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Instruction Bulletin

PowerLogic® Circuit Monitor

Series 4000 Reference Manual

(Includes Models 4000, 4250, 4000T)

Retain for future use.

Merlin Gerin
Square D
Telemecanique

Schneider Electric

HAZARD CATEGORIES AND SPECIAL SYMBOLS

Read these instructions carefully and look at the equipment to become familiar with the device before trying to install, operate, service or maintain it. The following special messages may appear throughout this bulletin or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of either symbol to a “Danger” or “Warning” safety label indicates that an electrical hazard exists which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

⚠ DANGER

DANGER indicates an imminently hazardous situation which, if not avoided, **will result in** death or serious injury.

⚠ WARNING

WARNING indicates a potentially hazardous situation which, if not avoided, **can result in** death or serious injury.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation which, if not avoided, **can result in** minor or moderate injury.

CAUTION

CAUTION, used without the safety alert symbol, indicates a potentially hazardous situation which, if not avoided, **can result in** property damage.

NOTE: Provides additional information to clarify or simplify a procedure.

PLEASE NOTE

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

FCC NOTICE

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. This Class A digital apparatus complies with Canadian ICES-003.

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CHAPTER 1—INTRODUCTION

CIRCUIT MONITOR DESCRIPTION

The circuit monitor is a multifunction, digital instrumentation, data acquisition and control device. It can replace a variety of meters, transducers, and other components. The circuit monitor can be located at the service entrance to monitor the cost and quality of power, and it can be used to evaluate the utility service. When located at equipment mains, the circuit monitor can detect voltage-based disturbances that cause costly equipment downtime. Features in the meter also help users troubleshoot the source and location of these disturbances.

The circuit monitor is equipped with RS-485 and RS-232 communications for integration into any power monitoring and control system. However, the Powerlogic® System Manager™ Software (SMS), written specifically for power monitoring and control, best supports the circuit monitor's advanced features.

The circuit monitor is a true rms meter capable of exceptionally accurate measurement of highly nonlinear loads. A sophisticated sampling technique enables accurate, true rms measurement through the 255th harmonic. Over 50 metered values plus extensive minimum and maximum data can be viewed on the display or remotely using software. Table 1–1 summarizes the readings available from the circuit monitor.

Table 1–1: Summary of Circuit Monitor Instrumentation

Real-Time Readings	Energy Readings
• Current (per phase, N, G, 3-Phase) • Voltage (L–L, L–N, N–G, 3-Phase) • Real Power (per phase, 3-Phase) • Reactive Power (per phase, 3-Phase) • Apparent Power (per phase, 3-Phase) • Power Factor (per phase, 3-Phase) • Frequency • Temperature (internal ambient) • THD (current and voltage) • K-Factor (per phase)	• Accumulated Energy, Real • Accumulated Energy, Reactive • Accumulated Energy, Apparent • Bidirectional Readings • Reactive Energy by Quadrant • Incremental Energy • Conditional Energy
Demand Readings	**Power Analysis Values**
• Demand Current (per phase present, 3-Phase average) • Demand Voltage (per phase present, 3-Phase average) • Average Power Factor (3-Phase total) • Demand Real Power (per phase present, peak) • Demand Reactive Power (per phase present, peak) • Demand Apparent Power (per phase present, peak) • Coincident Readings • Predicted Power Demand	• Crest Factor (per phase) • Displacement Power Factor (per phase, 3-Phase) • Fundamental Voltages (per phase) • Fundamental Currents (per phase) • Fundamental Real Power (per phase) • Fundamental Reactive Power (per phase) • Harmonic Power • Unbalance (current and voltage) • Phase Rotation • Harmonic Magnitudes and Angles (per phase) • Sequence Components

Accessories and Options for the Circuit Monitor

The circuit monitor has a modular design to maximize its usability. In addition to the main meter, the circuit monitor has plug-on modules and accessories, including:

- **Current/voltage module**. A standard part of the circuit monitor is the current/voltage module where all metering data acquisition occurs. The circuit monitor is calibrated at the factory at the time of manufacture and does not normally need to be recalibrated. However, in special cases where annual calibration is specified by the user, the current/voltage module can be removed and sent to the factory for recalibration without removing the entire circuit monitor. See “Replacing the Current/Voltage Module” in the **PowerLogic® Circuit Monitor: Series 4000 Installation Manual** for instructions on replacing the current/voltage module.

- **Current/voltage transient module (CVMT)**. A standard part of the CM4000T and an optional accessory for the CM4000 and CM4250. See “Section 11—Transient Circuit Monitor” in the **PowerLogic® Circuit Monitor: Series 4000 Reference Manual** for more information about the CM4000T.
- **Remote display**. The optional remote 4-line display is available with a back-lit liquid crystal display (LCD) or a vacuum fluorescent display (VFD). The VFD model includes an infrared port that can be used to communicate directly with the circuit monitor from a laptop computer. The VFD model can also be used to download firmware, keeping the circuit monitor up to date with the latest system enhancements.
- **I/O Extender**. The I/O extender can be attached to the circuit monitor to allow “plug in” capabilities for up to 8 industry-standard inputs and outputs. Several pre-configured combinations are available, or you can create a custom configuration.
- **Digital I/O Card**. The I/O capabilities of the circuit monitor can be further expanded by adding a digital I/O card (4 inputs and 4 outputs). This card fits into the option slot on the top of the circuit monitor.
- **Ethernet Communications Card**. The Ethernet communications card provides an Ethernet port that accepts a 100 Mbps fiber optic cable or a 10/100 Mbps UTP and provides an RS-485 master port to extend the circuit monitor communications options. This card is easily installed into the option slot on the top of the circuit monitor.

Table 1–2 lists the circuit monitor parts and accessories and their associated instruction bulletins.

Table 1–2: Circuit Monitor Parts, Accessories, and Custom Cables

Description	Part Number
Circuit Monitor	CM4250 CM4250MG
Current/Voltage Module with anti-aliasing	CVM42
Circuit Monitor Transient	CM4000T CM4000TMG
Current/Voltage Mudule Transient	CVMT
VFD Display with infrared (IR) port and proximity sensor	CMDVF CMDVFMG
LCD Display	CMDLC CMDLCMG
Optical Communications Interface (for use with the VFD display only)	OCIVF
I/O Extender Module ①	
with no preinstalled I/Os, accepts up to 8 individual I/O modules with a maximum of 4 analog I/Os	IOX
with 4 digital inputs (32 Vdc), 2 digital outputs (60 Vdc), 1 analog output (4–20 mA), and 1 analog input (0–5 Vdc)	IOX2411
with 4 analog inputs (4–20 mA) and 4 digital inputs (120 Vac/Vdc)	IOX0404
① For parts list of individual inputs and outputs, see Table 5–1 in the reference manual.	

Table 1–2: Circuit Monitor Parts, Accessories, and Custom Cables *(continued)*

Description	Part Number
with 8 digital inputs (120 Vac/Vdc)	IOX08
Digital I/O Card Field installable with 4 digital inputs (120 Vac), 3 (10 A) relay outputs (20-138 Vac/Vdc), 1 pulse output (KYZ)	IOC44
Ethernet Communications Card with 100 Mbps fiber or 10/100 Mbps UTP Ethernet port and 1 RS-485 master port	ECC21
Memory Expansion Kit (32 MB kit)	CM4MEM32M
CM4 Mounting Adapters	CM4MA
4-ft display cable (1.2 m)	CAB-4
12-ft display cable (3.6 m)	CAB-12
30-ft display cable (9.1 m)	CAB-30
10-ft RS-232 cable (3 m)	CAB-106

① For parts list of individual inputs and outputs, see Table 5–1 in the reference manual.

Features

Some of the circuit monitor’s many features include:

- True rms metering up to the 255th harmonic
- Accepts standard CT and PT inputs
- 690 volt direct connection on metering inputs for CM4250, CM4000T
  600 volt direct connection on metering inputs for CM4000
- Certified ANSI C12.20 revenue accuracy, IEC 687 Class 0.2S revenue accuracy
  IEC 62053-22 Class 0.2 for CM4250, CM4000T
- High accuracy—0.04% current and voltage
- Min/max readings of metered data
- Power quality analysis readings—THD, K-factor, crest factor
- Anti-aliasing filtering
- Real-time harmonic magnitudes and angles to the 63rd harmonic
- Current and voltage sag/swell detection and recording
- Downloadable firmware
- Easy setup through the optional remote display (password protected), where you can view metered values.
- Setpoint-controlled alarm and relay functions
- Onboard alarm and data logging
- Wide operating temperature range –25° to 70°C
- Modular, field-installable digital and analog I/O modules
- Flexible communications—RS-485 and RS-232 communications are standard, optional Ethernet communications card available with fiber-optic connection
- Two option card slots for field-installable I/O and Ethernet capabilities
- Standard 16 MB onboard logging memory (field upgradable to 32 MB and higher)
- CT and PT wiring diagnostics
- Revenue security with utility sealing capability
- Disturbance direction detection
- EN50160 evaluations
- Power quality, energy, and alarm summaries
- Waveshape alarms
- Alarm setpoint learning

- Harmonic power flows
- Harmonic and interharmonic measurements per IEC 61000-4-7 (CM4250 only)

TOPICS NOT COVERED IN THIS BULLETIN

Some of the circuit monitor's advanced features, such as onboard data logs and alarm log files, can only be set up over the communications link using SMS. This circuit monitor instruction bulletin describes many advanced features, but does not tell how to set them up. For instructions on using SMS, refer to the SMS online help and the SMS Setup Guide. For information about related instruction bulletins, see Table 1–2 on page 2.

CHAPTER 2—SAFETY PRECAUTIONS

BEFORE YOU BEGIN

This section contains important safety precautions that must be followed before attempting to install, service, or maintain electrical equipment. Carefully read and follow the safety precautions outlined below.

⚠ DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. In the U.S., see NFPA 70E.
- Only qualified workers should install this equipment. Such work should be performed only after reading this entire set of instructions.
- NEVER work alone.
- Turn off all power supplying this equipment before working on or inside.
- Always use a properly rated voltage sensing device to confirm that all power is off.
- Before performing visual inspections, tests, or maintenance on this equipment, disconnect all sources of electric power. Assume that all circuits are live until they have been completely de-energized, tested, and tagged. Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of backfeeding.
- Beware of potential hazards, wear personal protective equipment, and carefully inspect the work area for tools and objects that may have been left inside the equipment.
- Use caution while removing or installing panels so that they do not extend into the energized bus; avoid handling the panels, which could cause personal injury.
- The successful operation of this equipment depends upon proper handling, installation, and operation. Neglecting fundamental installation requirements may lead to personal injury as well as damage to electrical equipment or other property.
- Before performing Dielectric (Hi-Pot) or Megger testing on any equipment in which the circuit monitor is installed, disconnect all input and output wires to the circuit monitor. High voltage testing may damage electronic components contained in the circuit monitor.

Failure to follow these instructions will result in death or serious injury.

CHAPTER 3—OPERATION

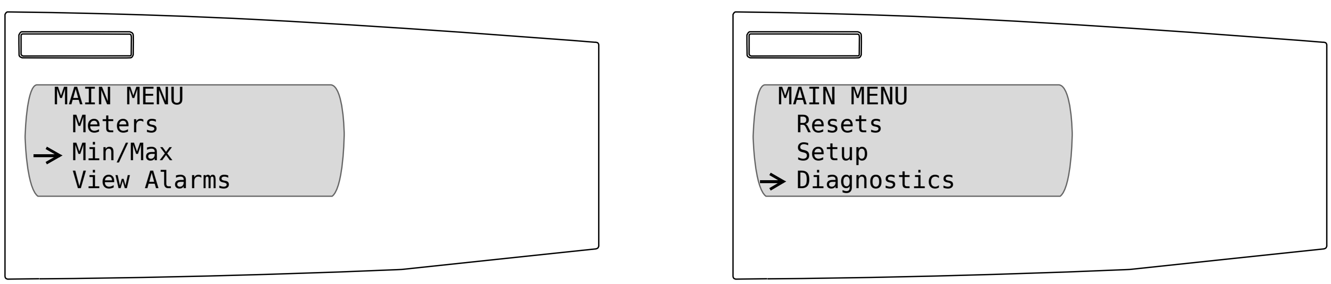
OPERATING THE DISPLAY

This section describes how to set up the circuit monitor from the display only. Some advanced features, such as configuring the onboard logs of the circuit monitor, must be set up over the communications link using SMS. Refer to the SMS instruction bulletin and online help file for instructions on setting up advanced features not accessible from the display.

VIEWING THE SCREEN

Figure 3–1 gives examples of the display screen. The display shows four lines of information at a time. Notice the arrow on the left of the display screen. This arrow indicates that you can scroll up or down to view more information. For example, on the Main Menu you can view the Resets, Setup, and Diagnostics menu options only if you scroll down to display them. When at the top of a list, the arrow moves to the top line. When the last line of information is displayed, the arrow moves to the bottom as illustrated on the right in Figure 3–1.

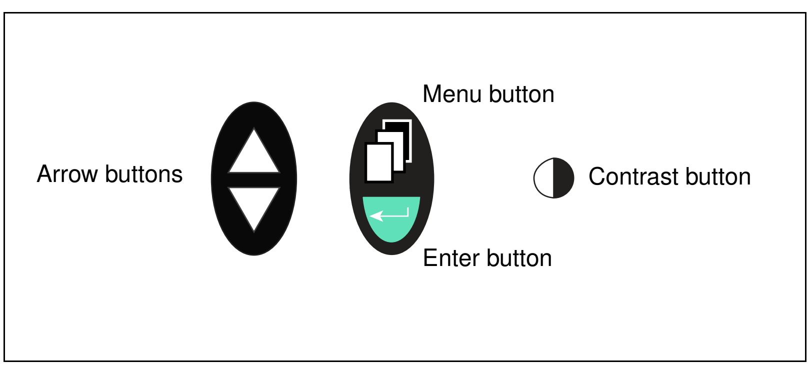
Figure 3–1: Arrow on the display screen



How the Buttons Work

The buttons on the display let you scroll through options and select information, move from menu to menu, and adjust the contrast. Figure 3–2 shows the buttons.

Figure 3–2: Display buttons



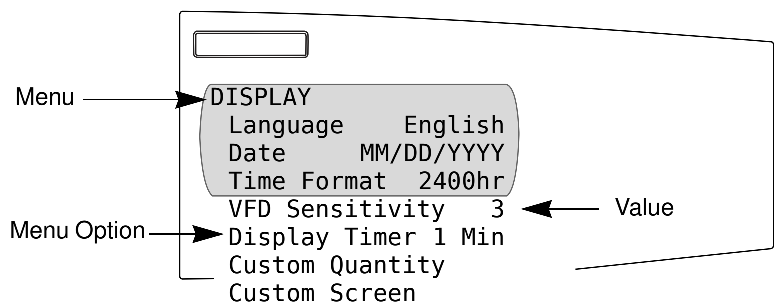
The buttons are used in the following way:

- **Arrow buttons**. Press the arrow buttons to scroll up and down the options on a menu. Also, when a value can be changed, use the arrow buttons to scroll through the values that are available. If the value is a number, holding the arrow button down increases the speed in which the numbers increase or decrease.
- **Menu button**. Press the menu button to move back one menu level. The menu button also prompts you to save if you've made changes to any options within that menu structure. (Press Enter to save.)
- **Enter button**. Press the enter button to select an option on a menu or to select a value to be edited.
- **Contrast button**. Press the contrast button to darken or lighten the display. On the LCD model, press any button once to activate the back light.

Display Menu Conventions

This section explains a few conventions that were developed to streamline instructions in this chapter. Figure 3–3 shows the parts of a menu.

Figure 3–3: Parts of a menu



Selecting a Menu Option

Each time you read "select" in this manual, choose the option from the menu by doing this:

1. Press the arrows to highlight the menu option.
2. Press the enter button to select that option.

Changing a Value

To change a value, the procedure is the same on every menu:

1. Use the arrow buttons to scroll to the menu option you want to change.
2. Press the enter button to select the value. The value begins to blink.
3. Press the arrow buttons to scroll through the possible values. To select the new value, press the enter button.
4. Press the arrow buttons to move up and down the menu options. You can change one value or all of the values on a menu. To save the changes, press the menu button until the circuit monitor displays:

   "Save changes? No"

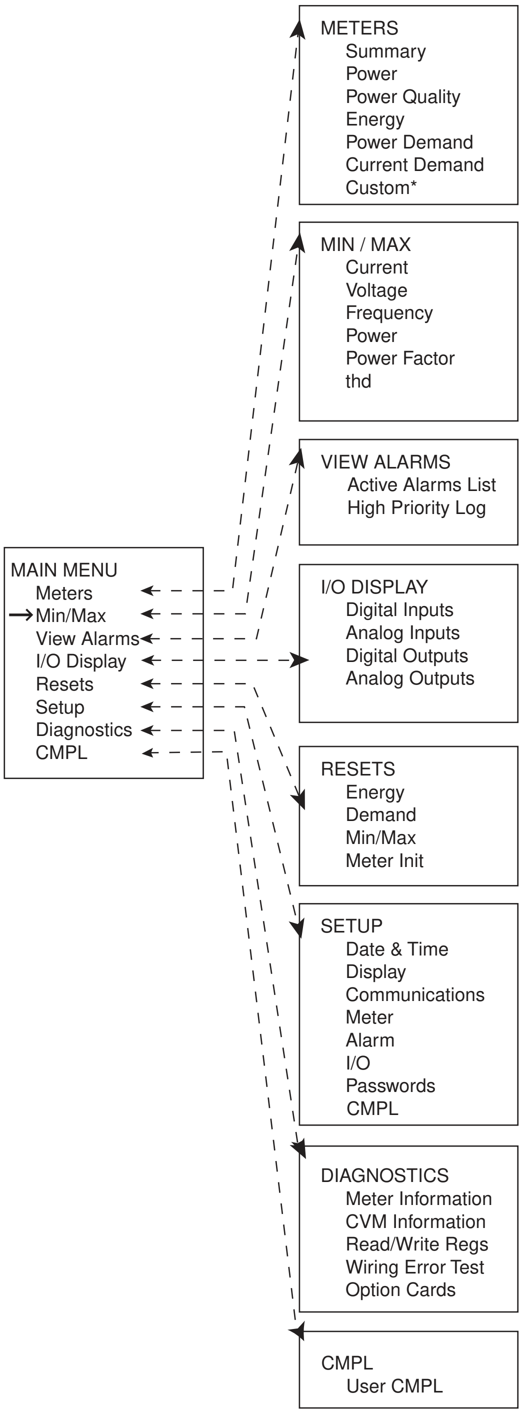
   NOTE: Pressing the menu button while a value is blinking will return that value to its most current setting.
5. Press the arrow to change to "Yes," then press the enter button to save the changes.

Cycling Screens on the Display

You can set up your display to cycle through summary screens as well as any custom screens. You can set this interval for cycling anywhere from one second to 60 seconds. Setting the interval to zero disables cycling. If the display is set to cycle through screens, it begins doing so after four minutes have passed and you have not pressed any keys. It continues cycling until you press a key. To activate this feature, set the interval for cycling in register 3603. See “Using the Command Interface to Change Configuration Registers” on page 162.

MAIN MENU OVERVIEW

Figure 3–4: Menu Options—Main Menu



*Only if custom screen has been defined by user.

The Main Menu on the display lists the menu options that you use to set up and control the circuit monitor and its accessories and to view metered data and alarms. Figure 3–4 shows the Main Menu options with additional selections under each option. Main menu options include the following:

- **Meters**—Lets you view metered values that provide information about power usage and power quality.
- **Min/Max**—Lets you view the minimum and maximum metered values since the last reset of the min/max values with their associated dates and times.
- **View Alarms**—Lets you view a list of all active alarms, regardless of the priority. In addition, you can view a log of high priority alarms, which contains the ten most recent high priority alarms.
- **I/O Display**—Lets you view the designation and status of each input or output. This menu displays the I/Os present, so you will see only the available menu items for the I/O modules installed.
- **Resets**—Lets you reset energy, peak demand, and minimum/maximum values.
- **Setup**—Lets you define the settings for the display, such as selecting the date format to be displayed. Creating custom quantities and custom screens are also options on this menu. In addition, use this menu to set up the circuit monitor parameters such as the CT and PT ratios. The Setup menu is also where you define the communications, alarms, I/Os, and passwords.
- **Diagnostics**—Lets you initiate the wiring error test. Also, use this menu to read and write registers and view information about the circuit monitor, such as its firmware version and serial number.
- **CMPL**. CMPL is the custom programming language for the circuit monitor. If a custom program is installed, you can view the name, version, date, and status of the program.

CONFIGURING THE CIRCUIT MONITOR USING THE SETUP MENU

Before you can access the Setup menu from the Main Menu, you must enter the Setup password. The default password is 0. To change the password, see “Setting Up Passwords” on page 31. The Setup menu has the following options:

- Date & Time
- Display
- Communications
- Meter
- Alarm
- I/O
- Passwords

Each of these options is described in the sections that follow.

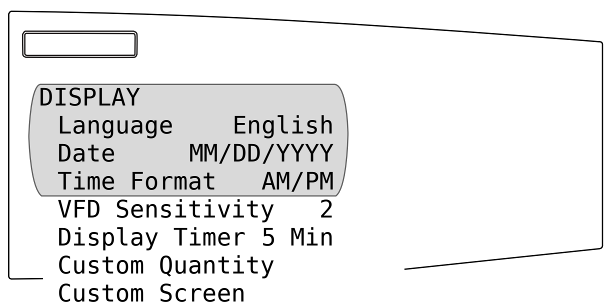
Setting Up the Display

Setting up the display involves, for example, choosing a date and time format that you want to be displayed. To set up the display, follow these steps:

1. From the Main Menu, select Setup > Display.

   When prompted for a password, press the arrow buttons to enter the password (default is 0) and then press the enter button. (See “Setting Up Passwords” on page 31 for more information.)

   The Display Setup menu displays. Table 3–1 describes the options on this menu.



2. Press the arrow buttons to scroll to the menu option you want to change.
3. Press the enter button to select the value.The value begins to blink. Press the arrow buttons to scroll through the available values. Then, press the enter button to select the new value.
4. Press the arrow buttons to scroll through the other options on the menu, or if you are finished, press the menu button to save.

Table 3–1: Factory Defaults for the Display Settings

Option	Available Values	Selection Description	Default
Language	English Francais Espanol Polski Italiano	Language used by the display.	English (Languages other than English require a language library file.)
Date	MM/DD/YYYY YYYY/MM/DD DD/MM/YYYY	Data format for all date-related values of the circuit monitor.	MM/DD/YYYY

Table 3–1: Factory Defaults for the Display Settings *(continued)*

Time Format	2400hr AM/PM	Time format can be 24-hour military time or 12-hour clock with AM and PM.	2400hr
VFD Sensitivity	Off 1 = 0–6 ft (0–15 m) 2 = 0–12 ft (0–31 m) 3 = 0–20 ft (0–51 m)	Sensitivity value for the proximity sensor (for the VFD display only).	2
Display Timer	1, 5, 10, or 15 minutes	Number of minutes the display remains illuminated after inactivity.	5
Custom Quantity	Creating custom quantities is an advanced feature that is not required for basic setup. To learn more about this feature, see “Creating Custom Quantities to be Displayed” on page 32.		
Custom Screen	Creating custom screens is an advanced feature that is not required for basic setup. To learn more about this feature, see “Creating Custom Screens” on page 35.		

Setting Up the Communications

The Communications menu lets you set up the following communications:

- *RS-485* communications for daisy-chain communication of the circuit monitor and other RS-485 devices.
- *RS-232* communications for point-to-point communication between the the circuit monitor and a host device, such as a PC or modem.
- *Infrared Port* communications between the circuit monitor and a laptop computer (available only on the VFD display).
- *Ethernet Options* for Ethernet communications between the circuit monitor and your Ethernet network when an Ethernet Communications Card (ECC) is present.

Each of these options is described in the sections that follow.

Setting the Device Address

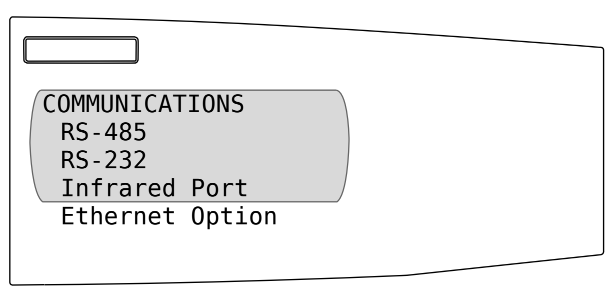
Each PowerLogic device on a communications link must have a unique device address. The term communications link refers to 1–32 PowerLogic compatible devices daisy-chained to a single communications port. If the communications link has only a single device, assign it address 1. By networking groups of devices, PowerLogic systems can support a virtually unlimited number of devices.

