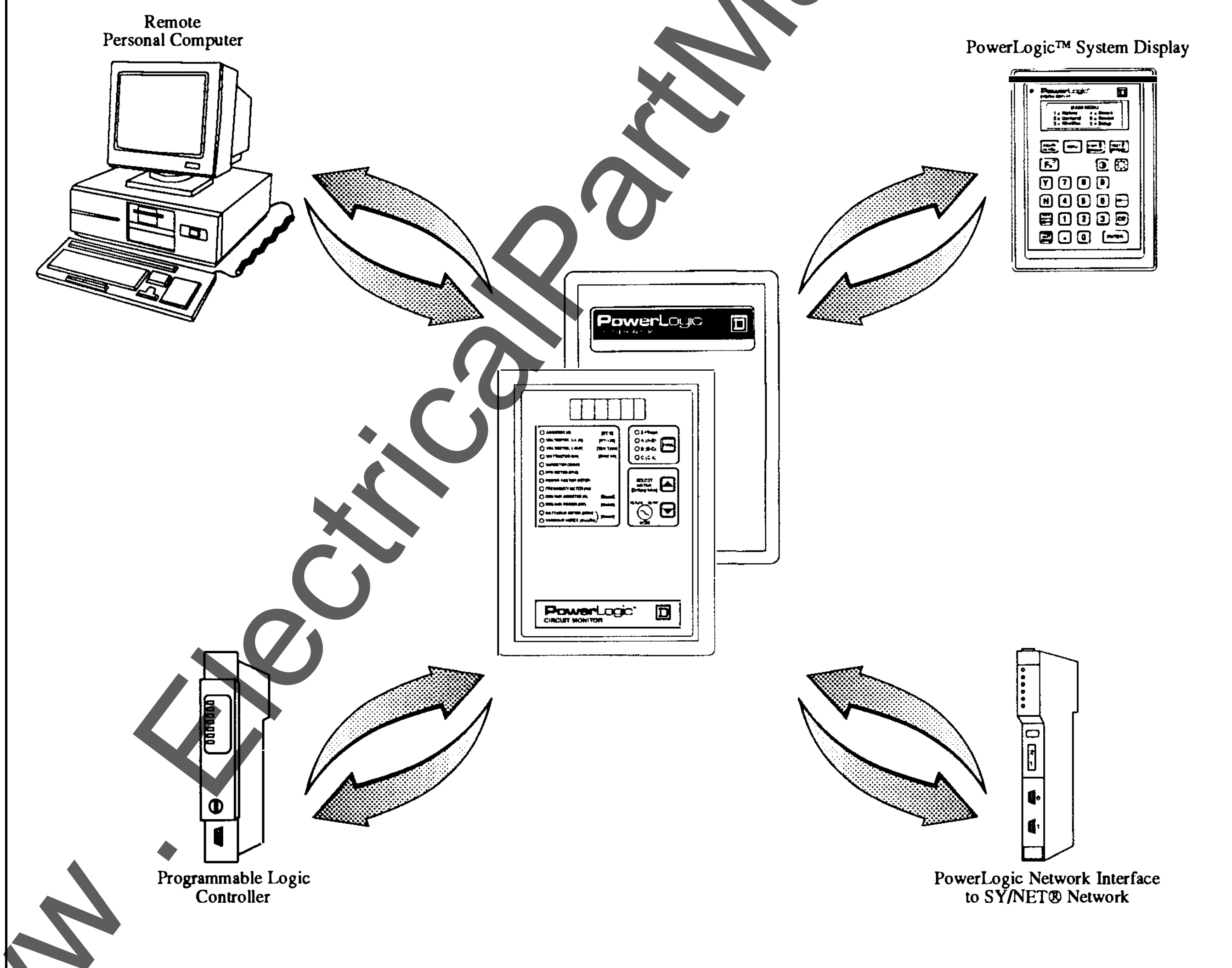
February 4, 1991 Bulletin: 63210-203-01

Reference Manual

Communications Reference
for PowerLogic Circuit Monitors
(Includes a complete listing of Circuit Monitor registers)



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1.0 INTRODUCTION

1.1 General

The PowerLogic™ Circuit Monitor supports a protocol which is compatible with standard SY/MAX® products. Circuit Monitor communications are made possible via an RS-485 electrical interface which offers RS-422 compatibility and allows multipoint communications from a single controlling source.

The RS-422 standard provides for point-to-point communications. This means that a SY/MAX® processor, for example, can communicate directly to a single device such as a Network Interface Module (NIM). The NIM must then regenerate the signal and send it to the next device. This process is repeated from point-to-point until the target device is reached.

In contrast, the RS-485 standard allows asynchronous, multipoint communication to a maximum of 32 Circuit Monitors per input channel. For example, 32 Circuit Monitors may be daisy chained to a single SY/MAX® processor's communications port. This allows the processor to send a message to a specific unit without the need for each Circuit Monitor to interpret and regenerate the signal. Data is directed to specific Circuit Monitors on a link with the use of a unique device address assigned to each Circuit Monitor. (Section 4.0 discusses device addressing).

1.2 Manual Use

This manual is intended to be used as a reference to Circuit Monitor communications. It describes the available communication options, along with the information needed to make a Circuit Monitor communicate to a host device, such as communication wiring, device addressing, setting the baud rate, routing, etc. It also provides select information on ladder programming. In addition, it provides a complete list of Circuit Monitor internal registers which may be used in creating custom software.

For users of PowerLogic Application Software, much of the communication programming information contained in this document is unnecessary since all important programming considerations have already been implemented in the software.

This document is not intended to completely describe the installation and operation of the Circuit Monitor. For additional information, refer to the Circuit Monitor instruction bulletin included with the device.

2.0 COMMUNICATIONS OPTIONS

2.1 General

The PowerLogic™ Circuit Monitor provides four communication alternatives. They are:

1) Connection to a PowerLogic System Display.
2) Connection to a Personal Computer (or SY/VIEW® workstation) via the RS-422 port of a SY/LINK® card.
3) Connection to a PowerLogic Network Interface Module for communication on the SY/NET® network.
4) Connection to a SY/MAX® programmable logic controller (PLC).

Each of these communication options is described below.

2.2 Connection to a PowerLogic System Display

The PowerLogic™ System Display provides real-time access to information from PowerLogic Circuit Monitors (up to 32 on a single communications channel). All instrumentation, status, and historical data stored in the Circuit Monitor are available on user command. Menu selections allow the user to reset metering and historical information and perform Circuit Monitor setup operations.

Where power equipment is in an inaccessible location, the System Display can be remote mounted (e.g., at floor level) for operator convenience and safety. The System Display can be located up to 10,000 feet from the farthest Circuit Monitor. (See Appendix B for distance limitations for 17-32 Circuit Monitors).

Up to 32 Circuit Monitors may be directly connected to the RS-485 communications port on the bottom of the System Display. (See Figure 2-1). A Multi-point Communications Adapter (3090 MCA-485) is connected to the communications port of the System Display. A Multi-point Communications Terminator (3090 MCT-485) is required on the last Circuit Monitor in a chain. Section 3.1 describes the use of these devices.

For additional information on the PowerLogic System Display, refer to the System Display instruction bulletin #63210-150-01.

2.3 Connection to a Personal Computer

Up to 32 Circuit Monitors may be directly connected to a personal computer to allow remote monitoring of circuit data. (See Figure 2-2). The personal computer may be located up to 10,000 feet from the farthest Circuit Monitor. (See Appendix B for distance limitations for 17-32 Circuit Monitors).

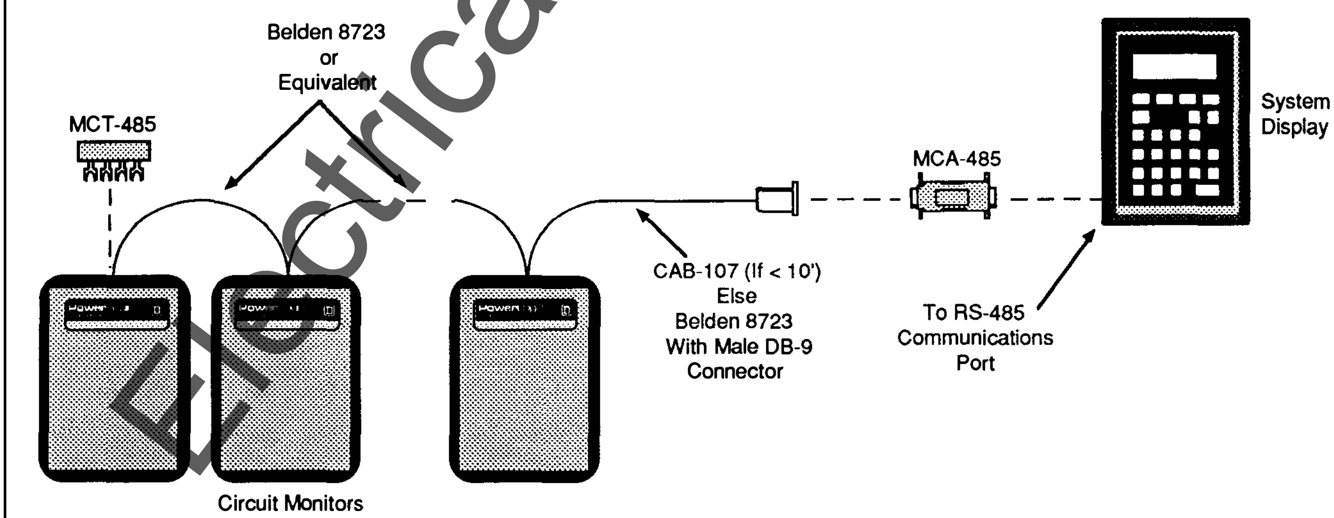


***Figure 2-1** - Circuit Monitors Connected to a PowerLogic System Display*

Circuit Monitors are connected to the personal computer via a SY/LINK® card (8010 SFI-510) installed in an expansion slot of the PC. The SY/LINK® card is a network communications card which handles communications processing and relieves the computer of the task.

The SY/LINK card has two communications ports. The top port is an RS-422 communications port. The bottom port is a network port for communications over the SY/NET® network. Circuit Monitors are connected to the RS-422 port.

A Multi-point Communications Adapter (3090 MCA-485) is connected to the RS-422 port of the SY/LINK card. A Multi-point Communications Terminator (3090 MCT-485) is required on the last Circuit Monitor in a chain. Section 3.1 describes the use of these devices.

2.4 Connection to a PowerLogic Network Interface Module (PNIM)

When multiple computers, or programmable controllers are used to perform monitoring and control functions, communications are performed over the SY/NET® Local Area Network (LAN). Circuit Monitors are connected to the network via a PowerLogic™ Network Interface Module (PNIM). (See Figure 2-3).

The PNIM has two RS-422 communication ports on its face (labeled 0 and 1) and a network port on its bottom. Circuit Monitors may only be connected to the top RS-422 port (port 0). Port 0 must be configured to operate in PowerLogic mode.

For instructions on configuring the PNIM, refer to the PNIM instruction bulletin #30598-756-01.

Up to 32 Circuit Monitors may be daisy-chained to a single PNIM. A Multi-point Communications Adapter (3090 MCA-485) must be connected to the top port of the PNIM. A Multi-point Communications Terminator (3090 MCT-485) is required on the last Circuit Monitor in a chain. Section 3.1 describes the use of these devices.

NOTE: The PNIM *cannot* be assigned the same address as any Circuit Monitor connected to it. For example, if ten Circuit Monitors, addressed 1 thru 10, are connected to a PNIM, then the PNIM *cannot* be assigned an address in the range 1 thru 10. For additional information, see Section 4.2 "Setting the Device Address."

2.5 Connection to a SY/MAX® Programmable Logic Controller (PLC)

In some cases, it may be desirable to connect Circuit Monitors directly to a SY/MAX® programmable logic controller (PLC). Up to 32 Circuit Monitors may be connected to a processor's RS-422 communications port. A Multi-point Communications Adapter (3090 MCA-485) must be connected to the processor's RS-422 port. A Multi-point Communications Terminator (3090 MCT-485) is required on the last Circuit Monitor in a chain. Section 3.1 describes the use of these devices.

NOTE: The PLC must use a ladder program written to access Circuit Monitor data in specified locations. Section 10.0 offers a complete list of Circuit Monitor register assignments.

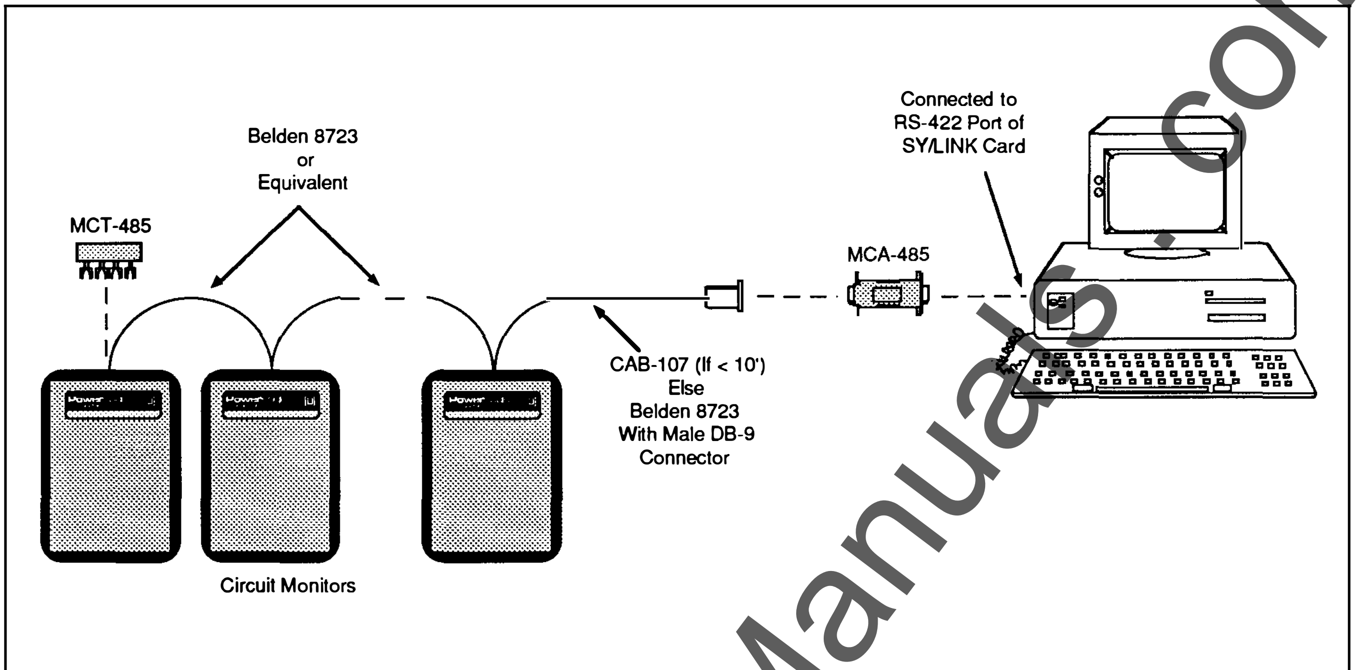


Figure 2-2 *- Circuit Monitors Connected to a Remote Personal Computer*

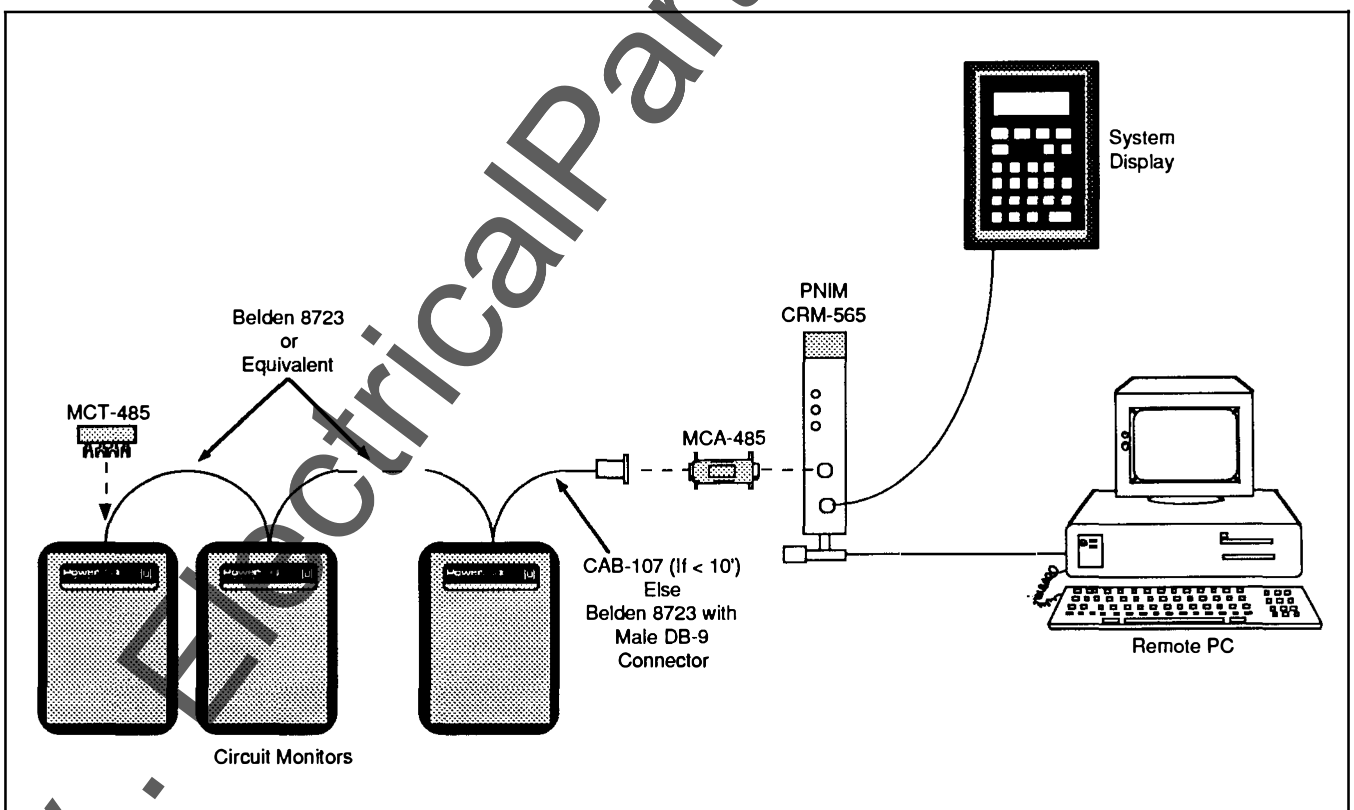


Figure 2-3 *- Circuit Monitors Connected to a PowerLogic Network Interface Module (PNIM)*

3.0 COMMUNICATION WIRING

The Circuit Monitor requires a communication cable containing two shielded twisted pairs (**Belden 8723** or equivalent). Communications wires are daisy-chained from one Circuit Monitor to the next, IN+ being wired to IN+, OUT- to OUT- and shield to shield. Figures 3-3 and 3-4 illustrate correct communication wiring.

3.1 Termination and Bias of Communication Lines

To ensure accurate communications, steps must be taken to properly terminate and bias the Circuit Monitor communication lines. The following paragraphs detail the necessary steps.

Termination of the communication lines is achieved with the use of the PowerLogic RS-485 Multipoint Communications Terminator (3090 MCT-485). The terminator has four spade connectors which are connected to the IN+, IN-, OUT+, and OUT- communication terminals on the rear of the Circuit Monitor. (See Figure 3-2).

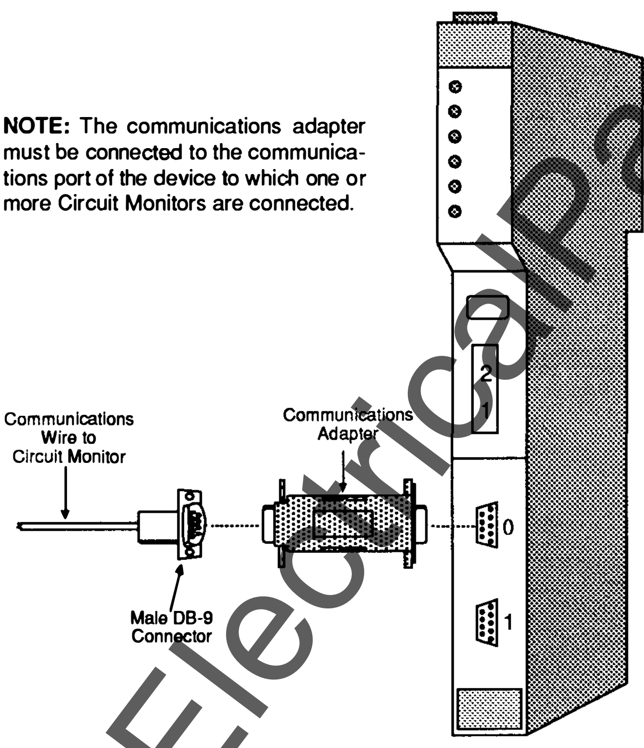


Figure 3-1 - Multipoint Communications Adapter

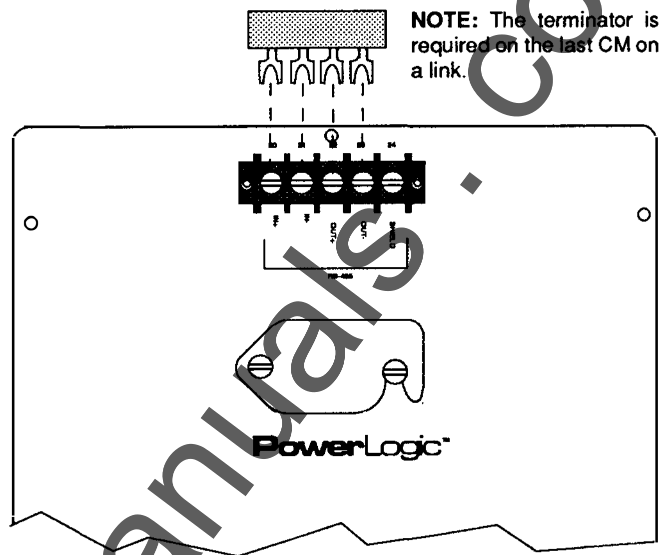
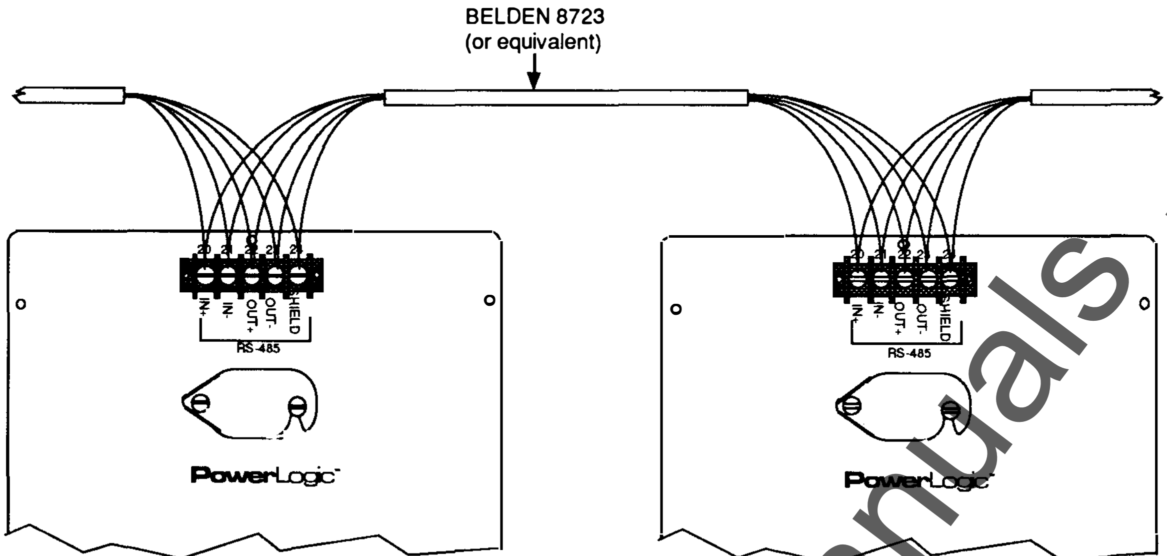


Figure 3-2 - Multipoint Communications Terminators

IMPORTANT: Only the last CM in a communications link must be terminated. For example, if a link contains only a single Circuit Monitor, that CM must have a terminator. If multiple CMs are daisy chained together, only the last CM in the link should be terminated. Figure 3-2 illustrates the proper placement of the terminator. Figures 2-1, 2-2, and 2-3 show the terminator applied in typical systems.

