SIEMENS

SIMATIC TI500/TI505

TIWAY 1 Gateway

User Manual

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Preface

Purpose of this Manual

This manual describes the basic features, operation, and installation of the TIWAY™ I Gateway™. The Gateway provides an interface between the SIMATIC® TIWAY I network and a distributed control system host using Modbus® protocol.

The TIWAY I Gateway translates Modbus commands from a host into the TIWAY I protocol format. Since the Modbus and TIWAY I systems are entirely different in protocol and interface requirements, the Gateway serves as a protocol translator and as a type of network monitor.

Gateway System Capacities

For example, the TIWAY I Gateway can provide protocol translation for the following host systems.

- The Honeywell TDC 2000® Data Highway Port (DHP) with one Gateway can monitor up to eight programmable controller (PLC) stations with one Network Interface Module (NIM) for each PLC.
- The Foxboro SPECTRUM™ FOXNET® Device Interface (FDG) with one Gateway can monitor up to 64 stations equipped with NIMs.
- The Fisher PROVOX® Programmable Controller Interface Unit (PCIU)™ can monitor up to 8 stations with NIMs.

TIWAY I Gateway Models

The TIWAY I Gateway is available in four models, offering a choice of communication ports and voltage supplies, as listed in Table 1.

Table 1 TIWAY I Gateway Models

Model Number	Communication Ports	Supply Voltage
PPX:500–7301	RS-232-C/Local Line	120 VAC
PPX:500–7302	Dual RS-232-C	120 VAC
PPX:500–7303	RS-232-C/Local Line	240 VAC
PPX:500–7304	Dual RS-232-C	240 VAC

NOTE: These models replace the previously available model PPX:500–7200 series of the TIWAY I Gateway.

Related Manuals

The information in this manual is supplemented by the following Siemens manuals. You may find it helpful to refer to these or other related manuals when using the TIWAY I Gateway.

- *TIWAY™ I Systems Manual* (2587871–0001)
- *TIWAY I Series 505™ Network Interface User's Manual* (2587871–0053)
- *TIWAY I Series 500™ Network Interface User's Manual* (2587871–0054)
- *SIMATIC® TI520C™/TI530C™/TI530T™ Manual Set* (2462158–0026)
- *SIMATIC® TI545™ Manual Set, Volumes 1 and 2* (2586546–0023)
- *SIMATIC TI545 System Manual* (2586546–0053)
- *SIMATIC® TI560T™/TI565T™ System Manual* (2597773–0035)
- *SIMATIC® TI500™/TI505™ TISOFT2™ Release 4.2 User Manual* (2588081–0019)

You should also refer to the appropriate user manual(s) for the Modbus host system's device interface.

Chapter 1

Product Overview

1.1 Introduction

The Gateway Interface

The TIWAY I Gateway allows a TIWAY I network of PLCs to be hosted by a Modbus-compatible host system. Figure 1-1 shows the relationship of the Gateway to one of several possible Modbus-compatible host systems.

Distributed Control Systems

The Foxboro SPECTRUM, Fisher PROVOX, and Honeywell TDC 2000 are distributed control systems which have interfaces to PLCs. These systems primarily perform supervisory control and data acquisition functions to the PLCs, using an RS-232-C type of connection into PLC data highways.

For example, the Honeywell TDC 2000 system communicates with the Gateway by way of a Data Highway Port (DHP), the Fisher PROVOX system uses a Programmable Controller Interface Unit (PCIU), and the Foxboro SPECTRUM system uses a FOXNET Device Interface (FDG).

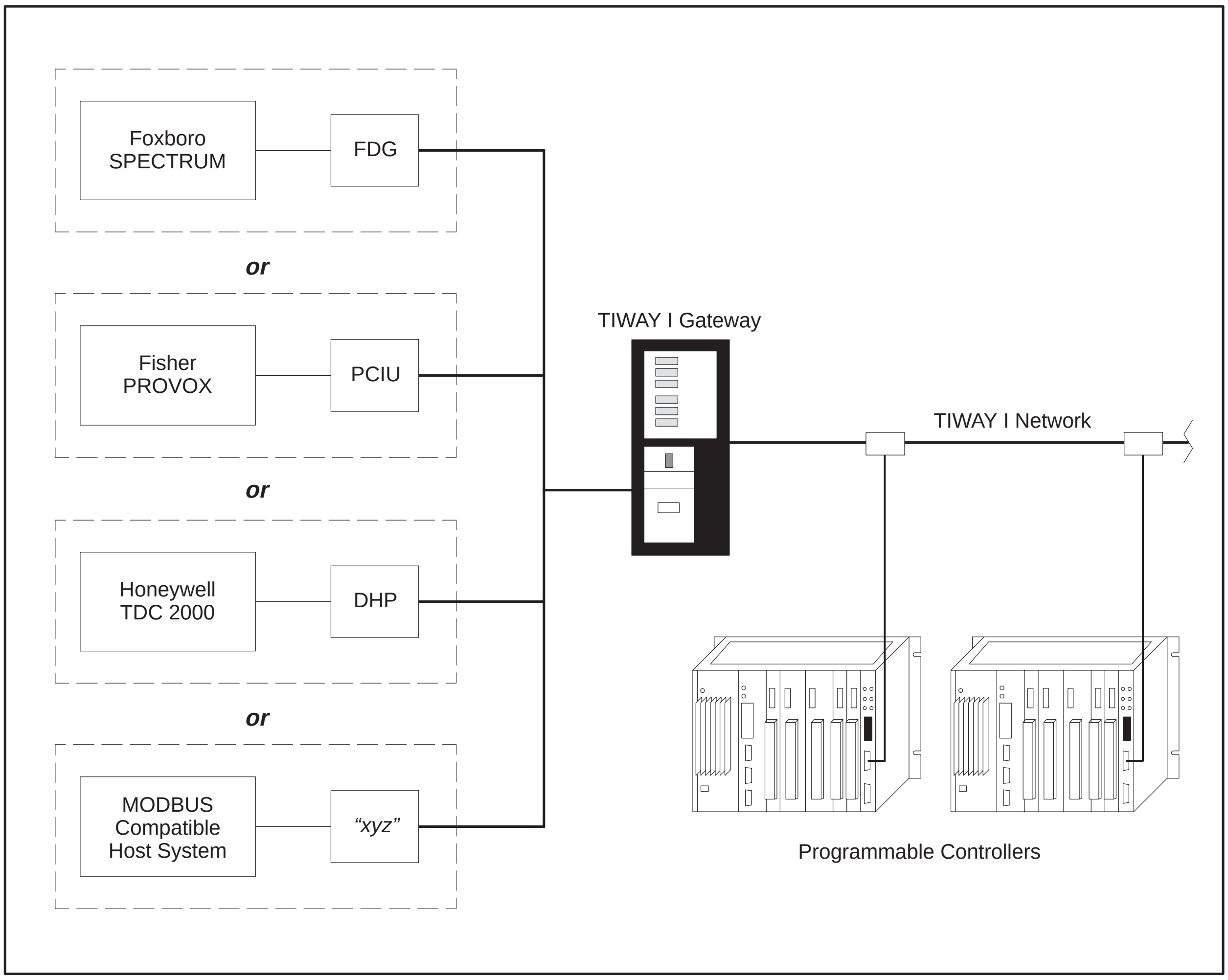


Figure 1-1 TIWAY I Gateway as Interface Between PLC Network and Host System

1.2 Basic Operating Features

Interface Ports

Two interface ports are located on the bottom of the TIWAY I Gateway unit. The AC power connections are also located on the bottom, covered by a protective plate. (See Figure 1-2.)

- Host: an RS-232-C host interface port (25-pin female D-shell connector)
- TIWAY I: the network port (9-pin female D-shell connector)

The host system is connected by cable to the host interface on the Gateway. The communications cable is supplied with the Gateway. The TIWAY I port provides communication interface with the TIWAY I network of PLCs or other secondary devices.

Refer to Chapter 2 for information on TIWAY I network installation. Chapter 3 describes the procedures for installing and configuring the TIWAY I Gateway and the communications cables.

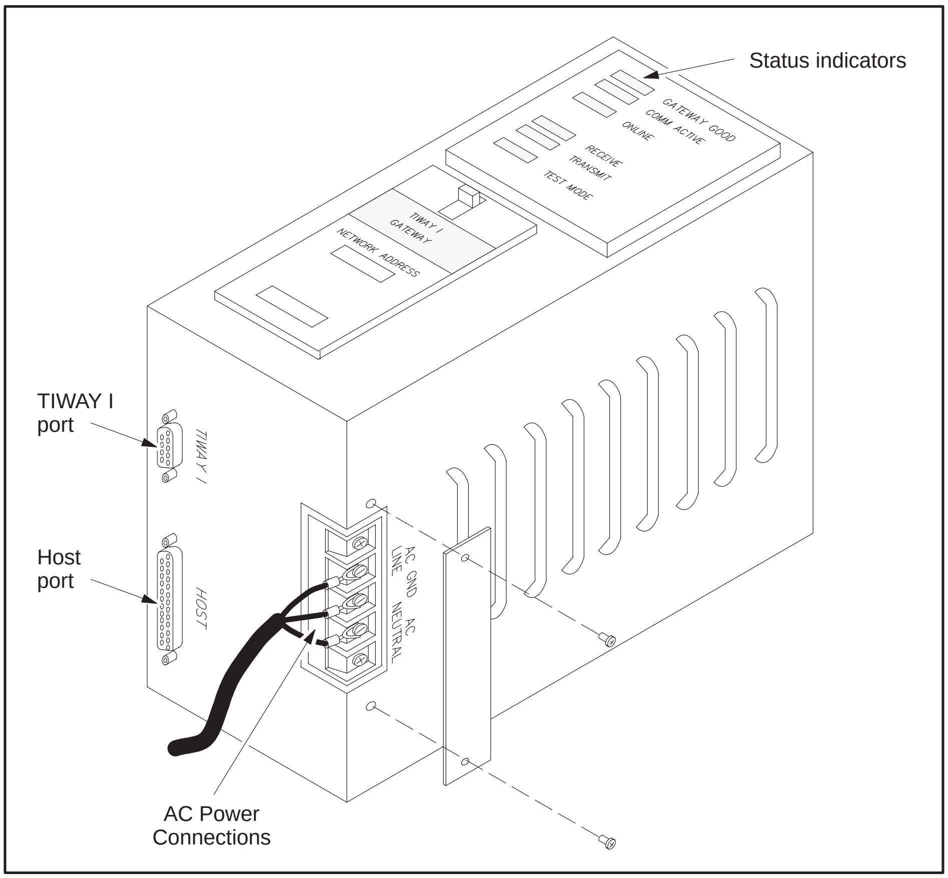


Figure 1-2 TIWAY I Gateway

Translating Commands between Host and PLC Network

The Gateway provides protocol and electrical interface conversion. A command issued by the host system is transmitted to the Gateway. Once it receives the command, the Gateway converts the protocol and electrical signals and then relays the command to the PLC which was addressed. After the PLC responds, the Gateway re-translates the information and sends it back to the host system through the interface device.

The primary function of the Gateway, then, is to translate host commands into TIWAY I commands. These commands are described in Appendix C.

Data Transmission Rates Supported

The TIWAY I Gateway supports data transmission rates from 110 bits per second (bps) to 19.2 kbps with the host, and from 110 bps to 115.2 kbps on the network interface. Table 1-1 summarizes the baud rates supported by the Foxboro, Honeywell, and Fisher host systems.

Table 1-1 Data Transmission Rates Supported

Host System	Data Transmission Rates Supported							
	110	150	300	600	1200	2400	4800	9600	19.2k
Foxboro			✓	✓	✓	✓	✓	✓	✓
Honeywell								✓	✓
Fisher			✓	✓	✓	✓	✓	✓	✓

Types of Data Accessed

The Gateway allows access to discrete I/O points and Control Relays (X, Y, and C), holding registers (V-memory), word input and output registers (WX and WY), as well as performance statistics for each PLC network interface. Information can be stored in variable (V) memory locations, retrieved, and changed from the operator's console of the distributed control system. Appendix A provides information on the maximum numbers of discrete inputs and outputs, holding registers, and word input registers.

Examples of data retrieval include the following:

- If you want to retrieve a process control loop integer value from a PLC, move this value into a register, or V-memory location, corresponding to the one configured in the distributed control system (refer to the appropriate DCS manuals).
- If you want to look at the current value of a counter, move this value into V-memory (using the ladder logic program) to a location configured as a register in the host system.

Discrete inputs and outputs (Xs, Ys, and Cs) generally do not require special conditioning in order to be read from the operator's console (as in the Fisher PROVOX system). See Appendix D for examples.

Chapter 2
Network Installation

2.1 TIWAY I Network and Gateway Installation Checklist

Quick Reference Installation Steps

Figure 2-1 is a quick reference list of steps to be taken when installing the TIWAY I Gateway. Refer to Chapter 3 for specific procedures and cautions.

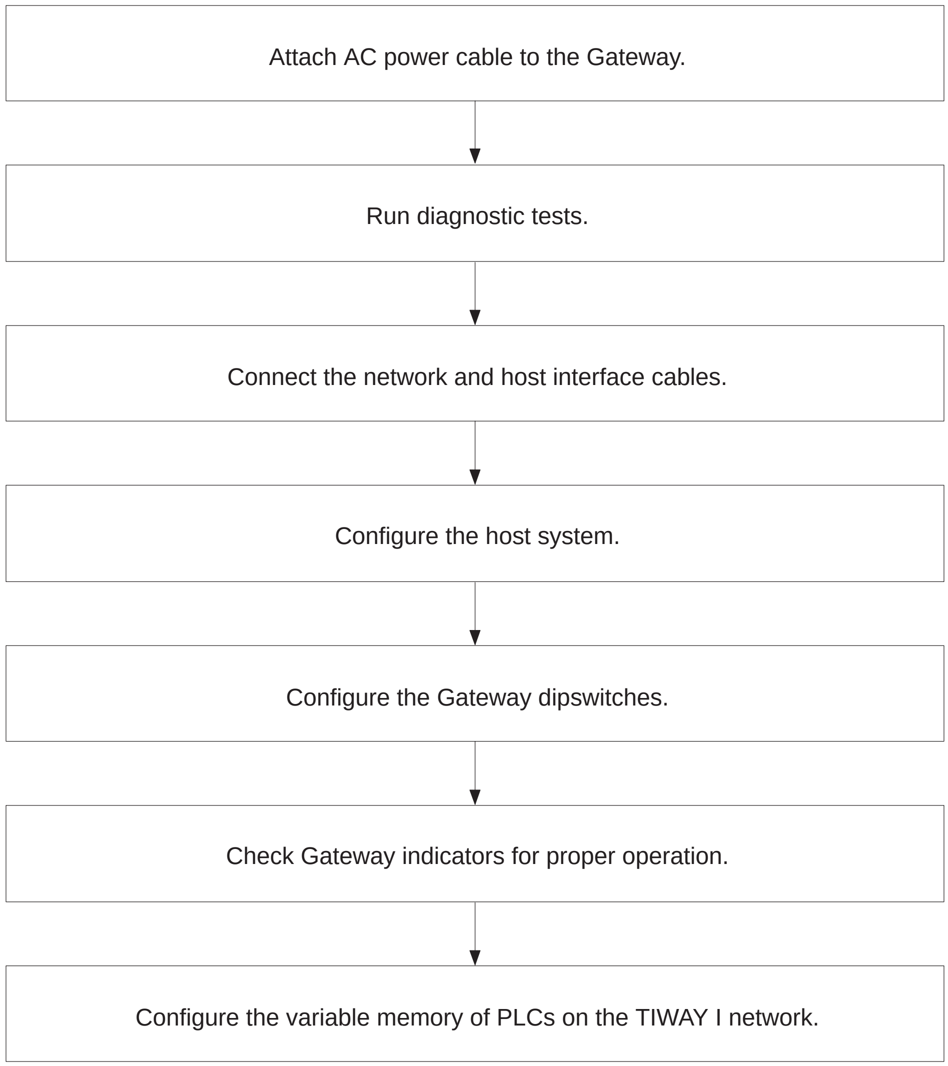


Figure 2-1 Basic Installation and Set-up Steps

Basic Installation Procedures

Some basic procedures to follow when installing a Gateway system include the following.

- Be sure you have all components necessary to install the Gateway and the network cables. (Refer to the checklist below for required parts.)
- Install the TIWAY I network and host system interface cables (see Section 2.2). Also refer to the appropriate host system installation manuals for specific information on cabling between the host and the Gateway.
- Install the Gateway in a NEMA panel or other suitable enclosure (see Chapter 3 for more details).

Requirements for Installing the Gateway

The items below are required to install the TIWAY I Gateway and to connect it to a host system and the TIWAY I network.

☐ TIWAY I Gateway

☐ L-shaped mounting brackets and bracket screws, or optional rack mount kit.

☐ Host interface cable (included; PPX:2462553–0003)

☐ Mounting screws (customer-supplied)

☐ AC power cable (customer-supplied)

☐ Loopback connector(s) for user-initiated diagnostic test (included; PPX:2703834–0001)

☐ TIWAY I Tap Housing (for Local Line installation) (PPX:500–5606)

☐ Tap cable for use with Local Line (customer-supplied), or

☐ RS-232-C/423 cable for use with modems (both cables and modems are customer-supplied)

2.2 Network Media Installation — Local Line

Overview

TIWAY I is a multi-drop communications network. It consists of a main trunk cable (the "spine") and dropline cables. The network can connect up to 248 secondaries to a host computer.

NOTE: Although addresses can range from 1 to 254 on TIWAY I, addresses 248 through 254 cannot be used because of the limitations of the Modbus protocol.

The selection of the media interface depends primarily upon two criteria: the distance to be spanned and the cost of installation. The main trunk can be up to 25,000 feet long, and each dropline can be up to 100 feet long, with Local Line. For distances exceeding 25,000 feet, the use of RS-232-C media interfaces and modems is required.

If cable redundancy is required (two TIWAY I cables), you will need two Gateways, two cables, and two host system interface devices. Refer to the appropriate host system user manuals for more specific information on redundant connections.

Local Line Cable Characteristics

The TIWAY I Local Line is a physical signalling technique (baseband, differential current drive) which operates over shielded, twisted-pair cabling. The Local Line cable may be up to 25,000 feet long. The Local Line uses tap housings to simplify the addition of connections onto TIWAY I.

The Local Line is designed to operate with shielded twisted-pair cable which has a characteristic impedance of 124 ohms. The interface is a male, 9-pin D-type connector with pin assignments as shown in Table 2-1.

