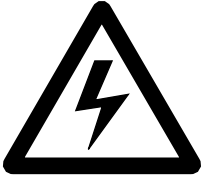# POWER LEADER™
Power Management Control System

Network Architecture Guide

WARNINGS, CAUTIONS, AND NOTES
AS USED IN THIS PUBLICATION

WARNINGS

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

Warning notices are also used for situations in which inattention or lack of equipment knowledge could cause either personal injury or damage to equipment.

CAUTIONS

Caution notices are used for situations in which equipment might be damaged if care is not taken or which may cause communication errors to occur.

NOTES

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

This document is based on information available at the time of its publication. While efforts have been made to ensure accuracy, the information contained herein does not cover all details or variations in hardware and software, nor does it provide for every possible contingency in connection with installation, operation, and maintenance. Features may be described herein that are not present in all hardware and software systems. GE Industrial Systems assumes no obligation of notice to holders of this document with respect to changes subsequently made.

This manual provides an overview of the network architecture associated with the GE POWER LEADER Power Management Control System (PMCS). Please read through this guide prior to laying out a PMCS network. You must complete the following steps before proceeding with the instructions in this manual:

1. Have instruction manuals on hand for all Intelligent Electronic Devices (IEDs) to be installed. (See Appendix B for a list of instruction manuals.)

2. Complete installation of all system IEDs.
   - All IEDs mounted.
   - All IEDs wired to control power and energized.
   - All IEDs assigned a unique address.

   Refer to the appropriate IED instruction manuals for these procedures.

3. Ensure that the PC serving as the Power Management Control System host is operational:
   - The RS-485 interface card, RS-232/RS-485 converter, or Ethernet Card is installed and functioning correctly.
   - Any Ethernet Gateways or Modbus Concentrators are installed and functioning correctly.
   - Windows 2000 SP2 is installed and functioning correctly.
   - The Power Management Control System software is installed and properly configured.
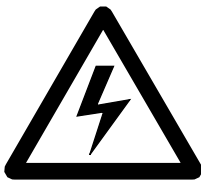
WARNING: Where personnel or equipment safety is involved, do not rely exclusively on information reported by the Power Management Control System or any power management equipment. ALWAYS confirm the status and safety of electrical power equipment in person by conventional test IEDs before operating, energizing or working on such equipment.

WARNING: Network wiring and grounding rules described herein apply primarily to commercial/industrial installations. Substation installations will exist in the presence of dangerously elevated ground potential relative to points outside of the station grid as well as large electromagnetic induction fields. Additionally, large ground faults can elevate substation ground potentials. Follow local utility best-practices/safety procedures to prevent risk of shock/electrocution to personnel and damage to equipment that could result in a loss of protection and communications.

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Welcome to PMCS!

Hello and welcome to POWER LEADER Power Management Control System (PMCS). You are about to begin using your computer in an exciting new way: as a tool to help you increase productivity and reduce downtime and energy costs through power management.

What is Power Management?

Inside every switchgear lineup, switchboard, panelboard, and motor control center flows a vast amount of information that can save and even make you money. The data is in the form of power (volts, amperes, and their time-dependent waveforms) that passes through the equipment every second of every hour of every day. With the proper IEDs, you can selectively access this wealth of information and use it to become more efficient and more productive. Your power distribution equipment can go beyond its fundamental protection role to become a profit-generating asset. This is what power management systems are all about.

Benefits of Power Management

A power management system provides the tools to control energy costs, minimize downtime and outages, and optimize operation to increase productivity. With such a system in place, you can benefit from:

Less downtime – Identify and correct problems before they lead to loss of power and/or costly damage to loads such as production equipment and computers.

Reduced energy costs – Find ways to conserve power, correct billing errors, reduce peak usage surcharges, and leverage interruptible rates.

Improved predictive maintenance – Identify simple maintenance tasks so you can make scheduled corrections before they become problems.

Faster corrective maintenance – Quickly pinpoint the root causes of problems using tools such as time-tagged alarms, sequence of events logs, and triggered waveform capture conditions.

Increased safety – Provide a centralized source of information, reducing the need for physical contact with equipment and shop-floor or sub-station presence.

Higher productivity – Free up maintenance and repair personnel to perform other needed duties.

Improved power quality – Identify sources of "dirty" power, otherwise invisible, and take corrective action to save wear, tear, and possible damage to critical production equipment and other loads.

It should come as no surprise that approximately half of all switchgear is now shipped with power management features. What began as an option is fast becoming an absolute necessity for efficient facility management and increased profitability.

What is PMCS?

PMCS is the latest Power Management Control software from GE Industrial Systems' robust line of POWER LEADER power management products. PMCS seamlessly integrates with the comprehensive family of POWER LEADER IEDs as well as with many new Modbus RTU and Ethernet IEDs and systems.

The Power Management Control System supplies the power-system information you need to optimize usage and minimize power cost and downtime.

Its state-of-the-art graphical interface is easy to use, with the ability to view systems from both the physical and electrical perspectives. Additional features include:

- Viewing metering information at remote locations.
- Historical trending of any metered data.
- Tracking the status of protective and metering IEDs.
- Alarm and event management.
- Report generation.
- Waveform capture and analysis.
- Remote control of IEDs.
- Remote configuration of IEDs.
- Interaction with Cost Allocation software to provide facility energy and demand data.

The Power Management Control System accomplishes these tasks through a network of attached IEDs that serve to protect equipment and collect and transmit data.

These IEDs include trip units, metering IEDs, protective relaying IEDs, and others. They communicate on either the POWER LEADER communication network (commnet), Modbus RTU communications protocols, OR Ethernet to transmit data to the PMCS software.

You can operate PMCS software from either a PC running directly on the Modbus platform or from a PC connected to an Ethernet network, which is linked to the Modbus network via the POWER LEADER Ethernet Gateway. (Some devices, such as the EPM 7700, communicate directly over an Ethernet network and do not require an Ethernet Gateway.)

Power Management Control System

Preface

How Does PMCS Work?

The PMCS software runs on a PC (called the host). The host is linked to the power management IEDs through a network (RS-485), and speaks to them using the Modbus RTU communications protocol[1]. The heart of PMCS is a piece of software called the PMCS Network and IED Configurator. The Network and IED Configurator is a Dynamic Data Exchange Server (we'll refer to it as the PMCS DDE Server or simply the Server). It responds to requests for data from other software packages called clients. When the PMCS DDE Server receives a request for data from a client, it sends a message out to the appropriate IED requesting the data. Each piece of data is called a tag. The PMCS DDE Server polls the appropriate tags (or blocks of tags) from each IED and passes the data back to the client which requested it. The Server then begins to monitor that tag; if it changes, the Server notifies the client that had previously requested the data; thus, not only is the current request answered, but the client is also kept informed of later changes.

Some power management IEDs are relatively simple and keep track of only a few power characteristics or events; they require only a few tags at the DDE Server. More sophisticated IEDs keep track of many more pieces of information, requiring a greater portion of the DDE Server's resources.

The limit on the number of IEDs that can be managed by the PMCS varies from network to network and is a function of the kind and sophistication of the IEDs that the DDE Server is tracking. Obviously, the more sophisticated the IEDs and the greater the demands they place on the DDE Server, the fewer IEDs that may be managed.

The host is networked to the power management IEDs in one of two fashions. The host may be based directly on the RS-485 platform and communicate with the RS-485 networks via interface cards. Alternatively, the host may reside on an Ethernet network, talking directly to Ethernet-capable IEDs such as the EPM 7700, and to Modbus-native devices via a separate Modbus-to-Ethernet converter which supports the RS-485 networks. This is described in greater detail later in the manual.

Using This Guide

This manual is a simple and direct guide to designing and connecting a power management system based on GE's Power Management Control System. Please read the entire manual before attempting to put it into practice.

Chapter 1 provides a basic overview of the PMCS: typical systems and intelligent electronic devices (IEDs) supported. It is imperative that you have a thorough understanding of what the PMCS is and its various components before you read the rest of this book.

Chapter 2 discusses the rules and requirements for designing the network on paper: how far apart IEDs may be located, addressing the IEDs, limits on the number of IEDs. Chapter 2 also provides several case studies as examples of how to design a PMCS network that will fit your needs. After studying this chapter and the case studies, you should understand how to lay out networks based on PMCS.

Chapter 3 explains the details of actual network construction: types of wire required, termination resistors, how to wire IEDs together. Actual connection details are given in the user manuals of each individual IED, which you should refer to directly.

Chapter 4 offers information on operations and trouble-shooting. The information provided here will help you get your system up and running and keep it that way!

Several Appendices offer more detailed descriptions of PMCS-compatible IEDs and a list of reference publications.

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[1] EPM 7700 devices are the exception; instead of using Modbus, they communicate directly over Ethernet.

Chapter 1 – Introduction

1–1 Typical Systems

The PMCS software is capable of operating on either of two platforms:

1. PMCS running on a Modbus-based host PC, or

2. PMCS running on an Ethernet-based host PC.

Determine where the PMCS will be based using the following flowchart:
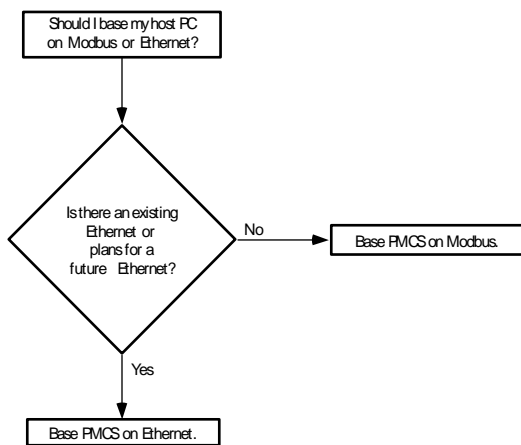
After you determine the appropriate base (Ethernet or Modbus) for the PMCS software, the general network architecture will fall into one of the forms illustrated in Figures 1 through 4. These figures offer samples of various network architecture configurations possible with PMCS.

	Protocols Utilized			
	Ethernet Direct	Modbus via Ethernet	Modbus Direct	Commnet
Figure 1			✓	
Figure 2		✓	✓	
Figure 3			✓	✓
Figure 4		✓	✓	✓
Figure 5	✓	✓	✓	✓

As the above table shows, Modbus RTU is required in all instances, whether it is being used as a stand-alone network, supporting commnet IEDs, or serving as a slave to an Ethernet-based host.

Figure 1 presents the Power Management Control System operating on a Modbus-only network.

Figure 2 shows a Modbus and Ethernet network.

Figure 3 shows a Modbus/commnet network.

Figure 4 shows an Ethernet/Modbus/commnet network, demonstrating the integration of all three protocols.

Figure 5 shows an example of an Ethernet-based host servicing native Ethernet devices, Modbus devices via the Ethernet Gateway, and Commnet devices via the Modbus Concentrator device.

NOTE: Some types of IEDs must be wired on dedicated private serial network segments, one IED per serial Modbus line. Figure 2a illustrates this configuration. The IEDs that require dedicated Modbus segments are the EPM 9650Q, EPM 3720, ML PQM, and EPM 7330.
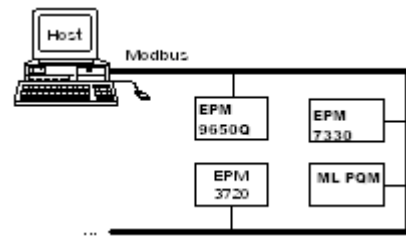
Figure 1. Modbus-only network.
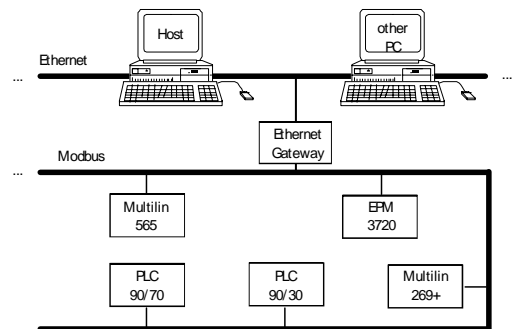
Figure 2. Commercial Ethernet and Modbus network.

Power Management Control System

Chapter 1 – Introduction
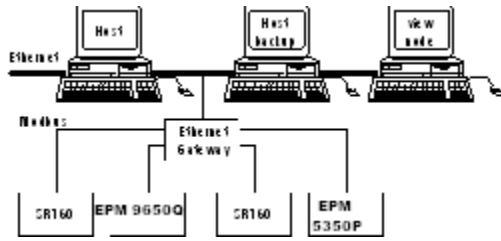
Figure 2a. Substation Ethernet and Modbus network.

Figure 3. Modbus and commnet network.
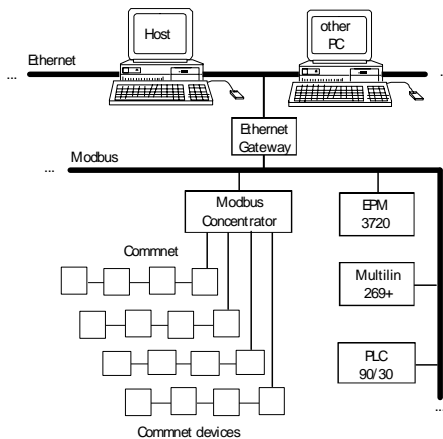
Figure 4. Ethernet, Modbus, and commnet network.

Figure 5. Ethernet-based host services Ethernet, Modbus, and commnet networks.

1–2 Master-Slave Organization

The PMCS in either a Modbus-host or an Ethernet-host configuration is a master-slave network. The host is considered to be the master, with the attached networks of IEDs serving as its slaves.

This relationship means that the communications are always initiated at the host; an IED will not speak without being asked to. The master requests information, the slave replies.

The PMCS DDE Server receives a request from a client application for some data, perhaps a relay waveform capture. The Server routes the request to the correct IED, the IED replies to the Server, and the Server passes the information back to the client that originally requested it.

For further details, refer to the PMCS Network and Device Configurator DDE Server User's Guide, GEH-6510.

1–3 Required Hardware

Several pieces of hardware are required to build a network based on PMCS. They are the host computer and the network interface card, each of which is described below. Once the host computer is operating and its interface card is installed, it is time to attach the power management IEDs to the network. These IEDs are described in Section 1–8.

Host Computer

The heart of the PMCS is software running on a host PC. Regardless of whether the host PC is based on an Ethernet or Modbus network, its functions include the following:

- Communication management
- Primary user interface
- Data collection, storage, and retrieval
- Event reporting with time and date stamp
- Energy calculations and trending
- Network IED status
- Alarming and reporting

The minimum requirements for the host PC are presented in GEH-6514, Read This Book First.

The communications interface is the connection between the host PC and the network of IEDs. Your host will require either an Ethernet communications card, an RS-485 communications card, or an RS-232/RS-485 converter. An Ethernet-based host PC requires an Ethernet network card. A Modbus-based host PC requires an RS-485 interface card or an RS-232/RS-485 converter. These are described below.

RS-485 Interface Card or RS-232/RS-485 Converter

The RS-485 interface card provides the interface between the host PC and the Modbus network and terminates the network at the host computer. This standard RS-485 interface card provides eight RS-485 ports. PMCS supports up to 256 RS-485 communication ports. See Sections 2–1, 2–4, and 2–7 for more details on using multiple RS-485 networks with PMCS.

For more modest needs, a single RS-485 network can be provided by an RS-232/RS-485 converter, a self-contained IED that converts signals between RS-232 and RS-485. This IED plugs into the RS-232 port on the back of the host PC and is less expensive than an RS-485 interface card.

Ethernet Network Card

The Ethernet network card provides the interface between the host PC and the Ethernet network. With the host communicating over Ethernet, another interface is required to communicate with RS-485 networks, where most power management IEDs reside. (Some recent power management IEDs, such as the EPM 7700, have built-in Ethernet capability. Install these devices using standard Ethernet networking procedures.)

This interface between Ethernet and RS-485 is provided by the Ethernet Gateway. See Section 1–4 for more information on Ethernet, and Section 1–1, Figures 2 and 4, for examples of how the Ethernet Gateway is used to integrate RS-485 networks into the Ethernet network.

1–4 Compatibility & Interconnection with Existing Ethernet Networks

PMCS and the Ethernet Gateway require TCP/IP to be installed on the host computer. The drivers for the TCP/IP protocol are included with Windows 2000 SP2, which is required to run PMCS, so any customer running PMCS should have these drivers available.

Consult your LAN personnel or system integrator for information on integrating PMCS with an existing Ethernet-based network.

1–5 Operation During Power Outage

PMCS will not lose any data in the event of a power outage; however, communications will be interrupted until power is restored.

Should control power to a Modbus Concentrator be lost, PMCS will be unable to communicate with any commnet IEDs downstream from the Concentrator until power is restored. No data will be lost, but communications will be interrupted.

The same is true of the Ethernet Gateway; as the linchpin connecting the host to the network of IEDs, if a Gateway loses control power, the host will be unable to communicate with any IEDs attached to the Gateway until power is restored.

You can avoid this situation by providing uninterruptable power supplies (UPS) to the host computer and by providing secure control power to the IEDs, either with UPS systems or battery backups (different IEDs have different requirements). Refer to individual user guides for information on control-power requirements.

1–6 Time & Date Stamping

PMCS stamps each event with a time and date code for precise reference. The time and date are set by the DDE Server and passed across the network to each IED, so that all IEDs are synchronized.

Additionally, some PMCS IEDs support IRIG time synchronization. If IRIG is used in a PMCS system, it is recommended that the host PC be IRIG time synched as well to maintain synchronization between the IEDs and the PMCS DDE Server.

1–7 Remote System Operation

PMCS also offers the ability to use modems to reach across wide areas to remote facilities or substations. For instance, you could use PMCS at a central location to collect power management data from IEDs in a factory, warehouse, or substation in another state or control the lights, air conditioning, or protective relays in your facility from across the country.

An example of this scenario is shown in Figure 5.
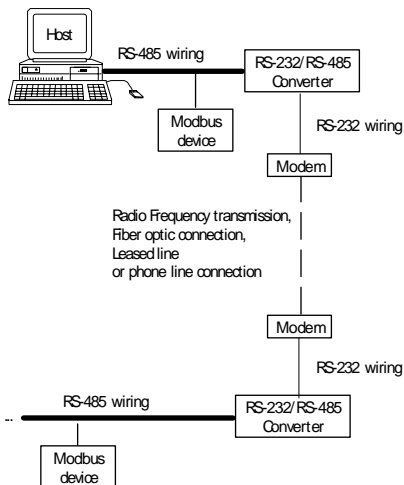
Figure 6. Example of remote operation using modems.

56kbps phone modems, radio frequency (RF) modems, and fiber optic modems (FOM) may be used with PMCS.

While it is possible to use dial-up lines to connect to distant RS-485 networks, the vagaries of the phone system and the excessive long-distance charges preclude using this as a twenty-four-hour-a-day connection. Leased lines dedicated to this purpose provide a viable alternative to a constant long-distance telephone connection.

For further information on using modems for long-range operation of PMCS, contact your GE sales representative.

1–8 Supported IEDs

PMCS supports a wide variety of GE and third-party power management IEDs. These IEDs are listed in Table 1, along with their function, communications protocol, and maximum communications speed for Modbus-based IEDs (Commnet IEDs must communicate through the Modbus Concentrator).

IED Name	Function	Communications Protocol (Modbus Speed)
239 Motor Protection Relay	Protection/Control	Modbus RTU (19.2 Kbaud)
269 Plus Motor Management Relay	Protection/Control	Modbus RTU (2400 baud)
565 Feeder Management Relay	Protection/Control	Modbus RTU (9600 baud)
735 Feeder Relay	Protection/Control	Modbus RTU (19.2 Kbaud)
GE-Zenith Generator PLC (Series 90-70)	Metering/Control	Modbus RTU (19.2 Kbaud)
GE-Zenith MX200 (Microprocessor Controller)	Protection/Control	Modbus RTU (19.2 Kbaud)
GE-Zenith MX250 (Microprocessor Controller)	Protection/Control	Modbus RTU (19.2 Kbaud)
EPM 7330	Metering	Modbus RTU (19.2 Kbaud)
EPM 3710 Meter	Metering	Modbus RTU (19.2 Kbaud)
EPM 3720 Meter	Metering	Modbus RTU (19.2 Kbaud)
EPM 7300 Meter	Metering	Modbus RTU (19.2 Kbaud)
EPM 7700 Meter	Metering/Control	Modbus RTU (19.2 Kbaud) Note: Native Ethernet device.
EPM 5000P Meter	Metering	Modbus RTU (9600 baud)
EPM 5200P Meter	Metering	Modbus RTU (9600 baud)
EPM 5300P Meter	Metering	Modbus RTU (9600 baud)
EPM 5350P Meter	Metering	Modbus TCP (Ethernet 10BaseT, RJ-45)
EPM 9450Q Meter	Metering/Control	Modbus RTU (38.4 Kbaud) Modbus TCP (Ethernet 10BaseT, RJ-45)
EPM 9650Q Meter	Metering/Control	Modbus RTU (38.4 Kbaud) Modbus TCP (Ethernet 10BaseT, RJ-45)
GE Fanuc PLC 90/30	Protection/Control	Modbus RTU (19.2 Kbaud)
GE Fanuc PLC 90/70	Protection/Control	Modbus RTU (19.2 Kbaud)
GE Fanuc PLC Micro 90	Protection/Control	Modbus RTU (19.2 Kbaud)
Universal Relay	Protection/Control	Modbus RTU (19.2 Kbaud)
MicroVersaTrip-C and -D Trip Units	Metering/Protection	commnet (requires Modbus Concentrator)
Modbus Concentrator	Communications	Modbus RTU (19.2 Kbaud)
POWER LEADER Electronic Power Meter	Metering	Modbus (19.2 Kbaud) or commnet (commnet requires Modbus Concentrator)
POWER LEADER Junction Box	Communications	commnet (requires Modbus Concentrator)
POWER LEADER Repeater	Communication	commnet (requires Modbus Concentrator)
Power Quality Meter (PQM)	Metering	Modbus RTU (19.2 Kbaud on 1 or 2 ports)

IED Name	Function	Communications Protocol (Modbus Speed)
EPM8000 - Power Quality Meter (PQMII)	Metering	Modbus RTU (19.2 Kbaud on 1 or 2 ports)
RS-485 Repeater	Communications	Modbus RTU (19.2 Kbaud)
369 Motor Management Relay	Metering/Control	Modbus RTU (19.2 Kbaud)
EPM 7500 Electronic Power Meter	Protection/Control	Modbus RTU (19.2 Kbaud)
EPM 7600 Electronic Power Meter	Protection/Control	Modbus RTU (19.2 Kbaud)
Motor Manager II (MMII)	Protection/Control	Modbus RTU (19.2 Kbaud)
EPM7430D/EPM7450D (Futura)	Protection/Control	Modbus RTU (9600 baud)
Spectra Electronic Control Module	Protection	commnet (requires Modbus Concentrator)
Spectra MVT for GEK Frame MCCB	Metering/Protection	commnet (requires Modbus Concentrator)
SR469 Motor Management Relay	Protection/Control	Modbus RTU (19.2 Kbaud on 1 or 2 ports)
SR489 Generator Management Relay	Protection/Control	Modbus RTU (19.2 Kbaud on 1 or 2 ports)
SR745 Transformer Management Relay	Protection/Control	Modbus RTU (19.2 Kbaud on 1 or 2 ports)
SR750 Feeder Management Relay	Protection/Control	Modbus RTU (19.2 Kbaud on 1 or 2 ports)
SR760 Feeder Management Relay	Protection/Control	Modbus RTU (19.2 Kbaud on 1 or 2 ports)
POWER LEADER MDP Overcurrent Relay	Protection	Modbus (19.2 Kbaud) or commnet (commnet requires Modbus Concentrator)
POWER LEADER Modbus Monitor	Monitoring	Modbus RTU (19.2 Kbaud on 1 or 2 ports)
POWER LEADER Meter	Metering	commnet (requires Modbus Concentrator)

Table 1. IEDs supported by PMCS.[2]

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2 The POWER LEADER Ethernet Gateway is not listed in Table 1. The Ethernet Gateway is an alternate host for the RS-485 networks used when the PMCS resides on the Ethernet level.