The communication lines are biased with the use of the PowerLogic RS-485 Multipoint Communications Adapter (3090 MCA-485). The 9-pin, male to female adapter is attached to the host device to which one or more CMs are daisy chained. **NOTE:** If a single CM is connected to a communications port and the adapter is used, the CM's address should be set to 01. (See Section 4.0).

Possible connection points include: the RS-422 port of a SY/LINK Card, the top RS-422 communications port of a PowerLogic Network Interface Module (PNIM), the communications port of a PowerLogic System Display and the communications port of a SY/MAX® processor. Figure 3-1 illustrates the adapter connected to a PNIM. Figures 2-1, 2-2, and 2-3 show the adapter applied in typical systems.



IMPORTANT: The communications shield is terminated at each Circuit Monitor.

Figure 3-3 *- Daisy chained Circuit Monitors*

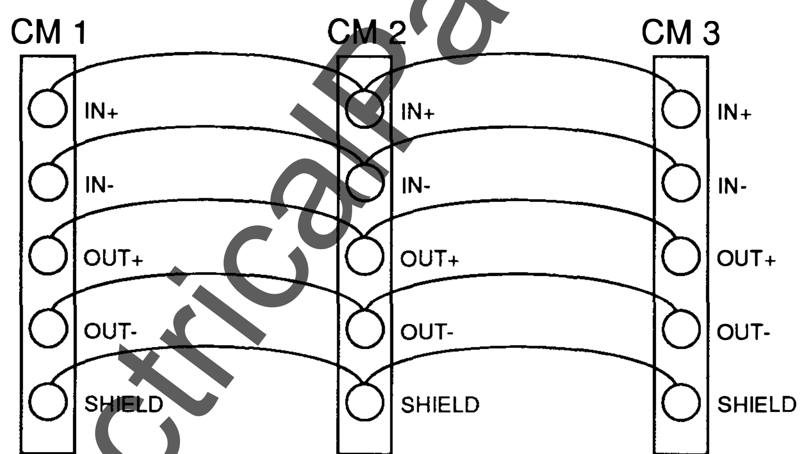


Figure 3-4 *- Circuit Monitor Communication Wiring*

4.0 SETTING THE BAUD RATE AND DEVICE ADDRESS

4.1 Setting the Baud Rate

The Circuit Monitor is capable of communicating at the following baud rates:

- 19.2 K baud
- 9600 baud
- 4800 baud
- 2400 baud
- 1200 baud

Each Circuit Monitor is shipped with a default setting of 9600 baud, which may be reset as required. The baud rate is set with the use of the device address switches located on the rear of the unit.

To change the baud rate, turn off the control power to the unit, set the device address switch to either 94, 95, 96, 97, or 98, and return control power to the unit. Table 4-1 shows the proper switch settings required for each baud rate.

After the baud rate has been changed, the Circuit Monitor's address must be reset. Section 4.2 details the setting of the Circuit Monitor address. The list that follows summarizes the steps required to change a Circuit Monitor's baud rate. Steps 1-3 change the unit's baud rate. Steps 5-7 reset the device address.

1) Turn off control power to the unit.
2) Set the device address switch to the proper baud rate setting (see Table 4-1).
3) Return control power to the unit.
4) Wait 5 seconds.
5) Turn off control power to the unit.
6) Reset the Circuit Monitor's address (see Section 4.2).
7) Return control power to the unit. The Circuit Monitor will communicate at the selected rate.

The Circuit Monitor will retain its baud setting upon control power loss.

Switch Setting	Baud Rate
94	1200
95	2400
96	4800
97	9600 (default)
98	19.2 K

Table 4-1 *- CM Baud Rate Switch Settings*

4.2 Setting the Device Address

Each Circuit Monitor on a single communications link must have a unique address assigned to it. (In this context, the term "communications link" means 1 to 32 Circuit Monitors daisy-chained to a communications port). Information sent over the communication lines is accompanied by the address of the target Circuit Monitor. In this way, information can be routed to specific CMs on a link.

A Circuit Monitor's address is determined by two ten-position rotary switches located behind a door on the rear of the unit. The switches are accessed by loosening the screws which secure the device address door, and sliding the right end of the door toward the bottom of the Circuit Monitor. The switches allow a total of 100 settings (0 to 99). The Circuit Monitor utilizes addresses 01..32 for addressing the unit. Table 4-2 offers a summary of Circuit Monitor switch settings.

The last CM in the chain, i.e. the CM which is located farthest from the port, should have the address 01. This is necessary to ensure maximum reliability with standard SY/MAX protocol. SY/MAX devices periodically send out an inquire signal to ensure that the communications link has not failed due to poor connections, device failure, etc... The inquire signal is sent to the device addressed as 01. Failure of CM 01 to respond indicates a possible break in the communications link. Assigning address 01 to the last CM in a chain, allows the connections preceding CM 01 to be checked since the signal must traverse the entire chain to reach the final unit. Subsequent units may then be assigned any address in the range (2..32), excluding the addresses of previously installed units (and excluding the address of the PNIM if the CMs are connected to a PNIM).

When a single Circuit Monitor is connected to a communications port, the address switches on the rear of the unit should be set to 01. If additional Circuit Monitors are added to the communications link, the last Circuit Monitor in the chain should retain the address 01.

NOTE: When a single Circuit Monitor is connected to a communications port, the address switches on the rear of the unit may be set to 00. This allows a single Circuit Monitor to communicate without the need for a Multipoint Communications Adapter. (Section 3.1 describes the adapter). If, at a later date, additional Circuit Monitors are added, CM 00 must be changed to 01 and a Multipoint Communications Adapter must be used. It is recommended that in single Circuit Monitor systems, the Circuit Monitor's address be set to 01 and the Multipoint Communications Adapter be used.

IMPORTANT: Each Circuit Monitor in a chain must be assigned a unique address in the range 1..32. This means that no two CMs on a chain can have the same address. Also, when CMs are connected to a PNIM, the PNIM *cannot* have the same address as any CM connected to it. For example, if sixteen CMs are connected to a PNIM and they are assigned addresses 1 thru 16, then the PNIM's address *cannot* fall in the range 1 thru 16.

Circuit Monitors are shipped with a default address of 01. To change the address of a Circuit Monitor complete the following steps:

1) Turn the control power to the unit off.
2) Set the address switches to a unique number in the range 1..32.
3) Return control power to the unit.

The Circuit Monitor must be powered down when the address switches are changed. Once changed, the Circuit Monitor will respond to the new address upon return of control power. The Circuit Monitor will retain its address upon loss of control power if the address switches are not changed during the period of power loss.

Switch Setting(s)	Function
1-32	Determines the Device Address
33-93	Reserved
94-98	Used to Set the Baud Rate
99	Reserved

***Table 4-2** - Summary of Circuit Monitor Address Switch Settings*

5.0 COMMUNICATION RULES

In addition to proper installation, there are some general rules to follow to ensure efficient communication between Circuit Monitors and the host device (the device to which one or more Circuit Monitors are connected). These rules are listed below:

General Rules:

1. The host device may communicate to *only one* CM at a time. For example, if Circuit Monitors are connected directly to a SY/MAX processor, only one communication rung from the SY/MAX processor to a CM may be activated at a time. This rung should maintain continuity until the communication is completed. When CMs are connected to a PNIM, the PNIM manages communications allowing only one message to be sent at a time.

2. The Circuit Monitor supports Priority and Non-priority READs, Priority and Non-priority WRITES, and Random Access READs only. (A Random Access READ is a non-priority operation which allows you to read non-contiguous groups of registers). In most cases, non-priority READs and WRITEs should be used.

3. The CM will only *respond* to communications from the host. The CM can not *initiate* any communications.

4. A PowerLogic™ Multipoint Communications Terminator (3090 MCT-485) must be placed on the last CM on a chain. The MCT-485 is also required when a single CM is connected to a communications channel. (See section 3.1).

5. A PowerLogic™ Multipoint Communications Adapter (3090 MCA-485) must be connected to the communications port to which one or more Circuit Monitors are connected. (See section 3.1).

6. When multiple CMs are connected to a single communications channel, each CM must have a unique address in the range 01..32.

7. When CMs are connected to a PNIM, the PNIM *cannot* have the same address as any CM connected to it. For example, a PNIM addressed as 20 may not have a CM connected to it whose address is 20.

8. There must be one (and only one) CM whose device address switches are set to 01. This should be the last CM on the link. (See section 4.0).

9. When a single CM is connected to a communication channel, its device address switches should be set to 01. The MCA-485 must be used. (See section 4.0).

10. Up to 32 Circuit Monitors can be daisy-chained to a single communications port. (See Appendix B for distance limitations).

6.0 GENERAL SY/LINK® INFORMATION FOR CIRCUIT MONITOR COMMUNICATIONS

6.1 Introduction

As noted in section 2.0, the Circuit Monitor may communicate directly to a personal computer via the RS-422 port of a SY/LINK® board. The SY/LINK board is a network interface board which mounts in a long expansion slot of an IBM personal computer or compatible. The board gives the computer direct access to the SY/NET® Local Area Network for communication with programmable controllers and other devices. In addition, the SY/LINK board offers an RS-422 port which allows RS-422 devices, including the Circuit Monitor, to access the network.

Exchange of information between the computer and CM's is accomplished through application programs written for the desired tasks. The SY/LINK system will operate with virtually any computer language that will run on a personal computer (BASIC, Compiled BASIC, FORTRAN, C, Assembler, etc.). This flexibility allows the user to design custom software in the language that is most familiar to him.

To achieve communication, the user program must address the following functions:

1. Initializing SY/LINK board parameters.
2. READ operations (for applications that gather information)
3. WRITE operations (for applications that send information)
4. Error handling

The remainder of Section 6.0 will touch upon each of these functions. **NOTE:** The following sections should by no means be considered a complete guide to SY/LINK communications. For complete instructions on the function and use of the SY/LINK card, refer to SY/MAX® instruction bulletin 30598-277-01.

6.2 Configuring the SY/LINK® Board for Circuit Monitor Communication

To allow the SY/LINK board to communicate on the network, the user (and the program) must properly configure the board. To configure the SY/LINK board, selections must be made for such items as computer memory address range, network address number, network baud rate, network size, RS-422 operating mode, and RS-422 port baud rate. Of greatest importance for Circuit Monitor communications is the proper configuration of the RS-422 port. Configuration of the RS-422 port is discussed below.

RS-422 Port Operating Mode - The RS-422 port can be configured to operate in four modes. They are SY/MAX mode, NET-TO-NET mode, Peripheral mode, and terminal mode. When communicating directly to Circuit Monitors, the port should be set to operate in NET-TO-NET mode.

Parity - The RS-422 port must be set to *Even* parity.

Word Size - Word size should be set to 8 bit.

Baud Rate - The SY/LINK card can operate at baud rates ranging from 110 to 19,200 baud. The Circuit Monitor offers five baud rates ranging from 1200 to 19,200 baud. The Circuit Monitor may be set to operate at any of the five supported baud rates. The RS-422 port of the SY/LINK Card must be set to operate at **the same** baud rate as the Circuit Monitor(s) to which it is communicating.

The SY/LINK board offers additional configuration options including network size, network baud, and more. For a complete description of SY/LINK initialization and configuration, refer to Sections 6.0 and 7.0 of the SY/LINK instruction bulletin, 30598-277-01.

6.3 READ Operations

READ operations allow the user program to obtain values from Circuit Monitor storage registers and storage registers located in other devices on the network or on the SY/LINK board.

To perform a READ operation, the user program loads values into certain memory locations. These values tell the SY/LINK board what registers to read and where to find them. When ready, the user program sets a send flag and the SY/LINK board performs the desired operation. If the READ is successful, the SY/LINK board will store the requested data in the reply data buffer and reset the send flag to zero. The user program can then examine the data. If the READ is unsuccessful, the SY/LINK board will place an error code in the error flag location and reset the send flag without storing data in the reply data buffer.

The Circuit Monitor supports three kinds of READ operations: Non-priority READ, Priority READ, and Random Access READ. For the majority of applications, the user program should use Non-priority READs. A Non-priority READ can be preempted by a Priority READ (or WRITE) operation that requires the network at the same time. The Non-priority READ can be preempted a maximum of 32 times before it is allowed on the network.

NOTE: Random Access READ operations can obtain data from a group of registers whose addresses are non-contiguous. (Standard Non-priority and Priority READs access contiguous blocks of registers). The Random Access READ is classified as a Non-priority operation; it can be preempted by a Priority READ. Priority and Non-priority READs are approximately twice as fast as Random Access READs.

For a complete description of the READ commands and their use, refer to Section 7.0 of bulletin 30598-277-01.

6.4 WRITE Operations

WRITE operations allow the user program to send data values to Circuit Monitor storage registers, storage registers in other devices on the network or on the SY/LINK board.

To perform a WRITE operation, the user program loads values into certain memory locations. These values tell the SY/LINK board which registers to write to, where to find them, and what data to put in them. When ready, the user program sets a send flag and the SY/LINK board performs the desired WRITE operation. If the WRITE is successful, the SY/LINK board will reset the send flag to zero. If the WRITE is unsuccessful, the SY/LINK board will place an error code in the error flag location and reset the send flag.

The Circuit Monitor understands and responds to two kinds of WRITE operations: Non-priority WRITE, and Priority WRITE. For the majority of applications, the user program should use Non-priority WRITEs. A Non-priority WRITE can be preempted by a Priority WRITE (or READ) operation that requires the network at the same time. The Non-priority WRITE can be preempted a maximum of 32 times before it is allowed on the network.

NOTE: Priority WRITEs should be employed in the user program only when there is a critical need to send data as quickly as possible. Over-use of Priority WRITEs can interfere with other network communications.

For a complete description of the WRITE commands and their use, refer to Section 7.0 of bulletin 30598-277-01.

6.5 Error Handling

During a READ or WRITE operation, the user program can monitor the Error Flag Location for non-zero values. A non-zero value placed here during a communication indicates that the communication was unsuccessful due to an error condition.

The user program can be designed to respond to the error in a manner corresponding to the nature of the error. For example, if the error code is 017 (Remote Device Inactive), the user could display or print a message informing the operator that the remote device is powered down or not connected.

Section 7.5 of the SY/LINK instruction bulletin (30598-277-01) offers more on error handling. A list of command/reply error codes and their meanings is given in Appendix C of the SY/LINK bulletin.

7.0 GENERAL LADDER PROGRAMMING INFORMATION

Communications to the CM can be accomplished via a ladder program stored in a SY/MAX processor. Only READ and WRITE operations may be performed directly on Circuit Monitor registers. This section offers a brief description of READ and WRITE instructions. It also describes LET and IF instructions. Sample ladder code illustrating these functions is shown in section 7.4.

This section should not be considered a complete guide to ladder programming. For additional programming information, refer to the instruction bulletin included with the SY/MAX processor.

7.1 READ and WRITE Instructions

Communications rungs are available to transfer storage register values from the processor to a CM (using WRITE instructions) and from a CM to the processor (using READ instructions). Processor communication instructions allow hosts to communicate directly with a CM or communicate with multiple CMs.

Communication operations are displayed as horizontal boxes preceded by at least one input condition. See Figure7-1 for an example. These operations are transitional, meaning that the input condition must experience an open to closed transition before the message is sent.

The first entry in the box is the operation type and the channel number. The channel number specifies the particular serial port on the processor which is being used for transmission. (Deluxe Model 300, Model 500, and Model 400 processors have two serial ports labeled Channel 1 and Channel 2. All Model 700 processors have four serial ports labeled Channels 1-4). The next entry in the box is the routing information which is used to establish a communication path between the processor (containing the communications rung) and the intended CM on the network. Also included in each type of communications operation is a message status register which is used to monitor the progress of the message and the response from the receiving device.

For the following examples, the word "local" refers to the processor that contains the communications rung in the ladder program.

ROUTING

A series of 3 digit numbers is entered under the header ROUTE in READ and WRITE boxes, to establish the communication route between the local processor and the intended remote CM.

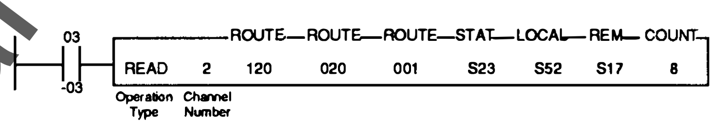


Figure 7-1 - Example READ Instruction.

Typically, only two 3 digit numbers are used to determine the route. The first 3 digit number represents the source (connection point of the PNIM to the network) and the last 3 digit number represents the destination (connection point of the remote CM to the PNIM).

As shown in Figure 7-1, a route number consists of three digits — the first indicates which of two ports on the NIM (Network Interface Module) the processor or remote CM is connected to, and the last two digits indicate the number of the NIM set by the thumb wheel switches on the NIM module. The first digit can be (1) or (0) (two ports on a NIM) and the last two digits can range from 00-99 (100 possible devices in one network). For the processor to communicate with a remote CM in this example, the routing statements 020, 120 and 001 would have to be contained in the communication rung (in the order shown) of the local processor.

Refer to section 8.0 for specific CM routing examples.

READ OPERATION

An example of a READ operation is shown in Figure 7-1. READ operations transfer data from a CM to the local processor.

CHANNEL NUMBER — This entry specifies which serial port on the processor being programmed is to be used for the transmission. (i.e. Deluxe Model 300, Model 400, and Model 500 have two serial ports labeled Channel 1 and Channel 2. Model 700 processors have 4 serial ports labeled Channels 1-4).

ROUTE — This entry is used to establish a communication path between the processor being programmed and the intended CM.

STAT — This entry is the address of the communication status register. This register is used to monitor the progress of the communication and the expected response.

LOCAL — This entry is the address of the register in the processor which will store the data that is read from the remote CM. There will be multiple local registers if a COUNT other than 1 is specified.

REMOTE — This entry is the address of the register in the CM whose data will be read by the local processor. There will be multiple remote registers if a COUNT other than 1 is specified.

COUNT — This entry specifies the number of consecutive registers, starting with the local and remote registers that will be involved in the READ operation.

Circuit Operation (Refer to Figure 7-1):

When input 03-03 of the local processor makes the transition from open to closed, the contents of storage registers S17 through S24 (the count of 8 storage registers starting with S17) in the remote drive controller are copied into storage registers S52 through S59 in the local processor. Channel 2 is used for the transmission, and local storage register S23 contains the message status information. In this example, the local processor is connected to port one of the PNIM numbered 20 (Route 120) and the CM is connected to port zero of the PNIM module numbered 20 (Route 020, CM #001).

Programming Considerations

1. The horizontal READ box must be preceded by at least one contact.

2. Each time the input condition controlling the READ box makes the transition from open to close, the transmission is initiated.

3. READ operations cannot be programmed in parallel within the same rung.

4. Contacts cannot be programmed in parallel with a READ operation.

5. The possible number of positions in each line of the contact matrix controlling a READ operation is reduced by the number of statements used inside the READ box. In Figure 7-1, the maximum size the contact matrix could be is 4 x 7 (28 contacts).

6. Only one channel number can be used in a READ operation.

7. Use the status register to indicate the completion of the transmission. (Refer to section 6.5 of CRT Programmers Manual, Bulletin: 30598-174-01). Do not use this register elsewhere in the control program.

8. Only the data portion (first 16 bits) of the registers are transferred to the local device when a read operation is performed.

9. When a READ rung is displayed (using the DISPLAY mode) the data shown below the register address in the REM column does not reflect the data in the remote CM (it is the data of the register having that address in the local processor).

10. When communicating to a CM that is directly connected to the processor (either alone or in a daisy chain), the only CM address that is required in the route statement is the address of the target CM.

11. Routes greater than 223 can only be programmed using a Deluxe CRT with software revision 2.4 or later.

12. Routes greater than 223 should not be programmed in Model 300 processor which have the following series designations or earlier.

Class 8020 Type SCP	Series
311	E
312	E
313	D
321	D
322	D
323	C
332	D
333	D
344	C

13. The maximum COUNT number is 128, independent of the processor containing the communications rung.

14. For the proper application of READ instructions, refer to instruction bulletin 30598-257-01.

WRITE OPERATION

An example of a WRITE operation is shown in Figure 7-2. A WRITE operation copies storage register data residing in the local processor to the specified CM register.

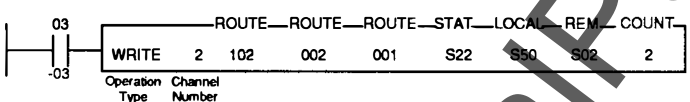


Figure 7-2 - Example WRITE Instruction.

CHANNEL NUMBER — This entry specifies which serial port on the processor being programmed is to be used for the transmission. (i.e. Deluxe Model 300, Model 400, and Model 500 have two serial ports labeled Channel 1 and Channel 2. Model 700 processors have 4 serial ports labeled Channels 1-4).

ROUTE — This entry is used to establish a communication path between the processor being programmed and the intended CM.

STAT — This entry is the address of the communication status register. This register is used to monitor the progress of the communication and the expected response.

LOCAL — This entry is the address of the register in the processor whose data is sent to the specified CM register. There will be multiple local registers if a COUNT other than 1 is specified.

REMOTE — This entry is the address of the register in the CM which will store the data sent from the processor. There will be multiple remote registers if a COUNT other than 1 is specified.

COUNT — This entry specifies the number of consecutive registers, starting with the local and remote registers that will be involved in the WRITE operation.