Table 2-1 Pin Assignments for Local Line Connector

Pin	Name	Description
1		Reserved
2		Reserved
3	Shield	Cable shield and signal common
4		Reserved
5		Reserved
6	LLM+	Positive biased signal line
7		Reserved
8		Reserved
9	LLM–	Negative biased signal line

TIWAY I Network Characteristics

The TIWAY I network cable consists of a main cable or spine with droplines or taps for each secondary. The maximum main line cable length, cable type, tap length, tap spacing, number of secondaries, and maximum baud rates are interrelated network variables and have a direct influence upon network performance.

Figure 2-2 shows the relationship of cable distance to the number of secondaries for different baud rates for two types of twisted-pair cable. The cable distance (in thousands of feet) is shown vertically; the maximum number of units that may be attached is shown horizontally.

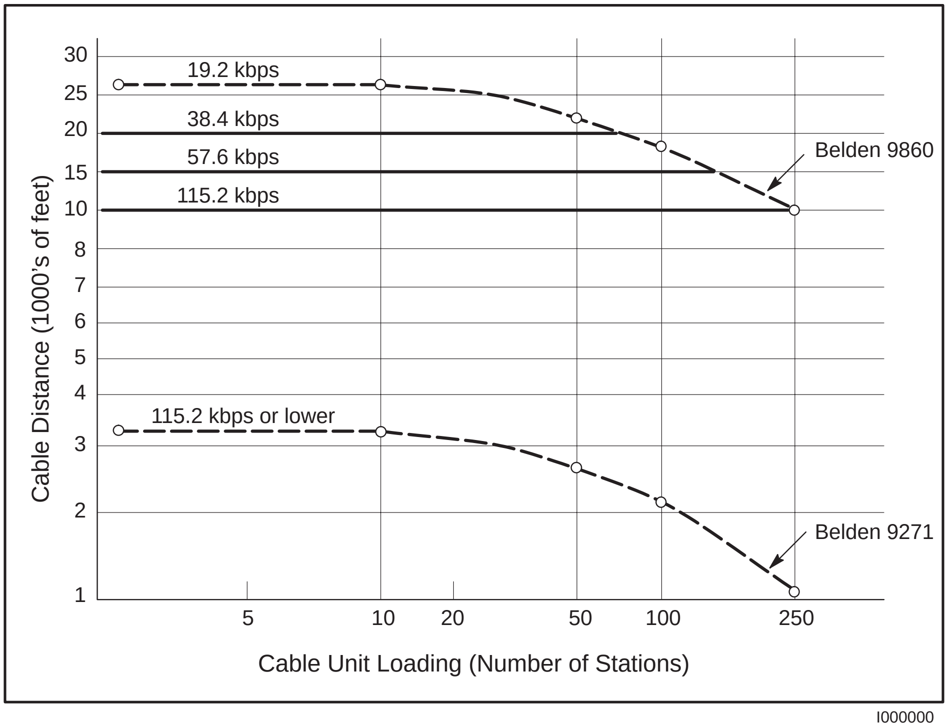


Figure 2-2 Number of Local Line Secondaries vs. Cable Distance

As shown in Figure 2-2, when you use Belden 9860 cable (or its equivalent), up to 75 stations can be attached to a network operating at 38.4 kbps and having a spine length of 20,000 feet. At 115.2 kbps, the maximum length of a Local Line network having 248 stations is 10,000 feet.

Local Line Hardware Components

The hardware components of a Local Line network consist of the following:

- TIWAY I Tap Housing (PPX:500–5606)
- Shielded, twisted-pair cabling (customer-supplied)

These components are described in the following sections.

Tap Housing

The TIWAY I Tap Housing, shown in Figure 2-3, is designed specifically for Local Line networks. The tap housing can be mounted rigidly to a NEMA panel or other enclosure. It could also be used to splice cables in a cable tray without being rigidly mounted.

The tap housing contains terminating resistors, and it also provides noise isolation for attached cabling, resists moisture, and relieves strain, thus allowing an orderly connection to the TIWAY I network. One tap housing is provided with each Gateway Local Line connection.

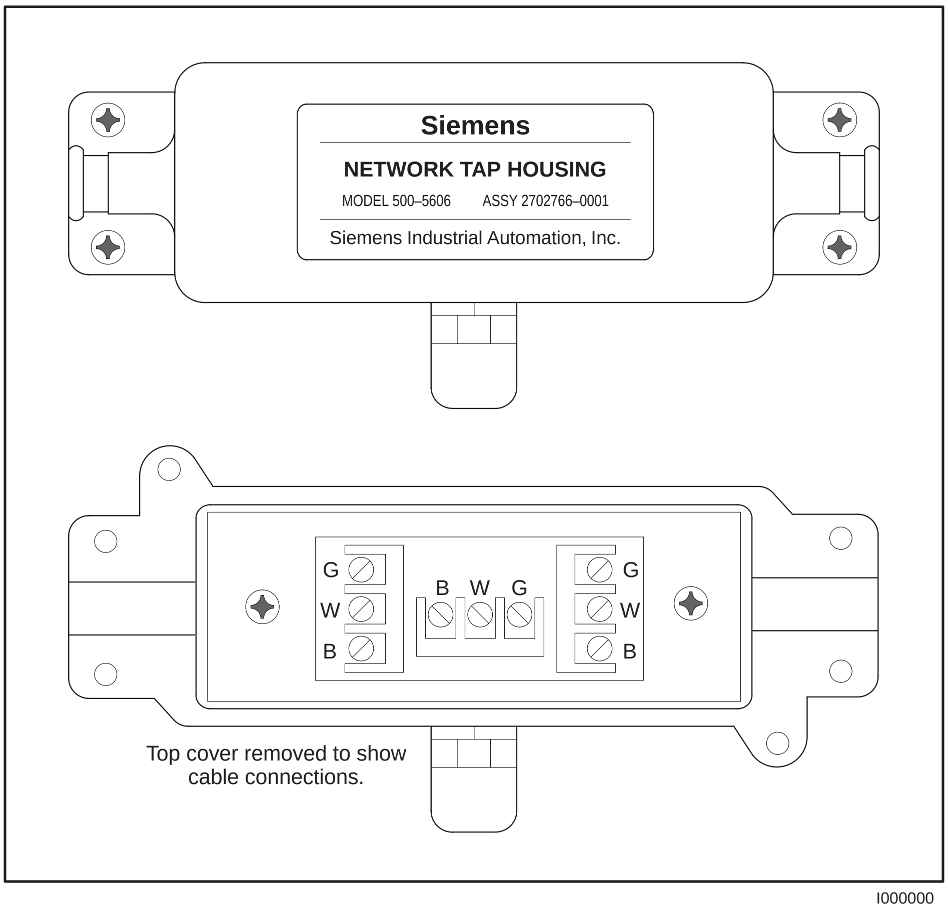


Figure 2-3 TIWAY I Tap Housing

Terminating the Main Line Cable

The terminating resistors must be used to ensure that the main line cable is properly terminated and biased for improved reliability. Each tap housing is supplied with terminating resistors to connect to the ends of the main line cable. At each end, a terminating resistor must be connected between LLM+ and the cable shield and also between LLM– and the cable shield inside the tap housing.

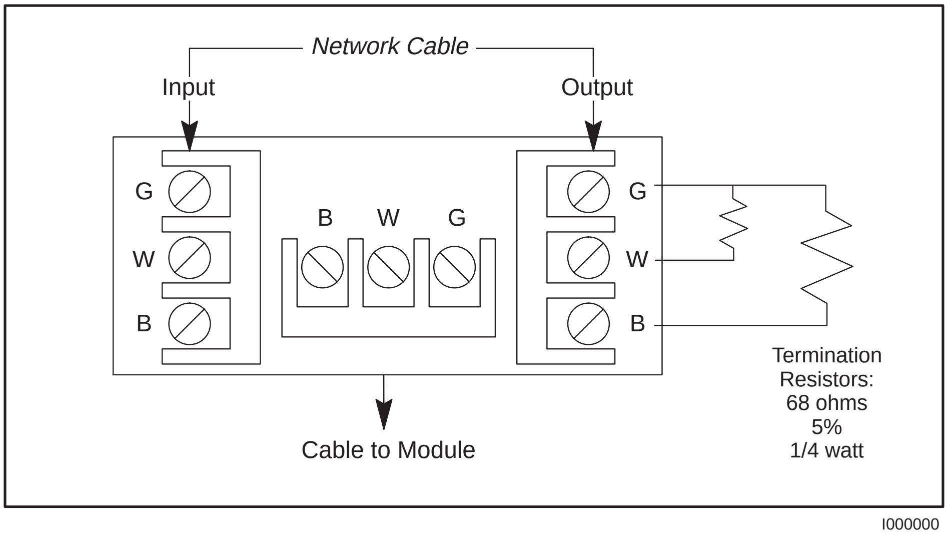


Figure 2-4 Terminating the Local Line

Twisted-Pair Cabling

Siemens Industrial Automation recommends Belden 9860 twisted-pair cabling or its equivalent for use as the Local Line network spine. Belden 9271 or its equivalent should be used for the dropline. Brands other than those listed here will be specified by Siemens upon request.

Important Planning Considerations

Some major points to consider during the planning phase of a Local Line network are the following.

- From the start, allow for system growth. Make provisions for the attachment of additional computing devices by routing cables through all probable areas of future plant expansion.
- Always make the network flexible enough to allow for re-arrangement of plant equipment.
- Since network system noise is usually picked up by its interconnecting wiring, take steps during installation to bypass or eliminate noise sources.
- If cable redundancy is required, make sure the two cables are never routed along the same path, since the environmental and other factors which disable one cable will very likely disable the second cable.

Local Line Tap Spacing Rules

Local Line networks must adhere to specific tap spacing requirements to maintain signal integrity. These requirements are outlined in the following sections.

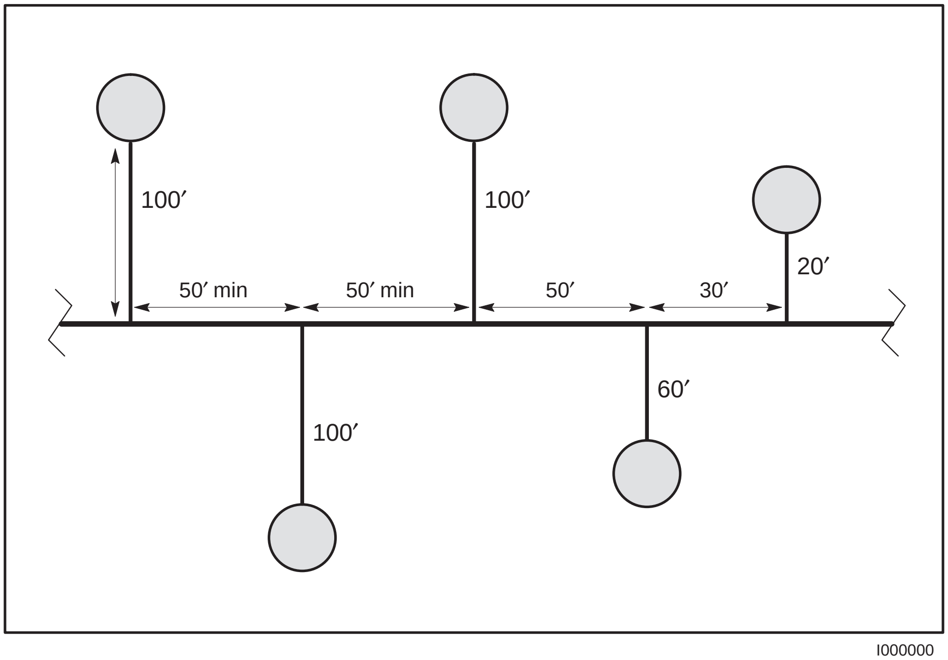


Figure 2-5 Basic Tap Spacing Rules

Basic Considerations

The rules for determining the correct distances between taps exist simply for the prevention of signal degradation caused by reflections.

Prior to configuring the distances between taps in the network cable, select a single tap as a physical point to use as reference. This tap should be one of the taps on the end of the network.

Primary Rule

The primary rule is that the minimum distance from one tap to the next ***cannot be less than one half the distance of the previous tap cable*** (drop line) length. This rule should be applied starting at the first tap on the network all the way to the end. Then, from the last tap on the network, the same rule should be applied back to the first tap again.

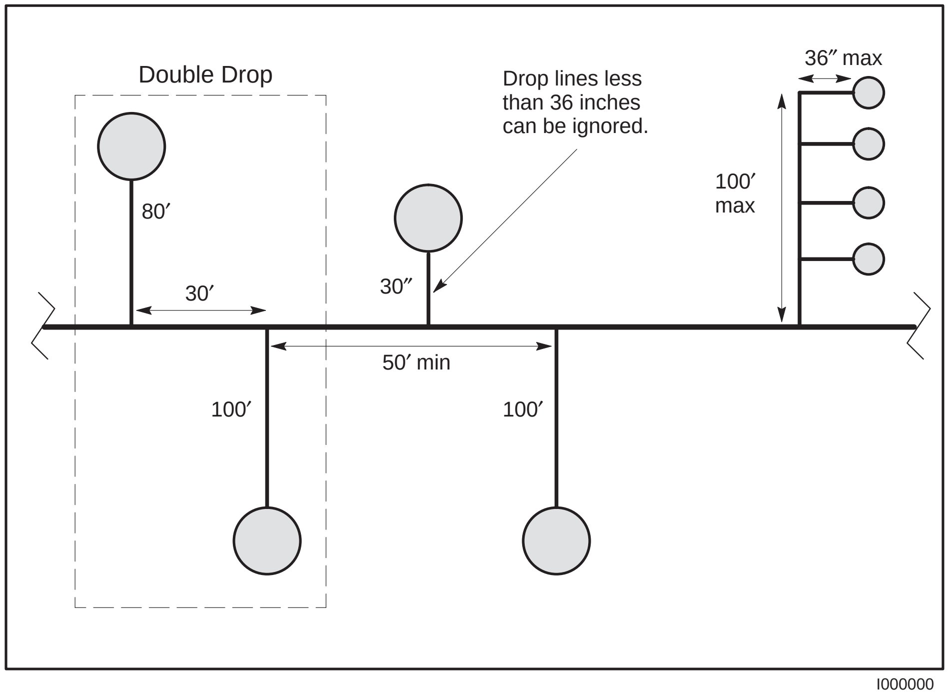


Figure 2-6 Additional Tap Spacing Rules

Double Drops

If a tap cable is installed *less than the minimum* distance as stated in the primary rule, then the two drops, the previous one and the one being installed, are considered a **double drop**.

Double drops are allowed, but triple drops are not allowed.

After installing a double drop, the next tap must be placed at the minimum distance or farther. In this case, the minimum distance would be one half the distance of the longest of the two tap lines making up the double drop.

Short Drops

Drops that have a tap line that is *less than 36 inches* can be ignored in calculating the minimum distance between taps.

Multidrop Taps

There is no limit to the number of drop stations that can be connected to the same tap line.

Each station must have its own tap, and the overall drop line length cannot exceed 100 feet. The cable used to attach each station to the drop line *cannot* exceed the 36-inch maximum.

Cable Routing

Cable routing should be planned as if the path between all stations on the network were free of obstructions. The next step is to modify the first routing to account for obstructions, then calculate the amount of cable needed.

⚠ **CAUTION**

Observe all local and national electrical and fire codes when installing wiring.

In general, there are three types of network cabling routes:

- Under-floor
- In-ceiling
- Surface ducting

Any combination of these three routes may be used on a single network. The choice is often determined by whether or not the building (or buildings) in which the network is being installed is new construction or an existing building. The following paragraphs describe some of the advantages and disadvantages of each type of cable routing.

Under-floor — For under-floor routing, the cable can be enclosed within ducts or, with raised flooring, in the "open air." Under-floor systems enclosed in ducts are usually expensive, and while they are better-protected against unauthorized taps than are open-air systems, they often make future expansion of the network more difficult and expensive.

Open-air under-floor cabling systems usually provide good access, and allow maximum network expansion and flexibility.

In-ceiling — For in-ceiling routing, network cables are usually supported in troughs or with hooks and clamps every 10 or 15 feet. Some advantages of in-ceiling installation are the following.

- Flexibility
- Low-cost installation
- Accessibility to cabling

Some disadvantages are the following.

- Is is impractical for buildings without drop ceilings
- Working in high ceilings can be hazardous
- Ceilings often collect dust and other debris

Surface ducting — Surface ducting for network cabling is usually installed along the baseboards or is attached to walls at desktop height. While surface ducting ordinarily protects cables from both physical and EMI effects, it may also require that network computing devices be positioned near a wall.

Obstructions

Aside from physical obstructions such as posts, walls, and partitions, electrical interference should also be avoided. Some sources of interference are the following.

- Power distribution mains
- Arcing motors
- Fluorescent lighting
- Teletypes
- Undesired signal transfer (cross-talk) between adjacent circuits
- Poor cable-to-equipment impedance matching

Noise Avoidance

In general, network cabling should never come into direct contact with any electrical conductor. If cabling is installed inside a conduit, the conduit should be grounded in accordance with applicable electrical codes. Keep a minimum of three feet of distance between all network cabling and the following sources of noise.

- Power lines
- Electric motors
- Transformers
- Rectifiers
- Generators
- Electric welders
- Induction furnaces and heaters
- All sources of microwave radiation

2.3 Network Media Installation — RS-232-C Modem Interface

Data Transmission Characteristics

The physical layer in TIWAY I provides a modem interface for synchronous or asynchronous communications at data transmission rates up to 115.2 K bps. The modem interface provides standard signals for control of two-way alternate data transmission using both half and full duplex modems.

RS-232 Pin Assignments

The modem interface is a standard Type E DTE configuration as defined in the EIA RS-232-C standard. This interface uses a male 25-pin D-type connector plug on the communication cable. The pin assignments are listed in Table 2-2.

Table 2-2 RS-232-C Connector Pin Assignments

Pin No.	Description
1	Protective Ground
2	Transmit Data
3	Receive Data
4	Request to Send (RTS)
5	Clear to Send (CTS)
6	Data Set Ready (DSR)
7	Signal Ground
8	Receive Line Signal Detector/Data Carrier Detect (RLSD/DCD)
15	Transmitter Signal Element Timing
17	Receiver Signal Element Timing
20	Data Terminal Ready (DTR)

Chapter 3

Gateway Installation and Configuration

3.1 Installing the TIWAY I Gateway

Basic Mounting Guidelines

There are three possible places on the Gateway where the two L-shaped mounting brackets can be located. Depending on how you want to mount the Gateway, attach the brackets to the appropriate locations, as shown in Figure 3-1.

