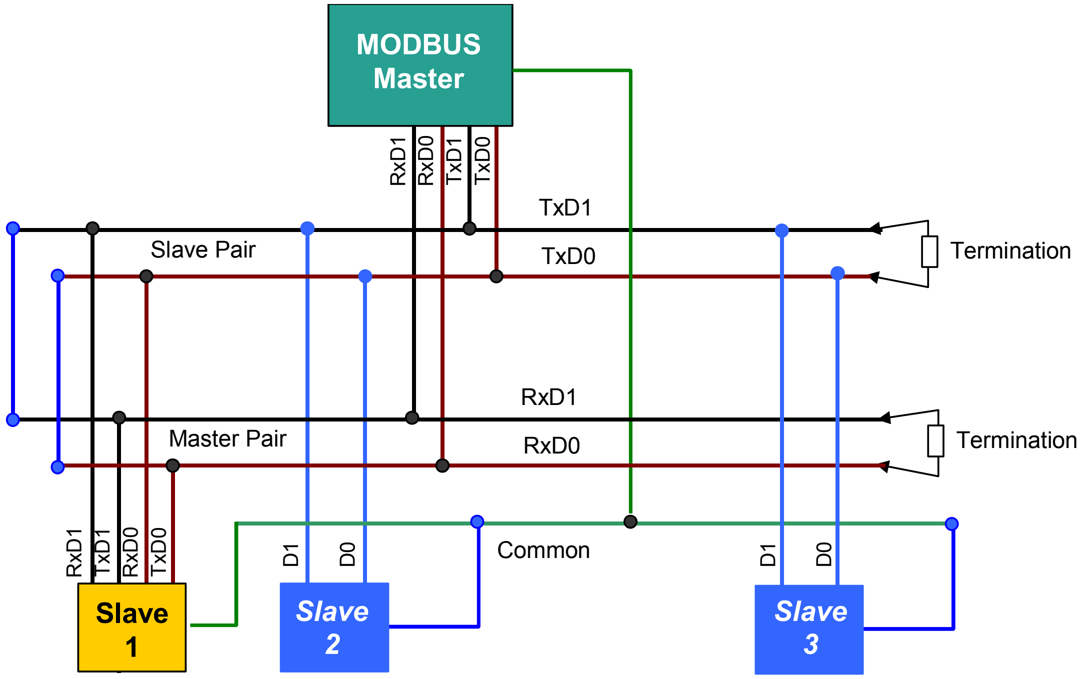
Connecting the Master Using a Passive Tap

Four-wire cable must cross the two pairs on the bus between the bus interface and the passive bus tap on the master. This may be done with crossed cables, but the recommended way to connect a 4-wire master device is to use a tap that provides a crossing capability.

	Signal on Master Interface to Passive Tap	***Type***	***RS-485***	***Signal on Trunk Interface***
Slave Pair	RxD1	In	B’	TxD1
	RxD0	In	A’	TxD0
Master Pair	TxD1	Out	B	RxD1
	TxD0	Out	A	RxD0

Connecting Two-Wire Devices in a Four-Wire System

Two-wire devices can be connected to a four-wire system as shown below. In this example, the master and slave 1 use a four-wire interface. Slaves 2 and 3 use a two-wire interface.



The TxD0 signal must be wired to the RxD0 signal, turning them into the D0 signal.

The TxD1 signal must be wired to the RxD1 signal, turning them into the D1 signal.

Multidrop Connections for Two-Wire MODBUS

On a two-wire network, the Transmit Data (TxD) and Receive Data (RxD) pairs of all devices are connected in parallel to a single pair of wires. Both ends of the pair must be terminated with 120-ohm resistors. All devices must be RS-485-compatible, in order to disable their transmitters except when transmitting. All devices must disable their receivers while transmitting.

The signal pair must be terminated at both ends. If either end device lacks a built-in terminator, a recommended 120-ohm, ¼ watt resistor must be wired across the signal pair inside the connector shell.

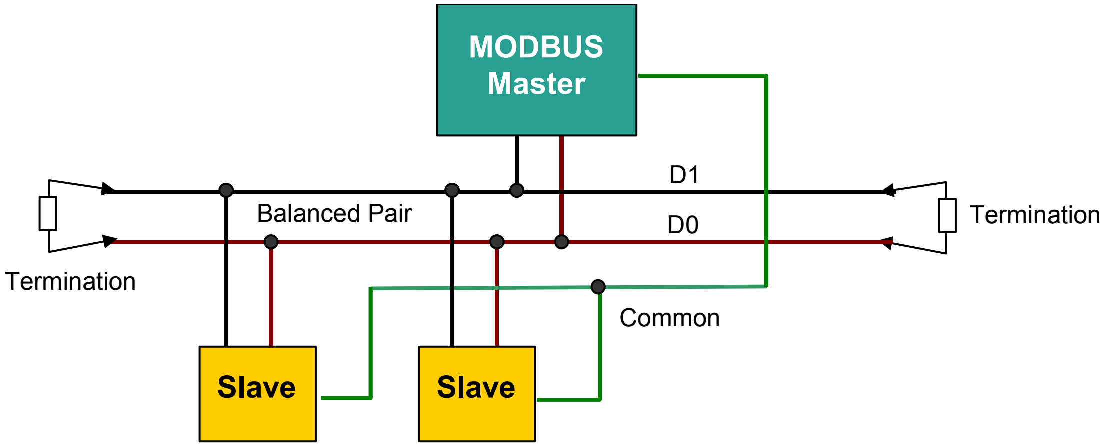
Any high-quality shielded twisted-pair cable is suitable for short cable runs (up to about 15 meters). Longer runs require a cable with a suggested nominal impedance of 120 ohms. Use a cable designed for RS-485 transmission such as Belden 3105A or equivalent.

Serial ports on all devices should be configured for Flow Control NONE.

RS-485 repeaters can also be used on 2-wire networks.

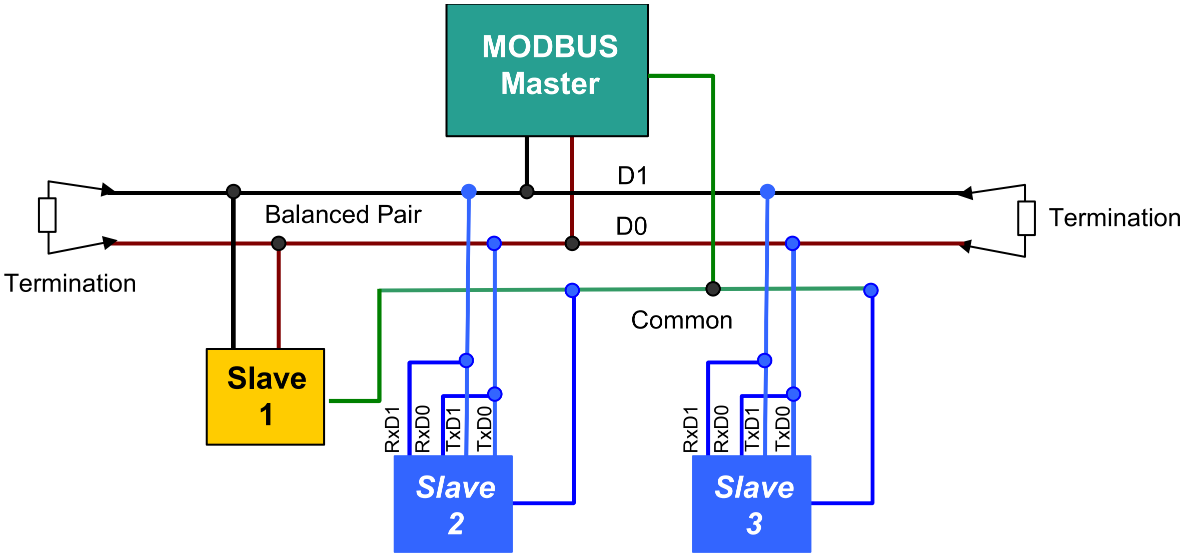
Connections for Two-Wire Devices

Two-wire bus cable includes two communications lines and a common line. Only one driver at a time has the right to transmit.



Connecting Four-Wire Devices to a Two-Wire Network

Four-wire devices can be connected to a two-wire network as shown below. In this example, the master and slave 1 use a two-wire interface. Slaves 2 and 3 use a four-wire interface.



For each four-wire device:

The TxD0 signal must be wired with the RxD0 signal, then connected to the D0 signal on the trunk.

The TxD1 signal must be wired with the RxD1 signal, then connected to the D1 signal on the trunk.

Chapter 3 Configuration

This chapter describes the configurable parameters of PACSystems RX3i Serial Communications modules.

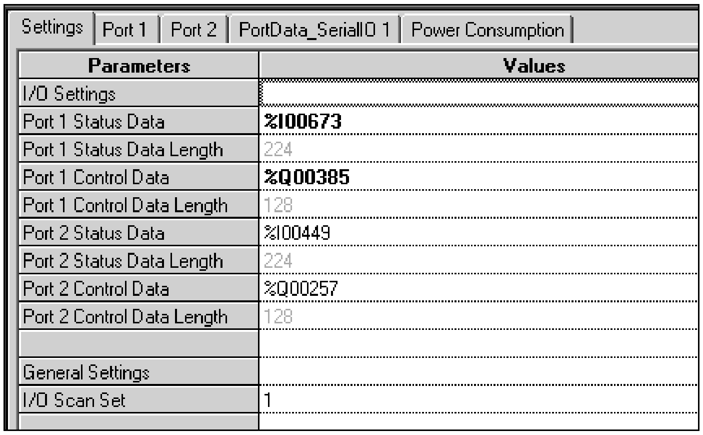
- **Configuring Basic Module Settings**
    - I/O Settings
    - General Settings
- **Configuring a Port for Serial I/O Protocol**
    - Serial Port Settings
    - Serial I/O Port Data
        - Serial I/O Read Configuration
        - Serial I /O Write Configuration
- **Configuring a Port for MODBUS Master Protocol**
    - Serial Port Settings
    - Configuring MODBUS Master Exchanges
- **Configuring a Port for MODBUS Slave Protocol**
    - Serial Port Settings
    - Automatic MODBUS Slave Exchanges
    - Configuring MODBUS Slave Exchanges
- **Configuring a Port for CCM Slave Protocol**

Configuring Basic Module Settings

Click on the slot and right-click to Add a Module. From the module catalog, select either of the following from the list of Communications Modules:

- IC695CMM002: RX3i Serial Communications Module (2 ports)
- IC695CMM004: RX3i Serial Communications Module (4 ports)

For the module, configure the following settings:



Parameters	Values
I/O Settings	
Port 1 Status Data	**%I00673**
Port 1 Status Data Length	224
Port 1 Control Data	**%Q00385**
Port 1 Control Data Length	128
Port 2 Status Data	%I00449
Port 2 Status Data Length	224
Port 2 Control Data	%Q00257
Port 2 Control Data Length	128
General Settings	
I/O Scan Set	1

I/O Settings

These parameters assign CPU reference memory for the port's status and control data, which is used to monitor and control communications activities on the port. This CPU reference memory is *not* used for the actual communications data. CPU reference memory for that data is assigned in a separate step.

Port [1, 2, 3, 4] Status Data Reference and Length: This reference location can be %I, %M, or %T memory. For each port, the length is fixed at 224 bits.

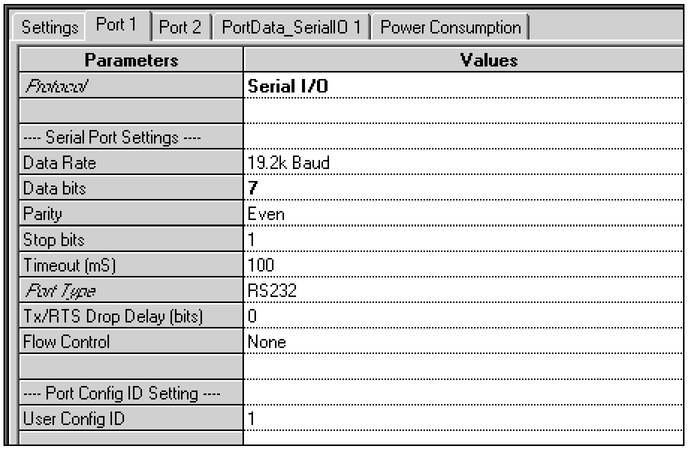
Port [1, 2, 3, 4] Control Data Reference and Length: The reference location can be %Q, %M, or %T memory. For each port, the length is fixed at 128 bits. If retentive memory (%Q or %M may optionally be set up to be retentive, %T is non-retentive) is used for Port Control Data, when a power cycle with battery or hot swap occurs, the control data remains in memory and is executed by the module on the next PLC output scan or output DO I/O unless that data is cleared by application logic.

General Settings

I/O Scan Set: Selecting I/O Scan 1 guarantees that the module's Port Status and Port Control data will be exchanged every I/O Scan. However, any scan set from 1 to 32 can be chosen.

Configuring a Port for Serial I/O Protocol

To set up a port for Serial I/O protocol, on the Port tab, set ***Protocol*** to Serial I/O, then configure the additional port parameters for Serial I/O as described below.



Parameters	Values
Protocol	**Serial I/O**
---- Serial Port Settings ----	
Data Rate	19.2k Baud
Data bits	7
Parity	Even
Stop bits	1
Timeout (mS)	100
Port Type	RS232
Tx/RTS Drop Delay (bits)	0
Flow Control	None
---- Port Config ID Setting ----	
User Config ID	1

Serial Port Settings

Data Rate: Default: 19.2k. Choices are 1200, 2400, 4800, 9600, 19.2k, 38.4k , 57.6k, and 115.2k Baud.

Data bits: Choices 7, 8.

Parity: None, Odd, Even.

Stop Bits: Default is 1. Choices: 1, 2.

Timeout (mS): Defaults to 100. Range is 0 to 65535ms. If the module is expecting to receive data and it hasn't received data before this assigned timeout period, a receive timeout error occurs for the exchange being processed. If there is data to be transmitted and the hardware handshaking isn't allowing data to be transmitted (CTS not asserted when in RS-232 mode with Hardware Control configured) for the assigned timeout value, a transmit error occurs for the exchange being processed.

Port Type: RS232, RS485 (2 wire), RS485 (4 wire).

Tx/RTS Drop Delay: defaults to 0. Range 0 to 15. This is the time from the end of the last transmitted character to the time when RTS is turned off (dropped). A Drop Delay may be needed for some modem communication with RTS and long-distance RS-485 connections. For RS-232 with Flow Control (next item), a suitable Drop Delay should be configured.

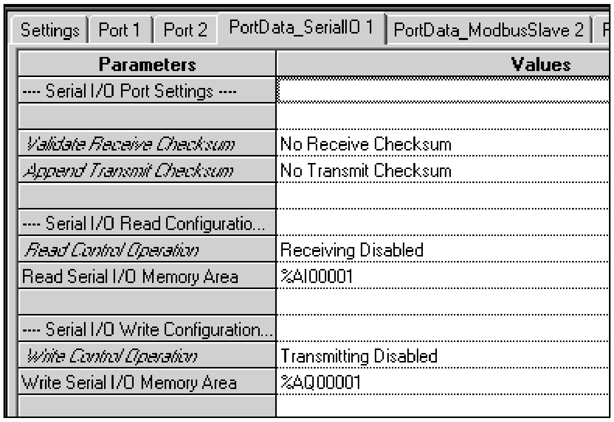
Flow Control: (for RS232 only): Default is none. If Hardware Control is selected, RTS and CTS will be used to control serial transmission flow, and the module will be able to control the flow of data without losing any data bytes. See chapter 6 for more information about managing Hardware Flow Control for RS-232 communications.

Port Config ID Setting

User Config ID: Default is 1, range is 0 to 255. Use of a configuration ID is optional. If a User Config ID is configured, the module returns it to the CPU in each sweep of its Port Status data (see chapter 4, *Port Status and Control Data*). This feature might be used in an application where the same application logic is used with different configurations.

Serial I/O Port Data

If the protocol selected for a port is Serial I/O, configure the following parameters on the corresponding PortData_Serial I/O tab.



Parameters	Values
---- Serial I/O Port Settings ----	
Validate Receive Checksum	No Receive Checksum
Append Transmit Checksum	No Transmit Checksum
---- Serial I/O Read Configuratio...	
Read Control Operation	Receiving Disabled
Read Serial I/O Memory Area	%AI00001
---- Serial I/O Write Configuration...	
Write Control Operation	Transmitting Disabled
Write Serial I/O Memory Area	%AQ00001

Checksum Configuration

Validate Receive Checksum: the default is No Receive Checksum. If Validate Checksum is configured, the module will automatically calculate a checksum on the data. If the calculated checksum does not match the checksum at the end of the received data, the module will not pass the data to the CPU. The checksum byte(s) are not sent with the data to the CPU if a checksum is calculated.

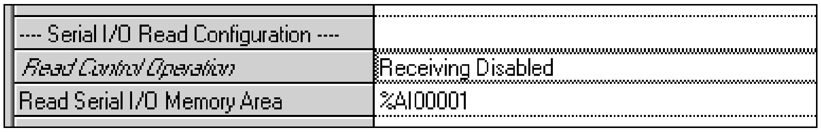
Append Transmit Checksum: the default is No Transmit Checksum. If the message should have a transmit checksum, select Append Transmit Checksum to End of Message, and specify the checksum type below.

Checksum Type: The default is CRC16. The module will calculate a 16-bit Cyclic Redundancy Check across all data, not including any end delimiters. If BCC is selected, the module will calculate a Block Check Character by doing an XOR of all data bytes.

Serial I/O Read Configuration

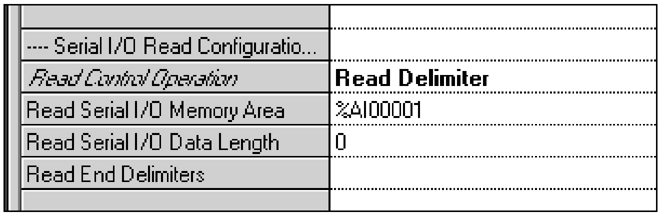
Read Control Operation. The default is Receiving Disabled; The other choices are: Read Delimiter, Byte Count.

Receiving Disabled: prevents Serial I/O read operations through the port. If Receiving Disabled is selected, a receive transaction will only read data bytes that are already in the port’s internal Receive Buffer (up to 2KB). The number of bytes actually read will be indicated in the byte 24 (bits 177 – 192) of the port’s input status data.



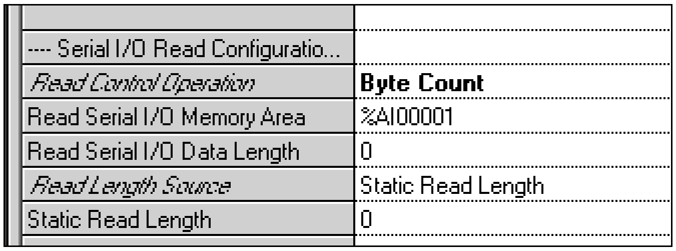
---- Serial I/O Read Configuration ----	
Read Control Operation	Receiving Disabled
Read Serial I/O Memory Area	%AI00001

Read Delimiter: if Read Delimiter is selected, the data in the port’s Input Buffer will be searched for the first occurrence of the configured Read End Delimiter terminating character(s). When the Read End Delimiters are found, the data is transferred to the CPU without the terminating characters. If the terminating characters cannot be found, the receive operation will be terminated after the timeout period has expired. The module will set the Exchange Error Report bit (bit 65 of the port’s status data) to 1 and byte 24 (bits 177 – 192) of the port’s input status data to 0.