Circuit Operation (Refer to Figure 7-2).

When input 03-03 of the local processor in Figure 7-2 makes the transition from open to closed, the contents of storage registers 0050 through 0051 (the count of two storage registers starting with 0050) in the local processor are copied to registers 0002 and 0003 in the CM. Channel 2 is used for the transmission, and local storage register 0022 contains the message status information. In this example, the local processor is connected to port one of the NIM numbered 02 (ROUTE 102) and the remote CM is connected to port zero of the NIM module numbered 01 (ROUTE 001, CM #001).

Programming Considerations

1. The horizontal WRITE box must be preceded by at least one contact.

2. Each time the input condition controlling the WRITE box makes the transition from open to close, the transmission is initiated.

3. WRITE operations cannot be programmed in parallel within the same rung.

4. Contacts cannot be programmed in parallel with a WRITE operation.

5. The possible number of positions in each line of the contact matrix controlling a WRITE operation is reduced by the number of statements used inside the WRITE box. In Figure 7-2, the maximum size the contact matrix could be is 4 x 7 (28 contacts).

6. Only one channel number can be used in a WRITE operation.

7. Use the status register to indicate the completion of the transmission. (Refer to section 6.5 of CRT Programmers Manual, Bulletin: 30598-174-01). Do not use this register elsewhere in the control program.

8. Only the data portion (first 16 bits) of the registers are transferred to the local device when a READ operation is performed.

9. When a WRITE rung is displayed (using the DISPLAY mode) the data shown below the register address in the REM column does not reflect the data

in the remote CM (it is the data of the register having that address in the local processor).

10. When communicating to a CM that is directly connected to the processor (either alone or in a daisy chain), the only CM address that is required in the route statement is the address of the target CM.

11. Routes greater than 223 can only be programmed using a Deluxe CRT with software revision 2.4 or later.

12. Routes greater than 223 should not be programmed in Model 300 processor which have the following series designations or earlier.

Class 8020 Type SCP	Series
311	E
312	E
313	D
321	D
322	D
323	C
332	D
333	D
344	C

13. The maximum COUNT number is 128, independent of the processor containing the communications rung.

14. For the proper application of WRITE instructions, refer to instruction bulletin 30598-257-01.

MESSAGE STATUS REGISTER

Each communications rung must contain a unique storage register. This storage register, called the message status register, is used to monitor the progress of the message and the expected response. Once a status register is assigned to a communication rung, that register must not be used in the program again. Bits #22 and #17 of the message status register provide information about the sending of the message and bits 1-16 provide information about the response coming back from the intended CM. Bits #1 through #24 of the message register are cleared when the input condition controlling a communication box is open.

Sending a Message

When the input to a communication box is closed, bit #22 of the status register will be set immediately upon that rung being scanned. If the channel selected by the communication rung is busy, the message will not be sent until the channel is free. When the channel is free bit #17 of the status register is set and the message is sent. After bits #22 and #17 are set, the processor can then process the next communication rung with bit #22 set (input condition closed) and bit #17 reset.

Responding to a Message

If a valid response to a READ, or WRITE is received, bit #16 will be set while bits #1 through #14 stay cleared. If an invalid response is received, bit #16 will stay cleared and an error code number will be loaded into bits #1 through #14. Bit #15, when set, indicates that the CM is running. The error code number in bits #1 through #14 will always be odd, therefore only bit #1 need be checked to determine if an error has occurred. The error codes used by the status register can be found in the error code appendix under the heading "Processor Errors" in instruction bulletin 30598-174-01.

7.2 LET and IF Instructions

LET and IF commands cannot be performed directly on CM registers. To perform LET and IF instructions with registers in the CM, you must first READ the value of the intended register into the processor. Once the value is in a processor register, the user may change its contents or copy its contents to another register using the LET and IF instructions. If the register's contents are changed, the new value in the register may then be transferred back to the CM via a WRITE statement.

Note: *The only commands that may be performed directly on CM registers are the READ and WRITE commands.*

LET Instruction

LET instructions are used to copy data from a storage register into another storage register or to enter a specific value into a CM register.

The LET instruction is programmed in a horizontal box with the word LET as the first entry in the box (See Figure 7-3). The first entry after the word LET must be a storage register in the processor followed by an equal (=) sign. The register following the equal sign will contain the data to be copied to the register preceding the equal sign. If there is a number following the equal sign, this value will be copied to the register preceding the equal sign.

```
──┤ LET  S(NUMBER)  =  (NUMBER OR STORAGE REGISTER) ├──
  INSTRUCTION          STORAGE REGISTER, DATA OR MATH RESULT
```

Figure 7-3 - Example LET Instruction.

General Programming Rules:

1. The LET box must occupy positions 10 and 11 in the programming matrix. Nothing can be programmed after a LET box.
2. Up to 8 contacts in series and 7 parallel branches may precede a LET box (8 x 7 matrix).
3. Nothing can be programmed in parallel with a LET box.
4. The only allowable entry after the equal (=) sign is a storage register address or a 5-digit number (0 to 32767). The value of this 5-digit will be defined by the allowed values for the control register into which it is copied.
5. IF boxes may precede the LET box providing the 10 x 7 matrix is not exceeded (See Rule 2).
6. A LET box does not have to be preceded by a contact.

LET Instruction Used as a Preset

If a number is programmed to the right of the equal sign, the LET instruction will perform a preset operation.

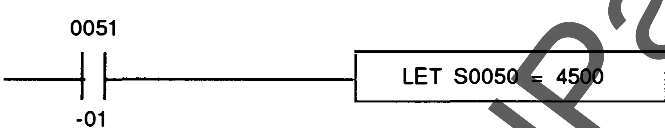


Figure 7-4 - LET Instruction Used as a Preset

Circuit Operation:

In Figure 7-4 when contact 51-01 is closed, the value 4500 will be placed in SY/MAX storage register 0050. If contact 51-01 is open, the preset will not be performed. The LET instruction in Figure 6-12 will be performed on every scan of the ladder program, provided that contact 51-01 remains closed. If the user wishes the preset to be performed only once, he may use a transitional LET instruction (see Section 5 in Bulletin 30598-174-01).

LET Instruction Used as a Data Transfer

If a storage register address is programmed to the right of the equal sign, the LET instruction will perform a data transfer operation.

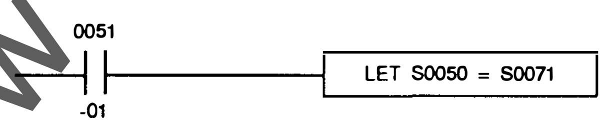


Figure 7-5 - LET instruction Used as a Data Transfer

Circuit Operation:

In Figure 7-5, when contact 51-01 is closed, the value in SY/MAX register 0071 will be transferred into SY/MAX register 0050. The transfer of data in Figure 7-5 will occur every time the processor makes a scan of the ladder program, provided that contact 51-01 is closed. If the user wished the data transfer to occur only once, he may use a transitional LET instruction (see Section 5 of Bulletin 30598-174-01).

IF Instruction

If statements are used to compare the number in a storage register to:

1. A number in another storage register.
2. A number as a result of a math function.
3. A constant.

The IF instruction is programmed in a horizontal box with the word IF as the first entry in the box. The next entry after the word IF must be a storage register (compare to register) followed by a compare symbol. The data in this storage register will be compared to the result of the right side of the compare symbol (See Figure 7-6).

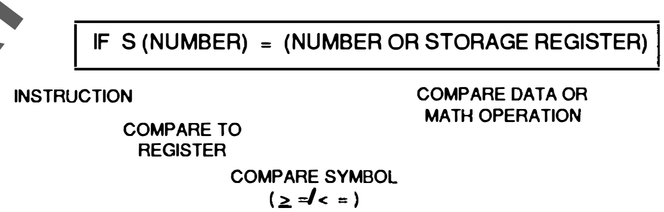


Figure 7-6 - IF Instruction

General Programming Rules

1. The IF box may occupy any position in the programming matrix except the coil position (position #11).
2. Multiple IF boxes can be programmed in series and/or parallel providing the 10 x 7 contact matrix is not exceeded.
3. Contacts may be programmed in series or parallel with an IF box.
4. The comparison symbols can be any of the following:
   a. (=) equal to
   b. (≠) not equal to
   c. (≥) greater than or equal to
   d. (<) less than
5. The only allowable entry after the comparison symbol is a storage register address or a 5-digit number (0 to 32767).

Comparison of a Storage Register Value to a Constant Value

When a number is programmed to the right of the comparison symbol, the storage register value will be compared to that number (See Figure 7-7).

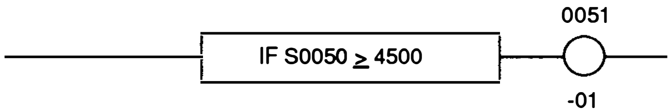


Figure 7-7 - Comparison of Register to Constant

Circuit Operation:

When the value of SY/MAX storage register 0050 is greater than or equal to 4500, coil 51-01 will be energized. When the comparison is not true (register 0050 < 4500) coil 51-01 will not be energized.

Comparison of Two Storage Register Values

When a SY/MAX storage register address is programmed to the right of the comparison symbol, it will be compared to the SY/MAX storage register address programmed to the left of the comparison symbol (See Figure 7-8).

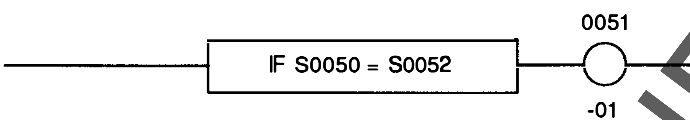


Figure 7-8- Comparison of Two Storage Registers

Circuit Operation:

When the value in SY/MAX storage register 0052 is equal to the value in SY/MAX storage register 0050, coil 51-01 will be energized. If the value in register 0052 is not equal to the value in register 0050, coil 51-01 will not be energized.

When used for comparison purposes, addition, subtraction, multiplication, and division can be programmed using the IF instruction.

For additional information on the LET and IF instructions refer to Section 5 of the CRT Programmer Instruction Bulletin (30598-174-01).

7.3 Sample Ladder Code

The following 3 pages contain sample ladder code illustrating methods for transmitting data to and acquiring data from the Circuit Monitor. **The rungs do not represent a complete ladder program for Circuit Monitor operation**, but are simply examples of the use of ladder instructions. The rungs do not incorporate error recovery, and other important ladder techniques. Refer to the appropriate SY/MAX® instruction bulletins for details on ladder programming.

Note: The ladder code that follows has been written for use with a Model 400 SY/MAX® processor. Some of the techniques used may not work with other SY/MAX processors.

Rungs 001-003 initialize four user-defined parameters: System Connection, Current Reporting Precision, CT and PT Ratios. Rung 0001 stores the decimal values 0003, 2000, 120 and 0016 in SY/MAX registers 200, 201, 202 and 203 respectively. Rung 0002 then writes the values stored in SY/MAX registers 200, 201, and 202 to CM registers 200, 201, and 202, respectively. Doing so sets the System Connection to a 3 wire system, Current Reporting Precision to Amps, CT ratio to 2000:5, and PT ratio to 120:120. (See the description of registers 200, 201, and 202 in Section 10.0).

Any time that a new value has been transmitted to CM registers 200, 201, or 202, the user must force a software restart of the CM. **Rung 0003** accomplishes this by writing a decimal value of 16 (the value stored in SY/MAX register202) to CM register 237. Since a decimal 16 is equivalent to a binary value of 0000 0000 0001 0000, this rung effectively sets bit 5 of CM register 237 forcing a software restart.

Since it is not desirable to re-initialize CM registers 200, 201 and 202 on each scan of the ladder code, we must insure that rungs 0001-0003 are only executed once. **Rung 0004** accomplishes this by setting a control bit after the CM has been initialized.

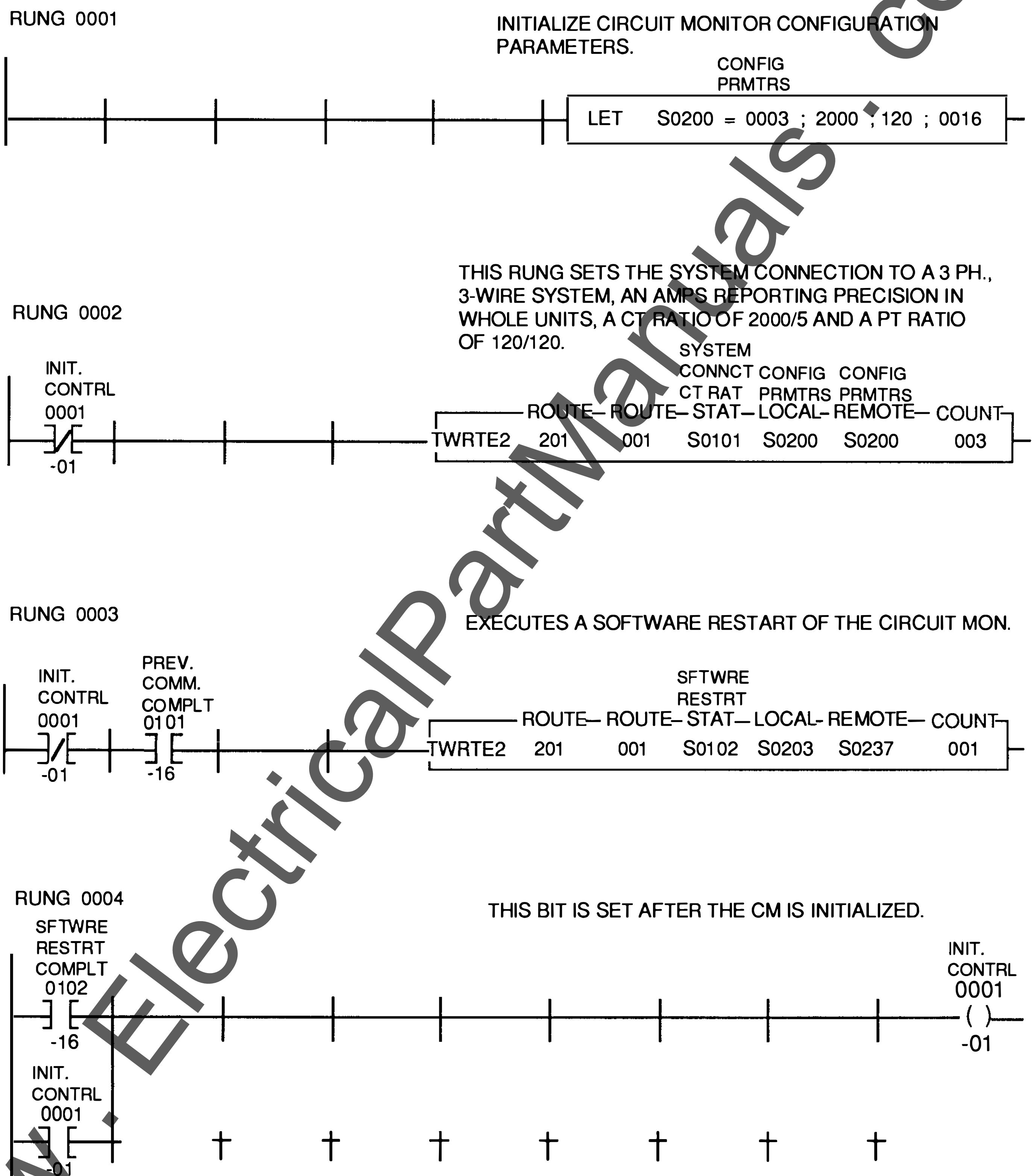
When used in CM communications, SY/MAX communication rungs should be controlled by a timer or counter. **Rung 0005** shows a timer which triggers a coil for one scan once every minute. Rungs 0006, 0012, and 0013 utilize this timer.

Rung 0006 reads the status of the CM clock once per minute.

Rung 0007 checks to see if the CM clock is reset or has not been initialized. If the value in SY/MAX register 30 is equal to 1900 (indicating an incorrect year and therefore an incorrect date/time), a coil is activated to begin the process of updating the CM clock.

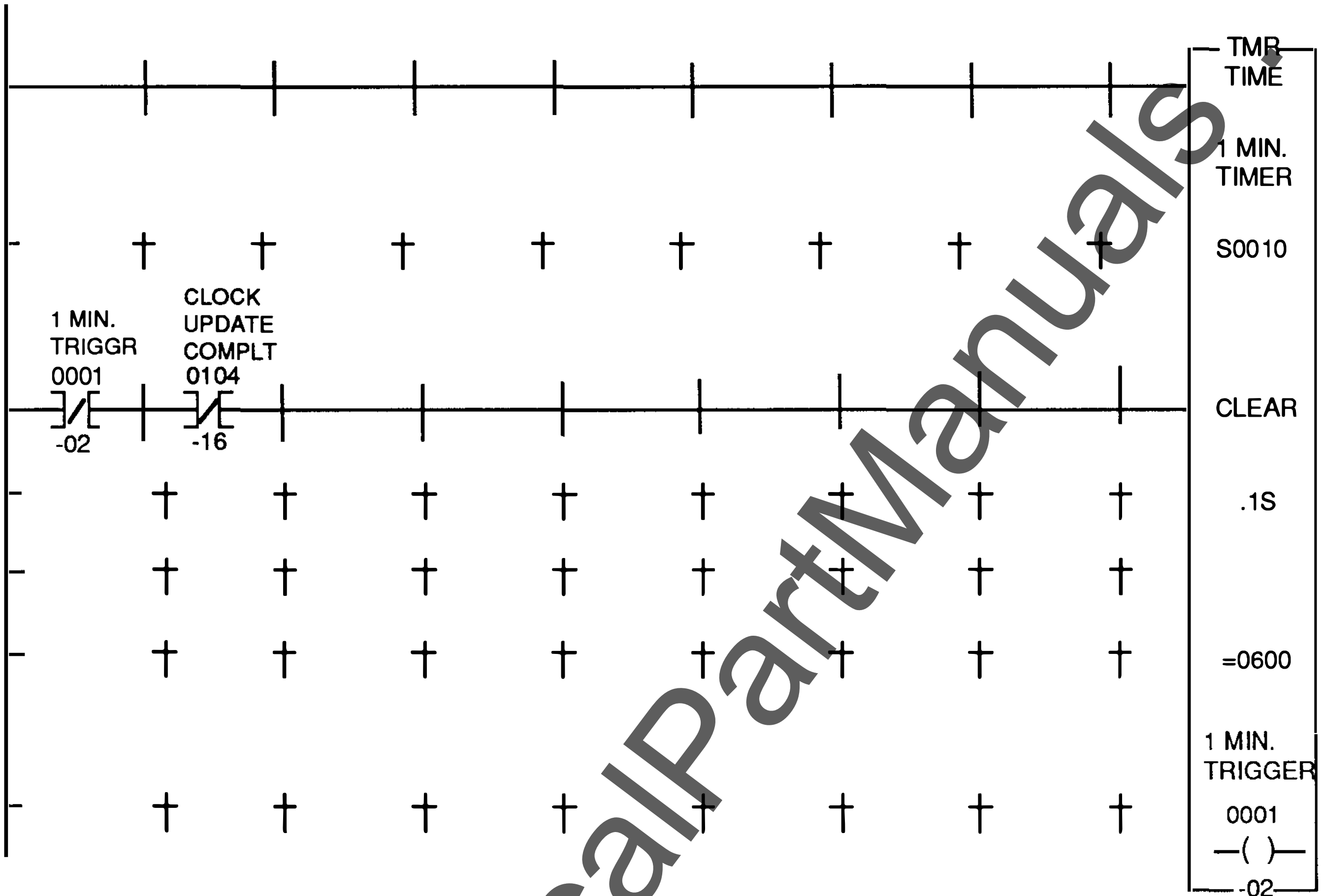
Rungs 0008-0009 transfer the date/time in the Model 400 processor to registers 784-789 in the Circuit Monitor. Rung 0008 transfers the seconds, minutes, and hour, while rung 0009 transfers the day, month, and year.

Rungs 0010-0011 illustrate the use of the READ instruction in acquiring CM data. Both rungs are controlled by a 1 minute trigger (see rung 0005). Rung 0012 reads the System Frequency and rung 0013 reads the Accumulated Energy.


RUNG 0001
INITIALIZE CIRCUIT MONITOR CONFIGURATION PARAMETERS.
CONFIG PRMTRS
LET S0200 = 0003 ; 2000 ; 120 ; 0016
RUNG 0002
THIS RUNG SETS THE SYSTEM CONNECTION TO A 3 PH., 3-WIRE SYSTEM, AN AMPS REPORTING PRECISION IN WHOLE UNITS, A CT RATIO OF 2000/5 AND A PT RATIO OF 120/120.
INIT. CONTRL 0001 -01
SYSTEM CONNCT CT RAT
CONFIG PRMTRS
CONFIG PRMTRS
TWRTE2 ROUTE 201 ROUTE 001 STAT S0101 LOCAL S0200 REMOTE S0200 COUNT 003
RUNG 0003
EXECUTES A SOFTWARE RESTART OF THE CIRCUIT MON.
INIT. CONTRL 0001 -01
PREV. COMM. COMPLT 0101 -16
SFTWRE RESTRT
TWRTE2 ROUTE 201 ROUTE 001 STAT S0102 LOCAL S0203 REMOTE S0237 COUNT 001
RUNG 0004
THIS BIT IS SET AFTER THE CM IS INITIALIZED.
SFTWRE RESTRT COMPLT 0102 -16
INIT. CONTRL 0001 -01
INIT. CONTRL 0001 ( ) -01

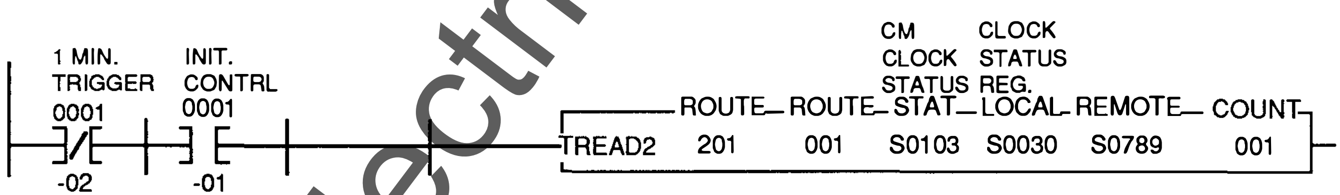
RUNG 0005

THIS COIL IS TRIGGERED FOR ONE SCAN
ONCE EVERY MINUTE.



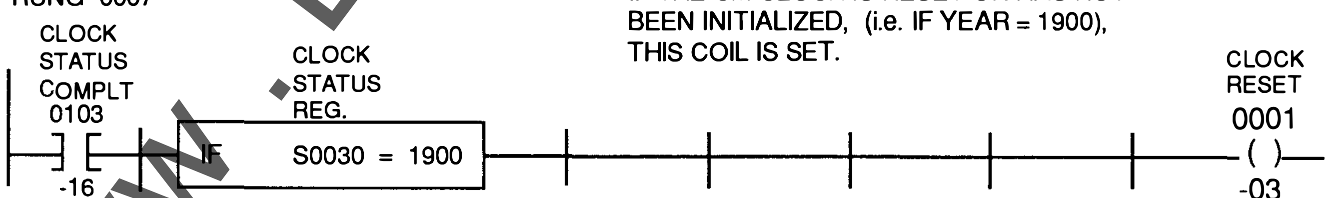
RUNG 0006

THIS RUNG READS THE STATUS OF THE CM CLOCK.