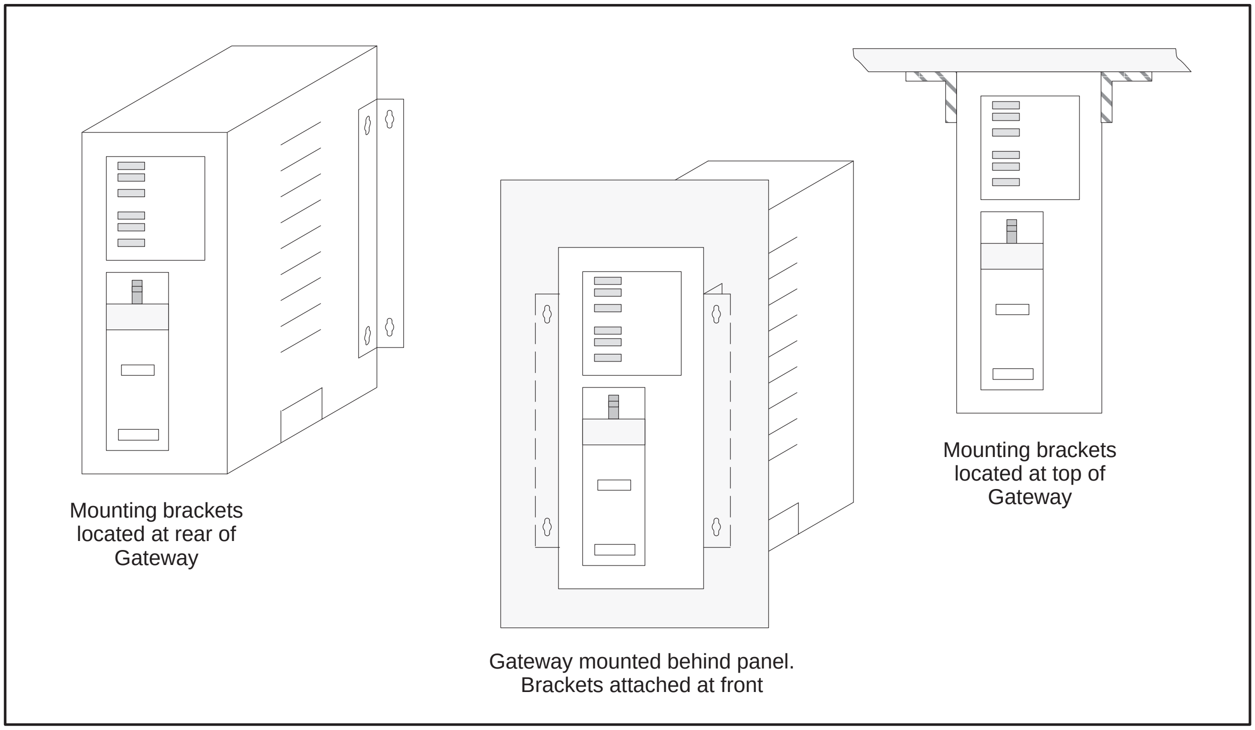


Figure 3-1 Possible Bracket Locations for Mounting Gateway

Mount the Gateway in a suitable enclosure (such as a NEMA panel) to reduce the possibility of shock hazard resulting from accessibility of live parts. Protect the Gateway from water or moisture sprays, and ensure that the temperature does not exceed the range of 0° to 60° C.

You can also mount the Gateway in a 19-inch rack. A rack mount kit is available from Siemens with the following order numbers. (Refer to the Installation Guide shipped with each rack mount kit.)

- PPX:500–7205 — for use with Gateway models –7301 and –7303
- PPX:500–7206 — for use with Gateway models –7302 and –7304

⚠ **CAUTION**

Be sure to allow adequate air flow around the air vents of the Gateway to avoid damage to the unit through overheating.

Power Connections and Initialization

After mounting the unit in an appropriate location, follow these steps for connecting the power supply and running diagnostic tests.

1. Remove the shield covering the three AC terminals (Line, Ground, and Neutral).
2. With power off, attach all three connections according to Figure 3-2 and then replace the shield.

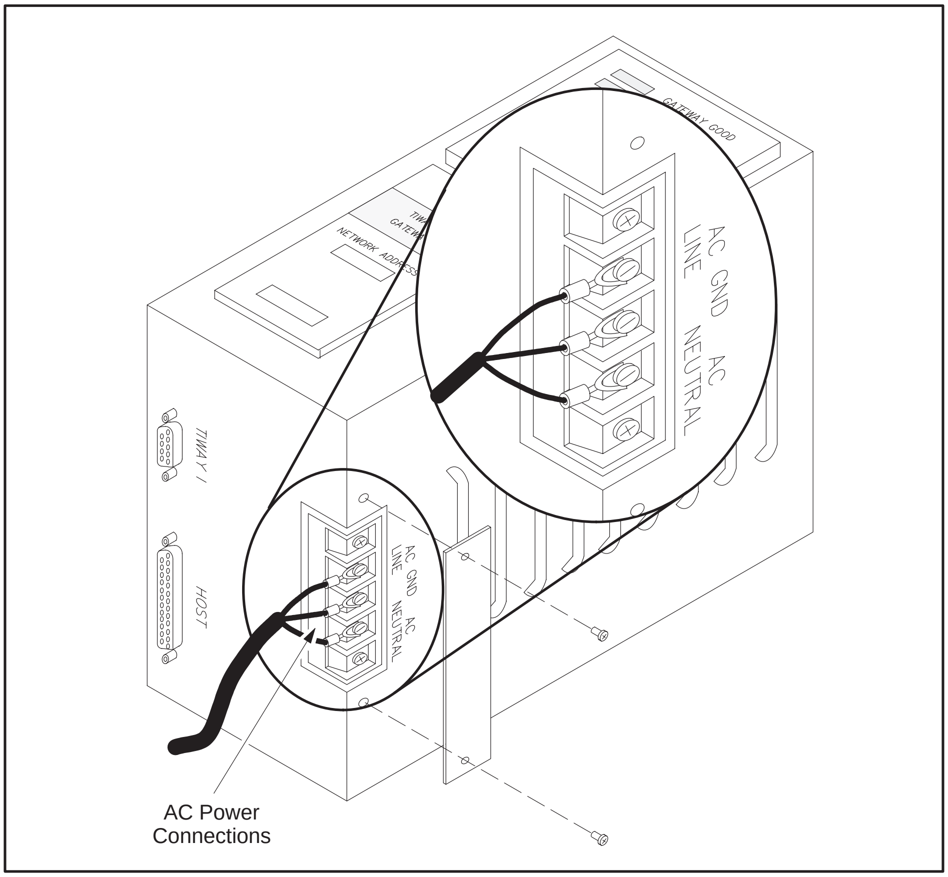
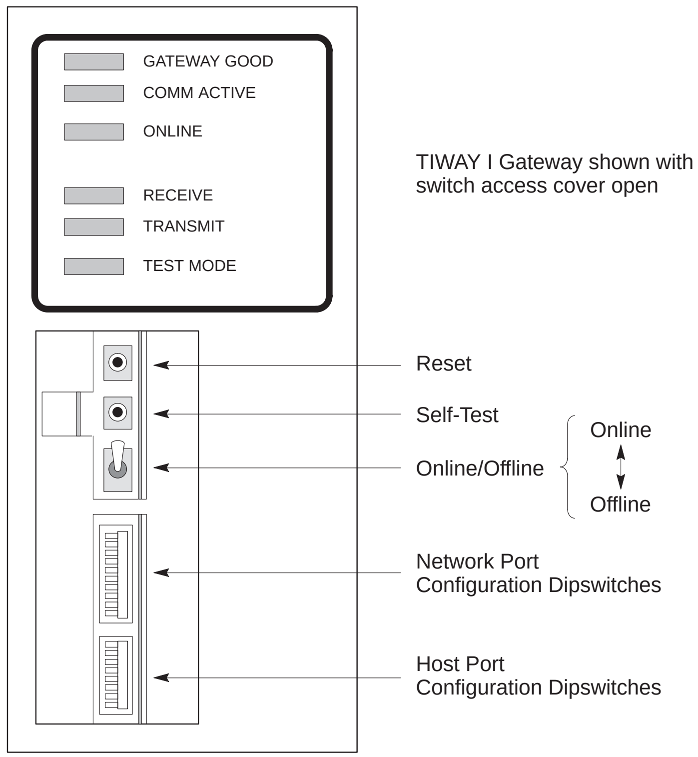


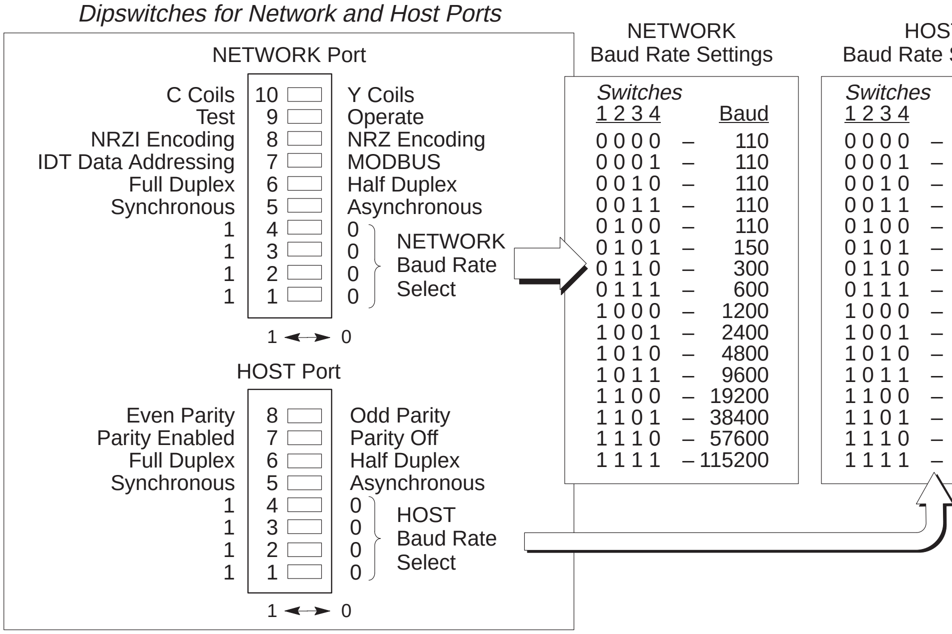
Figure 3-2 AC Power Connections

3. Apply power to the unit.
4. Install loopback connector on each RS-232 port.
5. Set the Online/Offline switch on the Gateway to the OFFLINE position.

6. Run the user-initiated test. (Refer to the Diagnostics Tests section.)
7. Remove loopback connector.
8. Set the Online/Offline switch on the Gateway to the ONLINE position.
9. Connect the Local Line or RS-232 interface cable to the TIWAY I port.
10. Connect the host system interface cable to to the host port.
11. Configure the communications parameters on the host system. Make sure that the host system baud rate matches the rate you plan to set on the Gateway.
12. Set the dipswitches on the Gateway. Be sure to set the parity, duplex, and synchronous/asynchronous selections to match the corresponding settings on the host system. (See Figure 3-3 and Section 3.2.)
13. Check to see that the GATEWAY GOOD, TRANSMIT, and RECEIVE indicators on the Gateway are on, and that TEST is flashing.
14. Configure the data and status registers in the variable memory of the PLCs on the TIWAY I network. (Refer to the appropriate PLC manuals for more information if necessary.)
15. Press the RESET button on the Gateway.
16. Begin program execution.



Dipswitches for Network and Host Ports



NETWORK Baud Rate Settings

Switches 1 2 3 4		Baud
0 0 0 0	–	110
0 0 0 1	–	110
0 0 1 0	–	110
0 0 1 1	–	110
0 1 0 0	–	110
0 1 0 1	–	150
0 1 1 0	–	300
0 1 1 1	–	600
1 0 0 0	–	1200
1 0 0 1	–	2400
1 0 1 0	–	4800
1 0 1 1	–	9600
1 1 0 0	–	19200
1 1 0 1	–	38400
1 1 1 0	–	57600
1 1 1 1	–	115200

HOST Baud Rate Settings

Switches 1 2 3 4		Baud
0 0 0 0	–	110
0 0 0 1	–	110
0 0 1 0	–	110
0 0 1 1	–	110
0 1 0 0	–	110
0 1 0 1	–	150
0 1 1 0	–	300
0 1 1 1	–	600
1 0 0 0	–	1200
1 0 0 1	–	2400
1 0 1 0	–	4800
1 0 1 1	–	9600
1 1 0 0	–	19200
1 1 0 1	–	19200
1 1 1 0	–	19200
1 1 1 1	–	19200

Figure 3-3 Dipswitch Settings for the Network and Host Ports

3.2 Dipswitch Configuration and Function

Overview

Two banks of dipswitches are located behind the access cover on the front of the Gateway. One is for the host port and the other is for the network port. The following sections define the switches and describe the effect they have on the Gateway's operation.

There are eight configuration switches for the host port, and ten for the network port. The switch settings are binary coded so that Switch 1 represents the most significant bit (MSB) and Switch 8 or 10 represents the least significant bit (LSB).

When setting the dipswitches on the Gateway, check to make sure that the settings match those on the host system and the network.

NOTE: Most of the dipswitch settings are read by the Gateway only after a reset. Any changes made to the dipswitch settings must be followed by a reset. (Network port switches 7 and 10 are read and updated every scan.)

Table 3-1 Host Port Dipswitch Configuration

Switch	Function	Configuration Settings
1 – 4	Baud Rate: (110 bps to 19.2 kbps)	Set these to match baud rate setting of the host system.
5	Asynchronous/Synchronous	Asynchronous
6	Full/Half Duplex	System-dependent; see page 3-7
7	Parity On/Off	System-dependent; match host system
8	Even/Odd Parity	System-dependent; match host system

Table 3-2 Network Port Dipswitch Configuration

Switch	Function	Configuration Settings
1 – 4	Baud Rate (110 bps to 115.2 kbps)	Set to desired TIWAY I baud rate; see Figure 3-3.
5	Asynchronous/Synchronous	System-dependent; see page 3-8
6	Full/Half Duplex	System-dependent; see page 3-9
7	IDT Data Addressing Mode	System-dependent; see page 3-9
8	NRZI/NRZ Encoding	Asynch = NRZI; Synch = NRZ or NRZI
9	Test/Operate	Always set to Operate (0)
10	Discrete Output type select	System-dependent; see page 3-9

Dipswitch Settings for the Host Interface Port

The 8-switch bank governs the host interface. The following paragraphs describe the switch-selectable options for setting the host interface parameters.

Data Transmission Rate Selection (Switches 1 through 4)**:** For the host port, Table 3-3 shows what data transmission rates are supported on the listed host systems. (Refer to Figure 3-3 for the host baud rate dipswitch settings.)

Table 3-3 Data Transmission Rates Supported

Host System	Data Transmission Rates Supported								
	110	150	300	600	1200	2400	4800	9600	19.2k
Foxboro			✓	✓	✓	✓	✓	✓	✓
Honeywell								✓	✓
Fisher			✓	✓	✓	✓	✓	✓	✓

Asynchronous/Synchronous Operation (Switch 5)**:** The Synch/Asynch switch is used for modem operation. In the synchronous mode, transmitter signal element timing is used to send *transmit* data. The transmitter and receiver signal timing elements are supplied by the modem. In the asynchronous position, the modem does not supply receiver or transmitter timing elements and the Gateway uses internal clocks to determine *receive* data sample points and to send *transmit* data. You should use the asynchronous setting.

Full/Half Duplex Operation (Switch 6)**:** the Full/Half Duplex switch selects operation compatible with full or half duplex modems even though communication with the Gateway is half duplex only. When you select Half-duplex operation, the Gateway does not activate the Request to Send circuit before Data Carrier Detect becomes inactive. Timing relationships between Data Carrier Detect and Request to Send are ignored when full duplex is selected. When you are using a half-duplex modem, you should use the Half-duplex setting; with a full-duplex modem, use the Full-duplex setting.

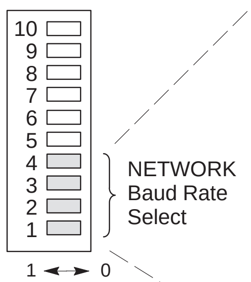
Parity Enable/Disable (Switch 7)**:** This will either enable or disable parity in all data transmissions.

Even/Odd Parity (Switch 8)**:** If Switch 7 (Parity Enable/Disable) is set to enable parity, switch 8 selects even or odd parity.

Dipswitch Settings for the Network Interface Port

The 10-dipswitch bank governs the network communications port. The following paragraphs describe the switch-selectable options available for the network port.

Data Transmission Rate Selection (Switches 1 through 4)**:** The TIWAY I network supports the following data transmission rates: 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115,200 bits per second. Set the dipswitches according to the chart in Figure 3-4.



Switches 1	2	3	4		Baud
0	0	0	0	–	110
0	0	0	1	–	110
0	0	1	0	–	110
0	0	1	1	–	110
0	1	0	0	–	110
0	1	0	1	–	150
0	1	1	0	–	300
0	1	1	1	–	600
1	0	0	0	–	1200
1	0	0	1	–	2400
1	0	1	0	–	4800
1	0	1	1	–	9600
1	1	0	0	–	19200
1	1	0	1	–	38400
1	1	1	0	–	57600
1	1	1	1	–	115200

I000000

Figure 3-4 Dipswitch Settings for Network Data Transmission Rates

Asynchronous/Synchronous Operation (Switch 5)**:** The Synch/Asynch switch is used for modem operation. In the Synchronous mode, the Gateway uses the transmitter signal element timing to transmit data. The transmitter and receiver signal timing elements are both supplied by the modem. In the Asynchronous position, the modem does not supply receiver or transmitter timing elements and the Gateway uses internal clocks to determine *receive* data sample points and to send *transmit* data. You should select Asynchronous operation when you are using the Local Line.

Full/Half Duplex Operation (Switch 6)**:** the Full/Half Duplex switch selects operation compatible with full or half-duplex modems even though communication with the Gateway is half-duplex only. When you select Half-duplex operation, the Gateway does not activate the Request to Send circuit before Data Carrier Detect becomes inactive. Timing relationships between Data Carrier Detect and Request to Send are ignored when full duplex is selected. When you are using a half-duplex modem, you should use the Half-duplex setting; with a full-duplex modem, select Full-duplex.

Modbus/IDT Data Addressing (Switch 7)**:** Set this switch to the On (1) position to implement a data addressing scheme for the IDT® family of operator interface products. Set this switch to the Off (0) position to select standard Modbus data addressing.