---- Serial I/O Read Configuratio...	
Read Control Operation	**Read Delimiter**
Read Serial I/O Memory Area	%AI00001
Read Serial I/O Data Length	0
Read End Delimiters	

Byte Count: if Byte Count is selected, a static or dynamic number of bytes will be read, depending on the additional choices below. Once the number of bytes selected is received, the data is transferred to the CPU.



---- Serial I/O Read Configuratio...	
Read Control Operation	**Byte Count**
Read Serial I/O Memory Area	%AI00001
Read Serial I/O Data Length	0
Read Length Source	Static Read Length
Static Read Length	0

Read Serial I/O Memory Area: the CPU reference area for data read from the serial device. Possible memory types are: %AI, %AQ, %R, %M, %Q, or %I.

Read Serial I/O Data Length: the length in 8-bit increments or 16-bit words, as appropriate, for the CPU reference area that will be used for Serial I/O read data. The length must accommodate the largest amount of data that may be read in one transaction.

Read Length Source: If Read Control Operation is set to Byte Count, and the length of the data will not always be the same, select Dynamic Read Length. When Dynamic Read Length is selected, the application program must supply the read length in bits 97-112 of the Port Control output data it sends to the module each I/O Scan. If the data length to read will always be the same, select Static Read Length.

Static Read Length: If Read Control Operation is set to Byte Count, and the length of data to be read using Serial I/O Protocol will always be the same, enter the number of bytes to be read. The range is 0 to 2048 (2K bytes), which is the total amount of data in the buffer. If the length is set to 0, the module will send the CPU all of the data in the port's input buffer.

Read End Delimiters: If Read Control Operation is set to Read Delimiter, configure the end delimiters using up to 4 ASCII characters separated by commas or spaces. During operation, the module will scan the incoming data for this combination of characters, and will receive the data once the terminating characters are found. The terminating characters may be any combination of individual characters: a-z, A-Z, 0-9, or as hexadecimal characters. For example:

0x41,a,b,c

a a

0x41

0x41 0x42 0x43 0x44

Because either commas or spaces can be used to separate characters when configuring the values, if a comma is desired as a delimiter, its ASCII hex code should be used.

When the hardware configuration is validated, any non-hexadecimal characters that have been entered in the configuration are automatically converted to their hexadecimal equivalents as shown below for the example values:

0x41,a,b,c is converted to: 0x41 0x61 0x62 0x63

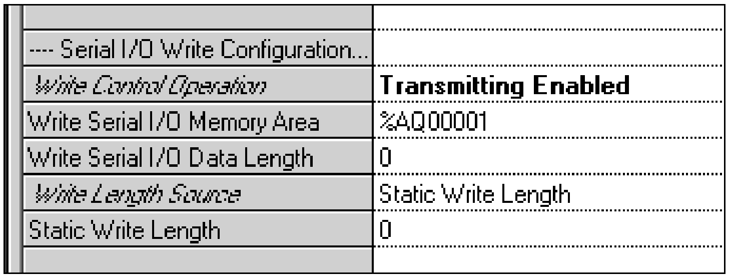
a a is converted to: 0x61 0x61

0x41 remains: 0x41

0x41 0x42 0x43 0x44 remains: 0x41 0x42 0x43 0x44

Serial I/O Write Configuration

Write Control Operation: Default is Transmitting Disabled. Alternative is Transmitting Enabled.



---- Serial I/O Write Configuration...	
Write Control Operation	**Transmitting Enabled**
Write Serial I/O Memory Area	%AQ00001
Write Serial I/O Data Length	0
Write Length Source	Static Write Length
Static Write Length	0

For Transmitting Enabled, configure the additional parameters shown.

Write Serial I/O Memory Area: Specify the beginning reference in CPU memory for the data that will be written to the serial device. Memory types are: %AI, %AQ, %R,%M, %Q, %I.

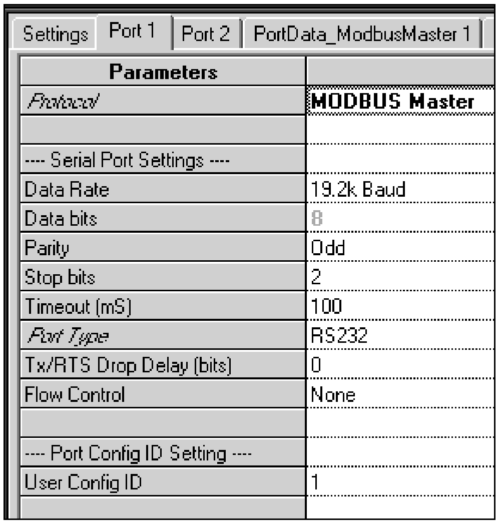
Write Serial I/O Data Length: Default is 0. Range is 0 to 1024. The length in 8-bit increments or 16-bit words, as appropriate, for the CPU reference area that will be used for Serial I/O transmitted data. The length must accommodate the largest amount of data that may be sent in one transaction.

Write Length Source: If the same length of data will always be written, choose Static Write Length and enter a value below. If the write length may change, choose Dynamic Write Length (Found in Output Scan Data). The CPU must then provide the data length in bits 113-128 of the Port Control output data it sends to the module each I/O Scan.

Static Write Length: Default is 0. Range is 0 to 2048 (2K bytes), which is the maximum amount of data the write buffer can contain.

Configuring a Port for MODBUS Master Protocol

On the port tab, set ***Protocol*** to MODBUS Master, then configure the additional port parameters as described below.



Parameters	
Protocol	**MODBUS Master**
---- Serial Port Settings ----	
Data Rate	19.2k Baud
Data bits	8
Parity	Odd
Stop bits	2
Timeout (mS)	100
Port Type	RS232
Tx/RTS Drop Delay (bits)	0
Flow Control	None
---- Port Config ID Setting ----	
User Config ID	1

Serial Port Settings

Data Rate: Default: 19.2k Baud. Choices are 1200, 2400, 4800, 9600, 19.2k, 38.4k , 57.6k, 115.2k Baud.

Data bits: Always 8 for MODBUS Master.

Parity: None, Odd, Even. When parity = ODD or EVEN, the character length used by MODBUS Master is 10 bits: one start bit, 8 data bits, one parity bit and one stop bit. There is no parity bit when parity = NONE, and the character length is 9 bits. The selection should match the parity used by other devices on the network.

Stop Bits: Default is 1. Choices: 1, 2. If Parity is set to Odd/Even, the number of Stop Bits should be 1. If Parity is set to None, the number of Stop Bits should be set to 2. The Stop Bits setting should be 1 stop bit for compatibility with GE Fanuc Automation MODBUS Slaves.

Timeout (mS): Range is 0 to 65535ms. An error will be reported to the status location if this timeout expires before a complete response is received. MODBUS requires a timeout in all cases. A 500 milliseconds timeout is recommended by the MODBUS standard. If no valid response from the slave is detected after the configured timeout period, an error code is returned to the status location.

Port Type: RS232, RS485 (2 wire), RS485 (4 wire)

Tx/RTS Drop Delay (bit times), defaults to 0. Range 0 to 15 bit times. This is the time from the end of the last transmitted character to the time when RTS is turned off (dropped).

The receiver is disabled during transmission and remains disabled during the RTS drop delay time. If the specified delay is longer than the MODBUS Slave's silent interval between the query and its response, the master will ignore all or part of the response.

Flow Control: (for RS232 only) Default is none. Choices are None, Hardware Control (RTS/CTS). If Hardware Control is specified, the port will assert RTS, then wait for CTS to become active before transmitting. If CTS does not become active within 2 seconds, a time-out error code is returned to the status location.

If CTS becomes active and then is de-asserted while the port is transmitting, up to 5 milliseconds may elapse before transmission stops. The maximum number of characters transmitted after CTS is de-asserted is proportional to the data rate. These values are in addition to the character that is being transmitted at the time CTS is de-asserted.

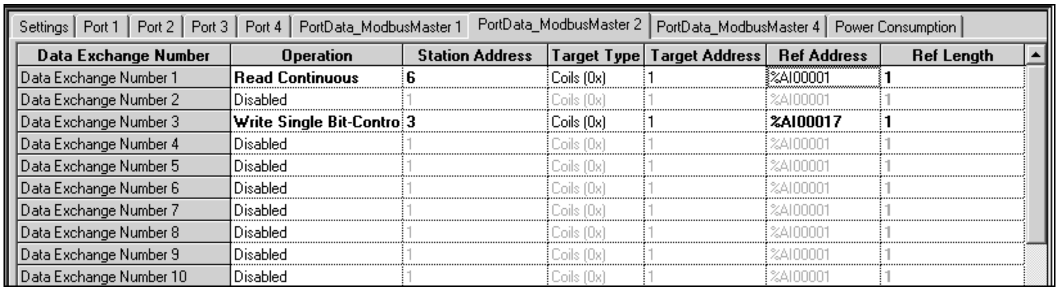
Outputs Disabled Control: Default is Stop Processing Exchanges. Alternative is Continue Processing Exchanges. This option applies to continuous read and write exchanges. It does not apply to bit-controlled continuous exchanges or to single exchanges.

Port Config ID Setting

User Config ID: Default is 1, range is 0 to 255.

Configuring MODBUS Master Exchanges

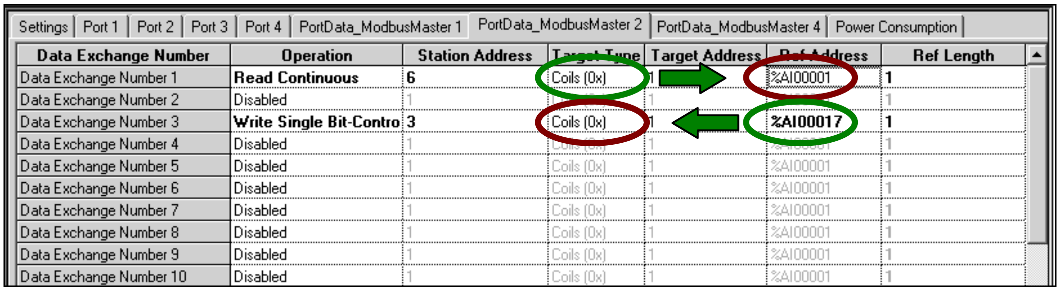
If the protocol selected for a port is MODBUS Master, configure up to 64 data exchanges on the corresponding PortData_Modbus Master tab. Based on the selections made on this screen, the Serial Communications module will execute the appropriate, standard MODBUS functions.



Settings | Port 1 | Port 2 | Port 3 | Port 4 | PortData_ModbusMaster 1 | PortData_ModbusMaster 2 | PortData_ModbusMaster 4 | Power Consumption

Data Exchange Number	Operation	Station Address	Target Type	Target Address	Ref Address	Ref Length
Data Exchange Number 1	Read Continuous	6	Coils (0x)	1	%AI00001	1
Data Exchange Number 2	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 3	Write Single Bit-Contro	3	Coils (0x)	1	%AI00017	1
Data Exchange Number 4	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 5	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 6	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 7	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 8	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 9	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 10	Disabled	1	Coils (0x)	1	%AI00001	1

When configuring master exchanges, remember that read exchanges will read data from the slave target and write it to the specified reference address. Write exchanges will read data from the specified reference address and write it to the slave target. Looking at the fields on the exchange configuration screen, read data "flows" from the target memory to the configured reference address. Write data "flows" from the configured reference address to the target memory.



Settings | Port 1 | Port 2 | Port 3 | Port 4 | PortData_ModbusMaster 1 | PortData_ModbusMaster 2 | PortData_ModbusMaster 4 | Power Consumption

Data Exchange Number	Operation	Station Address	Target Type	Target Address	Ref Address	Ref Length
Data Exchange Number 1	Read Continuous	6	Coils (0x)	1	%AI00001	1
Data Exchange Number 2	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 3	Write Single Bit-Contro	3	Coils (0x)	1	%AI00017	1
Data Exchange Number 4	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 5	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 6	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 7	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 8	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 9	Disabled	1	Coils (0x)	1	%AI00001	1
Data Exchange Number 10	Disabled	1	Coils (0x)	1	%AI00001	1

Operation: This parameter sets up how the MODBUS Master function will be performed. The default for each exchange is Disabled. Options are described below.

- *Read Continuous:* This type of exchange repeatedly reads the specified data from the target slave and places it into the assigned CPU reference addresses. The CPU does not control this exchange. It only stops when PLC outputs are disabled (if the Outputs Disabled parameter on the Port tab is set to disable continuous exchanges when outputs are disabled.
- *Read Continuous Bit-Control:* This type of exchange must be started by setting a bit in the CPU (see chapter 4 for details). The module then periodically reads the specified data from the slave until commanded to stop by clearing the same bit.

- *Read Single Bit-Control:* This type of exchange must be initiated by setting a bit in the CPU (see chapter 4 for details). The module reads the specified data once each time the control bit transitions.
- *Write Continuous:* This type of exchange repeatedly writes the specified bit or word data from the assigned CPU references to the slave's Coils (0x) or Holding Registers (4x) table. The CPU does not control this exchange. It only stops when PLC outputs are disabled (if the Outputs Disabled parameter on the Port tab is set to disable continuous exchanges when outputs are disabled.
- *Write Continuous Bit-Control:* This type of exchange must be started by setting a bit in the CPU (see chapter 4 for details). The module then periodically writes the specified data to the slave until commanded to stop by clearing the same bit.
- *Write Single Bit-Control:* This type of exchange must be initiated by setting a bit in the CPU (see chapter 4 for details). The module writes the specified data once each time the control bit transitions.

Station Address: Specify the MODBUS Device ID from of the slave associated with the exchange. For Read operations, the range of Device IDs is 1 to 247. For Write operations, the range of Device IDs is 0 to 247. If the MODBUS query should be broadcast to all slaves, enter 0 as the Device ID.

Target Type: Select the type of data to be exchanged: MODBUS Coils (0x), MODBUS Discrete Inputs (1x), MODBUS Input Registers (3x), MODBUS Holding Registers (4x), MODBUS Query data, or Diagnostic Status data.

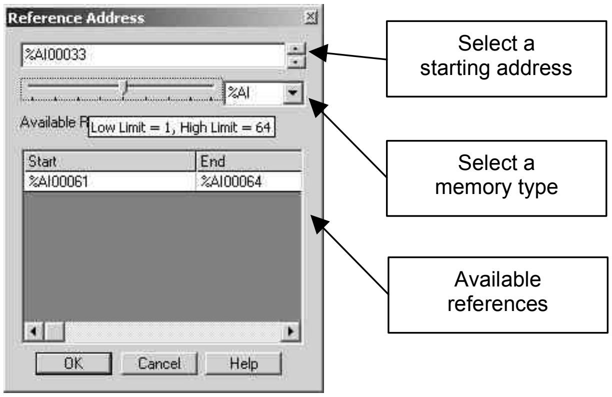
If *Diagnostic Status* is selected, the CPU can use this exchange to read from the Serial Communications Module a set of Diagnostic Status words for the port. See chapter 4 for details of the Diagnostic Status words.

If *Return Query Data* is selected, the CPU will use this exchange to automatically perform MODBUS function 08, Subfunction 00, Read Query Data. The module sends two bytes of data to the specified Slave Address, Target Type and Target Address, to see whether the slave echoes the data back. The data that is sent will be two bytes from the configured Reference Address. The content of the data is not meaningful.

Target Address: For MODBUS data, this is the starting address in the MODBUS table selected as the Target Type.

For *Diagnostic Status Data,* this is the first word of Diagnostic Status data to be read from the module. For example, entering a Target Address of 1 would access Word 1 of the Diagnostic Status data, which is the MODBUS Errors status word, as detailed in chapter 4.

Reference Address: Specify the CPU memory type and starting address for the data to be read or written in the Data Exchange. To select a memory type and starting address, double-click on the Ref Address field or right-click and select Data Entry Tool.



%AI00033

%AI

Low Limit = 1, High Limit = 64

Start	End
%AI00061	%AI00064

Select a starting address

Select a memory type

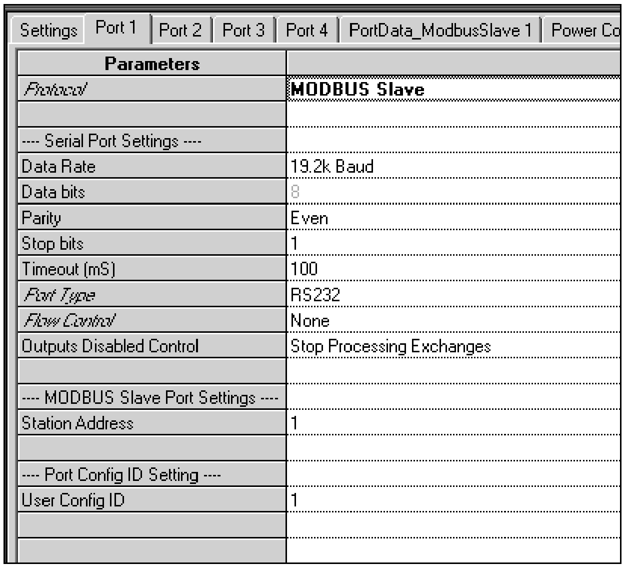
Available references

If the Data Exchange Target Type is Return Query, this reference should specify the start of two bytes of data to be sent to the specified slave. The content of the data is not meaningful, its purpose is to verify the slave's data to return the query.

Reference Length: Specify the length of the memory area selected above in bits or 16-bit words (registers). The default is 0. Range is 1 to 127 words or 1 to 2040 bits. For Diagnostic Status, this is fixed at 18 words (240 bits). For a Return Data Query, the length of this data area should be 16 bits (1 word).

Configuring a Port for MODBUS Slave Protocol

On the port tab, set ***Protocol*** to MODBUS Slave, then configure the additional port parameters as described below.



Parameters	
Protocol	**MODBUS Slave**
---- Serial Port Settings ----	
Data Rate	19.2k Baud
Data bits	8
Parity	Even
Stop bits	1
Timeout (mS)	100
Port Type	RS232
Flow Control	None
Outputs Disabled Control	Stop Processing Exchanges
---- MODBUS Slave Port Settings ----	
Station Address	1
---- Port Config ID Setting ----	
User Config ID	1

Serial Port Settings

Data Rate: Default: 19.2k. Choices are 1200, 2400, 4800, 9600, 19.2k, 38.4k , 57.6k, 115.2k baud.

Data bits: This is always 8 for MODBUS Slave.

Parity: None, Odd, Even. When parity = ODD or EVEN, the character length used by MODBUS Master is 11 bits: one start bit, 8 data bits, one parity bit and one stop bit. When None is selected, 2 stop bits are required.

Stop Bits: Default is 1. Choices: 1, 2. If Parity is set to Odd/Even, the number of Stop Bits should be 1. If Parity is set to None, the number of Stop Bits should be set to 2. The Stop Bits setting should be 1 stop bit for compatibility with other GE Fanuc Automation MODBUS Slaves.

Timeout (mS): Default is 100ms. Range is 0 to 65535ms. A 500 milliseconds timeout is recommended by the MODBUS standard. The time-out begins after the port has transmitted the last character of the query and stops when the character-gap timeout expires after the last response character is received. If the response timeout expires before the end of the character gap time-out, the port is checked for a response message. If one is detected (for example, because the response timeout expired after the response was received but before the gap timeout expired), the response is processed normally after the gap timeout expires. If no valid response is detected, a timeout error code is returned to the status location.

Port Type: RS232, RS485 (2 wire), or RS485 (4 wire).

Tx/RTS Drop Delay (bits), defaults to 0. Range 0 to 15 bits. For RS232 or RS485 (4 wire) This is the time from the end of the last transmitted character to the time when RTS is turned off (dropped).