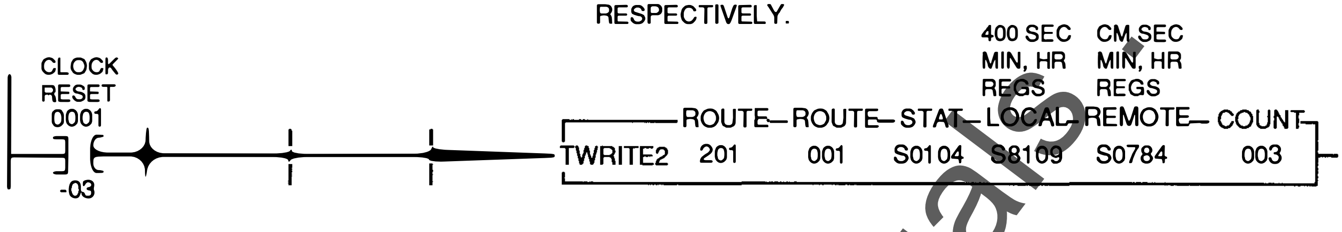
RUNG 0007

IF THE CM CLOCK IS RESET OR HAS NOT
BEEN INITIALIZED, (i.e. IF YEAR = 1900),
THIS COIL IS SET.



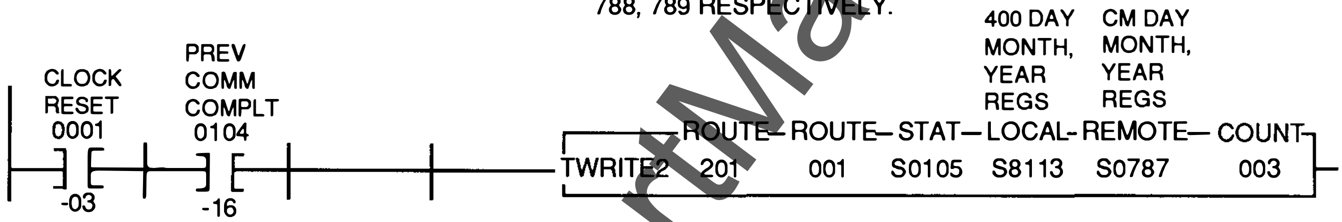
RUNG 0008

TRANSFER MODEL 400 SEC (S8109), MIN (S8110), HOUR (S8111) TO CIRCUIT MONITOR REGISTERS 784, 785, 786 RESPECTIVELY.



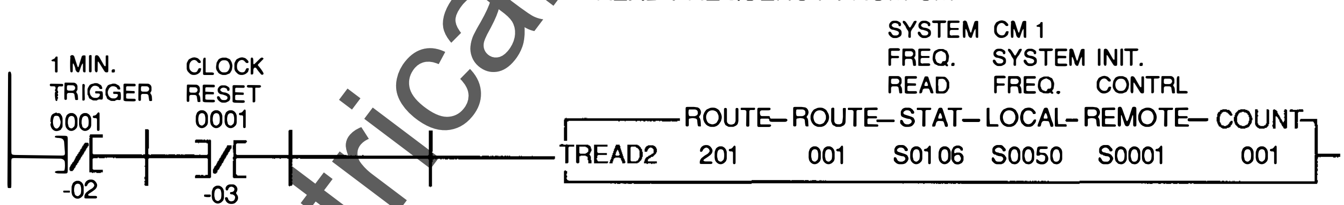
RUNG 0009

TRANSFER MODEL 400 DAY (S8113), MONTH (S8114), YEAR (S8115) TO CIRCUIT MONITOR REGISTERS 787, 788, 789 RESPECTIVELY.



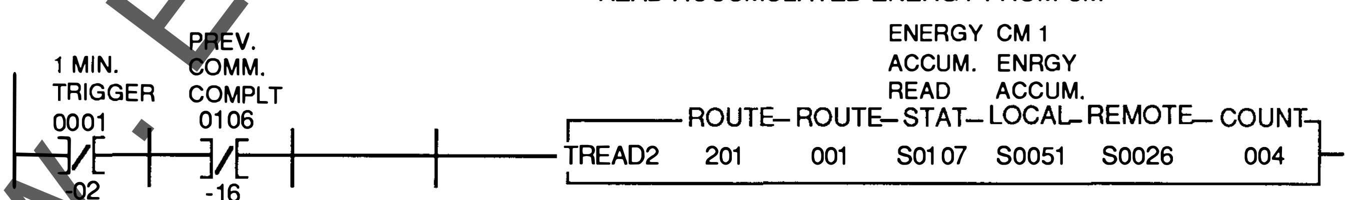
RUNG 0010

READ FREQUENCY FROM CM



RUNG 0011

READ ACCUMULATED ENERGY FROM CM



8.0 ROUTING IN POWERLOGIC COMMUNICATIONS

8.1 General

The PowerLogic™ system requires the use of network *route statements* for data communications over the SY/NET® local area network. The purpose of this section is to provide the basic information needed to utilize route statements in communicating to PowerLogic via the SY/NET® network. Additional information on the use of routing can be found in the instruction bulletin for the SY/NET Network Interface Module (30598-257-01).

8.2 What is Routing?

In many electrical distribution systems, data communications to and from multiple devices are carried over the same set of communication cables. This "cable sharing" greatly reduces the number of cables needed; however, this introduces a new problem: How to direct communications to a specific device in the system. This problem is solved by assigning each device on a network a unique device number (or address). A message may then be sent along a defined path (or Route) until it reaches the device with the desired address.

The remainder of this appendix, discusses the use of routing in PowerLogic Systems 1, 2, 3, and 4 and offers examples of route statements for each.

8.3 System 1 Routing Example

The most basic system involves the connection of up to 32 Circuit Monitors (CMs) to a PowerLogic System Display as shown in Figure 8-1. The System Display may be mounted at the equipment location, or in a more accessible remote location.

Typically, the address of the target Circuit Monitor is the last number in a route statement. But unlike other devices to which Circuit Monitors may be connected, the System Display must be configured with a table of the addresses of the Circuit Monitors connected to it. And since the System Display does not have a device address, a route statement is not required for a System 1 connection. (For additional information on configuring the System Display, refer to instruction bulletin #63210-150-01).

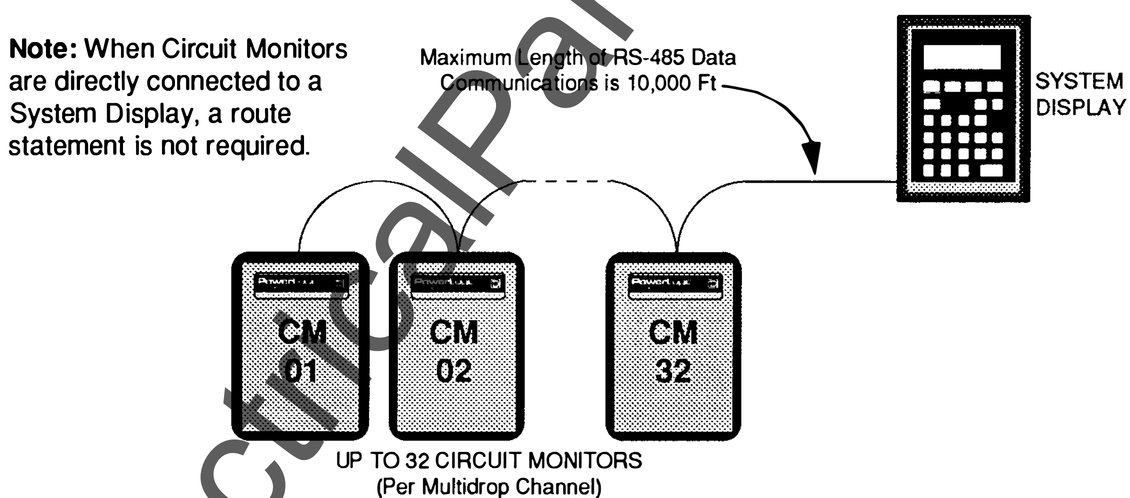


Figure 8-1 - *System 1 Routing Example.*

8.4 System 2 Routing Example

In System 2 a personal computer is used for remote communications to Circuit Monitors. (See Figure 8-3). The personal computer (PC) must contain a SY/LINK® Network Interface Card and supporting software to enable remote monitoring of the CM's. Unlike the System Display, the SY/LINK card is assigned a device address (from 00 to 99) which must always be the first route in the route statement, preceded by a 0. For example, if the SY/LINK card has been assigned the address 28, the first route in the route statement should be 028.

The SY/LINK card has two (2) nine-pin communication ports. (See Figure 8-2). The top port (female connector) is an RS-422 port (called port 1) and the bottom port (male connector) is a network port for connection to the SY/NET® network. In the system shown in Figure 8-3, the CMs are attached to the RS-422 port (port 1) of the SY/LINK card.

All messages sent from the SY/LINK card default to the network port unless otherwise specified in the software. Software redirection of communications from the network port to the RS-422 port is accomplished through the addition of a route in the second position of the route statement. This route consists of the SY/LINK card's address preceded by a '1'. The '1' informs the SY/LINK card to direct communications out the RS-422 port (port 1). Figure 8-3 shows sample route statements from the RS-422 port of a SY/LINK card to Circuit Monitors.

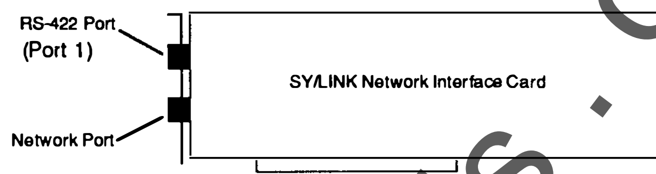


Figure 8-2 *- SY/LINK Card RS-422 and Network ports.*

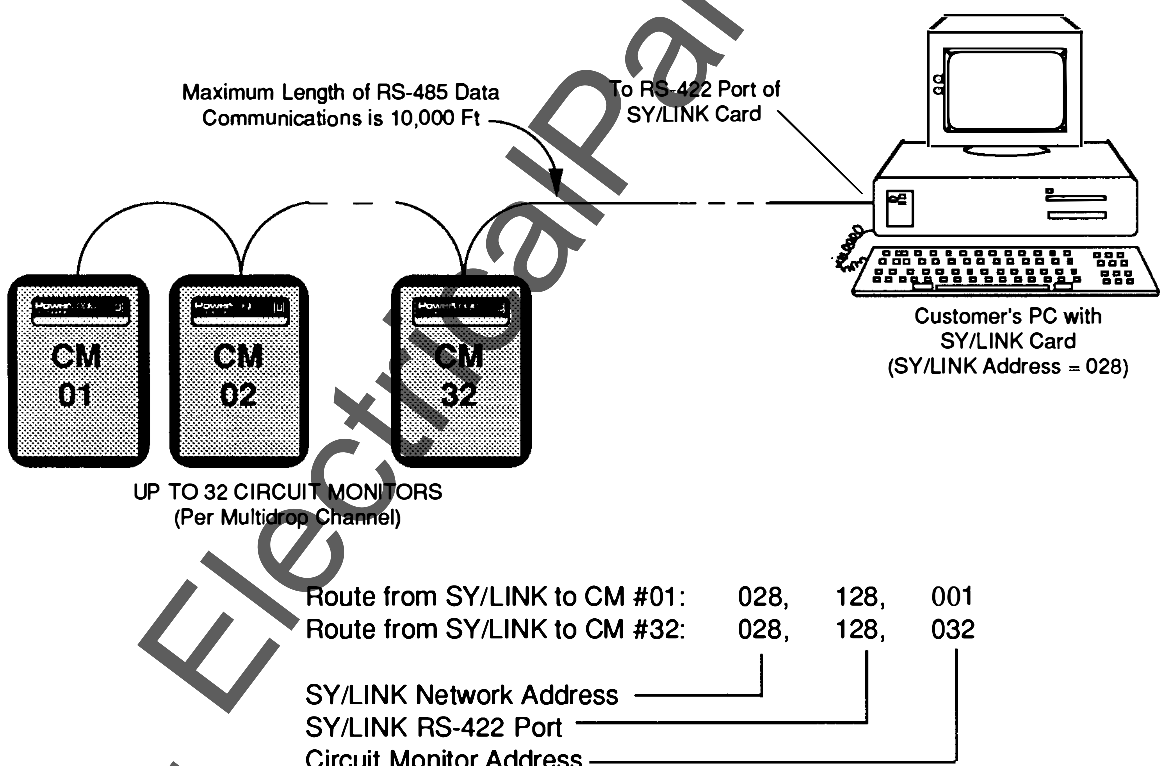


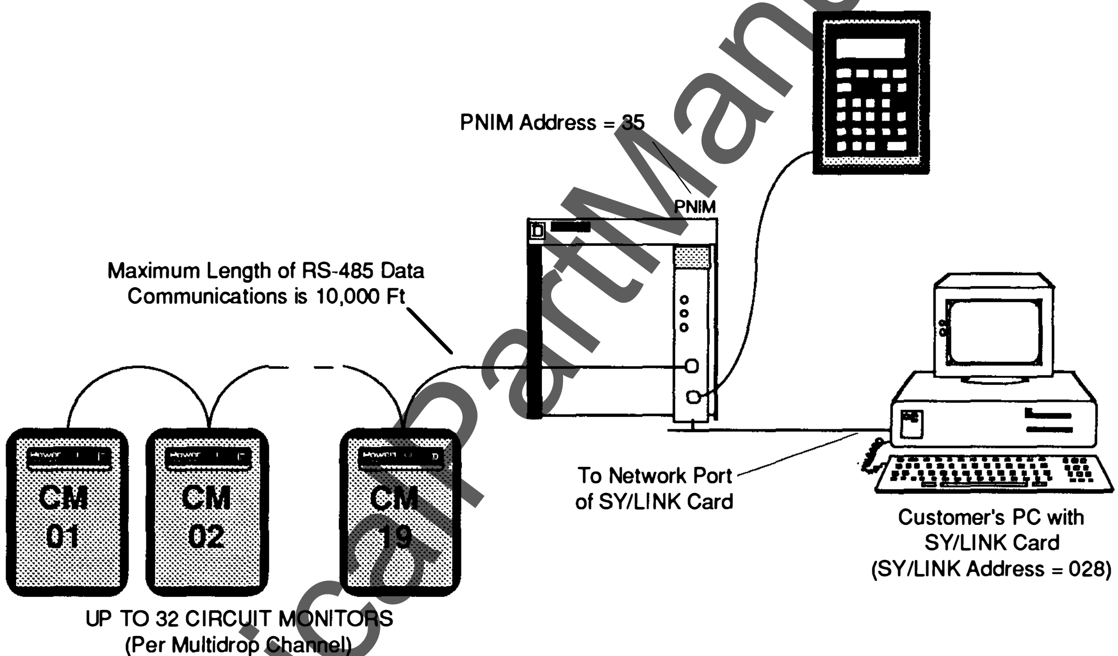
Figure 8-3 *- System 2 Routing Example.*

8.5 System 3 Routing Example

To incorporate both the System Display and personal computer options, a PowerLogic™ Network Interface Module (PNIM) must be used. (See Figure 8-4). This device controls data communications from the System Display and the PC to avoid collisions that could occur if both devices attempted to communicate to CM's at the same instant.

The PNIM, like the SY/LINK Card, must be assigned a unique address (from 00 to 99) which is used in route statements. Also, the PNIM has two (2) nine-pin communication ports. The top port is referred to as port '0' and the bottom as port '1'. The top port is the only port to which CM's may be connected, therefore the System Display must be connected to port '1'.

Since the PNIM has two RS-422 communication ports (0 and 1), the route statement must specify which port the target Circuit Monitor is connected to. This is done by including a route consisting of the address of the PNIM preceded by a 0 (since the CM is connected to port 0). Also, since the System Display is connected to port 1 of the PNIM, its route statement must indicate this by including a route consisting of the address of the PNIM preceded by a 1 (since the System Display is connected to port 1). Figure 8-4 shows sample route statements to CMs through a PNIM.



Route from SY/LINK to CM #01:	028,	035,	001
Route from SY/LINK to CM #19:	028,	035,	019

SY/LINK Network Address
PNIM Address (Port 0)
Circuit Monitor Address

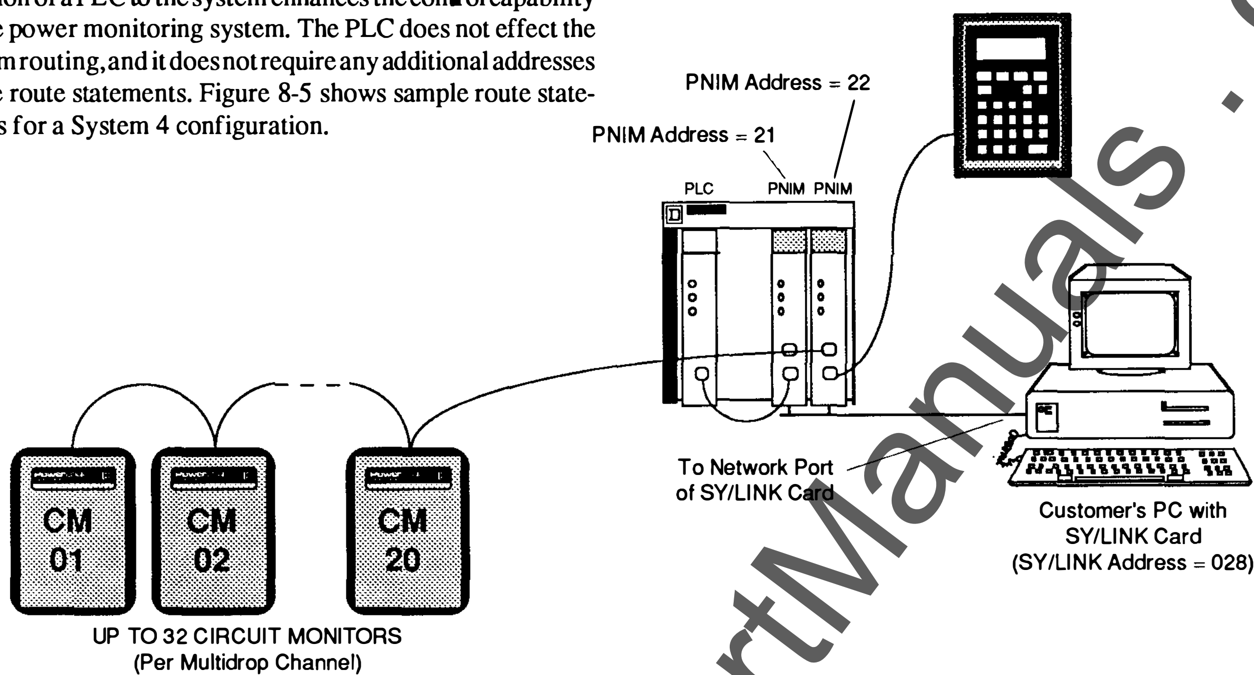
Route from System Display to CMs: 135, 035

System Display Address (none)
PNIM Address (Port 1)
PNIM Address (Port 0)
(Circuit Monitor Address Not Required)

***Figure 8-4** - System 3 Routing Example.*

8.6 System 4 Routing Example

A SY/MAX® programmable logic controller (PLC) may be added to a PowerLogic System 3 to create a System 4. The addition of a PLC to the system enhances the control capability of the power monitoring system. The PLC does not effect the system routing, and it does not require any additional addresses in the route statements. Figure 8-5 shows sample route statements for a System 4 configuration.



Route from SY/LINK to CM #01: 028, 022, 001
Route from SY/LINK to CM #20: 028, 022, 020

SY/LINK Network Address
PNIM Address (Port 0)
Circuit Monitor Address

Route from System Display to CMs: 122, 022

System Display Address (none)
PNIM Address (Port 1)
PNIM Address (Port 0)
(Circuit Monitor Address Not Required)

Route from PLC to CM #01: 121, 022, 01

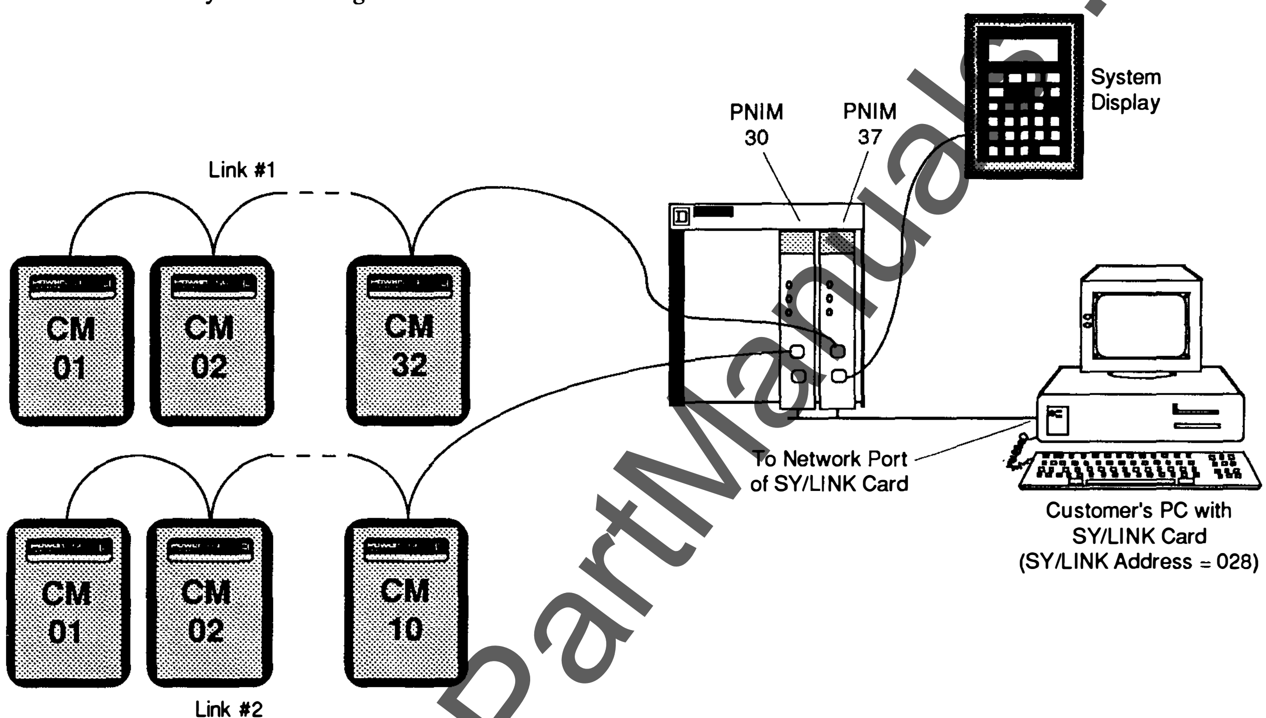
PNIM Address (Port 1)
PNIM Address (Port 0)
Circuit Monitor Address

***Figure 8-5** - System 4 Routing Example.*

8.7 Additional Routing Examples

Multiple PNIMs

When more than 32 Circuits need to be monitored, additional PNIMs may be added. Each PNIM may have up to 32 CMs daisy-chained to its top port (port 0). Figure 8-6 shows sample route statements for a system utilizing two PNIMs.