RS-485, RS-232, and Infrared Port Communications Setup

To set up RS-485, RS-232, or the infrared port communications, set the address, baud rate, and parity. Follow these steps:

1. From the Main Menu, select Setup > Communications.

   The Communications Setup screen displays.



NOTE: You can set up infrared communications only if the circuit monitor is equipped with a VFD display. Also, you can set up Ethernet communications only if the circuit monitor is equipped with an ECC card.

2. From the Communications Setup menu, select the type of communications that you are using. Depending on what you select, the screen displays as shown below. Table 3–2 describes the options on this menu.

```
RS-485
 Protocol     Modbus
 Address           1
 Baud Rate      9600
 Parity         Even
 Mode          Slave
 Timeout(sec)      2
 Redirect   Disabled
```

```
RS-232
 Protocol     Modbus
 Address           1
 Baud Rate      9600
 Parity         Even
 Mode          Slave
 Timeout(sec)      2
 Redirect   Disabled
```

```
INFRARED PORT
 Protocol     Modbus
 Address           1
 Baud Rate      9600
 Parity         Even
 Redirect   Disabled
```

```
ETHERNET
 IP 157.198.216.  83
 Sub 255.255.255.  0
 Rtr 157.198.216. 10
 Port Type 10T/100TX
```

3. Use the arrow buttons to scroll to the menu option you want to change.
4. Press the enter button to select the value.The value begins to blink. Use the arrow buttons to scroll through the available values. Then, press the enter button to select the new value.
5. Use the arrow buttons to scroll through the other options on the menu; or if you are finished, press the menu button to save.

Table 3–2: Options for Communications Setup

Option	Available Values	Selection Description	Default
Protocol	MODBUS JBUS	Select MODBUS or JBUS protocol.	MODBUS
Address	1–255	Device address of the circuit monitor. See “Setting the Device Address” on page 12 for requirements of device addressing.	1
Baud Rate	1200 2400 4800 9600 19200 38400	Speed at which the devices will communicate. The baud rate must match all devices on the communications link.	9600
Parity	Even, Odd, or None	Parity at which the circuit monitor will communicate.	Even
Mode	Master Slave	Operating mode of the Communications port.	Slave
Timeout	2-10	Timeout of communications transaction in seconds.	2
Redirect	Disabled To RS-232 To Subnet	Redirection options. See “Redirecting the Port” below.	Disables

Ethernet Communications Card (ECC) Setup

Ethernet communications is available only if you have an optional Ethernet Communications Card (ECC) that fits into slot A on the top of the circuit monitor. See the section on “Option Cards” in the *PowerLogic Circuit Monitor Series 4000* installation manual for more information. To set up the Ethernet communications between the circuit monitor and the network, refer to the instruction bulletin provided with the ECC.

Redirecting the Port

The port redirect feature lets you communicate to devices on a subnetwork through the infrared (IR) port of the display or the RS-232 port of your circuit monitor. You can redirect the following ports:

- Redirect the RS-232 or IR port to the RS-485.
- Redirect RS-232 or IR port to the ECC RS-485 subnetwork.

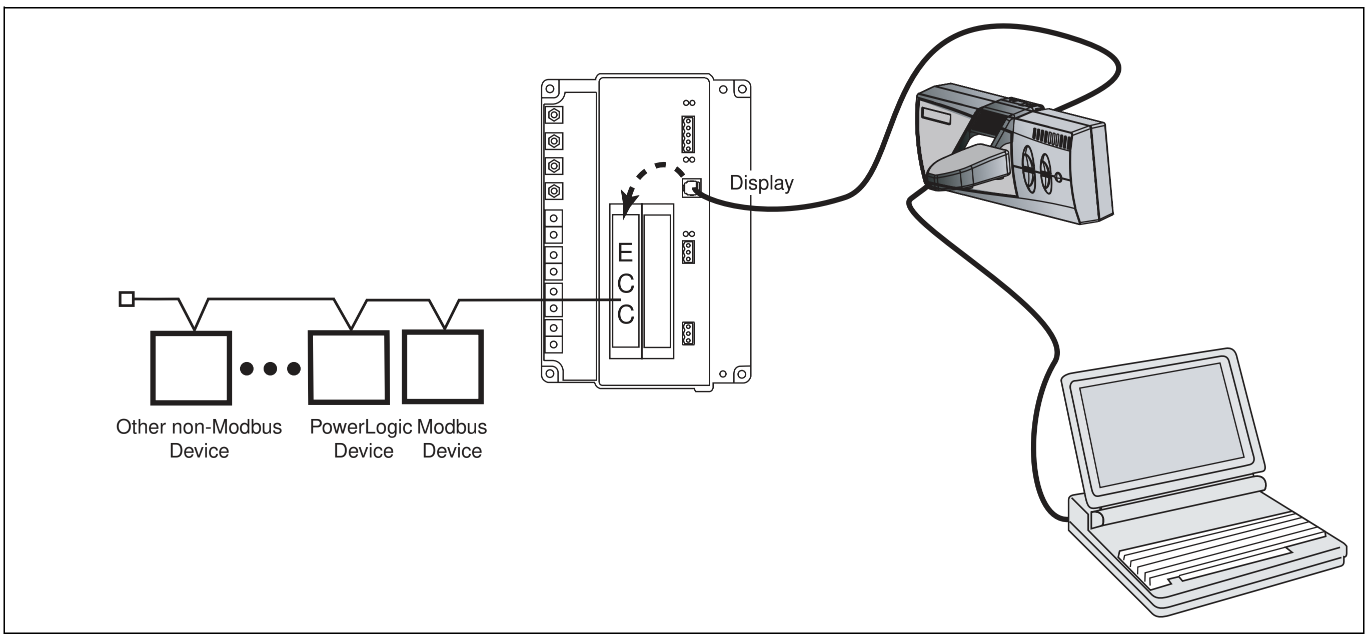
This feature can be especially useful for communication to non-Modbus devices on a mixed-mode daisy chain connected to the circuit monitor. For example, if your circuit monitor is equipped with an ECC21 (Ethernet Communications Card), you can use this feature to communicate to non-Modbus devices such as a Series 2000 Circuit Monitor on a subnetwork.

Redirecting the IR Port to the ECC Subnet

Redirecting the IR port to the ECC lets you communicate from your PC to devices on the ECC RS-485 subnet through the IR port as shown in Figure 3–5. You'll need the Optical Communication Interface (OCIVF) to communicate through the IR port. This configuration is useful in larger systems.

To redirect the IR port, select Setup > Communications > Infrared Port> Redirect to Subnet. Save your changes.

Figure 3–5: Redirected IR port to the ECC RS-485 subnet

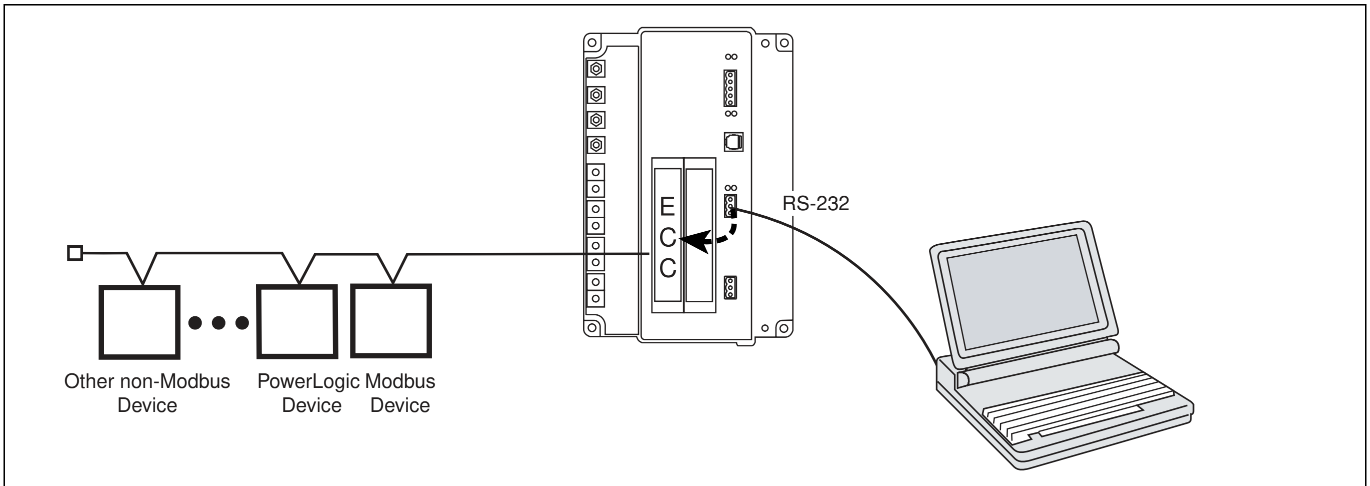


Redirecting the RS-232 Port to the ECC Subnet

Redirecting the RS-232 to the RS-485 port of the ECC lets you communicate from your PC directly to the ECC RS-485 subnet as shown in Figure 3–6. This configuration is useful in larger systems.

To redirect the RS-232 port, select Setup > Communications > RS-232 > Redirect to Subnet. Save your changes.

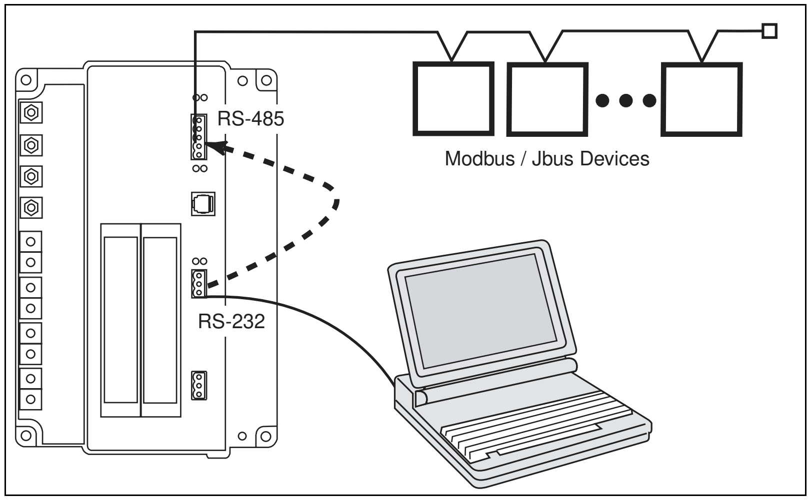
Figure 3–6: Redirected RS-232 port to the ECC RS-485 subnet



Redirecting the RS-232 to the RS-485 Port

Redirecting the RS-232 to the RS-485 lets you communicate directly from your PC to any device on the RS-485 daisy chain as illustrated in Figure 3–7. This configuration provides the benefit of a built-in RS-232 to RS-485 converter and is convenient for use in smaller systems.

Figure 3–7: Redirected RS-232 port to the RS-485 port



Follow these steps:

1. Set the RS-485 port to “Master” before redirecting the RS-232 to the RS-485 port. From the Main Menu of the display, select Setup > Communications > RS-485 > Mode > Master.

   NOTE: If the RS-485 port is not set to Master, the circuit monitor will disable the redirect of the RS-232 port.

2. To redirect the RS-232 port, from the Communications menu, select > RS-232 > Redirect to RS-485. Save your changes.

Redirecting the IR Port of the Display to the RS-485

Redirecting the IR port of the display to the RS-485 port lets you communicate from your PC to devices on the RS-485 daisy chain, without having a direct PC to RS-485 connection. You'll need the Optical Communication Interface (OCIVF) to communicate through the IR port. Figure 3–8 illustrates this connection. This configuration is useful in smaller systems.

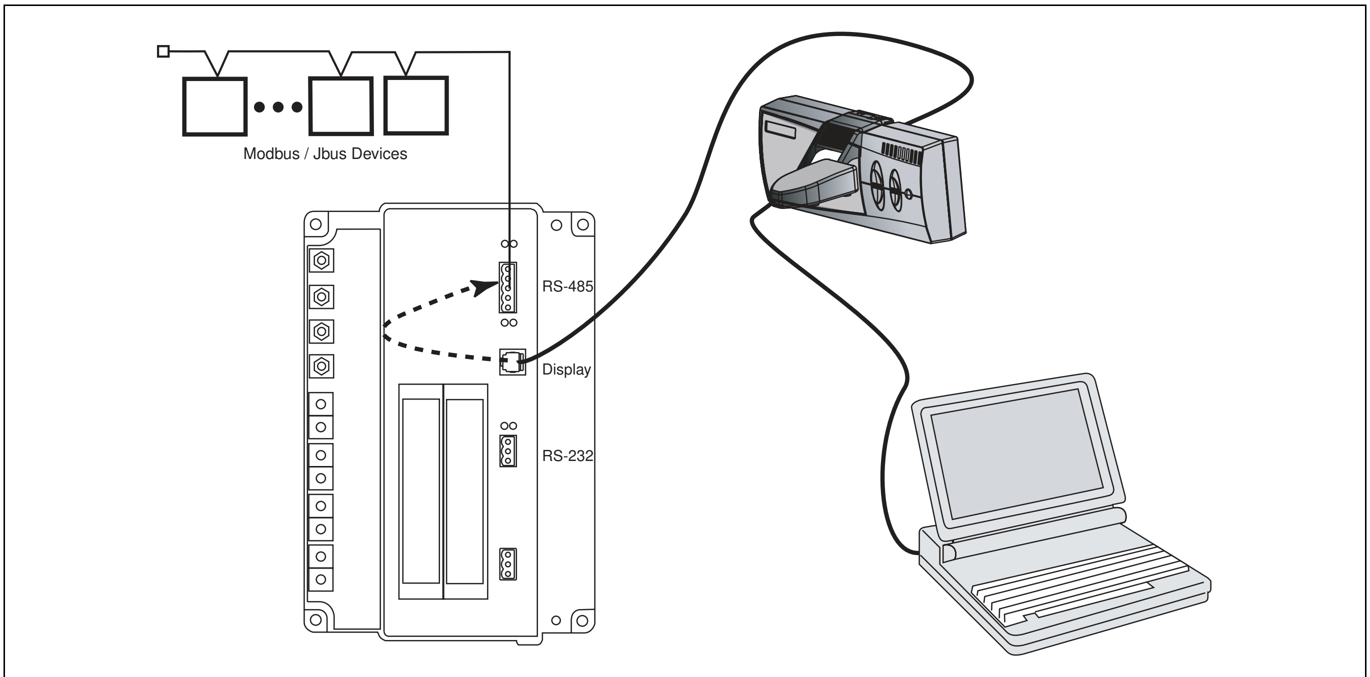
Follow these steps:

1. Set the RS-485 port to "Master" before redirecting the IR port to the RS-485 port. From the Main Menu of the display, select Setup > Communications > RS-485 > Mode > Master.

   NOTE: If the RS-485 port is not set to Master, the circuit monitor will disable the redirect of the RS-232 port.

2. To redirect the IR port, from the Communications menu, select Infrared Port> Redirect> to RS-485. Save your changes.

Figure 3–8: Redirected IR port to the RS-485



Setting Up the Metering Functions of the Circuit Monitor

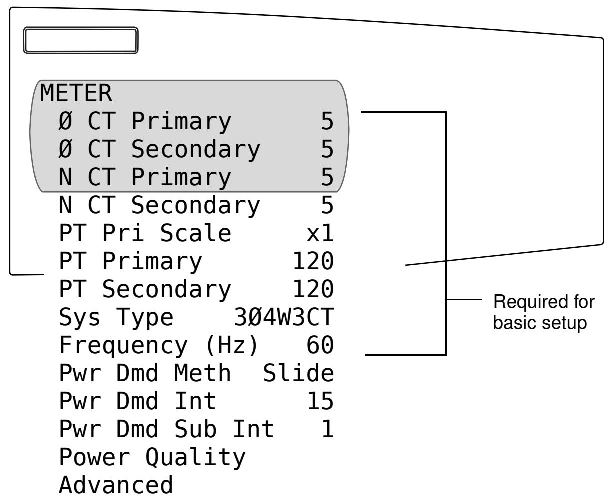
To set up the metering within the circuit monitor, you must configure the following items on the Meter setup screen for basic setup:

- CT and PT ratios
- System type
- Frequency

The power demand method, interval and subinterval, and advanced setup options are also accessible from the Meter Setup menu, but are not required for basic setup if you are accepting the factory defaults already defined in the circuit monitor. Follow these steps to set up the circuit monitor:

1. From the Main Menu, select Setup > Meter.

   The Meter setup screen displays. Table 3–3 describes the options on this menu.



2. Use the arrow buttons to scroll to the menu option you want to change.
3. Press the enter button to select the value. The value begins to blink. Use the arrow buttons to scroll through the available values. Then, press the enter button to select the new value.
4. Use the arrow buttons to scroll through the other options on the menu, or if you are finished, press the menu button to save.

Table 3–3: Options for Meter Setup

Option	Available Values	Selection Description	Default
CT Primary	1–32,767	Set the rating for the CT primary. The circuit monitor supports two primary CT ratings: one for the phase CTs and the other for the neutral CT.	5
CT Secondary	1 or 5	Set the rating for the CT secondaries.	5
PT Pri Scale	x1 x10 x100 No PT	Set the value to which the PT Primary is to be scaled if the PT Primary is larger than 32,767. For example, setting the scale to x10 multiplies the PT Primary number by 10. For a direct-connect installation, select “No PT.”	x1
PT Primary	1–32,767	Set the rating for the PT primary.	120
PT Secondary	100 110 115 120	Set the rating for the PT secondaries.	120
Sys Type	3Φ3W2CT 3Φ3W3CT 3Φ4W3CT 3Φ4W4CT 3Φ4W3CT2PT 3Φ4W4CT2PT	3Φ3W2CT is system type 30 3Φ3W3CT is system type 31 3Φ4W3CT is system type 40 3Φ4W4CT is system type 41 3Φ4W3CT2PT is system type 42 3Φ4W4CT2PT is system type 43 Set the system type. A system type code is assigned to each type of system connection. See Table 5–2 in the installation manual for a description of system connection types.	3Φ4W3CT (40)
Frequency (Hz)	50, 60, or 400 Hz	Frequency of the system.	60

Table 3–3: Options for Meter Setup *(continued)*

Pwr Dmd Meth	Select the power demand calculation method. The circuit monitor supports several methods to calculate average demand of real power. See “Demand Power Calculation Methods” on page 59 for a detailed description. Slide—Sliding Block Demand Slave—Slave Block Demand Therm—Thermal Demand RComms—Command-Synchronized Rolling Block Demand Comms—Command-Synchronized Block Demand RInput—Input-Synchronized Rolling Block Demand Input—Input-Synchronized Block Demand RClock—Clock-Synchronized Rolling Block Demand Clock—Clock-Synchronized Block Demand RBlock—Rolling Block Demand Block—Fixed Block Demand IncEngy—Synch to Incremental Energy Interval		Slide
Pwr Dmd Int	1–60	Power demand interval—set the time in minutes in which the circuit monitor calculates the demand.	15
Pwr Dmd Sub Interval	1–60	Power demand subinterval—period of time within the demand interval in which the demand calculation is updated. Set the subinterval only for methods that will accept a subinterval. The subinterval must be evenly divisible into the interval.	N/A
Power Quality	See “Using EN50160 Evaluation” on page 119 for more information.		
Advanced	See “Advanced Meter Setup” on page 39 in this chapter for more information.		

Setting Up Alarms

This section describes how to set up alarms and create your own custom alarms. For a detailed description of alarm capabilities, see **Alarms** on page 83. The circuit monitor can detect over 100 alarm conditions, such as over/under conditions, status input changes, and phase unbalance conditions. Some alarms are preconfigured and enabled at the factory. See “Factory Defaults” in the installation manual for information about preconfigured alarms. You can edit the parameters of any preconfigured alarm from the display.

For each alarm that you set up, do the following:

- Select the alarm group that defines the type of alarm:
  - — *Standard speed* alarms have a detection rate of one second and are useful for detecting conditions such as over current and under voltage. Up to 80 alarms can be set up in this group.
  - — *High speed* alarms have a detection rate of 100 milliseconds and are useful for detecting voltage sags and swells that last a few cycles. Up to 20 alarms can be set up in this group.
  - — *Disturbance monitoring* alarms have a detection rate of one cycle and are useful for detecting voltage sags and swells. Up to 20 alarms can be set up in this group.
  - — *Digital* alarms are triggered by an exception such as the transition of a status input or the end of an incremental energy interval. Up to 40 alarms can be set up in this group.
  - — *Boolean* alarms have a detection rate of the alarms used as inputs. They are used to combine specific alarms into summary alarm information. Up to 15 alarms can be set up in this group.
  - — *Transient* alarms are set up using the CM4000T. They detect and capture high-speed impulsive transients.
  - — *Waveshape* alarms compare present and previous waveforms to identify changes too small to be detected by a disturbance alarm. Up to 4 alarms can be set up in this group.

- Select the alarm that you want to configure. Keep the default name or enter a new name with up to 15 characters.
- Enable the alarm.
- Assign a priority to the alarm. Refer to “Viewing Alarms” on page 45 for information about the alarm priority levels.
- Define any required pickup and dropout setpoints, and pickup and dropout time delays (for standard, high speed, and disturbance alarm groups only, refer to “Setpoint-Driven Alarms” on page 84).

Setpoint Learning

The circuit monitor can learn normal operating ranges for specified alarm quantities and optimize alarm setpoints for these quantities. This process is called "setpoint learning." You determine the quantity to be learned and the period of time for the learning process. The learning period should take place during "normal" operation. Setpoint learning is available for standard-speed and high-speed analog alarms, disturbance alarms, and waveshape alarms.

Several configuration options allow you to customize setpoint learning to suit your application:

Options that apply to individual alarms in a learning period are:

- Enable/disable. The normal alarms (standard, high-speed, and disturbance) may be enabled or disabled during the learning period. Waveshape alarms must be enabled to learn.
- Setpoint type while learning. If an alarm is enabled while learning, the setpoints used by that alarm can be "fixed" or "dynamic." Alarms with fixed setpoints use setpoints that you configure; they are not updated during learning. Alarms with dynamic setpoints use the present value of the learned setpoints, updated at an interval you select (from 1 to 60 minutes).

Options that apply to all alarms in a learning period are:

- Action when finished learning
- Duration of learning period
- Stop learning if no setpoint change after
- Deadband percentage
- Interval to update dynamic setpoints

Learning is complete when **one** of the following two time periods has expired:

- Duration of learning period
- Stop earning if no setpoint change after

Notes:

- A learning period can include several quantities. The period is not complete until learning is complete for all quantities selected for learning.
- If you add an alarm to a learning period, the elapsed time for that learning period is reset.

Creating a New Custom Alarm

In addition to editing an alarm, you can also create new custom alarms by performing these steps:

1. Create the custom alarm.
2. Set up the new alarm.
3. Enable the new alarm.

   The recommended sequence is to set up the alarm and save the settings while the alarm is disabled. Then, go back into setup to enable the alarm.

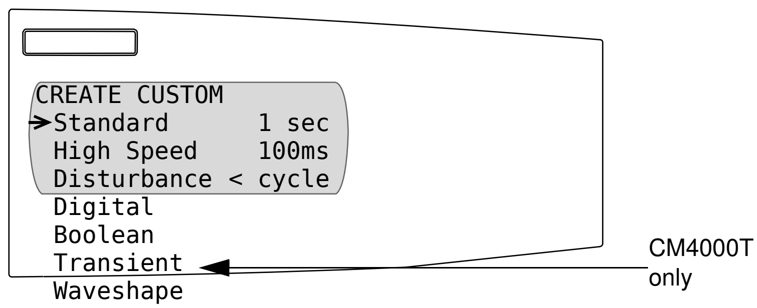
To use custom alarms, you must first create a custom alarm and then set up the alarm to be used by the circuit monitor. Creating an alarm defines information about the alarm including:

- Alarm group (standard, high speed, disturbance, digital, or boolean)
- Name of the alarm
- Type (such as whether it alarms on an over or under condition)
- Register number of the value that will be alarmed upon

To create an alarm, follow these steps:

1. From the Main Menu, select Setup > Alarm > Create Custom.

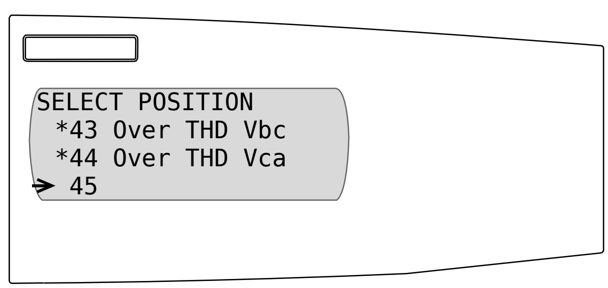
   The Create Custom screen displays.