NRZI/NRZ Encoding (Switch 8)**:** The NRZI/NRZ (non-return to zero inverted/non-return to zero) switch selects the type of encoding to be used during network communication. The NRZI encoding option is required for asynchronous operation. Either NRZI or NRZ may be used with synchronous operation, but NRZ encoding is recommended.

Test/Operate (Switch 9)**:** This switch selects either Test or Operate mode. You should always set this switch to Operate.

Y/C Coil Type Select (Switch 10)**:** This switch collects coil data from a secondary's Control Relay (C) memory when set to On (1). In the Off (0) position, coil information is collected from Discrete Output (Y) memory.

3.3 Switches and Indicator Lights

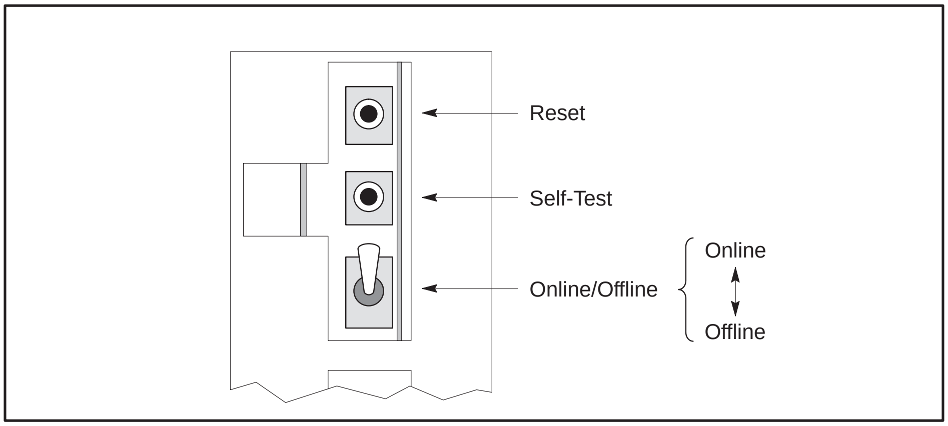


Figure 3-5 Gateway Operation Switches

Online/Offline Switch

The Online/Offline switch, when placed in the Online position, allows the Gateway to communicate with the network and the other systems connected to the Gateway. In the Offline position, the Gateway is disconnected from the network. This prevents access to the network while secondaries are being changed or while maintenance is being performed. The position of this switch is read before each communication cycle, so a reset of the Gateway is not necessary each time the Online/Offline switch position is changed.

Self-Test Button

The Self-Test button initiates a set of Gateway diagnostic tests, including a standalone Gateway communications loopback test. This test requires a special hardware set-up, using the loopback connector supplied with the Gateway. This procedure is described more fully in the section on Diagnostic Tests. The Gateway must have the Online/Offline switch in the Offline position to initiate the diagnostic tests.

Reset Button

Pressing the Reset button causes a hardware reset of the Gateway and initiates the power-on diagnostic test. The power-on test is explained in more detail in the section on Diagnostic Tests.

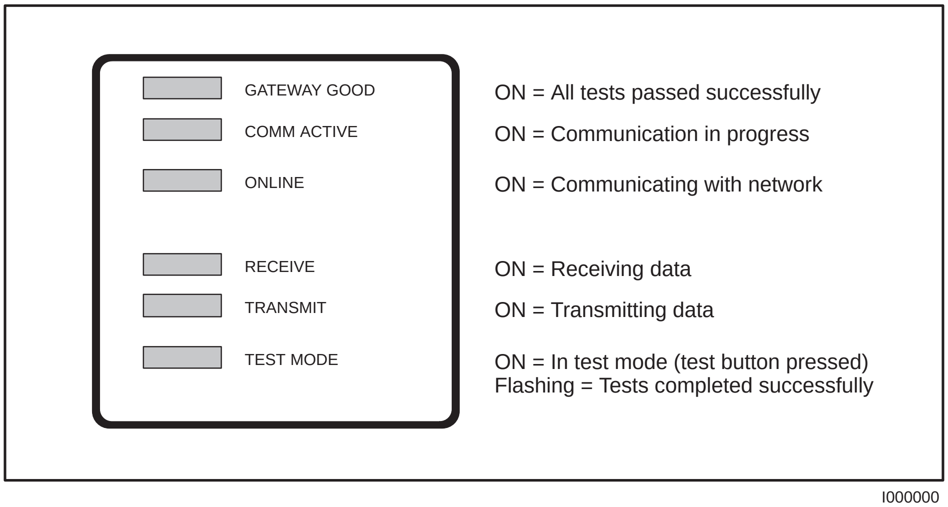


Figure 3-6 Indicator Lights

Status Indicator Lights

The six indicator lights on the front panel of the Gateway show module and communication status, as described in the following paragraphs.

Gateway Good

If the GATEWAY GOOD indicator is lit, it means that all power-on/reset or run-time diagnostic tests have been passed successfully. If the indicator is flashing or not lit, one of the Gateway components has failed a diagnostic test, and the Gateway is inoperable. If a reset does not remedy the situation, you should return the unit for repair.

Comm Active

The COMM ACTIVE indicator is lit continuously while any communication is in progress. It is not lit while the Gateway is in Test mode.

Online

The ONLINE indicator is lit while the Gateway is communicating with the network. However, if you have taken the Gateway off-line by placing the Online/Offline switch in the Offline position, the Online indicator will not be lit at any time.

Receive

The RECEIVE indicator is lit when the Gateway is receiving data on either port.

Transmit

The TRANSMIT indicator is lit when the Gateway is transmitting data on either port.

Test Mode

The TEST MODE indicator lights when you press the Self-Test button and the Gateway is in Test mode. The indicator remains lit while the diagnostic tests are being performed, and flashes when they are successfully completed.

3.4 Diagnostic Tests

Built-In Diagnostic Tests

The Gateway has five levels of built-in tests, three of which are designed for the user.

- Power-on test
- Operational Diagnostic test
- User-initiated test
- Burn-in test
- Final test

Used only in quality assurance tests by manufacturer (Burn-in test and Final test)

Power-On Test

The Power-on test executes the initialization routine following a master reset. All indicators light for approximately one second before any subtests begin. The only indicator which will be lit while the tests are running is the TEST MODE indicator. If the Gateway passes all tests successfully, the GATEWAY GOOD indicator will light.

The subtests include a RAM data and address integrity test, a ROM CRC integrity test, and a communications controller internal loopback test.

If the Gateway fails any of the power-on tests, the GATEWAY GOOD indicator will *flash*.

Operational Diagnostic Test

The Operational Diagnostic test executes during all normal modes of Gateway operation, off-line or on-line. The subtests do not disturb normal operation of the network. They are performed at least once per minute under all conditions.

An operational diagnostics failure is treated in the same way as a power-on test failure. The GATEWAY GOOD indicator will *flash* if the Gateway fails any diagnostic test.

User-Initiated Test

You should run the user-initiated test only when the Gateway is in Off-line mode (that is, when the On-line/Off-line switch is in the OFFLINE position). Normal Gateway operation is suspended during this test mode.

NOTE: Before initiating the diagnostic routine, make sure that the network and host computer cables are disconnected from the Gateway, and that the Gateway is in off-line mode. Only the GATEWAY GOOD indicator should be lit. If ONLINE is lit, you must first reset the Gateway before running the test.

---

1. Install a loopback connector on each RS-232-C port; (without one, the port will fail the external loopback subtest). Table 3-4 shows the signal line connections made by the loopback connector.

Table 3-4 RS-232-C/423 Loopback Connections

Pin #	to Pin #	Signal	to Signal
2	3	Data out	Data In
4	5	Request to Send (RTS)	Clear to Send (CTS)
20	6,8	Data Terminal Ready (DTR)	Data Set Ready (DSR) / Data Carrier Detect (DCD)

2. Press the SELF-TEST button to start the user-initiated test.

The diagnostics will perform internal and external loopback, jabberstop*, and data rate subtests to each channel. If a media card is missing or is bad, the test will fail. The subtests for the user-initiated diagnostic test include the following.

- RAM data and address line verification (internal and external RAM)
- ROM integrity using CRC and checksum
- Serial Communications Chip (SCC) using internal loopback and baud rate
- Transmitter/Receiver via external loopback and jabberstop
- Verification of watchdog timer
- Indicator operation

*The jabberstop is a Gateway feature which prevents a device from monopolizing the network.

Table 3-5 shows how to interpret the results of the user-initiated diagnostic test according to the status of the indicator lights.

Table 3-5 Indicator Status after User-Initiated Test

Indicator	Pass	Fail	Subtests Included
GATEWAY GOOD	On	Off	ROM, RAM, watchdog
TRANSMIT	On	Off	Network Port: loopback, jabberstop, network baud rate
RECEIVE	On	Off	Host Port: loopback, jabberstop, host port baud rate
TEST MODE	Flashing	Flashing	Test Completed
Note: During the test, the COMM ACTIVE and ONLINE indicators are off.			

3. If GATEWAY GOOD, TRANSMIT, and RECEIVE are not lit at the end of the test, first make sure that the loopback connector(s) are on securely, and repeat the test. If these indicators are still not on, contact your Siemens Industrial Automation, Inc. distributor for assistance.

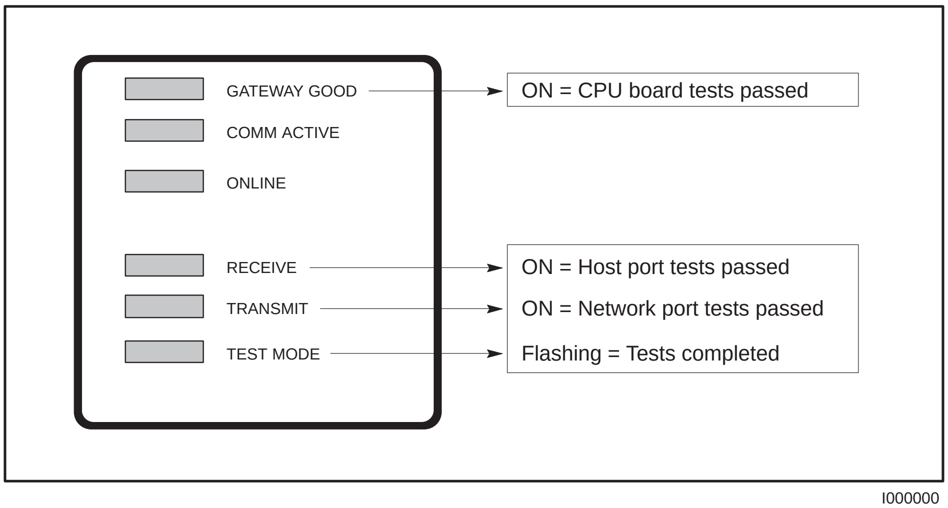


Figure 3-7 Indicator Status

4. To exit TEST mode, press the RESET button.

Burn-In and Final Tests

The burn-in and final tests are primarily factory quality tests and are normally not used in any applications.

Appendix A
Data Type Identification

A.1 Corresponding Data Types

This appendix provides information on which Siemens PLCs are supported by the Gateway, and how SIMATIC® TI® data types correspond to those of the host systems. Also included in this appendix are a list of features added to the latest release of the Gateway and a list of hardware specifications.

Table A-1 shows the correspondence between data types configured in the host systems and the data retrieved from SIMATIC TI PLCs.

Table A-1 Data Type Identification

PLC Data Type	Fisher Data Type	Foxboro Data Type	Honeywell Data Type
V-Memory (12 LSBs*)	N/A	12-bit Binary from Holding Registers	N/A
WX-Memory (12 LSBs*)	N/A	12-bit Binary from Input Registers	N/A
Y (discrete outputs) or C (control relays)	Digital Points	Discrete Coils	Digital Outputs
X (discrete inputs)	N/A	Discrete Contacts	Digital Inputs
V-Memory Words	Input Register	16-bit Word from Holding Registers	Analog Outputs
WX-Memory	N/A	16-bit Word from Input Registers	Analog Inputs
V-Memory	N/A	N/A	Accumulated Value

*Least significant bits

A.2 SIMATIC TI PLCs Supported by TIWAY I Gateway

Table A-2 shows all the PLCs supported by the TIWAY I Gateway and lists the maximum number of discrete points, V-memory locations, and word input memory locations which are accessible from the Gateway.

Table A-2 SIMATIC TI PLCs Supported and Accessible Data

SIMATIC TI PLC Models	Discrete Points (maximum no.)	V-Memory Locations (max.)	Word Input Locations (max.)
5TI	512 (read only)	Not accessible	Not accessible
TI520	128	512	128
TI520	1023	1024	1023
TI530	1023	2047	1023
TI530C	1023	5120	1023
TI530T	1024	12000	1024
PM550	512	1024	128
PM550C	512	1024	128
TI525	1024	4096	1024
TI535	1024	12000	1024
TI545	1024	28762	1024
TI560(T)	8192	65536	8192
TI565(T)	8192	65536	8192

A.3 TIWAY I Gateway Specifications

Table A-3 TIWAY I Gateway Features

TIWAY I Gateway Features	Before Rel. 1.3	≥ Release 1.3
User-defined commands for IDT products		✓
Message resynchronization after timeout		✓
Selectable coil type (Y or C)		✓
IDT data addressing scheme		✓
Command support:		
Read inputs	✓	✓
Read outputs	✓	✓
Read holding register	✓	✓
Read input register	✓	✓
Write holding register	✓	✓
Read exception status	✓	✓
Loopback test	✓	✓
Get communications event counter	✓	✓
Get communications event log	✓	✓
Write multiple coils	✓	✓
Write multiple holding registers	✓	✓

Table A-4 TIWAY I Gateway Physical and Environmental Specifications

Network Communication	1 channel per unit
Compatible PLCs	5TI, TI520/TI530, TI520C/TI530C, TI530T, PM550/C, TI560, TI565, TI560T, TI565T
Host port interface	RS-232-C/423
Maximum cable length	25,000 feet (Local Line); 50 feet (RS-232-C/423)
Network port interface	RS-232-C/423 or Local Line
Data link protocol	HDLC with 16-bit cyclic redundancy error checking (CRC–CCITT)
Network data rates	110 bps – 115.2 kbps
Host port data rates	110 bps – 19.2 kbps
Modem types supported	Asynchronous/synchronous Half/full duplex Multi-drop/point-to-point
Network undetected bit error rate	6×10^{-13} (calculated) with premium cables
Unit size	9.5″ H x 4.0″ W x 7.5″ D
Unit power consumption	20 VA maximum
Operating temperature	0 to 60°C (32 to 140°F)
Storage temperature	–40 to +85°C (–40 to 185°F)
Operating humidity range	0% to 95% relative humidity, noncondensing
Agency approvals	UL® Listed CSA Certified Factory Mutual Research: Class I, Div. 2 hazardous locations

Appendix B
System Configuration Forms

B.1 System Configuration

It is extremely important to keep complete, up-to-date records on system configuration. This appendix provides some sample record-keeping forms for use with a TIWAY I Gateway system.

Table B-1 System Configuration Form

Reference	PLC Type & Number	NIM Base/Slot Number	Block #	Status Word	V Offset
			1	V	
			2	V	
			3	V	
			4	V	
			5	V	
			6	V	
			7	V	
			8	V	

B.2 V-Memory Offset Tables

Table B-2 V-Memory Offset Table (Resident Information)

PLC #	Base/Slot #	Number of Words	V Offset
Word #	Moved From	Word/Image Register	Comments
1			
2			
3			
4			
5			
6			
7			
8			

Table B-3 V-Memory Offset Table (Received Information)

PLC #	Base/Slot #	Number of Words	V Offset
Word #	Moved To	Word/Image Register	Comments
1			
2			
3			
4			
5			
6			
7			
8			

Appendix C

Modbus Commands

C.1 Modbus Protocol Overview

This appendix describes the Modbus protocol in detail. For each of the Modbus functions described, examples of requests and responses are given.

Table C-1 describes the Modbus functions supported by the Gateway.

Table C-1 Modbus Functions Supported

Code	Type	Description
01	Read Coil Status	Get current status of a group of coils.
02	Read Input Status	Get current status of a group of discrete inputs.
03	Read Holding Register	Get current values from holding registers.
04	Read Input Register	Get current values from input registers.
05	Force a Single Coil	Change the state of a logic coil to On or Off, forced On or forced Off, or unforced.
06	Write a Single Register	Write a value into a holding register.
07	Read Exception Status	Get the 8 internal status coil values.
08	Execute Diagnostics	Send diagnostic tests to a slave.
11	Get Communications Event Counter	Enable the success or failure of a query to be determined.
12	Get Communications Event Log	Get the communications log for Modbus network transactions.
15	Write Multiple Coils	Change a number of consecutive coils.
16	Write Multiple Registers	Write values into a series of consecutive holding registers.

The RTU Transmission Frame

The TIWAY I Gateway operates in the RTU transmission mode. The RTU mode determines the start and finish of a message based on a time period of silence (no transmission) equivalent to the time it would take to transmit 3.5 characters at the chosen baud rate. The RTU transmission frame is shown in Figure C-1.

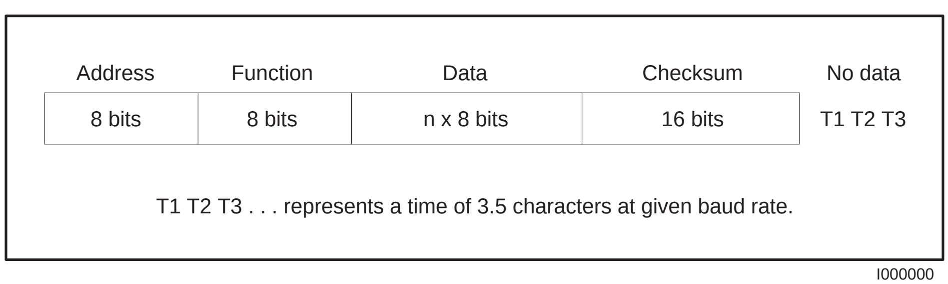


Figure C-1 RTU Transmission Frame

Message Delineation

The start and finish of a message is determined by timing in RTU mode. Any time longer than 3.5 character lengths marks the end of a transmission. The next character after that would then mark the start of the next message. This time period is dependent on the baud rate. Table C-2 shows the effect of baud rate on the time period (assuming 2 stop bits).

Table C-2 RTU Timing

Baud Rate	Time (ms)
19200	2.2
9600	4.4
7200	5.9
4800	8.8
3600	11.7
2400	17.5
1800	23.4
1200	35.0
600	70.0
300	140.0
200	210.0
150	280.0
110	383.0

The Address Field

The Address field identifies the node to which this message is being sent and is a number in the range of 1 to 247. Each node on any one network must have a unique address. Only those nodes addressed will respond unless the broadcast address 0 is used. In that case, each slave will read and act on the message but not respond.