Flow Control: (for RS232 only) Default is none. Choices are None, or Hardware Control (RTS/CTS). If Hardware Control is specified, the port will assert RTS, then wait for CTS to become active before transmitting. If CTS does not become active within 2 seconds, a time-out error code is returned to the status location.

If CTS becomes active and then is de-asserted while the port is transmitting, up to 5 milliseconds may elapse before transmission stops. The maximum number of characters transmitted after CTS is de-asserted is proportional to the data rate. These values are in addition to the character that is being transmitted at the time CTS is de-asserted.

Outputs Disabled Control: Default is Stop Processing Exchanges. Alternative is Continue Processing Exchanges.

MODBUS Slave Port Settings

If the Protocol Type is Modbus Slave only, select the ***Station Address*** of the slave (port). Range is 1 to 247

Port Config ID Setting

User Config ID: Default is 1, range is 0 to 255.

Automatic MODBUS Slave Exchanges

Proficy™ Machine Edition 5.6 SIM 6 or later provides a set of default Data Exchanges that will automatically accommodate all supported MODBUS queries from the master. By default, when the port is set up for MODBUS Slave operation, a set of predefined Data Exchanges map MODBUS addresses to PACSystems CPU reference addresses. When the default Data Exchanges are used, no additional slave exchanges need to be configured. Following are the RX3i addresses that correspond to MODBUS functions that may be received by the slave port:

Read Input Registers: %AI
Read Holding Registers: %R
Preset Single Register: %R
Preset Multiple Registers: %R
Mask 4X Registers: %R
Read/Write 4X Registers: %R
Read Input Status: %I
Read Coils Status: %Q
Force Single Coil: %Q
Force Multiple Coils: %Q

Changed Implementation of MODBUS Slave Exchanges

Earlier versions of Machine Edition, such as Machine Edition 5.5 with Service Pack 2 SIM 4, implemented MODBUS Slave Exchanges using the *Preconfigured Exchanges* field on the port configuration tab. Selecting *Preconfigured Exchanges* set up the automatic mapping described above, but prevented configuration of additional Data Exchanges for the port. With Machine Edition 5.6 SIM 6 or later, the *Preconfigured Exchanges* field is no longer available. The function is replaced by the preconfigured Data Exchanges, which provide greater configuration flexibility, as described below.

Customizing MODBUS Slave Exchanges

The default Data Exchanges in Machine Edition 5.6 SIM 6 or later permit the MODBUS Master to read all of the %I, %AI, %Q, and %R references and to write all of the %Q and %R references in the PACSystems RX3i CPU.

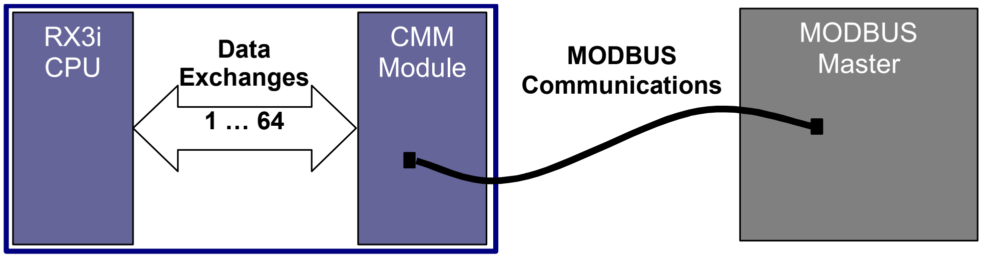
The default exchanges can be edited, and new Data Exchanges can be defined, in order to:

- Read or write additional reference types: %AI, %AQ, %R, %W, %M, %Q, %T, %I
- Prevent the MODBUS Master from writing to some or all memory in the RX3i CPU
- Limit MODBUS Master access to certain memory areas and types
- Target specific data items to be read or written.

The process of creating custom Data Exchanges is explained in this chapter.

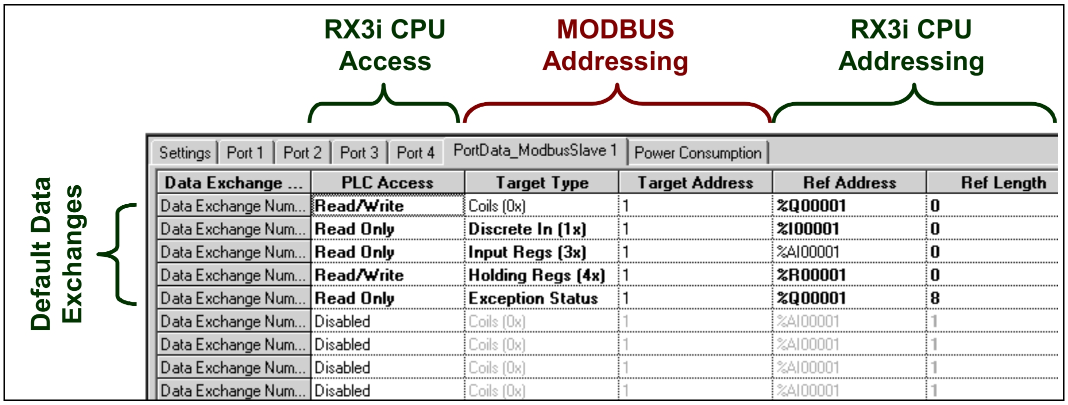
Setting Up MODBUS Slave Data Exchanges

Data Exchanges set up specific communications between a Serial Communications Module and its local RX3i PLC CPU over the RX3i backplane.



When a port is set up for MODBUS Slave operation, a set of default Data Exchanges is provided for that port that will permit the MODBUS Master to read or write all locations in %R, and %Q memory, and read %I and %AI memory, as well as the eight Exception Status bits in %Q memory in the PACSystems CPU.

The default Data Exchanges are shown below. These Data Exchanges match any request the module might receive from the MODBUS Master. The Ref Length of 0 for the default exchanges means there is no length restriction; the entire CPU table (Reference Address type) in that Data Exchange is accessible.



Data Exchange ...	PLC Access	Target Type	Target Address	Ref Address	Ref Length
Data Exchange Num...	Read/Write	Coils (0x)	1	%Q00001	0
Data Exchange Num...	Read Only	Discrete In (1x)	1	%I00001	0
Data Exchange Num...	Read Only	Input Regs (3x)	1	%AI00001	0
Data Exchange Num...	Read/Write	Holding Regs (4x)	1	%R00001	0
Data Exchange Num...	Read Only	Exception Status	1	%Q00001	8
Data Exchange Num...	Disabled	Coils (0x)	1	%AI00001	1
Data Exchange Num...	Disabled	Coils (0x)	1	%AI00001	1
Data Exchange Num...	Disabled	Coils (0x)	1	%AI00001	1
Data Exchange Num...	Disabled	Coils (0x)	1	%AI00001	1

Up to 64 data exchanges can be configured for the MODBUS Slave. Note that during operation, the module will scan the exchanges from 1 to 64, and select the *first* match for the Master query. If the default exchanges are used without being edited, they will match any query the Master might send, so any additional exchanges will never be reached. Some of the default exchanges must be changed or disabled to use additional exchanges.

If the default exchanges are suitable for the application, no additional slave exchanges need to be configured.

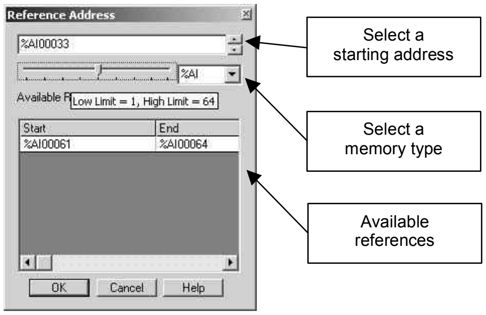
Configure the following parameters for each additional exchange that might be received by the MODBUS Slave port.

PLC Access: Specify whether the exchange is disabled, or if the MODBUS Master should have Read Only or Read/Write access to RX3i CPU memory. If Read Only or Read/Write is selected, configure the data mapping for the exchange as described below.

Target Type: Specify the type of MODBUS memory in the master that will be exchanged. The Default is Coils (0x). Alternatives are: Discrete Inputs (1x), Input Registers (3x), and Holding Registers (4x). If PLC Access is configured as Disabled, Target Type is read only.

Target Address: Enter a value from 1 to 65535. This is the offset within the Target Type memory for the data to be read/written.

Reference Address: Specify the PACSystems memory type and starting address for the data to be read or written in the Data Exchange. To select a memory type and starting address, double-click on the Ref Address field or right-click and select Data Entry Tool.


Reference Address

%AI00033

%AI

Available R Low Limit = 1, High Limit = 64

Start	End
%AI00061	%AI00064

Select a starting address

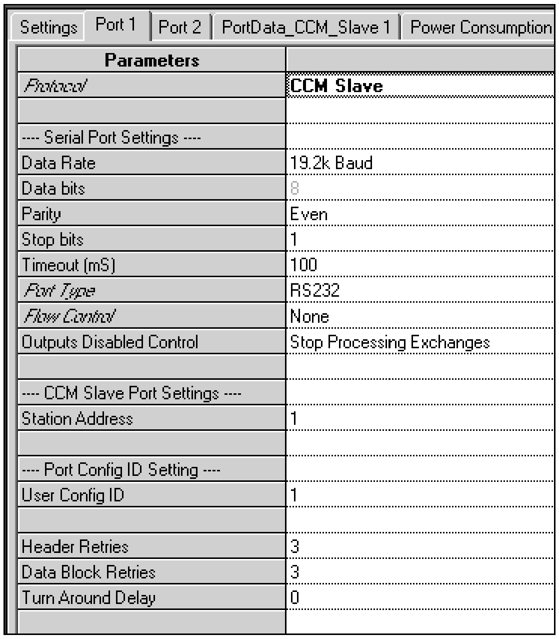
Select a memory type

Available references

Reference Length: Specify the length of the memory area selected above in bits or 16-bit words (registers). The default is 1. Range is 1 to 127 words (or 1 to 2040 bits).

Configuring a Port for CCM Slave Protocol

On the port tab, set ***Protocol*** to CCM Slave, then configure the additional port parameters as described below.



Parameters	
Protocol	**CCM Slave**
---- Serial Port Settings ----	
Data Rate	19.2k Baud
Data bits	8
Parity	Even
Stop bits	1
Timeout (mS)	100
Port Type	RS232
Flow Control	None
Outputs Disabled Control	Stop Processing Exchanges
---- CCM Slave Port Settings ----	
Station Address	1
---- Port Config ID Setting ----	
User Config ID	1
Header Retries	3
Data Block Retries	3
Turn Around Delay	0

Serial Port Settings

Data Rate: Default: 19.2k. Choices are 1200, 2400, 4800, 9600, 19.2k, 38.4k , 57.6k, 115.2k baud. Choose a baud rate that matches that used by the CCM Master. Note that RX3i Serial Communications modules do not support the 300 and 600 baud data rates of CCM hardware modules, such as the Series 90-30 CMM311 and CCM hardware modules do not support the faster data rates that are available on RX3i Serial Communications modules. Data rates of 1200 baud through 19.2K baud should be compatible with all modules.

Data bits: CCM protocol always uses eight data bits and one stop bit.

Parity: None, Odd, Even. Default is odd.

Stop Bits: Default is 1. CCM protocol always uses eight data bits and one stop bit.

Timeout: For CCM, there are eight predefined timeouts (see chapter 7) conditions. The overall timeout period is the sum of these eight timeouts, plus the configured Turn Around Delay, plus the Timeout in milliseconds configured here. If the Timeout value for CCM protocol is set to 0, timeouts are NOT disabled.

Port Type: RS232, RS485 (2 wire), or RS485 (4 wire). CCM Hardware Modules use the RS-232 or RS-422 communication standards. An RX3i Communications Module can be configured for RS-232 or RS-485. RS-485(4-wire mode) is backward compatible to RS-422 allowing the RX3i Communications Module to be used on CCM RS-422 networks. Refer to the hardware specification for more information.

Tx/RTS Drop Delay (bits), defaults to 0. Range 0 to 15 bit times. For RS485 (4 wire) only. This is the time from the end of the last transmitted character to the time when the transmitter is turned off (dropped). For RS-232 with Hardware Flow Control enabled, this is the time from the end of the last transmitted character to the time when RTS is turned off.

Flow Control: (for RS232 only) Default is none. Choices are None, or Hardware Control (RTS/CTS). If Hardware Control is specified, the port will assert RTS, then wait for CTS to become active before transmitting. If CTS does not become active before the timeout period expires, an error code (0x1A) is set in the Diagnostic Status data. If the exchange number is known when the error occurs, error code 0x1A is also set in the Exchange Error location.

If CTS becomes active and then is de-asserted while the port is transmitting, up to 5 milliseconds may elapse before transmission stops. The maximum number of characters transmitted after CTS is de-asserted is proportional to the data rate. These values are in addition to the character that is being transmitted at the time CTS is de-asserted.

Outputs Disabled Control: Default is Stop Processing Exchanges. Alternative is Continue Processing Exchanges.

CCM Slave Port Settings

Station Address: The CCM Slave ID used for the port. Default is 1. Range is 1 to 90.

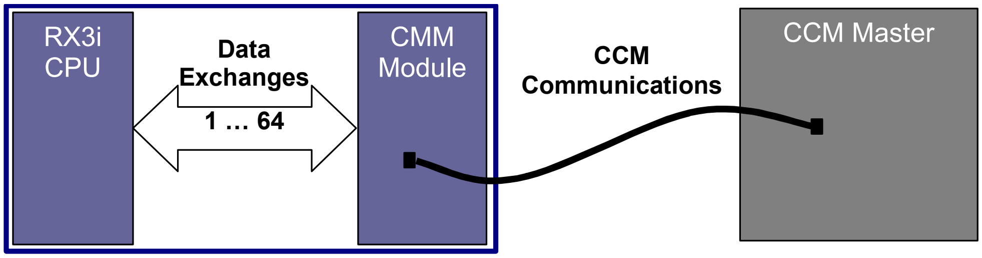
Header Retries: Number of times the CCM Slave will allow the Master to resend a header before sending EOT. Default is 3. Range is 0 to 5. If Header Retries is set to 0, the CCM slave will immediately end a transaction if a header is not valid.

Data Block Retries: Number of times the Slave will allow the Master to resend a data block before sending EOT. Default is 3, range is 0 to 5. If Data Block Retries is set to 0, the CCM slave will immediately end a transaction if a data block is not valid.

Turn Around Delay: Default is 0. Range is 0 to 65535mS. This is a time to be added to the CCM protocol’s base timeout period. Setting Turn Around Delay to 0 does NOT disable timeouts. For CCM, there are eight predefined timeouts (see chapter 7) conditions. The overall timeout period is the sum of these eight timeouts, plus the Turn Around Delay configured here, plus the configured Timeout in milliseconds.

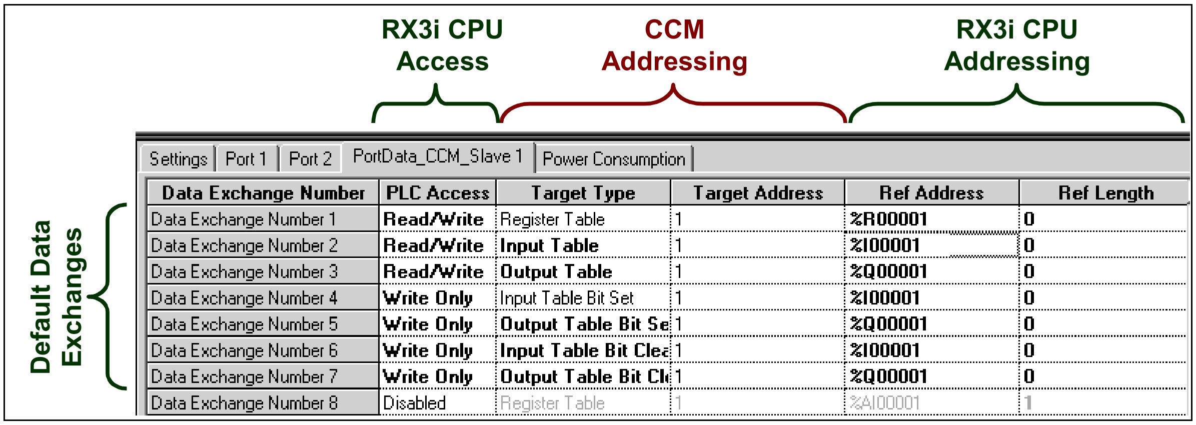
Setting Up CCM Slave Data Exchanges

Data Exchanges set up specific communications between a Serial Communications Module and its local RX3i PLC CPU over the RX3i backplane.



When a port is set up for CCM Slave operation, a set of default Data Exchanges is provided for that port that will permit the CCM Master to read or write all locations in %R, %I, and %Q memory, and to set and clear all bits %I and %Q memory in the PACSystems CPU.

The default Data Exchanges are shown below. These Data Exchanges match any CCM request the module might receive from the CCM Master. The Ref Length of 0 means there is no length restriction; the entire CPU table (Reference Address type) in that Data Exchange is accessible.



Data Exchange Number	PLC Access	Target Type	Target Address	Ref Address	Ref Length
Data Exchange Number 1	Read/Write	Register Table	1	%R00001	0
Data Exchange Number 2	Read/Write	Input Table	1	%I00001	0
Data Exchange Number 3	Read/Write	Output Table	1	%Q00001	0
Data Exchange Number 4	Write Only	Input Table Bit Set	1	%I00001	0
Data Exchange Number 5	Write Only	Output Table Bit Se	1	%Q00001	0
Data Exchange Number 6	Write Only	Input Table Bit Clea	1	%I00001	0
Data Exchange Number 7	Write Only	Output Table Bit Cl	1	%Q00001	0
Data Exchange Number 8	Disabled	Register Table	1	%AI00001	1

Configuring Custom Data Exchanges

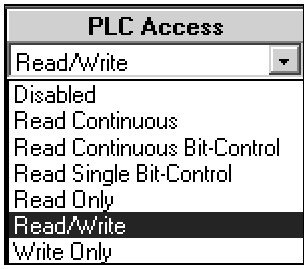
If the Master should NOT be permitted to read or write part or all of %R, %I, or %Q memory, or if the Master should be permitted access to other memory areas, the configuration can be customized on this tab. Also, by default the module will NOT automatically send its CCM Diagnostics Status data to the local RX3i CPU. If that data should be provided to the CPU, a new Data Exchange can be set up for that purpose, as described in this section.

When customizing the CCM Slave Data Exchanges, it helps to know how the Serial Communications Module will process the exchanges. The module maintains an internal record of up to 64 of Data Exchange definitions. When the module receives a CCM request from the Master, the module scans the Data Exchanges from 1 to 64. The module compares the Target Type, Starting Target Address, and Reference Length parameters of the request against the configured Data Exchanges until a match is found. If no match is found, an error is returned to the requesting master. If a match is found, the requested exchange is carried out. The first match found while scanning from exchange 1 to 64 is always used.

Data Exchange Parameters

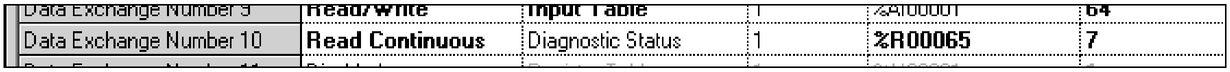
The following parameters can be defined for each Data Exchange type.

PLC Access



Disabled: the exchange number is not defined.

Read Continuous, Read Continuous Bit-Control, Read Single Bit-Control. These three PLC Access Types set up *local* data exchange between the Serial Communications Module and its RX3i CPU. The RX3i CPU will read the module's seven CCM Status Words, and place them into the specified Reference Address. The format of this data is shown in chapter 7. Depending on the PLC Access selected, CCM Status Words can be read continuously, continuously with application program control, or once with application program control. Here, the port is set up for continuous reading of its CCM Status Words, which will be placed into RX3i CPU memory starting at Reference Address %R00065.