2. Select the Alarm Group for the alarm that you are creating:

   — Standard—detection rate of 1 second
   — High Speed—detection rate of 100 millisecond
   — Disturbance—detection rate of less than 1 cycle
   — Digital—triggered by an exception such as a status input or the end of an interval
   — Boolean—triggered by condition of alarms used as inputs
   — Transient—detection rate of less than 1 microsecond
   — Waveshape—detection rate up to 32.5 microseconds

   The Select Position screen displays and jumps to the first open position in the alarm list.



3. Select the position of the new alarm.

   The Alarm Parameters screen displays.

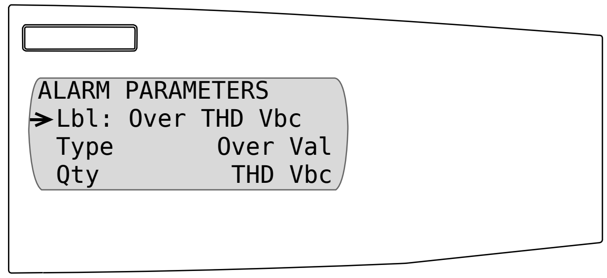


Table 3–4 describes the options on this menu.

Table 3–4: Options for Creating an Alarm

Option	Selection Description	Default
Lbl	Label—name of the alarm. Press the down arrow button to scroll through the alphabet. The lower case letters are presented first, then uppercase, then numbers and symbols. Press the enter button to select a letter and move to the next character field. To move to the next option, press the menu button. Available values displayed in forward order are: space, a-z, A-Z, 9-0, #, $, Φ. If you use the up arrow button to scroll, these values are displayed in reverse order.	—
Type	Select the type of alarm that you are creating. *Note: For digital alarms, the type is either ON state, OFF state, or Unary to describe the state of the digital input. Unary is available for digital alarms only.** Over Val—over value Over Pwr—over power Over Rev Pwr—over reverse power Under Val—under value Under Pwr—under power Phs Rev—phase reversal Phs Loss Volt—phase loss, voltage Phs Loss Cur—phase loss, current PF Lead—leading power factor PF Lag—lagging power factor See Table 6–4 on page 93 for a description of alarm types.	Undefined
Qty	For standard or high speed alarms, this is the quantity to be evaluated. While selected, press the arrow buttons to scroll through the quantity options: Current, Voltage, Demand, Unbalance, Frequency, Power Quality, THD, Harmonics, Temperature, Custom, and Register. Pressing the menu key while an option is displayed will activate that option's list of values. Use the arrow keys to scroll through the list of options, selecting an option by pressing the enter key.	Undefined

*Unary is a special type of alarm used for "end of" digital alarms. It does not apply to setting up alarms for digital inputs.

4. Press the menu button until "Save Changes? No" flashes on the display. Select Yes with the arrow button, then press the enter button to save the changes. Now, you are ready to set up the newly created custom alarm.

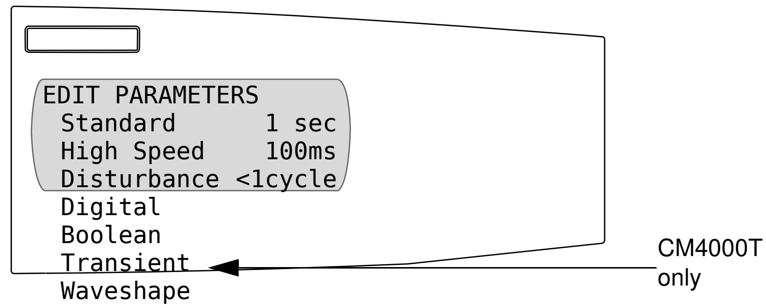
Setting Up and Editing Alarms

To set up any alarm—new or existing—for use by the circuit monitor, use the Edit Parameters option on the Alarm screen. You can also change parameters of any alarm, new or existing. For example, using the Edit Parameters option, you can enable or disable an alarm, change its priority, and change its pickup and dropout setpoints.

Follow these instructions to set up or edit an alarm:

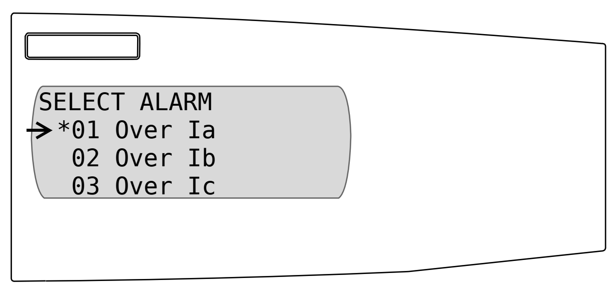
1. From the Main Menu, select Setup > Alarm > Edit Parameters.

   The Edit Parameters screen displays.



2. Select the Alarm Group:
   - — Standard
   - — High Speed
   - — Disturbance
   - — Digital
   - — Boolean
   - — Transient
   - — Waveshape

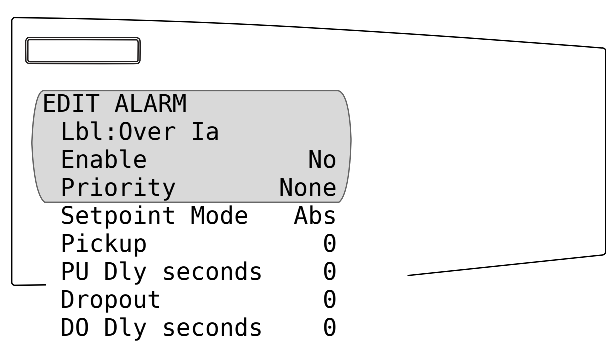
   The Select Alarm screen displays.



NOTE: If you are setting up or editing a digital alarm, alarm names such as Breaker 1 trip, Breaker 1 reset will display instead.

3. Select the alarm you want to set up or edit.

   The Edit Alarm screen with the alarm parameters displays. Table 3–5 describes the options on this menu.



NOTE: If you are setting up or editing a digital alarm, fields related to pickup and dropout are not applicable and will not be displayed.

4. Use the arrow buttons to scroll to the menu option you want to change, then edit the alarm options.
5. When you are finished with all changes, press the menu button until “Save Changes? No” flashes on the display. Select Yes with the arrow button, then press the enter button to save the changes.

   NOTE: An asterisk next to the alarm in the alarm list indicates that the alarm is enabled.

Table 3–5: Options for Editing an Alarm

Option	Available Values	Selection Description	Default
Lbl	Alphanumeric	Label—name of the alarm assigned to this position. Press the down arrow button to scroll through the alphabet. The lower case letters are presented first, then uppercase, then numbers and symbols. Press the enter button to select a letter and move to the next character field. To move to the next option, press the menu button.	Name of the alarm assigned to this position.
Enable	Yes No	Select *Yes* to make the alarm available for use by the circuit monitor. On preconfigured alarms, the alarm may already be enabled. Select *No* to make the alarm function unavailable to the circuit monitor.	Depends on individual alarm.
Priority	None Low Med High	*Low* is the lowest priority alarm. *High* is the highest priority alarm and also places the active alarm in the list of high priority alarms. To view this list from the Main Menu, select Alarms > High Priority Alarms. For more information, see “Viewing Alarms” on page 45.	Depends on individual alarm.
Setpoint Mode	Abs Rel	Selecting Abs indicates that the pickup and dropout setpoints are absolute values. Rel indicates that the pickup and dropout setpoints are a percentage of a running average, the relative value, of the test value.	
Pickup	1–32,767	When you enter a delay time, the number is multiples of time. For example, for standard speed the time is 2 for 2 seconds, 3 for 3 seconds, etc. For high speed alarms, 1 indicates a 100 ms delay, 2 indicates a 200 ms delay, and so forth. For disturbance the time unit is 1 cycle. See “Setpoint-Driven Alarms” on page 84 for an explanation of pickup and dropout setpoints.	Depends on individual alarm.
PU Dly Seconds	Pickup Delay 1–32,767		
Dropout	1–32,767		
DO Dly Seconds	Dropout Delay 1–32,767		

Setting Up I/Os

If you install an I/O Extender (IOX), you must configure each I/O module that is attached.

Selecting I/O Modules for the IOX

To set up an I/O, you must do the following:

1. Install the I/O option module following the instructions provided with the product.
2. If using an IOX, use the display to select which IOX option is installed.
3. Use the display to configure each individual input and output. You can also use SMS to configure inputs and outputs.

NOTE: After selecting which IOX option is installed, you can't configure the modules until you have saved the changes. After saving the changes, you then can configure the inputs and outputs.

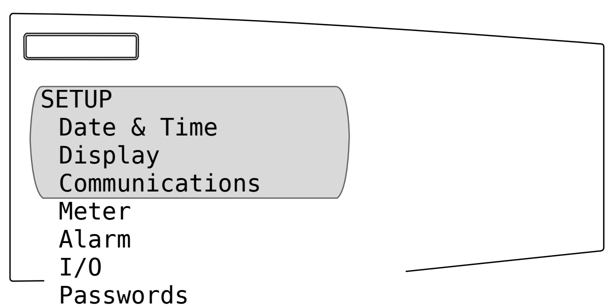
NOTE: For a description of I/O options, see "Input/Output Capabilities" on page 71. To view the status of an I/O, see "Viewing I/O Status" on page 47. You need to know the position number of the I/O to set it up. See "I/O Point Numbers" on page 160 to determine this number.

To set up an I/O, follow these steps:

1. From the Main Menu, select Setup.

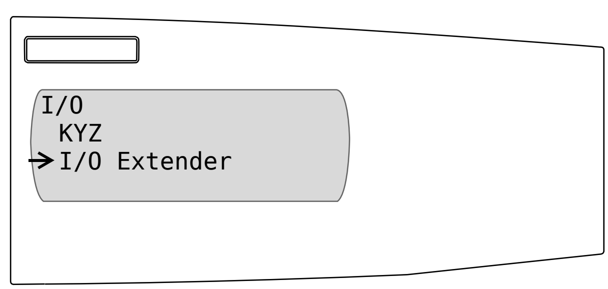
   The password prompt displays.
2. Select your password. The default password is 0.

   The Setup menu displays.



3. Select I/O.

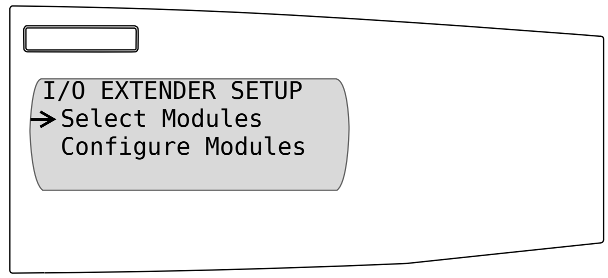
   The I/O Setup menu displays.



NOTE: Other option modules (Slot A or Slot B) display in the I/O menu if they are installed

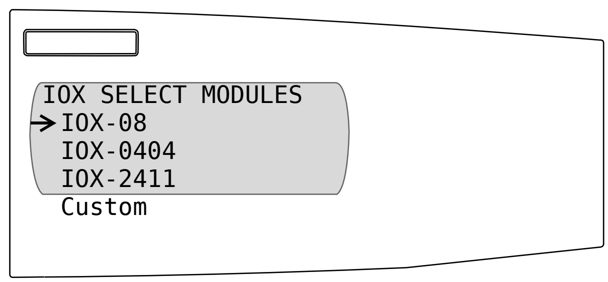
4. Select the I/O option that you have installed.

   The I/O Extender Setup menu displays.



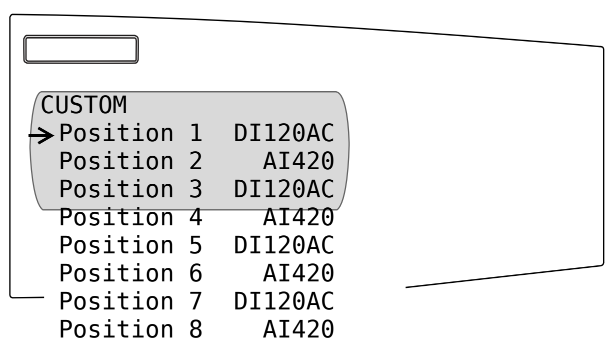
5. Select the Select Modules menu option.

   The IOX Select Modules menu displays.



6. If you have the IOX-08, IOX-0404, or IOX-2411, select the option you have installed. A pound sign (#) appears next to the option to indicate the present configuration. If you installed individual custom I/Os, select Custom on the IOX Select Modules menu.

   The Custom menu displays.



7. Select the position in which the I/O is installed. Then, using the arrow keys, select from the list which I/O module is located in that position. The individual I/Os are described in Table 3–6.

Table 3–6: I/O Descriptions

I/O Name	Description
Digital I/Os	
DI32DC	32 Vdc input (0.2ms turn on) polarized
DI120AC	120 Vac input
DO120AC	120 Vac output
DI240AC	240 Vac input
DO60DC	60 Vdc output
DO200DC	200 Vdc output
DO240AC	240 Vac output
Analog I/Os	
AI05	0 to 5 Vdc analog input
AI420	4 to 20 mA analog input
AO420	4 to 20 mA analog output

8. Press the menu button until “Save Changes? No” flashes on the display. Select Yes with the arrow button, then press the enter button to save the changes.

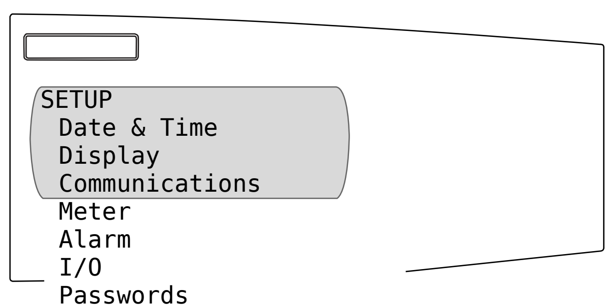
Configuring I/O Modules for the IOX

Follow the steps below to configure the inputs and outputs for the I/O module you selected.

1. From the Main Menu, select Setup.

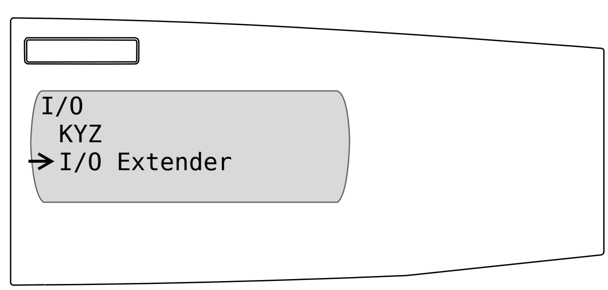
   The password prompt displays.
2. Select your password. The default password is 0.

   The Setup menu displays.



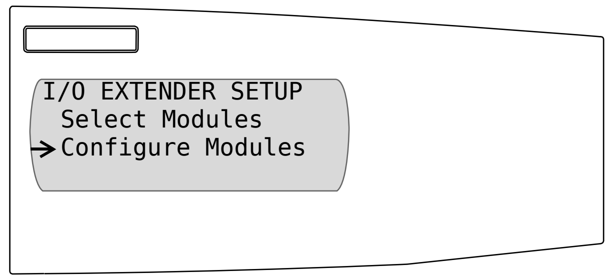
3. Select I/O.

   The I/O menu displays.



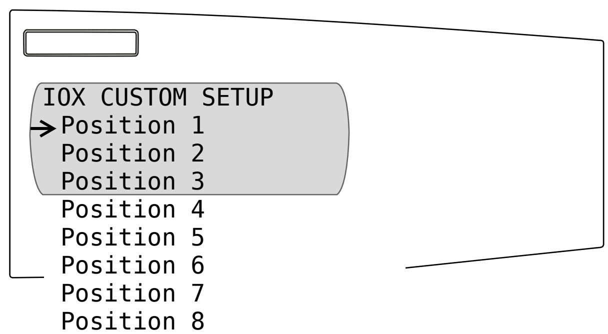
4. Select the I/O option that you have installed. In this example, we selected the I/O Extender.

   The I/O Extender Setup selection menu displays.



5. Select the Configure Modules menu option.

   The IOX Setup menu displays according to the IOX previously selected. In this example the IOX Custom Setup menu displays.



6. Select the position in which the I/O is installed.

   The I/O module's setup menu displays based on the type of module installed in the selected position.

```
ANALOG INPUT SETUP
  Lbl:  Analog In C02
  Type   4-20mA Input
  I/O Point #      36
  Multiplier        1
  Lower Limit     400
  Upper Limit    2000
```

```
ANALOG OUTPUT SETUP
  Lbl:  Analog OutC04
  Type  4-20mA Output
  I/O Point #      38
  Reference Reg   100
  Lower Limit     400
  Upper Limit    2000
```

```
DIGITAL INPUT SETUP
  Lbl:     Dig In C01
  Type   120Vac Input
  I/O Point #      35
  Mode         Normal
```

```
DIGITAL OUTPUT SETUP
  Lbl:    Dig Out C03
  Type 120 Vac Output
  I/O Point #      37
  Mode         Normal
  Pulse Const    ****
  Timer (secs)      0
  Control    External
  Associate Alarm
```

NOTE: For a description of the I/O options displayed above, refer to "Input/Output Capabilities" on page 71.

Configuring I/O Modules for the IOC

When you install a digital I/O card (IOC44) in either of the optional card slots located on the top of the circuit monitor, the circuit monitor automatically recognizes that the card has been installed.

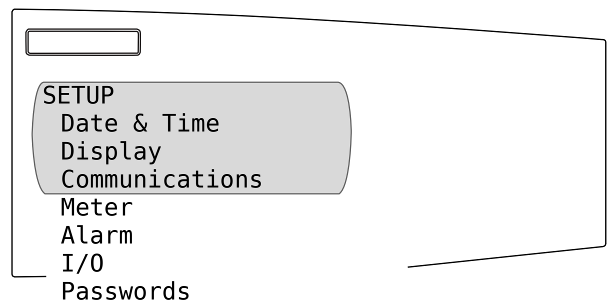
NOTE: For a description of I/O options, see “Input/Output Capabilities” on page 71. To view the status of an I/O, see “Viewing I/O Status” on page 47. You need to know the position number of the I/O to set it up. See “I/O Point Numbers” on page 160 to determine this number.

To set up the I/O options, follow these steps:

1. From the Main Menu, select Setup.

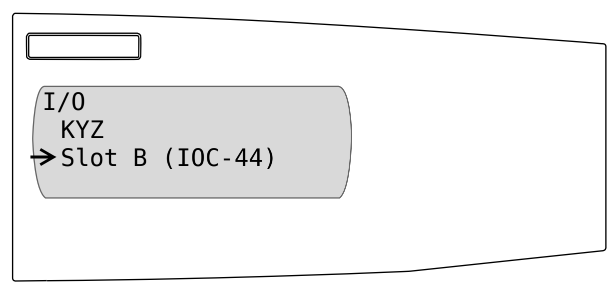
   The password prompt displays.
2. Select your password. The default password is 0.

   The Setup menu displays.



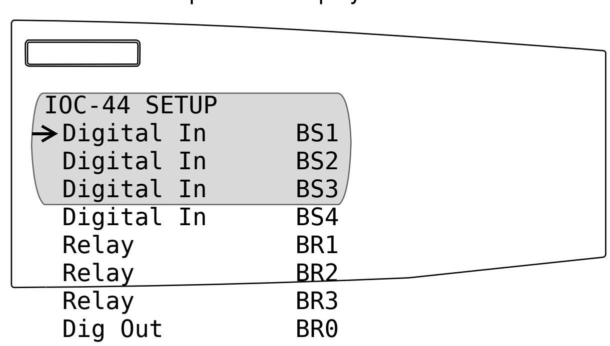
3. Select I/O.

   The I/O menu displays.



4. Select the I/O option that you have installed.

   The IOC-44 Setup screen displays.



5. Using the arrow buttons, select the options to configure for the individual inputs and relays. The setup menu that displays is based on which option you select.

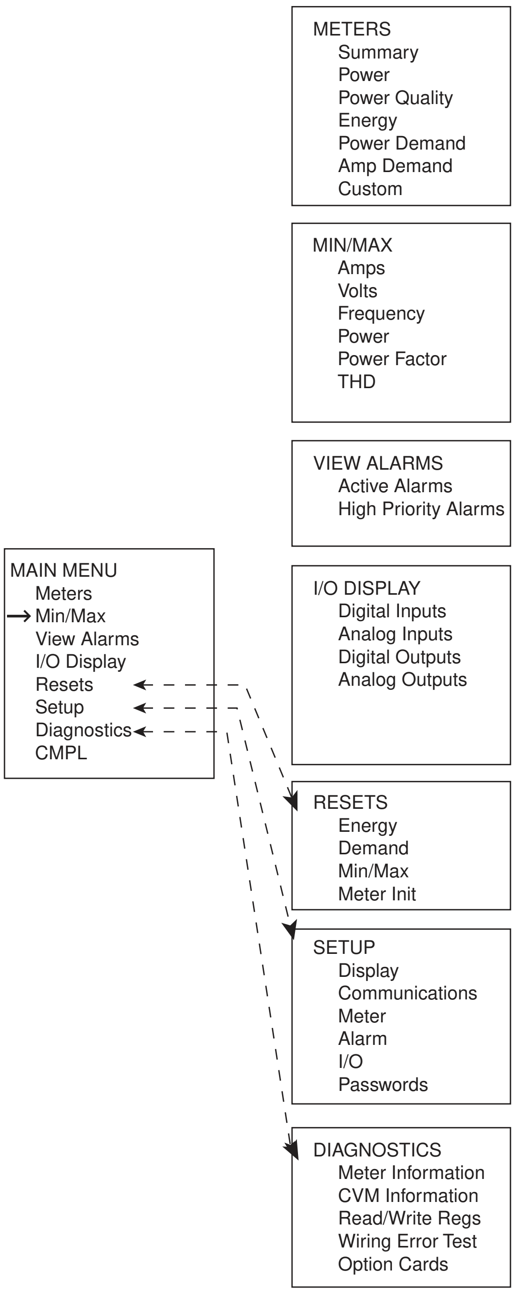
```
DIGITAL INPUT SETUP
 Lbl:      Dig In B52
 Type   120Vac Input
 I/O Point #      20
 Mode         Normal
```

```
DIGITAL OUTPUT SETUP
 Lbl:    Dig Out BR2
 Type 120 Vac Output
 I/O Point #      24
 Mode         Normal
 Pulse Const    ****
 Timer (secs)      0
 Control    External
 Associate Alarm
```

NOTE: For a description of the I/O options displayed above, refer to the installation documentation that ships with the IOC44.

Setting Up Passwords

Figure 3–9: Menus that can be password protected



A password is always required to access the following menus from the Main Menu:

- Resets (a separate password can be set up for Energy/Demand Reset and Min/Max Reset)
- Setup
- Read/Write Regs on the Diagnostics Menu

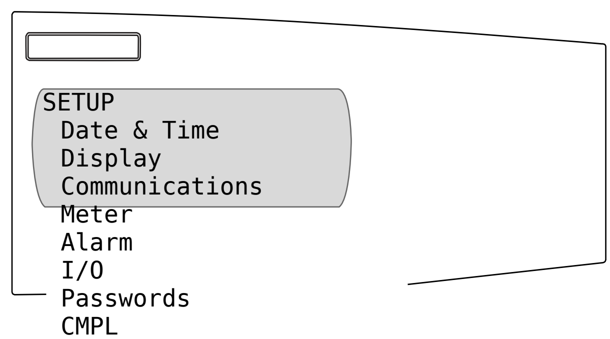
The default password is 0. Therefore, when you receive a new circuit monitor, the password for the Setup, Diagnostics, and Reset menu is 0. If you choose to set up passwords, you can set up a different password for each of the four menus options listed above.

To set up a password, follow these instructions:

1. From the Main Menu, select Setup.

   The password prompt displays.
2. Select 0, the default password.

   The Setup menu displays.



3. Select Passwords.

   The Passwords menu displays. Table 3–7 describes the options.

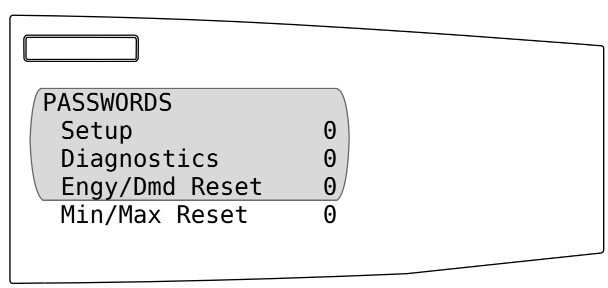


Table 3–7: Options for Password Setup

Option	Available Values	Description
Setup	0–9998	Enter the password to be used for the Setup option on the Main Menu.
Diagnostics	0–9998	Enter the password to be used for the Diagnostics option on the Main Menu.
Engy/Dmd Reset*	0–9998	Enter the password to be used for resetting Energy and Demand. These options appear on the Reset menu, and they can also be locked. See “Advanced Meter Setup” on page 39 for instructions.
Min/Max Reset*	0–9998	Enter the password to be used for resetting the Min/Max, which appears on the Reset menu. This option can also be locked. See “Advanced Meter Setup” on page 39 for instructions.