Chapter 2 – Network Design

This section describes how to design a Power Management Control System network on paper so that actual construction and configuration of the network will proceed smoothly.

You need two things for this exercise: a complete list of the IEDs to be networked and a diagram or map of where the IEDs will be located, preferably with realistic distances noted so that wiring runs may be kept within the appropriate limits.

Using the list of IEDs to be networked, refer to Table 1 and note which communications protocols are required (commnet or Modbus). For Modbus IEDs, note the communications speed at which each IED operates. For IEDs supporting both protocols, you will need to decide which protocol will be used. Generally, it is preferable to use Modbus rather than commnet unless the Modbus network is at or near capacity for physical IEDs.

When the list of IEDs and the floor plan are in hand, proceed to Section 2–1 for network design rules.

Power Management Control System
Chapter 2 – Network Design

2–1 Modbus Rules

The most basic network configuration for PMCS assumes that the software is running on a host PC supporting one or more RS-485 networks on the Modbus protocol. (See Figure 1 for an example of this configuration.)

Table 2 explains the configuration rules for PMCS networks based on the Modbus platform. Commnet IEDs may be integrated through the Modbus Concentrator (see Table 4 for commnet wiring rules).

Host PC is based on:	Follow these rules for the host…	And these rules for the attached Modbus network(s)…
Modbus	1. The host PC can support up to 256 independent Modbus networks. The actual number is determined by the communication cards installed in the host PC (see below). 2. The Modbus networks are connected to the host PC via an eight-port RS-485 communications card.[3] An option for more limited systems is an RS-232/RS-485 converter, which permits a single RS-485 network.[4] 3. The host PC must be located at one end of the Modbus network(s).	1. Each Modbus network supports up to 31 physical Modbus IEDs and up to 247 Modbus addresses. This is possible because commnet IEDs attached to Modbus Concentrators occupy Modbus addresses but do not create an electrical drain on the RS-485 network and thus are not counted as physical Modbus IEDs. 2. Each Modbus network must be properly terminated at each end of the network. See Section 2–4. 3. Maximum cable length of each Modbus network is 4000 feet. (See notes on using repeaters to increase this range, Section 2–4. Also, see the note regarding substation installation in Chapter 3.) 4. All Modbus IEDs attached to a single RS-485 network must communicate at the same baud rate. (See Table 1 for Modbus IEDs' communication speeds.) 5. RS-485 cable shields must be properly grounded. For maximum protection against surge and EMI damage, each IED on the network should have an isolated ground connection. See Section 2–4, Modbus rule 4, for an example of proper RS-485 wiring and grounding. Also, see the note regarding substation installation in Chapter 3.

Table 2. Host PC configuration rules.

---

[3] The following RS-485 interface card is recommended for providing the RS-485 connection at the host PC. If any other serial card is used, PMCS requires that the communications driver be compatible with the MS Windows serial communications protocol. Please refer to Section 3–1 for information on the special termination requirements of the RS-485 card.

Manufacturer	Description	Quantity/8 ports	Part, Order Number
Connect Tech, Inc.	Intellicon-Flex8 RS-485 card	1	I4808064XXNC
	Intellicon/DFLEX SLIM	4	SIMMS
	8 Port, DB9 I/O Box	1	IOB08DB9

[4] The following RS-232/RS-485 converter is recommended for providing a single RS-485 connection at the host PC.

Manufacturer	Description	Part, Order Number
Multilin	RS-485/RS-232 Converter	F485120

When using the above RS-232/RS-485 converter, remember that the converter has DIP switches inside that determine its baud rate. Switch group 3 should be set according to the baud rate at which the converter is to be used. Refer to the converter's documentation for further information.

2–2 Ethernet Configuration Rules

It is also possible to run the PMCS on a host PC operating on an Ethernet network. If PMCS is running on an Ethernet-based PC, an Ethernet Gateway is required to communicate with the attached Modbus network(s). (See Figure 2 for an example of this configuration.)

Recently, IEDs with built-in Ethernet support have begun to become available; PMCS is also capable of supporting these devices. Examples of such devices are the EPM 7700 meter and EPM 9450Q / 9650Q meters. These devices reside on the Ethernet network at the same level as the Ethernet Gateway.

Table 3 explains the configuration rules for PMCS networks based on the Ethernet platform. Commnet IEDs may be integrated through the Modbus Concentrator. (See Table 4 for commnet wiring rules.)

EPM 7700 devices require a separate network configuration beyond connecting the devices to the Ethernet LAN. Please refer to the following PMCS technical documentation for complete network configuration rules and guidelines:

GEH-6514, *PMCS Read-This-Book-First*. Refer to the section titled "Configuring the EPM 7700 Device Network."

DEH-40035, *GE 7700 Gateway User's Guide*. Refer to the section titled "EPM 7700 Network Configuration."

EPM9450Q and EPM9650Q devices require separate network configuration beyond connecting the devices to the Ethernet LAN. Refer to the instruction manuals of these devices and to the sections titled "Internal Network Option." Also refer to DEH-6510, *DDE Server User's Guide*. Refer to the sections describing the use and configuration of the Modbus TCP Server.

Host PC is based on:	Follow these rules for the host…	And these rules for the Modbus networks attached to the Ethernet Gateways…
Ethernet	1. Ethernet Gateway(s) must be used to communicate with non-Ethernet IEDs. Ethernet-capable IEDs may be installed directly on the Ethernet network at the same level as the Ethernet Gateway(s). 2. The host PC supports up to 64 Ethernet Gateways. 3. Each Ethernet Gateway supports up to four independent Modbus networks. The EPM 9450Q /9650Q devices will support one Modbus network. 4. The actual number of IEDs supported by the host varies from system to system, depending on the variety of IEDs used and the number of PMCS data tags required by the IEDs. See GEH-6509, PMCS DDE Interface Guide, for details. 5. Ethernet networks should conform to the design guidelines described in Section 2-3.	1. Each Modbus network supports up to 31 physical Modbus IEDs and up to 247 Modbus addresses. This is possible because commnet IEDs attached to Modbus Concentrators occupy Modbus addresses but are not seen as physical Modbus IEDs. 2. Each Modbus network must be properly terminated at each end of the network. See Section 2–4. 3. The Ethernet Gateway must be located at one end of the Modbus network(s). 4. Maximum cable length of each Modbus network is 4000 feet. (See notes on using repeaters to increase this range, Section 2–4. Also, see the note regarding substation installation in Chapter 3.) 5. All Modbus IEDs attached to a single RS-485 network must communicate at the same baud rate. (See Table 1 for Modbus IEDs' communication speeds.) 6. RS-485 cable shields must be properly grounded. For maximum protection against surge and EMI damage, each IED on the network should have an isolated ground connection. See Section 2–4, Modbus rule 4, for an example of proper RS-485 wiring and grounding. Also, see the note regarding substation installation in Chapter 3.

Table 3. Ethernet configuration rules2–3 Ethernet Network Considerations

This section describes some of the specifications, which must be considered when designing an Ethernet network to be used with PMCS.

Note: These specifications are guidelines only and should not be used for actual network design. Consult with a qualified LAN engineer for design requirements that meet your specific installation. The complete specifications are listed in IEEE 802.3 Ethernet. In addition, the National Electrical Code (NEC) and all applicable local codes must be followed for installing wiring.

Ethernet supports four physical media: 10Base-2 (thinnet), 10Base-5 (thicknet), 10Base-T (twisted pair), and 10Base-FL (fiber). 10Base-T is most common.

NOTE for EPM 7700 and 9450Q and 9650Q: The EPM 7700 with Xpress card directly uses either of two types of Ethernet physical media that must be specified when ordering the meter, 10Base-T, or 10Base-FL. EPM 9450Q and EPM 9650Q must be ordered with 10 Base-T Ethernet Option. The meters operate in a 10 Mbps system.

10Base-T is specified when twisted pair is used and 10Base-FL is specified where fiber optic cable is used. While media converters are available to allow the use of both twisted pair and fiber optic cable in the same LAN, and can be used to extend the length of the LAN, they are beyond the scope of this discussion.

CAUTION: The recommended installation practice is to implement optical fiber for connections between buildings to provide electrical isolation. This eliminates harmful ground loops caused by differences in the ground potential between structures.

CAUTION: Data line surge protection is recommended for network components such as hubs, computers, or modems connected to IEDs with copper wire, especially installations where the data communication cable is exposed (i.e., not encased in conduit) or runs parallel to power conductors. PMCS IEDs are routinely installed in areas exposed to heavy electromagnetic fields (EMF), which can induce damaging surges in data communication lines. Data line surge protection is not required for fiber optic connections.

10Base-T specifications and rules

10Base-T Ethernet uses CAT 3, 4 or 5 twisted pair cable, depending on the installation.

Maximum/Minimum length of segments

For a 10Base-T LAN, the maximum length of a segment is 100 meters (328 ft). The minimum length of any cable is 2.5 Meters or about 8 ft. This minimum length is of particular concern when a device is located in close proximity to the hub.

Maximum number of segments

A 10Base-T LAN can consist of up to 5 segments using 4 repeaters. However, only three of these segments can have devices connected.

Maximum number of devices

A 10Base-T LAN can have a maximum of 1024 devices connected.

Use of repeaters, routers, bridges, gateways, etc.

Repeaters may be used to connect LAN segments and do not determine the boundaries of the LAN. They are used to extend the LAN beyond a single segment. Routers, bridges and gateways may be used to connect the LAN to other LANs or to a WAN.

10Base-FL specifications and rules

Maximum/Minimum length of segments

For a 10Base-FL LAN, the maximum length of a segment is 2000 meters (6500 ft). The minimum length of any cable is 2.5 Meters or about 8 ft. This minimum length is of particular concern when a device is located in close proximity to the hub.

Maximum number of segments

A 10Base-FL LAN can consist of up to 5 segments using 4 repeaters. However, only three of these segments can have devices connected.

Maximum number of devices

A 10Base-FL LAN can have a maximum of 1024 devices connected.

Use of repeaters, routers, bridges, gateways, etc.

Repeaters may be used to connect segments and do not determine the boundaries of the LAN. They are used to extend the LAN beyond a single segment. Routers, bridges and gateways may be used to connect the LAN to other LANs or to a WAN.

2–4 Commnet Configuration Rules

POWER LEADER commnet IEDs may be integrated into a PMCS network through a special Modbus IED called the Modbus Concentrator. The rules outlined in Table 4 apply to using commnet IEDs with PMCS, regardless of whether the host PC is operating on an Ethernet or Modbus network. (See Figures 3 and 4 for examples of commnet IEDs operating on PMCS.)

Rules regarding:	Commnet IED configuration rules:	Reference Figure:
Modbus Concentrator limitations	1. Each Modbus Concentrator supports up to eight commnet segments.	Figure 15
	2. Each commnet segment supports up to four commnet IEDs.	Figure 15
	3. Only one waveform-capturing meter (POWER LEADER Meter) is allowed per commnet segment.	No figure provided
	4. POWER LEADER Repeaters and Junction/Outlet Boxes do not count toward the four-IED-per-segment limit.	Figure 19 and Figure 20
	5. No connections between commnet segments are permitted. Each segment must be wired independently (having no contact with other commnet segments) and connected to the Concentrator at one point only (no loops permitted).	Figure 28 – Figure 32
Commnet wiring limitations	1. Maximum cable length of a commnet segment is 1000 feet. Maximum range between commnet IEDs on a segment is 1000 feet (except for repeaters; see below).	Figure 16
	2. In no case may a commnet IED be wired more than 1000 feet from the Modbus Concentrator or a POWER LEADER Repeater.	Figure 16
	3. POWER LEADER Repeaters may be used to extend the range of commnet segments. A repeater regenerates the commnet signal to its original strength, allowing it to travel up to another 1000 feet.	Figure 17
	4. Long-distance segments may be created by placing multiple repeaters adjacent to one another in a commnet segment. A repeater communicating directly with another repeater may span up to 6000 feet.	Figure 18
	5. Maximum allowable cable length of a single commnet segment is 12,000 feet, which may be constructed with any allowable combination of repeaters and IEDs.	No figure provided
	6. For ease and economy of wiring, the POWER LEADER Junction/Outlet box may be used to create nodes of commnet IEDs with a common wiring point to be connected to the Modbus concentrator. The POWER LEADER Junction/Outlet Box allows the interconnection of as many as four shielded, twisted-pair cables to create this common wiring point. For instance, rather than a daisy-chain of wiring in a lineup from one meter or trip unit to the next, up to four IEDs may be wired to the POWER LEADER Junction/Outlet Box, which is then connected to the Modbus Concentrator.	Figure 19 and Figure 20

Table 4. Commnet IED configuration rules.

2–5 Modbus Wiring Rules – Diagrams

The Modbus network protocol has wiring rules and limits on the number of IEDs that may be attached.

This section describes in greater detail the rules you must follow when designing a Modbus network.

⚡ WARNING: Network wiring and grounding rules described herein apply primarily to commercial/industrial installations. Substation installations will exist in the presence of dangerously elevated ground potential relative to points outside of the station grid as well as large electromagnetic induction fields. Additionally, large ground faults can elevate substation ground potentials. Follow local utility best-practices/safety procedures to prevent **risk of shock/electrocution to personnel** and damage to equipment that could result in a loss of protection and communications.

⚠ NOTE: It is important to take future expandability into consideration when designing a network configuration. This is particularly so when the network is near its maximum number of IEDs or maximum cable length. Adding IEDs to a network after it has been installed may require rewiring the network.

✋ CAUTION: Wire-run distances mentioned in the configuration rules assume application above grade or in conduit. For below-grade applications, refer to Section 3–1, Wiring Requirements.

Regardless of which platform is supporting the RS-485 networks (Ethernet Gateway, RS-485 card, or RS-232/RS-485 converter), the following rules apply to each individual RS-485 network.

1. Each RS-485 network may support up to 31 Modbus IEDs. Figure 7 illustrates this rule. (See the exception below Figure 6.)
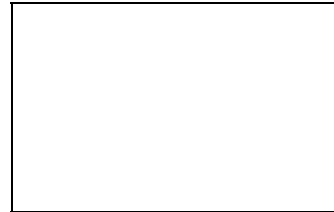
Figure 7. Network illustrating Modbus Rules 1 and 2.

Exception to Rule 1: Some types of IEDs must be wired on dedicated private serial network segments, one IED per serial Modbus line.

2. The host (or Ethernet Gateway) must always be located at one end of any Modbus segment. It may not be located in the center of a Modbus network. Figure 7 shows the correct placement of the host (PC or Ethernet Gateway).

3. All Modbus IEDs on a single RS-485 network must communicate at the same baud rate. If IEDs with different communication speeds are connected to the same RS-485 network, the whole segment will communicate at the speed of the slowest IED. Figure 8 illustrates this rule. (Communication speeds for supported IEDs are listed in Table 1.)
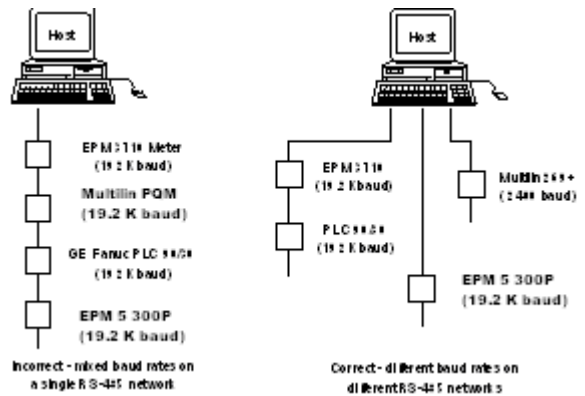
Figure 8. Network illustrating Modbus Rule 3.

4. Each RS-485 network must be properly terminated at both ends of the cable run after the final IED. (See Section 3–1 for details on termination.) Figure 9 illustrates this rule.

5. Each RS-485 network must have its shield properly grounded. Figure 9 illustrates proper RS-485 wiring and grounding.

CAUTION: Improper grounding may create a ground-loop condition and cause communications failures. Make sure you follow the wiring diagram carefully.

To ensure proper grounding, follow this procedure. Begin by grounding the RS-485 cable shield at the host. Follow the cable to the first IED on the network. Do NOT connect the cable ground to the IED. Pick up the RS-485 output cable from the IED and attach its ground to the IED's shield connection or grounding screw. For IEDs with no grounding connectors, connect to earth ground.

Follow the cable to the next IED, and repeat the above procedure. Do not connect the RS-485 shield from the previous IED, but DO connect the RS-485 OUT shield on its way to the next IED.

EXCEPTION: The Multilin 565 Feeder Management Relay does not have isolated communications ports. Do NOT connect the shield at this IED. Instead connect the shield of the incoming RS-485 cable to the shield of the outgoing RS-485 cable, skipping the Multilin 565.

Rules of thumb: RS-485 cable ground should always be connected at the previous IED, never upon arrival at an IED. All RS-485 IEDs must have either two communications cables attached or one communications cable and a terminating resistor.
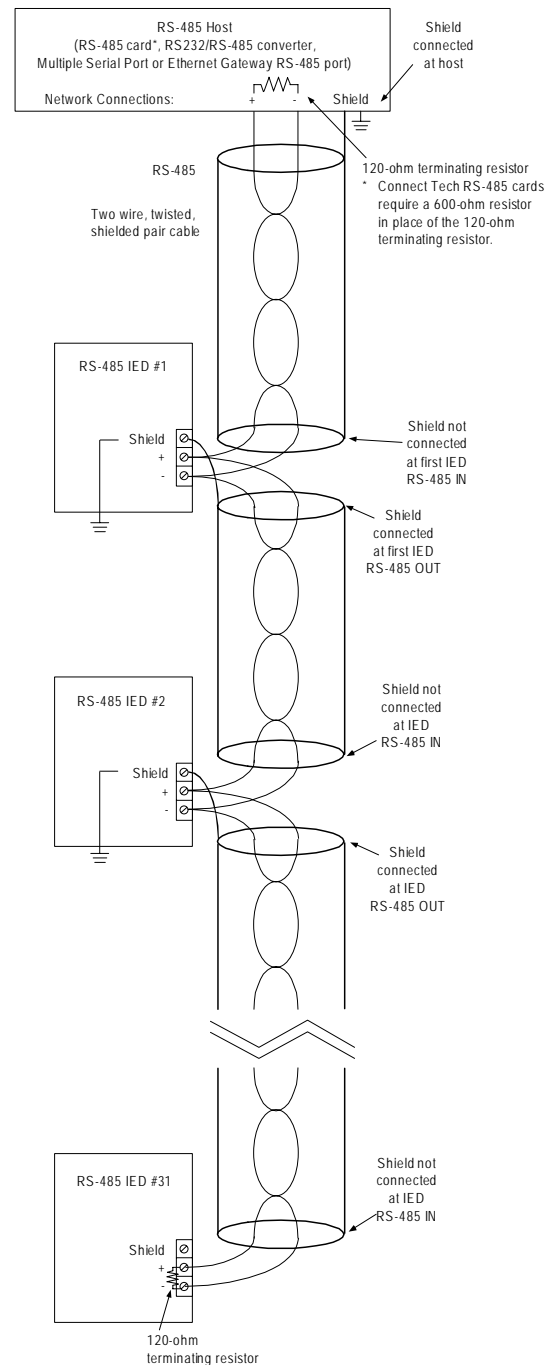
Figure 9. Network illustrating Modbus Rules 4 and 5.

6. A single RS-485 network may have up to 215 commnet IEDs attached to it via POWER LEADER Modbus Concentrators. Figure 10 illustrates this rule.
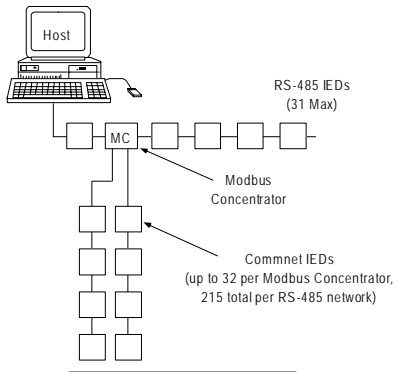
Figure 10. Network illustrating Modbus Rule 6.