Data Exchange Number 9	Read/Write	Input Table	1	%AI00001	64
Data Exchange Number 10	Read Continuous	Diagnostic Status	1	%R00065	7

The CCM Master can always access seven Diagnostic Status Words using a CCM Read command to that target memory type. The CCM Master can also clear the CCM Status Words in the PLC CPU by writing zeros to that target memory type.

Read Only, Read/Write, Write Only. These three PLC Access Types define how the application program can access the CCM Diagnostic Status Words. To read the seven Diagnostic Status words in the local RX3i CPU directly from the slave, an exchange of this type must be used. The local RX3i CPU can always clear these Diagnostic Status words through a control bit described in chapter 7.

Target Type: The CCM memory type. These types can be mapped to any RX3i CPU memory type in the Reference Address field.

If PLC Access is configured as Disabled, Target Type is read only.

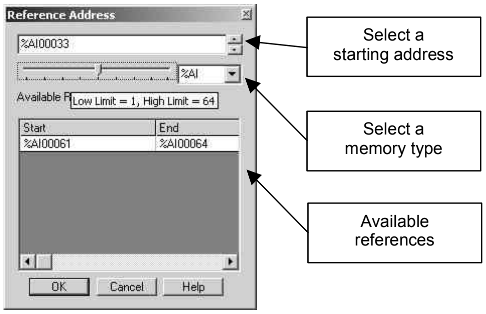
For the local data exchanges Read Continuous, Read Continuous-Bit Control, or Read Single-Bit Control, the only Diagnostic Status can be chosen.

If PLC Access is configured as Read Only or Read/Write, Target Type can be Register Table, Input Table, or Output Table.

If PLC Access is configured as Write Only, Target Type can be Input Table Bit Set, Input Table Bit Clear, Output Table Bit Set, or Output Table Bit Clear.

Target Address: Enter a value from 1 to 65535. This is the offset within the Target Type memory for the data to be read/written.

Reference Address: Specify the RX3i CPU memory type and starting address for the data to be read or written in the Data Exchange. To select a memory type and starting address, double-click on the Ref Address field or right-click and select Data Entry Tool.



Reference Address

%AI00033

%AI

Available R Low Limit = 1, High Limit = 64

Start	End
%AI00061	%AI00064

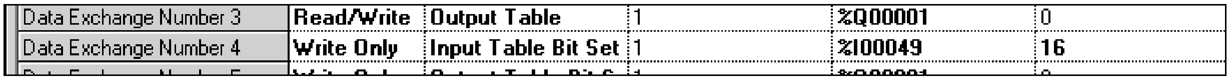
Select a starting address

Select a memory type

Available references

Reference Length: Specify the length of the memory area selected above in bits or 16-bit words (registers). The default is 0, which means there is no restriction and the entire table (starting at the Reference Address offset) is available for access by the CCM Master.

For example, here Data Exchange Number 5 has been edited so that the master can set only 16 bits beginning at %I00049 in the Input Table:



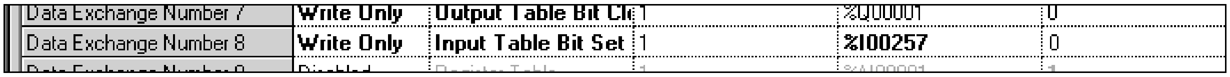
Data Exchange Number 3	**Read/Write**	**Output Table**	1	**%Q00001**	0
Data Exchange Number 4	**Write Only**	**Input Table Bit Set**	1	**%I00049**	**16**

More exchanges can be defined to allow the Master access to additional ranges within a memory type. For example, here Data Exchange Number 8 will allow the Master to set input bits from %I00257 to the end of the Input Table. In this example:

Input table bit 1 is written to %I00257
Input table bit 2 is written to %I00258

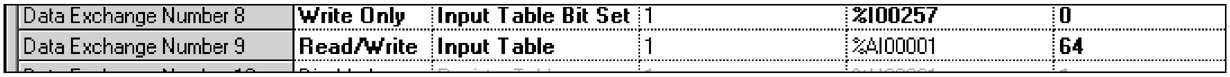
. . . .

Input table bit 400 is written to %I00656:



Data Exchange Number 7	**Write Only**	**Output Table Bit Cl**	1	%Q00001	0
Data Exchange Number 8	**Write Only**	**Input Table Bit Set**	1	**%I00257**	0

Access to other memory types can be provided by either editing the default exchanges, or defining additional exchanges. For example, here Data Exchange Number 9 will allow the Master to Read/Write the RX3i Analog Input Table:



Data Exchange Number 8	**Write Only**	**Input Table Bit Set**	1	**%I00257**	**0**
Data Exchange Number 9	**Read/Write**	**Input Table**	1	%AI00001	**64**

Data Exchange Number 9 includes both bit-type and word-type memories. For this exchange, the slave has 64 x 16 (1024)) bits of Input Table data mapped to the first 64 words of %AI memory for the Master to access.

Chapter 4 Port Status and Control Data

This chapter describes status, control, diagnostics, and communications data for PACSystems RX3i Serial Communications modules. It also explains how the DO I/O and Suspend I/O functions can be used with these modules.

- Transfer of Status and Control Data
- Port Status Input Data
- Port Control Output Data
- Error Status Handling
- Using DO I/O and Suspend I/O

Module Status and Control data does not include the serial communications data that is exchanged between the module and one or more serial devices. That data uses a different set of assigned CPU references, and is written to or read from the CPU outside of the CPU's normal I/O Scan.

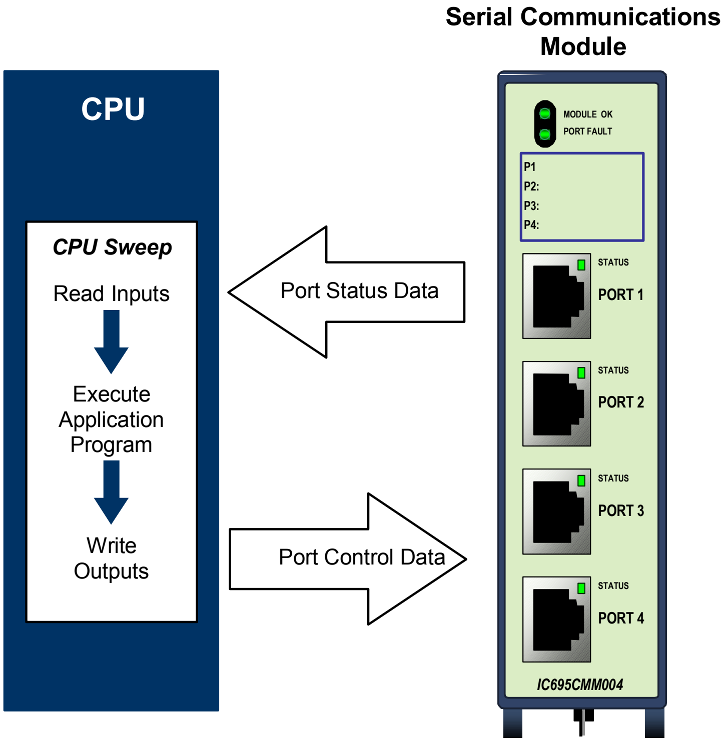
Because each protocol handles serial communications data differently, serial communications data is covered in the chapters of this manual that describe the individual port protocols.

Transfer of Status and Control Data

Module configuration reserves CPU memory for the module's Port Status and Control data. Each port's status and control data references are configured separately; lengths are fixed.

Data Type	***Total Data Length***	***Memory Type***
Port Status Data *224 bits per port*	CMM002: 448 bits CMM004: 896 bits	%I, %M, %T, or discrete I/O variables
Port Control Data *128 bits per port*	CMM002: 256 bits CMM004: 512 bits	%Q, %M, %T, or discrete I/O variables

During system operation, Port Status and Port Control data is transferred between the RX3i CPU and a Serial Communications module during the CPU's I/O Scan.



If the CPU is stopped with outputs disabled, it stops exchanging Port Status and Control data with the module. When the CPU goes back into Run mode, it resumes reading Port Status data and module status information.

The application should monitor the Port Status input data for information about serial communications status, and use the Port Control output data to send the module commands, acknowledge faults, or reset a port.

In addition to being transferred during the I/O Scan, transfer of status and control data can be controlled using the DO I/O and Suspend I/O program functions as described in this chapter.

Port Status Input Data

The Port Status input data format for each port is shown below. The byte and bit values used in the table represent relative offsets from the start of each port's status data.

Bytes	***Bits***	***Description***	
1 - 8	1 - 64	*Exchange Response Report (module sets all bits to 0 on startup)*	
		MODBUS Master	▪ For continuous exchanges: Last exchange completed successfully (one bit per exchange: bit 1 = exchange 1 to bit 64 = exchange 64) ▪ For single bit-control exchanges: Last exchange completed successfully when this matches the corresponding control bit (one bit per exchange: bit 1 = exchange 1 to bit 64 = exchange 64)
		MODBUS Slave	0 = Last Exchange Execution Failed or has yet to be executed 1 = Last exchange execution completed successfully (one bit per exchange: bit 1 = exchange 1 to bit 64 = exchange 64)
		Serial I/O	Bit 1 indicates a new Serial I/O receive has completed when this bit matches the corresponding control bit Bit 2 indicates a new Serial I/O transmit has completed when this bit matches the corresponding control bit Bits 2 - 64 are reserved
		CCM Slave	If PLC Access is configured as Read Only, Read/Write, or Write Only: 0 = Last Exchange Execution Failed or has yet to be executed 1 = Last exchange execution completed successfully (one bit per exchange: bit 1 = exchange 1 to bit 64 = exchange 64)
			If PLC Access is configured as any other type: ▪ For continuous exchanges: Last exchange completed successfully (one bit per exchange: bit 1 = exchange 1 to bit 64 = exchange 64) ▪ For single bit-control exchanges: Last exchange completed successfully when this matches the corresponding control bit (one bit per exchange: bit 1 = exchange 1 to bit 64 = exchange 64)
9 - 16	65 - 128	*Exchange Error Report*	
		MODBUS Master or Slave	0 = no error detected 1 = error detected. This bit remains 1 until errors are acknowledged. (One bit per exchange: bit 65 = exchange 1 to bit 128 = exchange 64.)
		Serial I/O	Bit 65 = 1 indicates a receive error has occurred Bit 66 = 1 indicates a transmit error has occurred Bits 67 – 128: Reserved
		CCM Slave	0 = no error detected 1 = error detected. This bit remains 1 until errors are acknowledged. (One bit per exchange: bit 65 = exchange 1 to bit 128 = exchange 64.)
17 - 18	129 - 144	*Port Status*	
		Bit 129	Port Ready = 1
		Bit 130	Configuration underway = 1
		Bit 131	1 = Control Bit Ready. The Exchange Control bit is being used for bit-controlled operations. Set to 0 if outputs are disabled.
		132 - 136	Reserved
		137 – 144	(Byte 18) Configuration ID from the Port configuration tab
19 -	145 –	MODBUS	Master / Slave: this data not used.

Bytes	***Bits***	***Description***		
24	192	Serial I/O	Protocol Status: Bit 145: CTS Status for RS232 when HW Control Disabled: 0 = Not CTS, 1 = CTS Bits 146 – 160: Spare Bits 161 – 176 (Word): Number of input buffer characters (bytes) available Bits 177 – 192 (Word): Number of characters(bytes) received	
		CCM Slave	Not used	
25	193-200	*Error Status Exchange Number*		
		MODBUS	Master / Slave: Exchange number of the error in the Error Status field (below)	
		Serial I/O	Value of 1 = receive error; 2 = transmit error	
		CCM Slave	Exchange number of the error in the Error Status field (below)	
26	201 – 208	*Error Status*		
		General Errors	0 = no error 1 = generic port error or module error 2 = receive overflow 3 = parity error 4 = framing error 5 = receive timeout	6 = transmit timeout 7 = module failed to send to CPU 8 = sent to CPU, but failure response 9 = not able to send to CPU, module timed out
		MODBUS	20 = unrecognized exception 21 = illegal function 22 = illegal data address 23 = illegal data value 24 = slave device failure 25 = acknowledge 26 = slave device busy 27 = negative acknowledge 28 = memory parity error	29 through 35 reserved 36 = CRC error on response 37 = unexpected slave address 38 = unexpected function code 39 =unexpected response length 40 = exchange register type is bad 41 = exchange register address is bad 42 =returned query data does not match
		Serial I/O	20 = data requested exceeds assigned memory 21 = bad checksum. Message discarded	22 = Data buffer overflow. New data discarded until characters have been removed from the buffer 23 = transmit command cancelled 24 = receive command cancelled 25 = data size exceeds 2k limit
		CCM Slave	No additional error codes defined.	
27 - 28	209 – 224	*Period Time*		
		The time to execute all Master exchanges, in milliseconds. 0 for slave protocols, 0 – 65535 for master protocols. Exchange times above 65535mS appear as 65535mS.		

Input Data Definitions

Exchange Response Report, Input Bits 1-64 (Bytes 1-8)

The Exchange Response Report bits reflect the execution status of the configured communications.

MODBUS Master: For Read or Write Continuous exchanges, if this bit is 1, the last execution of the exchange completed successfully. If this bit is 0, the last attempt has either failed or not yet completed. For Read or Write Continuous Bit-Controlled exchanges, if this bit is 1, the last exchange attempt completed successfully. If this bit is 0, the last attempt has either failed or not yet completed, or the control bit was set to 0 during the last output scan, causing no exchange to be attempted. For a read or write single (one-shot) exchange, if this bit matches the corresponding Exchange Control output bit in the output status data, the exchange has completed successfully. If this bit does not match the output data, the exchange is still pending. When the bit changes to match the commanded state, the exchange is complete.

MODBUS Slave: If this bit is 0, the exchange failed or has not yet executed. If this bit is 1, the last execution of the exchange completed successfully.

Serial I/O: only the first two Exchange Response bits are used. If bit 1 matches the corresponding Control bit, a new Serial I/O receive has completed. If this bit does not match the output data, the receive is still pending. When the bit changes to match the commanded state, the receive is complete. If bit 2 matches the corresponding Control bit, a new Serial I/O transmit has completed. If this bit does not match the output data, the transmit is still pending. When the bit changes to match the commanded state, the transmit is complete.

CCM Slave: For PLC Access of Read Only , Read/Write or Write Only, if this bit is 1, the last exchange attempt completed successfully. If this bit is 0, the last attempt has either failed or not yet completed, or the control bit was set to 0 during the last output scan, causing no exchange to be attempted. For all other types or PLC Access, if this bit is 1, the last execution of the exchange completed successfully. If this bit is 0, the last attempt has either failed or not yet completed.

Exchange Error Report, Input Bits 65-128 (Bytes 9-16)

The Exchange Error Report input bits reflect the error status of the configured communications.

For MODBUS Master or Slave and CCM Slave: the 64 Exchange Error Report *bits* report the error status of the configured exchanges. For each exchange, if the corresponding bit is = 1, an error occurred for that exchange. The bit remains set until one of the following occurs:

- The error is acknowledged by the application setting the Port Error Exchange Selector to the exchange number (Port Control bits 73-80) and the Port Command bit 65 to 1.
- All errors are cleared by the application setting Port Command bit 66.
- The port is reset by the application setting Port Command bit 67.
- The module receives a new configuration.

For Serial I/O: only the first two Exchange Error Report bits are used. If bit 65 = 1. a Serial I/O receive error has occurred. If bit 66 = 1, a transmit error has occurred.

Port Status, Input Bits 129-144 (Bytes 17, 18)

These two bytes provide information about the status of the port for all protocols.

- Bit 129 indicates whether or not the port is ready for communications
- Bit 130 indicates whether or not the port is currently being configured
- Bit 131 indicates whether or not the exchange Control bits are ready to control exchanges.
- Bits 132 to 136 are reserved.
- Byte 18 (bits 137 – 144) contains the Configuration ID that was configured for the port. If the application includes multiple configurations, this bit can be used to check which configuration is being used for the port.

Protocol Status, Input Bits 145-192 (Bytes 19 – 24)

For Serial I/O, these bits provide the following information. Not used for MODBUS.

CTS Status, Bit 145 is used for RS-232 communication, when the port's Flow Control parameter has been configured for Hardware Control (RTS/CTS). Before transmitting, the CPU should set *output* bit 84 (Activate RTS) in the port's Port Control Data to 1 to force RTS on the port. The CPU should then check input bit 145 (CTS active). When this bit is 1, the port can safely transmit. If CTS does not become active within 2 seconds, the module returns a timeout error to the status location.

After the last transmit character is sent, the CPU must set the RTS bit to 0. If CTS becomes active and then is de-asserted while the port is transmitting, up to 5 milliseconds may elapse before transmission stops. The maximum number of bytes transmitted after CTS is de-asserted is proportional to the data rate. These values are in addition to the byte that is being transmitted at the time CTS is de-asserted.

Data Rate	***Maximum Number of Characters Received after CTS is De-asserted***	***Data Rate***	***Maximum Number of Characters Received after CTS is De-asserted***
1200	1	19200	10
2400	2	38400	20
4800	3	57600	29
9600	5	115200	58

Bits 161 to 176, ”number of input buffer characters available” is a data word containing the number of input buffer bytes available in the module to receive data from the serial device. If there are no characters in the port's input buffer, the module ends the receive operation immediately. The module then sets the port's Exchange Error Report bit to 1 and the “received character count” (next item) to 0. The CPU is responsible for reading serial data out of the buffer to make room for new data.

Bits 177 to 192, “number of characters received” is a word of data that contains the number of bytes received by the module.

Error Status Exchange Number, Input Bits 193 – 200 (Byte 25)

For MODBUS Master or Slave: When an error occurs on a port, this byte identifies the exchange number that had the error. If the Error Exchange Number Selector (output bits 73-80) is 0, this byte contains the last processed exchange number, whether or not that exchange had an error. To retrieve the error status of a specific exchange, the CPU must send the module its exchange number in the Port Control output data.

For Serial I/O: A value of 1 in this byte indicates a receive error, and a value of 2 indicates a transmit error.

Error Status, Input Bits 201 – 208 (Byte 26)

When an error occurs on a port, this byte contains a number representing the error type (for example, 2 = receive overflow). See the previous table for a list of error numbers. If the Error Exchange Number Selector (*output* bits 73-80) is 0, this byte contains the error status of the last processed exchange, whether or not that exchange had an error. To retrieve the error status of a specific exchange, the CPU must send the module its exchange number in the Port Control output data.

Period Time, Input Bits 209 – 224 (Bytes 27, 28)

For MODBUS Master, these two bytes contain the time required to execute all master exchanges, in milliseconds. Each time all exchanges have been scanned (either processed or passed over) this value is updated, indicating the time it took for the Exchange scan to complete.

For MODBUS Slave and Serial I/O, these bytes are reserved.

Port Control Output Data

The Port Control output data for each port is shown below. The byte and bit values used in the table represent relative offsets from the start of each port’s control data.