*The word “Locked” appears next to a reset option that is inaccessible. If all of the reset options are locked, “Locked” will appear next to the Resets option in the Main Menu, and the Resets menu will be inaccessible.

Advanced Setup Features

The features discussed in this section are not required for basic circuit monitor setup, but can be used to customize your circuit monitor to suit your needs.

Creating Custom Quantities to be Displayed

Any quantity that is stored in a register in the circuit monitor can be displayed on the remote display. The circuit monitor has a list of viewable quantities already defined, such as average current and power factor total. In addition to these predefined values, you can define custom quantities that can be displayed on a custom screen. For example, if your facility uses different types of utility services—such as water, gas, and steam— you may want to track usage of the three services on one convenient screen. To do this, you could set up inputs to receive pulses from each utility meter, then display the scaled register quantity.

For the circuit monitor display, custom quantities can be used to display a value. Don’t confuse this feature with SMS custom quantities. SMS custom quantities are used to add new parameters which SMS can use to perform functions. SMS custom quantities are defined, for example, when you add a new PowerLogic-compatible device to SMS or if you want to import data into SMS from another software package. You can use the SMS custom quantities in custom tables and interactive graphics diagrams, but you cannot use circuit monitor display custom quantities in this way. *Custom quantities that you define for display from the circuit monitor are not available to SMS. They must be defined separately in SMS.*

To use a custom quantity, perform these tasks:

1. Create the custom quantity as described in this section.
2. Create a custom screen on which the custom quantity can be displayed.

   See “Creating Custom Screens” on page 35 for procedures. You can view the custom screen by selecting from the Main Menu, Meters > Custom. See “Viewing Custom Screens” on page 39 for more information.

To create a custom quantity, follow these steps:

1. From the Main Menu, select Setup.

   The password prompt displays.
2. Select your password. The default password is 0.

The Setup menu displays.

```
SETUP
 Date & Time
 Display
 Communications
 Meter
 Alarm
 I/O
 Passwords
 CMPL
```

3. Select Display.

   The Display menu displays.

```
DISPLAY
→Language    English
 Date     MM/DD/YYYY
 Time Format   AM/PM
 VFD Sensitivity   2
 Display Timer 5 Min
 Custom Quantity
 Custom Screen
```

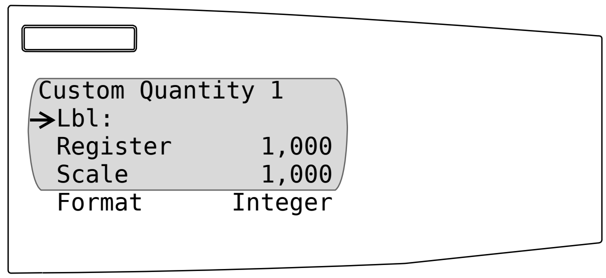
4. Select Custom Quantity.

   The Custom Quant Setup screen displays.

```
CUSTOM QUANT SETUP
→Custom Quantity 1
 Custom Quantity 2
 Custom Quantity 3
 Custom Quantity 4
 Custom Quantity 5
 Custom Quantity 6
 Custom Quantity 7
 Custom Quantity 8
 Custom Quantity 9
 Custom Quantity 10
```

5. Select a custom quantity.

   In this example, we selected Custom Quantity 1. Table 3–8 shows the available values.



6. Use the arrow buttons to scroll to the menu option you want to change.
7. Press the enter button to select the value. The value begins to blink. Use the arrow buttons to scroll through the available values. Then, press the enter button to select the new value.
8. Use the arrow buttons to scroll through the other options on the menu, or if you are finished, press the menu button to save the changes.

Table 3–8: Options for Custom Quantities

Option	Available Values	Default
Lbl	Name of the quantity up to 10 characters. Press the arrow buttons to scroll through the characters. To move to the next option, press the menu button.	
Register	4- or 5-digit number of the register in which the quantity exists.	1,000
Scale	Multiplier of the register value can be one of the following: .001, .01, .1, 1.0, 10, 100 or 1,000. See “Scale Factors” on page 89 for more information.	1,000
Format	Integer D/T—date and time MOD10L4—Modulo 10,000 with 4 registers ① MOD10L3—Modulo 10,000 with 3 registers ① MOD10L2—Modulo 10,000 with 2 registers ① Label ② Text	Integer

① Modulo 10,000 is used to store energy. See the SMS online help for more.
② Use the Label format to create a label with no corresponding data register.

   An asterisk (*) next to the quantity indicates that the quantity has been added to the list.

9. To save the changes to the Display Setup screen, press the menu button.

The custom quantity is added to the Quantities List in the Custom Screen Setup. The new quantity appears at the end of this list after the standard quantities. After creating the custom quantity, you must create a custom screen to be able to view the new quantity.

Creating Custom Screens

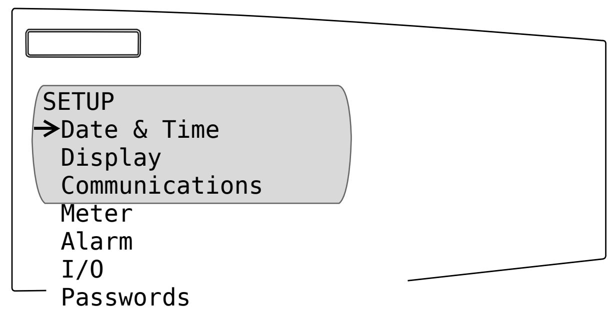
You choose the quantities—standard or custom—that are to be displayed on a custom screen. To display a custom quantity, you must first create it so that it appears on the Quantities List. See “Creating Custom Quantities to be Displayed” on page 32 for instructions.

To create a custom screen, follow these steps:

1. From the Main Menu, select Setup.

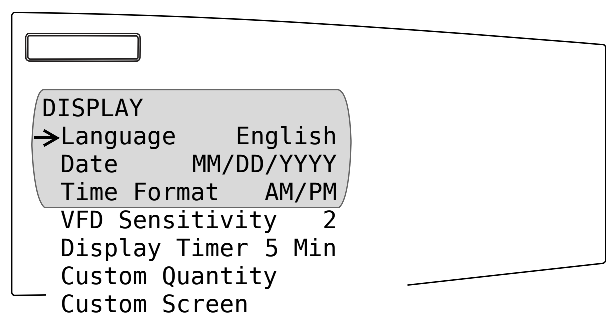
   The password prompt displays.
2. Select your password. The default password is 0.

   The Setup menu displays.



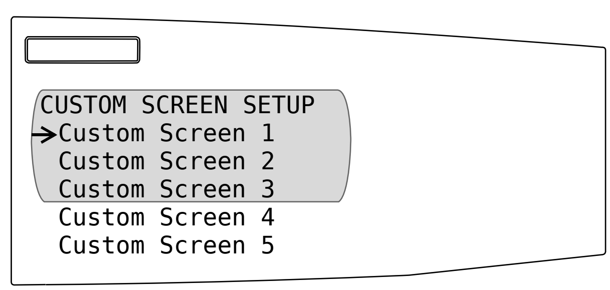
3. Select Display.

   The Display Setup menu displays.



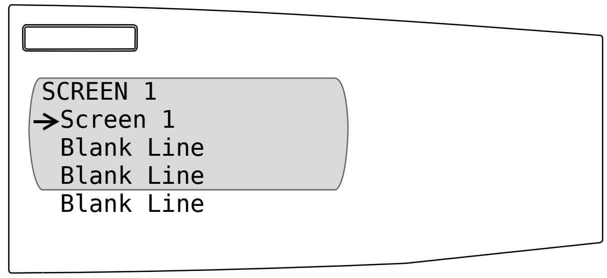
4. Select Custom Screen.

   The Custom Screen Setup screen displays.



5. Select a custom screen.

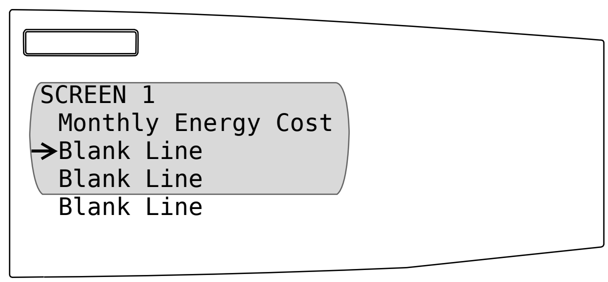
   In this example, we selected Custom Screen 1.



   The cursor begins to blink.

6. Create a name for the custom screen. Press the arrow buttons to scroll through the alphabet. Press the enter button to move to the next character field.
7. When you have finished naming the screen, press the menu button, then select the first blank line.

   The first blank line begins to blink.

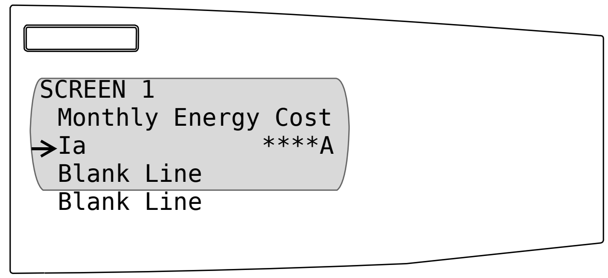


8. Press the menu button again, then use the arrow buttons to select one of the following quantity types:

   — Current
   — Voltage
   — Frequency
   — Power Factor
   — Power
   — THD
   — Energy
   — Demand
   — Harmonics
   — Unbalance
   — Custom

   To view the quantities of a quantity type, press the enter button.

The first quantity flashes on the display.



9. Use the arrow buttons to scroll through the list of quantities. Select the quantity that you want for your custom screen by pressing the enter button.

   Table 3–9 lists the default quantities. If you have created a custom quantity, it will be displayed at the bottom of this list.

Table 3–9: Available Default Quantities

Quantity Type	Quantity	Label*
Current	Current A	Ia
	Current B	Ib
	Current C	Ic
	Current N	In
	Current G	Ig
	Current Average	I Avg
Voltage	Voltage A–B	Vab
	Voltage B–C	Vbc
	Voltage C-A	Vca
	Voltage L–L Average	V L-L Avg
	Voltage A–N	Van
	Voltage B–N	Vbn
	Voltage C–N	Vcn
	Voltage L–N Average	V L-N Avg
Frequency	Frequency	Freq
Power Factor	Power Factor Total	PF Total
	Displacement Power Factor Total	Dis PF Tot
Power	Real Power Total	kW Total
	Reactive Power Total	kVAR Total
	Apparent Power Total	kVA Total
THD	THD Current A	THD Ia
	THD Current B	THD Ib
	THD Current C	THD Ic
	THD Current N	THD In
	THD Voltage A–N	THD Van
	THD Voltage B–N	THD Vbn
	THD Voltage C–N	THD Vcn
	THD Voltage A–B	THD Vab

Table 3–9: Available Default Quantities *(continued)*

Quantity Type	Quantity	Label*
	THD Voltage B–C	THD Vbc
	THD Voltage C–A	THD Vca
Energy	Real Energy, Total	kWHr Tot
	Reactive Energy, Total	kVARHr Tot
	Apparent Energy, Total	kVAHr Tot
Demand	Demand Current Average	Dmd I Avg
	Demand Current A	Dmd Ia
	Demand Current B	Dmd Ib
	Demand Current C	Dmd Ic
	Demand Current N	Dmd In
	Demand Voltage A–N	Dmd Van
	Demand Voltage B–N	Dmd Vbn
	Demand Voltage C–N	Dmd Vcn
	Demand Voltage L–N Average	Dmd V L-N
	Demand Voltage A–B	Dmd Vab
	Demand Voltage B–C	Dmd Vbc
	Demand Voltage C–A	Dmd Vca
	Demand Voltage L–L Avg	Dmd V L-L
	Demand Real Power (kWD)	Dmd kW
	Demand Reactive Power (kVARD)	Dmd kVAR
	Demand Apparent Power (kVA)	Dmd kVA
Harmonics	3rd Harmonic Magnitude Voltage A	Van 3rd
	5th Harmonic Magnitude Voltage A	Van 5th
	7th Harmonic Magnitude Voltage A	Van 7th
	3rd Harmonic Magnitude Voltage B	Vbn 3rd
	5th Harmonic Magnitude Voltage B	Vbn 5th
	7th Harmonic Magnitude Voltage B	Vbn 7th
	3rd Harmonic Magnitude Voltage C	Vcn 3rd
	5th Harmonic Magnitude Voltage C	Vcn 5th
	7th Harmonic Magnitude Voltage C	Vcn 7th
Unbalance	Current Unbalance Max	I Unbl Mx
	Voltage Unbalance Max L-L	V Unbl Mx L–L
	Voltage Unbalance Max L-N	V Unbl Mx L–N

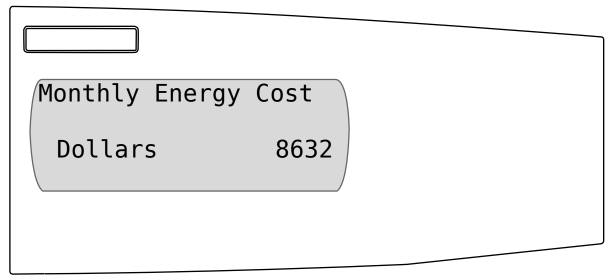
* Displayed on the screen.

10. Press the menu button until “Save Changes? No” flashes on the display. Press the arrow button to select Yes, then press the enter button to save the custom screen.

Viewing Custom Screens

If you have a custom screen setup, a “Custom” option will be displayed on the Meters menu.

To view a custom screen, from the Main Menu select Meters > Custom. In the following example, a custom screen was created for monthly energy cost.



Press the arrow button to view the next custom screen. Press the menu button to exit and return to the Meters Menu.

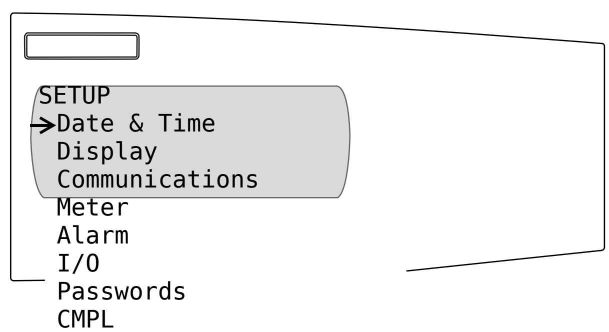
Advanced Meter Setup

The Advanced option on the Meter Setup screen lets you perform miscellaneous advanced setup functions on the metering portion of the circuit monitor. For example, on this menu you can change the phase rotation or the VAR sign convention. The advanced options are described below.

1. From the Main Menu, select Setup.

   The password prompt displays.
2. Select your password. The default password is 0.

   The Setup menu displays.



3. Select Meter.

   The Meter screen displays.

```
METER
→Ø CT Primary      5
 Ø CT Secondary    5
 N CT Primary      5
 N CT Secondary    5
 PT Pri Scale     x1
 PT Primary      120
 PT Secondary    120
 Sys Type    3Ø4W3CT
 Frequency (Hz)   60
 Pwr Dmd Meth  Slide
 Pwr Dmd Int      15
 Pwr Dmd Sub Int   1
 Power Quality
 Advanced
```

4. Scroll to the bottom of the list and select Advanced.

   The Advanced Meter Setup screen displays. Table 3–10 describes the options on this menu.

```
ADVANCED METER SETUP
→Phase Rotation  ABC
 Incr Energy Int  60
 THD Meth THD(%Fund)
 VAR Sign   IEEE/IEC
 Lock Energy Reset N
 Lock Pk Dmd Reset N
 Lock M/M Reset    N
 Lock Meter Init   N
```

5. Change the desired options and press the menu button to save.

Table 3–10: Options for Advanced Meter Setup

Option	Available Values	Selection Description	Default
Phase Rotation	ABC or CBA	Set the phase rotation to match the system.	ABC
Incr Energy Int	0–1440	Set incremental energy interval in minutes. The interval must be evenly divisible into 24 hours.	60
THD Meth	THD (%Fund) or thd (%RMS)	Set the calculation for total harmonic distortion. See “Power Analysis Values” on page 68 for a detailed description.	THD
VAR Sign	IEEE/IEC or ALT (CM1)	Set the VAR sign convention. See “VAR Sign Conventions” on page 58 for a discussion about VAR sign convention.	IEEE/IEC
Lock Energy Reset	Y or N	Lock the reset of the accumulated energy. If set to Y (yes), the Energy option on the Reset menu will be locked so that the value cannot be reset from the display, even if a password has been set up for the Reset option. See “Resetting Min/Max, Demand, and Energy Values” on page 41 for more information.	N

Table 3–10: Options for Advanced Meter Setup *(continued)*

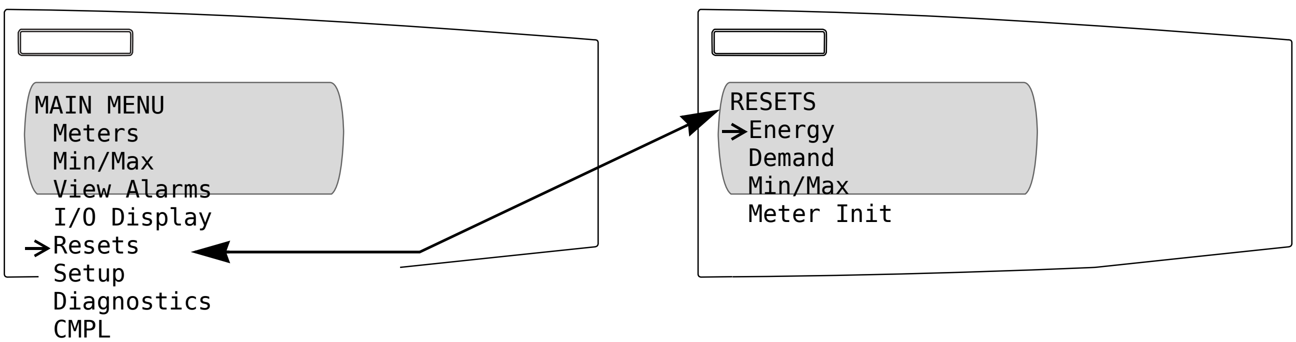
Lock Pk Dmd Reset	Y or N	Lock the reset of peak demand. If set to Y (yes), the Demand option on the Reset menu will be locked so that the value cannot be reset from the display, even if a password has been set up for the Reset option. See “Resetting Min/Max, Demand, and Energy Values” on page 41 for more information.	N
Lock M/M Reset	Y or N	Lock the reset of the min/max values. If set to Y (yes), the Min/Max option on the Reset menu will be locked so that the value cannot be reset from the display, even if a password has been set up for the Reset option. See “Resetting Min/Max, Demand, and Energy Values” on page 41 for more information.	
Lock Meter Init	Y or N	Lock access to Meter Initialization. If set to Y (Yes), the Meter Init option on the Resets menu will be locked so that this function cannot be done from the display, even if a password has been set up for the Setup/Meter Init option. See “Resetting Min/Max, Demand, and Energy Values” on page 41 for more information.	N

RESETTING MIN/MAX, DEMAND, AND ENERGY VALUES

A reset clears the circuit monitor’s memory of the last recorded value. For example, you might need to reset monthly peak demand power. From the Reset menu, shown in Figure 3–10, you can reset the following values:

- Energy—accumulated energy and conditional energy
- Demand—peak power demand and peak current demand
- Min/Max—minimum and maximum values for all real-time readings

Figure 3–10: Performing resets from the Reset menu



A password is required to reset any of the options on the Reset menu. The default password is 0. See “Setting Up Passwords” on page 31 for more information about passwords.

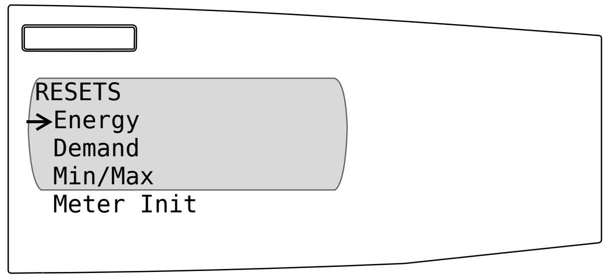
You can perform resets from the circuit monitor as described in this section; or, if you are using SMS, you can set up a task to perform the reset automatically at a specified time. See the SMS online help for instructions.

NOTE: To stop users from using the display to reset energy, peak demand, and min/max values, see “Advanced Meter Setup” on page 39 for instructions on using the reset locking feature.

To perform resets, follow these steps:

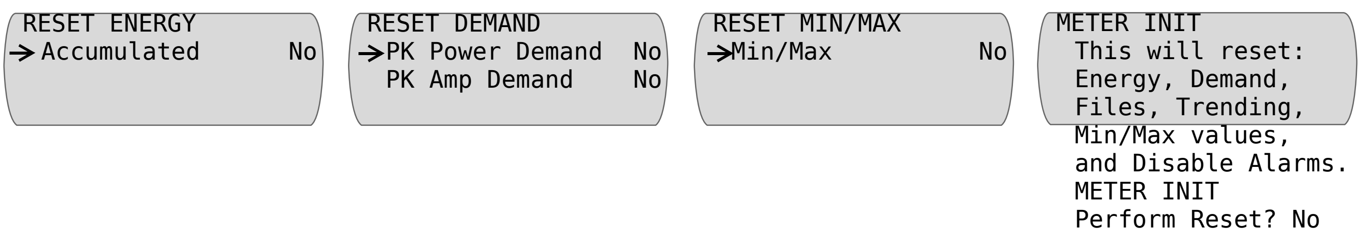
1. From the Main Menu, select Resets.

   The Resets menu displays.



2. Use the arrow buttons to scroll through the menu options on the Resets menu. To select a menu option, press the enter button.

   Depending on the option you select, the screen for that value displays.

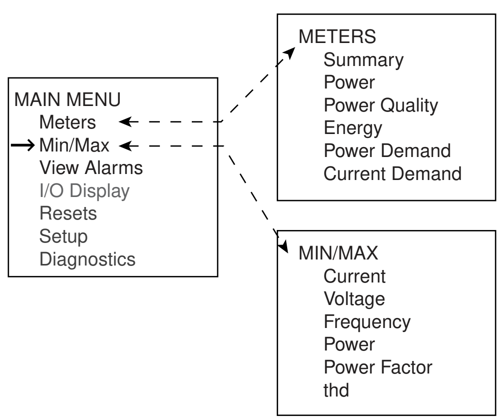


3. Select the option you would like to reset, and change No to Yes by pressing the arrow button.
4. Press Enter to move to the next option, or press the menu button to reset the value.

VIEWING METERED DATA

The Meters menu and the Min/Max menu, shown in Figure 3–11, are view-only menus where you can view metered data in real time.

Figure 3–11: Viewing metered data on the Meters and Min/Max menus



Use the arrow buttons to scroll through the menu options on the Meters menu. To select a menu option, press the enter button. To select another option, press the menu button.

Viewing Metered Data from the Meters Menu

From the Meters menu you can view the following information.

- **Summary**—lets you quickly move through and view the following:
  - — Summary total of volts, amperes, and kW
  - — Amperes and volts for all three phases, neutral and ground, line to line, line to neutral
  - — Power kW, kVAR, and kVA (real, reactive, and apparent power) 3-phase totals
  - — Power factor (true and displacement) 3-phase totals
  - — Total energy kWh, kVARh, and kVAh 3-phase totals (real, reactive, and apparent energy)
  - — Frequency in hertz
- **Power**—This option lets you view power per-phase kW, kVAR, and kVA (real, reactive, and apparent power). It is available only if the circuit monitor is configured for 4-wire system; it will not appear for 3-wire systems. If you are using a 4-wire system, you can view the leading and lagging values for true and displacement power factor.
- **Power Quality**—shows the following values per phase:
  - — THD voltage line to neutral and line to line
  - — THD amperes
  - — K-factor
  - — Fundamental volts and phase angle
  - — Fundamental amperes and phase angle
- **Energy**—shows accumulated and incremental readings for real and reactive energy into and out of the load, and the real, reactive, and apparent total of all three phases.
- **Power Demand**—displays total and peak power demand kW, kVAR, and kVA (real, reactive, and apparent power) for the last completed demand interval. It also shows the peak power demand kW, kVAR, and kVA with date, time, and coincident power factor (leading and lagging) associated with that peak.
- **Current Demand**—shows total and peak demand current for all three phases, neutral, and ground. It also shows the date and time of the peak demand current.