7. A single RS-485 network may have no more than 4000 feet of cable (total cable length, not distance between IEDs). Figure 11 illustrates this rule.
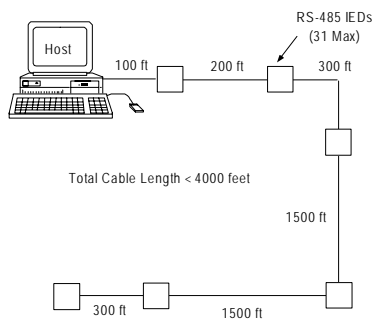
Figure 11. Network illustrating Modbus Rule 7.

8. RS-485 repeaters may be used to extend the range beyond 4000 feet. A single RS-485 repeater may be used to provide a 4000-foot extension, and each additional repeater in a sequence extends the range by another 4000 feet. Figure 12 illustrates this rule.
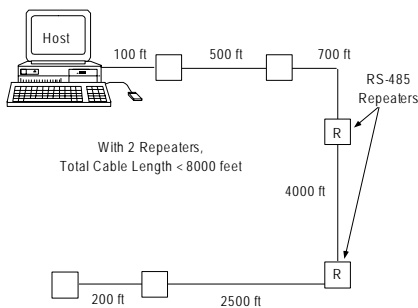
Figure 12. Network illustrating Modbus Rule 8.

9. There may be no more than two RS-485 repeaters between any two RS-485 IEDs. Figure 13 illustrates this rule.
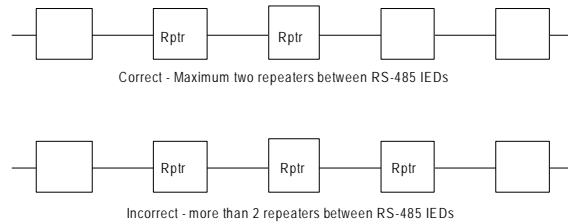
Figure 13. Network illustrating Modbus Rule 9.

NOTE ON DUAL-PORT RS-485 IEDS:

Several of the Multilin power management IEDs offer two RS-485 ports on the same IED. Do not connect both RS-485 ports to a PMCS network. The same data are available from both RS-485 ports and will cause conflicts if the PMCS attempts to access both ports simultaneously.

However, the Modbus Monitor's wiring scheme is slightly different from the Multilin scheme. The dual-port version of the POWER LEADER Modbus Monitor MUST be connected to two separate RS-485 networks. See Rule 10 for details.

10. Modbus Monitors (dual-port version) may not be wired in any configuration other than the four shown in Figure 14. Although the Monitor's RS-485 ports have separate addresses, you may NOT wire the same Modbus network to both ports. A two-port Modbus Monitor must be wired to two separate Modbus networks.

NOTE: For more information on wiring the POWER LEADER Modbus Monitor, refer to DEH-027, Modbus Monitor User's Guide.

Example A

Modbus
Segment A

Monitor
#1

Example B

Modbus   Modbus
Segment A   Segment B

Monitor
#1

Example C

Modbus
Segment A

Monitor
#1

Monitor
#2

Example D

Modbus   Modbus
Segment A   Segment B
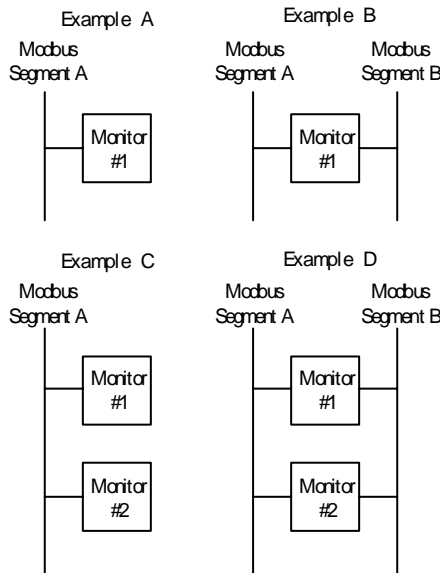
Monitor
#1

Monitor
#2

Figure 14. Valid Modbus Monitor network architectures.

CAUTION: Any other wiring of the Modbus Monitor may result in incorrect operation and errors.

CAUTION DUAL PORT MONITOR USERS: Do not connect the Monitor's two RS-485 ports to the same Modbus segment. This will cause communication errors and possibly damage the Monitor.

Example A shows a single Modbus Monitor wired to one Modbus segment. Example B shows the same monitor in a dual-port version, wired to two different Modbus segments.

Examples C and D illustrate fully loaded Modbus segments. No more than two Monitors are permitted on any Modbus segment.

Example C illustrates a pair of Monitors connected to a single Modbus segment. In this example, the Monitors may be either single port or dual-port versions, provided both are the same version (see note below). Example D shows the same pair of Monitors wired to a second Modbus segment.

CAUTION: With regard to Example C (two Monitors on a single RS-485 segment), it is not permissible to mix different models of Monitors on a segment. Monitors #1 and #2 must be of the same model, either both single-port or both dual-

port.

The nature of the other network architectures makes this concern irrelevant for examples A, B, and D, since in Example A you could have either a single- or a dual-port Monitor, while in Examples B and D you may only use a dual-port monitor(s).

2–6 Commnet Wiring Rules – Diagrams

POWER LEADER commnet IEDs may be integrated into PMCS through the use of the POWER LEADER Modbus Concentrator, which collects data from commnet IEDs and communicates that data across the RS-485 network. Each Modbus Concentrator supports up to eight commnet segments. Each commnet segment may accommodate up to four commnet IEDs. The following are the basic rules to ensure proper network operation for POWER LEADER commnet IEDs. Note that these rules apply only to individual commnet segments of a POWER LEADER Modbus Concentrator, not to the RS-485 network.

1. Each Modbus Concentrator supports up to eight commnet segments. Each commnet segment may support up to four commnet IEDs, only one of which may be a waveform-capturing meter. POWER LEADER Repeaters and Junction/Outlet Boxes are not counted as commnet IEDs. Figure 15 illustrates this rule.
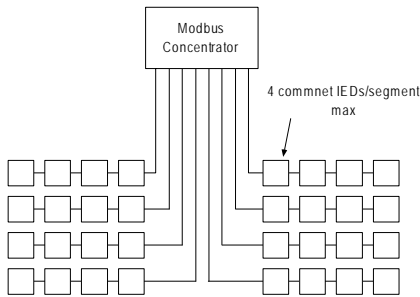
Figure 15. Network illustrating commnet Rule 1.

2. A commnet segment may have no more than 1000 feet of cable between the Modbus Concentrator and the final IED on a segment. (Repeaters may be used to extend this range; see Rule 3.) Figure 16 illustrates this rule.
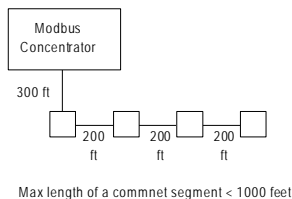
Figure 16. Network illustrating commnet Rule 2.

3. The maximum communication range of commnet IEDs (including the Modbus Concentrator's commnet ports) is 1000 feet, after which its signal degrades and the danger of errors rises to an unacceptable level. The Repeater regenerates a signal to its original strength, allowing it to travel up to another 1000 feet. Thus, each Repeater can add up to 1000 feet of range to the commnet segment.

For example, a segment containing a single Repeater may have no more than 2000 feet of total cable length. No more than 1000 feet of cable are permitted between the Modbus Concentrator and the first Repeater or between the Repeater and the last IED on the segment. Figure 17 illustrates this rule.

CAUTION: In no case may there be more than 1000 feet of cable between any two commnet IEDs other than Repeaters. At ranges over 1000 feet, commnet signals become degraded and communication errors may result.
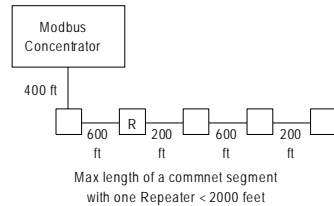
Figure 17. Network illustrating commnet Rule 3.

4. Long-distance cable runs may be built by placing two Repeaters adjacent to one another in the segment. A pair of adjacent Repeaters has a range of up to 6000 feet of cable. Figure 18 illustrates this rule.
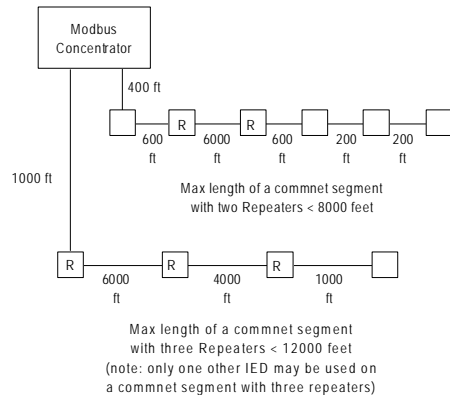
Figure 18. Network illustrating commnet Rule 4.

5. The maximum allowable cable length of a single commnet segment is 12,000 feet. This may be achieved with any allowable combination of Repeaters and IEDs.

6. For ease of wiring, the POWER LEADER Junction/Outlet Box may be used to create nodes of commnet IEDs with a common wiring point to be connected to the Modbus concentrator. The POWER LEADER Junction/Outlet Box allows the interconnection of as many as four shielded, twisted-pair cables to create this common wiring point. This can be of great help in economizing on wiring and offering greater flexibility in network design. For instance, rather than a daisy-chain of the wiring in a lineup from one meter or trip unit to the next, up to four IEDs may be wired to the POWER LEADER Junction Box, which is then connected to the Modbus Concentrator.

CAUTION: The four-IED-per-segment limit must be observed at all times. Although the POWER LEADER Junction Box has terminals to accept up to 12 commnet lines, do NOT connect more than four commnet IEDs to a single Junction Box or Modbus Concentrator commnet segment.

Examples of the use of a POWER LEADER Junction Box with the Modbus Concentrator are provided in Figure 19 and Figure 20. Junction Boxes are not counted as IEDs for purposes of the four IED per commnet segment limit. Figure 19 is an example of a Junction Box used to create a node connecting four commnet IEDs to a Modbus Concentrator. Figure 20 is an example of a Junction Box with Repeaters, observing the four IED per segment limit (the two Repeaters and the Junction Box do not count as IEDs).
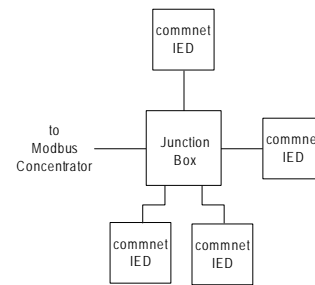
Figure 19. Network illustrating commnet Rule 6.
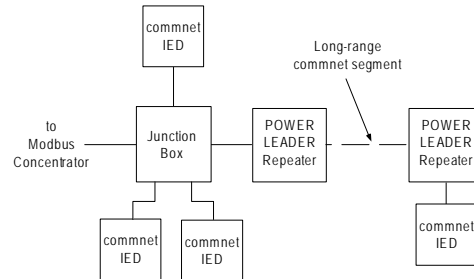
Figure 20. Network illustrating commnet Rule 6.

2–7 Performance Recommendations

Although a PMCS network will function as long as all the rules in the previous section are followed, you can enhance performance by considering the following recommendations for Modbus, commnet.

The Ideal Network

Theoretically, a single Modbus IED or 40 commnet IEDs distributed across five Modbus Concentrators (one IED per commnet segment) yields maximum performance.

Naturally, in the real world few networks will fall into this precise configuration. To extract maximum performance from the PMCS, follow the performance recommendations below.

Modbus performance recommendations

1. **Use multiple RS-485 networks if possible**, depending on the RS-485 connection at the host. If using an eight-port RS-485 card or an Ethernet Gateway (four ports) for connection to the network, you can improve performance by using the full number of ports available, rather than burdening a single RS-485 port. Distributing the IEDs across all available RS-485 ports permits the communications load to be distributed rather than asking a single network to carry the full load.

2. **Divide the IED loads evenly** when distributing IEDs across multiple RS-485 networks.

3. **Pay careful attention to Modbus Rule 2**, regarding the communication speeds of IEDs on a given network. Although a network will function with mixed IEDs, its communication speed will be dragged down to the lowest common denominator. Thus, a single 2400-baud IED forces the entire network to communicate at 2400 baud, regardless of the presence of any 19.2-kbaud IEDs.

Commnet performance recommendations

1. **Modbus is preferred over commnet** where either protocol is available. This is the case for the POWER LEADER Electronic Power Meter and the POWER LEADER MDP Overcurrent Relay. Each of these IEDs offers a Modbus communications option.

2. **Minimize the number of commnet IEDs per segment**. The Modbus Concentrator is a polling IED, meaning that it queries each commnet segment continuously and in order asking for information. It then stores the information until it is asked by the PMCS to transmit its data to the host. If the number of commnet IEDs is unevenly distributed, the Concentrator takes longer than necessary to poll each segment.

3. **Keep data-intensity in** mind when connecting more than eight commnet IEDs to a single Modbus Concentrator. If it is necessary to connect more than eight commnet IEDs to a single Modbus Concentrator, one or more segments will be supporting multiple IEDs. Keep the following list in mind when selecting which IEDs to double up on the same commnet segment. The best choices for doubling up are listed first.

    1. Spectra MicroVersaTrip trip unit
    2. Enhanced MicroVersaTrip-C and -D trip units
    3. POWER LEADER MDP Overcurrent Relay
    4. Spectra Electronic Control Module
    5. POWER LEADER Electronic Power Meter
    6. POWER LEADER Meter

IEDs at the top of the list are less data-intensive and easier for the Concentrator to poll. IEDs at the bottom of the list are very data-intensive and, if possible, should be given their own commnet segment. In other words, if you must put multiple IEDs on a segment, it is preferable to put low-demand IEDs together on a segment and try to keep high-demand IEDs on their own segments. Try to distribute the high-demand IEDs across the available segments, keeping the number of high-demand IEDs per segment evenly distributed.

2–8 Addressing the IEDs

Each IED attached to a PMCS network must have a unique address. Prior to installing any wiring, you should plan the addresses for the IEDs to avoid any conflicts. Keep in mind these important points when assigning network addresses.

- Keep a table of IED names and addresses to avoid conflicts and to help with host configuration. Table 5 summarizes Modbus addressing considerations, based on the following rules.
  - Modbus Concentrator addresses must be in the range of 1 to 32.
  - Modbus-native IEDs other than the Concentrator may occupy any address from 1 to 247.
  - Commnet IEDs must have Modbus-equivalent addresses in the range of 33 to 247.

- The host PC does not require an address due to the master-slave organization of the PMCS.

⚠ NOTE: Per the EIA485 standard, each RS-485 network supports up to 32 "drops" or electrical drains on the network. However, the Ethernet Gateway or RS-485 interface card counts as one drop. Thus, only 31 other IEDs may be attached to each RS-485 network, even though 32 Modbus addresses are available for use. Also, unlike commnet's POWER LEADER Repeaters, RS-485 repeaters are counted as IEDs because although they have no Modbus address, they do act as a drop on the network.

Modbus Address	Appropriate Usage/Supported IEDs
0	• Broadcast (not available to user)
1 – 32	• Modbus Concentrators must have addresses in this range • Other Modbus native IEDs may also have addresses in this range
33 – 247	• Modbus native IEDs may have addresses in this range • Commnet IEDs must have addresses in this range

Table 5. Modbus address range appropriate usage.

- Commnet IEDs are preprogrammed with a factory-set address. You must change this address immediately upon installation of the IED. Refer to the IED's user manual for instructions on assigning an address.
- Because the commnet network accepts a different range of addresses than the Modbus network, commnet addresses must be mapped to corresponding Modbus addresses. The formula for this mapping is: desired Modbus address + 267 = commnet address to set at IED. For example, to set a commnet IED to Modbus address 33, the commnet address set at the IED must be 300. Table 6 illustrates address mapping.

For Modbus Address:	Set commnet IED Address to:
33	300
34	301
35	302
...	...
246	513
247	514

Table 6. Modbus-to-commnet address mapping.

- You may want to block commnet address assignments by lineup and/or Modbus Concentrator segment. For example, start with 40 for the first lineup attached to one Modbus Concentrator, 50 for the second lineup attached, and so on. Addresses must be in the range 33 to 247. The example presented in Figure 18 demonstrates this.
- Increment the individual IEDs in each lineup by one. For example, if the first IED in a lineup is Modbus address 101, the second IED should be 102, the third IED should be 103, etc.
- Addresses may be entered or changed at any time that control power is present.

Figure 21 illustrates a sample network with IED addresses; Table 7 provides details of the IEDs shown in Figure 21.
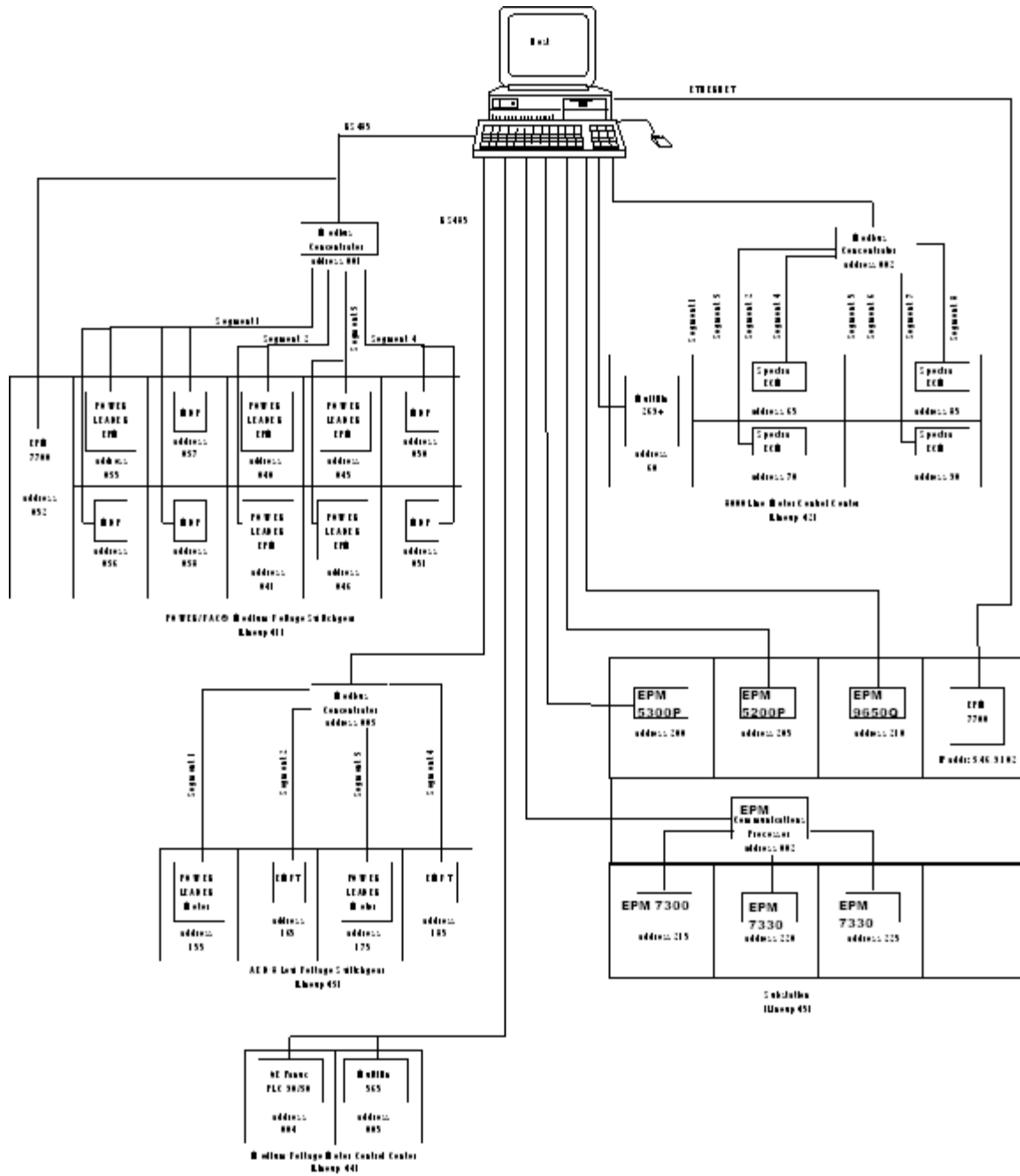
Figure 21. Sample network with IED addresses.

Equipment	Attached IEDs	Modbus Address	Commnet Address

Lineup 1
  POWER/VAC Medium-Voltage
  Switchgear
	Modbus Concentrator 1	001	—

	Segment 1		
	POWER LEADER Electronic Power Meter	035	302
	MDP Overcurrent Relay with commnet	036	303
	MDP Overcurrent Relay with commnet	037	304
	MDP Overcurrent Relay with commnet	038	305
	Segment 2		
	POWER LEADER Electronic Power Meter	040	307
	POWER LEADER Electronic Power Meter	041	308
	Segment 3		
	POWER LEADER Electronic Power Meter	045	312
	POWER LEADER Electronic Power Meter	046	313
	Segment 4		
	MDP Overcurrent Relay with commnet	050	317
	MDP Overcurrent Relay with commnet	051	318
	EPM 7700 Electronic Power Meter	052	—
Lineup 2 8000-Line Motor Control Center	Multilin 269 Plus Motor Relay	060	—
	Modbus Concentrator 2	002	—
	Segment 1 - Spectra Electronic Control Module	065	332
	Segment 2 - Spectra Electronic Control Module	070	337
	Segment 3 - Spectra Electronic Control Module	085	352
	Segment 4 - Spectra Electronic Control Module	090	357
	EPM 7700 Electronic Power Meter using IP address = 3.46.9.102	n/a	n/a
Lineup 3 AKD-8 Low-Voltage Switchgear	Modbus Concentrator 3	003	—
	Segment 1 - POWER LEADER Meter	155	422
	Segment 2 - Enhanced MicroVersaTrip trip unit	160	427
	Segment 3 - POWER LEADER Meter	165	432
	Segment 4 - Enhanced MicroVersaTrip trip unit	170	437
		175	442
		180	447
		185	452
Lineup 4 Medium-Voltage Motor Control Center	GE Fanuc Programmable Logic Controller 90/30	004	—
	Multilin 565 Feeder Management Relay	005	—
Lineup 5 Substation	EPM 5300P	200	—
	EPM 5200P	205	—
	EPM 9650Q	210	—
	EPM 7300	215	—
	EPM 7330	220	—
	EPM 7330	225	—

Table 7. IED-addressing scheme for Figure 21.