Route from SY/LINK to CM #01 on Link #1:	028,	037,	001
Route from SY/LINK to CM #10 on Link #2:	028,	030,	010

Route from System Display to CMs on Link #1:	137,	037
Route from System Display to CMs on Link #2:	137,	030

***Figure 8-6** - System 3 with two PNIMs Routing Example.*

Modem Communications

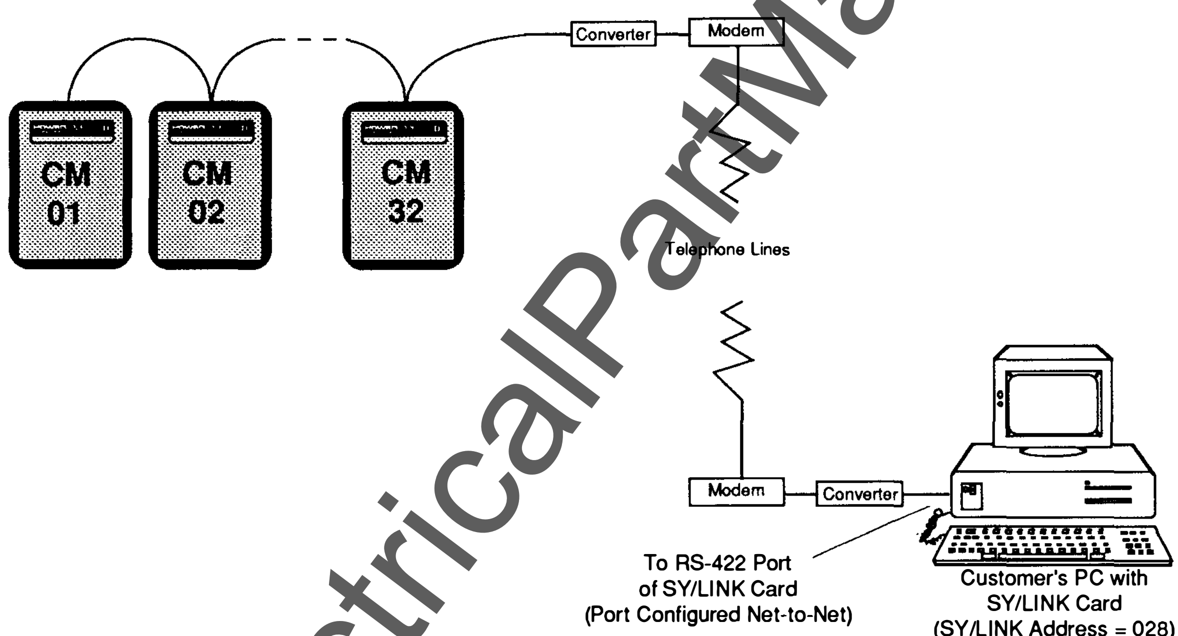
Modem Communications require the use of two modems and two signal converters. The converters translate between the RS-232 signal required by the modems and the RS-485/422 signal used by PowerLogic and SY/MAX® devices. There are two types of converters: a freestanding RS-232/485 converter, and a rack-mounted SY/MAX converter, the CRM-601 (See Figure 8-8). Though different in appearance, the converters perform virtually identical functions.

The converters and modems are not addressable and do not require routes in the route statement. Figure 8-7 shows a remote PC communicating to 32 Circuit Monitors via modem communications.

Figure 8-8 shows a remote PC communicating to 32 Circuit Monitors via modem communications. The system includes two PowerLogic Network Interface Modules (PNIMs) each supporting up to 32 CMs. The rack-mounted CRM-601 converter is used in place of the free-standing converter.

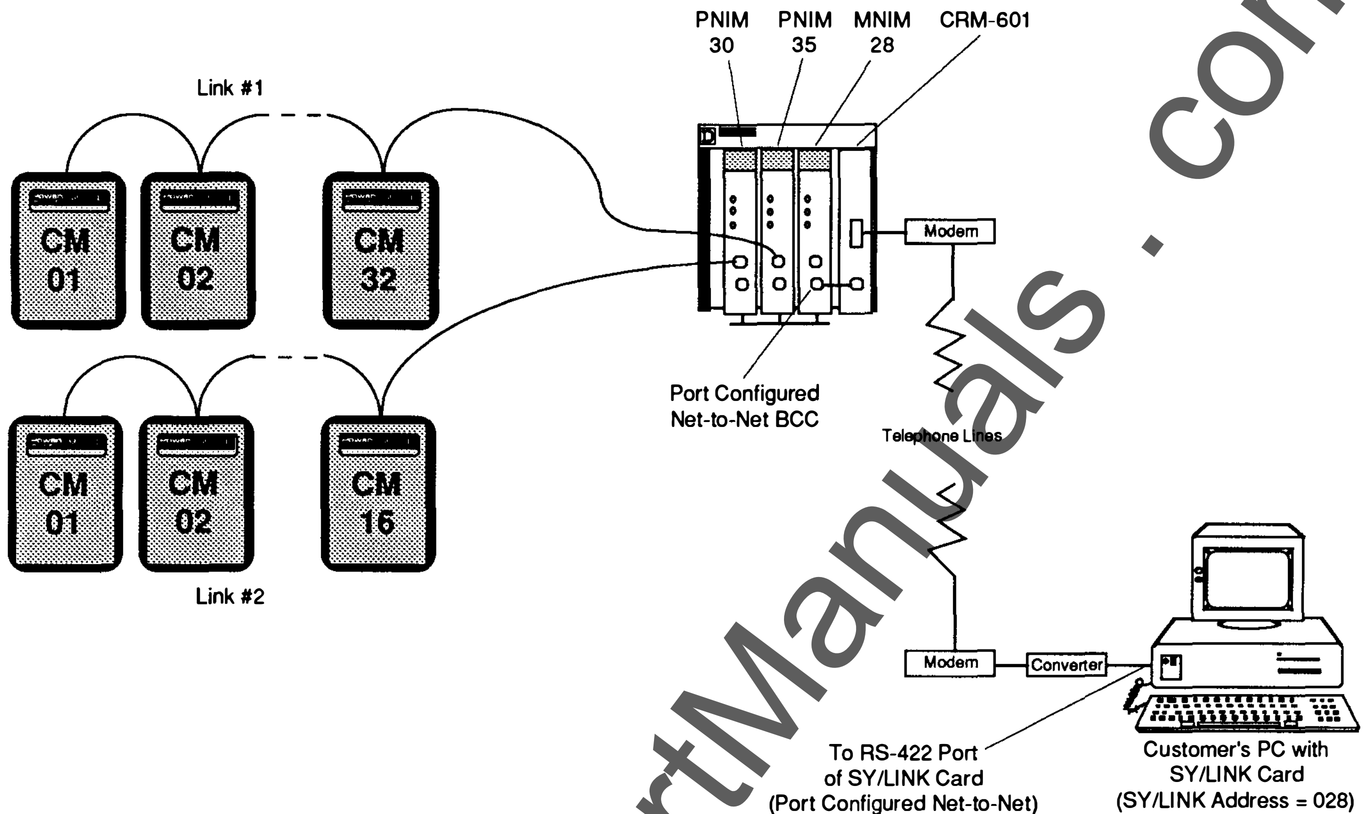
A SY/MAX Multi-Media Network Interface Module (MNIM) is required to complete communications. The MNIM port (port 1) to which the converter is connected must be configured to communicate in "Net-to-Net BCC" mode. The RS-422 port of the SY/LINK card must be configured for Net-to-Net operation. Also, the MNIM and the SY/LINK card must have the same network address. Figure 8-8 shows sample route statements for this configuration.

For more information on modem communications, refer to instruction bulletin #63210-153-02.



Route from SY/LINK to CM #01:	028,	128,	001
Route from SY/LINK to CM #32:	028,	128,	032

Figure 8-7 - System 2 with Modem Communications Routing Example.



Route from SY/LINK to CM #01 on Link #1:	028,	128,	035,	001
Route from SY/LINK to CM #16 on Link #2:	028,	128,	030,	016

Figure 8-8 - *System 2 with Network and Modem Communications Routing Example.*

9.0 CIRCUIT MONITOR REGISTER FORMATS

Each register in the Circuit Monitor has a total of 16 bits. The bits are numbered from 1 to 16, where 1 is the low bit (least significant), and 16 is the high bit (most significant). Figure 9-1 illustrates Circuit Monitor register format.

The majority of the data stored within the Circuit Monitor are single register, decimal values (stored in two's complement format). Exceptions to this include: Power Factor, Date/Time and Accumulated Energy values. The formats used to store these values are described below.

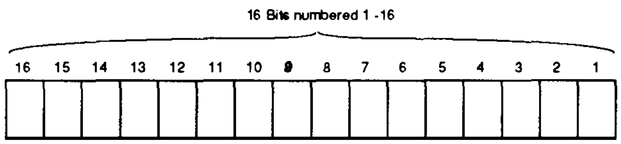


Figure 9-1 - Circuit Monitor Register

Power Factor

Each power factor value occupies one register. All power factor values (regs 14-17, 52-54, 74-77) are stored using signed magnitude notation. Bit number 16, the sign bit, is used to indicate leading/lagging. A positive value (Bit 16 = 0) indicates leading. A negative value (Bit 16 = 1) indicates lagging. Bits 1-8, store a value in the range 0-100 (decimal). Power factor values must be divided by 100 to obtain a power factor in the range 0 to 1.00. Figure 9-2 offers a graphical representation of a power factor register.

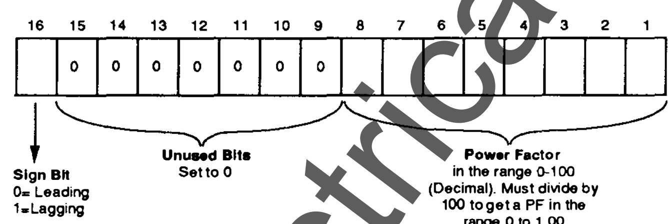


Figure 9-2 - Power Factor Register Format

SY/MAX® Compatible Date/Time Values

CM registers 700-795 contain date/time values in a format compatible with SY/MAX® processors. Each of the date/time fields occupies six storage registers. Seconds, minutes, hours, day, month, and year each occupy a register. For example, if a specific date/time field began in register n, then the field would be organized as shown in Table 9-1. (The example uses "Last Restart Date/time," regs 700-705).

Item	Register	Example
Seconds	n	700
Minutes	n+1	701
Hours	n+2	702
Day	n+3	703
Month	n+4	704
Year	n+5	705

Table 9-1 - Circuit Monitor SY/MAX® Compatible Date/Time Storage Format

Energy Accumulated and Reactive Energy Accumulated

The Circuit Monitor calculates values for Accumulated Energy (regs 24-27) and Accumulated Reactive Energy (regs 28-31). Each value occupies four storage registers. Each register contains a decimal value in the range -9999 to +9999.

The values are reported in a modulo 10,000 format. In other words, each register increments from 0 to +/- 9999 and then rolls over to 0 with a carry into the next register. The sign is also carried into the next register as the rollover occurs. Table 9-2 shows examples of energy values and their associated storage formats.

	Value Stored in Register			
Energy Value	**Reg n+3**	**Reg n+2**	**Reg n+1**	**Reg n**
0,000,000,000,009,999	0000	0000	0000	9999
0,000,000,000,010,000	0000	0000	0001	0000
-0,000,000,000,009,999	0000	0000	0000	-9999
-0,000,000,000,010,000	0000	0000	-0001	0000
0,000,000,099,999,999	0000	0000	9999	9999
0,000,000,100,000,000	0000	0001	0000	0000

Table 9-2 - Energy Values Storage Format Examples

10.0 CIRCUIT MONITOR REGISTER ASSIGNMENTS

Each Circuit Monitor (CM) has an identical set of SY/MAX compatible registers. Depending on the version of CM being dealt with, certain registers may simply be reserved or unused. This is indicated where appropriate. Reserved registers may be read but the values returned will simply be meaningless. This allows the user to read blocks of contiguous registers (up to 128) which contain reserved fields.

The CM has two types of registers:

a) Read Only registers
b) Write/Read registers

The read only registers will contain the values calculated based on the raw data sampled by the CM. The write/readregisters will contain user-defined parameters that are down-loaded or changed from the host. All registers contain decimal values in the range -32,767 to +32,767 unless otherwise noted. Appendix B discusses unusual register formats. (NOTE: If the host attempts to read from a non-existent register, a "0" value will be returned. However, if the host attempts to write to a non-existent register an error will be returned). Both types of registers have register numbers associated with them. Table 10-1 lists these register numbers:

Register Range	Type of Register
1-143	Read Only, Standard definition
200-242	Write/read, User defined parameters
246-255	Write/read, Utility registers
2000-2768	Waveform Data samples
2770-2798	Read Only, Data at time of waveform capture
8172-8192	Registers required to maintain SY/MAX compatibility

***Table 10-1** - Summary of Circuit Monitor Registers*

The standard registers come defined from the factory. Shown below are the standard definition of read only registers and their ranges that can be requested by a host and returned by a CM:

CM Reg #	Register Name	Register Description
1	Frequency	**Type**: Read only **Size**: 1 Register **Units**: Hertz in 100ths **Range**: 2300 - 6500 (23.00 - 65.00) **Function**: Frequency of circuit being monitored, as measured from measured voltage of phase A. If the frequency is not within the specified range, this register will return a 0 when read. **Restored at power-up / reset:** No

CM Reg #	Register Name	Register Description
2	Temperature	**Type:** Read only **Size**: 1 Register **Units:**Degrees Celsius (Centigrade) in 100ths **Range**: -10000 to +10000 (-100.00 to +100.00) **Function:** Temperature inside CM enclosure **Restored at power-up / reset:** Yes
3	Current, Phase A	**Type**: Read only **Size**: 1 Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function**: Measured RMS Phase A Current **Restored at power-up / reset:** No
4	Current, Phase B	**Type:** Read only **Size**: 1 Register **Units:** Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function**: Measured RMS Phase B Current **Restored at power-up / reset:** No
5	Current, Phase C	**Type**: Read only **Size:** 1 Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function:** Measured RMS Phase C Current **Restored at power-up / reset:** No
6	Current, 3 Phase Average	**Type**: Read only **Size**: 1 Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function:** Simple Arithmetic mean of the rms current flowing in the 3 phases. $((I_a + I_b + I_c)/3)$ I_a, I_b, I_c are contained in registers 3-5 **Restored at power-up / reset:** No
7	Current, Apparent rms	**Type:** Read only **Size**: 1 Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function**: This value is used to evaluate the impact of harmonics and other forms of distortion on a power circuit by reporting the "apparent" rms current as seen by many peak-sensing protection and instrumentation devices. This value is the maximum detected instantaneous peak current from any of the phases during the sample period, divided by the square root of 2 (the rms conversion factor for a true sinusoid). **Restored at power-up / reset:** No

CM Reg #	Register Name	Register Description
8	Voltage, Phase A to B	**Type:** Read only **Size:** 1 Register **Units:** Volts **Range:** 0 - 32,767 **Function:** RMS Voltage Between Phases A and B. (Measured in 3-wire, derived in 4-wire). **Restored at power-up / reset:** No
9	Voltage, Phase B to C	**Type**: Read only **Size**: 1 Register **Units**: Volts **Range**: 0 - 32,767 **Function**: RMS Voltage Between Phases B and C. (Measured in 3 wire, derived in 4 wire). **Restored at power-up / reset:** No
10	Voltage, Phase C to A	**Type:** Read only **Size:** 1 Register **Units**: Volts **Range:** 0 - 32,767 **Function**: Derived RMS Voltage Between Phases C and A **Restored at power-up / reset:** No
11	Voltage, Phase A to Neutral	**Type**: Read only **Size**: 1 Register **Units**: Volts **Range**: 0 - 32,767 **Function**: Measured RMS Voltage Between Phase A and Neutral In a 3 wire system, this value is not meaningful and when read will be returned as 32,767. **Restored at power-up / reset:** No
12	Voltage, Phase B to Neutral	**Type**: Read only **Size**: 1 Register **Units**: Volts **Range**: 0 - 32,767 **Function**: Measured RMS Voltage Between Phase B and Neutral In a 3 wire system, this value is not meaningful and when read will be returned as 32,767. **Restored at power-up / reset:** No
13	Voltage, Phase C to Neutral	**Type:** Read only **Size:** 1 Register **Units**: Volts **Range**: 0 - 32,767 **Function**: Measured RMS Voltage Between Phase C and Neutral In a 3 wire system, this value is not meaningful and when read will be returned as 32,767. **Restored at power-up / reset:** No

CM Reg #	Register Name	Register Description
14	Power Factor, 3 Phase Total✳	**Type:** Read only **Size:** 1 Register **Units:** Percent **Range:** +/- 100 (+/- 1.00) P.F. reported in percent; to convert back to a value in the range (-1.0 to 1.0), divide reported value by 100). The sign +/- indicates leading/ lagging. (See Section 9.0). Lead/Lag is always supplied, but the user should use per phase indication when available (i.e. when a 4 wire connection is used). **Function:** Total power factor of a 3 phase circuit calculated as the 3 phase total real power (reg 18) divided by the 3 phase total apparent power (reg 20). **Restored at power-up / reset:** No
15	Power Factor, Phase A✳	**Type:** Read only **Size:** 1 Register **Units:** Percent **Range:** +/- 100 (+/- 1.00) P.F. reported in percent; to convert back to a value in the range (-1.0 to 1.0), divide reported value by 100). The sign indicates leading/lagging (positive indicates leading, negative indicates lagging). **Function**: The ratio of the Phase A real power to the Phase A apparent power. Power Factor is described as "LAG" (current lagging voltage in an inductive circuit) or "LEAD" (current leading voltage in a capacitive circuit). A perfect unity (1.00) indicates a purely resistive circuit. [Note: per phase power factor values are not available in a 3 wire system and, when read, will be reported equal to 3-Phase Total Power Factor]. **Restored at power-up / reset:** No
16	Power Factor, Phase B✳	**Type:** Read only **Size:** 1 Register **Units**: Percent **Range**: same as reg #15 **Function**: Same as reg #15 only for Phase B **Restored at power-up / reset:** No
17	Power Factor, Phase C✳	**Type**: Read only **Size**: 1 Register **Units:**Percent **Range:** same as reg #15 **Function:** Same as reg #15 only for Phase C **Restored at power-up / reset:** No
18	Real Power, Three Phase Total (P)	**Type**: Read only **Size**: 1 Register **Units:** Kilowatts **Range:** - 32,767 to +32,767 **Function:** Sum of the real power values for each of the 3 phases **Restored at power-up / reset:** No

✳ Signed Magnitude Notation (See Appendix B)

CM Reg #	Register Name	Register Description
19	Reactive Power, Three Phase Total (Q)	**Type**: Read only **Size**: 1 Register **Units:** Kilovoltamperes Reactive (kVAr) **Range**: - 32,767 to +32,767 **Function**: Sum of the reactive power values for each of the 3 phases **Restored at power-up / reset:** No
20	Apparent Power, Three Phase Total (S)	**Type:** Read only **Size:** 1 Register **Units**: Kilovoltamperes (kVA) **Range:** 0 to +32,767 **Function**: Total volt-amps consumed in a 3 phase circuit. Magnitude of the complex power vector S. It is defined as: $\lvert S\rvert = \sqrt{P^2 + Q^2}$ Where P and Q are register 18 and 19 respectively. **Restored at power-up / reset:** No
21-23	Reserved	
24-27	Energy Accumulated	**Type:** Read only **Size:** 4 Registers **Units**: Watthours **Range**: 0 to +/- 9999999999999999 **Function**: This is a running accumulation over time, since last reset (by setting bit #2 of reg. 237), of the energy monitored in a given circuit. The total energy consumed is obtained by continuously integrating instantaneous real power with respect to time. Energy may be accumulated based on the absolute value of real power (regardless of direction of power flow) or based on its signed value (for reverse power flow, value of accumulated energy is reduced). Energy is accumulated as indicated by bit 1 of register 215. EAcc = WHr(Acc -1) + (P x t) if the signed mode of energy calculation is selected, and: EAcc = WHr(Acc -1) + (ABS(P) x t) if the unsigned mode of energy calculation is selected. Where Acc-1 = previous energy reading, P = 3 phase real power, t = time interval between calculations. **Restored at power-up / reset:** Yes
28-31	Reactive Energy, Accumulated	**Type:** Read only **Size:** 4 Registers **Units**: Varhours **Range**: 0 to +/- 9999999999999999 **Function:** This is a running accumulation over time, since last reset, of the reactive energy monitored in a given circuit. Reactive energy is obtained by using the equation above (regs #24-27), substituting varhours for watthours and Q (in vars) for P. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
32	Average Demand, Current Phase A	**Type**: Read only **Size**: 1 Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function**: Average demand current for phase A (reg 3) calculated using a sliding window over a 15 minute demand interval. **Restored at power-up / reset:** No
33	Average Demand, Current Phase B	**Type:** Read only **Size: 1** Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function:** Same as reg #32 except phase B current (reg 4) is used. **Restored at power-up / reset:** No
34	Average Demand, Current Phase C	**Type:** Read Only **Size**: 1 Register **Units:** Amps or tenths of Amps **Range:** 0 to 9999 (User-definable, See Reg 200) **Function:** Same as reg #32 except phase C current (reg 5) is used. **Restored at power-up / reset:** No
35	Average Demand, Real Power	**Type:** Read only **Size:** 1 Register **Units:** Kilowatts **Range**: - 32,767 to +32,767 **Function**: This is the average demand real power, calculated using a sliding window method over a user specified (see reg. 216) demand interval. **Restored at power-up / reset:** No
36	Predicted Demand Real Power	**Type:** Read only **Size**: 1 Register **Units:** Kilowatts **Range:** - 32,767 to +32,767 **Function:** This value is intended to provide a more meaningful predictor of real power usage when demand levels are changing. This value is obtained by taking the latest real power average demand, adding this to the most recent real power reading, and dividing by two. In this way, the predicted demand is weighted in favor of more recent data and, therefore, provides a means to anticipate changes in demand. **Restored at power-up / reset:** No
37	Peak Demand, Real Power	**Type**: Read only **Size**: 1 Register **Units**: Kilowatts **Range:** - 32,767 to +32,767 (Maximum of Average Demand Real Power) **Function:** This is maximum of the average demand real power (reg 35). It is not a true arithmetic maximum but is based on the absolute value of the Average Demand Power. **Restored at power-up / reset:** Yes

Registers 38-57 represent the minimum values for each of the registers discussed above since the last reset or minimum/maximum clear. Each time the present instantaneous value (registers 1 - 20) is updated it is compared to the previous minimum of that register, and if the new value is less than the previous, it becomes the new minimum value. All of the minimum value registers are saved in the event of a control power failure. The minimum value registers are of the same type, size, unit, and range as the corresponding instantaneous values.