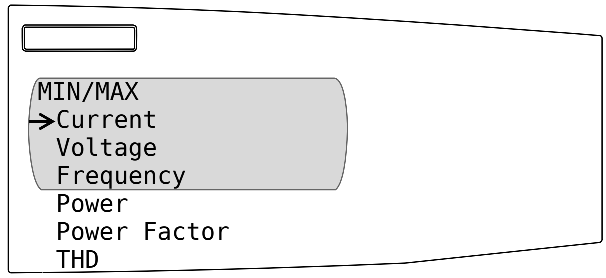
Viewing Minimum and Maximum Values from the Min/Max Menu

From the Min/Max menu, you can view the minimum and maximum values recorded by the circuit monitor, and the date and time when that min or max value occurred. These values are:

- Current
- Voltage
- Frequency
- Power
- Power Factor
- THD

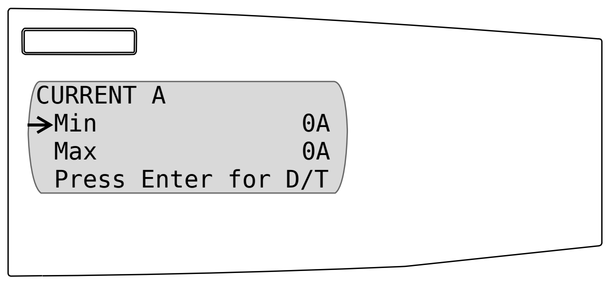
To use the Min/Max menu, follow these steps:

1. Use the arrow buttons to scroll through the menu options on the Min/Max menu.

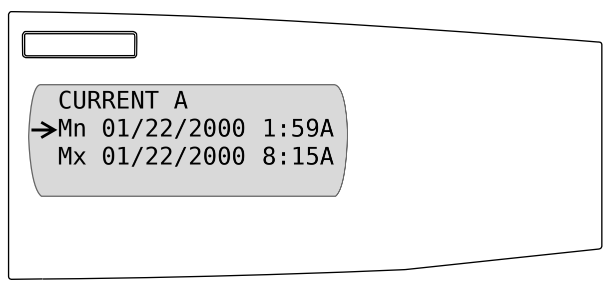


2. To select a menu option, press the enter button.

   The screen for that value displays. Press the arrow buttons to scroll through the min/max quantities.



3. To view the date and time when the minimum and maximum value was reached, press the enter button. Press the arrow buttons to scroll through the dates and times.

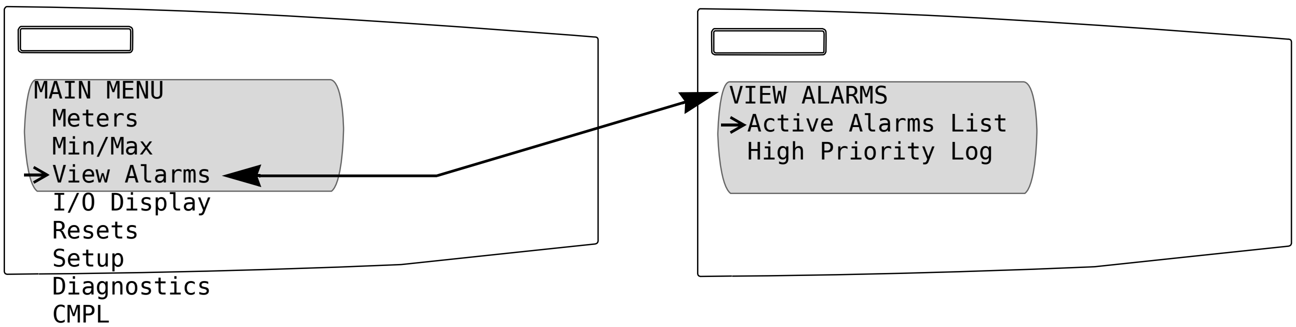


4. Press the enter button to return to the Min/Max values
5. Press the menu button to return to the Min/Max menu.

VIEWING ALARMS

The View Alarms menu, shown in Figure 3–12, lets you view active and high priority alarms.

Figure 3–12: View Alarms menu



When an alarm is first set up, an alarm priority is selected. Four alarm levels are available:

- **High priority**—if high priority alarm occurs, the display informs you in two ways:
  - — The LED on the display flashes while the alarm is active and until you acknowledge the alarm.
  - — A message displays whether the alarm is active or unacknowledged.
- **Medium priority**—if a medium priority alarm occurs, the LED flashes and a message displays only while the alarm is active. Once the alarm becomes inactive, the LED and message stop.
- **Low priority**—if a low priority alarm occurs, the LED on the display flashes only while the alarm is active. No alarm message is displayed.
- **No priority**—if an alarm is set up with no priority, no visible representation will appear on the display.

If multiple alarms with different priorities are active at the same time, the display shows the alarm message for the last alarm.

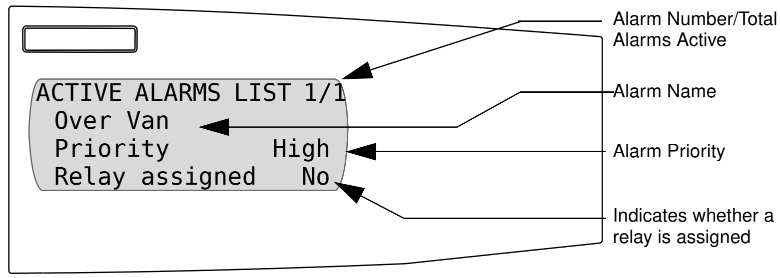
Each time an alarm occurs, the circuit monitor does the following:

- Puts the alarm in the list of active alarms. See “Viewing Active Alarms” on page 46 for more about active alarms.
- Performs any assigned action. The action could be one of the following:
  - — Operate one or more relays (you can view the status from the display)
  - — Force data log entries into the user-defined data log files (1–14 data logs can be viewed from SMS)
  - — Perform a waveform capture (can be viewed from SMS)
- Records the occurrence of high, medium, and low priority events in the circuit monitor’s alarm log (can be viewed using SMS).

Also, the LED and alarm messages will operate according to the priority selected when an alarm occurs.

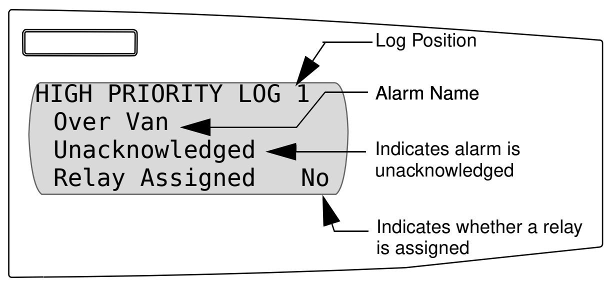
Viewing Active Alarms

The Active Alarms List displays currently active alarms, regardless of their priority. You can view all active alarms from the Main Menu by selecting View Alarms > Active Alarms List. The Active Alarms list displays. Use the arrow buttons to scroll through the alarms that are active.



Viewing and Acknowledging High Priority Alarms

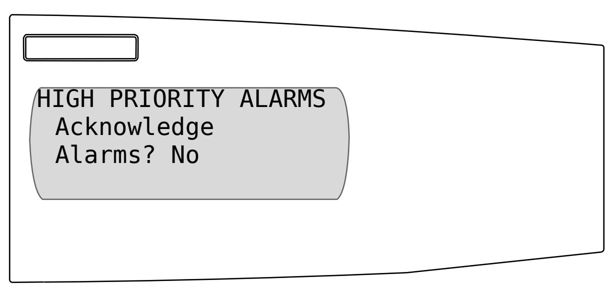
To view high priority alarms, from the Main Menu select View Alarms > High Priority Log. The High Priority Log screen displays. Use the arrow buttons to scroll through the alarms.



The High Priority Alarms screen displays the ten most recent, high-priority alarms. When you acknowledge the high-priority alarms, all digital outputs (relays) that are configured for latched mode will be released. To acknowledge all high-priority alarms, follow these steps:

1. After viewing the alarms, press the menu button to exit.

   The display asks you whether you would like to acknowledge the alarm.



2. To acknowledge the alarms, press the arrow button to change No to Yes. Then, press the enter button.
3. Press the menu button to exit.

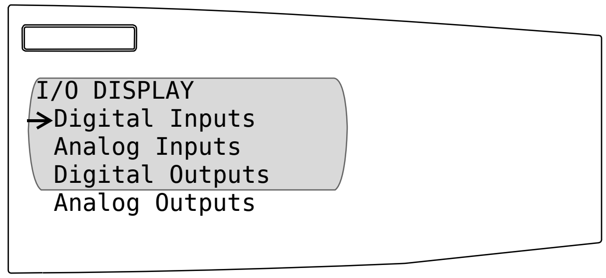
NOTE: You have acknowledged the alarms, but the LED will continue to flash as long as any high-priority alarm is active.

VIEWING I/O STATUS

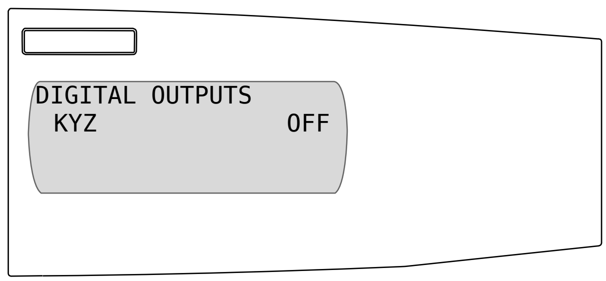
The I/O Display menu shows the ON or OFF status of the digital inputs or outputs. For analog inputs and outputs, it displays the present value. To view the status of inputs and outputs:

1. From the Main Menu, select I/O Display.

   The I/O Display screen displays.



2. Select the input or output for which you'd like to view the status. In this example, we selected Digital Outputs to display the status of the KYZ output.



3. Press the menu button to exit.

HARMONIC VALUES

The firmware has been updated to allow additional presentation units for harmonic magnitudes. See Table 3 on page 165 for register 3241 ammendments.

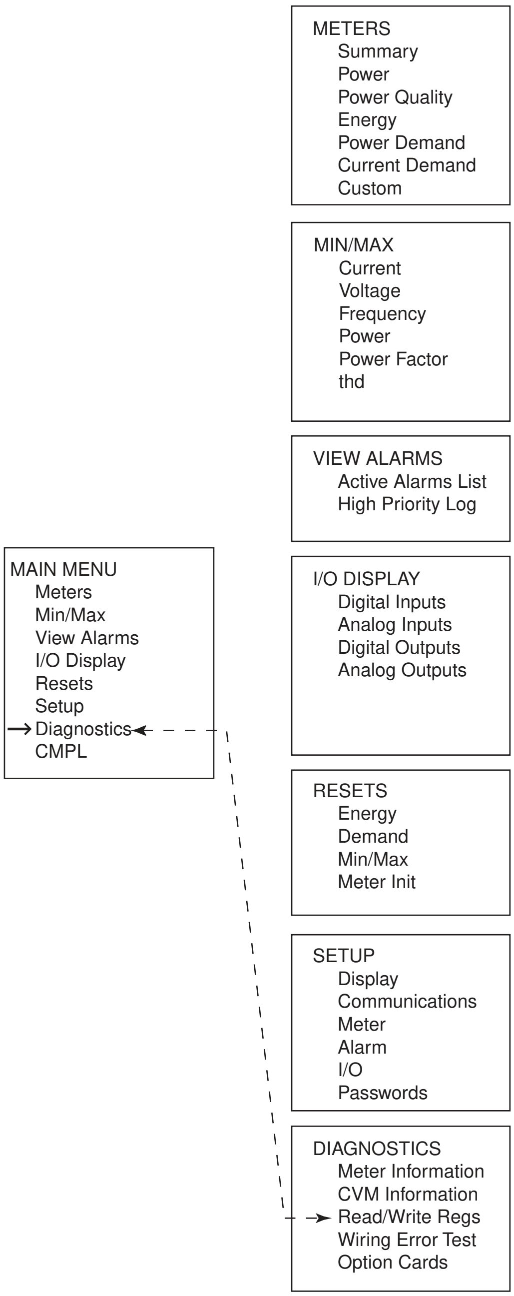
READING AND WRITING REGISTERS

You can access the read and write register menu option on the circuit monitor's display by selecting from the Main Menu > Diagnostics > Read/Write Regs as shown in Figure 3–13. This option lets you read and write circuit monitor registers from the display. This capability is most useful to users who:

- need to set up an advanced feature which is beyond the circuit monitor's normal front panel setup mode
- do not have access to SMS to set up the feature

NOTE: Use this feature with caution. Writing an incorrect value, or writing to the wrong register could affect the intended operation of the circuit monitor or its accessories.

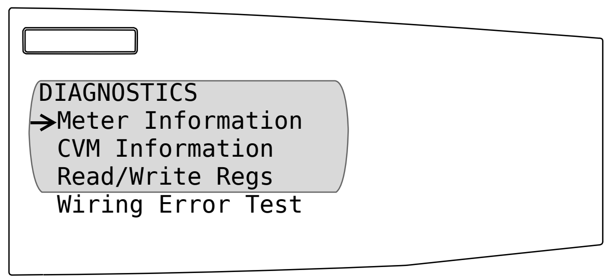
Figure 3–13: Diagnostics Menu accessed from the Main Menu



To read or write registers, follow these steps:

1. From the Main Menu, select Diagnostics.

   The Diagnostics menu displays.



2. Select Read/Write Regs.

   The password prompt displays.

3. Select your password. The default password is 0.

   The Read/Write Regs screen displays. Table 3–11 describes the options on this screen.

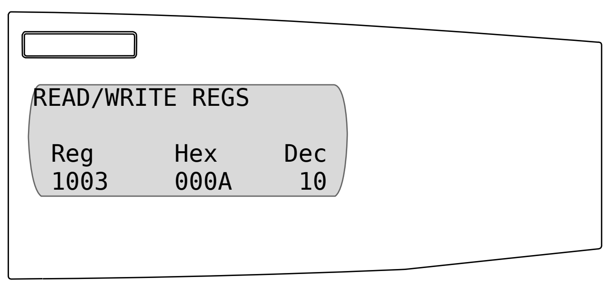


Table 3–11: Read/Write Register Options

Option	Available Values
Reg	List the register numbers.
Hex	List the hexidecimal value of that register.
Dec	List the decimal value of that register.

If you are viewing a metered value, such as voltage, the circuit monitor updates the displayed value as the register contents change. Note that scale factors are not taken into account automatically when viewing register contents.

4. To scroll through the register numbers, use the arrow buttons.
5. To change the value in the register, press the enter button.

   The Hex and Dec values begin to blink. Use the arrow buttons to scroll through the numeric values available.

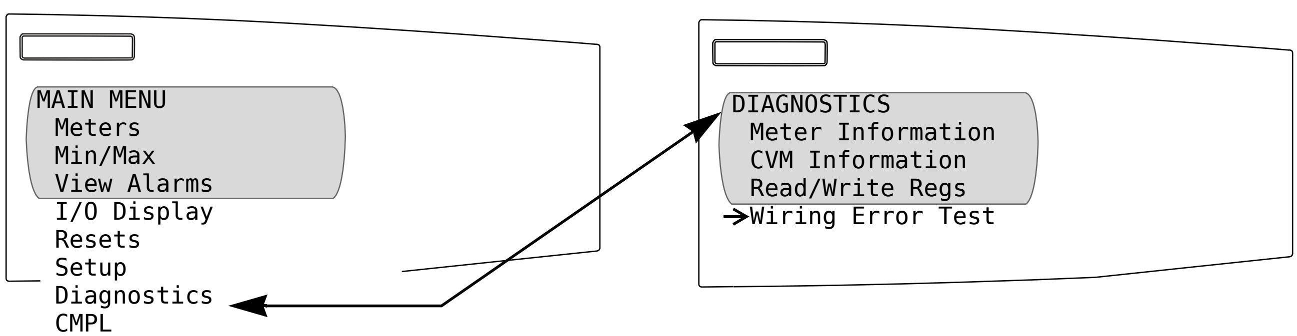
   *NOTE: Some circuit monitor registers are **read/write**, some are **read only**. You can write to read/write registers only.*

6. When you are finished making changes to that register, press the enter button to continue to the next register, or press the menu button to save the changes.

PERFORMING A WIRING ERROR TEST

The circuit monitor has the ability to perform a wiring diagnostic self-check when you select the Diagnostic > Wiring Error Test from the Main Menu as shown in Figure 3–14.

Figure 3–14: Wiring Error Test option on the Diagnostics menu.



The circuit monitor can diagnose possible wiring errors when you initiate the wiring test on the Diagnostics menu. Running the test is not required, but may help you to pinpoint a potentially miswired connection. Before running the wiring test, you must first wire the circuit monitor and perform the minimum set up of the circuit monitor, which includes setting up these parameters:

- CT primary and secondary
- PT primary and secondary
- System type
- Frequency

After you have wired and completed the minimum set up, run the wiring test to verify proper wiring of your circuit monitor. The wiring test assumes that the following is true about your system:

- Voltage connection V_{an} (4-wire) or V_{ab} (3-wire) is correct. This connection must be properly wired for the wiring check program to work.
- 3-phase system. The system must be a 3-phase system. You cannot perform a wiring check on a single-phase system.
- System type. The wiring check can be performed only on the six possible system types: 3Φ3W2CT, 3Φ3W3CT, 3Φ4W3CT, 3Φ4W4CT,

3Φ4W3CT2PT, and 3Φ4W4CT2PT (system types are described in the installation manual).

- Expected displacement power factor is between .60 lagging and .99 leading.
- The load must be at least 1% of the CT Primary setting.

This wiring error program is based on the assumptions above and based on a typical wiring system, results may vary depending on your system and some errors may not apply to your system. When the wiring test is run, the program performs the following checks in this order:

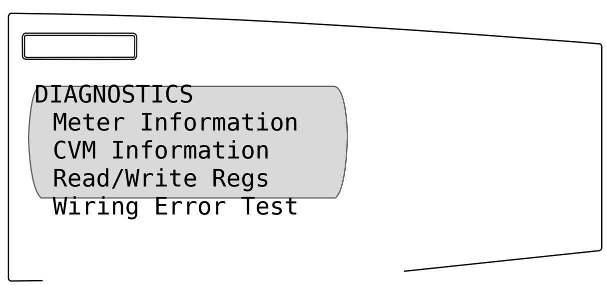
1. Verifies that the system type is one of those listed above.
2. Verifies that the frequency is within ±5% of the frequency that you selected in circuit monitor set up.
3. Verifies that the voltage phase angles are 120° apart. If the voltage connections are correct, the phase angles will be 120° apart.
4. If the voltage connections are correct, the test continues.
5. Verifies that the measured phase rotation is the same as the phase rotation set up in the circuit monitor.
6. Verifies the magnitude of the currents to see if there is enough load on each phase input to perform the check.
7. Indicates if the 3-phase real power (kW) total is negative, which could indicate a wiring error.
8. Compares each current angle to its respective voltage.

Running the Diagnostics Wiring Error Test

When the circuit monitor detects a possible error, you can find and correct the problem and then run the check again. Repeat the procedure until no error messages are displayed. To perform a wiring diagnostic test, follow these steps:

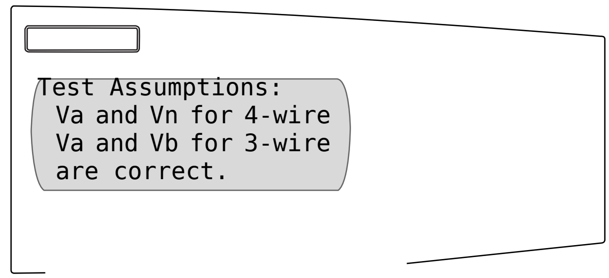
1. From the Main Menu, select Diagnostics.

   The Diagnostics menu displays.



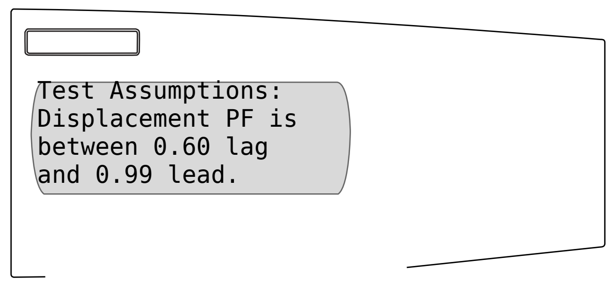
2. Select Wiring Error Test from the menu.

   The circuit monitor asks if the wiring matches the test assumptions.



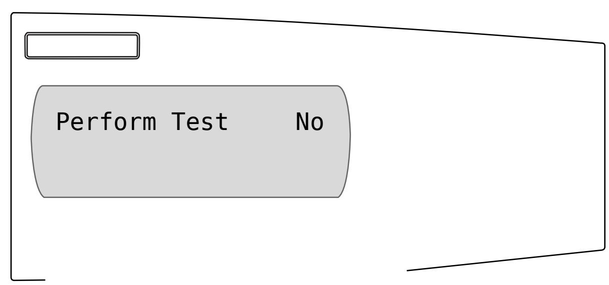
3. Press the down arrow button.

   The circuit monitor asks if the expected displacement power factor is between 0.60 lagging and 0.99 leading.



4. Press the down arrow button, again.

   The circuit monitor asks if you'd like to perform a wiring check.



5. Select "Yes" to perform the test by pressing the up arrow button and then pressing the enter button.

   The circuit monitor performs the wiring test.

   If it doesn't find any errors, the circuit monitor displays "Wire test complete. No errors found!". If it finds possible errors, it displays "Error detected. See following screens for details."
6. Press the arrow buttons to scroll through the wiring error messages.

   Table 3–12 on page 52 explains the possible wiring error messages.
7. Turn off all power supplying the circuit monitor. Verify that the power is off using a properly rated voltage testing device.

⚠ DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- Turn off all power supplying the circuit monitor and the equipment in which it is installed before working on it.
- Use a properly rated voltage testing device to verify that the power is off.
- Never short the secondary of a PT.
- Never open circuit a CT; use the shorting block to short circuit the leads of the CT before removing the connection from the circuit monitor.

Failure to follow this instruction will result in death or serious injury.

8. Correct the wiring errors.
9. Repeat these steps until all errors are corrected.

Table 3–12: Wiring Error Messages

Message	Description
Invalid system type	The circuit monitor is set up for a system type that the wiring test does not support.
Frequency out of range	Actual frequency of the system is not the same as the selected frequency configured for the circuit monitor.
Voltage not present on all phases	No voltage metered on one or more phases.
Severe voltage unbalance present	Voltage unbalance on any phase greater than 70%.
Not enough load to check wiring	Metered current below deadband on one or more phases.
Suspected error: Check meter configuration for direct connection	Set up for voltage input should be “No PT.”
Suspected error: Reverse polarity on all current inputs	Check polarities. Polarities on all CTs could be reversed.
Phase rotation does not match meter setup	Metered phase rotation is different than phase rotation selected in the circuit monitor set up.
Negative kW, check CT & VT polarities	Metered kW is negative, which could indicate swapped polarities on any CT or VT.
No voltage metered on V1–n	No voltage metered on V1–n on 4-wire system only.
No voltage metered on V2–n	No voltage metered on V2–n on 4-wire system only.
No voltage metered on V3–n	No voltage metered on V3–n on 4-wire system only.
No voltage metered on V1–2	No voltage metered on V1–2.
No voltage metered on V2–3	No voltage metered on V2–3.
No voltage metered on V3-1	No voltage metered on V3-1.
V2–n phase angle out of range	V2–n phase angle out of expected range.
V3–n phase angle out of range	V3–n phase angle out of expected range.
V2–3 phase angle out of range	V2–3 phase angle out of expected range.
V3–1 phase angle out of range	V3–1 phase angle out of expected range.
Suspected error: Reverse polarity on V2–n VT	Polarity of V2–n VT could be reversed. Check polarity.
Suspected error: Reverse polarity on V3–n VT	Polarity of V3–n VT could be reversed. Check polarity.
Suspected error: Reverse polarity on V2–3 VT	Polarity of V2–3 VT could be reversed. Check polarity.
Suspected error: Polarity on V3–1 VT	Polarity of V3–1 VT could be reversed. Check polarity.
Suspected error: Check V1 input, may be V2 VT	Phase 2 VT may actually be connected to input V1.
Suspected error: Check V2 input, may be V3 VT	Phase 3 VT may actually be connected to input V12
Suspected error: Check V3 input, may be V1 VT	Phase 1 VT may actually be connected to input V3.