2–9 Multiple RS-485 Networks – Addressing

PMCS supports up to 256 independent Modbus networks.

Regardless of how many RS-485 networks are connected, the addressing concepts regarding multiple RS-485 networks remain the same. Each RS-485 network is addressed independently of the others. Thus, Network 1 may have an IED with Modbus address 20, and Network 2 may have an IED with Modbus address 20 without conflict. The PMCS will be aware that they are different IEDs, much as the postal system delivering mail realizes that 17 Mulberry Lane in Town A is a different address than 17 Mulberry Lane in Town B.

2–10 System Expansion

Whenever new IEDs are added to the network, be sure to observe these points:

- Follow the proper installation procedures.
- Ensure that the system configuration rules have been followed.
- All new IEDs are shipped with the same default address. To avoid conflicts, change the address of each new IED immediately upon installation to an unoccupied address in the PMCS networks.

2–11 Case Studies

Five case studies are provided as examples of how to design a network based on PMCS. In each case, a fictitious company called GHO Corp. is installing a power management system based on PMCS.

In Case One, GHO Corp. has only a few Modbus RTU-based IEDs that it would like to network to the PMCS software for remote control and viewing of power consumption and alarms.

In Case Two, GHO Corp. wishes to expand the Modbus network it developed in Case One by adding some commnet IEDs to the network.

In Case Three, GHO Corp. already has an existing network based on Ethernet and would now like to integrate a power management system with this network. GHO Corp. still has only a few Modbus RTU-based IEDs that it would like to network to the PMCS for remote control and viewing of power consumption and alarms. Now, however, it wants the host to be based on Ethernet rather than Modbus, which requires the use of an Ethernet Gateway.

In Case Four, GHO Corp. wishes to install a PMCS power management system using both Modbus- and commnet-based IEDs, with the host based on Ethernet.

Case Five demonstrates the use of dual-port RS-485 IEDs in a Modbus network, showing the differences between the Multilin dual-port IEDs and the POWER LEADER Modbus Monitor, which also provides two RS-485 ports.

Case Study One

GHO Corp. has assigned its plant engineer, Bill, the task of designing and installing a simple power management system. GHO Corp. wishes to use PMCS to monitor and control several Modbus power management IEDs.

Bill's first task is an easy one. He must choose a platform on which the PMCS host will reside. Using the flowchart in Section 1-1, he makes his decision. There is no existing Ethernet network in his facility, nor are there any plans for one. Bill chooses Modbus as his basic platform for the PMCS.

Next, Bill makes a list of the IEDs that GHO Corp. wants to include on their PMCS network:

- One PLC 90/30 Programmable Logic Controller for process control
- Three EPM 3720 Meters for monitoring power
- One Multilin 269+ Motor Relay for motor protection
- One Multilin 565 Feeder Management Relay for feeder protection

He checks the list of communications protocols in Table 1 and notes that all of the IEDs communicate on Modbus; because no commnet IEDs are being used, no Modbus Concentrators are needed. The Modbus IEDs communicate at different baud rates, though, and Bill makes a note that they should be placed on separate RS-485 networks for improved performance.

Bill now turns to his floor layout to see just where the wiring could be run and how many feet of cable will be needed. He maps where his IEDs must be located and where the host PC will sit. He measures the cable runs required to connect the IEDs to the host PC, keeping in mind that the wiring rules require him to daisy-chain the IEDs on each RS-485 network one after another. His floor layout is shown in Figure 22.

Chapter 2 – Network Design
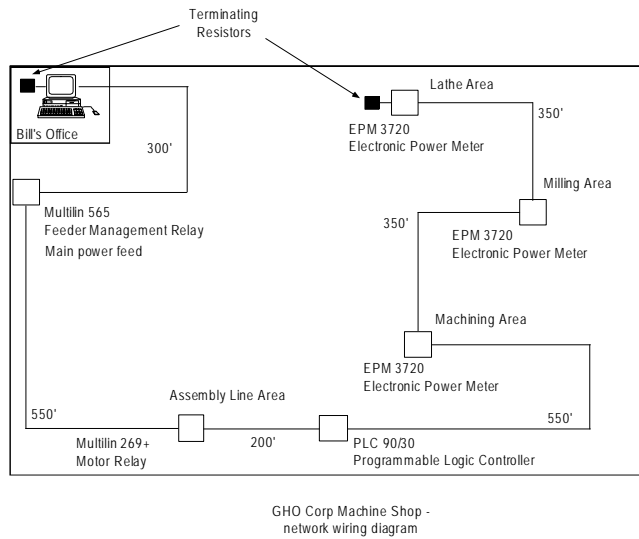
Figure 22. Floor layout for Case One.

Figure 23. Redesigned layout for Case One.

Bill's calculates his total cable length at 2300 feet, well short of the 4000-foot limit.

Next, Bill checks Table 2 for the Modbus wiring rules.

Proper termination is required at each end of the network, and is provided at the RS-485 card by attaching jumpers to the correct pins (see RS-485 card user manual). The appropriate terminating resistors must be used at the opposite end of each RS-485 network, per Section 2–4, rule 3.

His cable length is well under the 4000-foot limit, so no repeaters will be needed.

Because he has only six IEDs to connect, only one RS-485 network is required, and thus an RS-232/RS-485 converter would do the job. However, he considers the performance recommendations given in Section 2-6 and, remembering his earlier note about the different baud rates of his Modbus IEDs, he decides to distribute the IEDs across four ports of an RS-485 network card, so that he can place IEDs with matching baud rates on the same RS-485 network.

The system redesigned for optimum performance is shown in Figure 23.

Confident that his new design will provide maximum performance, and with his wiring requirements and limits met, Bill moves on to select Modbus addresses for the IEDs. He checks Section 2-7 and sees that he can assign his IEDs any Modbus address between 1 and 247. He selects addresses and records them for future reference. The address chart is shown in Table 8.

IED Type	Physical Location	Modbus Address
PLC 90/30	Assembly line	01
EPM 3720	Milling	02
EPM 3720	Lathe area	03
EPM 3720	Machining	04
Multilin 269+	Assembly line	05
Multilin 565	Power intake area	06

Table 8. IED Addresses for Case One.

Chapter 3 provides Bill with physical wiring requirements and rules. He finds that he'll have to use Belden 3074F cable, readily available. He also locates the correct terminating resistors at both ends of each RS-485 network.

He installs the IEDs according to the instructions in the user manual for each IED. He then makes connections to the RS-485 communications cable in daisy-chain fashion, one IED to the next, terminated at each end of each RS-485 network, double-checking his wiring against the example provided in Section 2–4.

He must also bear in mind proper shield-grounding considerations – each RS-485 IED grounded at only one

point and no two IEDs' grounds connected (Rule 4, Section 2-4).

Bill assigns a Modbus address to each IED. He then sets communication speeds and functional and protective parameters according to the instructions in each user manual.

Bill installs the PMCS software at the host PC and configures IED addresses at the host to match the addresses assigned to each on the network.

When all connections have been made and the IEDs and software are appropriately configured, Bill applies power to the system and runs tests to assure that everything is functioning properly.

If any difficulties are encountered, Bill refers to the trouble-shooting guide in Chapter 4.

Case Two

Case Two begins where Case One left off. The Modbus network is in place and GHO Corp. has been so pleased with their new PMCS system that they now wish to tie in a second building (Facility Two) and add several additional power management IEDs. However, the IEDs they wish to add are all commnet IEDs.

The host platform is based on Modbus, with a multi-port RS-485 interface card providing the connection to the networks. Knowing the host platform and its currently attached IEDs, Bill makes a list of the IEDs that GHO Corp. want to add to their PMCS network. His list of additional IEDs is:

- Six Enhanced MicroVersaTrip trip units for equipment protection
- Three POWER LEADER Meters for waveform capture
- One POWER LEADER EPM
- One POWER LEADER MDP Overcurrent Relay
- One Spectra Electronic Control Module

Commnet IEDs require Modbus Concentrators to be recognized by the PMCS. Bill has nine commnet IEDs to connect, so he will need only one Modbus Concentrator (each Concentrator supports up to 32 commnet IEDs). However, with some of the commnet IEDs located in Facility Two, well beyond the 1000-foot segment limit, Bill realizes that he must either locate the Modbus Concentrator in Facility 1 and run several very long commnet segments using POWER LEADER Repeaters to span the long runs or place a Modbus Concentrator in Facility Two and extend his RS-485 network over to Facility Two with RS-485 repeaters. Bill decides that it will be easier and more cost effective to run a single long RS-485 segment with a pair of RS-485 repeaters than to extend six commnet segments. An added benefit: each repeater uses optical isolation between its incoming and outgoing lines, eliminating harmful ground loops that can result when the ground potential between two structures is different. For even greater electrical isolation Bill could have used an optical fiber link between the two remote locations.

Bill turns to his floor layout, to see just where the wiring could be run and how much distance it must cover. He knows where his host PC is located and realizes that he will have to interrupt the Modbus network at one or more locations to insert Modbus Concentrators to support his commnet IEDs. He maps where his IEDs must be located and, based on this information, where the Concentrators will be mounted. Next he plans the commnet segments and measures the cable runs required for each segment to connect the IEDs to the Modbus Concentrator, keeping in mind that the commnet rules require him to daisy-chain the IEDs one after another (unless he uses a Junction/Outlet box). His floor layout is shown in Figure 24.

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RS485 networks terminated at host PC
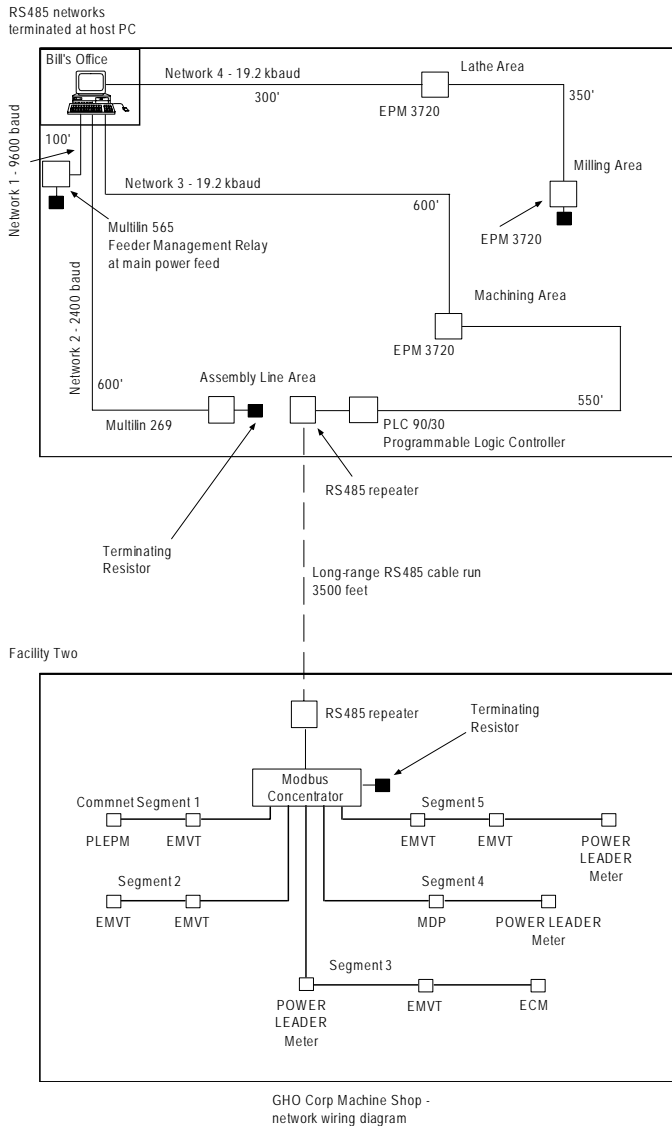
Figure 24. Floor layout for Case Two.

IED Type	Physical Location	Modbus Address
PLC 90/30	Assembly line	01
EPM 3720	Milling	02
EPM 3720	Lathe area	03
EPM 3720	Machining	04
Multilin 269+	Assembly line	05
Multilin 565	Power Intake area	06
Modbus Concentrator	Facility 2, north wall	10
Enhanced MicroVersaTrip	Facility 2, Segment 1	33
Enhanced MicroVersaTrip	Facility 2, Segment 2	34
Enhanced MicroVersaTrip	Facility 2, Segment 2	35
Enhanced MicroVersaTrip	Facility 2, Segment 3	36
Enhanced MicroVersaTrip	Facility 2, Segment 5	37
Enhanced MicroVersaTrip	Facility 2, Segment 5	38
POWER LEADER Meter	Facility 2, Segment 3	39
POWER LEADER Meter	Facility 2, Segment 4	40
POWER LEADER Meter	Facility 2, Segment 5	41
POWER LEADER EPM	Facility 2, Segment 1	42
MDP Overcurrent Relay	Facility 2, Segment 4	43
Spectra ECM	Facility 2, Segment 3	44

Table 9. IED Addresses for Case Two.

He must also bear in mind proper shield grounding considerations – each RS-485 IED grounded at only one point and no two IED's grounds connected (Rule 4, Section 2-4).

Bill checks Table 4 for the commnet wiring rules and finds that he must keep his POWER LEADER Meters on separate commnet networks, limit his commnet IEDs to four per segment, and keep each segment under 1000 feet (unless he uses repeaters). The commnet segments he has planned satisfy all these rules.

Because his cabling limits are met, Bill selects Modbus-equivalent addresses for the IEDs and adds them to his address chart for future reference. His updated address chart is shown in Table 9.

Bill next checks Chapter 3 for physical wiring requirements and rules. He knows he needs Belden 3074F cable for the new RS-485 wiring to extend RS-485 Network 3 to the RS-485 repeater for the jump to Facility Two and to make the connection to the Modbus Concentrator from the RS-485 repeater in Facility Two. He moves the terminating resistor from the end of RS-485 Network 3 out to the new end at the Modbus Concentrator in Facility Two.

Commnet wiring requires Belden 8719 cable. Bill installs the IEDs according to the instructions in each user manual. He wires each commnet segment in daisy-chain fashion, one IED to the next, being sure to ground the shield at the Modbus Concentrator only.

Bill then sets local addresses on the IEDs in accordance with the addressing rules in Section 2–6. He sets communication speeds and parameters according to the instructions in each user manual.

Bill installs the PMCS software at the host PC and configures the IED addresses.

When all connections have been made and the IEDs and software are appropriately configured, Bill applies power to the system and runs tests to assure that everything is functioning properly.

If any difficulties are encountered, Bill refers to the trouble-shooting guide in Chapter 4.

Case Three

In Case Three, GHO Corp. has an existing Ethernet network installed and would now like to add power management capabilities with PMCS. Once again, plant engineer Bill has been given the task of designing and installing this system.

As before, Bill's first task is to choose a platform on which the PMCS host will reside. Using the flowchart in Section 1-1, he decides that the PMCS will reside on Ethernet, requiring one or more Ethernet Gateways to communicate with the RS-485 networks.

Next, Bill makes a list of the IEDs that GHO Corp. needs to support on their PMCS network. The IED list is the same as in Case One:

- One PLC 90/30 Programmable Logic Controller for process control
- One EPM 3720 Meter for monitoring power
- One Multilin SR745 Transformer Management Relay
- One Multilin SR469 Motor Management Relay
- One Multilin 269+ Motor Relay for motor protection
- One Multilin 565 Feeder Management Relay for feeder protection

The list of communication protocols in Table 1 shows that all the IEDs communicate on Modbus; because no commnet IEDs are being used, no Modbus Concentrators are needed. However, because the PMCS will be operating on Ethernet, he will need to use an Ethernet Gateway to relay communications between the host and the Modbus networks. Table 1 also indicates that the Modbus IEDs

have different communication speeds. For performance reasons, Bill decides to break the IEDs off to independent networks rather than connect all of them to the same RS-485 network. The Ethernet Gateway offers four RS-485 ports, so using more than one port poses no additional cost burdens or configuration concerns.

Bill turns to his floor layout, to see just where the wiring could be run and how much distance it must cover. He maps where his IEDs must be located and where the Ethernet Gateway will sit. He then measures the cable runs required to connect the IEDs to the Ethernet Gateway, keeping in mind that the RS-485 rules require him to daisy-chain the IEDs one after another. His floor layout is shown in Figure 25.
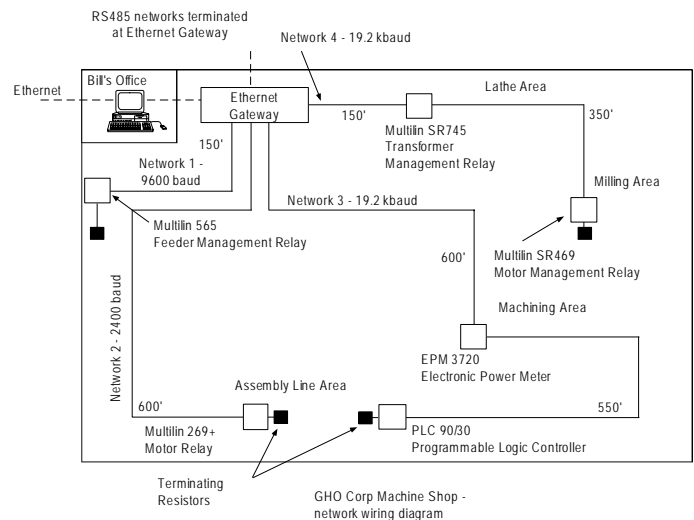
Figure 25. Floor layout for Case Three.

Next, Bill checks Table 2 for the Modbus wiring rules and Table 3 for the Ethernet wiring rules.

He notes that he must properly terminate the RS-485 network at each end and that he must keep his total RS-485 cable length under 4000 feet, unless he invests in RS-485 repeaters or puts the IEDs on separate RS-485 networks, which may run in different directions and effectively increase his range.

His cabling limits are satisfied, so Bill selects Modbus addresses for the IEDs, and records them for future reference. His address chart is shown in Table 10.

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IED Type	Physical Location	RS-485 Port, Modbus Address
Multilin 565	Power Intake Area	1, 01
Multilin 269+	Assembly Line	2, 01
PLC 90/30	Assembly Line	3, 01
EPM 3720	Machining	3, 02
Multilin SR745	Lathe Area	4, 01
Multilin SR469	Milling	4, 02

Table 10. IED Addresses for Case Three.

Bill next checks Chapter 3 for physical wiring requirements and rules. He finds that he'll have to use Belden 3074F cable for the RS-485 wiring. He also locates the correct terminating resistors at each end of the RS-485 network.

He installs the IEDs according to the instructions in each user manual. He makes communication connections to the RS-485 communication cable in daisy-chain fashion, one IED to the next, with terminating resistors at the final IED and the host (Ethernet Gateway). While wiring, he follows the RS-485 cable shield wiring rules explained in Section 2–4 (rule 4).

Bill then assigns local Modbus addresses to the IEDs and sets communication speeds and parameters according to the instructions in each user manual.

He installs the PMCS software at the host PC and configures the IED addresses to match the addresses set at the IEDs.

When all connections have been made and the IEDs and software are appropriately configured, Bill applies power to the system and runs tests to assure that everything is functioning properly.

If any difficulties are encountered, he refers to the trouble-shooting guide in Chapter 4.

Case Four

In Case Four, GHO Corp. wishes to create a power management system that will interconnect with their existing corporate Ethernet. They would like the capabilities of both Modbus and commnet IEDs and plan to integrate three separate facilities using repeaters. GHO Corp. plant engineer Bill has been given the task of designing and installing this system.

As in the previous cases, Bill's first task is to choose a platform on which the PMCS host will reside. GHO Corp. requires Ethernet integration, so the flowchart in Section 1-1 determines that the PMCS will reside on Ethernet, requiring an Ethernet Gateway.

Next, Bill makes a list of the IEDs that GHO Corp. wishes to support on their PMCS network. His IED list is:

- One PLC 90/30 Programmable Logic Controller for process control
- Two EPM 3720 Meters and one EPM 7700 for monitoring power
- One Multilin 269+ Motor Relay for motor protection
- One Multilin 565 Feeder Management Relay for feeder protection
- Six Enhanced MicroVersaTrip trip units
- Three POWER LEADER Meters (with waveform capture)
- One POWER LEADER EPM
- One POWER LEADER MDP Overcurrent Relay
- One Spectra Electronic Control Module

Bill knows that he will need an Ethernet Gateway to connect his Modbus network(s) to Ethernet and both RS-485 and POWER LEADER Repeaters to reach the remote locations in Facility Two and Facility Three. He checks his IED list against the list of communication protocols in Table 1 and notes that some of the IEDs communicate on Modbus and some on commnet, so he will also need at least one Modbus Concentrator to support communications with the commnet IEDs. The Modbus IEDs do not all communicate at the same speed, so more than one RS-485 network is required.

Next, Bill checks Tables 2 through 4 for the Modbus, Ethernet and commnet wiring rules.

The EPM 7700, being a native Ethernet device, can be connected directly to the Ethernet hub Bill intends to install near his office. He'll connect the hub to the corporate LAN, to his PC, to the 7700, and finally to the Ethernet Gateway. Bill, realizing the LAN is shared by the entire building, installs an Ethernet data line surge

protector at the hub on the incoming line from the EPM 7700 IED to shield the rest of the network from potentially damaging transients.

Because he has only six Modbus IEDs (five IEDs and the Modbus Concentrator) and 12 commnet IEDs to connect, he requires only one RS-485 network (each RS-485 network accommodates up to 31 Modbus IEDs and up to 215 commnet IEDs). However, because his Modbus IEDs communicate at several different baud rates, Bill decides to assign them to different RS-485 networks to achieve greater system performance.