Byte	Bit	Description	
1 - 8	1 - 64	*Exchange Control Bits*	
		MODBUS	Master: One bit per exchange. Used if the Operation type is one of the Bit-Control choices (such as Read Single, Bit-Control).
		Serial I/O	Bit 1 = Receive. Setting this bit to a different value than the corresponding Port Status bit enables the module to receive a new packet, if one exists. Bit 2 – Transmit. Setting this bit to a different value than the corresponding Port Status bit commands the module to initiate the next packet transmission.
		CCM Slave	One bit per exchange. Used if the PLC Access type is one of the Bit-Control choices (such as Read Single, Bit-Control). One bit per exchange. Not used for other PLC Access types.
9	65 - 72	*Port Command*	
		Bit 65: 1 = Acknowledge the error indicated in the Error Status and Error Status Exchange Number input data fields. Bit 66: 1 = Clear All Errors Bit 67: 1 = Port Reset Bits 68 - 72: spare	
10	73 – 80 (byte)	*Port Exchange Error Selector*	
		Specifies the Exchange Number for which the Error Status and Error Status Exchange Number will be returned by the module in the input data.	
11 - 16	81 - 128	*Output Commands to the Module*	
		MODBUS	Master / Slave: this data not used.
		Serial I/O	Bit 81: 1 = cancel pending receive operation Bit 82: 1 = cancel pending transmit operation Bit 83: 1 = flush input buffer Bit 84: 1 = activate RTS (RS232 only, with HW Control disabled Bits 85–96: not used Bits 97 – 112 (word): Number of characters to read when Dynamic Read is configured Bits 113 – 128 (word): Number of characters to write when Dynamic Write is configured

Byte	Bit	Description	
		CCM Slave	Bytes 11-14: Used for data to be sent when module receives Quick Response (Q) sequence from Master. Byte 15, Bit 0: the Clear CCM Errors Control bit. Used to select automatic clearing of CCM Diagnostic Status Words. 0 = CCM errors will be accumulated. 1 = CCM errors will be cleared each time a CCM port is processed. Byte 15 bits 1-15 and Byte 16: not used.

Output Data Definitions

Exchange Control, Output Bits 1 – 64 *For MODBUS Master (not used for MODBUS Slave):* The CPU must set these bits to start execution of MODBUS Master exchanges that have been configured as: *Read Periodic-Bit Control*, *Read Single Bit-Control, Write Periodic Bit-Control,* and *Write Single Bit-Control.* These bits do NOT control exchanges configured as *Read Periodic* or *Write Periodic.* Those exchanges are executed regardless of the state of the corresponding control bits.

For all of these exchange types, the module automatically provides success or error status for the exchange in the Port Status input data as described earlier in this chapter.

- Read Periodic, Bit-Control: This type of exchange continuously reads MODBUS data from the specified slave for as long as the corresponding Exchange Control Bit is set to a 1.
- Read Single, Bit-Control: This type of exchange reads data from the specified slave once when the corresponding Exchange Control Bit transitions to 1. To be sure the exchange is not missed or unintentionally repeated, the Control Bit should remain set to 1 until the module has completed the exchange and notified the CPU by setting the corresponding input Exchange Success Report or Exchange Error Report bits to 1. This type of exchange is controlled by a toggle bit. Note that if Input Status bit 131, Control Bit Ready, transitions to 0, all Exchange Control outputs bits must be reset to 0 to guarantee that the exchange is not processed. If the exchange should be processed after the control bits are ready again (Input Status bit 131 goes to 1), set the Exchange Control bit to 1.

  For example, if the Input Status bit for Exchange Number 4 is currently 0, to execute the exchange on the next output scan, the application logic should set the control bit to 1. The exchange is complete when the Input Status bit also becomes 1. To execute exchange 4 a second time, set the control bit to 0. The second execution is complete when the input status bit becomes 0 again.
- Write Periodic, Bit-Control: This type of exchange writes to the specified slave continuously, for as long as the corresponding Exchange Control Bit is set to 1.

- Write Single, Bit-Control: Uses toggle bit operation as described above for Read Single, Bit-Control. This type of exchange writes data to the specified slave only once when the Exchange Control Bit transitions to 1. To be sure the exchange is not missed or unintentionally repeated, the Control Bit should remain set to 1 until the module has completed the exchange and notified the CPU by setting the corresponding input Exchange Success Report or Exchange Error Report bits to 1.

For Serial I/O: Only the first two bits are used. Receive and Transmits use toggle bits, as described for MODBUS Master, Read Single, Bit-Control. The CPU can set either of these bits to initiate a new Serial I/O packet transmission. The CPU must first check state of the corresponding Port Status input bit.

- Bit 1, Receive Packet: If the state of the first bit in the Port's Status input data is the same as the current state of the first output bit (Receive Packet), it means that the previous Serial I/O receive has completed. The CPU can begin a new receive operation by setting this bit to its opposite state (if the Receive Packet output bit is 1, set it to 0, or vice-versa).
- Bit 2, Transmit Packet: If the state of the second bit in the Port's Status input data is the same as the current state of the second output bit (Transmit Packet), it means that the previous Serial I/O transmission has completed. The CPU can begin a new transmission by setting this bit to its opposite state (if the Transmit Packet output bit is 1, set it to 0, or vice-versa).

Port Command, Output Bits 65-72 (Byte 9)

The CPU can set individual the Port Command output bits to acknowledge or clear errors, or reset the port.

Acknowledge Current Error, Output Bit 65: The CPU can set this bit to 1 to acknowledge the error that is currently indicated by the Error Status and Error Status Exchange Number input data fields. The module responds by mirroring the Port Exchange Error Selector value in the port's Error Status Exchange Number field (input bits 193-200), and by setting the Error Status field (input bits 201-208) to 0.

The CPU can acknowledge multiple exchange errors by sending the module a sequence of commands and updating the Port Exchange Error Selector value (output bits 73-80) without toggling the Acknowledge Current Error bit (output bit 65) from 1 to 0 to 1 for each acknowledgement.

Clear All Errors, Output Bit 66: The CPU can set output bit 66 to 1 to acknowledge all exchange errors and reset their error status to 0.

Port Reset, Output Bit 67: Setting the Port Reset bit to 1 stops processing on that port and restarts operation as though the port just received another configuration. All port operations and data are initialized and reset according to the configuration. The port will only be reset again if the module sees a transition from the Port Reset bit from a 0 to a 1. The port remains in Reset if the CPU is not in Run mode.

Port Exchange Error Selector, Output Bits 73 - 80

The value in byte 10 (output bits 73 – 80) of the port Output Data is the Port Exchange Error Selector. Initially there are no errors for any exchange on a port, so this value can be set to 0. As long as the Error Exchange Number Selector value is 0, the Error Status (input bits 201-208) and Error Status Exchange Number (input bits 193-200) fields contain the last processed exchange error status and the exchange number respectively.

If the number of a specific exchange is entered in this byte, the module will return its error status in the Port Status input data.

Output Commands to the Module, Output Bits 81 – 128

For Serial I/O: The CPU can use output bytes 11-16 (bits 81 – 128) for each port to control Serial I/O Protocol operations.

- *Cancel Pending Receive Operation, Output Bit 81:* Setting this bit to 1 stops a pending Serial I/O receive. If this bit is set when a Receive is ongoing, the Receive stops and the error code is changed to 24. The data is not flushed from the buffer when this occurs Subsequent Receive attempts are canceled while this bit is set. If this bit is set and then reset before the next Receive, error code 24 is written and the next Receive operation will not be cancelled. If this bit is set when a Receive is not ongoing, the error code switches to 24 and no Receives can occur until this bit is reset.
- *Cancel Pending Transmit Operation, Output Bit 82:* Setting this bit to 1 stops a pending Serial I/O transmission. If this bit is set when a Transmit is ongoing, the Transmit stops and the error code changes to 23. Subsequent Transmit attempts are cancelled while this bit is set. If this bit is set and then reset before the next Transmit, there is no effect. If this bit is set and then reset before the next Transmit, error code 23 is written and the next Transmit operation will not be cancelled. If this bit is set when a Transmit is not ongoing, the error code switches to 23 and no Transmits can occur until this bit is reset.
- *Flush Input Buffer, Output Bit 83:* Setting this bit to 1 clears the port's input buffer of all characters that have been received but not read by the CPU. If a read buffer is pending at the same time a flush buffer operation is requested, the read buffer operation will be executed first, before clearing the contents of the buffer.
- *Activate RTS, Output Bit 84:* If the port is configured for RS232 operation and Flow Control is configured for HW Control (RTS/CTS), the CPU should set output bit 84 to 1 to force RTS on the port. The CPU should then check input bit 145 (CTS active). When that bit is 1, the port can safely transmit. If CTS does not become active within 2 seconds, the module returns a timeout error to the status location. After the last transmit character is sent, the CPU must set the RTS bit to 0.

- *Dynamic Read Length (bytes 13-14, bits 97 – 112 (word)):* If the Read Control Operation parameter is set to Dynamic Read Length, the CPU must specify the length of data in bytes to be read here.
- *Dynamic Write Length (bytes 15 – 16, bits 113 – 128 (word)):* If the Write Length Source parameter is set to Dynamic Write Length, the CPU must specify the length of data in bytes to be written here.

For CCM Slave: bytes 11 through 14 of the Port Control Output data are used for CCM Quick Response data. As described in chapter 7, the CCM Master can request four bytes of data directly from the Serial Communications Module using a Quick Read request. The Serial Communications Module automatically receives this data from the RX3i CPU in its output data, and stores it internally. The RX3i application program is responsible for maintaining the content of these four bytes in the CPU.

The least significant bit of byte 15 of the Port Control Output data can be used to control whether or not the CCM Diagnostic Status Words will be cleared automatically. If this bit is set to 1, CCM errors will be cleared continuously on the module until it is cleared to 0. If this bit is set to 0, CCM errors are accumulated in the module, and could still be cleared by the CCM Master using a Write command to the Diagnostic Status Words.

Error Status Handling

The module automatically returns the error status of an exchange in the Port Status input data. The Error Status field contains the exchange status. The Error Status Exchange Number contains the exchange number. For MODBUS Master or Slave protocol, this bit corresponds to the exchange number where the error occurred. For Serial I/O protocol, bit 1 is set if there is a receive error. Bit 2 is set if there is a transmit error.

To retrieve the status of a specific exchange, specify the exchange number in the Port Exchange Error Selector field (output bits 73-80), and clear the Acknowledge Current Error bit (output bit 65) to 0. The module responds by setting the Error Status Exchange Number field (input bits 193-200) to match the selected exchange number. If there is no current error for the exchange, the exchange number is returned in the Error Status Exchange Number (inputs 193-200) and the Error Status value (inputs 201-208) is 0.

If the Port Exchange Error Selector value is set to 0, the module returns the error status and exchange number of the most recently-completed exchange.

If an error has occurred, the module also sets the corresponding Exchange Error Report bit in the Port Status input data to 1. When an error bit is set, it remains set until the application has:

- acknowledged the error
- cleared all errors
- reset the port
- downloaded a new configuration

For a Read Single or Write Single Bit controlled exchange, the Exchange Error Report bit will automatically be cleared if the next exchange has no errors.

Acknowledging Errors

To acknowledge one error, specify the error number in the Port Exchange Error Selector (output bits 73-80), and set the Acknowledge Current Error bit (output bit 65) to 1. Multiple exchange errors can be acknowledged by sending the module a sequence of commands, updating the Port Exchange Error Selector value without toggling the Acknowledge Current Error for each acknowledgement.

The module responds by mirroring the Port Exchange Error Selector value in the port's Error Status Exchange Number field (input bits 193-200), and by setting the Error Status field (input bits 201-208) to 0.

Clearing All Errors on a Port

All exchange errors are acknowledged and reset to 0 by setting the Clear All Errors bit, setting the Port Reset bit, or downloading a new configuration.

Using DO I/O and Suspend I/O

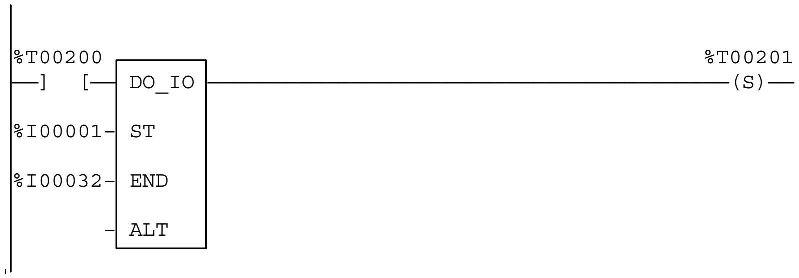
Both the DO I/O and Suspend I/O program functions can be used with PACSystems RX3i Serial Communications modules. Suspend I/O suspends I/O updates for the module. DO I/O immediately updates the module’s I/O data when the function executes in the application program. Both of these functions operate according to the standard for PACSystems controllers and modules.

The data that is updated by DO I/O is the data that is the Port Status Data and Port Control Data described in this chapter. DO I/O cannot be used with serial communications data, which is not part of the normal I/O Scanning process.

The PLC CPU and Serial Communications modules do not permit back-to-back DO I/O commands or normal output scans to overwrite output data before the module can read it. If output DO I/O will overwrite the previous output data that has not yet been consumed by the module, the DO I/O will discard the outputs and NOT pass power flow. The application must retry output DO I/O until successful, or retry later.

DO I/O Function Block Format

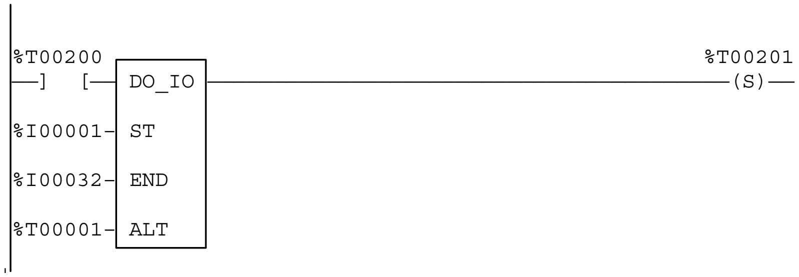
The DO I/O function has four input parameters and one output parameter. When the function receives power flow and input references are specified, the input points starting at the reference ST and ending at END are scanned. If an input reference is specified, with no alternate destination, all of the module’s input data is updated. Overwriting of all previous input data is only supported when no alternate location is specified. If a reference is specified for ALT, a copy of the new input values is placed in memory beginning at the alternate reference, and the regular input points are not updated; however only inputs from the specified reference table are copied.



The example DO I/O function block above will update both the bit and word data for a module with a %I starting reference of %I00001. When the DO I/O function receives power flow and output references are specified, the output points starting at the reference ST and ending at END are written to the referenced module(s).

If outputs should be written to the output modules from internal memory other than %Q or %AQ, the beginning reference can be specified using the ALT input. If a discrete (%Q) reference is specified with no alternate source both the control (%Q) and command (%AQ) data are updated using the module's %Q and %AQ data.

The example DO IO function block below will transfer 32 bits of discrete data from the alternate source location starting at %T1 to the module configured with %Q starting reference of %Q00001.



If previous outputs have not been consumed because DO I/O has been attempted within less than one module sweep since outputs were last written, then DO I/O terminates and does not pass power flow.

Chapter 5 MODBUS Communications

MODBUS communications are set up primarily within the module's configuration as described in chapter 3, *Configuration*. Chapter 4, *Port Status and Control Data*, details the data that is automatically exchanged between the module and the RX3i CPU each I/O Scan. The application uses that automatic data transfer to control and monitor communications through each port.

This chapter describes MODBUS Master and MODBUS Slave operations for RX3i Serial Communications modules.

- **MODBUS Communications Overview**
  - Messages and Responses
  - MODBUS Message Formats
  - MODBUS Data Addressing
- **MODBUS Communications for RX3i Serial Communications Modules**
  - Supported MODBUS Functions
  - Supported Transmission Mode
  - How MODBUS Functions are Implemented
- **MODBUS Master Operation for RX3i Serial Communications Modules**
  - How the Module Handles a Write Request in Master Mode
  - How the Module Handles a Read Request in Master Mode
  - MODBUS Master Diagnostics
- **MODBUS Slave Operation for RX3i Serial Communications Modules**
  - How the Module Handles a Read Request in Slave Mode
  - How the Module Handles a Write Request in Slave Mode
- **MODBUS Functions for RX3i Serial Communications Modules** - This section describes each MODBUS function that is supported by RX3i Serial Communications modules, and explains how to implement the function for a Serial Communications module in master or slave mode.

MODBUS Communications Overview

This section is a quick reference to MODBUS communications. For a Serial Communications module port configured as a MODBUS Slave, refer to the documentation for the MODBUS Master system for information on implementing MODBUS communications.

On a MODBUS serial line, the Master operates as the client and the slaves operate as servers. The Master issues explicit commands to one of the slaves and processes responses. Slaves do not typically transmit data without a request from the master, and they do not communicate with other slaves.

The MODBUS Master does not have a specific address on the bus; only slaves have addresses.

A MODBUS network has one master device and one or more (up to 247) slave devices. A serial network interconnects all these devices. If there is only one slave, a point-to-point connection is used. A multidrop connection is needed for two or more slaves.

Unicast or Broadcast Messages

The master can issue requests in two modes:

Unicast: the master sends a message to a single slave by specifying its unique address (1 – 247) on the serial bus. After receiving and processing the request, the slave returns a reply message to the master. In unicast mode, a MODBUS transaction consists of two messages: a request from the master and a reply from the slave.

Broadcast: the master sends a message to all slaves by specifying the broadcast address 0. Broadcast requests are always write messages. Slaves do not respond to a broadcast message.

The MODBUS Master does not have a specific address on the bus; only slaves have addresses.

Messages and Responses

MODBUS is a query-response protocol. The MODBUS Master sends a query to a MODBUS Slave, which responds. A slave cannot send a query; it can only respond.

After powerup, the Master goes into idle mode. The Master can only send messages while it is in idle mode. After sending a request, the Master waits for a reply. A Response timeout starts. If no reply is received within this time, an error is generated and the Master goes back to the idle state. The response timeout must be set long enough for any slave to process the request and return the response. A timeout can be configured for the port as described in chapter 3, *Configuration.*

The query/response transaction completes when the master receives a well-formed response. After receiving a reply from the slave, the Master checks the reply.

Normal Response

After the slave performs the function requested by the query, it sends back a normal response for that function. This indicates that the request was successful.

Error Response

If the slave receives a query, but for some reason it cannot perform the requested function, it sends back an error response to the master, indicating the reason the request could not be processed. No error message is sent for certain types of errors. See chapter 4 for a list of error codes.

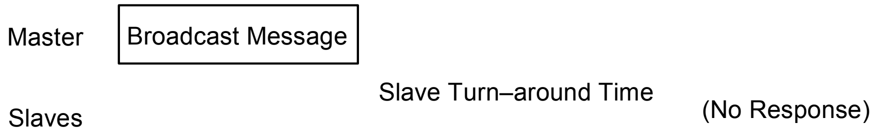
Broadcast Messages

The MODBUS master sends a broadcast message addressed to all slaves by using address 0.

Slaves do not respond to broadcast messages. However, the Master expects a delay so that the slaves can process the request. This delay is called the Turnaround Delay. The master goes into a Waiting Turnaround Delay state.

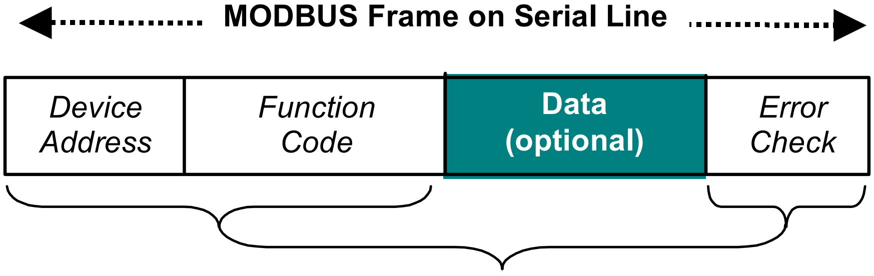
The Turnaround Delay must be long enough for any slave to be able to process the request and receive a new one. Therefore, the Turnaround Delay should be shorter than the Response Timeout. Typically, the response timeout is 1s to several seconds at 9800 bps and the turnaround delay is 100ms to 200ms.