Table 3–12: Wiring Error Messages *(continued)*

Message	Description
Suspected error: Check V1 input, may be V3 VT	Phase 3 VT may actually be connected to input V1.
Suspected error: Check V2 input, may be V1 VT	Phase 1 VT may actually be connected to input V2.
Suspected error: Check V3 input, may be V2 VT	Phase 2 VT may actually be connected to input V3.
I1 load current less than 1% CT	Metered current on I1 less than 1% of CT. Test could not continue.
I2 load current less than 1% CT	Metered current on I2 less than 1% of CT. Test could not continue.
I3 load current less than 1% CT	Metered current on I3 less than 1% of CT. Test could not continue.
I1 phase angle out of range. Cause of error unknown.	I1 phase angle is out of expected range. Cause of error unable to be determined.
I2 phase angle out of range. Cause of error unknown	I2 phase angle is out of expected range. Cause of error unable to be determined.
I3 phase angle out of range. Cause of error unknown.	I3 phase angle is out of expected range. Cause of error unable to be determined.
Suspected error: Reverse polarity on I1 CT.	Polarity of I1 CT could be reversed. Check polarity.
Suspected error: Reverse polarity on I2 CT	Polarity of I2 CT could be reversed. Check polarity.
Suspected error: Reverse polarity on I3 CT	Polarity of I3 CT could be reversed. Check polarity.
Suspected error: Check I1 input, may be I2 CT	Phase 2 CT may actually be connected to input I1.
Suspected error: Check I2 input, may be I3 CT	Phase 3 CT may actually be connected to input I2.
Suspected error: Check I3 input, may be I1 CT	Phase 1 CT may actually be connected to input I3.
Suspected error: Check I1 input, may be I3 CT	Phase 3 CT may actually be connected to input I1.
Suspected error: Check I2 input, may be I1 CT	Phase 1 CT may actually be connected to input I2.
Suspected error: Check I3 input, may be I2 CT	Phase 2 CT may actually be connected to input I3.
Suspected error: Check I1 input, may be I2 CT with reverse polarity	Phase 2 CT may actually be connected to input I1, and the CT polarity may also be reversed.
Suspected error: Check I2 input, may be I3 CT with reverse polarity	Phase 3 CT may actually be connected to input I21, and the CT polarity may also be reversed.
Suspected error: Check I3 input, may be I1 CT with reverse polarity	Phase 1 CT may actually be connected to input I3, and the CT polarity may also be reversed.
Suspected error: Check I1 input, may be I3 CT with reverse polarity	Phase 3 CT may actually be connected to input I1, and the CT polarity may also be reversed.
Suspected error: Check I2 input, may be I1 CT with reverse polarity	Phase 1 CT may actually be connected to input I2, and the CT polarity may also be reversed.
Suspected error. Check I3 input, may be I2 CT with reverse polarity	Phase 2 CT may actually be connected to input I3, and the CT polarity may also be reversed.

CHAPTER 4—METERING CAPABILITIES

REAL-TIME READINGS

The circuit monitor measures currents and voltages and reports in real time the rms values for all three phases, neutral, and ground current. In addition, the circuit monitor calculates power factor, real power, reactive power, and more.

Table 4–1 lists some of the real-time readings that are updated every second along with their reportable ranges.

Table 4–1: One-Second, Real-Time Readings Samples

Real-Time Readings	Reportable Range
Current	
Per-Phase	0 to 32,767 A
Neutral*	0 to 32,767 A
Ground*	0 to 32,767 A
3-Phase Average	0 to 32,767 A
Apparent rms	0 to 32,767 A
% Unbalance	0 to ±100.0%
Voltage	
Line-to-Line, Per-Phase	0 to 1,200 kV
Line-to-Line, 3-Phase Average	0 to 1,200 kV
Line-to-Neutral, Per-Phase*	0 to 1,200 kV
Neutral to Ground*	0 to 1,200 kV
Line-to-Neutral, 3-Phase Average	0 to 1,200 kV
% Unbalance	0 to 100.0%
Real Power	
Per-Phase*	0 to ± 3,276.70 MW
3-Phase Total	0 to ± 3,276.70 MW
Reactive Power	
Per-Phase*	0 to ± 3,276.70 MVAR
3-Phase Total	0 to ± 3,276.70 MVAR
Apparent Power	
Per-Phase*	0 to ± 3,276.70 MVA
3-Phase Total	0 to ± 3,276.70 MVA
Power Factor (True)	
Per-Phase*	–0.010 to 1.000 to +0.010
3-Phase Total	–0.010 to 1.000 to +0.010
Power Factor (Displacement)	
Per-Phase *	–0.010 to 1.000 to +0.010
3-Phase Total	–0.010 to 1.000 to +0.010
Frequency	
45–67 Hz	45.00 to 67.00 Hz
350–450 Hz	350.00 to 450.00 Hz
Temperature (Internal Ambient)	–100.00°C to +100.00°C

* Wye systems only.

The circuit monitor also has the capability of 100 ms updates. The 100 ms readings listed in Table 4–2 can be communicated over MODBUS TCP and are useful for rms event recording and high-speed alarms.

Table 4–2: 100 ms Real-Time Readings

Real-Time Readings	Reportable Range
Current	
Per-Phase	0 to 32,767 A
Neutral*	0 to 32,767 A
Ground*	0 to 32,767 A
3-Phase Average	0 to 32,767 A
Apparent rms	0 to 32,767 A
Voltage	
Line-to-Line, Per-Phase	0 to 1,200 kV
Line-to-Line, 3-Phase Average	0 to 1,200 kV
Line-to-Neutral, Per-Phase*	0 to 1,200 kV
Neutral to Ground*	0 to 1,200 kV
Line-to-Neutral, 3-Phase Average*	0 to 1,200 kV
Real Power	
Per-Phase*	0 to ± 3,276.70 MW
3-Phase Total	0 to ± 3,276.70 MW
Reactive Power	
Per-Phase*	0 to ± 3,276.70 MVAR
3-Phase Total	0 to ± 3,276.70 MVAR
Apparent Power	
Per-Phase*	0 to ± 3,276.70 MVA
3-Phase Total	0 to ± 3,276.70 MVA
Power Factor	
3-Phase Total	–0.010 to 1.000 to +0.010

* Wye systems only.

MIN/MAX VALUES FOR REAL-TIME READINGS

When any one-second real-time reading reaches its highest or lowest value, the circuit monitor saves the value in its nonvolatile memory. These values are called the minimum and maximum (min/max) values. Two logs are associated with min/max values. The Min/Max Log stores the minimum and maximum values since the last reset of the min/max values. The other log, the Interval Min/Max/Average Log, determines min/max values over a specified interval and records the minimum, maximum, and average values for pre-defined quantities over that specified interval. For example, the circuit monitor could record the min, max, and average every 1440 minutes (total minutes in a day) to record the daily value of quantities such as kW demand. See **Logging** on page 101 for more about the Min/Max/Average log.

From the circuit monitor display you can:

- View all min/max values since the last reset and view their associated dates and times. See “Viewing Minimum and Maximum Values from the Min/Max Menu” on page 43 for instructions.
- Reset min/max values. See “Resetting Min/Max, Demand, and Energy Values” on page 41 for reset instructions.

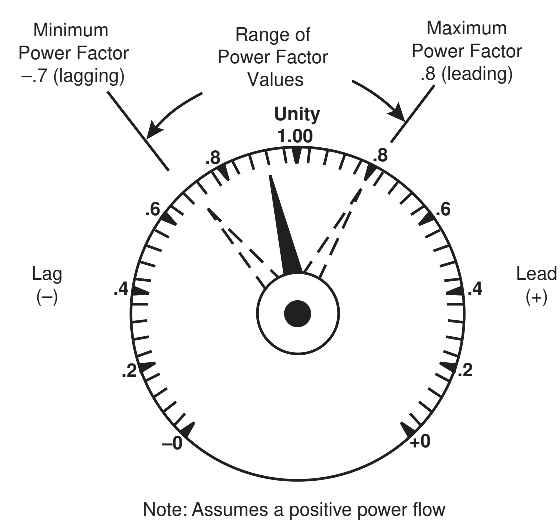
Using SMS you can also upload both onboard logs—and their associated dates and times—from the circuit monitor and save them to disk. For instructions on working with logs using SMS, refer to the SMS online help file included with the software.

Power Factor Min/Max Conventions

All running min/max values, except for power factor, are arithmetic minimum and maximum values. For example, the minimum phase A–B voltage is the lowest value in the range 0 to 1200 kV that has occurred since the min/max values were last reset. In contrast, because the power factor’s midpoint is unity (equal to one), the power factor min/max values are not true arithmetic minimums and maximums. Instead, the minimum value represents the measurement closest to –0 on a continuous scale for all real-time readings –0 to 1.00 to +0. The maximum value is the measurement closest to +0 on the same scale.

Figure 4–1 below shows the min/max values in a typical environment in which a positive power flow is assumed. In the figure, the minimum power factor is –.7 (lagging) and the maximum is .8 (leading). Note that the minimum power factor need not be lagging, and the maximum power factor need not be leading. For example, if the power factor values ranged from –.75 to –.95, then the minimum power factor would be –.75 (lagging) and the maximum power factor would be –.95 (lagging). Both would be negative. Likewise, if the power factor ranged from +.9 to +.95, the minimum would be +.95 (leading) and the maximum would be +.90 (leading). Both would be positive in this case.

Figure 4–1: Power factor min/max example

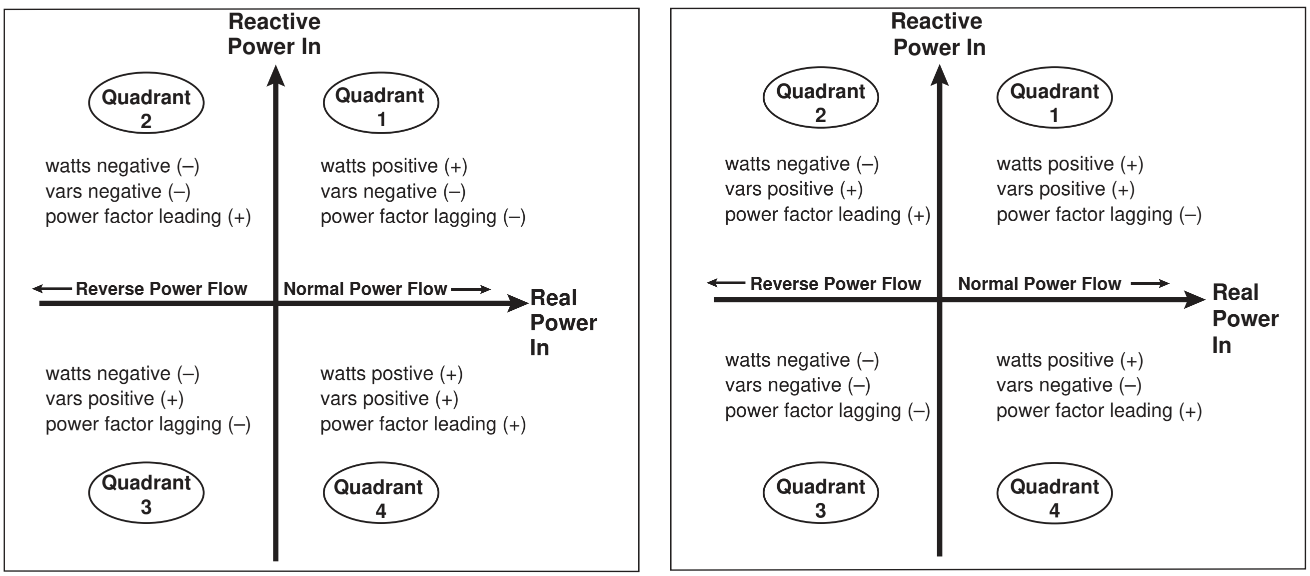


An alternate power factor storage method is also available for use with analog outputs and trending.

VAR SIGN CONVENTIONS

The circuit monitor can be set to one of two VAR sign conventions, the standard IEEE or the ALT (CM1). Circuit monitors manufactured before March 2000 default to the ALT VAR sign convention.The Series 4000 circuit monitors (all modles) default to the IEEE VAR sign convention. Figure 4–2 illustrates the VAR sign convention defined by IEEE and the default used by previous model circuit monitors (CM1). For instructions on changing the VAR sign convention, refer to “Advanced Meter Setup” on page 39.

Figure 4–2: Reactive Power—VAR sign convention



ALT (CM2/CM2000) VAR Sign Convention

IEEE VAR Sign Convention (Series 4000 (all models) Circuit Monitor Default)

DEMAND READINGS

The circuit monitor provides a variety of demand readings, including coincident readings and predicted demands. Table 4–3 lists the available demand readings and their reportable ranges.

Table 4–3: Demand Readings

Demand Readings	Reportable Range
Demand Current, Per-Phase, 3Ø Average, Neutral	
Last Complete Interval	0 to 32,767 A
Peak	0 to 32,767 A
Demand Voltage, L–N, L–L, Per-phase, Average, N-G	
Last Complete Interval	0 to 1200 kV
Minimum	0 to 1200 kV
Peak	0 to 1200 kV
Average Power Factor (True), 3Ø Total	
Last Complete Interval	–0.010 to 1.000 to +0.010
Coincident with kW Peak	–0.010 to 1.000 to +0.010
Coincident with kVAR Peak	–0.010 to 1.000 to +0.010
Coincident with kVA Peak	–0.010 to 1.000 to +0.010
Demand Real Power, 3Ø Total	
Last Complete Interval	0 to ± 3276.70 MW
Predicted	0 to ± 3276.70 MW
Peak	0 to ± 3276.70 MW
Coincident kVA Demand	0 to ± 3276.70 MVA
Coincident kVAR Demand	0 to ± 3276.70 MVAR
Demand Reactive Power, 3Ø Total	
Last Complete Interval	0 to ± 3276.70 MVAR
Predicted	0 to ± 3276.70 MVAR
Peak	0 to ± 3276.70 MVAR
Coincident kVA Demand	0 to ± 3276.70 MVA
Coincident kW Demand	0 to ± 3276.70 MW
Demand Apparent Power, 3Ø Total	
Last Complete Interval	0 to ± 3276.70 MVA
Predicted	0 to ± 3276.70 MVA
Peak	0 to ± 3276.70 MVA
Coincident kW Demand	0 to ± 3276.70 MW
Coincident kVAR Demand	0 to ± 3276.70 MVAR

Demand Power Calculation Methods

Demand power is the energy accumulated during a specified period divided by the length of that period. How the circuit monitor performs this calculation depends on the method you select. To be compatible with electric utility billing practices, the circuit monitor provides the following types of demand power calculations:

- Block Interval Demand
- Synchronized Demand

The default demand calculation is set to sliding block with a 15 minute interval. You can set up any of the demand power calculation methods from the display or from SMS. For instructions on how to setup the demand calculation from the display, see “Setting Up the Metering Functions of the Circuit Monitor” on page 17. See the SMS online help to perform the set up using the software.

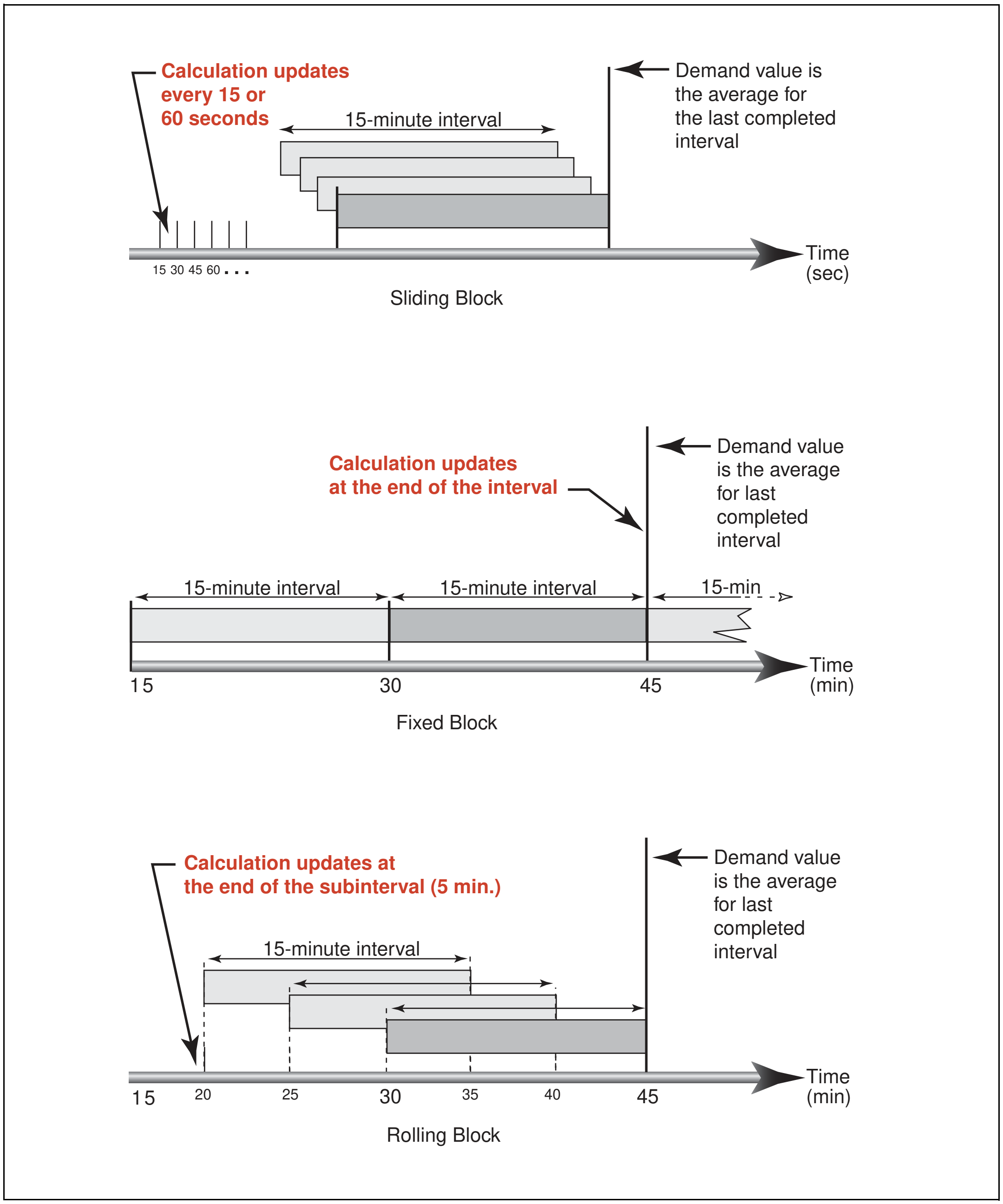
Block Interval Demand

In the block interval demand method, you select a “block” of time that the circuit monitor uses for the demand calculation. You choose how the circuit monitor handles that block of time (interval). Three different modes are possible:

- **Sliding Block**. In the sliding block interval, you select an interval from 1 to 60 minutes (in 1-minute increments). If the interval is between 1 and 15 minutes, the demand calculation *updates every 15 seconds*. If the interval is between 16 and 60 minutes, the demand calculation *updates every 60 seconds*. The circuit monitor displays the demand value for the last completed interval.
- **Fixed Block**. In the fixed block interval, you select an interval from 1 to 60 minutes (in 1-minute increments). The circuit monitor calculates and updates the demand at the end of each interval.
- **Rolling Block**. In the rolling block interval, you select an interval and a subinterval. The subinterval must divide evenly into the interval. For example, you might set three 5-minute subintervals for a 15-minute interval. Demand is *updated at each subinterval*. The circuit monitor displays the demand value for the last completed interval.

Figure 4–3 on page 61 illustrates the three ways to calculate demand power using the block method. For illustration purposes, the interval is set to 15 minutes.

Figure 4–3: Block Interval Demand Examples



Synchronized Demand

The demand calculations can be synchronized by accepting an external pulse input, a command sent over communications, or by synchronizing to the internal real-time clock.

- **Input Synchronized Demand.** You can set up the circuit monitor to accept an input such as a demand synch pulse from an external source. The circuit monitor then uses the same time interval as the other meter for each demand calculation. You can use any digital input installed on the meter to receive the synch pulse. When setting up this type of demand, you select whether it will be input-synchronized block or input-synchronized rolling block demand. The rolling block demand requires that you choose a subinterval.
- **Command Synchronized Demand**. Using command synchronized demand, you can synchronize the demand intervals of multiple meters on a communications network. For example, if a PLC input is monitoring a pulse at the end of a demand interval on a utility revenue meter, you could program the PLC to issue a command to multiple meters whenever the utility meter starts a new demand interval. Each time the command is issued, the demand readings of each meter are calculated for the same interval. When setting up this type of demand, you select whether it will be command-synchronized block or command-synchronized rolling block demand. The rolling block demand requires that you choose a subinterval.
- **Clock Synchronized Demand**. You can synchronize the demand interval to the internal real-time clock in the circuit monitor. This enables you to synchronize the demand to a particular time, typically on the hour. The default time is 12:00 am. If you select another time of day when the demand intervals are to be synchronized, the time must be in minutes from midnight. For example, to synchronize at 8:00 am, select 480 minutes. When setting up this type of demand, you select whether it will be clock-synchronized block or clock-synchronized rolling block demand. The rolling block demand requires that you choose a subinterval.

Demand Current

The circuit monitor calculates demand current using the thermal demand method. The default interval is 15 minutes, but you can set the demand current interval between 1 and 60 minutes in 1-minute increments.

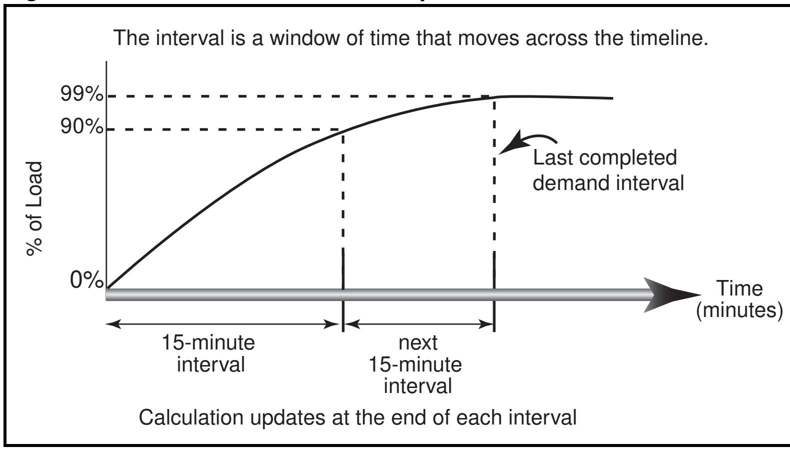
Demand Voltage

The circuit monitor calculates demand voltage. The default voltage demand mode is thermal demand with a 15-minute demand interval. You can also set the demand voltage to any of the block interval demand modes described in “Block Interval Demand” on page 60.

Thermal Demand

The thermal demand method calculates the demand based on a thermal response, which mimics thermal demand meters. The demand calculation updates at the end of each interval. You select the demand interval from 1 to 60 minutes (in 1-minute increments). In Figure 4–4 the interval is set to 15 minutes for illustration purposes.

Figure 4–4: Thermal Demand Example

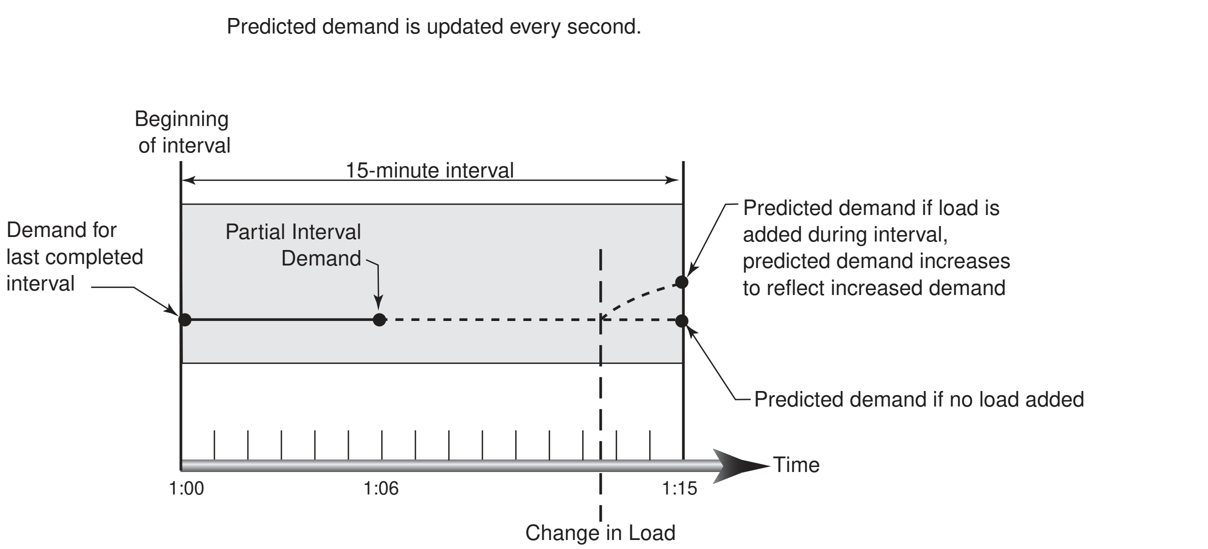


Predicted Demand

The circuit monitor calculates predicted demand for the end of the present interval for kW, kVAR, and kVA demand. This prediction takes into account the energy consumption thus far within the present (partial) interval and the present rate of consumption. The prediction is updated every second.