CM Reg #	Register Name	Register Description
38	Minimum Frequency	**Type**: Read only **Size**: 1 Register **Units**: Hertz in 100ths **Range**: 2300 - 6500 (23.00 - 65.00) **Function**: Minimum frequency (reg 1) of the circuit being monitored. This register is only updated when the frequency is within the given range. **Restored at power-up / reset:** Yes
39	Minimum Temperature	**Type**: Read only **Size:** 1 Register **Units:** Degrees Celsius (Centigrade) in 100ths **Range:** -10000 to +10000 (-100.00 to +100.00) **Function:** Minimum temperature inside CM enclosure **Restored at power-up / reset:** Yes
40	Minimum Current, Phase A	**Type**: Read only **Size**: 1 Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function**: Minimum measured RMS Phase A Current (reg 3). **Restored at power-up / reset:** Yes
41	Minimum Current, Phase B	**Type**: Read only **Size**: 1 Register **Units:** Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function**: Minimum measured RMS Phase B Current (reg 4). **Restored at power-up / reset:** Yes
42	Minimum Current, Phase C	**Type**: Read only **Size:** 1 Register **Units**: Amps or tenths of Amps **Range**: 0 to +9999 (User-definable, See Reg 200) **Function:** Minimum measured RMS Phase C Current (reg 5). **Restored at power-up / reset:** Yes
43	Minimum Current, 3 Phase Average	**Type**: Read only **Size**: 1 Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function:** Minimum Simple Arithmetic mean of the rms current flowing in the 3 phases (reg 6). $((I_a + I_b + I_c)/3)$ I_a, I_b, I_c are contained in registers 3-5. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
44	Minimum Current, Apparent rms	**Type:** Read only **Size**: 1 Register **Units**: Amps or tenths of Amps (User-definable, See Reg 200) **Range**: 0 to 9999 **Function**: The minimum of reg 7, the value used to evaluate the impact of harmonics and other forms of distortion on a power circuit by reporting the "apparent" rms current as seen by many peak-detecting protection and instrumentation devices. **Restored at power-up / reset:** Yes
45	Minimum Voltage, Phase A to B	**Type**: Read only **Size**: 1 Register **Units**: Volts **Range:** 0 - 32,767 **Function**: Minimum measured RMS Voltage Between Phases A and B (reg 8). **Restored at power-up / reset:** Yes
46	Minimum Voltage, Phase B to C	**Type**: Read only **Size**: 1 Register **Units**: Volts **Range**: 0 - 32,767 **Function**: Minimum measured RMS Voltage Between Phases B and C (reg 9). **Restored at power-up / reset:** Yes
47	Minimum Voltage, Phase C to A	**Type:** Read only **Size:** 1 Register **Units**: Volts **Range:** 0 - 32,767 **Function**: Minimum measured RMS Voltage Between Phases C and A (reg 10). **Restored at power-up / reset:** Yes
48	Minimum Voltage, Phase A to Neutral	**Type**: Read only **Size**: 1 Register **Units**: Volts **Range**: 0 - 32,767 **Function**: Minimum measured rms voltage between Phase A and Neutral (reg 11). In a 3 wire system, this value is not meaningful and when read will be returned as 32,767. **Restored at power-up / reset:** Yes
49	Minimum Voltage, Phase B to Neutral	**Type**: Read only **Size**: 1 Register **Units**: Volts **Range**: 0 - 32,767 **Function**: Minimum measured rms voltage Between Phase B and Neutral (reg 12). In a 3 wire system, this value is not meaningful and when read will be returned as 32,767. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
50	Minimum Voltage, Phase C to Neutral	**Type:** Read only **Size:** 1 Register **Units**: Volts **Range**: 0 - 32,767 **Function**: Minimum measured rms Voltage Between Phase C and Neutral (reg 13). In a 3 wire system, this value is not meaningful and when read will be returned as 32,767. **Restored at power-up / reset:** Yes
51	Minimum Power Factor, 3 Phase Total⁕	**Type:** Read only **Size:** 1 Register **Units:** None **Range:** +/- 100 (+/- 1.00) The sign indicates leading/lagging (positive indicates leading, negative indicates lagging). (See Section 9.0). Lead/Lag is always supplied, but the user should use per phase indication when available (i.e. when a 4 wire connection is used). **Function:** Minimum total power factor of a 3 phase circuit calculated as the 3 phase total real power divided by the 3 phase total apparent power (reg 14). **Restored at power-up / reset:** Yes
52	Minimum Power Factor, Phase A⁕	**Type:** Read only **Size:** 1 Register **Units:** None **Range:** +/- 100 (+/- 1.00) The sign indicates leading/lagging (positive indicates leading, negative indicates lagging). **Function**: Minimum of the ratio of the Phase A real power to the Phase A apparent power. Power Factor is described as "LAG" (current lagging voltage in an inductive circuit) or "LEAD" (current leading voltage in a capacitive circuit). A perfect unity (1.00) indicates a purely resistive circuit. [Note: per phase power factor values are not available in a 3 wire system and, when read,will be reported equal to 3-Phase Total Power Factor]. **Restored at power-up / reset:** Yes
53	Minimum Power Factor, Phase B⁕	**Type:** Read only **Size:** 1 Register **Units**: None **Range**: Same as reg #52 **Function**: Same as reg #52 only for Phase B (reg 16). **Restored at power-up / reset:** Yes
54	Minimum Power Factor, Phase C⁕	**Type**: Read only **Size**: 1 Register **Units:** None **Range**: Same as reg #52 **Function:** Same as reg #52 only for Phase C (reg 17) **Restored at power-up / reset:** Yes

⁕ Signed Magnitude Notation (See Appendix B)

CM Reg #	Register Name	Register Description
55	Minimum Real Power, Three Phase Total (P)	**Type**: Read only **Size**: 1 Register **Units:** Kilowatts **Range:** - 32,767 to +32,767 **Function:** Minimum sum of the real power values for each of the 3 phases (reg 18). **Restored at power-up / reset:** Yes
56	Minimum Reactive Power, Three Phase Total (Q)	**Type**: Read only **Size**: 1 Register **Units:** Kilovoltamperes Reactive (kVAr) **Range**: - 32,767 to +32,767 **Function**: Minimum sum of the reactive power values for each of the 3 phases (reg 19). **Restored at power-up / reset:** Yes
57	Minimum Apparent Power, Three Phase Total (S)	**Type:** Read only **Size:** 1 Register **Units**: Kilovoltamperes **Range:** 0 to +32,767 **Function**: Minimum total volt-amps consumed in a 3 phase circuit (reg 20). Magnitude of the complex power vector S. It is defined as: $\lvert S\rvert = \sqrt{P^2 + Q^2}$ Where P and Q are register 18 and 19 respectively. **Restored at power-up / reset:** Yes
58-60		Reserved

Registers 61-86 represent the maximum values for each of the registers discussed above since the last reset or minimum/maximum clear. Each time the present instantaneous value (registers 1-20, 32-34) is updated it is compared to the previous maximum of that register and if the new value is greater than the previous it becomes the new maximum value. All of the maximum value registers are saved in the event of a control power failure. The maximum value registers are of the same type, size, unit, and range as the corresponding instantaneous values.

CM Reg #	Register Name	Register Description
61	Maximum Frequency	**Type**: Read only **Size**: 1 Register **Units**: Hertz in 100ths **Range**: 2300 - 6500 (23.00 - 65.00) **Function**: Maximum system frequency (reg 1). This register is only updated when the frequency falls within the given range. **Restored at power-up / reset:** Yes
62	Maximum Temperature	**Type**: Read only **Size**: 1 Register **Units:** Degrees Celsius (Centigrade) in 100ths **Range**: -10000 to +10000 (-100.00 to +100.00) **Function:** Maximum temperature inside CM enclosure **Restored at power-up / reset:** Yes
63	Maximum Current, Phase A	**Type**: Read only **Size**: 1 Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function**: Maximum measured RMS Phase A Current (reg 3). **Restored at power-up / reset:** Yes
64	Maximum Current, Phase B	**Type:** Read only **Size**: 1 Register **Units:** Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function**: Maximum measured RMS Phase B Current (reg 4). **Restored at power-up / reset:** Yes
65	Maximum Current, Phase C	**Type**: Read only **Size:** 1 Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function:** Maximum measured RMS Phase C Current (reg 5). **Restored at power-up / reset:** Yes
66	Maximum Current, 3 Phase Average	**Type**: Read only **Size**: 1 Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function:** Maximum simple arithmetic mean of the rms current flowing in the 3 phases (reg 6). $((I_a + I_b + I_c)/3)$ I_a, I_b, I_c are contained in registers 3-5. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
67	Maximum Current, Apparent rms	**Type:** Read only **Size**: **1** Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function**: The maximum of reg 7, the value used to evaluate the impact of harmonics and other forms of distortion on a power circuit by reporting the "apparent" rms current as seen by many peak-detecting protection and instrumentation devices. **Restored at power-up / reset:** Yes
68	Maximum Voltage, Phase A to B	**Type**: Read only **Size**: 1 Register **Units**: Volts **Range:** 0 - 32,767 **Function**: Maximum measured RMS Voltage Between Phases A and B (reg 8) **Restored at power-up / reset:** Yes
69	Maximum Voltage, Phase B to C	**Type**: Read only **Size**: 1 Register **Units**: Volts **Range**: 0 - 32,767 **Function**: Maximum measured RMS Voltage Between Phases B and C (reg 9) **Restored at power-up / reset:** Yes
70	Maximum Voltage, Phase C to A	**Type:** Read only **Size:** 1 Register **Units**: Volts **Range:** 0 - 32,767 **Function**: Maximum measured RMS Voltage Between Phases C and A (reg 10) **Restored at power-up / reset:** Yes
71	Maximum Voltage, Phase A to Neutral	**Type**: Read only **Size**: 1 Register **Units**: Volts **Range**: 0 - 32,767 **Function**: Maximum measured RMS Voltage Between Phase A and Neutral (reg 11). In a 3 wire system, this register is meaningless, and when read, will return 32,767 . **Restored at power-up / reset:** Yes
72	Maximum Voltage, Phase B to Neutral◆	**Type**: Read only **Size**: 1 Register **Units**: Volts **Range**: 0 - 32,767 **Function**: Maximum measured RMS Voltage Between Phase B and Neutral (reg 12). In a 3 wire system, this register is meaningless, and when read, will return 32,767 . **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
73	Maximum Voltage, Phase C to Neutral	**Type:** Read only **Size:** 1 Register **Units**: Volts **Range**: 0 - 32,767 **Function**: Maximum measured RMS Voltage Between Phase C and Neutral (reg 13). In a 3 wire system, this register is meaningless, and when read, will return 32,767. **Restored at power-up / reset:** Yes
74	Maximum Power Factor, 3 Phase Total✳	**Type:** Read only **Size:** 1 Register **Units:** None **Range:** +/- 100 (+/- 1.00) The sign indicates leading/lagging (positive indicates leading, negative indicates lagging). (See Section 9.0). Lead/Lag is always supplied, but the user should use per phase indication when available (i.e. when a 4 wire connection is used). **Function:** Maximum total power factor of a 3 phase circuit calculated as the 3 phase total real power divided by the 3 phase total apparent power (reg 14). **Restored at power-up / reset:** Yes
75	Maximum Power Factor, Phase A✳	**Type:** Read only **Size:** 1 Register **Units:** None **Range:** +/- 100 (+/- 1.00) The sign indicates leading/lagging (positive indicates leading, negative indicates lagging). **Function**: Maximum of the ratio of the Phase A real power to the Phase A apparent power. (reg 15). Power Factor is described as "LAG" (current lagging voltage in an inductive circuit) or "LEAD" (current leading voltage in a capacitive circuit). A perfect unity (1.00) indicates a purely resistive circuit. [Note: per phase power factor values are not available in a 3 wire system and, when read,will be reported equal to 3-Phase Total Power Factor]. **Restored at power-up / reset:** Yes
76	Maximum Power Factor, Phase B✳	**Type:** Read only **Size:** 1 Register **Units**: None **Range**: Same as reg #75 **Function**: Same as reg #75 only for Phase B (reg 16). **Restored at power-up / reset:** Yes
77	Maximum Power Factor, Phase C✳	**Type**: Read only **Size**: 1 Register **Units:** None **Range**: Same as reg #75 **Function:** Same as reg #75 only for Phase C (reg 17). **Restored at power-up / reset:** Yes

✳ Signed Magnitude Notation (See Appendix B)

CM Reg #	Register Name	Register Description
78	Maximum Real Power, Three Phase Total (P)	**Type**: Read only **Size**: 1 Register **Units:** Kilowatts **Range:** - 32,767 to +32,767 **Function:** Maximum sum of the real power values for each of the 3 phases (reg 18) **Restored at power-up / reset:** Yes
79	Maximum Reactive Power, Three Phase Total (Q)	**Type**: Read only **Size**: 1 Register **Units:** Kilovoltamperes Reactive (kVAr) **Range**: - 32,767 to +32,767 **Function**: Maximum sum of the reactive power values for each of the 3 phases (reg 19). **Restored at power-up / reset:** Yes
80	Maximum Apparent Power, Three Phase Total (S)	**Type:** Read only **Size:** 1 Register **Units**: Kilovoltamperes **Range:** 0 to +32,767 **Function**: Maximum of the total volt-amps consumed in a 3 phase circuit (reg 20).Magnitude of the complex power vector S. It is defined as: $\|S\| = \sqrt{P^2 + Q^2}$ Where P and Q are register 18 and 19 respectively. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
81	Input Status Register	**Type:** Read only **Size:** 1 Register **Units:** None **Range:** Bit mapped field. See description below. **Function:** This register indicates the status of the inputs from Circuit Monitors equipped with eight digital inputs (CM-108 and CM-208) and Circuit Monitors equipped with four inputs and four outputs (CM-144 and CM-244). This register also returns the position of the keyswitch on the Circuit Monitors with outputs. **CM-108, CM-208:** Bits 1-8 indicate the status of inputs S1-S8, respectively. A bit value of 1 indicates that the input is ON (CLOSED). A bit value of 0 indicates that the input is OFF (OPEN). Bit 1 = Input 1 Bit 2 = Input 2 Bit 3 = Input 3 Bit 4 = Input 4 Bit 5 = Input 5 Bit 6 = Input 6 Bit 7 = Input 7 Bit 8 = Input 8 Bits 9-16 = Reserved **CM-144, CM-244:** Bits 1-4 indicate the status of inputs S1-S4, respectively. A bit value of 1 indicates that the input is ON (CLOSED). A bit value of 0 indicates that the input is OFF (OPEN). Bits 9-16 indicate the position of the keyswitch. Bit 1 = Input 1 Bit 2 = Input 2 Bit 3 = Input 3 Bit 4 = Input 4 Bits 5-8 = Reserved Bits 9-16 = Keyswitch Position as indicated below. **Value (Decimal)** — **Position** 01 — RUN, Outputs Enabled 02 — SETUP, Outputs Disabled 03 — LOCKOUT, outputs locked out 04 — RESET 255 — No keyswitch detected **Restored at power-up / reset:** Yes
82	Reserved	
83	3-Phase Power Factor at Peak Demand kW	**Type**: Read only **Size**: 1 Register **Units**: Percent **Range**: Same as register #14. **Function**: When a new Peak Demand Real Power (register 37) is reached, the current 3-Phase Total Power Factor (register 14) is stored here. This value is automatically reset when the Peak Demand Real Power value is reset (see reg 237). The date/time is the same as registers 100-102. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
84	Peak Demand Current Phase A	**Type**: Read only **Size**: 1 Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function**: Maximum average demand current for phase A (reg 32) calculated using a sliding window over a 15 minute demand interval. **Restored at power-up / reset:** Yes
85	Peak Demand Current Phase B	**Type:** Read only **Size:** 1 Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function:** Same as reg #84 except phase B current (reg 33) is used. **Restored at power-up / reset:** Yes
86	Peak Demand Current Phase C	**Type:** Read Only **Size**: 1 Register **Units:** Amps or tenths of Amps **Range:** 0 to 9999 (User-definable, See Reg 200) **Function:** Same as reg #84 except phase C current (reg 34) is used. **Restored at power-up / reset:** Yes
87	CM Address Switch Setting	**Type:** Read only **Size:** 1 Register **Range:** 0-99 **Function:** When this register is read, it returns the current address of the CM as shown on the device address switches on the rear of the unit. **Restored at power-up / reset:** Yes
88-90	Last Restart Date/time	**Type:** Read only **Size:** 3 Registers **Units**: Month, Day, Yr, Hr, Min, Sec **Range:** Register 88, Month (byte 1) = 1 - 12, Day (byte 2) = 1 - 31, Register 89, Year (byte 3) = 0 - 199, Hour (byte 4) = 0 - 23, Register 90, Minutes (byte 5) = 0 - 59, Seconds (byte 6) = 0 - 59. The year is zero based on the year 1900 in anticipation of the 21st century, (e.g. 1989 would be represented as 89 and 2009 would be represented as109). **Function:** The date/time in these registers is the last time the CM was restarted from the host by writing to register 237 with bit 5 = 1. The date and time are taken from the CM internal clock. **Restored at power-up / reset:** Yes
91-93	Date/time of Peak Demand Current,Phase A	**Type**: Read only **Size:** 3 Registers **Units:** Same as regs # 88-90 **Range:** Same as regs # 88-90 **Function:** These registers store the date/time when a new peak demand for current phase A was recorded (reg 84). The date and time are taken from the CM internal clock. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
94-96	Date/time of Peak Demand Current, Phase B	**Type:** Read only **Size:** 3 Registers **Units:** Same as regs # 88-90 **Range:** Same as regs # 88-90 **Function:** These registers store the date/time when a new peak demand for current phase B is recorded (reg 85). The date and time is taken from the CM internal clock. **Restored at power-up / reset:** Yes
97-99	Date/time of Peak Demand Current, Phase C	**Type:** Read only **Size:** 3 Registers **Units:** Same as regs # 88-90 **Range**: Same as regs # 88-90 **Function**: These registers store the date/time when a new peak demand for current phase C was recorded (reg 86). The date and time is taken from the CM internal clock. **Restored at power-up / reset:** Yes
100-102	Date/time of Peak Demand, (Average Real Power)	**Type**: Read only **Size:** 3 Registers **Units**: Same as regs # 88-90 **Range:** Same as regs # 88-90 **Function**: These registers store the date/time when the last peak demand (reg 37) was recorded. The date and time is taken from the CM internal clock. **Restored at power-up / reset:** Yes
103-105	Date/time of Last Reset of Peak Demand Currents	**Type:** Read only **Size:** 3 Registers **Units:** Same as regs # 88-90 **Range:** Same as regs # 88-90 **Function:** The date/time in these registers record the last time a write to register 237 with bit 3 = 1 occurred. The time is taken from the CM internal clock. **Restored at power-up / reset:** Yes
106-108	Date/time of Last Min/Max Clear of Instantaneous Values	**Type:** Read only **Size:** 3 Registers **Units**: Same as regs # 88-90 **Range:** Same as regs # 88-90 **Function**: These registers store the date/time when a write to register 237 with bit 1 = 1 last occurred causing the instantaneous max and min values to be reset to their present values. **Restored at power-up / reset:** Yes
109-111	Date/time of Last Write to Circuit Tracker™ Setpoint Register	**Type:** Read only **Size:** 3 Registers **Units:** Same as regs #88-90 **Range:** Same as regs #88-90 **Function:** This is the date/time when reg 238 was last written to by the host. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
112-114	Date/time When Peak Demand (Average Real Power) Was Last Cleared	**Type**: Read only **Size:** 3 Registers **Units:** Same as regs # 88-90 **Range**: Same as regs # 88-90 **Function:** The date/time in these registers record the last occurrence of a write to reg. 237 with bit 4 = 1, causing the peak demand to be set equal to the current average demand, real power. (Register 35). **Restored at power-up / reset:** Yes
115-117	Date/time When Accumulated Energy Last Cleared	**Type**: Read only **Size**: 3 Registers **Units**: Same as regs # 88-90 **Range:** Same as regs # 88-90 **Function:** These registers store the date/time when the accumulated energy values, both real and reactive, in registers 24-31 are zeroed. This is accomplished by a write to register 237 with bit 2 = 1. The date and time are taken from the CM internal clock. **Restored at power-up / reset:** Yes
118-120	Date/time When The Control Power Failed Last	**Type:** Read only **Size:** 3 Registers **Units**: Same as regs # 88-90 **Range:** Same as regs # 88-90 **Function:** These registers store the date/time when the control power to the CM failed last. The date and time is taken from the CM internal clock. **Restored at power-up / reset:** Yes
121	Level 1 Energy Management Setpoint Last Exceeded Level	**Type**: Read only **Size**: 1 Register **Units**: Kilowatts **Range**: - 32,767 to +32,767 **Function:** This value represents the highest value of real power average demand (reg #35) which exceeded the level 1 energy management setpoint (reg # 239). **Restored at power-up / reset:** Yes
122	Level 2 Energy Management Setpoint Last Exceeded Level	**Type:** Read only **Size**: 1 Register **Units**: Kilowatts **Range**: - 32,767 to +32,767 **Function:** This value represents the highest value of real power average demand (reg #35) which exceeded the level 2 energy management setpoint (reg #240). **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
123	Level 3 Energy Management Set-point Last Exceeded Level	**Type:** Read only **Size**: 1 Register **Units**: Kilowatts **Range**: - 32,767 to +32,767 **Function**: This value represents the highest value of real power average demand (reg #35) which exceeded the level 3 energy management setpoint (reg #241). **Restored at power-up / reset:** Yes
124-126	Date/time When Level 1 Energy Management Set-Point Alarm Period Was Last Entered	**Type:** Read only **Size**: 3 Registers **Units:** Same as regs # 88-90 **Range:** Same as regs # 88-90 **Function:** These registers store the date/time when the level 1 energy management setpoint (regs # 239) was last exceeded and entered a level 1 alarm period. This date/time does NOT indicate when the highest exceeded value (regs #121) was recorded. The date and time are taken from the CM internal clock. **Restored at power-up / reset:** Yes
127-129	Date/time When Level 2 Energy Management Set-Point Alarm Period Was Last Entered	**Type:** Read only **Size**: 3 Registers **Units:** Same as regs # 88-90 **Range**: Same as regs # 88-90 **Function**: The date/time in these registers is when the level 2 energy management setpoint (regs # 240) was last exceeded and entered a level 2 alarm period. This date/time does NOT indicate when highest exceeded value (regs #122) was recorded. The date and time are taken from the CM internal clock. **Restored at power-up / reset:** Yes
130-132	Date/time When Level 3 Energy Management Set-point Alarm Period Was Last Entered	**Type**: Read only **Size:** 3 Registers **Units**: Same as regs # 88-90 **Range**: Same as regs # 88-90 **Function**: The date/time in these registers is when the level 3 energy management setpoint (regs # 241) was last exceeded and entered a level 3 alarm period. This date/time does NOT indicate when highest exceeded value (regs #123) was recorded. The date and time are taken from the CM internal clock. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
133	Number of Messages Sent To This Unit	**Type**: Read only **Size: 1** Register **Units**: None **Range**: 0 - 32,767 (Rolls over to 0 when max is exceeded) **Function**: This value is a counter that is incremented every time a communications exchange with the host and this CM is executed without errors. **Restored at power-up / reset:** Yes
134	Number of Messages Sent To Other Units	**Type:** Read only **Size:** 1 Register **Units**: None **Range:** 0 - 32,767 (Rolls over to 0 when max is exceeded) **Function**: This value is a counter that is incremented every time a communications exchange occurs with another CM and the host. **Restored at power-up / reset:** Yes
135	Number of Messages With Invalid Addresses	**Type**: Read only **Size**: 1 Register **Units**: None **Range**: 0 - 32,767 (Rolls over to 0 when max is exceeded) **Function**: This value is a counter that is incremented every time a message is sent from the host with an invalid CM address or route number. **Restored at power-up / reset:** Yes
136	Number Of Messages With Bad Checksum	**Type:** Read only **Size:** 1 Register **Units**: None **Range**: 0 - 32,767 (Rolls over to 0 when max is exceeded) **Function**: This value is a counter that is incremented every time a message for this CM is received but has a bad checksum. **Restored at power-up / reset:** Yes
137	Number Of Bad Messages Received At This CM	**Type**: Read only **Size:** 1 Register **Units:** None **Range**: 0 - 32,767 (Rolls over to 0 when max is exceeded) **Function**: This value is a counter that is incremented every time a bad message is received at this CM. **Restored at power-up / reset:** Yes
138	Number of Messages Received At This CM With Illegal Opcode	**Type**: Read only **Size:** 1 Register **Units:** None **Range:** 0 - 32,767 (Rolls over to 0 when max is exceeded) **Function**: This value is a counter that is incremented every time a message is received with an illegal opcode. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
139	Number of Messages Received At This CM With Illegal Registers	**Type**: Read only **Size**: 1 Register **Units**: None **Range**: 0 - 32,767 (Rolls over to 0 when max is exceeded) **Function:** This value is a counter that is incremented every time a message is received for this CM and has illegal Registers. **Restored at power-up / reset:** Yes
140	Number of Messages Received At This CM With Illegal Counts	**Type**: Read only **Size**: 1 Register **Units**: None **Range:** 0 - 32,767 (Rolls over to 0 when max is exceeded) **Function:** This value is a counter that is incremented every time a message is received for this CM and has illegal counts. **Restored at power-up / reset:** Yes
141	Number of Messages Received At This CM With Bad Frames	**Type**: Read only **Size**: 1 Register **Units:** None **Range:** 0 - 32,767 (Rolls over to 0 when max is exceeded) **Function:** This value is a counter that is incremented every time a message is received for this CM and has bad frames. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
142	Metering Microprocessor Status	**Type:** Read only **Size:** 1 Register **Units**: None **Range:** Not Applicable **Function:** This value is a status register reflecting the state of the meter micro-processor.