All slaves that receive the broadcast message perform the requested function. When a broadcast message is sent to all slaves, they do not send responses. Instead of waiting for a response, the master instead waits a specified length of time for the slaves to process the request, before the master sends another message.



MODBUS Message Formats

Each MODBUS serial message consists of a sequence of message fields: a Device Address, a Function Code, optional Data fields and an error check field. The diagram below shows the basic format of a MODBUS message frame.



Automatically Supplied by RX3i Serial Communications Module

In MODBUS Master mode, an RX3i Serial Communications module automatically supplies the Device Address, Function Code, and Error Check portions of the basic MODBUS message, as indicated in the diagram. Only the optional data portion of the message, highlighted above and in the individual message descriptions in this chapter, must be handled by the application logic in the CPU.

The Device Address field identifies the slave that will receive the data transfer. An RX3i Serial Communications module automatically supplies this portion of a MODBUS message from the Station Address that is configured as part of each exchange that is set up for the port in MODBUS Master mode.

The Function Code field is a predefined number that identifies the MODBUS query type. In MODBUS Master mode, an RX3i Serial Communications module automatically determines the correct Function Code to use, based on the configured parameters of the exchange. No application programming is needed to provide this information.

The module also automatically performs the error-checking function. A 16-bit error check (Cyclic Redundancy Check) is included as the final field of each MODBUS query and response to ensure accurate transmission of data. This error check is applied to the entire message frame, as shown above. It is independent of any parity checking that is done, if configured, on the individual characters within the message.

MODBUS Data Addressing

The MODBUS protocol's reference table definition is different from the internal structure of the PACSystems reference tables. MODBUS terminology refers to Holding Register, Input Register, Input Discrete and Coil tables; PACSystems terminology refers to Discrete Input (%I), Discrete Output (%Q), Analog Input (%AI), Register (%R), and Word (%W) reference tables.

The following table compares MODBUS data types and lengths with equivalent PACSystems reference tables.

PACSystems Reference Tables	***MODBUS Holding Register Table (4xxxx)***	***MODBUS Input Register Table (3xxxx)***	***MODBUS Input Discrete Table (1xxxx)***	***MODBUS Coil Table (0xxxx)***
%I1 – 32768 (bits)	---	---	1 – 32768 (bits)	---
%AI1 – 32640 (16-bit words)	---	1 – 32640 (16-bit words)	---	---
%Q1 – 32768 (bits)	---	---	---	1 – 32768 (bits)
%R1 – 32640 (16-bit words)	1 – 32640 (16-bit words)	---	---	---

MODBUS Communications for RX3i Serial Communications Modules

PACSystems RX3i Serial Communications modules IC695CMM002 and IC695CMM004 use the standard MODBUS Function codes listed below to communicate with MODBUS devices.

Supported MODBUS Functions

Function Code	Function	MODBUS Master	MODBUS Slave
01	Read Coil Status (Read Output Table)	Yes	Yes
02	Read Input Status (Read Input Table)	Yes	Yes
03	Read Holding Registers	Yes	Yes
04	Read Input Registers (Read Registers)	Yes	Yes
05	Force Single Coil (Force Single Output)	Yes	Yes
06	Preset/Write Single Register	Yes	Yes
07	Read Exception Status	No	Yes
08	Diagnostics (Loopback Maintenance)	Yes	Yes
	Diagnostic Code 00: Return Query Data: Reads query data from one slave.	Yes	Yes
15	Write Multiple Coils (Force Multiple Outputs)	Yes	Yes
16	Preset/Write Multiple Registers Presets a group of contiguous registers to a specified value.	Yes	Yes
17	Report Slave ID(Report Device Type).	No	Yes
20	Mask 4x Registers	No	Yes
23	Read/Write 4x Registers	No	Yes

Supported Transmission Mode

RX3i Serial Communications modules execute MODBUS communications in RTU (Remote Terminal Unit) transmission mode. The entire message is transmitted as a continuous stream of characters. Between characters, the line is held in the 1 state. In RTU transmission mode, gaps of silence are used to frame a message. Because message frames must be separated by intervals of silence, MODBUS RTU is not recommended for use with modems, which can compress or change the gaps between frames and interfere with message timing.

How MODBUS Functions are Implemented

PACSystems RX3i Serial Communications modules handle MODBUS Master and Slave communications without the need for COMMREQ commands in the application program. For reference, the table below lists in the left column MODBUS functions that are done using COMMREQs for RX3i CPUs. For RX3i Serial Communications modules in MODBUS Master mode, the same functions are handled by configuring Data Exchanges, as shown in the center column.

When used in MODBUS Slave mode, Serial Communications modules can handle all MODBUS communications automatically, with no need to configure Data Exchanges. Additional Data Exchanges can be configured as suitable for the application.

PACSystems RX3i CPU, use COMMREQ to Perform MODBUS Function:	***RX3i Serial Communications Module in Master Mode, Configure a Data Exchange to:***	***RX3i Serial Communications Module in Slave Mode:***
Read Coil Status (01)	Read up to 254 bytes from the slave’s Coils (0x) table.	Handled automatically by default
Read Input Status (02)	Read up to 254 bytes from the slave’s Discrete Input (1x) table	
Read Holding Registers (03)	Read up to 127 words from the slave’s Holding Registers (4x) table.	
Read Input Registers (04)	Read up to 127 words from the slave’s Input Registers (3x) table.	
Force Single Coil (05)	Not available in Master mode.	
Preset Single Register (06)	Write one register (two bytes) of data to the slave’s register memory.	
Read Exception Status (07)	Read the exception status of the slave by configuring a Target Type of “Diagnostic Status”.	
Diagnostics (08), diagnostic code 00	Read or write, with a Target Type of “Return Query Data”.	
Write Multiple Coils (15)	Write up to 254 bytes of data to the slave’s Coils (0x) table.	
Preset/Write Multiple Registers (16)	Write one or more registers of data to a slave’s Registers (4x) table.	
Report Slave ID (17)	Not available in Master mode.	
Mask 4x Registers (22)	Not available in Master mode.	
Read/Write 4x Registers (23)	Not available in Master mode.	

MODBUS Master Operation for RX3i Serial Communications Modules

When a port is configured for MODBUS Master operation, the module acts on behalf of the CPU to exchange data with MODBUS Slaves on the network. Because the RX3i Serial Communications modules handle the details of MODBUS communications automatically, it is only necessary to set up MODBUS device addresses, exchange types and memory addresses in the hardware configuration. The application program only needs to handle any data that is sent to MODBUS devices, or received from them, and the sending and receiving of MODBUS data that is controlled by the exchange control bits. The module automatically forms a complete MODBUS message around the data to be read or written.

For both Master and Slave protocols, the Exchange information includes an address to reference memory locations with the RX3i CPU and an address to MODBUS memory locations with the externally-connected Slave. Both addresses are selected in the Machine Edition configuration.

The maximum data length that can be exchanged between the master and the slave is 254 bytes. The length is configured in each exchange.

When the module is started up, it receives its configuration from the CPU.

The module processes each exchange in order from 1 to 64. An exchange is processed if it is enabled and the control operation indicates it is ready to be processed. Processing the exchange consists of a single read or write operation with an externally-connected slave.

For a read operation, the module requests data from the specified slave. When the module has received all of the requested data, it writes the data to the configured reference addresses in CPU memory.

For a write operation, the module reads CPU memory and sends the data it to one or more slave device(s). Upon completion of processing the exchange, status information is set. Once all enabled exchanges have been processed, operation continues with exchange number 1.

How the Module Handles a Write Request in Master Mode

The module forms a standard MODBUS write request for each Write Continuous, Write Continuous Bit Control, or Write Single Bit Control exchange that has been set up in the port configuration.

At startup, or after the application turns on or toggles the control bit associated with the exchange, the module follows these steps:

1. The module sends the appropriate write query via the MODBUS serial port.
2. For a directed write request, the module then waits for a positive acknowledge response from the slave.
3. The module will make up to 3 attempts to send the message before declaring failure if a response is not received.
4. The module updates the exchange completion status.

How the Module Handles a Read Request in Master Mode

The module forms a standard MODBUS read request for each Read Continuous, Read Continuous, Bit Control, or Read Single, Bit Control exchange that has been set up in the port configuration.

At startup, or after the application turns on the control bit associated with the exchange, the module follows these steps:

1. The module sends the read query via the MODBUS serial port.
2. The module waits for positive acknowledge response.
3. The module will make up to 3 attempts to send the message before declaring failure if a response is not received.
4. After receiving data from the slave, the module immediately sends the data to the CPU.
5. The module updates the exchange completion status.

MODBUS Master Diagnostics

The module automatically tracks the status of each MODBUS Master exchange. This data is not provided to the CPU automatically. If the application will monitor this data, the port configuration should include a Data Exchange with a Target Type of Diagnostic Status. The Reference Length is always 18 words (288 bits), the length of the status data. Additional configuration setup includes selecting an Operation type for the Data Exchange. It can be:

Read Continuous: to read the data continually, without having to set the exchange's Control Bit.

Read Continuous Bit-Control: to read the data continually after triggering the operation using the exchange's Control Bit.

Read Single Bit-Control: to read the diagnostic data each time the Control Bit is toggled.

Word Offset	***Description***	
1	Most recent internal error or MODBUS exception. Hexadecimal error codes include:	
	0000	No error
	0001	Illegal function: function code not supported by slave.
	0002	Illegal data address: address is not available in slave, or diagnostic code not supported
	0003	Illegal value: data format incorrect or data length specified is longer than data received.
	0004	Slave device failure: query processing failure in the slave.
	0005	Acknowledge
	0006	Slave device busy
	0007	Negative acknowledge
	0008	Memory Parity error
	8xxx Internal errors:	
	8001	Query timeout:
	8002	Response timeout
	8003	UART response error
	8004	Response length invalid
	8005	Response CRC invalid
	8006	Response slave ID invalid
	8007	Response received after timeout
2	Number of queries failed due to timeout.	
3, 4	Number of queries sent on the MODBUS port.	
5	Number of normal responses received.	
6	Number of exception responses received.	
7	Number of responses failed due to timeout.	
8	Number of responses failed due to UART errors.	
9	Number of responses failed due to invalid length received.	
10	Number of responses failed due to invalid CRC received.	
11	Number of responses failed due to invalid slave address.	
12	Number of responses failed due to invalid function code.	
13	Number of responses failed due to invalid query data.	
14	Number of responses received after timeout.	
15, 16, 17, 18	The first 8 bytes of the most recent query.	

MODBUS Slave Operation for RX3i Serial Communications Modules

For a port in MODBUS Slave mode, the module acts on behalf of the CPU to respond to queries from the MODBUS Master over the serial bus, as they are received.

How the Module Handles a Read Request in Slave Mode

If the module receives a request to read RX3i CPU data from a MODBUS Master, the module follows these steps:

1. Each configured exchange is checked for a match. If the requested MODBUS Address (Target Type and Target Address from Master) is not mapped or not valid, the module automatically sends a MODBUS exception response on the bus. Otherwise:
2. If the requested exchange is enabled and valid, the module immediately requests the specified data from the CPU.
3. After receiving the data from the CPU, the module replies to the request by sending a response to the master.
4. The module updates the exchange completion status. The module sets an Exchange Status Report bit to 1 if the exchange was successful. If the exchange was unsuccessful, the module sets the Exchange Status Report bit to 0, and updates additional status information for the exchange as detailed in chapter 4, *Port Status and Control Data.*

How the Module Handles a Write Request in Slave Mode

If the module receives a request to write RX3i CPU data from a MODBUS Master, the module follows these steps:

1. Each exchange is checked for a match. If the requested MODBUS Address (Target Type and Target Address from Master) is not mapped or not valid, the module automatically sends a MODBUS exception response on the bus. Otherwise:
2. If the requested exchange is enabled and valid, the module immediately sends the data to the CPU.
3. The module sends a normal response to the master.
4. The module updates the exchange completion status as detailed in chapter 4, *Port Status and Control Data*.

MODBUS Functions for RX3i Serial Communications Modules

This section describes each MODBUS function that is supported by RC3i Serial Communications modules, and explains how to implement the function for a Serial Communications module in master or slave mode.

Read Coil Status (Read Output Table), MODBUS Function 01

The master can direct a MODBUS Read Coil Status message to a specified slave to read up to 254 bytes of data from the slave's discrete outputs (coils, 0x) table. The query and normal response formats are:

Master Query	Device Address	Function Code 01	Starting Point No.	Number of Points	Error Check
Slave Normal Response	Device Address	Function Code 01	Byte Count	**Data**	Error Check

RX3i Serial Communications Module, Port in MODBUS Master Mode

An RX3i Serial Communications module automatically forms a Read Coil Status query (function code 01) from a Read exchange that has a Target Type of Coils (0x). The module directs the query to the device address (configured Station Address) of the slave.

- The starting point number (configured exchange Target Address) can be any value less than the highest output point number available in the slave.
- The number of points (configured exchange Reference Length) specifies the number of output bits requested. The sum of the starting point number value and the number of points value must be less than or equal to the highest output point number in the slave.

When all the data has been received from the MODBUS Slave, the module automatically writes the data (highlighted above) to the configured CPU Reference Address area, and updates the exchange status information.

RX3i Serial Communications Module, Port in MODBUS Slave Mode

- Using the default Data Exchanges, the module automatically requests from the CPU an area of the %Q reference table. The starting reference address and length are specified in the master's query.
- If a new exchange is configured, the PLC Access mode may be Read Only or Read/Write. The Target Type must be Coils (0x). The Target Address is the offset from the start of the Master's Coils table. The configured Reference Address and Reference Length specify the CPU location of the data available to be read.
- The module requests the data from the CPU. After receiving the data, the module immediately sends it to the MODBUS Master using a Normal Response as shown above.

Read Input Status (Read Input Table), MODBUS Function 02

The master can direct a MODBUS Read Input Status message to a specified slave to read up to 254 bytes of data from the slave's discrete inputs (1x) table. The query and normal response formats are:

Master Query	Device Address	Function Code 02	Starting Point No.	Number of Points	Error Check
Slave Normal Response	Device Address	Function Code 02	Byte Count	**Data**	Error Check

RX3i Serial Communications Module, Port in MODBUS Master Mode

An RX3i Serial Communications module automatically forms a Read Input Status query (function code 02) from a Read exchange that has a Target type of Discrete In (1x). The module directs the query to the device address (configured Station Address) of the slave.

- The starting point number (configured Target Address) can be any value less than the highest input point number available in the slave.
- The number of points (configured Reference Length) specifies the number of input bits requested. The sum of the starting point number value and the number of points value must be less than or equal to the highest output point number in the slave.

When all the data has been received from the MODBUS Slave, the module automatically writes the data (highlighted above) from the configured CPU Reference Address area, and updates the exchange status information.

RX3i Serial Communications Module, Port in MODBUS Slave Mode

- Using the default Data Exchanges, the module automatically requests from the CPU an area of the %I reference table. The starting reference address and length are specified in the master's query.
- If a new exchange is configured, the PLC Access mode may be either Read Only or Read/Write. The Target Type must be Discrete In (1x). The Target Address is the offset from the start of the Master's Discrete Inputs table. The configured Reference Address and Reference Length specify the CPU location of the data available to be read.
- The module receives the requested data from the CPU, then immediately sends it to the MODBUS Master using a Normal Response as shown above.

Read Holding Registers (Read Registers), MODBUS Function 03

The master can direct a MODBUS Read Holding Registers message to a specified slave to read up to 254 bytes (127 registers) from the slave's registers (holding registers, 4x) table. The query and normal response formats are:

Master Query	Device Address	Function Code 03	Starting Register No.	Number of Registers	Error Check
Slave Normal Response	Device Address	Function Code 03	Byte Count	**Data**	Error Check

RX3i Serial Communications Module, Port in MODBUS Master Mode

An RX3i Serial Communications Module automatically forms a Read Holding Registers query (function code 03) from a Read exchange that has a Target Type of Holding Registers (4x). The module directs the query to the device address (configured Station Address) of the slave.

- The starting register (configured Target Address) can be any value less than the highest holding register number available in the slave.
- The number of registers (configured exchange Reference Length) specifies the number of registers requested. The sum of the starting register number value and the number of registers value must be less than or equal to the highest register number in the slave.
- When all the data has been received from the MODBUS Slave, the module automatically writes the data (highlighted above) to the configured CPU Reference Address area, and updates the exchange status information.

RX3i Serial Communications Module, Port in MODBUS Slave Mode

- Using the default Data Exchanges, the module automatically requests from the CPU an area of the %R reference table. The starting reference address and length are specified in the master's query.
- If a new exchange is configured, the PLC Access mode may be either Read Only or Read/Write. The Target Type must be Holding Regs (4x). The Target Address is the offset from the start of the Master's Holding Registers table. The configured Reference Address and Reference Length specify the CPU location of the data available to be read.
- The module receives the requested data from the CPU, then immediately sends it to the MODBUS Master using a Normal Response as shown above.

Read Input Registers (Read Analog Inputs), MODBUS Function 04

The master can direct a MODBUS Read Registers message to a specified slave to read up to 254 bytes (127 registers) of the slave's analog inputs (input registers 3x) table. The query and normal response formats are:

Master Query	Device Address	Function Code 04	Starting Register No.	Number of Registers	Error Check
Slave Normal Response	Device Address	Function Code 04	Byte Count	**Data**	Error Check

RX3i Serial Communications Module, Port in MODBUS Master Mode

An RX3i Serial Communications Module automatically forms a Read Registers query (function code 04) from a Read exchange that has a Target Type of Input Registers (3x). The module directs the query to the device address (configured Station Address) of the slave.

- The starting register (configured Target Address) can be any value less than the highest register number available in the slave.
- The number of registers (configured Reference Length) specifies the number of registers requested. The sum of the starting register number value and the number of registers value must be less than or equal to the highest register number in the slave.
- When all of the data has been received from the MODBUS Slave, the module automatically writes the data (highlighted above) to the configured CPU Reference Address area, and updates the exchange status information.

RX3i Serial Communications Module, Port in MODBUS Slave Mode

- Using the default Data Exchanges, the module automatically requests from the CPU an area of the %AI reference table. The starting reference address and length are specified in the master's query.
- If a new exchange is configured, he PLC Access mode may be either Read Only or Read/Write. The Target Type must be Input Regs (3x). The Target Address is the offset from the start of the Master's Input Registers table. The configured Reference Address and Reference Length specify the CPU location of the data available to be read.
- The module receives the requested data from the CPU, then immediately sends it to the MODBUS Master using a Normal Response as shown above.

Force Single Coil, MODBUS Function 05

The master can issue a MODBUS Force Single Coil message to a specified slave or to all slaves to change the state of one point in the discrete outputs (coils 0x) table. The specified output is forced automatically. This command is not an output override command. The output is guaranteed to be forced only once.

Master Query	Device Address	Function Code 05	Point Number	**Data** **00H**	Error Check
Slave Normal Response	Device Address	Function Code 05	Point Number	**Data** **00H**	Error Check

RX3i Serial Communications Module, Port in MODBUS Master Mode

This function is not available for an RX3i Serial Communications module port in MODBUS Master mode.

RX3i Serial Communications Module, Port in MODBUS Slave Mode

- Using the default Data Exchanges, the Serial Communications module automatically writes to the CPU %Q reference table. The starting reference address and length are specified in the master's query.
- A new exchange can be configured that maps some amount of %Q memory to coils. The PLC Access mode must be Read/Write. The Target Type must Coils (0x). The Target Address is the offset from the start of the Master's Input Registers table. The configured Reference Address and Reference Length specify the CPU location of the coils available to be forced by the master.
- After writing the received data to the CPU, the module replies to the MODBUS Master using a normal response as shown above. The normal response to a force single output query is identical to the query.