The Function Field

The Function field is an 8-bit code that determines the action that a slave takes when receiving the message. These function codes are summarized in Table C-1 and described in more detail with examples in section C.2.

The Data Field

The Data field contains the information needed by the specified node to perform the required operation, or the information returned by the node to the host computer.

Checksum

The checksum needs 16 bits and uses the Cyclic Redundancy Checksum (CRC) method. The calculation of this checksum is described in the *Modbus Protocol Reference Manual*.

Invalid Characters and Messages

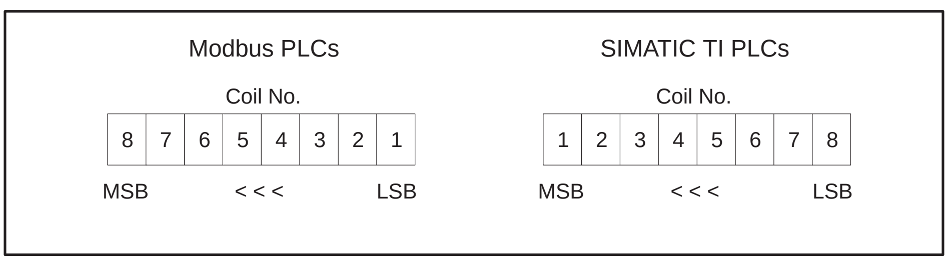
The Gateway ignores messages that contain invalid characters. Messages containing the following errors will also be ignored.

- Incorrect checksum
- Parity error
- Framing errors
- Incomplete transmission

Modbus Functions

This section outlines some of the differences between Modbus and TIWAY I network commands.

- Whereas Modbus uses *Functions Codes*, TIWAY I uses *Primitives*. Primitives differ from Function codes in one important way: primitives use TT-types to allow one primitive to address different types of data. With Modbus a different function code is required for each type of data.
- For all SIMATIC TI Series 505 PLCs, the first address for each type of memory is always 1. Modbus PLCs by comparison allow 0 as the first legal address.
- If each system were to return one byte (8 bits) representing eight discrete coils, they would each be positioned as shown in Figure C-2.



I000000

Figure C-2 Bit Orientation

- Terminology is another area in which differences occur. Some of the differences in terms are given in Table C-3.

Table C-3 Terminology Differences

Modbus-based PLCs	SIMATIC TI PLCs
Coil	Discrete output (Y) or Control Relay (C)
Input Register	Word Image Register (WX/WY)
Holding Register	Variable Memory (V-memory)
Slave	Secondary Node
P/C (Programmable Controller)	PLC
Function code	Primitive
Modbus	TIWAY I
Disabled (coil)	Forced
Enabled (coil)	Unforced

Addressing

The TIWAY I Gateway uses the absolute position of the data for the address. That is, if you want to address the 3066th coil, then that is the address you pass with the command (as hexadecimal value BFA). The maximum address is 65535 (FFFF hex). For example, if you want to access 1000 coils starting at the 703rd coil, the Function Code 01 would be as follows:

01 01 02 BF 03 E8 0C E8

Address Limits

Modbus imposes a buffer size limit of 256 bytes. Because of this restriction, TIWAY I Gateway requests have been limited to the following values.

Function Code	Quantity
01	2000 coils
02	2000 discrete inputs
03	125 output registers
04	125 input registers
15	800 coils
16	100 registers

The command checking will reject requests for data greater than the limits shown above. What the checking does *not* do is check the request against the available PLC memory. When a request goes beyond the memory of a particular PLC, the command will be rejected by the PLC and the host computer will be notified by the Exception Code 02.

C.2 Modbus Function Descriptions

Introduction

In the descriptions that follow, each function starts on a separate page and includes the TIWAY primitive sent to the secondary in square brackets. For each function, an example of request and response is given.

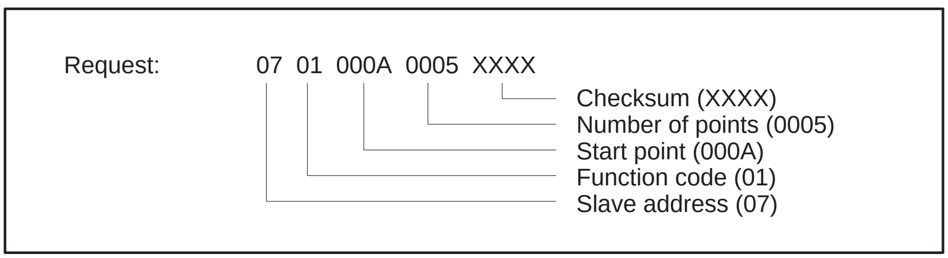
Code 01 — Read Coil Status

Code 01 enables the user to read the On/Off values of logic coils. The data passed with this command is the start address and the number of coils to be read. Addressing is sequential up to the maximum memory size for a particular PLC. The maximum number of coils that can be addressed with one command is 2000. If more are requested, the whole command will be rejected with an Exception code 03.

⚠ WARNING

SIMATIC TI PLCs number memory locations starting at address 1. Modbus PLCs number areas of memory starting from address 0. Failure to alter host computer application programs may result in the wrong bits being read.

Example:



I000000

Figure C-3 Read Coil Status Example — Request

This request is asking the Gateway to return the data from 5 coils (On/Off) starting at the 10th coil.

[This is equivalent to sending a TIWAY Primitive 20 request using TT-type 7 (Packed Discrete Outputs) or TT-type 8 (C Packed), depending on the position of Switch 10 of the network dipswitch bank in the Gateway.]

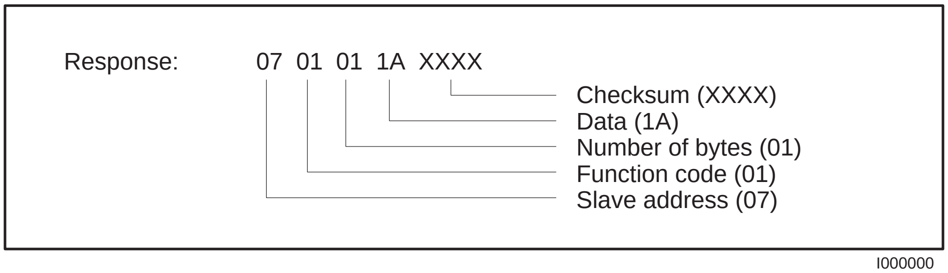


Figure C-4 Read Coil Status Example — Response

The response returns in the data field a single byte (1A) which contains the 1's or 0's for the 5 coils, packed out with zeros for the three high bits.

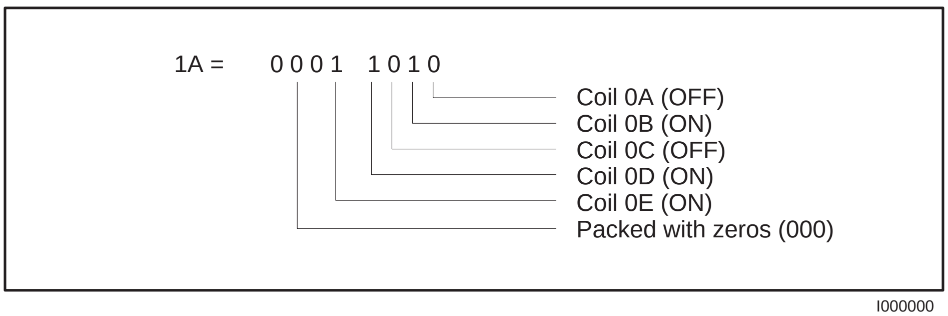


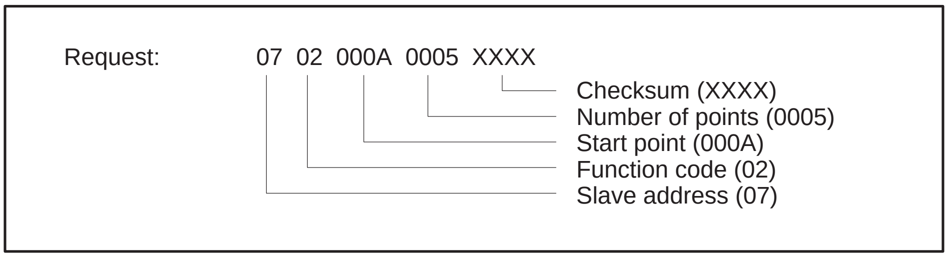
Figure C-5 Read Coil Status Example — Data Field

Code 02 — Read Input Status

Code 02 allows the application to read a series of discrete inputs. The command includes the start address and the number of points to be read.

Addressing is sequential up to the maximum memory size for a particular PLC. The maximum number of inputs that can be addressed with one command is 2000. If more are requested, the whole command will be rejected with an Exception code 03.

Example:

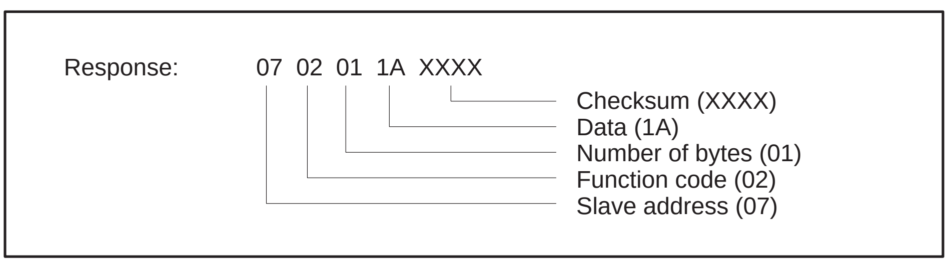


I000000

Figure C-6 Read Input Status Example — Request

This request is for the data from 5 discrete inputs (On/Off) starting at the 10th input.

[This command is equivalent to sending a TIWAY I Primitive 20 request using TT-type 6 (Packed Discrete Inputs)].



I000000

Figure C-7 Read Input Status Example — Response

The response returns in the data field a single byte (1A) containing the 1's or 0's for the 5 discrete inputs, packed out with zeros for the three high bits.

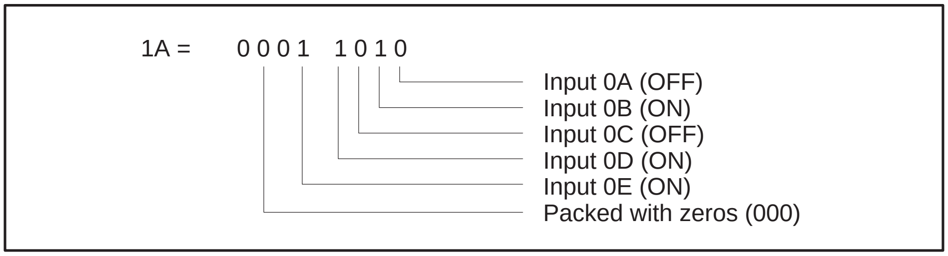


Figure C-8 Read Input Status Example — Data Field

Code 03 — Read Output Registers

Code 03 allows you to read the contents of holding registers in the attached secondary device. The data field of this command includes the start address of the registers and the number of registers to be read.

Addressing is sequential up to the maximum memory size for a particular PLC. The maximum number of registers that can be addressed with one command is 125. If more are requested, the whole command will be rejected with an Exception code 03.

[This command is equivalent to issuing a TIWAY I Primitive 20 request with a TT-type 01 (Variable Memory)].

Example:

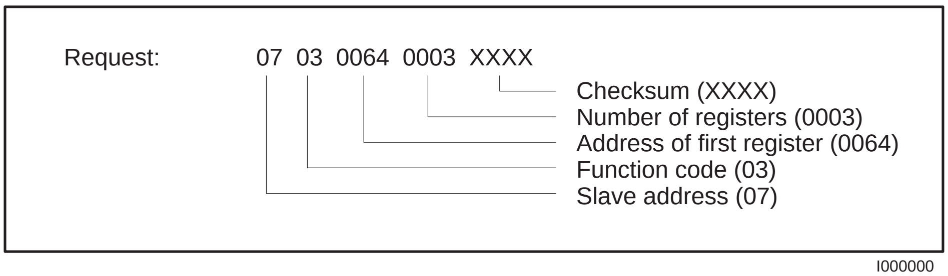


Figure C-9 Read Output Register Example — Request

This request is for secondary address 7 to read the contents of registers 0064, 0065, and 0066 (100, 101, and 102 decimal).

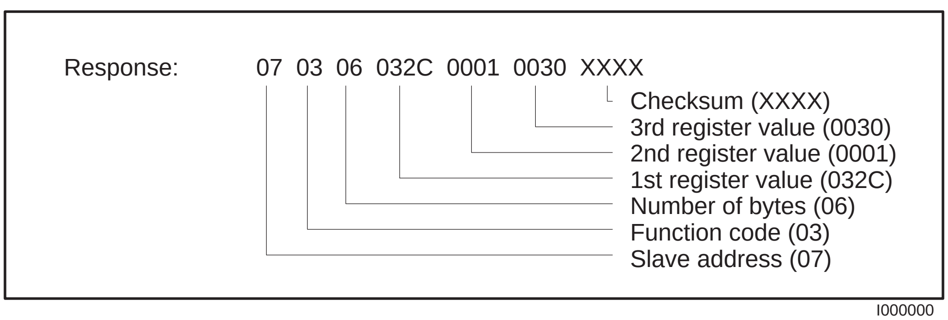


Figure C-10 Read Output Register Example — Response

The response has returned the number of bytes of data (06) and the values for the requested registers; these are 032C, 0001, and 0030 respectively (812, 1, and 48 decimal).

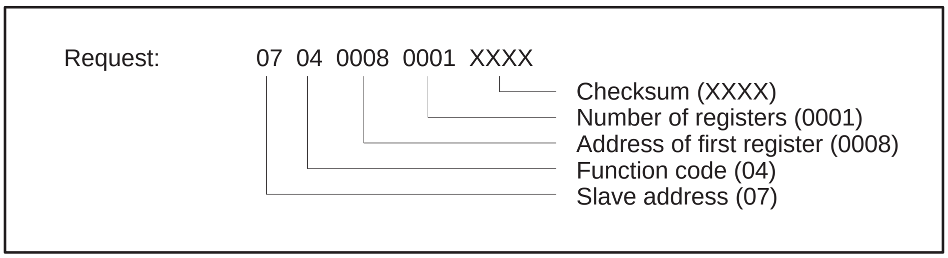
Code 04 — Read Input Registers

Code 04 allows you to read the contents of input registers in the attached PLC. These registers hold the values returned by the I/O devices. The data field of this command includes the start address of the registers and the number of registers to be read.

Addressing is sequential up to the maximum memory size for a particular PLC. The maximum number of registers that can be addressed with one command is 125. If more are requested, the whole command will be rejected with an Exception code 03.

[This command is equivalent to issuing a TIWAY I Primitive 20 request with a TT-type 09 (Word input WX)].

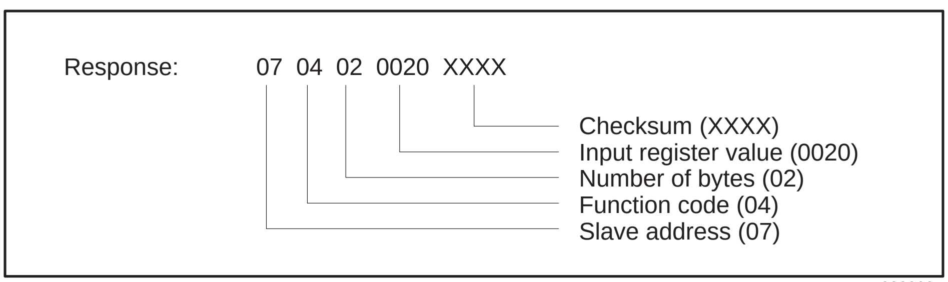
Example:



I000000

Figure C-11 Read Input Register Example — Request

This request is for secondary address 7 to read and return the value stored in input register 0008.



I000000

Figure C-12 Read Input Register Example — Response

The response has returned the number of bytes of data (02) and the value 0020 (32 decimal) from the requested input register (0008).

Code 05 — Write a Single Coil

Code 05 allows a designated coil [discrete output Y or C, depending on the position of Switch 10 on the network dipswitches] to be written. Depending on the code passed in the data field, it can be changed to On (1) or Off (0), forced On or Off, or unforced. The two-byte codes are the following.

FF00 (hex) . . . . ON
0000 (hex) . . . . OFF

NOTE: All other values are illegal and will result in error response 03.

Where the Broadcast address (00) is used, the Gateway will send the change coil command to all attached secondaries.

[This command is comparable to Primitive 30, using TT-type 4 (Y coils) or type 5 (Cs).]

⚠ **WARNING**

Because of differences in memory mapping between Modbus PLCs and SIMATIC TI PLCs, you should be quite certain of the effects of the broadcast command before issuing it.

Example:

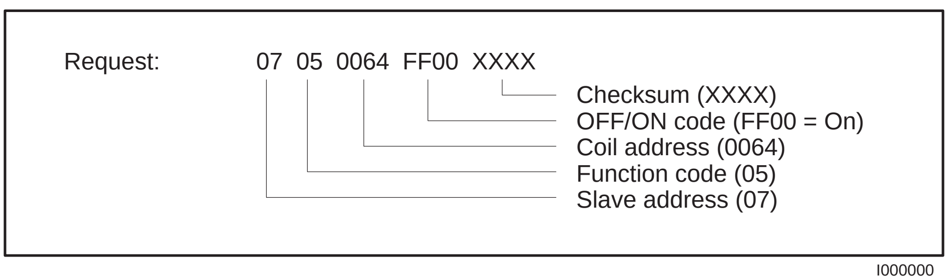
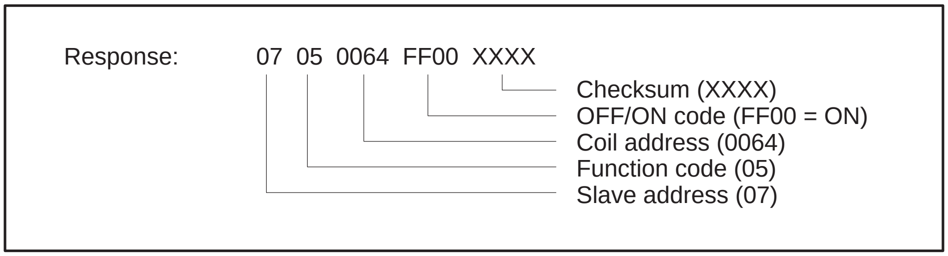


Figure C-13 Write a Single Coil Example — Request

This request to secondary 7 is asking for coil 0064 (100 decimal) to be changed to the on state.