Figure 4–5 illustrates how a change in load can affect predicted demand for the interval.

Figure 4–5: Predicted Demand Example



Peak Demand

In nonvolatile memory, the circuit monitor maintains a running maximum for power demand values, called “peak demand.” The peak is the highest average for each of these readings: kWD, kVARD, and kVAD since the last reset. The circuit monitor also stores the date and time when the peak demand occurred. In addition to the peak demand, the circuit monitor also stores the coinciding average 3-phase power factor. The average 3-phase power factor is defined as “demand kW/demand kVA” for the peak demand interval. Table 4–3 on page 59 lists the available peak demand readings from the circuit monitor.

You can reset peak demand values from the circuit monitor display. From the Main Menu, select Resets > Demand. You can also reset the values over the communications link by using SMS. See the SMS online help for instructions.

NOTE: You should reset peak demand after changes to basic meter setup, such as CT ratio or system type.

The circuit monitor also stores the peak demand during the last incremental energy interval. See “Energy Readings” on page 66 for more about incremental energy readings.

Generic Demand

The circuit monitor can perform any of the demand calculation methods, described earlier in this chapter, on up to 20 quantities that you choose. In SMS the quantities are divided into two groups of 10, so you can set up two different demand “profiles.” For each profile, you do the following in SMS:

- **Select the demand calculation method** (thermal, block interval, or synchronized).
- **Select the demand interval** (from 5–60 minutes in 1–minute increments) and select the demand subinterval (if applicable).
- **Select the quantities** on which to perform the demand calculation. You must also select the units and scale factor for each quantity.

Use the Device Setup > Basic Setup tab in SMS to create the generic demand profiles. For example, you might set up a profile to calculate the 15-minute average value of an analog input. To do this, select a fixed-block demand interval with a 15-minute interval for the analog input.

For each quantity in the demand profile, the circuit monitor stores four values:

- Partial interval demand value
- Last completed demand interval value
- Minimum values (date and time for each is also stored)
- Peak demand value (date and time for each is also stored)

You can reset the minimum and peak values of the quantities in a generic demand profile by using one of two methods:

- Use SMS (see the SMS online help file), or
- Use the command interface.
  Command 5115 resets the generic demand profile 1.
  Command 5116 resets the generic demand profile 2.

Input Metering Demand

The circuit monitor has ten input pulse metering channels. The channels count pulses received from one or more digital inputs assigned to that channel. Each channel requires a consumption pulse weight, consumption scale factor, demand pulse weight, and demand scale factor. The consumption pulse weight is the number of watt-hours or kilowatt-hours per pulse. The consumption scale factor is a factor of 10 multiplier that determines the format of the value. For example, if each incoming pulse represents 125 Wh, and you want consumption data in watt-hours, the consumption pulse weight is 125 and the consumption scale factor is zero. The resulting calculation is 125×10^{0}, which equals 125 watt-hours per pulse. If you want the consumption data in kilowatt-hours, the calculation is 125×10^{-3}, which equals 0.125 kilowatt-hours per pulse.

Time must be taken into account for demand data so you begin by calculating demand pulse weight using the following formula:

$$\text{watts} = \frac{\text{watt-hours}}{\text{pulse}} \times \frac{3600\text{ seconds}}{\text{hour}} \times \frac{\text{pulse}}{\text{second}}$$

If each incoming pulse represents 125 Wh, using the formula above you get 450,000 watts. If you want demand data in watts, the demand pulse weight is 450 and the demand scale factor is three. The calculation is 450×10^{3}, which equals 450,000 watts. If you want the demand data in kilowatts, the calculation is 450×10^{0}, which equals 450 kilowatts.

NOTE: The circuit monitor counts each input transition as a pulse. Therefore, for an input transition of OFF-to-ON and ON-to-OFF will be counted as two pulses.

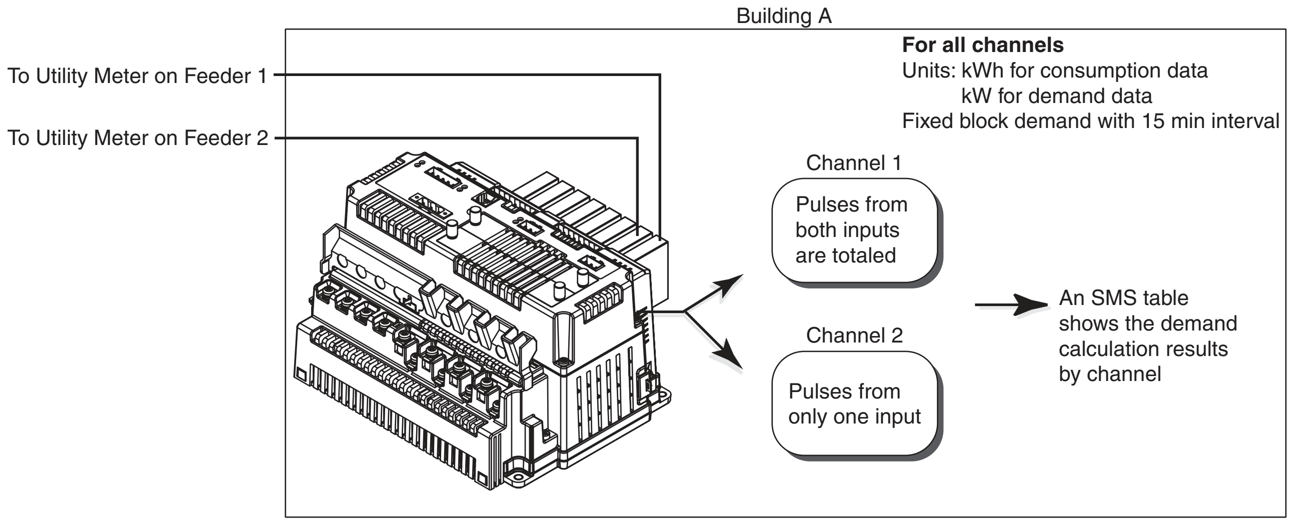
For each channel, the circuit monitor maintains the following information:

- Total consumption
- Last completed interval demand—calculated demand for the last completed interval.
- Partial interval demand—demand calculation up to the present point during the interval.
- Peak demand—highest demand value since the last reset of the input pulse demand. The date and time of the peak demand is also saved.
- Minimum demand—lowest demand value since the last reset of the input pulse demand. The date and time of the minimum demand is also saved.

For example, you can use channels to verify utility charges. In Figure 4–6, Channel 1 is adding demand from two utility feeders to track total consumption and demand for the building. This information could be viewed in SMS and compared against the utility charges.

To use the channels feature, first set up the digital inputs from the display or from SMS. See “Setting Up I/Os” on page 25 in Operation for instructions. Then using SMS, you must set the I/O operating mode to Normal and set up the channels. The demand method and interval that you select applies to all channels. See the SMS online help for instructions on device set up of the circuit monitor.

Figure 4–6: Input pulse metering example



ENERGY READINGS

The circuit monitor calculates and stores accumulated energy values for real and reactive energy (kWh and kVARh) both into and out of the load, and also accumulates absolute apparent energy.

Table 4–4 lists the energy values the circuit monitor can accumulate.

Table 4–4: Energy Readings

Energy Reading, 3-Phase	Reportable Range	Shown on the Display
Accumulated Energy		
Real (Signed/Absolute)	-9,999,999,999,999,999 to 9,999,999,999,999,999 Wh	0000.000 kWh to 99,999.99 MWh and 0000.000 to 99,999.99 MVARh
Reactive (Signed/Absolute)	-9,999,999,999,999,999 to 9,999,999,999,999,999 VARh	
Real (In)	0 to 9,999,999,999,999,999 Wh	0000.000 kWh to 99,999.99 MWh and 0000.000 to 99,999.99 MVARh
Real (Out)	0 to 9,999,999,999,999,999 Wh	
Reactive (In)	0 to 9,999,999,999,999,999 VARh	
Reactive (Out)	0 to 9,999,999,999,999,999 VARh	
Apparent	0 to 9,999,999,999,999,999 VAh	
Accumulated Energy, Conditional		
Real (In) *	0 to 9,999,999,999,999,999 Wh	Not shown on the display. Readings are obtained only through the communications link.
Real (Out) *	0 to 9,999,999,999,999,999 Wh	
Reactive (In) *	0 to 9,999,999,999,999,999 VARh	
Reactive (Out) *	0 to 9,999,999,999,999,999 VARh	
Apparent *	0 to 9,999,999,999,999,999 VAh	

Table 4–4: Energy Readings *(continued)*

Accumulated Energy, Incremental		
Real (In)	0 to 999,999,999,999 Wh	0000.000 kWh to 99,999.99 MWh and 0000.000 to 99,999.99 MVARh
Real (Out)	0 to 999,999,999,999 Wh	
Reactive (In)	0 to 999,999,999,999 VARh	
Reactive (Out)	0 to 999,999,999,999 VARh	
Apparent	0 to 999,999,999,999 VAh	
Reactive Energy		
Quadrant 1 *	0 to 999,999,999,999 VARh	Not shown on the display. Readings are obtained only through the communications link.
Quadrant 2 *	0 to 999,999,999,999 VARh	
Quadrant 3 *	0 to 999,999,999,999 VARh	
Quadrant 4 *	0 to 999,999,999,999 VARh	

* Values can be displayed on the screen by creating custom quantities and custom displays.

The circuit monitor can accumulate the energy values shown in Table 4–4 in one of two modes: signed or unsigned (absolute). In signed mode, the circuit monitor considers the direction of power flow, allowing the magnitude of accumulated energy to increase and decrease. In unsigned mode, the circuit monitor accumulates energy as a positive value, regardless of the direction of power flow. In other words, the energy value increases, even during reverse power flow. The default accumulation mode is unsigned.

You can view accumulated energy from the display. The resolution of the energy value will automatically change through the range of 000.000 kWh to 000,000 MWh (000.000 to 000,000 MVARh), or it can be fixed.

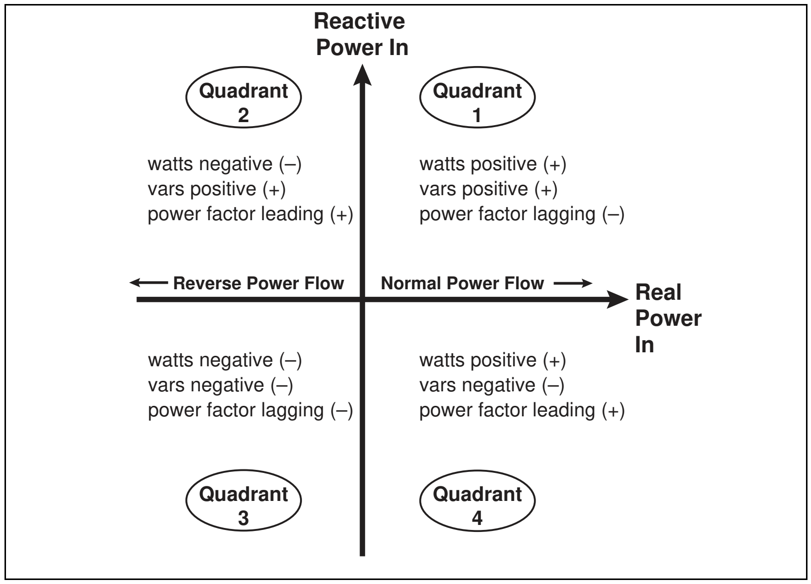
For conditional accumulated energy readings, you can set the real, reactive, and apparent energy accumulation to OFF or ON when a particular condition occurs. You can do this over the communications link using a command, or from a digital input change. For example, you may want to track accumulated energy values during a particular process that is controlled by a PLC. The circuit monitor stores the date and time of the last reset of conditional energy in nonvolatile memory.

Also, the circuit monitor provides an additional energy reading that is only available over the communications link:

- **Four-quadrant reactive accumulated energy readings**. The circuit monitor accumulates reactive energy (kVARh) in four quadrants as shown in Figure 4–7. The registers operate in unsigned (absolute) mode in which the circuit monitor accumulates energy as positive.

NOTE: The reactive accumulated energy is not affected by the VAR sign convention and will remain as shown in the image below.

Figure 4–7: Reactive energy accumulates in four quadrants



POWER ANALYSIS VALUES

The circuit monitor provides a number of power analysis values that can be used to detect power quality problems, diagnose wiring problems, and more. Table 4–5 on page 70 summarizes the power analysis values.

- **THD**. Total Harmonic Distortion (THD) is a quick measure of the total distortion present in a waveform and is the ratio of harmonic content to the fundamental. It provides a general indication of the “quality” of a waveform. THD is calculated for both voltage and current. The circuit monitor uses the following equation to calculate THD where H is the harmonic distortion:

$$THD = \frac{\sqrt{H_2^2 + H_3^2 + H_4^2 + \dots}}{H_1} \times 100\%$$

- **thd**. An alternate method for calculating Total Harmonic Distortion. It considers the total harmonic current and the total rms content rather than fundamental content in the calculation. The circuit monitor calculates thd for both voltage and current. The circuit monitor uses the following equation to calculate thd where H is the harmonic distortion:

$$thd = \frac{\sqrt{H_2^2 + H_3^2 + H_4^2 + \dots}}{\text{Total rms}} \times 100\%$$

- TDD. Total Demand Distortion (TDD) is used to evaluate the harmonic voltages and currents between an end user and a power source. The harmonic values are based on a point of common coupling (PCC), which is a common point that each user receives power from the power source. The following equation is used to calculate TDD where I_h is the magnitude of individual harmonic components, h is the harmonic order, and I_L is the maximum demand load current in register 3233:

$$TDD = \sqrt{\frac{\sum_{h=2}^{255} I_h^2}{I_L}} \times 100\%$$

- **K-factor**. K-factor is a simple numerical rating used to specify transformers for nonlinear loads. The rating describes a transformer's ability to serve nonlinear loads without exceeding rated temperature rise limits. The higher the K-factor rating, the better the transformer's ability to handle the harmonics. The circuit monitor uses the following equation to calculate K-factor where I_h is harmonic current and h is the harmonic order:

$$K = \frac{SUM\left(I_h^2 \bullet h^2\right)}{SUM\left(I_{rms}^2\right)}$$

- **Displacement Power Factor**. Power factor (PF) represents the degree to which voltage and current coming into a load are out of phase. When true power factor is based on the angle between the fundamental components of current and voltage.
- **Harmonic Values**. Harmonics can reduce the capacity of the power system. The circuit monitor determines the individual per-phase harmonic magnitudes and angles through the 63rd harmonic for all currents and voltages. The harmonic magnitudes can be formatted as either a percentage of the fundamental (default) or a percentage of the rms value. Refer to "Setting Up Individual Harmonic Calculations" on page 165 for information on how to configure harmonic calculations.
- **Harmonic Power.** Harmonic power is an indication of the non-fundamental components of current and power in the electrical circuit. The circuit monitor uses the following equation to calculate harmonic power.

$$\text{Harmonic Power} = \sqrt{\text{Overall Power}^2 - \text{Fundamental Power}^2}$$

- **Distortion Power Factor.** Distortion power factor is an indication of the distortion power content of non-linear loads. Linear loads do not contribute to distortion power even when harmonics are present. Distortion power factor provides a way to describe distortion in terms of its total contribution to apparent power. The circuit monitor uses the following equation to calculate the distortion power factor.

$$\text{Distortion Power Factor} = \frac{\text{Overall Power Power Factor}}{\text{Fundamental Power Power Factor}}$$

Table 4–5: Power Analysis Values

Value	Reportable Range
THD—Voltage, Current 3-phase, per-phase, neutral	0 to 3,276.7%
thd—Voltage, Current 3-phase, per-phase, neutral	0 to 3,276.7%
Total Demand Distortion	0 to 10,000
K-Factor (per phase)②	0.0 to 100.0
K-Factor Demand (per phase)①②	0.0 to 100.0
Crest Factor (per phase) ①	0.0 to 100.0
Displacement P.F. (per phase, 3-phase) ①	–0.010 to 1.000 to +0.010
Fundamental Voltages (per phase) Magnitude Angle	 0 to 1,200 kV 0.0 to 359.9°
Fundamental Currents (per phase) Magnitude Angle	 0 to 32,767 A 0.0 to 359.9°
Fundamental Real Power (per phase, 3-phase) ①	0 to 32,767 kW
Fundamental Reactive Power (per phase) ①	0 to 32,767 kVAR
Harmonic Power (per phase, 3-phase) ①	0 to 32,767 kW
Phase Rotation	ABC or CBA
Unbalance (current and voltage) ①	0.0 to 100.0%
Individual Harmonic Magnitudes ①③	0 to 327.67%
Individual Harmonic Angles①③	0.0° to 359.9°
Distortion Power	–32,767 to 32,767
Distortion Power Factor	0 to 1,000

① Readings are obtained only through communications.
② K-Factor not available at 400Hz.
③ Harmonic magnitudes and angles through the 63rd harmonic at 50Hz and 60Hz; harmonic magnitudes and angles through the 7th harmonic at 400Hz.

HARMONIC POWER

Circuit monitor models 4250 and 4000T calculate harmonic power flows and display them in registers.

At the point of metering, the circuit monitor can determine the magnitude and direction of real (kW), reactive (kvar), and apparent power (kVA) flows up to and including the 40th harmonic. Readings from harmonic power flows can provide valuable information to help you determine the locations and types of harmonic generating loads. Refer to the Master Register List, available at www.powerlogic.com, for registers that contain the harmonic power flow data.

CHAPTER 5—INPUT/OUTPUT CAPABILITIES

I/O OPTIONS

The circuit monitor supports a variety of input and output options including:

- Digital Inputs
- Analog Inputs
- Mechanical Relay Outputs
- Solid State KYZ Pulse Outputs
- Analog Outputs

The circuit monitor has one KYZ output as standard. You can expand the I/O capabilities by adding the optional I/O Extender (IOX) and the digital I/O option card (IOC-44).

For module installation instructions and detailed technical specifications, refer to the individual instruction bulletins that ship with the product. For a list of these publications, see Table 1–2 on page 2 of this bulletin.

Table 5–1 lists the many available I/O options. The I/O options are explained in detail in the remainder of this section.

Table 5–1: I/O Extender Options

I/O Extender Options	Part Number
with no preinstalled I/Os, accepts up to 8 individual I/O modules with a maximum of 4 analog I/Os	IOX
with 4 digital inputs (32 Vdc), 2 digital outputs (60 Vdc), 1 analog output(4–20 mA), and 1 analog input (0–5 Vdc)	IOX2411
with 4 digital inputs (120 Vac) and 4 analog inputs (4–20 mA)	IOX0404
with 8 digital inputs (120 Vac)	IOX08
Individual I/O Modules*	Part Number
Digital I/Os	
120 Vac input	DI120AC
240 Vac input	DI240AC
32 Vdc input (0.2ms turn on) polarized	DI32DC
120 Vac output (3.5A maximum)	DO120AC
200 Vdc output (3.5A maximum)	DO200DC
240 Vac output (3.5A maximum)	DO240AC
60 Vdc output (3.5A maximum)	DO60DC
Analog I/Os	
0 to 5 Vdc analog input	AI05
4 to 20 mA analog input	AI420
4 to 20 mA analog output	AO420

* The circuit monitor must be equipped with the I/O Extender (IOX) to install the modules.

DIGITAL INPUTS

The circuit monitor can accept up to 16 digital inputs depending on the I/O accessories you select. Digital inputs are used to detect digital signals. For example, the digital input can be used to determine circuit breaker status, count pulses, or count motor starts. Digital inputs can also be associated with an external relay, which can trigger a waveform capture in the circuit monitor. You can log digital input transitions as events in the circuit monitor's on-board alarm log. The event is date and time stamped with resolution to the millisecond, for sequence of events recording. The circuit monitor counts OFF-to-ON transitions for each input, and you can reset this value using the command interface.

Digital inputs have four operating modes:

- **Normal**—Use the normal mode for simple on/off digital inputs. In normal mode, digital inputs can be used to count KYZ pulses for demand and energy calculation. Using the input pulse demand feature, you can map multiple inputs to the same channel where the circuit monitor can total pulses from multiple inputs (see"Input Metering Demand" on page 65 in Metering Capabilities for more information). To accurately count pulses, set the time between transitions from OFF to ON and ON to OFF to at least 20 milliseconds.
- **Demand Interval Synch Pulse**—you can configure any digital input to accept a demand synch pulse from a utility demand meter (see "Demand Synch Pulse Input" on page 72 for more about this topic). For each demand profile, you can designate only one input as a demand synch input.
- **Time Synch**—you can configure one digital input to receive a signal from a GPS receiver that provides a serial pulse stream in accordance to the DCF-77 format to synchronize the internal clock of the circuit monitor.
- **Conditional Energy Control**—you can configure one digital input to control conditional energy (see "Energy Readings" on page 66 for more about conditional energy).

To set up a digital input on the I/O extender, you must first define it from the display. From the main menu, select Setup > I/O. Select the appropriate digital input option. For example, if you are using IOX-2411 option of the I/O Extender, select IOX-2411. For detailed instructions, see "Setting Up I/Os" on page 25 in Operation. Then using SMS, define the name and operating mode of the digital input. The name is a 16-character label that identifies the digital input. The operating mode is one of those listed above. See the SMS online help for instructions on device set up of the circuit monitor.

DEMAND SYNCH PULSE INPUT

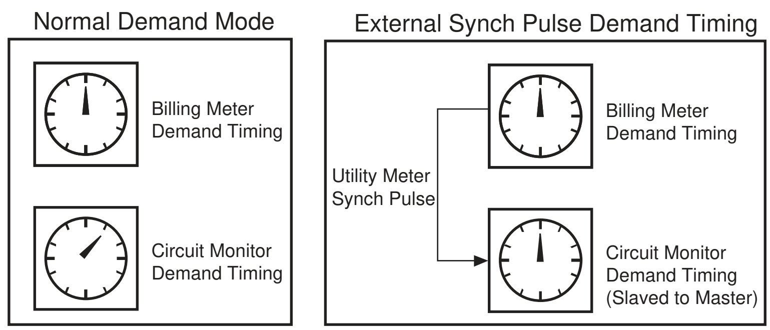
You can configure the circuit monitor to accept a demand synch pulse from an external source such as another demand meter. By accepting demand synch pulses through a digital input, the circuit monitor can make its demand interval "window" match the other meter's demand interval "window." The circuit monitor does this by "watching" the digital input for a pulse from the other demand meter. When it sees a pulse, it starts a new demand interval and calculates the demand for the preceding interval. The circuit monitor then uses the same time interval as the other meter for each demand calculation. Figure 5–1 illustrates this point. See "Synchronized Demand" on page 62 for more about demand calculations.

When in demand synch pulse operating mode, the circuit monitor will not start or stop a demand interval without a pulse. The maximum allowable time between pulses is 60 minutes. If 66 minutes (110% of the demand interval) pass before a synch pulse is received, the circuit monitor throws out the demand calculations and begins a new calculation when the next pulse is received. Once in synch with the billing meter, the circuit monitor can be used to verify peak demand charges.

Important facts about the circuit monitor's demand synch feature are listed below:

- Any installed digital input can be set to accept a demand synch pulse.
- Each demand system can choose whether to use an external synch pulse, but only one demand synch pulse can be brought into the meter for each demand system. One input can be used to synchronize any combination of the demand systems.
- The demand synch feature can be set up from SMS. See the SMS online help for instructions on device set up of the circuit monitor.

Figure 5–1: Demand synch pulse timing



ANALOG INPUTS

Depending on the I/O modules you select, the circuit monitor can accept either voltage or current signals through its analog inputs. See Table 5–1 on page 71 for a list of I/O options. The circuit monitor stores a minimum and a maximum value for each analog input.

For technical specifications and instructions on installing I/O modules, refer to the instruction bulletin that ships with the I/O (see Table 1–2 on page 2 for a list of these publications). To set up analog inputs, you must first set it up from the display. From the main menu, select Setup > I/O, then select the appropriate analog input option. For example, if you are using the IOX0404 option of the I/O Extender, select IOX-0404. For detailed instructions, see “Setting Up I/Os” on page 25. Then, in SMS define the following values for each analog input:

- **Name**—a 16-character label used to identify the analog input.
- **Units—**the units of the monitored analog value (for example, “psi”).
- **Scale factor**—multiplies the units by this value (such as tenths or hundredths).
- **Report Range Lower Limit**—the value the circuit monitor reports when the input reaches a minimum value. When the input current is below the lowest valid reading, the circuit monitor reports the lower limit.
- **Report Range Upper Limit**—the value the circuit monitor reports when the input reaches the maximum value. When the input current is above highest valid reading, the circuit monitor reports the upper limit.