Bit Positions

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Bit 1 = If any of the other bits is a 1 this bit will be set to 1.
Bit 2 = If an on board ram error occurred during self test this bit will be set to 1.
Bit 3 = If an off board ram error occurred during self test this bit will be set to 1.
Bit 4 = If an EPROM checksum error occurred during self test this bit will be set to 1.
Bit 5 = If an interrupt error occurred during self test this bit will be set to 1.
Bit 6 = If the phase A current is 0, this bit will be set to 1.
Bit 7 = If the phase B current in a 4 wire system is 0, this bit will be set to 1.
Bit 8 = If the phase C current is 0 this bit will be set to 1.
Bit 9 = If the measured temp in the CM exceeds 70 C, this bit will be set to 1.
Bit 10 = If the phase A voltage is 0, this bit will be set to 1.
Bit 11 = If the phase B voltage is 0, this bit will be set to 1.
Bit 12 = If the phase C voltage in a 4 wire system is 0, this bit will be set to 1.
Bit 13 = Reserved
Bit 14 = Invalid Parameters in reg 200-202. This bit is set to 1 when any of the following invalid parameters occur:
- a) The value in reg 200 is not 3 or 4.
- b) The value in reg 201 in less than 5.
- c) The value in reg 202 is less than 120.

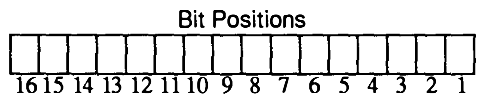
Bit 15 = No Frequency. This bit is set to 1 when any of the following conditions occurs:
- a) Overvoltage (Saturation of the A/D Converter)
- b) DC Voltage
- c) No Voltage
- d) Frequency not withing the range 23-65 HZ

Bit 16 = Reserved

Once this register has been read by the host, the register will be cleared so new status information will be current. This register is updated after each sample pass of the raw data.

Restored at power-up / reset: No

CM Reg #	Register Name	Register Description
143	Communications Microprocessor Status	**Type:** Read only **Size**: 1 Register **Units**: None **Range**: Not Applicable **Function**: This value is a status register reflecting the state of the communication microprocessor.



Bit 1 = If any of the other bits is a 1 this bit will be set to 1

Bit 2 = If an error occurred in the meter microprocessor (reg #142) this bit is set to a 1.

Bit 3 = If a power fail occurred this bit will be set to 1. When the CM date/time is reset, i.e. registers 784-789 or 228-230 are written to, this bit is cleared (set to 0).

Bit 4 = If an on board ram error occurred during self test this bit will be set to 1.

Bit 5 = If an off board ram error occurred during self test this bit will be set to 1.

Bit 6 = If an error was detected in the non-volatile ram during self test this bit will set to a 1.

Bit 7 = If an EPROM checksum error was detected during self test this bit will be set to 1.

Bit 8 = If an interrupt error was detected during self test this bit will be a 1.

Bit 9 = If excessive communication errors (reg # 135-141) have occurred this bit will be set to a 1.

Bit 10 = Level 1 Energy Management Setpoint Being Exceeded. This bit is set while the Real Power Average Demand value is exceeding the Level 1 Energy Management Setpoint (reg #239). It remains set while the Real Power Average Demand value exceeds the setpoint and is reset to 0 when the Real Power Average Demand falls below the setpoint.

Bit 11 = Level 2 Energy Management Setpoint Being Exceeded. This bit is set while the Real Power Average Demand value is exceeding the Level 2 Energy Management Setpoint (reg #240). It remains set while the Real Power Average Demand value exceeds the setpoint and is reset to 0 when the Real Power Average Demand falls below the setpoint.

Bit 12 = Level 3 Energy Management Setpoint Being Exceeded. This bit is set while the Real Power Average Demand value is exceeding the Level 3 Energy Management Setpoint (reg #241). It remains set while the Real Power Average Demand value exceeds the setpoint and is reset to 0 when the Real Power Average Demand falls below the setpoint.

Bit 13 = This bit is set to 1 when communications to the Display board are lost. (CM-150, CM-250 only).

Bits 14-16 = Reserved

After this register has been read by the host it will be cleared so new status information will be current. This register is updated after each sample pass of the raw data.

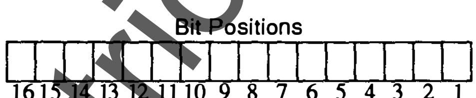
Restored at power-up / reset: No

The following registers (200 - 241) are write/read registers that can be read and written to over the communications link. (Regs 203-214 cannot be written to in the field). Some of these items are used in the calculations, some are for identification purposes, and some cause commands to be executed. **NOTE**: After writing to a register in the range 200-214, the user must force a software restart by setting bit #5 of register 237 (i.e. writing 16 to it).

CM Reg #	Register Name	Register Description
200	System Connection/ Current Reporting Precision	**Type:** Write/Read **Size:** 1 Register **Units:** None **Range:** 03, 04, 19, 20 **Function**: This register is used to set two independent parameters: System Connection and Current Reporting Precision. System Connection is used to indicate the way in which the CM is connected to the circuit being monitored. Current Reporting Precision indicates whether Current related values will be reported in amps or tenths of amps. Specific decimal values must be written to this register to indicate the desired configuration. The chart that follows indicates the decimal values which should be transmitted to achieve each configuration. **System Connection / Current Precision / Decimal Val** 3 wire / amps / 03 3 wire / tenths / 19 4 wire / amps / 04 4 wire / tenths / 20 **Restored at power-up / reset:** Yes
201	CT Rating	**Type**: Write/Read **Size**: 1 Register **Units**: None **Range**: 5 - 9999 **Default**: 5 **Function**: This value represents the primary rating of the current transformers connected to the CM (This assumes 5A secondary CTs). **Restored at power-up / reset:** Yes
202	PT Rating	**Type:** Write/Read **Size**: 1 Register **Units**: None **Range**: 120 - 32,767 **Default:** 120 **Function**: This value represents the primary rating of the potential transformers connected to the CM (This assumes 120V secondary PTs). **Restored at power-up / reset:** Yes
203	Channel A Voltage Gain	**Type:** Write/Read **Size**: 1 Register **Units**: None **Range**: 0.0000 - 3.0000 in 10,000ths (Nominal = 1.0000) **Function**: This value is used for calibration of the CM and is set at the factory. This register cannot be written to in the field. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
204	Channel A Voltage Offset	**Type:** Write/Read **Size:** 1 Register **Units**: None **Range:** -3.0000 to +3.0000 in 10,000ths (Nominal = 0.0000) **Function**: This value is used for calibration of the CM and is set at the factory. This register cannot be written to in the field. **Restored at power-up / reset:** Yes
205	Channel B Voltage Gain	**Type:** Write/Read **Size:** 1 Register **Units**: None **Range**: 0.0000 - 3.0000 in 10,000ths (Nominal = 1.0000) **Function**: Same as reg # 203 except for channel B. **Restored at power-up / reset:** Yes
206	Channel B Voltage Offset	**Type**: Write/Read **Size**: 1 Register **Units**: None **Range**: -3.0000 to +3.0000 in 10,000ths (Nominal = 0.0000) **Function**: Same as reg # 204 except for channel B. **Restored at power-up / reset:** Yes
207	Channel C Voltage Gain	**Type**: Write/Read **Size**: 1 Register **Units**: None **Range:** 0.0000 - 3.0000 in 10,000ths (Nominal = 1.0000) **Function**: Same as reg # 203 except for channel C. **Restored at power-up / reset:** Yes
208	Channel C Voltage Offset	**Type**: Write/Read **Size**: 1 Register **Units**: None **Range**: -3.0000 to +3.0000 in 10,000ths (Nominal = 0.0000) **Function**: Same as reg # 204 except for channel C. **Restored at power-up / reset:** Yes
209	Channel A Current Gain	**Type**: Write/Read **Size**: 1 Register **Units**: None **Range**: 0.0000 - 3.0000 in 10,000ths (Nominal = 1.0000) **Function**: This value is used for calibration of the CM and is set at the factory. This register cannot be written to in the field. **Restored at power-up / reset:** Yes
210	Channel A Current Offset	**Type**: Write/Read **Size**: 1 Register **Units**: None **Range**: -3.0000 to +3.0000 in 10,000ths (Nominal = 0.0000) **Function**: This value is used for calibration of the CM and is set at the factory. This register cannot be written to in the field. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
211	Channel B Current Gain	**Type**: Write/Read **Size**: 1 Register **Units**: None **Range**: 0.0000 - 3.0000 in 10,000ths (Nominal = 1.0000) **Function**: Same as reg # 209 except for channel B. **Restored at power-up / reset:** Yes
212	Channel B Current Offset	**Type**: Write/Read **Size**: 1 Register **Units**: None **Range**: -3.0000 to +3.0000 in 10,000ths (Nominal = 0.0000) **Function**: Same as reg # 210 except for channel B. **Restored at power-up / reset:** Yes
213	Channel C Current Gain	**Type**: Write/Read **Size**: 1 Register **Units**: None **Range**: 0.0000 - 3.0000 in 10,000ths (Nominal = 1.0000) **Function**: Same as reg # 209 except for channel C. **Restored at power-up / reset:** Yes
214	Channel C Current Offset	**Type**: Write/Read **Size**: 1 Register **Units**: None **Range**: -3.0000 to +3.0000 in 10,000ths (Nominal = 0.0000) **Function**: Same as reg # 210 except for channel C. **Restored at power-up / reset:** Yes
215	CM Operating Mode Selections	**Type**: Write/Read **Size**: 1 Register **Units**: None **Range**: Bit mapped field, see below.



Bit 1: This bit tells the CM to do either signed or unsigned energy calculations. (This effects only the value stored in registers 24-27). A zero (0) indicates that energy will be accumulated as positive regardless of the direction of power flow. A one (1) instructs the CM to consider the direction of power flow when doing energy calculations, thus allowing the accumulated energy magnitude to both increase and decrease. A change in this field will not affect the reporting of energy previously accumulated. If it is desired to clear a negative accumulated energy total, the user would have to reset the energy total in addition to setting this field to 0. Stated another way, energy totals are always reported as signed quantities. This field only affects how the accumulated energy calculation is done.

Bits 2-16: Reserved

Restored at power-up / reset: Yes

CM Reg #	Register Name	Register Description
216	Demand Interval	**Type**: Write/Read **Size**: 1 Register **Units**: Minutes **Range**: 5 - 60, in whole numbers **Function**: This value is the time interval (sliding window) used in the Average Demand calculations for Real Power (registers 35). It is recommend that this value be a multiple of 5, i.e. (5, 10, 15, 20, 25, ..., 60). Values in the range 5..60 that are not divisible by 5 will work but will introduce a slight error in demand calculations. **Restored at power-up / reset:** Yes
217	Output Command Verification	**Type:** Write/Read **Size:** 1 Register **Units:** None **Range:** -32,767 to +32,767 **Function:** This field contains a value used as a security mechanism to ensure that the output contacts are not inadvertantly closed. The value written to register 236 must match the value stored here to allow output contact operation. This register can only be written to when the keyswitch on the front of the Circuit Monitor is in the SETUP position. When the keyswitch is in any other position, this is a read only register. This register is initialized to 23130 (decimal) or 5A5A (hex) at the factory. **Restored at power-up / reset:** Yes
218-219	CM Label	**Type**: Write/Read **Size**: 2 Registers **Units**: ASCII Characters **Range**: 20 hex(space) - 7A hex("z") **Function**: These 4 characters are a label associated with this circuit monitor. It can be assigned by the user. **Restored at power-up / reset:** Yes
220-227	CM Nameplate	**Type**: Write/Read **Size**: 8 Registers **Units**: ASCII Characters **Range**: 20 hex(space) - 7A hex("z") **Function**: These 16 characters are a name by which the circuit being monitored can be identified or associated with. For example if the circuit being monitored supplied power to the welder on production line three the nameplate may be "Welder Line #3". **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
228-230	Set Date/Time	**Type**: Write/Read **Size**: 3 Registers **Units**: Month, Day, Year, Hour, Minutes, and Seconds **Range**: Month (byte 1) = 1 - 12, Day (byte 2) = 1 - 31, Year (byte 3) = 0 - 199, Hour (byte 4) = 0 - 23, Minutes (byte 5) = 0 - 59, Seconds (byte 6) = 0 - 59 The year is zero based on the year 1900 in anticipation of the 21st century, (e.g. 1989 would be represented as 89 and 2009 would be represented as109). **Function**: By writing to these three registers together, the date and time are set in this CM. From that point on the CM will advance the date and time based on its internal clock. This register can be read to get the date and time. Upon power up, the date is set to 1-1-1900 and the time to 00:00:00. **Restored at power-up / reset:** No
231	Software Revision Level	**Type**: Write/Read **Size**: 1 Register **Units**: Release:Revision, Release:Revision **Range**: 0-15 : 0-15, 0-15 : 0-15 **Function:** This register represents the firmware release and revision numbers. The least significant byte (bits 1-8) represents the communications processor release and revision, where bits 1-4 are the revision number and bits 5-8 are the release number. The most significant byte (bits 9-16) represents the metering processor release and revision, where bits 9-12 are the revision number and bits 13-16 are the release number. A release is a major upgrade or change in firmware features whereas a revision is a change to the current feature set to improve performance. For example, release level 2.0 may provide some new calculated values that were not available in release 1.0. Revision 2.1 may change the format of the new calculated values. This register can only be written to at the factory. **Restored at power-up / reset:** Yes
232-234	Date/Time Of Calibration	**Type**: Write/Read **Size**: 3 Registers **Units**: Same as regs # 88-90 **Range**: Same as regs # 88-90 **Function**: These registers store the date/time when the CM was tested and calibrated at the factory. This register can only be written to at the factory. NOTE: The Circuit Monitor's date and time (Regs 228-230) must be set prior to value stored in this register. This register is updated every time a register in the range 203-214 is written to. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
235	Output Control Register *	**Type**: Write/Read **Size**: 1 Register **Units**: None **Range**: Bit mapped field. See description below. **Function**: This register is used to control the Circuit Monitor outputs (CM-144, CM-244 only). To operate an output, the correct password must be written to register 236 in the same write statement. For example, to operate output 1, a decimal value of 1 must be written to this register and the correct password must be written to register 236 in the same write statement. Bit 1 = Output 1 (To operate, write a decimal 1) Bit 2 = Output 2 (To operate, write a decimal 2) Bit 3 = Output 3 (To operate, write a decimal 4) Bit 4 = Output 4 (To operate, write a decimal 8) **Restored at power-up / reset:** No
236	Output Security Register *	**Type**: Write/Read **Size**: 1 Register **Units**: None **Range**: -32,767 to +32,767 **Function**: This register must be written to at the same time that register 235 is written (i.e. in the same write statement). The value written here is compared to the value in register 217. If the values match, then the output command is carried out. If the value does not match, the output is not activated and the value in register 300 is incremented. **Restored at power-up / reset:** No

* For more information on the operation of CM-144 and CM-244 relay outputs, refer to instruction bulletin #63210-142-01.

CM Reg #	Register Name	Register Description
237	Command Register	**Type**: Write/Read **Size**: 1 Register **Units**: None **Range**: Bit mapped field **Function**: Writing to this register with specific bits set to a 1 will cause certain values to be zeroed, cleared, or set to the most recent metered values as appropriate. When this register is read, all bits except bit 11 are returned as 0.

Bit Positions

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Bit 1 = Reset all Min/Max values associated with instantaneous measurements (regs # 38-57, 61-80) to their present values and record the date and time in regs 106-108.
Bit 2 = Zero Accumulated Energy values (regs #24-31) and record the date and time in registers 115-117.
Bit 3 = Reset all Peak Demand Current values (regs #84-86) to their most recent values and record the date and time in registers 103-105.
Bit 4 = Reset the Peak Demand (Max of Real Power Avg Demand) (regs #37) to its present value and record the date and time in registers 112-114.
Bit 5 = Software restart and record the date and time in registers 88-90.
Bit 6 = Zero communication counters (regs # 133-141, 300)
Bit 7 = Reset Energy Management Level 1 Setpoint Last Exceeded Level to zero (reg. 121) and reset associated date and time (reg 124-126) to 01-01-1900, 00:00:00
Bit 8 = Reset Energy Management Level 2 Setpoint Last Exceeded Level to zero (reg. 122) and reset associated date and time (reg 127-129) to 01-01-1900, 00:00:00
Bit 9 = Reset Energy Management Level 3 Setpoint Last Exceeded Level to zero (reg. 123) and reset associated date and time (reg 130-132) to 01-01-1900, 00:00:00
Bit 10= Writing a 1 to this bit will initiate the transfer of raw voltage and current waveform samples from the metering uP to the comm uP (registers 2000 -2767). After requesting this transfer, the user should wait for bit 11 of this register to be set to a 1, indicating that the transfer is complete. Writing to this register with bit 10 = 1 will clear bit 11.
Bit 11= When set to a 1, this bit indicates that raw sample data is available in registers 2000 to 2767. The bit is reset to a 0 by writing to this register with bit 10 = 1.
Bits 12 - 16 = Reserved

Restored at power-up / reset: No

CM Reg #	Register Name	Register Description
238	Circuit Tracker™ Setpoint Register	**Type :** Read Only **Size:** 1 Register **Units:** None **Range:** -32767 to 32767 **Function:** This register contains a setpoint value which is written to and read by the host. This register is passive in regard to the CM in that it requires no action except to record the date/time (reg 109-111) when this register was written to. **Restored at power-up / reset:** Yes
239	Level 1 Energy Management Setpoint	**Type**: Write/Read **Size**: 1 Register **Units**: Kilowatts **Range**: 0 to +32,767 **Function**: This is an alarm set point that is checked after the most recent Real Power Average Demand calculation. It is used in updating the values in registers 121, 124-126. **Restored at power-up / reset:** Yes
240	Level 2 Energy Management Setpoint	**Type**: Write/Read **Size**: 1 Register **Units**: Kilowatts **Range**: 0 to +32,767 **Function**: This is an alarm set point that is checked after the most recent Real Power Average Demand calculation. It is used in updating the values in registers 122, 127-129. **Restored at power-up / reset:** Yes
241	Level 3 Energy Management Setpoint	**Type**: Write/Read **Size**: 1 Register **Units**: Kilowatts **Range**: 0 to +32,767 **Function**: This is an alarm set point that is checked after the most recent Real Power Average Demand calculation. It is used in updating the values in registers 123, 130-132. **Restored at power-up / reset:** Yes

NOTE: While the three preceding energy management setpoints are specified as unsigned values, the energy management reporting system functions in a bipolar mode, that is for both positive and negative excursions of Average Demand Real Power.Therefore, specifying a single value is equivalent to specifying both positive and negative setpoints of equal magnitude.

CM Reg #	Register Name	Register Description
242	Square D ID No.	**Type:** Read/Write **Size**: 1 Register **Units**: None **Range:** 450-455 **Function:** Square D ID number indicating CM model, where 450=CM-100, 451=CM-200, 452=CM-108, 453=CM-208, 454=CM-144, 455=CM-244, 456=CM-150, 457=CM-250. The CM firmware automatically copies this value to CM register 8188. This register cannot be written to in the field. **Restored at power-up / reset:** Yes
243-245		Reserved
246-255	Utility Registers	**Type:** Read/Write **Size:** 10 Registers **Units:** None **Range:** -32,767 to +32,767 **Function:** These 10 registers have been established for use by the application programmer as required. **Restored at power-up / reset:** Yes
300	Number of Failed Output Attempts	**Type:** Read Only **Size**: 1 Register **Units**: None **Range:** 0 to 32,767 (rolls over to 0 when maximum is exceeded) **Function:** This value is a counter that is incremented each time an attempt to control an output fails. Outputs are controlled by writing to registers 235 and 236 simultaneously. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description

400 — Output Operation Mode

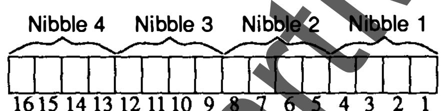
Type: Read Only or Read/Write (See below) **Size**: 1 Register **Units:** None
Range: Bit Mapped Field. See description below.