I000000

Figure C-14 Read Input Register Example — Response

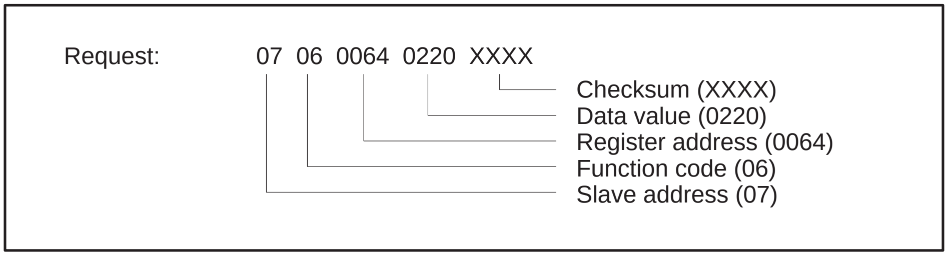
The response to Function Code 05 is to return the request as received. In the case of a broadcast request, there is no response.

Code 06 — Write a Single Register

Code 06 allows the contents of a holding register to be changed. Addressing is sequential up to the maximum memory size for a particular PLC. This function is limited to integer values contained in V-memory. The Gateway will also direct any broadcast address (00) to all attached secondaries.

[This command is comparable to a TIWAY I request using Primitive 30 and TT-type 01 (Variable memory)].

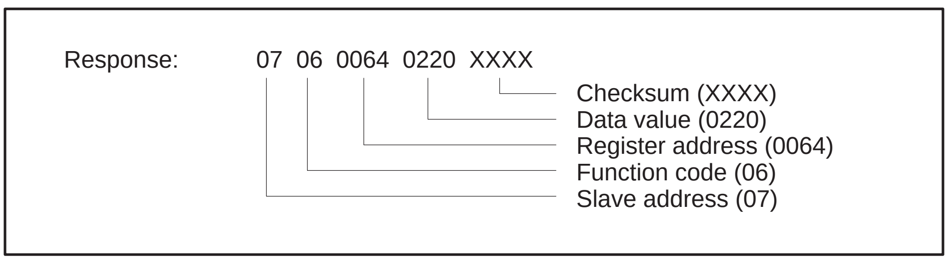
Example:



I000000

Figure C-15 Write a Single Register Example — Request

This request to secondary 7 is asking for the value of holding register 0064 (100 decimal) to be changed to 0220 (544 decimal).



I000000

Figure C-16 Write a Single Register Example — Response

The response to Function Code 06 is to return the request as received. In the case of a broadcast request, there is no response.

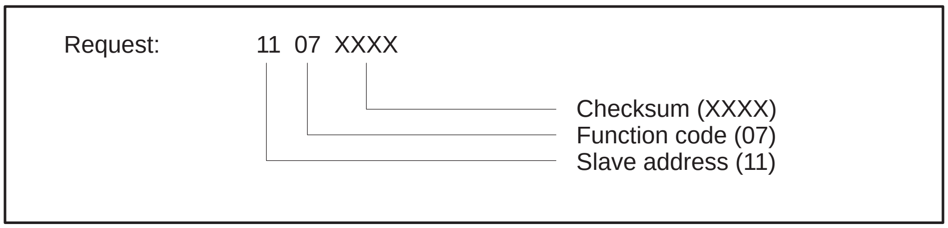
Code 07 — Read Exception Status

Code 07 instructs the Gateway to read 8 predefined Cs within a secondary.

This implementation will read the first 8 Cs in the discrete image register in a secondary and pack them into one data byte.

NOTE: The programmer of a non-Modbus PLC must make certain that the application program running within the PLC will place meaningful data in these locations. This data can reflect status information.

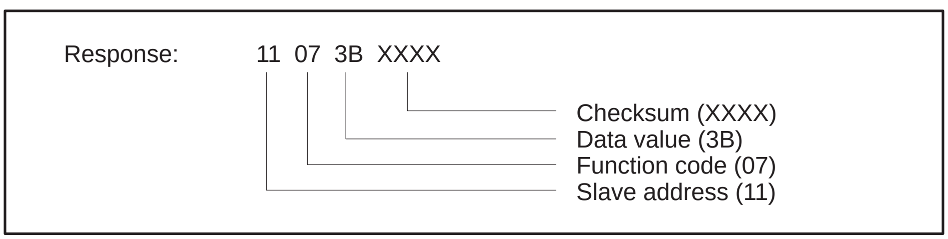
Example:



I000000

Figure C-17 Read Exception Status Example — Request

This request to secondary 17 (decimal) is asking for exception status data.



I000000

Figure C-18 Read Exception Status Example — Response

The response shows that 3B (hex) has been returned. If the individual bits are examined, they indicate the status of each bit.

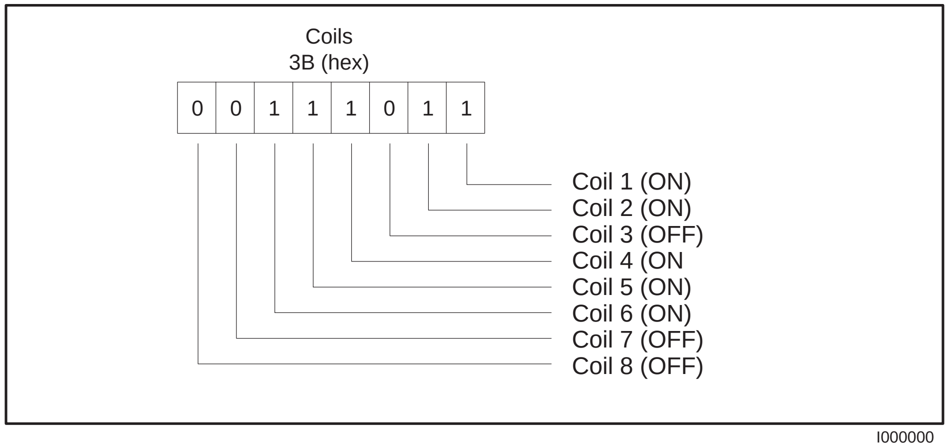


Figure C-19 Exception Status Bits

Code 08 — Execute Diagnostics

Code 08 enables diagnostic information to be retrieved to conduct network testing. This function does not affect the operation of the PLC.

Example:

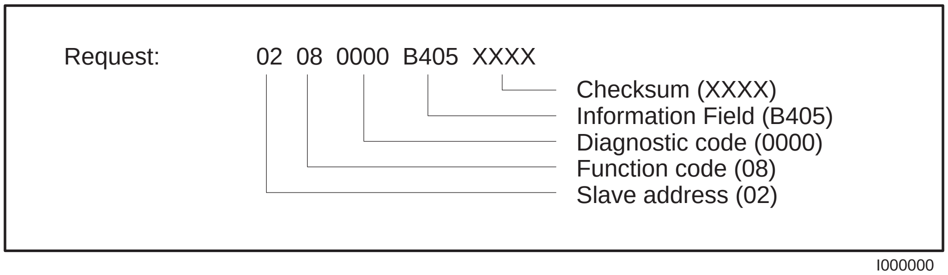


Figure C-20 Execute Diagnostics Example — Request

This example shows a request to conduct diagnostic test 0000. This is the loopback query, where the outgoing message field is returned unchanged.

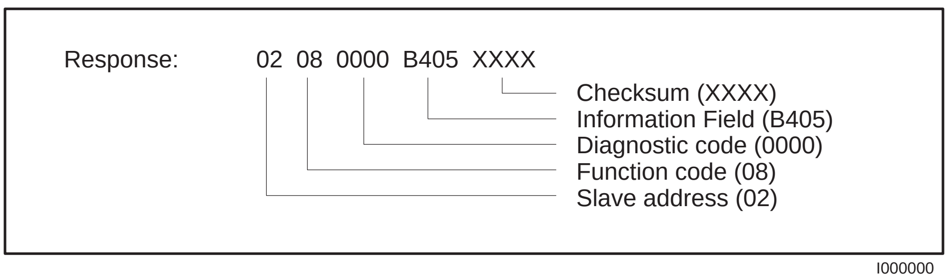


Figure C-21 Execute Diagnostics Example — Response

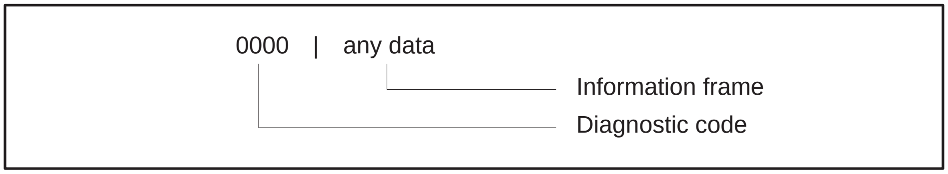
Table C-4 details the diagnostic codes supported.

Table C-4 Diagnostic Codes Supported

Code (hex)	Diagnostic Description	Is Code Supported?
00	Return request message	Yes
01	Restart communications with the slave	Yes
02	Return diagnostics register	No
03	Change message end character	No
04	Set slave in listen only mode	No
0A	Clear counters and diagnostics	No
0B	Return message count	No
0C	Return checksum error count	No
0D	Return exception count	No
0E	Return slave message count	No
0F	Return slave no response count	No
10	Return slave NAK count	No
11	Return slave busy count	No
12	Return character overrun count	No
13	Return overrun error count	No
14	Clear character overrun count	No

The diagnostics codes supported are described in the following paragraphs.

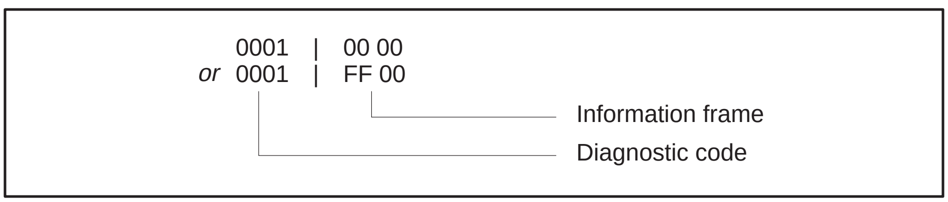
Diagnostic Code — 00



I000000

When Function Code 08 uses diagnostic code 0000, any data passed in the information field is returned to the host computer by the Gateway. The Gateway will send Primitive 02 to the secondary. If the secondary has a fatal error, communications loopback is not performed to indicate fatal error. The purpose of this command is to determine if the communications are functioning correctly, and may be used in conjunction with diagnostic tests described later.

Diagnostic Code — 01



I000000

When Function Code 08 uses diagnostic code 0001, the information frame can contain 0000 or FF00. This function causes the Gateway to clear all internal counters and registers. If the information frame contains FF00, the Communications Event Log will be cleared. If any other value is passed in the information field, the Communications Event Log will not be cleared, and no response will be returned.

Code 11 — Get Comms Event Counter

Code 11 returns a 2-byte status word and an associated 2-byte event counter. The status word is defined in the Modbus Protocol Reference Specification as being 0 for no command in progress and FFFF if a previous command is in progress. The status will always be 0 in the Gateway.

The event counter is incremented for every successful message; it is not incremented for exceptions or polls, or for this code or Code 12. This code can be used to determine if a single command was successful when a communication error occurred during the request or response.

The event counter will increment to the value FFFF (65535 decimal), then begin again from zero.

Example:

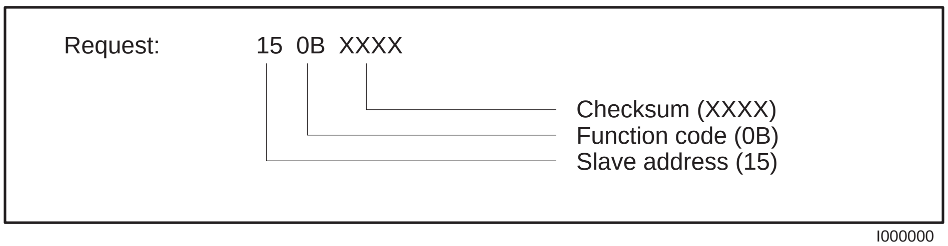


Figure C-22 Get Comms Event Counter Example — Request

In this example, secondary node 21 (15 hex) has been asked to return the event counter and the associated status word.

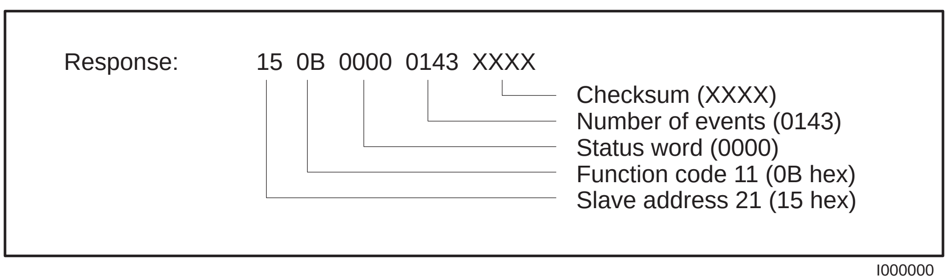
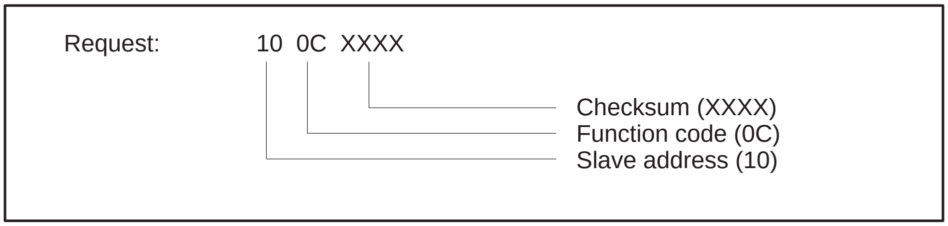


Figure C-23 Get Comms Event Counter Example — Response

The response shows that the status word is 0000 and that 323 (decimal) events have occurred.

Code 12 — Get Comms Event Log

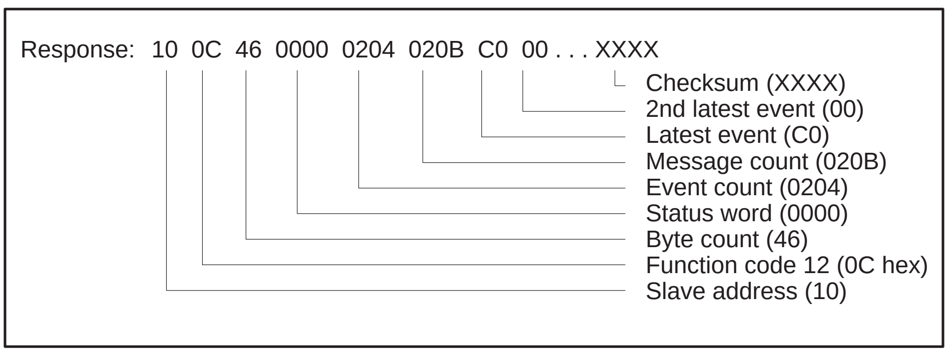
Code 12 returns the same information as Function Code 11 plus a message count and an additional 64-event byte. This means that a 2-byte status word, a 2-byte event counter, a message count, and the most recent 64 events are returned. A buffer records each send or receive operation and overwrites the oldest event with the latest event. No events are recorded for this code or Code 11. The Event Byte types are shown in Table C-5.



I000000

Figure C-24 Get Comms Event Log Example — Request

This request to address 16 (decimal) is for the Exception Event Log.



I000000

Figure C-25 Get Comms Event Log Example — Response

The response has returned 70 bytes of data (2 status bytes + 2 event counter bytes + 2 message counts + 64 event bytes). Only two of the event bytes are shown; these indicate the secondary node was reset (00) and then received a broadcast message (C0). The most recent events are returned first.

Table C-5 Event Byte Types

Event Byte	Bit Definitions
Slave Bus Receive. Byte stored on receipt of message	Bit 0 – Reserved Bit 1 – Set if communications error Bit 2 – Reserved Bit 3 – Reserved Bit 4 – Set if character overrun Bit 5 – Set if in Listen Only mode Bit 6 – Set if Broadcast Bit 7 – 1
Slave Bus Transmit. Byte stored when message sent	Bit 0 – Set if an exception (1–3) is sent Bit 1 – Set if secondary abort exception (6) is sent Bit 2 – Set if secondary busy exception (6) is sent Bit 3 – Not used Bit 4 – Set if write timeout occurred Bit 5 – Set if in Listen Only mode Bit 6 – 1 Bit 7 – 0
Initiate Communications Reset. Complete log is set to zeros.	Bit 0 – 0 Bit 1 – 0 Bit 2 – 0 Bit 3 – 0 Bit 4 – 0 Bit 5 – 0

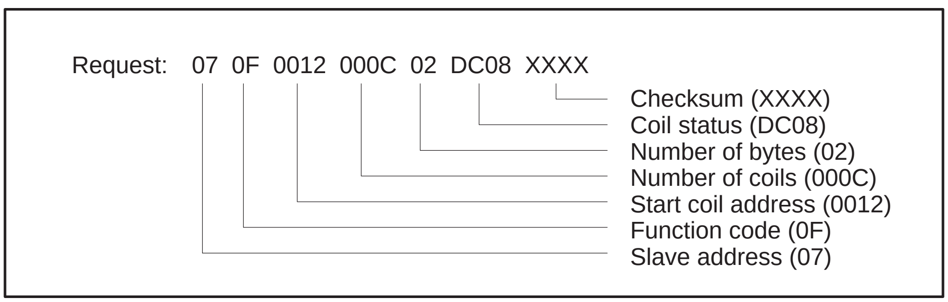
Code 15 — Write Multiple Coils

Code 15 allows the host computer to write multiple coils. When this command is given, successive coils are changed, by an associated bit pattern, to the indicated state; where each bit indicates: **1 = ON   0 = OFF**

Addressing is sequential up to the maximum memory size for a particular secondary. The maximum number of coils that can be addressed with one command is 800. If more are given, the whole command will be rejected with an Exception code 03.

The broadcast address (00) can be used to change the same coils in all networked programmable controllers.