He also notes that each RS-485 network must be properly terminated at each end. He must keep the RS-485 cable length of each RS-485 network under 4000 feet, unless he uses RS-485 repeaters, as on Network 3, to span the 3,500 feet to Facility 2.

The commnet rules are also easy to comply with. Each of the commnet segments must be kept under 1000 feet, unless repeaters are used to extend the range of the segments, as is required to reach the commnet IEDs in Facility 3. Each commnet segment is limited to four commnet IEDs, and no segment may have more than one waveform capture meter (POWER LEADER Meter). Bill makes sure that his POWER LEADER Meters are limited to one per segment.

Bill now turns to his floor layout, to see just where the wiring could be run and how much distance it must cover. He maps where his IEDs must be located and where the host PC will sit. He then measures the cable runs required to connect the IEDs to the host PC, keeping in mind that the RS-485 rules require him to daisy-chain the Modbus IEDs one after another from the Ethernet Gateway and the commnet IEDs (four per segment) from the Modbus Concentrator. His floor layout is shown in Figure 26.

The RS-485 cabling is less than 4000 feet for each of the RS-485 networks, except for Network 3, where RS-485 repeaters are used to bridge the 3,500 feet to Facility Two. Each of the commnet segments requires less than 1000 feet of cable, except for segment three, where POWER LEADER Repeaters are used to span the 5000 feet to Facility Three. The wiring rules are satisfied.

Bill selects Modbus addresses for the Modbus IEDs and Modbus equivalent addresses for the commnet IEDs, using the worksheets in the back of the Modbus Concentrator User Guide (GEH-6491), and records them for future reference. Bill's address chart, found in Table 11, follows the floor layout.
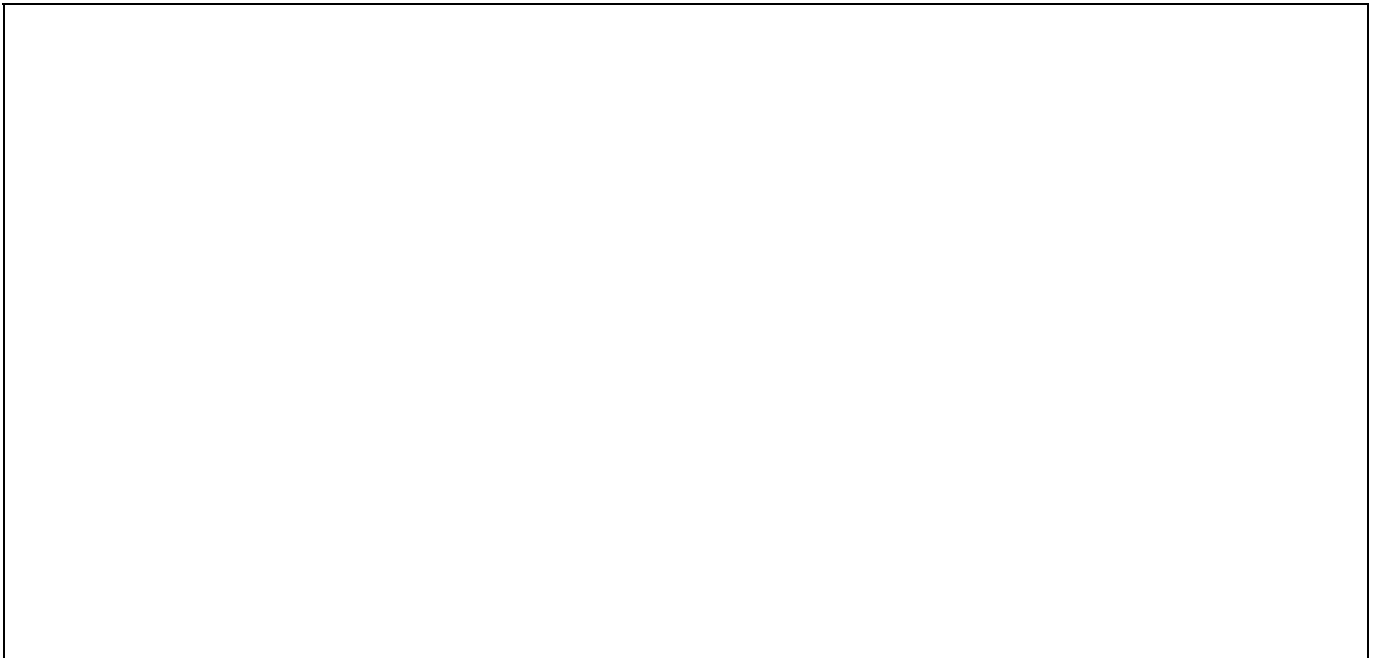
Figure 26. Floor layout for Case Four.

IED Type	Physical Location	RS-485 Port, Modbus (or equivalent) Address
Multilin 565	Power intake area	Port 1, IED 01
Multilin 269+	Assembly line	Port 2, IED 01
EPM 7700	Lathe area	N/A - native Ethernet IED
PLC 90/30	Assembly line	Port 3, IED 02
Modbus Concentrator	Facility 2, north wall	Port 3, IED 03
EPM 3720	Machining	Port 4, IED 01
EPM 3720	Milling	Port 4, IED 02
Enhanced MicroVersaTrip trip unit	Facility 2, Segment 1	Port 3, IED 33
Enhanced MicroVersaTrip trip unit	Facility 2, Segment 2	Port 3, IED 40
Enhanced MicroVersaTrip trip unit	Facility 3, Segment 2	Port 3, IED 41
Enhanced MicroVersaTrip trip unit	Facility 2, Segment 3	Port 3, IED 50
Enhanced MicroVersaTrip trip unit	Facility 2, Segment 5	Port 3, IED 70
Enhanced MicroVersaTrip trip unit	Facility 2, Segment 5	Port 3, IED 71
POWER LEADER Meter	Facility 3, Segment 3	Port 3, IED 51
POWER LEADER Meter	Facility 2, Segment 5	Port 3, IED 72
POWER LEADER Meter	Facility 2, Segment 4	Port 3, IED 60
POWER LEADER EPM	Facility 2, Segment 1	Port 3, IED 34
POWER LEADER MDP Overcurrent Relay	Facility 2, Segment 4	Port 3, IED 61
Spectra ECM	Facility 3, Segment 3	Port 3, IED 52

Table 11. IED Addresses for Case Four.

Chapter 3 provides physical wiring requirements and rules. For commnet wiring, he'll use Belden M8719 cable. For RS-485 wiring, he'll use Belden 3074F cable and the correct terminating resistors for both ends of the RS-485 networks.

Bill installs the IEDs at the equipment according to the instructions in each user manual and runs the RS-485 cable for each RS-485 network from the Ethernet Gateway to each Modbus IED in daisy-chain fashion, one IED to the next, and terminated at each end.

Bill runs the commnet cable from the Modbus Concentrator for each commnet segment, grounded only at the Modbus Concentrator.

He assigns local Modbus addresses to the Modbus IEDs and sets communication speeds and parameters according to the instructions in each user manual.

Next, Bill sets the local address at each commnet IED according to what he wants the Modbus-equivalent address of each IED to be. He configures the Modbus Concentrator, either manually or with the autoconfigure

option, following the instructions in the Concentrator User Manual. During configuration, the Concentrator probes each of its commnet segments for IEDs, records their commnet addresses, and assigns a Modbus-equivalent address so that communication from the PMCS will be directed to the correct IED.

Bill configures the Ethernet Gateway, assigning a unique IP network address after he checks with the LAN administrator to determine which IP addresses are available. He then sets the serial port communication parameters for each Gateway port after referring to document GEH-6505, *Ethernet Gateway User's Guide*, for information on configuring the Gateway serial ports.

Bill assigns a unique IP address to the EPM 7700 meter's Xpress Card based on information in the EPM 7700 user documentation and the addresses he received from the LAN administrator.

He installs the PMCS software at the host PC and configures the IED addresses in the DDE server. Next, Bill modifies the 7700 network configuration file for the EPM

7700, according to the *GE 7700 Gateway User's Guide* (DEH-40035).

When all connections have been made and the IEDs and software are appropriately configured, Bill applies power to the system and runs tests to assure that everything is functioning properly. If any difficulties are encountered, he refers to the trouble-shooting guide in Chapter 4.

Case Five

In this case study, the circumstances are similar to those in Case One, with the addition of several RS-485 dual-port IEDs. The PMCS host resides on Modbus, connected to several RS-485 Modbus segments.

The IED list is:

- One EPM 7300 Electronic Power Meter
- One Multilin SR745 Transformer Management Relay
- One Multilin SR760 Feeder Management Relay
- One Multilin 269+ Motor Relay
- One Multilin 565 Feeder Management Relay
- Two dual-port RS-485 Modbus Monitors to serve as remote-viewing stations for the IEDs on segments 3 and 4
- One Modbus Concentrator to support the commnet IEDs below
- One POWER LEADER Electronic Power Meter
- One Spectra Electronic Control Module
- One Enhanced MicroVersaTrip-C trip unit

He checks the list of communication protocols in Table 1 and notes that most of his IEDs communicate on Modbus, but because he wants to use several commnet IEDs in the Machining area, he'll need a Modbus Concentrator. As well, the Modbus IEDs communicate at different baud rates, and Bill makes a note that they should be placed on separate RS-485 networks for improved performance. He decides to use four RS-485 networks supported by the recommended communications card at the host PC.

Bill now turns to his floor layout to see just where the wiring could be run and how many feet of cable will be needed. He maps where his IEDs must be located and where the host PC will sit. Next he measures the cable runs required to connect the IEDs to the host PC, keeping in mind that the wiring rules require him to daisy-chain the IEDs on each RS-485 network one after another.

Bill calculates the cable length of each RS-485 network and finds that none are over the 4000-foot limit, so he won't need to use any RS-485 repeaters. The commnet

segments are also within the wiring limits, so no POWER LEADER Repeaters are required.

The factory floor is very large though, and Bill wants to be able to view IED data at several locations to save walking all the way back to his office every time he wants to check an IED. To serve this purpose, he's purchased a pair of dual-port Modbus Monitors, which he will install in the Milling and the Machining areas, respectively. He checks the Modbus Monitor wiring rules and sees that he'll be able to connect RS-485 Network 3 to the RS-485 Port A of each Monitor and RS-485 Network 4 to the RS-485 Port B of each Monitor. This will allow him to view data from the IEDs in these areas at either station as well as back in his office at the host PC.

Proper termination is required at each end of the network and is provided at the RS-485 card by placing jumpers between the correct pins (see RS-485 card user manual). The appropriate terminating resistors must be used at the opposite end of each RS-485 network, per Section 2–4, rule 4.

The network architecture diagram Bill creates is shown in Figure 27.
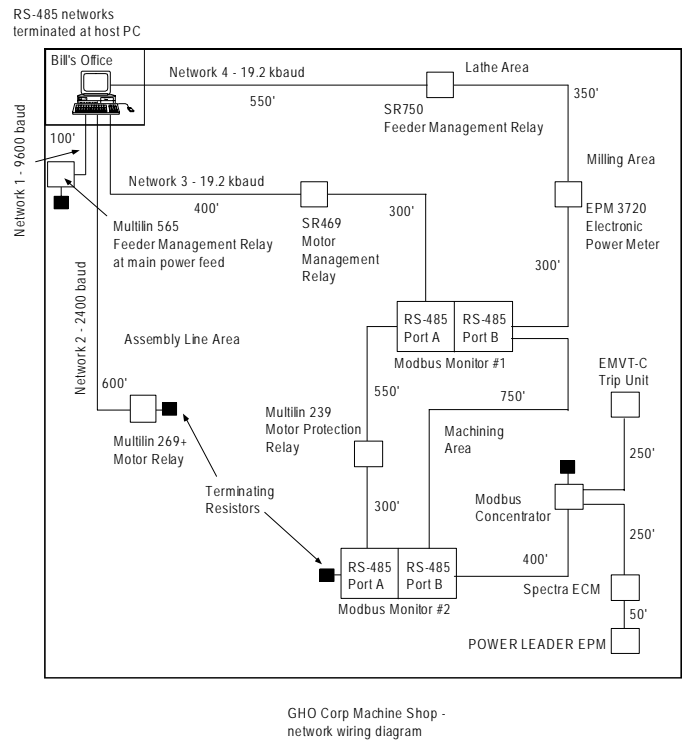
Figure 27. Floor layout for Case Five.

Confident that his new design will provide maximum performance and with his wiring requirements and limits met, Bill selects Modbus addresses for the IEDs. He checks Section 2-7 and sees that he can assign the Modbus IEDs on each network any Modbus address between 1 and 247 (except for the Modbus Concentrator, which must have an address between 1 and 32). The commnet IEDs must have Modbus-equivalent addresses between 33 and 247. He selects addresses and records them for future reference. The address chart is shown in Table 12.

RS-485 Network #	IED Type	Physical Location	Modbus Address
1	Multilin 565	Power intake area	01
2	Multilin 269+	Assembly line	01
3	SR469 Motor Management Relay	Assembly line	01
3	Modbus Monitor #1, RS-485 Port A	Lathe area	02
3	Multilin 239 Motor Protection Relay	Machining area	03
3	Modbus Monitor #2, RS-485 Port A	Machining	04
4	Multilin SR750 Feeder Management Relay	Milling area	01
4	EPM 3720	Milling area	02
4	Modbus Monitor #1, RS-485 Port B	Lathe area	03
4	Modbus Monitor #2, RS-485 Port B	Machining area	04
4	Modbus Concentrator	Machining area	05
4	EMVT-C trip unit	Machining area	33
4	Spectra ECM	Machining area	34
4	POWER LEADER EPM	Machining area	35

Table 12. IED Addresses for Case Five.

Chapter 3 provides Bill with physical wiring requirements and rules. He'll use Belden 3074F cable, readily available. He also locates the correct terminating resistors at both ends of each RS-485 network.

He installs the IEDs according to the instructions in each IED's user manual. He then makes connections to the RS-485 communications cable in daisy-chain fashion, one IED to the next, terminated at both ends of each RS-485 network, double-checking his wiring against the example provided in Section 2–4. Since several of his Multilin IEDs have two ports, he is careful to connect only one RS-485 port per IED. The Modbus Monitors are also RS-485 dual-port, but Bill carefully follows the wiring instructions to correctly connect them to the RS-485 networks. The A port of each Monitor is connected to one RS-485 network and the B port of each is connected to another network.

He must also bear in mind proper shield-grounding considerations: each RS-485 IED grounded at only one point and no two IEDs' grounds connected (Rule 4, Section 2-4). The Multilin 565 special grounding considerations are also taken into account (see Chapters 2 and 3).

Bill assigns a Modbus address to each IED. He then sets communication speeds and functional and protective parameters according to the instructions in each user manual.

Bill installs the PMCS software at the host PC and configures IED addresses at the host to match the addresses assigned to each IED on the network.

Configuration files for the Modbus Monitors are downloaded to the units or created using the Monitor's "Create from PMCS" feature (see DEH-027 for details).

When all connections have been made and the IEDs and software are appropriately configured, Bill applies power to the system and runs tests to assure that everything is functioning properly.

If any difficulties are encountered, Bill refers to the trouble-shooting guide in Chapter 4.

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Chapter 3. Network Wiring and Construction

Once the network has been carefully laid out on paper and IED addresses have been planned, you need to check the following wiring requirements before beginning assembly of the system.
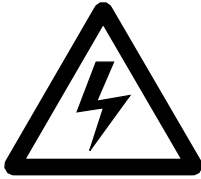
WARNING: Network wiring and grounding rules described herein apply primarily to commercial and industrial installations. Substation installations will exist in the presence of dangerously elevated ground potential relative to points outside of the station grid as well as large electromagnetic induction fields. Additionally, large ground faults can elevate substation ground potentials. Follow local utility best practices and safety procedures to prevent risk of shock or electrocution to personnel and damage to equipment that could result in a loss of protection and communications.

CAUTION: The recommended installation practice is to implement optical fiber for connections between buildings to provide electrical isolation. This eliminates harmful ground loops caused by differences in the ground potential between structures.

CAUTION: Data line surge protection is recommended for network components such as hubs, computers, or modems connected to IEDs with copper wire, especially installations where the data communication cable is exposed (i.e., not encased in conduit) or runs parallel to power conductors. PMCS IEDs are routinely installed in areas exposed to heavy electromagnetic fields (EMF), which can induce damaging surges in data communication lines. Data line surge protection is not required for fiber optic connections.

Power Management Control System
Chapter 3 – Network Wiring and Construction

3–1 Wiring Requirements

Each type of network (Ethernet, Modbus, and commnet) has unique wiring requirements. These rules are summarized in Table 13. Further detail is provided following the table.

WARNING: The National Electrical Code (NEC) and all applicable local codes must be followed when installing wiring.

Network	Wiring Required	Shield Grounding	Termination
Ethernet	10Base-T or 10Base-FL CAT-3, 4, or 5 UTP, Rated 300V. A 600V requirement may be satisfied by applying 600V tubing to the cable.	See 10Base-T or 10Base-FL wiring standards. Check with your LAN administrator.	See 10Base-T or 10Base-FL wiring standards. Check with your LAN administrator.
Modbus	Indoors/outdoors in conduit above grade Belden 3074F – Data Tray 600 V industrial twinax 18 AWG (7X26); or Belden 9841 – 300 V Communication cable 24 AWG (7X32); or Alpha 6412 – 300 V Communication cable 24 AWG (7x32). NOTES: Use one of the above-approved cables that meet the NEC and UL requirements for the application. A 600 V requirement may be satisfied by using the Belden 3074F or by applying 600 V tubing to either the Belden 9841 or Alpha 6412. No substitutions are permitted.	Each RS-485 network should be grounded at the host and at the RS-485 OUT port of each IED, with no continuity between wire-segment shields. (See Section 2–4, rule 4)	The RS-485 cables must be terminated at each end of the network. The terminator should be a 120-ohm, $^1/_2$-watt resistor, 5%. (See section titled Termination in this chapter for specific details on Connect Tech RS-485 card and Ethernet Gateway.)
Commnet	Indoors/outdoors in conduit above grade Belden 8719 – 600 V shielded instrumentation cable, 16 AWG (19X29). Below-grade applications[5] Belden 83702.	Each commnet segment's cable shield must be grounded at the Modbus Concentrator at the port to which it is connected.	N/A: no termination is needed on commnet segments.

Table 13. Wiring requirements.

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[5] Belden 83702 is rated for direct burial and air plenum, non-conduit applications, but the length limits for this cable are two-thirds of the lengths specified in the configuration rules of Chapter 2.

Type of Wire

Ethernet

10Base-T applications may use any appropriate Category 3, 4 or 5 UTP cable, provided it is rated at least 300V. Category 3 cable is sufficient for 10 Mbps applications such as PMCS. Category 5 cable supports 100 Mbps network applications. Category 4 cable is not widely available, having been superseded by Category 5 cable in the marketplace. Any of these cables may be used in 600 volt applications by applying 600V tubing to the cable.

Modbus

Belden 9841 or Alpha 6412 may be used for applications under 300 V that are indoors or outdoors in conduit above grade. These cables may be also be used for 600 V requirements by applying 600 V tubing to them. Belden 3074F may be used for applications greater than 300 V which are indoors or outdoors in conduit above grade.

Commnet

Belden M8719 shielded instrumentation cable #16 AWG wire (shielded, twisted-pair) is recommended for commnet wiring for applications indoors or outdoors in conduit above grade.

For below-grade applications, Belden 83702 shielded 16 AWG cable is recommended. Belden 83702 is rated for direct burial and air plenum, nonconduit applications, but the length limits for this cable are two-thirds of the lengths specified in the configuration rules of Section 2-1. For example, a network segment connecting up to four IEDs may have a total cable length of no more than 667 feet of Belden 83702, versus the 1000-foot limit on total cable length for Belden 8719.

Termination

RS-485 cables must be terminated at each end of the network with a 120-ohm, $^1/_2$-watt, 5% tolerance resistor.

> ⚠ IMPORTANT NOTE FOR CONNECT TECH CARD USERS: The Connect Tech RS-485 card recommended for use with PMCS systems requires a 600-ohm rather than a 120-ohm resistor. Use the 600-ohm resistor at the Connect Tech card only. The other end of the Modbus network(s) should be terminated with the usual 120-ohm resistor.

> ⚠ IMPORTANT NOTE FOR ETHERNET GATEWAY USERS: The POWER LEADER Ethernet Gateway provides internal termination for its four RS-485 ports. No terminating resistor is needed at the POWER LEADER Ethernet Gateway.

See Figure 9 for an example of the cable run terminated at the final IED on the network.

Shield Grounding

Modbus

The RS-485 cable shield must be grounded at only a single point on each RS-485 wire. Connect the shield to the ground terminal at the Ethernet Gateway or RS-485 interface card. Connect the cable shield to the shield terminal at each IED on the RS-485 network except the Multilin 565, which does not have isolated communication ports (Modbus Rule 5, Section 2–4).

Commnet

The commnet cable shield must be grounded at only a single point in each commnet segment. This is done at the POWER LEADER Modbus Concentrator. Each commnet port on the Modbus Concentrator has a ground terminal, and each commnet segment should be grounded at the port to which it is connected.

Figure 28 shows a POWER LEADER Modbus Concentrator connected to a series of commnet IEDs. The shield of the cable to the downstream IEDs is grounded at the Modbus Concentrator on its internal shield-ground terminal strip.

3–2 Modbus – Commnet Integration

The rules regarding the number of IEDs per Modbus Concentrator and wiring-distance limits are explained in Chapter 2. The rules expressed in this section are more low-level and concern the physical connections of commnet IEDs to a Modbus Concentrator. You must follow these rules to provide for proper shielding and communications.

Wiring Concerns

No commnet segment should have more than one wiring connection at any point, such as the Modbus Concentrator, a Junction Box, or a Repeater. You must avoid this condition, which is known as looping.