Preset/Write Single Register, MODBUS Function 06

The master can issue a MODBUS Preset/Write Single Register message to one slave or to all slaves, to set a single register in the registers (holding registers, 4x) table. The register is written automatically.

Master Query	Device Address	Function Code 06	Register Number High	Register Number Low	**Data High**	**Data Low**	Error Check
Slave Normal Response	Device Address	Function Code 06	Register Number High	Register Number Low	**Data High**	**Data Low**	Error Check

RX3i Serial Communications Module, Port in MODBUS Master Mode

An RX3i Serial Communications Module automatically forms a Preset/Write Single Register query (function code 06) from a Write exchange that has a Target Type of Holding Registers (4x) and a length of 1 register. The module directs the query to the device address (configured Station Address) of the slave

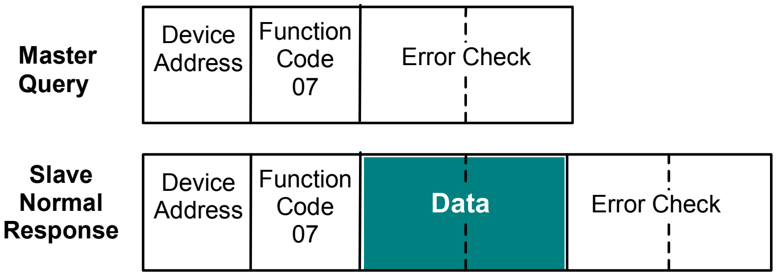
- The register number (configured Target Address) can be any register available in the slave.
- The data field is two bytes in length. The module supplies this data from the register value received from the CPU.
- As soon as the module receives the data from the CPU, it writes the query to the MODBUS Slave.

RX3i Serial Communications Module, Port in MODBUS Slave Mode

- Using the default Data Exchanges, the Serial Communications module automatically writes to the CPU %R reference table. The starting reference address and length are specified in the master's query.
- If a new exchange is configured, the PLC Access mode must be Read/Write. The Target Type must Holding Registers (4x). The configured Reference Address and Reference Length specify the CPU location of the data available to be written to.
- The module writes the received data to the CPU, then immediately replies to the MODBUS Master using a normal response as shown above. The normal response to a preset single register query is identical to the query.

Read Exception Status, MODBUS Function 07

The master can direct a Read Exception Status MODBUS message to a specified slave to read the first eight output points.



RX3i Serial Communications Module, Port in MODBUS Master Mode

The Read Exception Status function (function code 07) is not explicitly supported by RX3i Serial Communications modules RX3i Serial Communications Module, Port in MODBUS Master mode. Configuring a Read exchange with a length of Target Type of Coils (0x) and a Target Address of 1 will accomplish the same function.

- The module automatically forms a Read Coils query from the configured exchange, and directs it to the slave.
- The data field of the normal response is one byte in length. It contains the states of output points one through eight. The output states are packed in order of number with output point one's state in the least significant bit and output point eight's state in the most significant bit. As soon as all of the data has been received, the module automatically writes it to the configured CPU Reference Address area.

RX3i Serial Communications Module, Port in MODBUS Slave Mode

- Using the default Data Exchanges, the Serial Communications module automatically requests the first 8 bits in the CPU's %Q reference table.
- If a new exchange is configured, the PLC Access mode may be either Read Only or Read/Write. The Target Type must be Coils (0x). The Target Address is the offset from the start of the Master's Coils table. The configured Reference Address and Reference Length specify the CPU location of the data available to be read.
- The module receives the requested data from the CPU, then immediately sends it to the MODBUS Master using a Normal Response as shown above.

Diagnostics, Return Query Data, MODBUS Function 08

The master can direct a MODBUS Diagnostic (Loopback Maintenance) query to a specified slave to test the slave's ability to mirror the same data back to the master. The query and normal response formats are:

Master Query	Device Address	Function Code 08	Diagnostic Code 00	**Data**	Error Check
Slave Normal Response	Device Address	Function Code 08	Diagnostic Code 00	**Data**	Error Check

RX3i Serial Communications Module, Port in MODBUS Master Mode

An RX3i Serial Communications Module automatically forms a Diagnostics query (function code 08) with a Diagnostic Code of 00 from a Read Exchange that has a Target Type of Return Query Data.

- The module requests from the CPU two bytes of data from the configured Reference Address location. The values of the two data field bytes in the query are arbitrary.
- After receiving the data from the CPU, the module directs the query to the slave
- The module waits for the slave to return a copy of the query.

RX3i Serial Communications Module, Port in MODBUS Slave Mode

No exchange configuration is needed. The Serial Communications module automatically responds with a copy of the master's query, regardless of whether or not it is configured for Preconfigured Exchanges This command does not cause the module to exchange any data with the CPU.

Write Multiple Coils (Force Multiple Outputs), MODBUS Function 15

The MODBUS Master can issue a Write Multiple Coils message to force up to 254 contiguous points in one slave's or all slaves' discrete outputs (coils 0x) table. The specified outputs are forced automatically. Write Multiple Coils is *not* an output override command. The outputs are guaranteed to be forced only once. The query and normal response formats are:

Master Query	Device Address	Function Code 15	Starting Point Number	Number of Points	Byte Count	**Data**	Error Check

Slave Normal Response	Device Address	Function Code 15	Starting Point Number	Number of Points	Error Check

RX3i Serial Communications Module, Port in MODBUS Master Mode

An RX3i Serial Communications module automatically forms a Write Multiple Coils query (function code 15) from a Write exchange that has a Target Type of Coils (0x).

- The module requests the content of the configured CPU reference address. The values for the output points must be ordered by number starting with the LSB of the first byte.
- The number of points is based on the configured reference length.
- As soon as the module receives the data from the CPU, it directs the query to the device address (configured Station Address) of the slave.
- The starting point number configured as the Target Address can be any value less than the highest output point number available in the slave. The sum of the starting point number and the number of points value must be less than or equal to the highest output point number available in the slave. If the number of points is not a multiple of 8, the last data byte contains zeros in its higher order bits.

RX3i Serial Communications Module, Port in MODBUS Slave Mode

- Using the default Data Exchanges, the Serial Communications module automatically writes to the CPU %Q discrete outputs. The starting reference address and length are specified in the master's query.
- If a new exchangeis configured, the PLC Access mode must be Read/Write. The Target Type must Coils (0x). The configured Reference Address and Reference Length specify the CPU location of the data to be written.
- The module writes the received data to the CPU, then immediately replies to the MODBUS Master using a normal response as shown above.

Preset/Write Multiple Registers, MODBUS Function 16

The master can issue a MODBUS Preset/Write Multiple Registers message to preset a group of up to 127 contiguous registers in one slave or all slaves to a specified value.

Master Query	Device Address	Function Code 16	Starting Register Number	Number of Registers	Byte Count	**Data**	Error Check

Slave Normal Response	Device Address	Function Code 16	Starting Register Number	Number of Registers	Error Check

RX3i Serial Communications Module, Port in MODBUS Master Mode

An RX3i Serial Communications module automatically forms a Preset/Write Multiple Registers query (function code 16) from a Write exchange that has a Target Type of Holding Registers (4x).

- The module requests the content of the configured CPU references addresses, to be written in the query.
- The starting register number (configured Target Address) can be any value less than the highest register number available in the slave.
- The number of registers (configured Reference Length) specifies the number of registers to write. The sum of the starting register number (configured Target Address) and the configured Reference Length must be less than or equal to the highest register number available in the slave.
- As soon as the module receives the data (highlighted above) from the CPU, it directs the query to the device address (configured Station Address) of the slave.

RX3i Serial Communications Module, Port in MODBUS Slave Mode

- Using the default Data Exchanges, the Serial Communications module automatically writes to the CPU %R registers. The starting reference address and length are specified in the master's query.
- If a new exchange is configured, the PLC Access mode must be Read/Write. The Target Type must Registers (4x). The configured Reference Address and Reference Length specify the CPU location of the data to be written.
- The module writes the received data to the RX3i CPU, then immediately replies to the MODBUS Master using a normal response as shown above.

Report Slave ID, MODBUS Function 17

A master can direct a MODBUS Report Slave ID message to a specified slave to find the device type of the slave. For an RX3i Serial Communications Module, this function is only used in slave mode.

Master Query	Device Address	Function Code 17	Error Check				
Slave Normal Response	Device Address	Function Code 17	Byte Count	Device Type	Slave Run Light	**Data**	Error Check

RX3i Serial Communications Module, Port in MODBUS Master Mode

Not supported by a port configured for MODBUS Master mode.

RX3i Serial Communications Module, Port in MODBUS Slave Mode

No exchange configuration is needed. The Serial Communications module automatically returns the Normal Response shown above.

- The slave run light field is one byte in length. This field indicates the state of the backplane Run line.
- The slave response contains the following data.

Response Data	*Model*
0	Slave Address
1	Function Number (17 decimal or 0x11 hex)
2	5 data count
3	Major Revision Code (eg: 1 for 1.03)
4	Backplane Run Status
5	Minor Revision Code (eg: 03 for 1.03)
6	0 (reserved)
7	0 (reserved)
8	0xXX CRC (error check)
9	0xXX CRC (error check)

Mask Write 4x Memory (Register Table), MODBUS Function 22

The master can issue MODBUS message Mask Write 4x Memory (function code 22) to modify the content of a specified register in slave Register (Holding Registers, 4x) memory. The query and response formats are:

Master Query	Device Address	Function Code 22	Register Number	**AND Mask**	**OR Mask**	Error Check
Slave Normal Response	Device Address	Function Code 22	Register Number	**AND Mask**	**OR Mask**	Error Check

RX3i Serial Communications Module, Port in MODBUS Master Mode

This function is not supported by an RX3i Serial Communications module port configured for MODBUS Master mode.

RX3i Serial Communications Module, Port in MODBUS Slave Mode

- Using the default Data Exchanges, the module automatically requests from the CPU an area of the %R reference table. The starting reference address and length are specified in the master's query.
- If a new exchange is configured, the PLC Access mode must be Read/Write. The Target Type must be Holding Regs (4x). The Target Address is the offset from the start of the Master's Holding Registers table. The configured Reference Address and Reference Length specify the CPU location of the data available to be written
- When the module receives a query with function code 22, it automatically reads the contents of the two CPU registers that have been defined in the exchange. The module uses the query's AND mask and OR values mask to change the register's current content:

  Result = (Current Content AND And_Mask) OR (Or_Mask AND $\overline{\text{And\_Mask}}$)

  Example

	Hex	*Binary*	
Current Contents	12	0001	0010
And_Mask	F2	1111	0010
Or_Mask	25	0010	0101
$\overline{\text{And\_Mask}}$	0D	0000	1101
Result	17	0001	0111

- The module returns the revised data to the same CPU registers, then replies to the master using the normal response shown above.

Read/Write 4x (Register Table) Memory, MODBUS Function 23

The master can issue MODBUS message Read/Write 4x Memory to both read and write data in one MODBUS transaction. The function writes new contents to one group of registers, and returns the contents of a different group of registers.

Master Query	Device Address	**Function Code** 23	**Starting Register to Read**	**Number of Registers to Read**	**Starting Register to Write**	**Number of Registers to Write**	**Data**	Error Check
Slave Normal Response	Device Address	**Function Code** 23	**Byte Count**	**Data**	Error Check			

RX3i Serial Communications Module, Port in MODBUS Master Mode

This function is not supported by an RX3i Serial Communications module port configured for MODBUS Master mode.

RX3i Serial Communications Module, Port in MODBUS Slave Mode

- Using the default Data Exchanges, the module automatically requests from the CPU an area of the %R reference table. The starting reference address and length are specified in the master's query.
- If a new exchange is configured, the PLC Access mode must be Read/Write. The Target Type must be Holding Regs (4x). The Target Address is the offset from the start of the Master's Holding Registers table. The configured Reference Address and Reference Length specify the CPU location of the data to be written
- When the module receives a query with function code 23, it first performs the write operation to the CPU registers. It then performs the read from CPU registers.
- After completing both actions, the module replies to the MODBUS Master using a normal response as shown above.

Chapter 6

Serial I/O Communications

This chapter describes the Serial I/O feature of RX3i Serial Communications modules. Serial I/O communications can be used to exchange up to 2K bytes of data with an individual serial device, such as a modem, that is connected to one of the module's ports.

Serial I/O Communications for RX3i Serial Communications Modules

PACSystems RX3i Serial Communications modules support the same Serial I/O protocol as the RX3i CPU. Serial I/O protocol can be used to communicate with a serial device, such as a modem, connected to one of the module's ports. The module has a 2048-byte buffer to receive data from a serial device.

Serial I/O Features of Serial Communications Modules

PACSystems RX3i Serial Communications modules provide the Serial I/O protocol features listed below. Unlike the PACSystems RX3i CPU, RX3i Serial Communications modules do NOT use Communication Request (COMMREQ) commands for Serial I/O. Instead, the CPU sets up data communications in the port's configuration parameters, and controls communications through the status and control data that it exchanges with the module each I/O Scan (detailed in chapter 5, *Status and Control Data*).

For reference, the table below compares the Serial I/O functions implemented using COMMREQs in an RX3i CPU with the same functions for an RX3i Serial Communications module.

PACSystems RX3i CPU	***RX3i Serial Communications Module***
Local functions – do not receive or transmit data through the serial port.	
Initialize Port	Set bit 67 (port reset) in the Port's Control Data to 1.
Set Up Input Buffer	No action necessary. The module automatically maintains a 2K memory buffer for Serial I/O data.
Flush Input Buffer	Set bit 83 (flush input buffer) in the Port's Control Data to 1.
Read Port Status	Check the status bits in the Port's Status Data.
Write Port Control	Set bit 84 (activate RTS) in the Port's Control Data to 1.
Cancel COMMREQ Operation	Not needed; you can cancel a pending receive or transmit by using bit 81 to cancel a receive or bit 82 to cancel a pending transmit.
Remote functions – receive and/or transmit data through the serial port.	
Autodial	Use multiple write operations of different lengths to dial the modem, send the data, and send the hang up sequence.
Write bytes	Toggle bit 2 of the Port's Control Data to initiate write.
Read bytes	Toggle bit 1 of the Port's Control Data to initiate read of specific data length.
Read String	Toggle bit 1 of the Port's Control Data to initiate read up to specified termination sequence.

Local Serial I/O Operations

Local Serial I/O operations are performed by the CPU using the port's control output data. The CPU automatically sends this data to the module each CPU sweep. It can also be sent using a DO I/O block in the application program. Details of the Port Control Output data are provided in chapter 4, *Port Status and Control Data.*

Initializing (Resetting) the Port

Resetting a port stops processing on that port and restarts operation as though the port just received another configuration. Resetting the port initializes all port operations according to the port's configuration.

To reset a port, the application logic sets bit 67 (Port Reset) in the port's Port Control Data to 1. The port will only be reset again if the module sees another scan of the Port Reset bit still set to 1. The port remains in Reset if the CPU is not in Run mode. The port will reset again every time this bit is not set back to 0 for an output scan.

Managing Hardware Flow Control for RS-232 Communications

For RS-232 communication, if the port's Flow Control parameter has been configured for Hardware Flow Control (RTS/CTS), the application should set output bit 84 (Activate RTS) in the port's Port Control Data to 1 to force RTS on the port before transmitting.

The application should then check input bit 145 (CTS active). When this bit is 1, the port can safely transmit. If CTS does not become active within 2 seconds, the module returns a timeout error to the status location. If CTS becomes active and then de-asserts, additional data transmission must stop until CTS reasserts. After the last transmit character is sent, the application must set the RTS bit to 0.

Reading Serial I/O Data

When the module receives Serial I/O input data, it automatically stores the data in the 2048-byte input buffer. If the buffer becomes full, any additional data received from the serial port is lost. The application logic can monitor port status to see how much space is used in the input buffer. The application logic is responsible for reading data out of the buffer in a timely manner, so that incoming data will not be lost. The application can also flush the input buffer, which removes input data that has not yet been read.

Reading the Port Status

Each CPU sweep, the module automatically informs the CPU of the status of the Serial I/O input buffer in the Port Status input data. The application logic should monitor this status to be sure input data is not lost.

- Port input bits 161-176 (word data) contain the number of input buffer characters that have been received.
- Port input bits 177-192 (word data) contain the number of input buffer characters that were last transferred from the input buffet to PLC memory. This makes it possible to determine how many bytes of the last received data are new.

Flushing the Input Buffer

The port's Serial I/O input buffer can be cleared by setting bit 83 (flush input buffer) in the Port Control output data to 1. This operation empties the input buffer of any characters received through the serial port but not yet read by the CPU. If the application tries to flush the buffer while a read operation is pending, the read buffer operation is executed first, then the buffer is cleared of all remaining data.

Reading Input Data

The application logic in the RX3i CPU is responsible for reading data from the input buffer into its assigned CPU reference area.

1. To read Serial I/O data from the RX3i Serial Communications module's input buffer, the application program toggles bit 1 of the Port's Control output data to the opposite state.
2. The module reads the requested data from its internal buffer. The amount of data transferred depends on the parameters that were chosen for the Serial I/O Read configuration:
   - ***Read Input Buffer Only:*** If the *Read Control Operation* configuration parameter is set to *Receiving Disabled*, the receive transaction will only read data bytes that are already in the port's input buffer. The number of bytes actually read is indicated in the word of data between bits 177 – 192 of the port's input status data
   - ***Read a Data String***: If the *Read Control Operation* parameter is configured for *Read Delimiter*, the module reads data until the specified termination sequence occurs, or until an error is detected. If a Timeout value has been configured and a timeout occurs before the termination sequence is received, any data collected before the timeout is discarded. If the terminating character cannot be found, the receive operation terminates immediately.
   - ***Read Fixed Byte Count***: If the port's *Read Control Operation* is configured for *Byte Count,* the module will return all data from the serial channel up to the specified number of bytes. If the length is set to 0, all bytes in the port's input buffer will be received. The word of data between bits 177 – 192 of the port's input status data indicates the number of bytes read. If there are no characters in the port's input buffer, the module terminates the receive operation immediately. The module sets the port's Exchange Error Report bit to 1 and the "received character count" to 0.
   - ***Read Dynamic Byte Count***: If the port's *Read Control Operation* is configured for *Dynamic Read Length*, the application sends the number of bytes to be read in the word between bits 97-112 of the Port Control Data. The module then reads the data as described above for Read Fixed Byte Count.
3. The module immediately sends the serial data to the CPU.
4. The module updates the port's error status, received character count, and input buffer characters available information in the Port Status data, and sets input bit 1 to match the state of output bit 1. When these two bits match, it indicates that the Serial I/O read has been completed.

Writing Serial I/O Data

The CPU references to be used for serial data and the length of data that will be written in each transmission are set up in the port configuration. The application logic controls transmission of serial data using the port's status and communications data, which is explained in more detail in chapter 4.

To write data to a Serial I/O device, the application should:

1. Application program toggles Port Control output bit 2 to the opposite state to initiate the next packet transfer.
2. The Serial Communications module responds by immediately requesting the contents of the configured Serial I/O transmit references from the CPU (the data should not be changed until the operation is complete). For example:

Data	***Values***
6568	'h' (68h), 'e' (65h)
6C6C	'l' (6Ch), 'l' (6Ch)
006F	'o' (6Fh)

   Although printable ASCII characters are used in this example, there is no restriction on the values of the characters that can be transmitted.