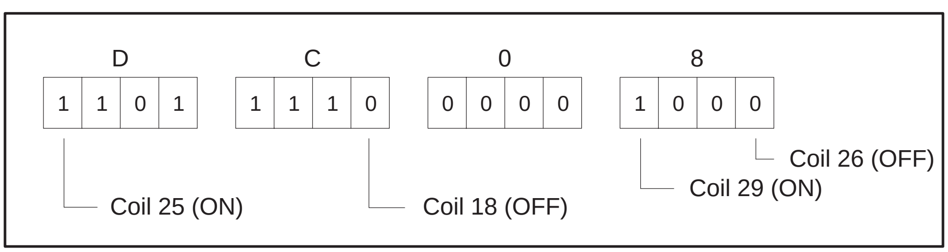
[This command is equivalent to TIWAY Primitive 30 using data types 04, 07 (Y unpacked, packed) or data types 05, 08 (C unpacked, packed), depending on the position of network port Switch 10.]



I000000

Figure C-26 Write Multiple Coils Example — Request

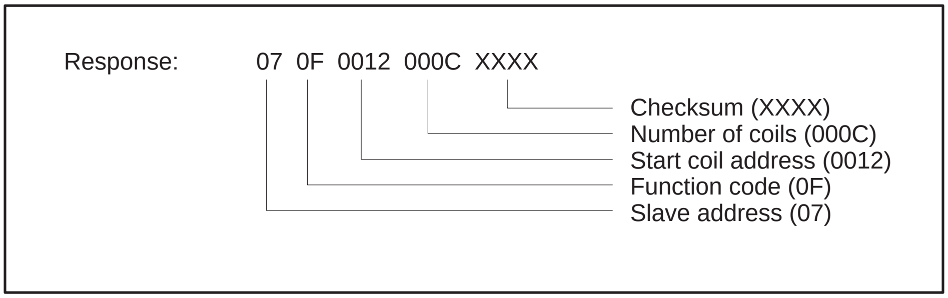
This request is for the secondary node to change the values of 12 (0C hex) coils starting at address 12 (18 decimal) to the states given by the following bit pattern.



I000000

Figure C-27 Coil Bit Pattern

The bit pattern indicates that coils 19, 20, 21, 22, 24, 25, and 29 are to be changed to ON and 18, 23, 26, 27, and 28 changed to OFF.



I000000

Figure C-28 Write Multiple Coils Example — Response

Code 16 — Write Multiple Registers

Code 16 allows the host computer to write multiple values into successive registers. Addressing is sequential up to the maximum memory size for a particular PLC. The maximum number of registers that can be addressed with one command is 100. If more are given, the whole command will be rejected with an Exception code 03.

[This command is equivalent to a TIWAY I request using Primitive 30 with TT-type 01 (Variable memory)].

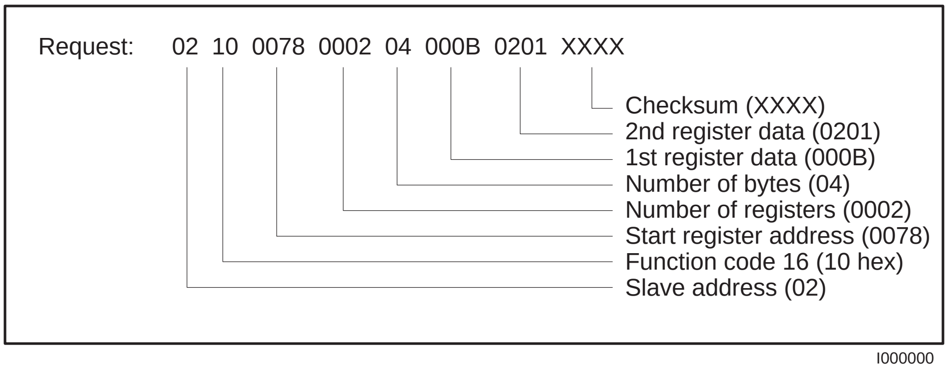


Figure C-29 Write Multiple Registers Example — Request

This request is to the secondary node to change the values of 2 holding registers, starting at address 0078 (120 decimal) to 11 and 513 respectively.

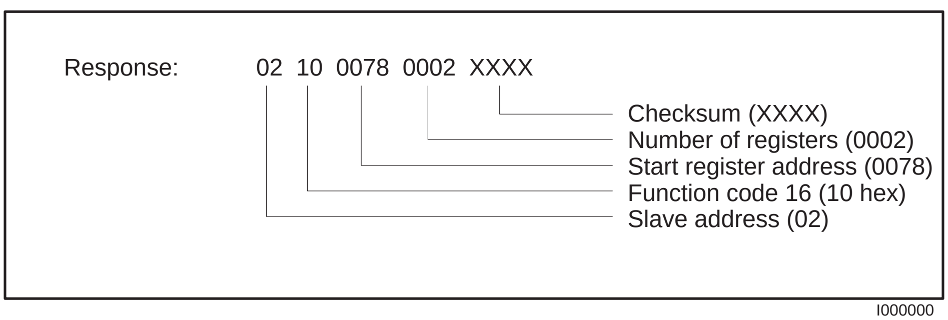


Figure C-30 Write Multiple Registers Example — Response

The response to this command is to return the address, code, starting address, and the numbers of registers to be changed.

C.3 User-Defined Modbus Commands

There are three user-defined commands implemented in the TIWAY I Gateway. These commands, described below, allow the Gateway to work with the IDT operator interface family of products.

Command 65 — Read C Memory

This command permits the collection of Control Relay (C) data. The format of the command is as follows.

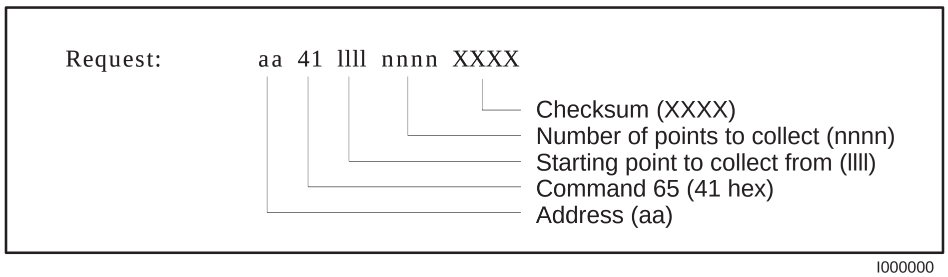


Figure C-31 Command 65 — Request

The response for this command is as follows.

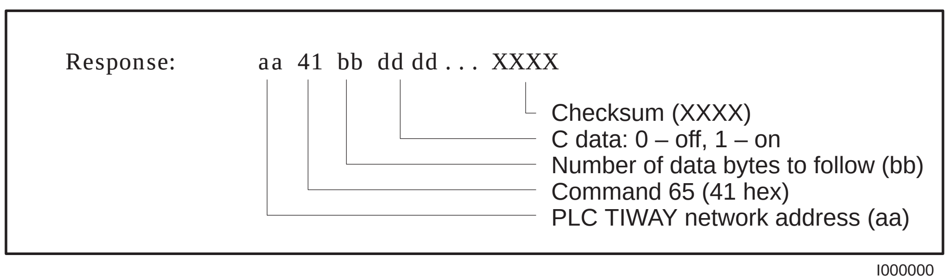


Figure C-32 Command 65 — Response

Command 66 — Read K Memory

This command permits the collection of constant (K) memory. The formats of the command and response are as follows.

```
Request:        aa 42 llll nnnn XXXX
```

- Checksum (XXXX)
- Number of locations to collect (nnnn)
- Starting location to collect from (llll)
- Command 66 (42 hex)
- Address (aa)

I000000

Figure C-33 Command 66 — Request

```
Response:       aa 42 bb dddd . . . XXXX
```

- Checksum (XXXX)
- K-memory data
- Number of data bytes to follow (bb)
- Command 66 (42 hex)
- PLC TIWAY network address (aa)

I000000

Figure C-34 Command 66 — Response

Command 67 — Read WY Memory

This command permits the collection of Word Output memory. The formats of the command and response are as follows.

```
Request:        aa 43 llll nnnn XXXX
```

- Checksum (XXXX)
- Number of locations to collect (nnnn)
- Starting location to collect from (llll)
- Command 67 (43 hex)
- Address (aa)

I000000

Figure C-35 Command 67 — Request

```
Response:       aa 43 bb dddd . . . XXXX
```

- Checksum (XXXX)
- WY memory data
- Number of data bytes to follow (bb)
- Command 67 (43 hex)
- PLC TIWAY network address (aa)

I000000

Figure C-36 Command 67 — Response

C.4 Error Responses

Errors such as illegal addressing or failure of communications with a PLC are reported by exception responses. Exception responses replace the expected response to a request and are recognized by the returned Function Code with the top bit set high (see example in Figure C-37).

Request:

Address	Function	Data	Checksum
07	01	00000041	XXXX

Response:

Address	Function	Exception Code	Checksum
07	81	02	XXXX

I000000

Figure C-37 Exception Response Frame

In this example, the request is for secondary node 07 to return the data for 65 (41 hex) coils starting at address 00, which is an illegal address for a SIMATIC TI PLC. The response is an exception indicated by the Function Code 81 (01 with the high bit set), with the exception code 02 indicating that the data address was illegal.

NOTE: The TIWAY I network uses Exception Primitives. Exceptions sent by SIMATIC TI PLCs are mapped to Modbus Exception Codes.

Table C-6 list the exception responses that apply to the functions supported by the TIWAY I Gateway.

Table C-6 Exception Responses

Code	Name	Description
01	Illegal Function	The function received is not defined for this application [equivalent to SIMATIC TI exception codes 00, 01, 06, 15].
02	Illegal Data Address	The address contained in the data field is not valid for the secondary being addressed [equivalent to SIMATIC TI code 02]
03	Illegal Data Value	The value passed in the data field is not allowable for the secondary being addressed [equivalent to SIMATIC TI codes 10, 19, 1D].

Appendix D

Configuring the PLC for Fisher PROVOX

D.1 Considerations for Configuring a TIWAY I/PROVOX System

PLC Configuration Requirements

To configure the PLC to operate with the Fisher PROVOX Programmable Controller Interface Unit (PCIU), you need to consider the following restrictions and requirements.

- A maximum of eight PLCs can be networked with each PCIU on a PROVOX system.
- A total of 64 data registers can be distributed in V-memory across one to eight PLCs on the PCIU.
- The PCIU can be configured to access up to 8 blocks of contiguous V-memory. These blocks may encompass up to 64 words of data. The network cannot access any data that is not defined in one of these blocks.
- Data can be read from and written to contiguous blocks of V-memory.
- Words within a block of V-memory may be defined as integer or discrete registers. The values of the discrete registers correspond to the values of a contiguous block of 16 Y points.
- For each V-memory block in a PLC that the PCIU is configured to read, the first word in the block must be reserved as a status register. This word does not count toward the 64-word limit.
- All registers should be defined in the V-memory of the PLC. The starting V-memory address for each PLC register block must be configured in the PCIU.
- Each PLC should have an address assigned to it ranging from 1 to 247.

These requirements have several important consequences in network and PLC program design.

Network Design Considerations

The restriction to 8 contiguous memory blocks defined for a given PCIU means that there is a maximum of 8 PLCs that the PROVOX system can access on a single TIWAY I network. However, if more than one contiguous block is defined within a single PLC, then for every block after the first in the PLC, one less PLC on the TIWAY I network can be accessed by the PCIU. For example, if 3 V-memory blocks were defined for each PLC connected to the PROVOX system, then a maximum of 2 PLCs could be attached to each PCIU, with each PCIU having 2 unused memory blocks.

D.2 PLC Programming Considerations

Blocking Network Data

The restrictions on data types and numbers of contiguous data blocks that can be accessed by a PCIU influence the design of the PLC programs to be used in a PROVOX environment. To increase the number of secondaries that can be supported by a single PCIU, you should group together the data to be read by the network into a single contiguous block. Similarly, data supplied to the PLC from the network should be written into a single contiguous block. In most cases, data is read from and written to the same block of memory. This puts the burden of blocking and unblocking the network data on the PLC.

Box functions in Series 500, Series 505, and PM550 PLCs make this blocking and unblocking of data a relatively easy task. Refer to the appropriate user manuals for more information about this function.

Writing to Integer Registers

Another important consideration is that the network writes values into the PLC memory; it does not force the memory to the given value. This distinction implies that if, after a value has been written into a memory location, the PLC program writes a value to the same location, the network data will be overwritten.

NOTE: The PLC ladder logic program must be carefully designed to avoid this problem.

Writing to Discrete Points

The PROVOX system allows you to write discrete values to any Y point that is defined in a discrete register. However, the PCIU expects the contents of the discrete register to accurately reflect the status of the Y points defined in it. The ladder logic program must be designed to ensure that this is the case. This can be accomplished by moving the contents of the Y points to the discrete register.

PLC Status Register

The first word of each contiguous V-memory block serves as the PLC status register. This register is used to pass information about the state of the PLC and the process it is controlling to the PROVOX system. The exact contents of this register are user-definable.

Section D.3 provides an example of network and PLC program design for a Fisher PROVOX system.

D.3 PLC Programming Example

Data to be Accessed

Assume that you have several Series 500 or Series 505 PLCs and PM550 PLCs which need to be attached to a PROVOX system. You need to access the following data from each PLC in the network.

Table D-1 PLC Data to be Accessed

Series 500/505 PLCs	PM550 PLCs	Network Operation
Y1 – Y16	Y0 – Y15	Read
Y22	Y21	Read
X41 – X44	X40 – X43	Read
V14 – V16	V13 – V15	Read
WX17	A101	Read
TCC1	C100	Read
V50	V50	Write
C29 – C32	CR28 – CR31	Read/Write
WY25	A201	Write

The V-memory block is defined as follows in Table D-2.

Table D-2 V-Memory Block

Address	Type	Contents
V200	Status	PLC status register
V201	Discrete	Y1 – Y16
V202	Discrete	Y22, X41 – X44, C29 – C32
V203	Integer	V14
V204	Integer	V15
V205	Integer	V16
V206	Integer	WX17
V207	Integer	TCC1
V208	Integer	V50
V209	Integer	WY25

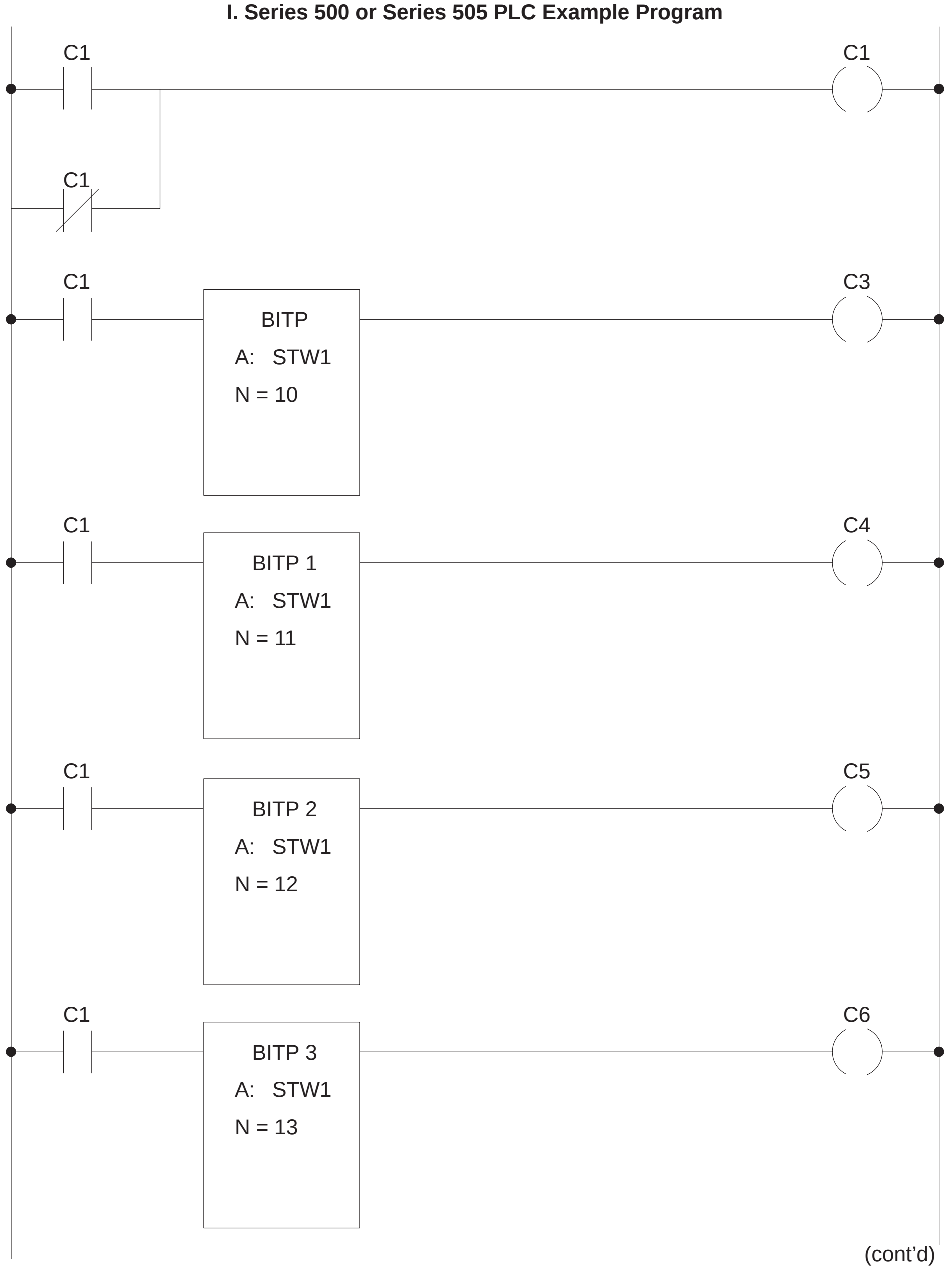
NOTE: The contents column is defined in terms of Series 500/505 data; for PM550s, you should substitute the corresponding PM550 data.

The V-memory block now has 9 data words (plus the status register) in each PLC. From the 64-register limit, you would calculate that there could be a maximum of 7 PLCs (64/9 = 7) configured like this and connected to a single PCIU.