Examples of correct wiring conditions and various illegal looping conditions are illustrated in Figure 28 through

Figure 32. Figure 28 illustrates correct commnet wiring. Figure 29 through Figure 32 show illegal looped wiring. You can correct looping by removing either of the looped connections indicated by the large Xs in the figure.

You must never connect a single commnet segment to the Modbus Concentrator at more than one point or to more than one port on the Modbus Concentrator.

Figure 28 represents the correct wiring scheme for a commnet segment – linear, one IED to the next, connected to the concentrator at one port only.

Figure 29 through Figure 32 show various incorrect wiring schemes – commnet segments that are 'looped' and nonlinear. Avoid these wiring situations as they will cause communication errors.

Figure 30. Incorrect wiring. Looping to two Modbus Concentrator commnet ports.

Figure 28. Commnet shield grounding wired correctly.
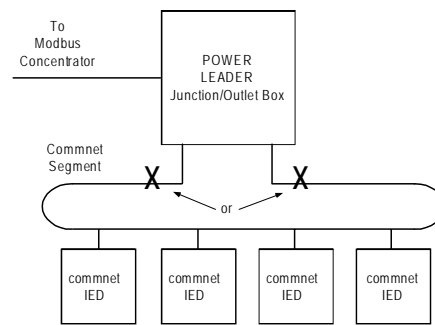
Figure 31. Incorrect wiring. Looping on segment connected to Junction Box.

Figure 29. Incorrect wiring. Looping on one Modbus Concentrator commnet port.
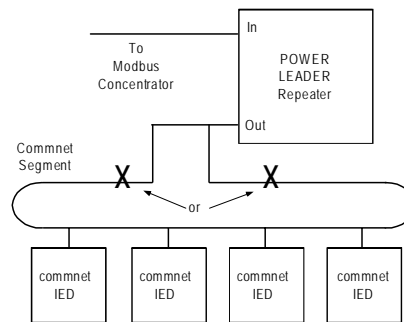
Figure 32. Incorrect wiring. Looping on segment connected to POWER LEADER Repeater.

3–3 Modbus – Ethernet Integration

Ethernet comes into play only as an alternative platform for the host PC. It is most often used when an existing Ethernet network is in place or being installed for data-networking purposes, or when Ethernet-only devices such as the EPM 7700 are to be used with PMCS.

To communicate with the Modbus networks (and any commnet segments beneath them), a host PC based on Ethernet requires an Ethernet Gateway. Rather than use an RS-485 interface card, connect the Modbus networks to the RS-485 ports on the Ethernet Gateway, which is connected to the Host PC via Ethernet, over which it communicates data from the Modbus networks.

The Ethernet Gateway offers a more nearly plug-and-play format, with fewer wiring complexities and rules than the Modbus Concentrator. See GEH-6505, Ethernet Gateway User Guide, for detailed information on installing and configuring the Ethernet Gateway.

3–4 Local Configuration of IEDs

You must properly configure each IED connected to the PMCS. Be sure to set the IED address at the IED and at the host software, set the communication speed, and configure any necessary settings.

For detailed directions on setting addresses, communication speed, and protection parameters, refer to the user guide for each IED.

3–5 Applying Power to the System

⚠ WARNING:

Voltages hazardous to personnel and equipment may be present at the power connections.

Once you've installed the PMCS network, you should apply power to the network from the bottom up. Follow this procedure when applying power to the system for the first time:

1. Make sure that all communications wiring has been correctly connected to each IED and that the system matches the plan exactly, meeting all rules and requirements explained in this manual.

2. Make sure that all wiring for control power to IEDs has been correctly installed and that the correct control voltage is present at each IED.

3. If commnet IEDs are installed, apply control power to the IEDs and then to the Modbus Concentrator to which they are attached.

4. Apply control power to any Modbus RTU IEDs.

5. Apply control power to the Ethernet Gateway, if one is being used.

6. Turn the computer on and start the PMCS software according to the instructions in the software manuals.

3–6 Software Loading and Startup

Refer to the Power Management Control System software installation procedures in GEH-6514, Read This Book First.

Chapter 4 –Trouble-Shooting

This chapter presents basic trouble-shooting procedures for PMCS networks. It is not meant to be a comprehensive guide covering every possible contingency, but will help to resolve the most common difficulties. If the information presented here does not resolve the problem, contact a Resolution Engineer at the GE Resolution Center, at 1-888-GE-RESOLV.

4–1 Communication Network Trouble-Shooting

One of the most useful tools for trouble-shooting network problems is a one-line diagram. The following procedure uses such a diagram.

1. Obtain a one-line diagram of the system.

2. Verify that none of the Modbus network configuration rules, detailed in Chapter 2, have been violated.

3. If POWER LEADER commnet IEDs are attached to the network via Modbus Concentrators, you must check their configuration as well. Examine each Concentrator and its attached commnet IEDs to verify that none of the commnet network configuration rules detailed in Chapter 2 have been violated.

If the network complies with these rules, or has been modified to comply with them, and problems persist, continue with the remaining steps.

4. Determine if any communication is possible. Select a Modbus IED whose wiring connections you have checked from the host to the IED and attempt communication from the host to the IED. If no communication can be established, check that the communication settings for the RS-485 network match those set at the IED and that the Modbus address at the IED matches the address assigned at the host. Reattempt communications.

   Communication with an IED connected to an RS-485 network requires that it have a Modbus address. Addresses are assigned during IED setup. After the IED address has been assigned, it must be entered into the host computer. Commnet IEDs must be assigned Modbus-equivalent addresses at the Modbus Concentrators and commnet addresses at the IED. Refer to each IED's instruction manual for detailed procedures. When the address is entered at the host, the host will attempt to communicate with the IED. If communication can be established with

some IEDs, continue with step 5; otherwise, go to step 6.

5. Establish a pattern for the IEDs that do not respond. Are all the IEDs with problems Modbus IEDs? Are they all commnet IEDs? Are they all on one RS-485 network or a single commnet segment, or are they located on different networks or segments? Do all the IEDs on a segment up to a certain point communicate, while IEDs after that point do not?

   If communication cannot be established with any of the IEDs on a network, go to step 7.

6. If the error is limited to certain IEDs, the following checklist should help you isolate the problem.
   • The IED is powered up.
   • The IED's communication settings match those of the network it is on (baud rate, parity, stop bits).
   • The IED's address has been assigned.
   • The same address is not assigned to another IED.
   • The network connections are good.

7. If the network has no repeaters, go to step 8.

   For commnet segments with Repeaters, you can localize the problem by checking all repeaters for red LEDs, which indicate disabled segments. Each repeater should have one LED lit on each input and output (either red or green). If more than one LED is lit or if none of the LEDs are lit, refer to the trouble-shooting section of the repeater manual.

⚠ NOTE: If other IEDs are connected to the segment, the status LEDs may glow dimly when the cables are connected, even though the POWER LEADER Repeater is not powered.

8. When the error has been localized to one RS-485 network, commnet segment, check that control power is available to every IED requiring it. If control power to certain IEDs is disconnected or turned off, it may disable communications on that segment.

9. If all the IEDs on the network or segment have control power and the error persists, disconnect all the IEDs except the Repeaters. If practical, disconnect the IEDs one at a time to see which IED is causing the error.

10. If it is not possible to test communication as each IED is disconnected, check the Repeaters with all other IEDs disconnected. Both green LEDs should be lit on every Repeater. If a red LED is lit, it may indicate that the COMM+ and COMM– lines are shorted somewhere on that segment. Refer to the trouble-shooting section of the Repeater manual if both green LEDs are not lit.

11. If all Repeaters on the commnet segment show two green LEDs when connected to the commnet cable, the error is probably caused by one of the IEDs on the segment. Connect the IEDs one at a time, establishing communication with each one. Refer to the IED instruction manuals for procedures for communicating with each IED.

4–2 Host Trouble-Shooting

If the procedure for communication network trouble-shooting does not isolate the problem, use the following procedure to determine if the host is at fault.

1. If the host is at fault, it probably will not be able to communicate with any IED. If this host can communicate with one or more IEDs, return to Section 4-1.

2. Check that power is connected to the network interface card in the host PC; if you are using an Ethernet Gateway, make sure that its control power is connected. Ensure that the Ethernet network interface card in the Host PC is properly connected and seated in its expansion slot.

3. If using an RS-485 interface card(s), check that the card(s) is seated properly in its slot and that the proper terminating resistors are applied.

4–3 IED Trouble-Shooting

To determine if an IED is causing network problems, disconnect it from the network, then refer to the appropriate user manual for the trouble-shooting procedure.

4–4 Equipment Trouble-Shooting

To determine if a section of equipment is causing network problems, disconnect it from the network, then refer to the appropriate user manual for the trouble-shooting procedure.

4–5 Product Service Procedure

Call the GE Resolution Center at 1-888-GE-RESOLV if you have any additional questions or problems.

4–6 Trouble-Shooting Guide

Symptom	Possible Cause	Corrective Action
1. No communication to any IEDs on the network.	1. Host PC not powered.	Check that the host PC has control power and is running correctly (no PC error conditions exist).
	2. Windows 2000 SP2 not running correctly.	Check that Windows 2000 SP2 is properly installed and running correctly (no crashes or system lock ups).
	3. PMCS not properly installed or not properly configured with IED addresses and communication settings.	Check that PMCS is correctly installed and running and has been configured with the Modbus addresses and communication settings of all attached IEDs.
	4. DDE Server not running.	Check that the DDE Server is correctly installed and running.
(RS-485 host only)	5. RS-485 interface installed incorrectly or not functioning.	Ensure that the RS-485 card or RS-232/RS-485 converter is properly installed at the host PC and that the RS-485 cables are correctly attached to the interface card or converter.
		RS-232/RS-485 converter: Ensure that the DIP switches inside the converter are set properly for the baud rate of the RS-485 segment. See the converter documentation for further information & instructions.
(Ethernet host only)	6. Ethernet network down or improperly connected.	Check the connections at the host PC Ethernet card for loose or improper connections. Check with LAN personnel for network-wide problems that might be affecting the Ethernet Gateway or host.
(Ethernet host only)	7. Ethernet Gateway not powered, not connected to Ethernet or RS-485 ports, or connected but improperly configured.	Check that the Ethernet Gateway has control power and is properly connected to the Ethernet and to the RS-485 ports. Make sure that the Gateway has been properly configured for the attached RS-485 networks.
(EPM 7700 only)	8. Device communication settings are incorrect.	Refer to the XPRESS Card manual that accompanied your meter. PMCS Ethernet connections require the following XPRESS Card settings:
		1. An IP address (mandatory)
		2. A subnet mask (network-dependent option)
		3. A default gateway (optional; required to communicate between networks)
		4. IP port number must be set to 7700 (mandatory)
		5. Use the ION protocol (mandatory)

Symptom	Possible Cause	Corrective Action
(EPM 7700 only)	9. Network configuration is incorrect.	Refer to the following PMCS technical documentation: 1. DEH-40035, GE 7700 Gateway User's Guide, section titled "EPM 7700 Network Configuration." 2. GEH-6514, the PMCS Read-This-Book-First, section titled "Configuring the EPM 7700 Device Network."
(EPM 9450Q / 9650Q with Ethernet option only)	10. Device communication settings are incorrect.	Using the EPM 9000 Series Communicator software check device profile: 1. A device IP address (Host address) 2. Device Port set to 502 3. A subnet mask (network-dependent option) 4. A default gateway (optional; required to communicate between networks)
(EPM 9450Q / 9650Q with Ethernet option and acting as an Ethernet Gateway only)	11. Device communication settings are incorrect.	Check that the Ethernet Gateway Port of the EPM 9450Q/9650Q Gateway is wired to each Modbus device Port 1. Using the EPM 9000 Series Communicator software check device profiles: 1. The pass through baud rate setting of EPM 9450Q/9650Q Gateway must match the baud rates of all Modbus devices 2. All Modbus devices must have unique addresses.
2. No communication to one or more Modbus IEDs; some IEDs OK.	1. The IED or a repeater is not powered.	Check that control power is supplied to all IEDs and repeaters. If the IED or repeater does not operate when control power is present, contact the GE Resolution Center at 1-888-GE-RESOLV.
	2. RS-485 wiring is shorted or improperly connected.	Locate and remove the short or incorrect connection.
	3. An RS-485 shield has been grounded incorrectly.	Refer to Section 2–4, Rule 5 for proper RS-485 grounding considerations. Recheck the RS-485 network for compliance. Improper grounding can cause communication errors.
	4. The network configuration is incorrect.	Check that the network conforms to Rules 1 through 8 regarding RS-485 wiring in Chapter 2.
	5. The IED is not addressed.	Ensure that each IED's Modbus address corresponds to the address set at the PMCS.

Symptom	Possible Cause	Corrective Action
	6. Two or more Modbus IEDs have the same address.	Check IEDs for duplicate address assignments. Change the address of the affected IED, then attempt to communicate with the original address to see if another IED has that address. Check any dual-port IEDs to be sure that each RS-485 port is wired to a separate RS-485 network.
3. No communication to any IEDs on one commnet segment.	1. The IEDs or a Repeater on that segment is not powered.	Check that control power is supplied to all IEDs. Check that two LEDs are lit on each Repeater, indicating that control power is present. If the IED or Repeater does not operate when control power is present, contact the GE Resolution Center at 1-888-GE-RESOLV.
	2. Commnet wires are shorted or improperly connected.	Locate and remove the short or incorrect connection.
	3. The network configuration of the segment is incorrect.	Check that the segment conforms to Rules 1 through 5 in Chapter 2 regarding the number of IEDs permitted per commnet segment and wiring requirements and limitations.

Symptom	Possible Cause	Corrective Action
4. No communication to one or more commnet IEDs.	1. The IED or a Repeater on that segment is not powered.	Check that control power is supplied to all IEDs. Check that two LEDs are lit on each Repeater, indicating that control power is present. If the IED or Repeater does not operate when control power is present, contact the GE Resolution Center at 1-888-GE-RESOLV.
	2. The IED is not addressed.	Set the commnet address at the IED and configure the Modbus Concentrator to recognize the IED and assign it a Modbus-equivalent address. Enter the Modbus-equivalent address into the PMCS.
	3. Two or more IEDs on the Modbus Concentrator have the same address.	Check the Modbus Concentrator and IEDs for duplicate address assignments. Change the address of the affected IED (at the IED and the Concentrator), then attempt to communicate with the original address to see if another IED has that address.
5. Intermittent communication to an IED (Modbus or commnet).	1. The network configuration is incorrect.	Check that the network conforms to the rules in Chapter 2.
	2. The IED or a Repeater is not powered or has inconsistent power.	Check the control power supplied to the IED and to any Repeaters on the network or segment.
	3. Two or more IEDs on the network have the same address.	Check the host for duplicate address assignments. Change the address of the affected IED, then attempt to communicate with the original address to see if another IED has that address.

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Overview

A power management system consists of a host IED connected via a communication network to metering and protective IEDs. PMCS supports up to 256 RS-485 Modbus RTU communication networks, to which are attached various power management IEDs. Each RS-485 network is capable of supporting up to 247 IEDs on up to 4000 feet of interconnecting shielded, twisted-pair cable per network. The network protocol is peer-to-peer, contention-sensing, multiple-access, collision-detection (CSMACD).

This appendix lists the features and functions of various IEDs that are compatible with Power Management Control System. The title bar above each IED gives its name and its general function. This is followed by a brief description of the IED and its features and functions.

239 Motor Protection Relay

The 239 relay is designed to fully protect three-phase ac motors against conditions that can cause damage. In addition to motor protection, the relay has features that can protect associated mechanical equipment, give an alarm before damage results from a process malfunction, diagnose problems after a fault, and allow verification of correct relay operation during routine maintenance.

Using the Modbus serial communications interface, motor starters throughout a plant can be connected to a central control and monitoring system for continuous monitoring and fast fault diagnosis of a complete process.

One relay is required per motor starter. Setpoints are entered via the front panel or with a computer. Status, actual values, and trouble-shooting information are available in clear English from the front-panel display. A simulation mode and pickup indicator allow testing and verification of correct operation without requiring a relay test set.

With the use of the RTD option, up to three RTDs can be monitored. These can all be in the stator or one in the stator and two in the bearings. An optional analog output is also available for direct PLC interface or metering of the motor thermal capacity.

Installing a 239 relay in a motor starter for protection and monitoring of small- to medium-sized motors will minimize downtime due to process problems.

Application
- Small- to medium-sized motors
- Pumps, conveyors, compressors, fans, sawmills, mines
- Variable-frequency drives

Protection
- Overload (15 selectable curves)
- Phase short circuit
- Locked rotor/mechanical jam
- Thermal memory lockout
- Single phase/unbalance
- Ground fault
- Overtemperature: thermistor
- Additional three RTDs optional
- Undercurrent
- Trip/alarm/auxiliary/service outputs
- Five switch inputs

Monitoring and Metering
- Status/current/temperature display
- Process control
- Optional analog output
- Simulation mode for field testing

User Interface
- RS-485 Modbus communications
- 40-character illuminated display
- Six LED indicators
- Keypad

Features
- ac/dc control power
- Compact size, fits most motor starters
- NEMA12/IP53 enclosure

269+ Motor Management Relay

The 269 Plus Motor Relay provides complete, accurate protection for industrial motors and their associated mechanical systems, offering a wide range of protection, monitoring, and diagnostic features including the following (functions with an asterisk require the optional Meter Transducer Module):

Metering
- Currents (Ia, Ib, Ic)
- Ground Current
- Voltages* (Va-b, Vb-c, Vc-a)
- kW*, kVAR*
- Power Factor*

- Running MWHr*
- Frequency

Protection

- Overload
- Short Circuit
- Rapid Trip
- Immediate Overload
- Current Unbalance
- Ground Fault
- Overtemperature
- Overvoltage
- Undervoltage
- Power Factor
- Undercurrent
- Thermal Capacity

565 Feeder Management Relay

The 565 feeder management relay is designed to provide complete and accurate feeder protection, providing the following functions (functions with an asterisk require the optional Meter Transducer Module):

Metering

- RMS phase and ground current
- Phase volts
- Peak amps demand
- Frequency
- Power factor*
- kW*, kVAR*, kWHr*
- Peak kW*, kVAR demand*

Protection and alarm

- Phase and ground-overcurrent
- Current unbalance
- Overvoltage
- Undervoltage
- Power factor*
- Under/Over frequency*
- Peak Amps, kW*, kVAR* demand
- Undercurrent
- Thermal capacity

735 Feeder Relay

The 735 is a microprocessor-based relay for primary circuit protection on distribution networks at any voltage level. Protection features include three-phase

timed overcurrent, phase instantaneous overcurrent, ground timed overcurrent, and ground instantaneous overcurrent. Each protection element can be selectively enabled with the front-panel dial settings. Flexible settings and selectable curve shapes enable accurate coordination with other IEDs. Installation and maintenance costs are lower when the SR735 is used instead of the eight separate over-current protection IEDs it can replace.

The SR735 has three output contacts: trip, auxiliary trip, and service required. The auxiliary trip may be set to follow the main trip relay, act as an 86 Lockout relay, or to respond only to ground-overcurrent faults, while the main trip responds only to phase-overcurrent faults.

The SR735 has eight trip indicators on the front panel, along with a button to reset the relay. Four status indicators provide a quick visual check of relay status. A bar graph indicates current load as a percent of CT rating.

Communications switches on the front panel set baud rate, relay address, and the simulation mode for testing. An RS-485 connection is provided for computer access. Software is provided with the relay to allow setup and simulation testing.

Computer access allows the display of a trip record, which contains the pre-trip currents and the last five trip conditions. Computer access also allows the display of metered current values as a percent of CT rating, output relay status, status indicators, and dial settings.

The SR735 has a drawout construction and can be door or 19-inch rack mounted.

Application

- Feeder protection, any voltage level

Protection and Control

- Three-phase time overcurrent
- Ground time overcurrent
- Five curve shapes
- Four curve-shift multipliers per curve
- 10 time multipliers per curve
- ANSI, IAC, or IEC/BS142 curves
- Phase instantaneous overcurrent
- Ground instantaneous overcurrent
- Pickup level for each overcurrent
- Outputs: trip, aux. trip, service
- Aux. trip: 86 lockout, ground trip
- Block instantaneous on autoreclose

Monitoring

- Trip record of last five trips
- Pre-trip data includes currents
- True RMS sensing
- Monitor currents, output relays, status, settings

User Interface
- Eight LED trip indicators
- Four LED status indicators
- Current bar graph, percent of CT rating
- RS-485 communications
- Modbus RTU protocol
- Baud rate up to 19,200
- Software for setup and simulation

Features
- 1 amp or 5 amp CT input
- 20–260 V ac/dc control power
- Drawout case
- Switchgear door or 19-inch rack mount

MX200 (Microprocessor Controller)

GE Zenith Controls MX200 advanced microprocessor controller is designed for the most demanding transfer or bypass switch applications. It may be specified with standard options or programmed to use any or all of the most commonly used options for today's transfer switch operation. It also may be equipped with our ZNET200 remote communication interface for use with annunciators, modems or PC control.

The MX200 manages switch operation via a convenient touchpad that provides indication setting and diagnostic capabilities. As an embedded digital controller, the device offers high reliability and ease of unattended operation across a range of applications.

The GE-Zenith MX200 (Microprocessor offers the following features:
- Multipurpose display: LEDs for continuous monitoring of switch position and source availability; a four-line by 20-character, backlit LCD display for settings, functions, programming and annunciation
- Through-the-door programming and display
- Simplified keypad entry—menu-driven system is designed for ease of use

- Built-in diagnostics with displays for ease of troubleshooting
- Passcode protected to limit user access
- Timer countdown display for ease of operation
- User settings unaffected by power outages
- Wide range of accessories and configurations available for the most demanding applications

Design and Construction Features
- Close differential three-phase under-voltage sensing of the normal source—factory standard setting 90% pickup, 80% dropout (adjustable); under-frequency sensing of the normal source factory setting 95% pickup (adjustable)
- Voltage and frequency sensing of the emergency source—factory standard setting 90% pickup voltage, 95% pickup frequency (adjustable)
- Test switch (fast test/load/no load) to simulate normal source failure—automatically bypassed should the emergency source fail
- Type 1 enclosure is standard; also available in open style or Types 3R, 4 or 12
- Double-throw, mechanically interlocked contactor mechanism
- Electrically operated, mechanically held
- Designed for emergency and standby applications

MX250 (Microprocessor Controller)

GE Zenith Controls MX250 advanced microprocessor controller is designed for the most demanding transfer or bypass switch applications. It may be specified with standard options or programmed to use any or all of the most commonly used options for today's transfer switch operation. It also may be equipped with our ZNET250 remote communication interface for use with annunciators, modems or PC control.