Function: This register applies to CM-144 and CM-244 only.This register can only be written to when the keyswitch on the front of the Circuit Monitor is in the SETUP position. When the keyswitch is in any other position, this is a read only register.

This register is used to set the manner in which outputs will operate. Each output is represented by 4 bits in this register. Each group of 4 bits is called a nibble. Outputs are assigned to nibbles as follows:

Output 1 = nibble 1
Output 2 = nibble 2
Output 3 = nibble 3
Output 4 = nibble 4

Nibble 1 is assigned to bits 1-4, nibble 2 to bits 5-8, nibble 3 to bits 9-12, and nibble 4 to bits 13-16. This is illustrated below.



Assume that the bits in each nibble are labeled *dcba* where *d* is the most significant bit (e.g. bit 4 in the case of nibble 1) and *a* is the least significant bit (e.g. bit 1 in the case of nibble 1). The functions assigned to each bit are described below.

d, c = reserved for future use
b = When this bit is 0, the output state will be Open (Off) upon Circuit Monitor power-up. When this bit is 1, the output will return to the state it was in when power was lost, unless the Fail-Safe mode is activated. (See below).
a = When this bit is 0, the output will operate in a *latch mode*. When this bit is 1, the output will operate in a *Fail-Safe mode*. This means that when an output is Closed (On) it will only remain closed for the period of time specified in register 401, after which it will Open (turn off). Anytime a software restart is performed (typically on power-up) the contact remains open until refreshed.

Restored at power-up / reset: Yes

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401 — Fail-Safe Duration Register

Type: Read Only or Read/Write (See below) **Size:** 1 Register **Units:** Seconds
Range: 0 to +32,767

Function: This is the time period, in seconds, which an output configured for fail-safe operation will remain Closed (On) before it automatically Opens (turns off). (See register 400). The maximum allowable value is 32,767 seconds or approximately 9.1 hours. This register can only be written to when the keyswitch on the front of the Circuit Monitor is in the SETUP position. When the keyswitch is in any other position, this is a read only register.

Restored at power-up / reset: Yes

The following registers (700-795) contain Circuit Monitor date/time fields in a format compatible with the date/time format used by SY/MAX® Processors. Date/time values stored in Circuit Monitor registers 88-120, 124-132, and 228-234 are mapped into CM registers 700-795. Each of the date/time fields occupies six storage registers. Seconds, minutes, hours, day, month, and year each occupy a register. For example, if a specific date/time field began in register n, then the field would be organized as follows:

ITEM	REGISTER
Seconds	n
Minutes	n+1
Hours	n+2
Day	n+3
Month	n+4
Year	n+5

Refer to registers 700-705 for a specific example.

CM Reg #	Register Name	Register Description
700-705	Last Restart Date/time (Extended)	**Type:** Read only **Size:** 6 Registers **Units:** Sec, Min, Hour, Day, Month, Year **Range:** Seconds (Reg 700) = 0-59 Minutes (Reg 701) = 0-59 Hours (Reg 702) = 0-23 Day (Reg 703) = 1-31 Month (Reg 704) = 1-12 Year (Reg 705) = 1900-2099 **Function:** The date/time in these registers is the last time the CM was restarted from the host by writing to register 237 with bit 5 = 1. The date and time are mapped from CM registers 88-90. **Restored at power-up / reset:** Yes
706-711	Date/time of Peak Demand Current,Phase A (Extended)	**Type**: Read only **Size:** 6 Registers **Units:** Sec, Min, Hour, Day, Month, Year **Range:** Same as regs # 700-705 **Function:** These registers store the date/time when a new peak demand for current phase A was recorded (reg 84). The date and time are mapped from CM registers 91-93. **Restored at power-up / reset:** Yes
712-717	Date/time of Peak Demand Current, Phase B (Extended)	**Type:** Read only **Size:** 6 Registers **Units:** Sec, Min, Hour, Day, Month, Year **Range:** Same as regs # 700-705 **Function:** These registers store the date/time when a new peak demand for current phase B is recorded (reg 85). The date and time are mapped from CM registers 94-96. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
718-723	Date/time of Peak Demand Current, Phase C (Extended)	**Type:** Read only **Size:** 6 Registers **Units:** Sec, Min, Hour, Day, Month, Year **Range**: Same as regs # 700-705 **Function**: These registers store the date/time when a new peak demand for current phase C was recorded (reg 86). The date and time are mapped from CM registers 97-99. **Restored at power-up / reset:** Yes
724-729	Date/time of Peak Demand, (Average Real Power) (Extended)	**Type**: Read only **Size:** 6 Registers **Units**: Sec, Min, Hour, Day, Month, Year **Range:** Same as regs # 700-705 **Function**: These registers store the date/time when the last peak demand (reg # 37) was recorded. The date and time are mapped from CM registers 100-102. **Restored at power-up / reset:** Yes
730-735	Date/time of Last Reset of Peak Demand Current (Extended)	**Type:** Read only **Size:** 6 Registers **Units:** Sec, Min, Hour, Day, Month, Year **Range:** Same as regs # 700-705 **Function:** The date/time in these registers record the last time a write to register 237 with bit 3 = 1 occurred. The date and time are mapped from CM registers 103-105. **Restored at power-up / reset:** Yes
736-741	Date/time of Last Min/Max Clear of Instantaneous Values (Extended)	**Type:** Read only **Size:** 6 Registers **Units**: Sec, Min, Hour, Day, Month, Year **Range:** Same as regs # 700-705 **Function**: These registers store the date/time when a write to register 237 with bit 1 = 1 last occurred causing the instantaneous max and min values to be reset to their present values. The date and time are mapped from CM registers 106-108. **Restored at power-up / reset:** Yes
742-747	Date/time of Last Write to Circuit Tracker™ Setpoint Register (Extended)	**Type:** Read only **Size:** 6 Registers **Units:** Sec, Min, Hour, Day, Month, Year **Range:** Same as regs #700-705 **Function:** This is the date/time when reg 238 was last written to by the host.The date and time are mapped from CM registers 109-111. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
748-753	Date/time When Peak Demand (Average Real Power) Was Last Cleared (Extended)	**Type**: Read only **Size:** 6 Registers **Units:** Sec, Min, Hour, Day, Month, Year **Range**: Same as regs # 700-705 **Function:** The date/time in these registers record the last occurrence of a write to reg. 237 with bit 4 = 1, causing the peak demand to be set equal to the current average demand, real power. (Register 35). The date and time are mapped from CM registers 112-114. **Restored at power-up / reset:** Yes
754-759	Date/time When Accumulated Energy Last Cleared (Extended)	**Type**: Read only **Size**: 6 Registers **Units**: Sec, Min, Hour, Day, Month, Year **Range:** Same as regs # 700-705 **Function:** These registers store the date/time when the accumulated energy values, both real and reactive, in registers 24-31 are zeroed. This is accomplished by a write to register 237 with bit 2 = 1. The date and time are mapped from CM registers 115-117. **Restored at power-up / reset:** Yes
760-765	Date/time When The Control Power Failed Last (Extended)	**Type:** Read only **Size:** 6 Registers **Units**: Sec, Min, Hour, Day, Month, Year **Range:** Same as regs # 700-705 **Function:** These registers store the date/time when the control power to the CM failed last. The date and time are mapped from CM registers 118-120. **Restored at power-up / reset:** Yes
766-771	Date/time When Level 1 Energy Management Set-Point Alarm Period Was Last Entered (Extended)	**Type:** Read only **Size**: 6 Registers **Units:** Sec, Min, Hour, Day, Month, Year **Range:** Same as regs # 700-705 **Function:** These registers store the date/time when the level 1 energy management setpoint (regs # 239) was exceeded and entered a level 1 alarm period. This date/time does NOT indicate when the highest exceeded value (regs #121) was recorded. The date and time are mapped from CM registers 124-126. **Restored at power-up / reset:** Yes

CM Reg #	Register Name	Register Description
772-777	Date/time When Level 2 Energy Management Set-Point Alarm Period Was Last Entered (Extended)	**Type:** Read only **Size**: 6 Registers **Units:** Sec, Min, Hour, Day, Month, Year **Range**: Same as regs # 700-705 **Function**: The date/time in these registers is when the level 2 energy management setpoint (regs # 240) was exceeded and entered a level 2 alarm period. This date/time does NOT indicate when highest exceeded value (regs #122) was recorded. The date and time are mapped from CM registers 127-129. **Restored at power-up / reset:** Yes
778-783	Date/time When Level 3 Energy Management Set-point Alarm Period Was Last Entered (Extended)	**Type**: Read only **Size:** 6 Registers **Units**: Sec, Min, Hour, Day, Month, Year **Range**: Same as regs # 700-705 **Function**: The date/time in these registers is when the level 3 energy management setpoint (regs # 241) was exceeded and entered a level 3 alarm period. This date/time does NOT indicate when highest exceeded value (regs #123) was recorded. The date and time are mapped from CM registers 130-132. (See Section 2.3). **Restored at power-up / reset:** Yes
784-789	Set Date/Time (Extended)	**Type**: Write/Read **Size**: 6 Registers **Units**: Sec, Min, Hour, Day, Month, Yr **Range**: Same as regs # 700-705 **Function**: By writing to these three registers together, the date and time are set in this CM. From that point on the CM will advance the date and time based on its internal clock. This register can be read to get the date and time. Upon power up, the date is set to 1-1-1900 and the time to 00:00:00. The date and time are mapped from CM registers 228-230. Writing to registers 228-230 will cause the date/time to be automatically mapped into registers 784-789; likewise, writing to registers 784-789 will cause the date/time to be automatically written to regs 228-230. **Restored at power-up / reset:** No

CM Reg #	Register Name	Register Description
790-795	Date/Time Of Calibration (Extended)	**Type**: Write/Read **Size**: 6 Registers **Units**: Sec, Min, Hour, Day, Month, Year **Range**: Same as regs # 700-705 **Function**: These registers store the date/time when the CM was tested and calibrated at the factory. This register can only be written to at the factory. NOTE: The Circuit Monitor's date and time in regs 228-230 or in regs 784-789 must be set prior to calibration of the unit to ensure accuracy of the value stored in this register. This register is updated every time a register in the range 203-214 is written to. The date and time are mapped from CM registers 232-234. Writing to registers 232-234 will cause the date/time to be automatically mapped into registers 790-795; likewise, writing to registers 790-795 will cause the same date/time to be automatically written to regs 232-234. **Restored at power-up / reset:** Yes

Registers 2000-2767 are used to store the sampled waveform data available in Circuit Monitors equipped with the waveform capture feature. 256 data points are sampled from each phase's current and voltage waveforms upon each read request from the host. To initiate the transfer of sampled waveform data from the metering microprocessor to the communications microprocessor, write to register 237 with bit 10=1 (See the definition for Reg 237). The values stored in registers 2000-2767 will remain unchanged until another transfer is initiated.

Each sampled data point requires 1/2 register of storage; therefore, the 256 data points sampled from each waveform require 128 storage registers each. Table 10-2 shows the registers utilized by each phase's voltage and current waveforms.

The date and time that the waveform capture was initiated are also stored. In addition, the Circuit Monitor stores the instantaneous values (Voltage, Current, Power Factor, etc) that were present in registers 1 through 20 at the time the waveform capture was initiated. All of these registers are listed below.

	Waveform Sampled	
Registers Used	**4 Wire System**	**3 Wire System**
2000-2127	Phase A-N Voltage	Phase A-B Voltage
2128-2255	Phase B-N Voltage	Phase C-B Voltage
2256-2383	Phase C-N Voltage	Phase A Current
2384-2511	Phase A Current	Phase C Current
2512-2639	Phase B Current	Not Used
2640-2767	Phase C Current	Not Used
2768	Intersample Interval*	Intersample Interval*

Note: The contents of registers 2000-2768 are not saved at power fail/reset and are not restored when power is restored.

** The time, in multiples of 100 nanoseconds, between samples. This is updated along with registers 2000-2767.*

Table 10-2 - Register Usage For Sampled Waveform Data

CM Reg #	Register Name	Register Description
2770-2772	Time Waveform Capture Initiated	**Type**: Read only **Size**: 1 Register **Units**: Month, Day, Yr, Hr, Min, Sec **Range**: Same as registers #88-90. **Function**: This is the date/time that the waveform capture was initiated. **Restored at power-up / reset:** No
2773-2778	Time Waveform Capture Initiated (SY/MAX format)	**Type**: Read only **Size**: 1 Register **Units**: Sec, Min, Hr, Day, Month, Yr **Range**: Same as registers #700-705. **Function**: This is the date/time that the waveform capture was initiated in a SY/MAX® compatible format. **Restored at power-up / reset:** No

CM Reg #	Register Name	Register Description
2779	Frequency	**Type**: Read only **Size**: 1 Register **Units**: Hertz in 100ths **Range**: 2300 - 6500 (23.00 - 65.00) **Function**: Frequency of circuit being monitored, as measured from measured voltage of phase A at the time the waveform capture was initiated. Taken from register 1. **Restored at power-up / reset:** No
2780	Temperature	**Type:** Read only **Size**: 1 Register **Units:**Degrees Celsius (Centigrade) in 100ths **Range**: -10000 to +10000 (-100.00 to +100.00) **Function:** Temperature inside CM enclosure at the time the waveform capture was initiated. Taken from register 2. **Restored at power-up / reset:** Yes
2781	Current, Phase A	**Type**: Read only **Size**: 1 Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function**: Measured RMS Phase A Current at the time the waveform capture was initiated. Taken from register 3. **Restored at power-up / reset:** No
2782	Current, Phase B	**Type:** Read only **Size**: 1 Register **Units:** Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function**: Measured RMS Phase B Current at the time the waveform capture was initiated. Taken from register 4. **Restored at power-up / reset:** No
2783	Current, Phase C	**Type**: Read only **Size:** 1 Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function:** Measured RMS Phase C Current at the time the waveform capture was initiated. Taken from register 5. **Restored at power-up / reset:** No
2784	Current, 3 Phase Average	**Type**: Read only **Size**: 1 Register **Units**: Amps or tenths of Amps **Range**: 0 to 9999 (User-definable, See Reg 200) **Function:** 3 Phase Average Current at the time the waveform capture was initiated. Taken from register 6. **Restored at power-up / reset:** No

CM Reg #	Register Name	Register Description
2785	Current, Apparent rms	**Type:** Read only **Size**: 1 Register **Units**: Amps or tenths of Amps (User-definable, See Reg 200) **Range**: 0 to 9999 **Function**: Apparent RMS Current at the time the waveform capture was initiated. Taken from register 7. **Restored at power-up / reset:** No
2786	Voltage, Phase A to B	**Type:** Read only **Size:** 1 Register **Units:** Volts **Range:** 0 - 32,767 **Function**: RMS Voltage Between Phases A and B at the time the waveform capture was initiated. Taken from register 8. **Restored at power-up / reset:** No
2787	Voltage, Phase B to C	**Type**: Read only **Size**: 1 Register **Units**: Volts **Range**: 0 - 32,767 **Function**: RMS Voltage Between Phases B and C at the time the waveform capture was initiated. Taken from register 9. **Restored at power-up / reset:** No
2788	Voltage, Phase C to A	**Type:** Read only **Size:** 1 Register **Units**: Volts **Range:** 0 - 32,767 **Function:** Derived RMS Voltage Between Phases C and A at the time the waveform capture was initiated. Taken from register 10. **Restored at power-up / reset:** No
2789	Voltage, Phase A to Neutral	**Type**: Read only **Size**: 1 Register **Units**: Volts **Range**: 0 - 32,767 **Function**: Measured RMS Voltage Between Phase A and Neutral at the time the waveform capture was initiated. Taken from register 11. **Restored at power-up / reset:** No
2790	Voltage, Phase B to Neutral	**Type**: Read only **Size**: 1 Register **Units**: Volts **Range**: 0 - 32,767 **Function**: Measured RMS Voltage Between Phase B and Neutral at the time the waveform capture was initiated. Taken from register 12. **Restored at power-up / reset:** No

CM Reg #	Register Name	Register Description
2791	Voltage, Phase C to Neutral	**Type:** Read only **Size:** 1 Register **Units**: Volts **Range**: 0 - 32,767 **Function**: Measured RMS Voltage Between Phase C and Neutral at the time the waveform capture was initiated. Taken from register 13. **Restored at power-up / reset:** No
2792	Power Factor, 3 Phase Total	**Type:** Read only **Size:** 1 Register **Units:** Percent **Range:** +/-100 (+/- 1.00) P.F. reported in percent; to convert back to a value in the range shown in Table 2.2, divide reported value by 100). The sign +/- indicates leading/lagging. (See Section 9.0). Lead/Lag is always supplied, but the user should use per phase indication when available (i.e. when a 4 wire connection is used). **Function:** 3 Phase Total Power Factor at the time the waveform capture was initiated. Taken from register 14. **Restored at power-up / reset:** No
2793	Power Factor, Phase A	**Type:** Read only **Size:** 1 Register **Units:** Percent **Range:** +/- 100 (+/- 1.00) P.F. reported in percent; to convert back to a value in the range -1.0 to +1.0, divide reported value by 100). The sign indicates leading/lagging (positive indicates leading, negative indicates lagging). **Function**: Phase A Power Factor at the time the waveform capture was initiated. Taken from register 15. **Restored at power-up / reset:** No
2794	Power Factor, Phase B	**Type:** Read only **Size:** 1 Register **Units**: Percent **Range**: same as reg #2793 **Function**: Phase B Power Factor at the time the waveform capture was initiated. Taken from register 16. **Restored at power-up / reset:** No
2795	Power Factor, Phase C	**Type**: Read only **Size**: 1 Register **Units:**Percent **Range**: same as reg #2793 **Function:** Phase C Power Factor at the time the waveform capture was initiated. Taken from register 17. **Restored at power-up / reset:** No
2796	Real Power, Three Phase Total (P)	**Type**: Read only **Size**: 1 Register **Units:** Kilowatts **Range:** - 32,767 to +32,767 **Function:** Three Phase Total Real Power at the time the waveform capture was initiated. Taken from register 18. **Restored at power-up / reset:** No

CM Reg #	Register Name	Register Description
2797	Reactive Power, Three Phase Total (Q)	**Type**: Read only **Size**: 1 Register **Units:** Kilovoltamperes Reactive (kVAr) **Range**: - 32,767 to +32,767 **Function**: Three Phase Total Reactive Power at the time the waveform capture was initiated. Taken from register 19. **Restored at power-up / reset:** No
2798	Apparent Power, Three Phase Total (S)	**Type:** Read only **Size:** 1 Register **Units**: Kilovoltamperes (kVA) **Range:** 0 to +32,767 **Function**: Three Phase Total Apparent Power at the time the waveform capture was initiated. Taken from register 20. **Restored at power-up / reset:** No

To maintain compatibility with other SY/MAX equipment the CM must respond correctly to read operations from specific registers. These read only registers are shown in Table 10-3 along with the default value that will be returned to the host.

Reg #	Register Description	Default Value
8172	Scan Time	0
8173	End Fenced Register	8176
8174	Begin Fenced Register	1
8175	Error Number	0
8176	Processor Control/Status Bits	0
8177	Password Register	0
8178	Restriction Register	0
8179-8180	Not Used	
8181-8182	Memory Size Available for ladder	0
8183-8184	Secondary Error Register	0 further defines 8175
8185	Number of Rack Addresses	0
8186	Processor/Keyswitch Status	4
8187	Number of Rungs	0
8188	I.D. and Revision	(See Register #242)
8189-8190	Memory Size in Bytes	0
8191-8192	Memory Used in Bytes	0

Note: Registers 8172-8192 are not saved at power fail but are initialized to default values on power-up / reset.

***Table 10-3** -CM default values for SY/MAX compatibility registers*

Appendix A - Scaling the Data Provided During Waveform Capture

Each raw data point captured by the Circuit Monitor is a byte in 8 bit 2's complement notation. Thus a data point read directly from the CM is returned as a hexadecimal value in the range 0 - FF. This makes it necessary to convert the raw data points captured by the CM to measured currents and voltages.

The equations for performing these conversions are below.

To convert a raw data point (V(R) or I(R)) to its corresponding measured value (V(M) or I(M)) the following equations must be used:

VOLTAGE: V(M) = PTR * AGV * GFV(K) * V(R)

Where:

- PTR = Potential Transformer Nominal Primary Voltage / 120V
- AGV = Analog Voltage Gain Factor = 2.040 (Constant for all voltages)
- GFV(K) = Voltage Gain Calibration Factor for phase K {K = A, B, or C in a 4 wire system. In a 3 wire system use the Average of A and B for V(A-B) or C and B in V(C-B)}

CURRENT: I(M) = CTR * AGI * GFI(K) * I(R)

Where:

- CTR = Current Transformer Nominal Primary Current / 5A
- AGI = Analog Current Gain Factor = 0.07828
- GFI(K) = Current Gain Calibration Factor for Current I(K)

NOTE: Conversion to I(M) is the same even with RMS currents reported to the nearest 0.1 amps.

EXAMPLES:

A. Assume V(R) for phase A = C5 HEX = -59 Decimal, PT nominal primary voltage is 1200 Volts, and GFV(A) = 1.01. Then:

V(M) = (1200/120) * 2.040 * 1.01 * (-59) = -1216 Volts

B. Assume I(R) for phase C = 4 A HEX = 74 Decimal, CT nominal primary current = 1000 AMPS, and GFI(C) = 0.99. Then:

I(M) = (1000/5) * 0.07828 * 0.99 * 74 = 1146 Amps.

NOTE: Current and Voltage Gain Factors are stored in read only registers within the CM and may be read as needed. (See registers 203, 205, 207, 209, 211, and 213 in the register allocation list).

Appendix B - Maximum Distances for Circuit Monitor Communications

The Circuit Monitor's RS-485 communications allow a maximum of 32 Circuit Monitors to be connected to a host communication port. For example, up to 32 Circuit Monitors may be connected to the top RS-422 communications port of a PowerLogic Network Interface Module (PNIM). When 1 to 16 Circuit Monitors are connected to a single communications port, the entire length of the communications link (i.e. the distance from the comm port to the last CM in the chain) may be up to 10,000 feet. When more than 16 Circuit Monitors are connected to a single communications port, the maximum length of the communications link becomes shorter. This is necessary to insure accurate communications at high rates of speed (up to 19,200 baud). Table B-1 shows the maximum distances recommended at varying baud rates.

Maximum Distances		
Baud Rate	**Number of Devices**	
	16	**17-32**
1200	10,000	10,000
2400	10,000	5,000
4800	10,000	5,000
9600	10,000	4,000
19200	10,000	2,500

Table B-1 *- Distance limitations for Circuit Monitor communications*

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