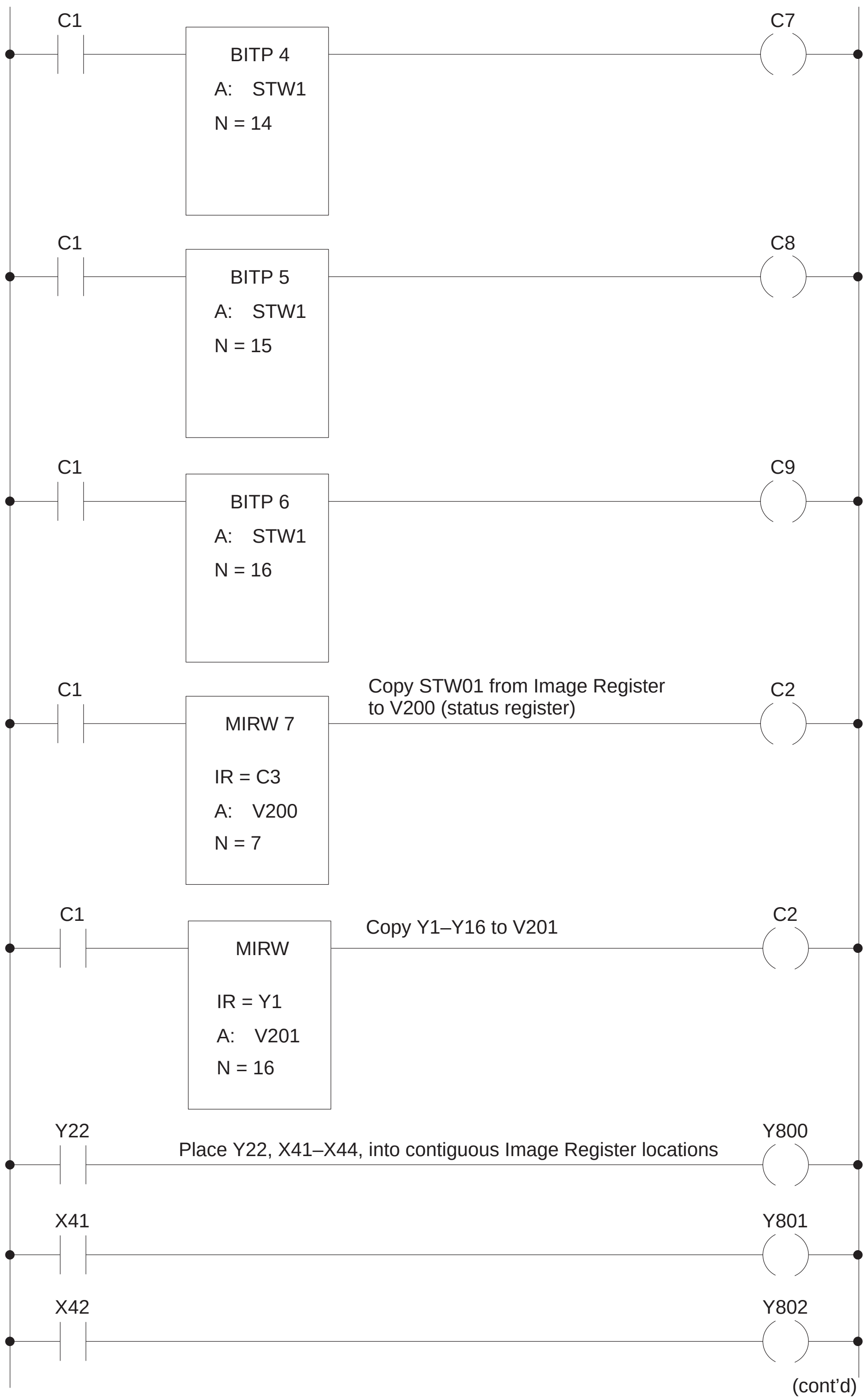
Relay Ladder Logic Program

The following Relay Ladder Logic (RLL) programs for your Series 500/505 or PM550 PLC will block and unblock data to be accessed by way of the network.

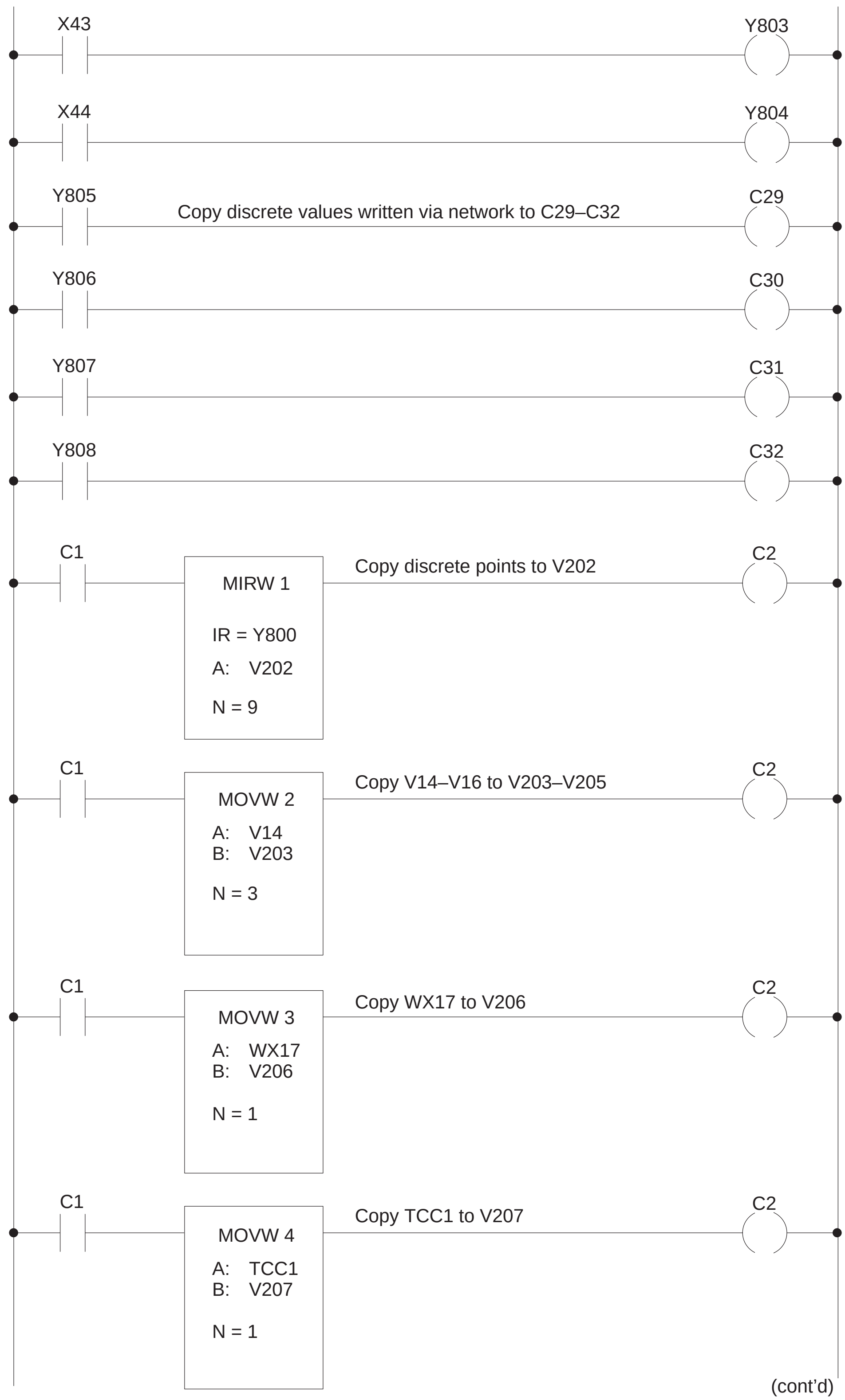
I. Series 500 or Series 505 PLC Example Program



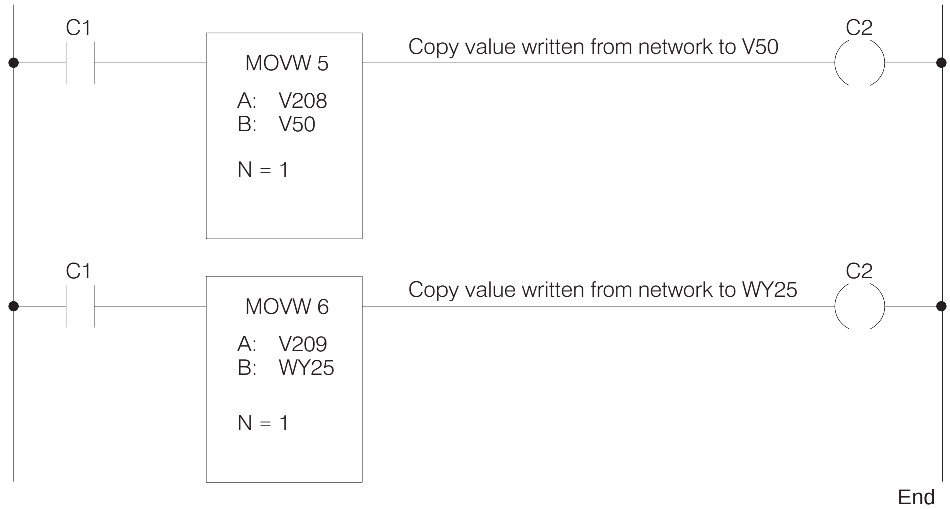
(cont'd)


C1
BITP 4
A: STW1
N = 14
C7
C1
BITP 5
A: STW1
N = 15
C8
C1
BITP 6
A: STW1
N = 16
C9
C1
MIRW 7
IR = C3
A: V200
N = 7
Copy STW01 from Image Register to V200 (status register)
C2
C1
MIRW
IR = Y1
A: V201
N = 16
Copy Y1–Y16 to V201
C2
Y22
Place Y22, X41–X44, into contiguous Image Register locations
Y800
X41
Y801
X42
Y802

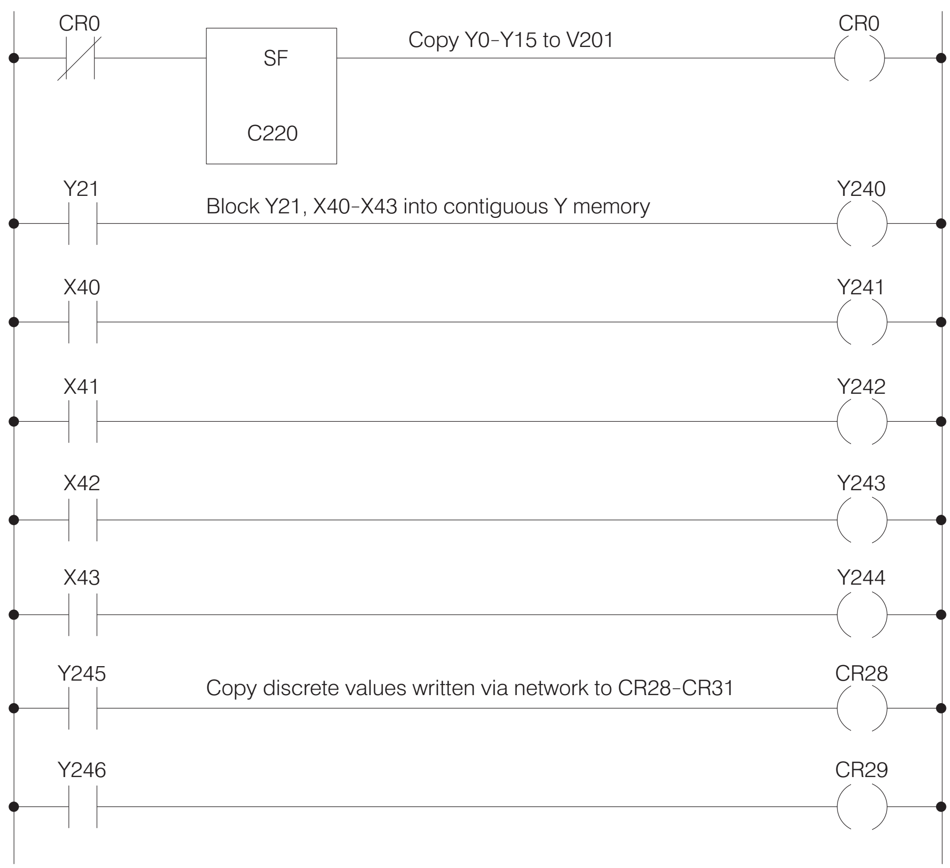
(cont'd)


X43
Y803
X44
Y804
Y805
Copy discrete values written via network to C29–C32
C29
Y806
C30
Y807
C31
Y808
C32
C1
MIRW 1
IR = Y800
A: V202
N = 9
Copy discrete points to V202
C2
C1
MOVW 2
A: V14
B: V203
N = 3
Copy V14–V16 to V203–V205
C2
C1
MOVW 3
A: WX17
B: V206
N = 1
Copy WX17 to V206
C2
C1
MOVW 4
A: TCC1
B: V207
N = 1
Copy TCC1 to V207
C2

(cont'd)

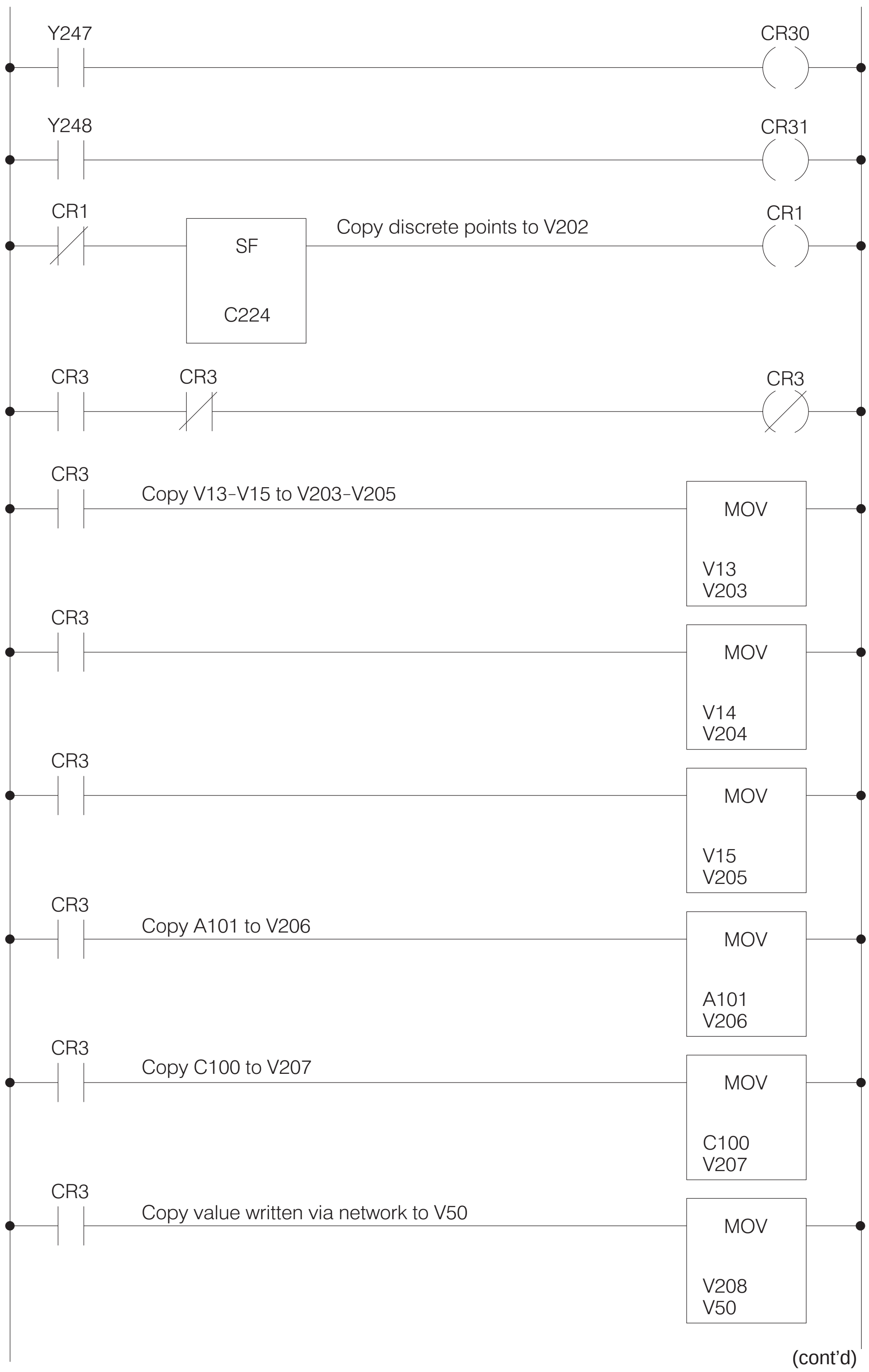


II. PM550 Example Program

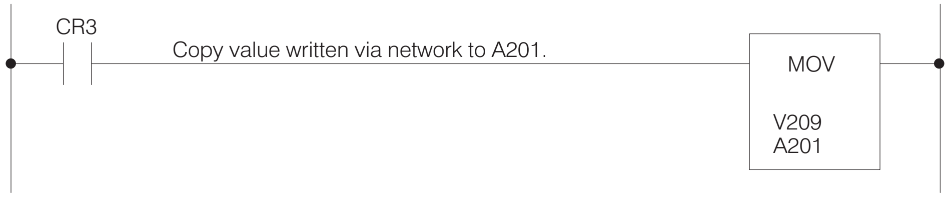


(cont’d)

PLC Programming Example (continued)



(cont'd)



V13	=	1	V206	=	0
V14	=	2	V207	=	1234
V15	=	3	V208	=	98
V50	=	98	V209	=	987
V203	=	1	C100	=	1234
V204	=	2	A101	=	0
V205	=	3	A201	=	0

SPECIAL FUNCTION 15
I/O MOVE

START ADDRESS: C220 NEXT ADDRESS: C224

ERROR OUTPUT? . . . . N
ERROR OUTPUT DESIGNATOR: . . . .

NUMBER OF WORDS: 1

FROM IR? . . . . Y
FROM IR ADDRESS: Y0

FROM V, C MEMORY ADDRESS: . . . .

TO IR? . . . . N
TO IR ADDRESS: . . . .

TO V, C MEMORY ADDRESS V201

SPECIAL FUNCTION 15
I/O MOVE TABLE

FROM		TO	
ADDRESS	VALUE	ADDRESS	VALUE
		V201	–2

SPECIAL FUNCTION 15
I/O MOVE

START ADDRESS: C224 NEXT ADDRESS: C228

ERROR OUTPUT? . . . . N
ERROR OUTPUT DESIGNATOR: . . . .

NUMBER OF WORDS: 1

FROM IR? . . . . Y
FROM IR ADDRESS: Y240

FROM V, C MEMORY ADDRESS: . . . .

TO IR? . . . . N
TO IR ADDRESS: . . . .

TO V, C MEMORY ADDRESS V202

SPECIAL FUNCTION 15
I/O MOVE TABLE

FROM		TO	
ADDRESS	VALUE	ADDRESS	VALUE
		V202	484

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