The MX250 manages switch operation via a convenient touchpad that provides indication setting and diagnostic capabilities. As an embedded digital controller, the device offers high reliability and ease of unattended operation across a range of applications.

The GE-Zenith MX250 (Microprocessor offers the following features:

- Multipurpose display: LEDs for continuous monitoring of switch position and source availability; a four-line by 20-character, backlit LCD display for settings, functions, programming and annunciation
- Through-the-door programming and display
- Simplified keypad entry—menu-driven system is designed for ease of use
- Built-in diagnostics with displays for ease of troubleshooting
- Passcode protected to limit user access
- Timer countdown display for ease of operation
- User settings unaffected by power outages
- Wide range of accessories and configurations available for the most demanding applications

Design and Construction Features
- Close differential three-phase under-voltage sensing of the normal source—factory standard setting 90% pickup, 80% dropout (adjustable); under-frequency sensing of the normal source factory setting 95% pickup (adjustable)
- Voltage and frequency sensing of the emergency source—factory standard setting 90% pickup voltage, 95% pickup frequency (adjustable)
- Test switch (fast test/load/no load) to simulate normal source failure—automatically bypassed should the emergency source fail
- Type 1 enclosure is standard; also available in open style or Types 3R, 4 or 12
- Double-throw, mechanically interlocked contactor mechanism
- Electrically operated, mechanically held
- Designed for emergency and standby applications

Generator PLC (Series 90-70)

The Generator PLC is configured in such a way that Master PLC has all the information of all the 16 Generator Parameters.

The Generator PLC offers the following features:

Metering and Monitoring
- Metering: A, V, W, var, Hz
- Generator Parameters
- Paralleling Switch gear parameters

Electronic Power Meter EPM 7330

The EPM 7330 gives you all the high-accuracy measurements of the EPM 7300, plus on-board data storage, setpoints, standard digital I/O and an optional Ethernet port and optional built-in modem either of which can be used as a gateway to as many as 31 serial devices.

Applications Summary

- **Cost Allocation & Billing**
- **Demand & Power Factor Control**
- **Load Studies & Circuit Optimization**
- **Equipment Monitoring & Control**
- **PreventativeMaintenance**

The EPM 7330 offers the following features:

Measurements
- Energy: bi-directional, absolute & net
- Demand: Sliding Window, Predicted, & Thermal
- Harmonics: individual & total harmonic distortion up to the 15th

Communications
- allows distribution of metered data and alarms over the Internet
- 1 Optional built-in modem allows access to up to 31 RS-485 devices
- 1 Optional Ethernet port with EtherGate™, allows access to RS-485 device networks
- 2 RS-485 ports
- 1 front panel optical port
- Modbus™ RTU on serial, Ethernet, modem, & infrared ports
- DNP 3.0 on serial, modem, & infrared ports

On-Board Data Logging
- Scheduled or event-driven logging of up to 32 parameters
- Sequence-of-events & min/max logging
- Setpoints for Control and Alarms
- Setpoint on any parameter or condition
- 1 second operation

Inputs and Outputs
- 4 digital inputs for status/counter functions
- 4 relay outputs for control/pulse functions
- Optional Analog inputs and outputs

Switchboard Draw-out Cases

- Fits into existing GE S1 or ABB FT21 switchboard cases.

Instantaneous Measurements

- Voltage (l-l/l-n), per phase and average
- Current, per phase and average
- Real Power, per phase and total
- Reactive Power, per phase and total
- Apparent Power, per phase and total
- Power Factor, (lead/lag), per phase and total
- Voltage Unbalance
- Current Unbalance
- Frequency

Energy

- Imported, exported, absolute and net kWh & kVARh. Accumulated kVAh

Demand

- Sliding Window, Predicted, and Thermal Demand on kW, kVAR, kVA, and I average

Minimums and Maximums

- Voltage (l-l/l-n) per phase
- Current per phase
- kW, kVAR, kVA, Power Factor, Frequency

Sliding Window Demand for kW and kVA

Electronic Power Meter EPM 3710

The Electronic Power Meter (EPM) 3710 is a 16-bit microprocessor-based digital instrumentation package for three-phase industrial, commercial, and utility power systems. The EPM 3710 offers a large array of measurements, waveform capture for harmonic analysis, and setpoint-controlled relays, including the following features:

- Three-phase voltage inputs
- Three-phase current inputs
- Neutral/ground current input
- Three relay outputs
- Four digital inputs with pulse counter on one input with maximum pulse-count frequency 0.3 Hz
- One analog voltage input, one analog current output
- 80 measured parameters
- Waveform-capture triggering communication port

- Trend log with one preset log, 12 parameters, 1200-record capacity, triggered by time interval (Optional: one programmable log, 12 parameters, 11,520 record capacity [40 days])
- Event log with 50 records standard, one-second resolution (optional: 100 records)
- Minimum/maximum log with 17 parameters
- 17 standard-speed setpoints trigger event log or relay control

The Electronic Power Meter 3710 offers 38 high-accuracy, real-time measured parameters, minima and maxima for 21 parameters, and 25 status parameters.

All voltage, current, power, and energy readings are true RMS, including harmonics. Energy readings provide bi-directional (import/export) indication.

No potential transformers (PTs) are required on the voltage inputs for systems up to 347 Vac line-to-neutral/600 Vac line-to-line. For higher voltage systems, PTs with 120 Vac secondaries may be used. The transformer-coupled current inputs provide 300 A surge protection and accept CTs with 5 A full-scale outputs.

Electronic Power Meter EPM 3720

The Electronic Power Meter 3720 offers the same capabilities as the EPM 3710, plus many additional measurements and more advanced features, including the following:

- Three-phase voltage inputs
- Three-phase current inputs
- Neutral/ground current input
- Three relay outputs
- Four digital inputs with pulse-counter on all four inputs with maximum pulse count frequency of 10 Hz
- One analog voltage input, one analog current output
- 729 measured parameters, including harmonic distortion and demand
- Waveform-capture triggering communications port or setpoint
- Waveform-recording triggering communications port or setpoint
- Eight programmable trend logs, 12 parameters each, 11,520 record capacity (40 days), triggered by time interval or setpoint
- Event log with 100 records standard, resolution one second

- Minimum/maximum logs: one preset with over 100 parameters; 16 programmable logs of 16 parameters each with a trigger parameter for each log
- 17 setpoints: 11 standard-speed, six high-speed; trigger event log, relay control, snapshot log, waveform capture or waveform recorder

The Electronic Power Meter 3720 provides hundreds of high-accuracy real-time measured parameters, as well as minima, maxima, and status parameters.

All voltage, current, power, and energy readings are true RMS and sensitive to beyond the 50th harmonic. Four-quadrant readings measure bidirectional (import/export) energy flow, useful in any cogeneration application.

No PTs are required on the voltage inputs for systems up to 347 Vac line-to-neutral and 600 Vac line-to-line. For higher-voltage systems, PTs with 120 Vac secondaries may be used. The transformer-coupled current inputs provide 300 A surge protection and accept CTs with 5 A full-scale outputs.

Electronic Power Meter EPM 7300

The Electronic Power Meter 7300 provides over 100 high-accuracy, three-phase measurements. Its compact size, simple installation and high reliability make it ideal for use in panelboards, switchboards, switchgear, gensets and UPS systems. With RS-485 communications, it can be integrated into a power management system such as PMCS.

Instantaneous Measurements
- Voltage (l-l/l-n), per phase and average
- Current, per phase and average
- Real Power, per phase and total
- Reactive Power, per phase and total
- Apparent Power, per phase and total
- Power Factor, (lead/lag), per phase and total
- Voltage Unbalance
- Current Unbalance
- Frequency

Energy
- Imported, exported, absolute and net kWh & kVARh. Accumulated kVAh

Demand
- Sliding Window, Predicted, and Thermal Demand on kW, kVAR, kVA, and I average

Minimums and Maximums
- Voltage (l-l/l-n) per phase
- Current per phase
- kW, kVAR, kVA, Power Factor, Frequency
- Sliding Window Demand for kW and kVA

Electronic Power Meter EPM 7500/7600/7700

The EPM 7500/7600/7700 is a highly advanced digital power meter, suited to virtually any power monitoring and control application. This Intelligent Electronic Device (IED) can take the place of numerous transducers, meters and control circuits in a power monitoring system. The EPM 7700 provides true RMS measurements of voltage, current, power and energy, complemented by extensive I/O capabilities, comprehensive logging, and advanced power quality functions.

Instantaneous Measurements
- Voltage (l-l/l-n), per phase and average
- Current, per phase, average and neutral
- Real Power, per phase and total
- Reactive Power, per phase and total
- Apparent Power, per phase and total
- Power Factor, (lead/lag), per phase and total
- Voltage and Current Unbalance
- Frequency

Energy
- Imported, exported, absolute and net kWh & kVARh. Accumulated kVAh.

Demand
- Calculates Demand and Peak Demand on any instantaneous value. Defaults: Sliding Window, Predicted, and Thermal Demand on kW, kVAR, kVA, and I average

Minimums and Maximums
- Any parameter over any time interval (e.g., daily, monthly)

GE Fanuc PLC 90/30

GE Fanuc's Series 90/30 Programmable Logic Controller (PLC) is a family of controllers, I/O systems, and specialty modules designed to meet the demand for a versatile industrial control. Its compact backplane design allows up to five modules to be easily snapped in for access to a large variety of discrete and analog I/O modules, as well as specialty modules. Various modules

can provide control for a wide range of applications, such as high-speed packaging, material handling, complicated motion control, water treatment, continuous emissions monitoring, mining, food processing, elevator control, and injection molding. PLC 90/30 functions supported by PMCS are listed below, under the PLC 90/70 heading.

GE Fanuc PLC 90/70

GE Fanuc's Series 90/70 Programmable Logic Controller offers a greater level of power and flexibility than the Series 90/30, and is the preferred choice for high-density input/output. The 90/70 shares the flexible backplane design of the 90/30, while offering a selection of more powerful microprocessor CPUs.

The Series 90/70 PLC offers access to a large variety of discrete and analog I/O modules. Input modules supporting eight to 32 circuits in a variety of voltages are available, as are a range of output modules. The features and functions provided by the PLC 90/70 vary depending on the options installed in the backplane. See your GE Industrial Systems sales engineer for more details on the PLC 90/30 or 90/70.

The PLC 90/30 and PLC 90/70 functions supported by the Power Management Control System include the following:

- Reading of input and output tables
- Reading of registers
- Reading of analog inputs
- Reading of exception status
- Preset single registers
- Force multiple outputs
- Preset multiple registers
- Report IED type
- Read scratchpad memory

GE Fanuc PLC Micro 90

GE Fanuc's Series 90 Micro PLC Programmable Logic Controller offers power, flexibility, and robust construction in a compact package. The Series 90 Micro PLC is an ideal way to replace relays and automate small processes. Its all-in-one construction saves panel space and its powerful features bring productivity and cost savings to even the most cost-conscious control applications. The Micro PLC is a perfect solution for such applications as packaging, industrial machinery, material handling, and printing.

EPM 5000P/5200P/5300P/5350P

The EPM 5000P/5200P/5300P/5350P advanced multifunction monitoring system replaces all individual single-function meters and transducers. This monitor measures volts, amps, frequency and all power functions, including watts, vars, frequency, power, watt-hours, var/hours, demand, harmonics and more. It offers 283 readings in a standard switchboard-size footprint.

The EPM 5000P/5200P/5300P/5350P also displays %THD, K factor and harmonic waveforms.

The EPM 5350P offers the following features other than in the series

- Ethernet TCP/IP

The 5000P/5200P/5300P/5350P device series offers the following features:

- Measures Volts, Amps, Watts, Vars, VA, PF, Frequency, Watt-Hour, VA/hour, VAR/hour
- Measure Harmonics to the 31st Order
- Provides Captured Waveform of Voltage and Current Set Point
- Control With Logical Descriptors Relay Outputs and Pulse Outputs Max and Min for
- Ten Channels of Analog Outputs (0-1 or 4-20mA)
- KYZ-Pulse Outputs (For EPM 5200P)

MicroVersaTrip-C and -D and Spectra MicroVersaTrip Trip Units

PMCS supports three varieties of this popular line of electronic trip units: the Enhanced MicroVersaTrip-C, Enhanced MicroVersaTrip-D, and the Spectra MicroVersaTrip. MicroVersaTrip trip units act to trip the circuit breaker when one of the following user-defined parameters is exceeded (parameters identified by an asterisk are optional features of the trip unit.):

Overcurrent
- Long-time
- Short-time*
- Instantaneous
- High-range instantaneous*
- Ground fault*
- Zone select*

Protective relays*
- Overvoltage

- Undervoltage
- Overcurrent
- Voltage unbalance
- Current unbalance
- Reverse power

The MicroVersaTrip trip unit is also capable of limited metering functions. It can measure current and voltage at a circuit breaker and use these to calculate other electrical parameters. Information on current is supplied by the breaker's current sensors. Voltage information is supplied by the equipment bus potential transformers through voltage conditioners.

It can measure or calculate values of the following parameters.

- RMS current: phases A, B, and C
- RMS voltage: phases A, B, and C
- Watts: phases A, B, and C
- Volt-amperes: phases A, B, and C
- Watt-hours: phases A, B, and C
- Frequency
- Power factor

Modbus Concentrator

The POWER LEADER Modbus Concentrator allows PMCS to communicate with POWER LEADER commnet IEDs. The Modbus Concentrator is an RS-485-native IED that collects data from up to 32 attached POWER LEADER commnet IEDs and communicates this data to the PMCS across the POWER LEADER Modbus communication network. In this respect, the POWER LEADER Modbus Concentrator effectively serves as the host IED on up to eight commnet networks while acting as a slave to the master-slave Modbus network.

The major functions provided by the POWER LEADER Modbus Concentrator are:

- Configuration of commnet IEDs
- Data collection from commnet IEDs
- Processing of metering data
- Demand and Energy calculations
- Processing of events (trips and alarms)
- Executions of commands upon host request

Electronic Power Meter (PLEPM)

The POWER LEADER Electronic Power Meter (PLEPM) is a full-function electronic meter with optional pulse initiation. The PLEPM continuously monitors specified line characteristics and shows the desired functions and calculated values on a two-line, back-lit liquid crystal display on the front panel.

The PLEPM monitors and stores values for each current and voltage input. From these values it calculates RMS voltage, RMS current, real and reactive power, and other time-based functions. Data are then sent automatically to the display.

The PLEPM monitors and displays the following electrical parameters:

- RMS current (Phases A, B, C and neutral)
- RMS voltage (Phases A-N, B-N, C-N, A-B, B-C, C-A)
- Watts (Phases A, B, C and total)
- VARs
- Volt-amps (Phases A, B, C, and total)
- Power Factor, total
- Watt-hours total
- VARs (Phase A, B, C, and total)
- VAR-Hours, Total Lag, Total Lead, and Total
- Current demand
- Peak current
- Watts demand
- Peak watts demand
- Frequency Hz

The PLEPM is available in configurations accepting direct voltage inputs from 69 Vac to 600 Vac. For system voltages greater than 600 Vac external PTs must be supplied. Meter current inputs are rated at 5 amps ac nominal. External CTs must be supplied.

POWER LEADER Ethernet Gateway

The Power Management Control System host may be located on a PC connected to an Ethernet. If this is the case, an IED named the POWER LEADER Ethernet Gateway is required to connect Modbus-based networks of IEDs to the Ethernet-based host PC. The POWER LEADER Ethernet Gateway is an industrial computer equipped with Modbus and Ethernet communications.

It provides an interface for transferring messages between an Ethernet network and up to four Modbus networks containing up to 31 IEDs each, serving as a "traffic controller" to pass messages between the Modbus network(s) and Ethernet network.

When the Gateway receives a message from the Ethernet or Modbus network, it translates the message

protocol and forwards the message to the correct destination. The Ethernet Gateway converts messages from the Modbus RTU protocol to Ethernet's TCP/IP protocol (and vice versa) directly. No interpretation or concentration of IED data is performed by the Gateway.

The Ethernet Gateway's major functions are:
- Relay data from Modbus network(s) to the PMCS host on the Ethernet network
- Deliver messages and commands from the host to the attached Modbus and commnet IEDs

POWER LEADER Junction/Outlet Box

The POWER LEADER Junction/Outlet Box allows the interconnection of as many as four commnet cables to create system nodes on a commnet segment attached to the Modbus Concentrator. This is useful to economize the wiring on a given commnet segment.

POWER LEADER MDP Overcurrent Relay

The MDP Overcurrent Relay is a microprocessor-based, non-directional overcurrent relay that protects circuits from phase-to-phase and phase-to-ground faults.

Included with the MDP Overcurrent Relay are four measuring units, one for each of the three-phase currents and one for ground or residual current. Each of the four measuring units includes a time and an instantaneous overcurrent unit.

Features include:
- Inverse overcurrent, including four characteristic curves and four values of definite time protection, and instantaneous overcurrent protection with programmable delay.
- Phase and ground current measurement.
- Phase and ground current metering.
- Operating time and fault current of the last trip.

POWER LEADER Meter

The POWER LEADER Meter measures currents and voltages in a single compartment and uses these to calculate other system parameters. The current inputs are taken from standard 5 A CT secondaries, while the voltage inputs are taken from 120 Vac PT secondaries. The following parameters can be viewed:
- RMS current
- RMS voltage
- Watts

- VARs
- Volt-amps
- Power Factor
- Watt-hours
- VAR-hours
- Current demand
- Peak current
- Watts demand
- Peak watts demand
- Frequency
- Harmonic distortion
- Waveform capture

These parameters can also be viewed at the host computer. Requests may be entered locally or from the host.

The Meter has two relay outputs that can be programmed to provide IED protection.

POWER LEADER Modbus Monitor

The POWER LEADER Modbus Monitor provides a central station for viewing metering and status information collected from multiple remote power management IEDs. The Monitor may be mounted in equipment or independently and offers two RS-485 ports for connection to one or two separate RS-485 networks. Up to two Modbus Monitors may be installed on a single RS-485 network, providing multiple locations to view data.

Features
- Easy-to-use, menu-driven user interface
- Large, high-visibility display
- Customizable display of data
- View the event log of the previous 50 events with time and date stamp
- View PMCS log – displays last 50 events logged by the PMCS Event Logger, regardless of which network the events happened on
- Universal power supply accepts 100–240 Vac, 125–250 Vdc

POWER LEADER Repeater

The POWER LEADER Repeater regenerates signals on long commnet segments and allows the range of the commnet segment to be extended beyond the 1000-foot limit. See Section 2–1 for configuration rules to create extended-range commnet segments.

Power Management Control System
Appendix A — IED Descriptions

Power Quality Meter (PQM)

When continuous monitoring of a three-phase system is required, the Power Quality Meter (PQM) is an ideal choice. It provides metering for current, voltage, real and reactive power, energy use, cost of power, power factor, and frequency. Programmable setpoints and four assignable output relays allow control functions to be added for specific applications. These include basic alarm on over/undercurrent or -voltage, unbalance, demand-based load shedding, and capacitor power factor-correction control. More complex control is possible using the four switch inputs, which also can be used for status, such as breaker open or closed and flow information.

The PQM is a data-gathering IED for a plant-automation system that integrates process, instrument, and electrical requirements. All monitored values are available via two digital RS-485 communication ports running the Modbus protocol. If analog values are required for direct interface to a PLC, any of the monitored values can be output as a 4–20 mA signal to replace up to four separate transducers. A process variable can be measured using the analog input. An RS-232 communication port can be connected to a PC for simultaneous access of information by other plant personnel via the front panel.

With increasing use of electronic loads, such as computers, ballasts, or variable-frequency drives, the quality of the power system is important. With the PQM's harmonic-analysis option, any phase current or voltage can be displayed and the harmonic content calculated. Knowing the harmonic distribution, you can take action to prevent overheated transformers, motors, capacitors, and neutral wires and nuisance breaker trips. Redistribution of system loading can also be determined. Waveform and chart recorder printouts available from the PQM assist in problem diagnosis.

Applications
- Metering of distribution feeders, transformers, generators, capacitor banks, and motors
- Medium- and low-voltage systems
- Commercial, industrial, utility
- Flexible control for demand load shedding, power factor, etc.
- Power quality analysis

Measure/Control
- A, V, W, var, VA, varh, Wh, PF, Hz unbalance
- A, W, var, VA demand
- Load shedding

- Power factor control

Communication
- Ports: RS232 front, dual RS-485 rear
- Modbus RTU protocol
- Mini RTU: digital four in/four out
- Analog one in/four out
- Local/remote display of all values

Maintenance
- Harmonic analysis through 62nd harmonic with THD and TIF
- Event recorder
- Waveform capture
- Data logger

RS-485 Repeater

Repeaters extend the range of an RS-485 network. The following commercially available RS-485 repeater is recommended for use with the PMCS, in accordance with the configuration rules explained in Chapter 2.

Manufacturer	Description
OPTO 22	AC38 RS-485 Isolated Multidrop Repeater

EPM8000 Power Quality Meter (PQMII)

When continuous monitoring of a three-phase system is required, the Power Quality Meter (PQMII) is an ideal choice. It provides metering for current, voltage, real and reactive power, energy use, cost of power, power factor, and frequency. Programmable setpoints and four assignable output relays allow control functions to be added for specific applications. These include basic alarm on over/undercurrent or -voltage, unbalance, demand-based load shedding, and capacitor power factor-correction control. More complex control is possible using the four switch inputs, which also can be used for status, such as breaker open or closed and flow information.