3. The amount of data transferred depends on the parameters that were chosen for the Serial I/O Write configuration:
   - ***Write Fixed Byte Count***: If the port's *Write Length Source* is configured for *Static Write Length,* the module will write the configured number of bytes.
   - ***Write Dynamic Byte Count***: If the port's *Write Length Source* is configured for *Dynamic Write Length*, the application sends the number of bytes to be read in the word between bits 113-128 (word 16) of the Port Control Data.
4. The CPU provides the requested data to the module.
5. The status of the operation is not complete until all of the characters have been transmitted or until a timeout occurs (for example, if hardware flow control is being used and the remote device never enables the transmission). After transmitting all of the data, the module updates any error status in the Port Status Data, and sets bit 2 of the Port Status input data to the same state as output bit 2.
6. The application logic should monitor status bit 2. When input bit 2 and output bit 2 are the same, it indicates that the last transmission was completed successfully.

Dialing a Modem

Serial I/O writes can be used to dial a modem and send a specified byte string. For example, pager enunciation can be implemented by three commands, requiring three commands:

- Dial the modem.
- Specify an ASCII string to be sent from the serial port.
- Sending the hang-up command string. It is the responsibility of the application logic to hang up the connection..

Command Strings to Dial or Hang Up a Modem

Commonly-used command strings for Hayes-compatible modems are listed below:

Command String	***Length***	***Function***
ATDP15035559999<CR>	16 (10h)	Pulse dial the number 1-503-555-9999
ATDT15035559999<CR>	16 (10h)	Tone dial the number 1-503-555-9999
ATDT9,15035559999<CR>	18 (12h)	Tone dial using outside line with pause
ATH0<CR>	5 (05h)	Hang up the phone
ATZ <CR>	4 (04h)	Restore modem configuration to internally saved values

For example, these strings tone-dial the number 234-5678 using a Hayes-compatible modem.

Data	***Values***
5441h	A (41h), T (54h)
5444h	D (44h), T (54h)
3332h	Phone number: 2 (32h), 3 (33h)
3534h	4 (34h), 5 (35h)
3736h	6 (36h), 7 (37h)
0D38h	8 (38h) <CR> (0Dh)

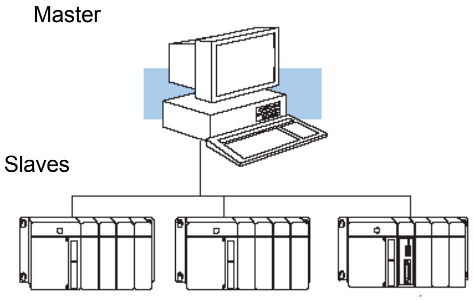
Chapter 7 CCM Communications

Built-in CCM slave protocol allows a PACSystems RX3i Serial Communications module (revision 1.10 or later) to communicate with a variety of GE Fanuc devices. Communications characteristics are set up primarily within the module's configuration as described in chapter 3, *Configuration*. Chapter 4, *Port Status and Control Data*, details the data that is automatically exchanged between the module and the RX3i CPU each I/O Scan. The application uses that automatic data transfer to control and monitor communications through each port.

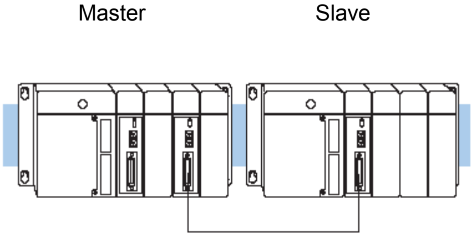
This chapter describes CCM Slave operations for RX3i Serial Communications modules.

CCM Overview

CCM protocol is a serial communications protocol used by GE Fanuc Programmable Logic Controllers (PLCs) to share data between PLCs, or between PLCs and a host computer.



Multi-Drop Network



Point-to-Point Connection

The Master may download data to the slave stations, or upload data from the Slave stations. Slave stations only respond to requests from the Master station and cannot initiate communications. Masters cannot "broadcast" a message to all Slaves.

CCM Networks use the RS-232 / RS-422 communication standards. RS-422/485 is necessary for a multi-drop Master-Slave network. Communication is asynchronous, half-duplex at speeds up to 115.2K baud. To avoid data collisions on a multi-drop network, slaves only “speak when spoken to”.

A PACSystems Serial Communications Module port can be used as a CCM Slave only, on either a point-to-point or multidrop link. Other CCM-compatible devices on the link may include:

- Series 90-70 Communications Coprocessor Module, IC697CMM711
- Series 90-70 Programmable Coprocessor Module, IC697PCM711
- Series 90-30 Communications Coprocessor Module, IC693CMM311
- Series 90-30 Programmable Coprocessor Module, IC693PCM300, 301, or 311

CCM protocol is NOT available on Series 90 CPU serial ports.

CCM protocol was originally developed for Series Six Communications Control Modules (CCMs), such as IC600CB536, IC600CB537, and IC600BF948.

Instructions for using CCM protocol on other modules are not included here. For Series 90 CCM applications, refer to the *Series 90 PLC Serial Communications Manual,* GFK-0582D. For Series 90 PCM applications, refer to the *Series 90 Programmable Coprocessor Module Manual,* GFK-0255K. For Series Six CCM applications, refer to the *Series Six PLC CCM Communications Manual,* GFK-25386A*.* These documents are available at the GE Fanuc website, and on the Infolink CD documentation library.

CCM Commands for RX3i Serial Communications Modules

As a CCM Slave, an RX3i Serial Communications Module supports the CCM Master commands listed below. The Command Numbers listed in the left column are used in the Master's application program to identify the command to be executed; they are not part of the CCM communication itself, and they are not relevant to the RX3i Serial Communications Module.

Master Command Number	***Command Description for CCM Masters***	***Implementation for RX3i Serial Communications Modules***
[6001]	Set Q Response. Local command, which passes four bytes of data from the CPU to the CCM interface.	CCM Command number not supported. This function is automatically handled in the module's Port Control Output data, as described in chapter 4.
[6002]	Clear CCM Status Words. Local command	CCM Command number not supported. This function is handled with the Clear CCM Errors Control bit.
[6003]	Read CCM Diagnostic Status Words. Local command, which reads CCM Diagnostic Status Words from CCM interface to CPU.	CCM Command number not supported. This function is handled by configuring a Data Exchange to read Diagnostic Status data from the module to a memory location in the RX3i CPU.
[6004]	Software Configuration. Local command.	CCM Command number not supported. This function is handled by port configuration in Machine Edition.
6101	Read from Target (slave) to Source (CCM Master) Register Table	Read/Write Register Table Data Exchange sets up CCM Master reads to any specified RX3i memory area, as configured. Multiple memory areas and types can be configured.
6102	Read from Target (slave) to Source (CCM Master) Input Table	
6103	Read from Target (slave) to Source (CCM Master) Output Table	
6109	Read Q-Response to Source Output Table.	The module returns the requested data to the Master.
6110	Single Bit Write. This function writes one bit to %I or %Q. Bit may be set to 1 or cleared to 0, depending on the memory type specified, as explained in the CCM Master documentation.	Configured Data Exchanges in the Serial Communications Module define Input Table B set and/or clear, and Output Table Bit set and/or clear. Multiple memory areas and types can be configured.
6111	Write to Target from Source Register Table. This function writes a specified number of words from Master to %R Register Table	Read/Write Register Table Data Exchange sets up CCM Master writes to any specified RX3i memory area, as configured. Multiple memory areas and types can be configured.
6112	Write to Target from Source Input Table. This function writes a specified number of bits from Master to %I Input Table	
6113	Write to Target from Source Output Table. This function writes a specified number of bits from Master to %Q Output Table	

CCM Memory Types

RX3i Serial Communications modules permit the CCM Master to perform the following read or write operations. By default, CCM Memory Types 1-3 and 13-18 are set up in the Serial Communications Module to access the conventional CCM Memory Types. However, the CCM Master can also access other memory types, as described in chapter 3.

CCM MemoryType	***Description***	***Memory Type in RX3i Slave accessed by CCM***	***Read***	***Write***
1	CPU Register Table	Defaults to %R – Register Table *	**yes**	**yes**
2	CPU Input Table	Defaults to %I – Input Table *	**yes**	**yes**
3	CPU Output Table	Defaults to %Q – Output Table *	**yes**	**yes**
6	CCM Scratchpad * *	CCM Scratchpad in module	**Yes**	**no**
9	CCM Diagnostic Status Words * *	CCM Diagnostic Status Words ***	**yes**	**yes**
13	Input Table Bit Set	Defaults to %I – Input Table *	**Not applicable**	**yes**
14	Output Table Bit Set	Defaults to %Q – Output Table *		**yes**
17	Input Table Bit Clear	Defaults to %I – Input Table *		**yes**
18	Output Table Bit Clear	Defaults to %Q – Output Table *		**yes**

* can be configured in Serial Communications Module to access any RX3i CPU memory type: %R, %AI, %AQ, %W, %M, %Q, %T, %I.

** These types are stored internally in the RX3i Serial Communications module; they are not mapped to PLC memory by default. A Read Exchange can be programmed in the exchange table to allow local access to the CCM Diagnostic Status Words only (not Scratchpad).

*** The Master can clear the CCM Diagnostic Status Words by writing zeros to the seven Diagnostic Status words.

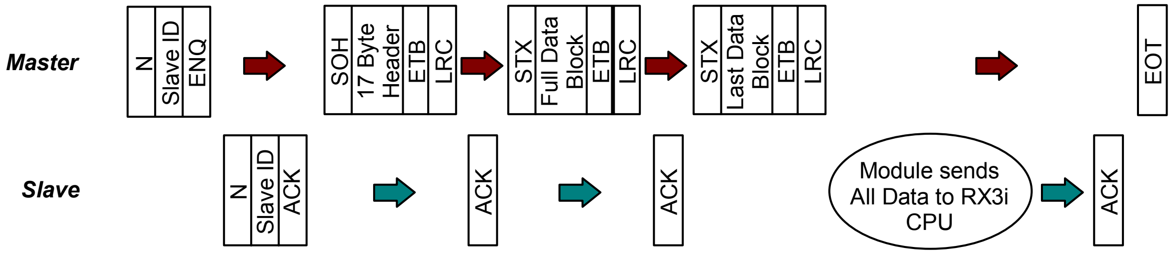
CCM Slave Operations for the Serial Communications Module

Because an RX3i Serial Communications Module can only be used as a CCM Slave, this manual does not include detailed information about implementing CCM communications. CCM Slave operation for the RX3i Serial Communications Module is summarized below.

Write Request from the CCM Master

The Master can write up to 2K bytes of data to the RX3i CPU.

A Write Request from the Master starts with a "Normal" (N) Enquiry, which has the ASCII character N as its first byte. The Slave acknowledges the Enquiry with an ACK character (or a NAK if the Slave port is busy). The Master then sends the slave a 17-byte Header message that specifies the type of communication being requested (write, target memory address, data length).



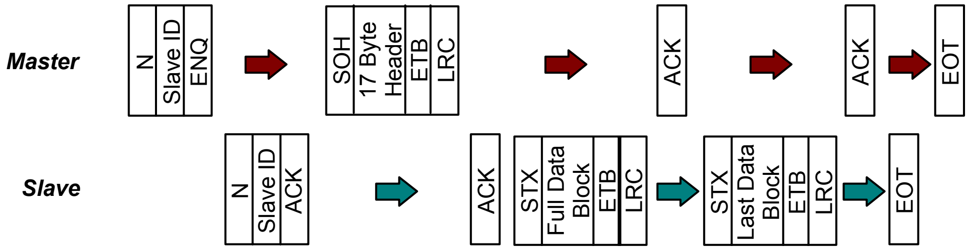
After the Slave acknowledges receiving the Header, the Master sends the data. If there are more than 256 bytes of data, the data is sent in multiple blocks, each with the format shown above. All data blocks except the last have 256 data bytes. The Slave returns an ACK response after successfully receiving each individual data block.

The Serial Communications Module buffers the incoming data. After successfully receiving all of the data blocks, the Serial Communications Module transfers all of the data to the RX3i CPU in a single backplane communication. The transfer of data is generally completed within 4-16mS. However, if the module is running processor-intensive protocols on the other ports, it may take longer. The Serial Communications Module Slave then responds to the Master with an ACK character. Because it first must transfer the data to the CPU, the module takes longer to send ACK/NAK for the last block than the preceding data blocks.   The Master responds with an End-of-Transmission character and the transaction is completed.

If the Serial Communications Module is not able to successfully transfer all of the data to the RX3i CPU, the Slave port sends an EOT character instead of ACK after the last data block, then goes to an idle state. If the CCM Master receives an EOT instead of an ACK after a Write Request, it should interpret the EOT as an indication that the write to the RX3i CPU did not occur.

Normal Read Request from the CCM Master

The Master can read up to 2K bytes of data from the RX3i CPU. The Read Request starts start with a “Normal” (N) Enquiry, which has the ASCII character N as its first byte. The Slave ACKnowledges the Enquiry (it sends a NAK if it is busy). The Master then sends the slave a 17-byte Header that specifies the type of communication being requested (read, target memory address, data length).

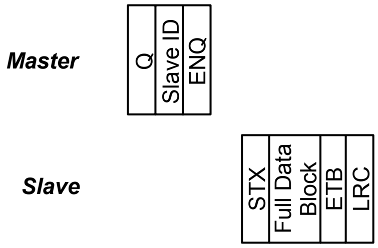


After receiving a data read request, the Serial Communications module requests the data from the RX3i CPU. The CPU transfers all of the requested data to the module in a single backplane write. The transfer is generally completed within 4-16mS. However, if the module is running processor-intensive protocols on the other ports, it may take longer.

The Serial Communications Module Slave starts returning the data to the Master immediately after Acknowledging the Header. If the Master has requested more than 256 bytes of data, the data is returned in multiple blocks, each with the format shown above. All blocks except the last have 256 data bytes. The Master returns an ACK response after receiving each data block. After the Master acknowledges the last data block, the Slave returns an End of Transmission character to the Master. The Master responds with an End of Transmission character, ending the communication.

Quick Read Request from the CCM Master

The Master can use a Quick Read request to read bytes 11 through 14 of the Port Control Output Data directly from the module. The application program is responsible for supplying appropriate content for these four bytes in the CPU. See chapter 4 for information about Port Control Output Data. A Quick Read Enquiry starts with the ASCII character Q as its first byte.



After receiving a Quick Read Enquiry, the module immediately sends the 4 bytes of requested data from its internal memory. The Slave response ends the communication.

Scratchpad Data

Read-only Scratchpad memory in the Serial Communications Module can be read by the CCM Master. It is not accessible from the application program in the local CPU. Any element within the 256 byte range may be read. If the read request extends beyond the length of the scratchpad memory, the module replies with an NAK. The information within this memory is limited to a few parameters (see table). Valid Target Memory address range is 0 - 255.

Scratchpad Address (Byte Offset)	***Field Identifier***	***Definition/Bits***
0x00	Outputs Enabled Status	1=Outputs enabled 0=Outputs disabled
0x01-0x0D	Reserved	Always 0.
0x0E	CMM Firmware Revision	Major
0x0F	CMM Firmware Revision	Minor
0x10-0x15	Reserved	Always 0.
0x16	CCM CPU ID Number	Slave: 1-90 (Decimal)
0x17-0xFF	Reserved	Always 0.

Diagnostics Data for CCM Slave Ports

The RX3i Communications Module keep a running total of errors. Diagnostic Status Words are independent for each port.

Word Offset	Description	
0	Byte 1: Spare	Byte 2: Most Recent Error Code -see next page
1	Number of Successful Conversations (serial communications via the port)	
2	Number of Aborted Conversations	
3	Number of Header Retries	
4	Number of Block Retries	
5	Number of Non-Existent Exchanges Requests Received	
6	RX3i Comms FW Version, MSB = Major, LSB = Minor (read only)	

Diagnostic Status Words can be accessed in two ways:

- From the Master, by reading the Diagnostic Status Words Target Memory Type through the serial port.
- From the local CPU, using the Read Data Exchange in the Port Data – CCM Slave tab (not through the serial port)

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Diagnostic status words can be cleared in two ways:

- From the Master, by writing zeros over the Diagnostic Status Words Target Memory Type through the serial port.
- From the local CPU, by setting the Clear CCM Errors bit (not through the serial port).

Error Codes in the Diagnostic Status Words

Error Code		Description
Hex	Dec	
00	0	Successful Transfer
01	1	A time out occurred on the serial link
03	3	An external device attempted to read or write a non-existent I/O point (bit)
04	4	An external device attempted to access more data than is available in a particular memory type
05	5	An external device attempted to read or write an odd number of bytes to Register memory or the Diagnostic Status Words
06	6	An external device attempted to read or write one or more a non-existent Registers
07	7	An external device specified the transfer of zero data bytes
09	9	An external device attempted to transfer data to or from an invalid memory type or absolute source address
0A	10	An external device attempted to read or write one or more a non-existent Diagnostic Status Words
0C	12	Serial communication was aborted after a data block was retried three times, or more times than permitted
14	20	One or more of the following errors occurred during a data block transfer: An invalid STX (Start of Text) character was received An invalid ETB (End of Block) character was received An invalid ETX (End of Text) character was received An invalid LRC (Longitudinal Redundancy Check) character was received A parity, framing, or overrun error occurred
15	21	An EOT (End of Transmission) character was expected and not received
16	22	An ACK (Acknowledge) or NAK (Negative Acknowledge) character was expected and not received
1A	26	A timeout occurred during an attempt to transmit on a port due to CTS being in an inactive state too long
1D	29	An error occurred when data was being transferred between the Module and Backplane (Mail system error)
1E	30	A parity, framing, or overrun error occurred during a Header transfer
1F	31	A parity, framing, or overrun error occurred during a data block transfer

Transmission Errors

CCM uses parity checking and LRC (longitudinal redundancy checking).

Parity checking is used to detect errors within a character. It can be configured as even, odd, or none. The parity bit is derived by the sender and monitored by the receiver.

LRC checking is used to detect errors in an entire block. The sending device inserts the LRC at the end of the header block and each block of data text. The receiving device generates its own block check character based on the incoming data and compares it to the transmitted

LRC to detect errors. This is handled automatically by the Serial Communications Modules, if set up in the configuration.

Transmission Timing Errors

Timing problems between transmitter and receiver can produce transmission errors such as overrun, framing, and time-out errors.

Overrun

An Overrun error is reported if timing problems between the transmitter and receiver cause characters to be sent faster than the receiver can handle them. If that happens, the previous character is overwritten and an error is indicated.

Framing Errors

A Framing error is reported if the receiver mistakes a logic 0 data bit or a noise burst for a start bit. The error is detected because the receiver knows which bit after the start bit must be a logic 1 stop bit. If the start bit is really a data bit, and the expected stop bit is not the stop bit but a start or data bit the framing error will be reported.

Timeout Errors

Time-outs are used to ensure that a good link exists between devices during a communication. When a source device initiates a communication, the target must respond within a certain amount of time or a time-out will occur causing the communication to be aborted.

For an RX3i Serial Communications Module, timeouts are the sum of the base value shown below plus the configured Timeout (mS), plus the configured Turnaround Delay of 0 to 65,535 milliseconds. If the sum of the base timeout and the configured turnaround delay are greater than 65,535 (0xFFFF), 65,535 is used. Setting the Timeout parameter to 0 does not disable timeouts for the CCM Slave.

Condition	***Base Timeout in mSec***
Wait on ACK/NAK following ENQ	800
Wait on start of header following ACK of ENQ	800
Wait on header to finish	670
Wait on ACK/NAK following header	2000
Wait on start of data following ACK of header	20000
Wait on ACK/NAK following data block	20000
Wait on data block to finish	8340
Wait on EOT to close link	800