The PQM is a data-gathering IED for a plant-automation system that integrates process, instrument, and electrical requirements. All monitored values are available via two digital RS-485 communication ports running the Modbus protocol. If analog values are required for direct interface to a PLC, any of the monitored values can be output as a 4–20 mA signal to replace up to four separate transducers. A process

variable can be measured using the analog input. An RS-232 communication port can be connected to a PC for simultaneous access of information by other plant personnel via the front panel.

With increasing use of electronic loads, such as computers, ballasts, or variable-frequency drives, the quality of the power system is important. With the PQM's harmonic-analysis option, any phase current or voltage can be displayed and the harmonic content calculated. Knowing the harmonic distribution, you can take action to prevent overheated transformers, motors, capacitors, and neutral wires and nuisance breaker trips. Redistribution of system loading can also be determined. Waveform and chart recorder printouts available from the PQM assist in problem diagnosis.

Applications
- Metering of distribution feeders, transformers, generators, capacitor banks, and motors
- Medium- and low-voltage systems
- Commercial, industrial, utility
- Flexible control for demand load shedding, power factor, etc.
- Power quality analysis

Measure/Control
- A, V, W, var, VA, varh, Wh, PF, Hz unbalance
- A, W, var, VA demand
- Load shedding
- Power factor control

Communication
- Ports: RS232 front, dual RS-485 rear
- Modbus RTU protocol
- Mini RTU: digital four in/four out
- Analog one in/four out
- Local/remote display of all values

Maintenance
- Harmonic analysis through 62nd harmonic with THD and TIF
- Event recorder
- Waveform capture
- Data logger

RS-485 Repeater

Repeaters extend the range of an RS-485 network. The following commercially available RS-485 repeater is recommended for use with the PMCS, in accordance with the configuration rules explained in Chapter 2.

Manufacturer	Description
OPTO 22	AC38 RS-485 Isolated Multidrop Repeater

369 Motor Management Relay

The 369 is a digital relay that provides protection and monitoring for three phase motors and their associated mechanical systems. A unique feature of the 369 is its ability to "learn" individual motor parameters and to adapt itself to each application. Values such as motor inrush current, cooling rates, and acceleration time may be used to improve the 369's protective capabilities.

369 offers the following features:

- AC/DC control power
- Flash memory
- Simulation mode for field testing
- Trip/Alarm/Aux1/Aux2 Relay Outputs
- Optional split mounting
- Optional remote RTD module

Spectra Electronic Control Module (ECM)

The Spectra RMS Electronic Control Module (ECM) is a microprocessor-based IED that functions as an adjustable overload relay to protect motor starters in GE 8000 Line Motor Control Centers. It works in series with a Spectra RMS Mag-Break® Motor Circuit Protector and a contactor.

The ECM provides the following functions:
- Electronic overload protection in coordination with Motor Circuit Protector
- User-selectable current phase-loss protection
- User-selectable phase-unbalance protection
- User-selectable equipment ground-fault protection
- Control voltage/undervoltage contactor coil
- Current metering (via commnet)
- Full-load amps adjustment of 33–100% of breaker rating plug value
- NEC Relay Class 10/20/30 selection
- Contact for monitoring trip status

Power Management Control System
Appendix A — IED Descriptions

SR469 Motor Management Relay

The SR469 Motor Management Relay is intended for protection and management of medium- and large-horsepower motors and driven equipment. Motor protection, fault diagnostics, power metering, and communication functions have been integrated into one complete, economical draw-out package.

The SR469 has integrated every protection feature that could be considered a benchmark for medium- and large-motor protection. This high degree of integration allows for standardization on one motor-protection relay regardless of application.

The heart of the SR469 is the thermal model. In addition to the current-protection elements, RTD inputs are provided for stator- and bearing-temperature protection. The addition of VT inputs allows for voltage- and power-protection elements. Phase-differential CT inputs are provided for phase-differential protection. All of the protection elements are self-contained and may be enabled as required. This design makes programming the SR469 a simple exercise.

The SR469 has complete monitoring and metering functions. An event recorder stores 40 time- and date-stamped records. Waveform capture of 16 cycles allows for setting the number of pre-trip and post-trip cycles recorded. The SR469 learns the acceleration time, starting current, and thermal capacity required during motor starts. If motor load during starting is relatively consistent, these learned values may be used to fine-tune the acceleration protection. The SR469 can also learn the average motor load over a period of time.

The relay has compete local and remote user interface capabilities. A forty-character display, keypad, and LED indicators provide local communication. A front-panel RS-232 port provides convenient computer access. Two rear-panel RS-485 ports are provided for remote communication.

Applications
- Medium and large motors
- Driven equipment
- Motors with high inertial loads

Protection and Control
- Thermal model biased with RTD feedback and negative sequence current
- Voltage-compensated acceleration
- Undervoltage, overvoltage
- Phase-differential protection

- Underpower for load loss
- Out-of-step for synchronous motors
- Dual overload curves for two-speed motors
- Reduced-voltage starting control
- Trip coil supervision for breakers

Inputs and Outputs
- 12 RTDs, programmable
- Five pre-defined and four assignable digital inputs
- Four analog inputs
- Six output relays
- Four programmable analog outputs

Metering and Monitoring
- A, V, W, var, VA, PF, Hz, Wh, varh demand
- Event recorder – last 40
- Waveform capture – 16 cycles

User Interface
- 22 front-panel LED indicators
- 40-character display
- Control keys and numeric keypad
- RS-232 and two RS-485 ports

SR489 Generator Management Relay

The SR489 Generator Management Relay provides economical protection, metering, and monitoring functions. It can be used as primary or backup protection on synchronous or induction generators of 25, 50, or 60 Hz. It may be applied in primary, backup and cogenerator applications.

The SR489 offers comprehensive generator protection features. These features include phase differential, 100% stator ground, ground-overcurrent, negative-sequence overcurrent, voltage-restrained phase-overcurrents, over- and undervoltage, over- and underfrequency and reverse power. To accommodate synchronous generators, the protection features include overexcitation, loss of field, and inadvertent generator energization.

Monitoring functions include RMS current, negative-sequence current, voltage, three-phase power, and temperature via 12 RTD inputs.

Voltage terminal fuse and breaker operation are monitored and failures reported.

Four analog inputs may be used for monitoring vibration or control transducers. The four analog output channels can be configured to reflect any measured parameter, and may be used to eliminate

costly transducers. Digital inputs may be used to route signals through the SR489 for protection, control, or diagnostic functions.

The user interface includes a 40-character display and a keypad. Twenty-two LED indicators on the front-panel indicate status of the SR489, the generator, and the output relays. A front-panel RS-232 port allows easy local computer access. Two rear-panel RS-485 ports provide remote access. Data communication rates range from 300 to 19,200 baud. All data can be transmitted simultaneously through the three communications ports to PMCS software.

Application
- Synchronous or induction generators
- Primary, backup, and cogenerator

Protection and Control
- Phase differential
- 100% stator ground
- Ground overcurrent
- Anti-motoring (reverse power)
- Loss of field
- Negative-sequence overcurrent
- Instantaneous overcurrent (startup)
- Voltage-restrained phase-overcurrent
- Overexcitation, Volts/Hz
- Undervoltage and overvoltage
- Voltage phase reversal
- Underfrequency and overfrequency
- Stator overtemperature
- Bearing overtemperature, vibration
- Inadvertent generator energization
- Sequential-tripping logic
- Breaker-failure detection
- Overspeed
- VT fuse-failure detection
- Trip coil supervision
- Four analog outputs, four analog inputs
- Seven digital inputs, 12 RTD inputs

Metering and Monitoring
- Metering: A, V, W, var, VA, Wh, varh, PF, Hz
- Demand values: A W var VA
- Event record: last 40 events
- Waveform capture: 16 cycles

User Interface
- 40-character display and keypad
- One RS232 port, two RS-485 ports

SR745 Transformer Management Relay

The SR745 is a high-speed, multiprocessor based, three-phase, two- or three-winding, Transformer Management Relay™ intended for primary protection and management of small, medium and large power transformers.

The SR745 combines percent differential, overcurrent, frequency, and overexcitation protection elements along with monitoring of individual harmonics and THD in one economical package.

The SR745 provides a variety of adaptive relaying features. Adaptive harmonic restraint addresses the problem of false tripping during inrush. Adaptive time-overcurrent elements adjust their pickup settings based on the calculated transformer capability when supplying load currents with high harmonic content. Multiple setpoint groups allow you to enter and dynamically select from as many as four groups of relay settings to address the protection requirements of different power-system configurations. Dynamic CT-ratio mismatch correction monitors the on-load tap position and automatically corrects for CT-ratio mismatch. FlexLogic™ allows PLC-style equations based on logic inputs and protection elements to be assigned to any of the SR745 outputs.

Simulation mode provides a powerful testing and simulation feature. This provides the ability to test the relay operation based on captured or computer-generated waveform data. These data can be converted to a digitized format and downloaded into the SR745's simulation buffer for playback.

The SR745 also provides its own waveform-capture function, which records waveform data for faults, inrush, or alarm conditions.

The autoconfiguration function eliminates the need for any special CT connections by having all CTs connected in wye.

Application
- Small, medium, and large power transformers

Protection
- Percent differential
- Adaptive harmonic restraint
- Multiple overcurrent elements
- Adaptive time O/C elements
- Underfrequency
- Frequency rate-of-change
- Overexcitation

- Multiple setpoint groups

Metering and Monitoring

- All currents
- THD and harmonics
- Demand
- Percent of rated load
- Harmonic analysis
- Tap position
- Ambient temperature
- Analog transducer input
- Waveform capture and playback
- Simulation mode

Inputs/Outputs

- Three analog transducer inputs
- 16 digital (logic) inputs
- Seven analog transducer outputs
- Nine control outputs

Additional Features

- FlexLogic™ (programmable logic)
- Auto-configuration (vector group compensation)
- Dynamic CT-ratio mismatch correction
- RS-232 and RS-485 ports
- Draw-out construction

SR750 Feeder Management Relay

The SR750 Feeder Management Relay is a microprocessor-based relay intended for the management and primary protection of distribution feeders. It can also be used for management and backup protection of busses, transformers, and power lines. The relay tracks the power-system frequency and adjusts the sampling rate to maintain accuracy at all times.

The relay is specifically designed as an economical feeder-management system, incorporating the requirements for protection, control, metering, and both local and remote user interfaces in one assembly. This eliminates the need for expensive discrete components.

Complete overcurrent protection is provided. This includes phase, neutral, ground, and negative-sequence protection for time-overcurrent, hi-set overcurrent, lo-set overcurrent, and directional control. Overvoltage, undervoltage, and underfrequency functions each have two independent stages. With 14 programmable logic

inputs and seven outputs, the SR750 can be easily configured for specific applications. The relay has extensive monitoring and metering functions. It has an internal memory that allows it to record the last 100 events, the last 10 faults, and a total of 256 cycles of oscillography data. The relay performs self-tests in the background during operation. A simulation function allows you to test the relay without the need for external ac voltage and current inputs.

The relay has a two-line display and keypad, as well as three serial ports for computer interface.

Application

- Industrial and utility feeders

Protection and Control

- Complete time overcurrent
- Complete instantaneous overcurrent
- Directional overcurrent control
- Undervoltage and overvoltage
- Negative-sequence voltage
- Undervoltage automatic restoration
- Bus underfrequency
- Underfrequency automatic restoration
- Breaker failure
- Manual close control
- Cold-load pickup control
- Four setting groups
- Syncrocheck - V, f, Hz, & dead-source
- 14 programmable logic inputs
- Bus transfer

Monitoring and Metering

- Fault locator, record of last 10 faults
- Breaker operation & trip failure
- VT Failure
- Power factor – two independent stages
- Analog input – level and rate
- Total breaker arcing current
- Event recorder – Last 100 events
- Oscillography – 256 cycles
- Metering: V, I, Hz, var, VA, PF
- Demand: I_0, I_0, I_0, MW, Mvar, MVA
- Data Logger

User Interface

- 40-character display and 24 LEDs
- Full numeric keypad
- RS-232 and RS-485 ports

SR760 Feeder Management Relay

The Multilin SR760 Feeder Management Relay is an enhanced version of the Multilin SR750 relay, adding a four-shot recloser.

EPM7430D/EPM7450D

The Futura+ multifunction digital power-monitoring system offers the most extensive monitoring and analysis available. Surpassing all other meters in its class, this unit fulfills all your metering, data recording and power analysis needs. This is simply the best power monitoring and analysis solution ever. For a graphical view of all the meter can do, check out the Futura+ Communicator link. You will be very impressed.

Features

- Multifunction Power Monitoring, Measuring Every Parameter of Electrical Power
- True RMS with 0.15% Accuracy
- Extensive On-Board Storage for Virtually Unlimited Data Trending
- 100 High-Speed Captured Waveform Events for Voltage and Current Surges and Sags (All 6 Channels, 60 Cycles Per Channel Constitute an Event)
- Dual Digital Communication Ports: Modbus RTU/ASCII, DNP 3.0, Modbus+ and Ethernet TCP/IP
- Harmonic Distortion to the 31st Order
- Multiple and Remote Displays
- Extensive Digital and Analog I/O Capabilities and Storage

Motor Manager II (MMII)

The Motor Manager 2 (MM2) combines control functions and comprehensive motor protection in one package. This compact device provides sophisticated control and protective relaying at significant cost savings over the discrete devices normally found in a low voltage motor control center (MCC). One MM2 is required for every starter in the MCC. The contactor can be energized and de-energized using the MM2's direct wired inputs, or via the serial port. A total of 6 fixed and 10 programmable switch inputs are available. A wide range of starter types may be controlled by the MM2 using two contactor outputs and two auxiliary outputs. One analog input can be programmed by the user. A programmable undervoltage auto restart function is available. Motor protection features for the

Error! No index entries found.most common causes of failure are provided to prevent costly shut downs and rewinds. These include overload, phase unbalance, locked rotor (stall), ground fault, undercur-rent and underpower. As well, a thermistor input can be provided to protect a hot winding. The relay also checks the contactor status at start and stop commands to indicate contactor failure. Alarms are provid-ed to warn of additional abnormal conditions.

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Appendix B lists documents that may be useful in designing and constructing a PMCS-based power management system.

Questions and problems should be addressed to the GE Resolution Center, 1-888-GE-RESOLV.

Document Number	IED/Subject
GEH-6491	POWER LEADER Modbus Concentrator User's Guide
GEH-6505	POWER LEADER Ethernet Gateway User's Guide
GEH-5904	POWER LEADER Repeater User's Guide
GEH-5947	POWER LEADER Junction Box User's Guide
GEH-6273	MicroVersaTrip Plus and MicroVersaTrip PM Trip Units for Type AKR Low-Voltage Power Circuit Breakers, Power Break I and Power Break II Insulated-Case Circuit Breakers, and R-Frame Molded-Case Circuit Breakers, and Low-Voltage Power Circuit Breaker Conversion Kits
GEH-5892	POWER LEADER Meter User's Guide
GEH-6302	POWER LEADER Electronic Power Meter User's Guide
DEH-027	POWER LEADER Modbus Monitor User's Guide
GEH-6435	Spectra RMS Electronic Control Module
GEK-100682	MDP Overcurrent Relay with commnet
GEH-5933	MicroVersaTrip Plus and MicroVersaTrip PM Rating Plugs
GEH-5934	MicroVersaTrip Plus and MicroVersaTrip PM Trip Units in Spectra RMS Molded-Case Circuit Breakers
GFK-0356	GE Fanuc Series 90™/30 Programmable Logic Controller Installation Manual
GFK-0262	GE Fanuc Series 90™/70 Programmable Logic Controller Installation Manual
GFK-0582	GE Fanuc Series 90™ Programmable Logic Controller Serial Communications User's Manual
MRP70000-0007	Electronic Power Meter 3710
MRP70000-0004	Electronic Power Meter 3720
1665-0003-C5	Multilin Power Quality Meter (PQM)
GEK-106435C	Multilin Power Quality Meter II (PQMII) - EPM8000
1601-0067-C6	Multilin 239 Motor Protection Relay
16010013-BC	Multilin 269+ Motor Management Relay
1601-0057-D3	Multilin SR469 Motor Management Relay
1601-0071-E1	Multilin SR489 Generator Management Relay
1601-0017-E4	Multilin 565 Feeder Management Relay
1601-0048-DA	Multilin 735 Feeder Relay
1601-0070-A3	Multilin SR745 Transformer Management Relay
1601-0044-A8	Multilin SR750/760 Feeder Management Relay
GEH-6508	Modbus Protocol Guide
GEH-6509	PMCS DDE Interface Guide
GEH-6510	PMCS Network and IED Configurator DDE Server Users Guide
GEH-6511	PMCS Waveform Capture
GEH-6512	PMCS Event Logger
GEH-6513	PMCS Interface Toolkit
GEH-6514	PMCS Read This Book First (installation guide)
GEH-6515	PMCS System Test Simulator
DEH-40035	GE 7700 Gateway User's Guide
70000-0019	7300 ION Installation and Operation Manual
N/A	EPM 5200P, 5300P, 5350P Digital Multifunction Power Monitor Instruction Manual
N/A	EPM5000P Digital Multifunction Power Monitor Instruction Manual
N/A	EPM 9450Q and EPM 9650Q Advanced Power Monitor with Power Quality Control Functions, Instruction Manual
Third-party IEDs	Refer to the documentation that accompanied the device.

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This section describes the connections required to wire the following PMCS IEDs into a Modbus RS-485 network:

- GE Fanuc 90/30 and 90/70 PLC's with Communications Coprocessor modules.

- GE Fanuc Micro 90 PLC

- DB9 connections to the Connect Tech RS-485 card

- DB9 connections to the POWER LEADER Ethernet Gateway

90/30 and 90/70 PLCs

To wire the Communications Coprocessor module of a PLC 90/30 or PLC 90/70 to an RS-485 network, you will need two 100-inch lengths of Belden 9271 cable covered with sleeving and a male DB-25 connector.

The DB-25 connector should have the following jumper connections made inside the connector.

- Pin 9 to Pin 13
- Pin 21 to Pin 25
- Pin 22 to Pin 23
- Pin 10 to Pin 11

Connect the two cables to the DB-25 connector as follows:

	Conductor	DB-25 Pin
Cable 1	White	21
	Blue	9
	Shield	1
Cable 2	White	25
	Blue	13
	Shield	1

Apply heat-shrink tape or jacket over the connector for protection.

At the end opposite the connector, strip about 3 inches off the outer jacket of each cable. Label one cable "RS-485 IN" and the other cable "RS-485 OUT".

Micro 90 PLC

NOTE: Micro 90 PLCs withfirmware revisions V3.10 and higher support 2 wire Modbus connections directly – the conversion from 4 wire to 2 wire is only needed with earlier versions.

To wire the communications port of a PLC Micro 90 to an RS-485 network, you will need two 100-inch lengths of Belden 9271 cable covered with sleeving and a B&B Electronics 485FWTW (or equivalent) two-to-four wire converter, a female DB-25 connector, and a male DB-15 connector.

The DB-15 connector should have the following jumper connections made inside the connector:

- Pin 6 to Pin 15
- Pin 8 to Pin 14

Connect the two cables to the B&B 486FWTW as shown in Figures C-1 and C-2.
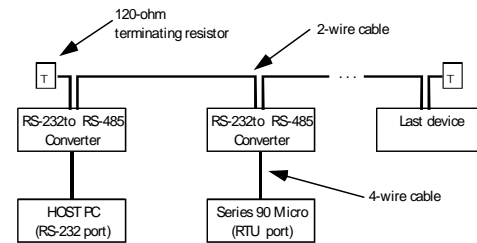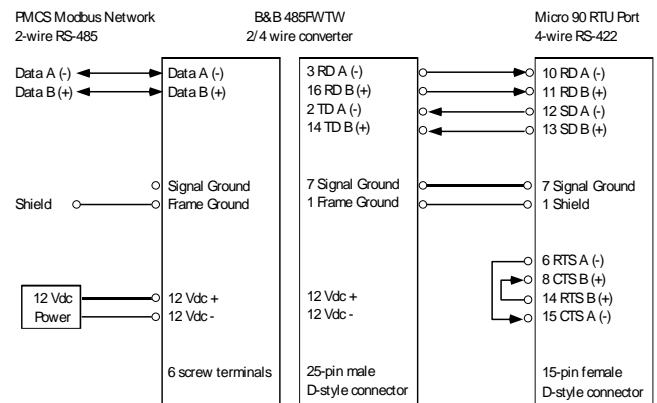

Figure C-1. RS-485 two-wire Modbus network.

Figure C-2. Modbus network and Series 90 Micro RTU Port Wiring.

Power Management Control System
Appendix C – Special Wiring Considerations

⚠ *NOTE:* The RTU port ground signal connection is not required but may be connected if needed. A one- to two-foot length should be enough for the four-wire RTU cable (with 25-pin female and 15-pin male D connectors) between the PLC and the 2/4 wire converter. Only Port 2 can be used for RTU communication on the 28-point Micro 90.

Blue	2
Shield	5

Apply heat-shrink tape or jacket over the connector for protection.

At the end opposite the connector, strip about 3 inches off the outer jacket of the cable.

Connect Tech RS-485 card

For this connection, you'll need a length of Belden 9271 cable covered with sleeving and a female DB-9 connector.

The DB-9 connector should have the following jumper connections made inside the connector.

- Pin 1 to Pin 2
- Pin 3 to Pin 4
- Pin 6 to Pin 7
- Pin 8 to Pin 9

Connect the cable to the DB-9 connector as follows:

	Conductor	DB-9 Pin
Cable 1	White	1
	Blue	3
	Shield	Metal shell

Apply heat-shrink tape or jacket over the connector for protection.

At the end opposite the connector, strip about 3 inches off the outer jacket of the cable.

Ethernet Gateway

The Ethernet Gateway RS-485 connection requires one 48-inch length of Belden 9271 cable covered with sleeving and a male DB-9 connector.

Connect one end of the cable to the DB-9 connector as follows:

Conductor	DB-9 Pin
White	1

GE Industrial Systems