For instructions on setting up analog inputs in SMS, see device set up of the circuit monitor in the SMS online help.

Analog Input Example

Figure 5–2 shows an analog input example. In this example, the analog input has been configured as follows:

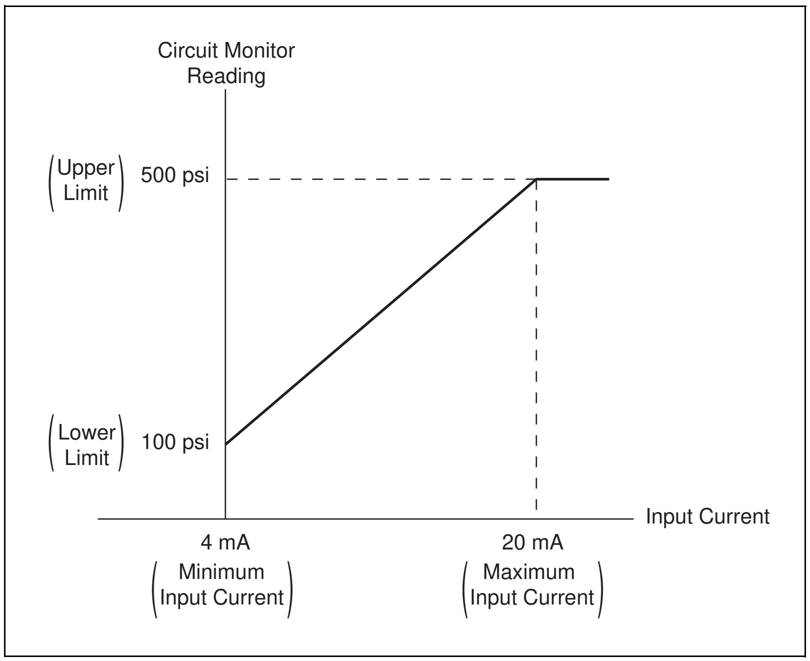
— Upper Limit: 500
— Lower Limit: 100
— Units: psi

Table 5–2 shows circuit monitor readings at various input currents.

Table 5–2: Sample register readings for analog inputs

Input Current (mA)	Circuit Monitor Reading (psi)
3 (invalid)	100
4	100
8	200
10	250
20	500
21 (invalid)	500

Figure 5–2: Analog input example



RELAY OUTPUT OPERATING MODES

Before we describe the 11 available relay operating modes, it is important to understand the difference between a relay configured for remote (external) control and a relay configured for circuit monitor (internal) control.

Each relay output defaults to external control, but you can choose whether the relay is set to external or internal control:

- **Remote (external) control**—the relay is controlled either from a PC using SMS or a programmable logic controller using commands via communications.
- **Circuit monitor (internal) control**—the relay is controlled by the circuit monitor in response to a set-point controlled alarm condition, or as a pulse initiator output. Once you've set up a relay for circuit monitor control, you can no longer operate the relay remotely. However, you can temporarily override the relay, using SMS.

NOTE: If any basic setup parameters or I/O setup parameters are modified, all relay outputs will be de-energized.

The 11 relay operating modes are as follows:

- **Normal**
  - — *Remotely Controlled:* Energize the relay by issuing a command from a remote PC or programmable controller. The relay remains energized until a command to de-energize is issued from the remote PC or programmable controller, or until the circuit monitor loses control power. When control power is restored, the relay will be re-energized.
  - — *Circuit Monitor Controlled:* When an alarm condition assigned to the relay occurs, the relay is energized. The relay is not de-energized until *all* alarm conditions assigned to the relay have dropped out, the circuit monitor loses control power, or the alarms are over-ridden using SMS software. If the alarm condition is still true when the circuit monitor regains control power, the relay will be re-energized.
- **Latched**
  - — *Remotely Controlled:* Energize the relay by issuing a command from a remote PC or programmable controller. The relay remains energized until a command to de-energize is issued from a remote PC or programmable controller, or until the circuit monitor loses control power. When control power is restored, the relay will not be re-energized.
  - — *Circuit Monitor Controlled:* When an alarm condition assigned to the relay occurs, the relay is energized. The relay remains energized—even after all alarm conditions assigned to the relay have dropped out—until a command to de-energize is issued from a remote PC or programmable controller, until the high priority alarm log is cleared from the display, or until the circuit monitor loses control power. When control power is restored, the relay will not be re-energized if the alarm condition is not TRUE.
- **Timed**
  - — *Remotely Controlled:* Energize the relay by issuing a command from a remote PC or programmable controller. The relay remains energized until the timer expires, or until the circuit monitor loses control power. If a new command to energize the relay is issued before the timer expires, the timer restarts. If the circuit monitor loses control power, the relay will be re-energized when

control power is restored and the timer will reset to zero and begin timing again.

— *Circuit Monitor Controlled:* When an alarm condition assigned to the relay occurs, the relay is energized. The relay remains energized for the duration of the timer. When the timer expires, the relay will de-energize and remain de-energized. If the relay is on and the circuit monitor loses control power, the relay will be re-energized when control power is restored and the timer will reset to zero and begin timing again.

- **End Of Power Demand Interval**

  This mode assigns the relay to operate as a synch pulse to another device. The output operates in timed mode using the timer setting and turns on at the end of a power demand interval. It turns off when the timer expires. Because of it's long life, this mode should be used with solid state relay outputs.

- **Absolute kWh Pulse**

  This mode assigns the relay to operate as a pulse initiator with a user-defined number of kWh per pulse. In this mode, both forward and reverse real energy are treated as additive (as in a tie circuit breaker).

- **Absolute kVARh Pulse**

  This mode assigns the relay to operate as a pulse initiator with a user-defined number of kVARh per pulse. In this mode, both forward and reverse reactive energy are treated as additive (as in a tie circuit breaker).

- **kVAh Pulse**

  This mode assigns the relay to operate as a pulse initiator with a user-defined number of kVAh per pulse. Since kVA has no sign, the kVAh pulse has only one mode.

- **kWh In Pulse**

  This mode assigns the relay to operate as a pulse initiator with a user-defined number of kWh per pulse. In this mode, only the kWh flowing into the load is considered.

- **kVARh In Pulse**

  This mode assigns the relay to operate as a pulse initiator with a user-defined number of kVARh per pulse. In this mode, only the kVARh flowing into the load is considered.

- **kWh Out Pulse**

  This mode assigns the relay to operate as a pulse initiator with a user-defined number of kWh per pulse. In this mode, only the kWh flowing out of the load is considered.

- **kVARh Out Pulse**

  This mode assigns the relay to operate as a pulse initiator with a user-defined number of kVARh per pulse. In this mode, only the kVARh flowing out of the load is considered.

MECHANICAL RELAY OUTPUTS

The optional Input/Output Card IOC44 provides three Form-C, 10 A mechanical relays that can be used to open or close circuit breakers, annunciate alarms, and more.

The mechanical output relays of the circuit monitor can be configured to operate in one of 11 operating modes:

- Normal
- Latched (electrically held)
- Timed
- End of power demand interval
- Absolute kWh pulse
- Absolute kVARh pulse
- kVAh pulse
- kWh in pulse
- kVARh in pulse
- kWh out pulse
- kVARh out pulse

See the previous section “Relay Output Operating Modes” on page 75 for a description of the modes.

The last seven modes in the list above are for pulse initiator applications. All Series 4000 Circuit Monitors are equipped with one solid-state KYZ pulse output rated at 96 mA and an additional KYZ pulse output is available on the IOC44 card. The solid-state KYZ output provides the long life—billions of operations—required for pulse initiator applications. The mechanical relay outputs have limited lives: 10 million operations under no load; 100,000 under load. For maximum life, use the solid-state KYZ pulse output for pulse initiation, except when a rating higher than 96 mA is required. See “Solid-State KYZ Pulse Output” on page 78 for a description of the solid-state KYZ pulse output.

To set up a mechanical relay output, from the Main Menu, select Setup > I/O. Select input option IOC44. For detailed instructions, see “Setting Up I/Os” on page 25. Then using SMS, you must define the following values for each mechanical relay output:

- **Name**—A 16-character label used to identify the digital output.
- **Mode**—Select one of the operating modes listed above.
- **Pulse Weight**—You must set the pulse weight, the multiplier of the unit being measured, if you select any of the pulse modes (last 7 listed above).
- **Timer**—You must set the timer if you select the timed mode or end of power demand interval mode (in seconds).
- **Control**—You must set the relay to be controlled either remotely or internally (from the circuit monitor) if you select the normal, latched, or timed mode.

For instructions on setting up digital I/Os in SMS, see the SMS online help on device set up of the circuit monitor.

NOTE: The IOC44 can be set up using the display or SMS. The IOX must be identified using the display, then set up using the display or SMS.

Setpoint-Controlled Relay Functions

The circuit monitor can detect over 100 alarm conditions, including over/under conditions, digital input changes, phase unbalance conditions, and more (see **Alarms** on page 83 for more about alarms). Using SMS, you can configure a relay to operate when an alarm condition is true. For example, you could set up the three relays on the IOC44 card to operate at each occurrence of "Undervoltage Phase A." Then, each time the alarm condition occurs—that is, each time the setpoints and time delays assigned to Undervoltage Phase A are satisfied—the circuit monitor automatically operates relays R1, R2, and R3 according to their configured mode of operation. See "Relay Output Operating Modes" on page 75 for a description of the operating modes.

Also, you can assign multiple alarm conditions to a relay. For example, relay AR1 on the IOC44 card could have "Undervoltage Phase A" and "Undervoltage Phase B" assigned to it. The relay would operate whenever either condition occurred.

NOTE: Setpoint-controlled relay operation can be used for some types of non-time-critical relaying. For more information, see "Setpoint-Controlled Relay Functions" on page 86.

SOLID-STATE KYZ PULSE OUTPUT

This section describes the pulse output capabilities of the circuit monitor. For instructions on wiring the KYZ pulse output, see "Wiring the Solid-State KYZ Output" in the **Wiring** section of the installation manual.

The circuit monitor is equipped with one solid-state KYZ pulse output located near the option card slots. The IOC44 option card also has a solid-state KYZ output. The solid-state relays provides the extremely long life—billions of operations—required for pulse initiator applications.

The KYZ output is a Form-C contact with a maximum rating of 100 mA. Because most pulse initiator applications feed solid-state receivers with low burdens, this 100 mA rating is adequate for most applications. For applications where a higher rating is required, the IOC44 card provides 3 relays with 10 ampere ratings. Use SMS or the display to configure any of the 10 ampere relays as a pulse initiator output. Keep in mind that the 10 ampere relays are mechanical relays with limited life—10 million operations under no load; 100,000 under load.

To set the kilowatthour-per-pulse value, use SMS or the display. When setting the kWh/pulse value, set the value based on a 3-wire pulse output. For instructions on calculating the correct value, see "Calculating the Kilowatthour-Per-Pulse Value" on page 80.

The circuit monitor can be used in 2-wire or 3-wire pulse initiator applications. Each of these applications is described in the sections that follow.

The KYZ pulse output can be configured to operate in one of 11 operating modes. See "Relay Output Operating Modes" on page 75 for a description of the modes.

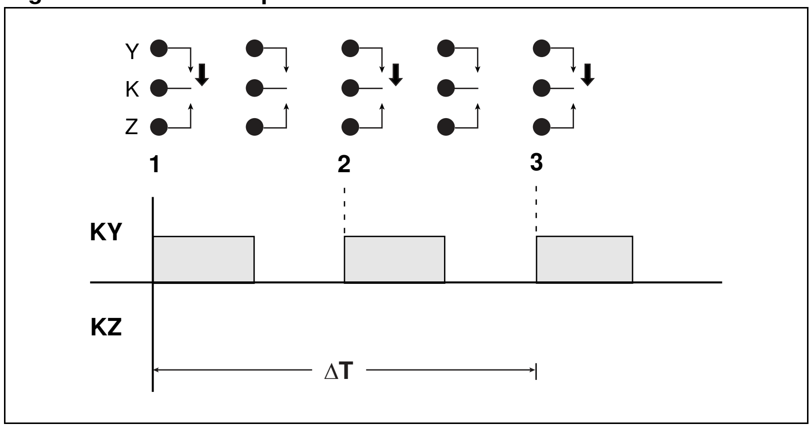
The setup in SMS or at the circuit monitor display is the same as a mechanical relay. See the previous section "Mechanical Relay Outputs" on page 77, for the values you must set up in SMS.

2-Wire Pulse Initiator

Most digital inputs in energy management systems use only two of the three wires provided with a KYZ pulse initiator. This is called a 2-wire pulse initiator application. Figure 5–3 shows a pulse train from a 2-wire pulse initiator application.

In a 2-wire application, the pulse train looks like the alternating open and closed states of a Form-A contact. Most 2-wire pulse initiator applications use a Form-C contact, but tie into only one side of the Form-C contact where the pulse is the transition from OFF to ON of that side of the Form-C relay. In Figure 5–3, the transitions are marked as 1 and 2. Each transition represents the time when the relay transitions from KZ to KY. Each time the relay transitions, the receiver counts a pulse. The circuit monitor can deliver up to 25 pulses per second in a 2-wire application.

Figure 5–3: Two-wire pulse train

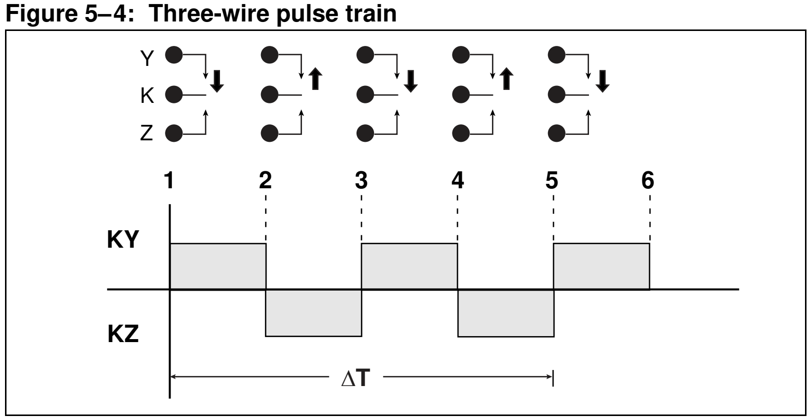


3-Wire Pulse Initiator

Some applications require the use of all three wires provided with the KYZ pulse initiator. This is called a 3-wire pulse initiator application. Figure 5–4 shows a pulse train for a 3-wire pulse initiator application.

Three-wire KYZ pulses are the transitions between KY and KZ. These transitions are the alternate contact closures of a Form-C contact. In Figure 5–4, the transitions are marked as 1, 2, 3, and 4. The receiver counts a pulse at each transition. That is, each time the Form-C contact changes state from KY to KZ, or from KZ to KY, the receiver counts a pulse.The circuit monitor can deliver up to 50 pulses per second in a 3-wire application.

Figure 5–4: Three-wire pulse train



CALCULATING THE KILOWATTHOUR-PER-PULSE VALUE

This section shows an example of how to calculate kilowatthours per pulse. To calculate this value, first determine the highest kW value you can expect and the required pulse rate. In this example, the following assumptions are made:

- The metered load should not exceed 1600 kW.
- About two KYZ pulses per second should occur at full scale.

Step 1: Convert 1600 kW load into kWh/second.

$$(1600 \text{ kW})\ (1 \text{ Hr}) = 1600 \text{ kWh}$$

$$\frac{(1600 \text{ kWh})}{1 \text{ hour}} = \frac{\text{“X” kWh}}{1 \text{ second}}$$

$$\frac{(1600 \text{ kWh})}{3600 \text{ seconds}} = \frac{\text{“X” kWh}}{1 \text{ second}}$$

$$X = 1600/3600 = 0.4444 \text{ kWh/second}$$

Step 2: Calculate the kWh required per pulse.

$$\frac{0.4444 \text{ kWh/second}}{2 \text{ pulses/second}} = 0.2222 \text{ kWh/pulse}$$

Step 3: Round to nearest hundredth, since the circuit monitor only accepts 0.01 kWh increments.

$$\text{Ke} = 0.22 \text{ kWh/pulse}$$

Summary:

- 3-wire application—**0.22** kWh/pulse provides approximately 2 pulses per second at full scale.
- 2-wire application—**0.11** kWh/pulse provides approximately 2 pulses per second at full scale. (To convert to the kWh/pulse required for a 2-wire application, divide Ke by 2. This is necessary because the circuit monitor Form C relay generates two pulses—KY and KZ—for every pulse that is counted.)

ANALOG OUTPUTS

This section describes the circuit monitor's analog output capabilities. For technical specifications and instructions on installing the I/O Extender or analog output modules, refer to the instruction bulletin that ships with the I/O (see Table 1–2 on page 2 for a list of these publications).

To set up analog outputs, you must first define it from the display. From the main menu, select Setup > I/O. Select the appropriate analog output option. For example, if you are using the IOX0404 option of the I/O Extender, select IOX0404. For detailed instructions, see "Setting Up I/Os" on page 25. Then using SMS, you must define the following values for each analog output:

- Name—A 16-character label used to identify the output. Default names are assigned, but can be customized
- Output register**—**The circuit monitor register assigned to the analog output.
- Lower Limit—The value equivalent to the minimum output current. When the register value is below the lower limit, the circuit monitor outputs the minimum output current.
- Upper Limit—The value equivalent to the maximum output current. When the register value is above the upper limit, the circuit monitor outputs the maximum output current.

For instructions on setting up an analog output in SMS, see the SMS online help on device set up of the circuit monitor.

CAUTION
HAZARD OF EQUIPMENT DAMAGE
Each analog output represents an individual 2-wire current loop; therefore, use an isolated receiver for *each* individual analog output on the I/O Extender (IOX).
Failure to observe this instruction can result in equipment damage.

Analog Output Example

Figure 5–5 illustrates the relationship between the output range of current (in milliamperes) and the upper and lower limit of power usage (real power in kW). In this example, the analog output has been configured as follows:

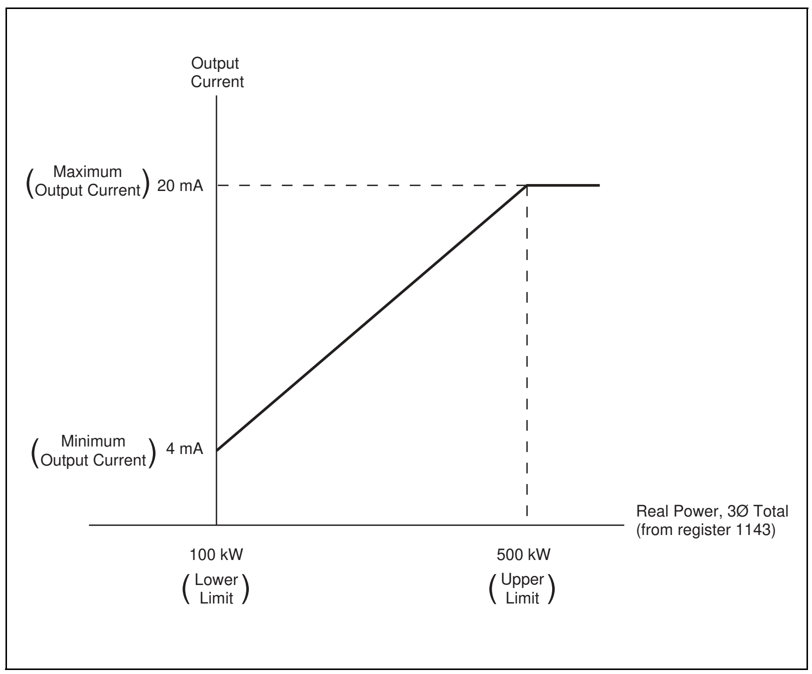
- — Register Number: 1143 (Real Power, 3-Phase Total)
- — Lower Limit: 100 kW
- — Upper Limit: 500 kW

Table 5–3 shows the output current at various register readings.

Table 5–3: Sample register readings for analog output

Register Reading (kW)	Output Current (mA)
50	4
100	4
200	8
250	10
500	20
550	20

Figure 5–5: Analog output example



CHAPTER 6—ALARMS

ABOUT ALARMS

The circuit monitor can detect over 100 alarm conditions, including over or under conditions, digital input changes, phase unbalance conditions, and more. It also maintains a counter for each alarm to keep track of the total number of occurrences. A complete list of default alarm configurations are described in Table 6–3 on page 91. In addition, you can set up your own custom alarms and set up relays to operate on alarm conditions.

When one or more alarm conditions are true, the circuit monitor will execute a task automatically. Using SMS or the display, you can set up each alarm condition to perform these tasks:

- Force data log entries in up to 14 user-defined data log files. See **Logging** on page 101 for more about data logging.
- Perform event captures. See **Waveform and Event Capture** on page 107 for more about event recording.
- Operate relays. Using SMS you can assign one or more relays to operate when an alarm condition is true. See the SMS online help for more about this topic.

Alarms Groups

Whether you are using a default alarm or creating a custom alarm, you first choose the alarm group that is appropriate for the application. Each alarm condition is assigned to one of these alarm groups:

- **Standard**—Standard alarms have a detection rate of 1 second and are useful for detecting conditions such as over current and under voltage. Up to 80 alarms can be set up in this alarm group
- **High Speed**—High speed alarms have a detection rate of 100 milliseconds and are useful for detecting voltage sags and swells lasting only a few cycles. Up to 20 alarms can be set up in this group.
- **Disturbance**—Disturbance alarms have a detection rate one cycle and are useful for detecting voltage sags and swells. Up to 20 alarms can be set up in this group. See **Disturbance Monitoring** on page 113 for more about disturbance monitoring.
- **Digital**—Digital alarms are triggered by an exception such as the transition of a digital input or the end of an incremental energy interval. Up to 40 alarms can be set up in this group.
- **Boolean**—Boolean alarms use Boolean logic to combine up to four enabled alarms. You can choose from the Boolean logic operands: AND, NAND, OR, NOR, or XOR to combine your alarms. Up to 15 alarms can be set up in this group.
- **Waveshape**—Waveshape alarms identify abnormalities by comparing present waveforms to preceding waveforms. See “Waveshape Alarm” on page 97 for more information on this alarm group.

Use either SMS or the display to set up any of the alarms.

Setpoint-Driven Alarms

Many of the alarm conditions require that you define setpoints. This includes all alarms for over, under, and phase unbalance alarm conditions. Other alarm conditions such as digital input transitions and phase reversals do not require setpoints. For those alarm conditions that require setpoints, you must define the following information:

- Pickup Setpoint
- Pickup Delay (depending on the alarm group, you choose the time in seconds, 100 ms increments, or cycles)
- Dropout Setpoint
- Dropout Delay (depending on the alarm group, you choose the time in seconds, 100 ms increments, or cycles)

NOTE: Alarms with both Pickup and Dropout setpoints set to zero are invalid.
To understand how the circuit monitor handles setpoint-driven alarms, see Figure 6–2. Figure 6–1 shows what the actual alarm Log entries for Figure 6–2 might look like, as displayed by SMS.

NOTE: The software does not actually display the codes in parentheses—EV1, EV2, Max1, Max2. These are references to the codes in Figure 6–2.

Figure 6–1: Sample alarm log entry

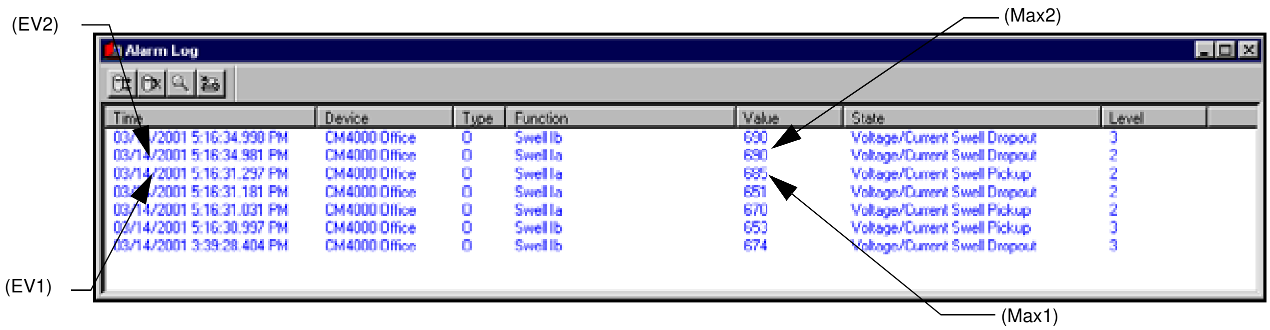
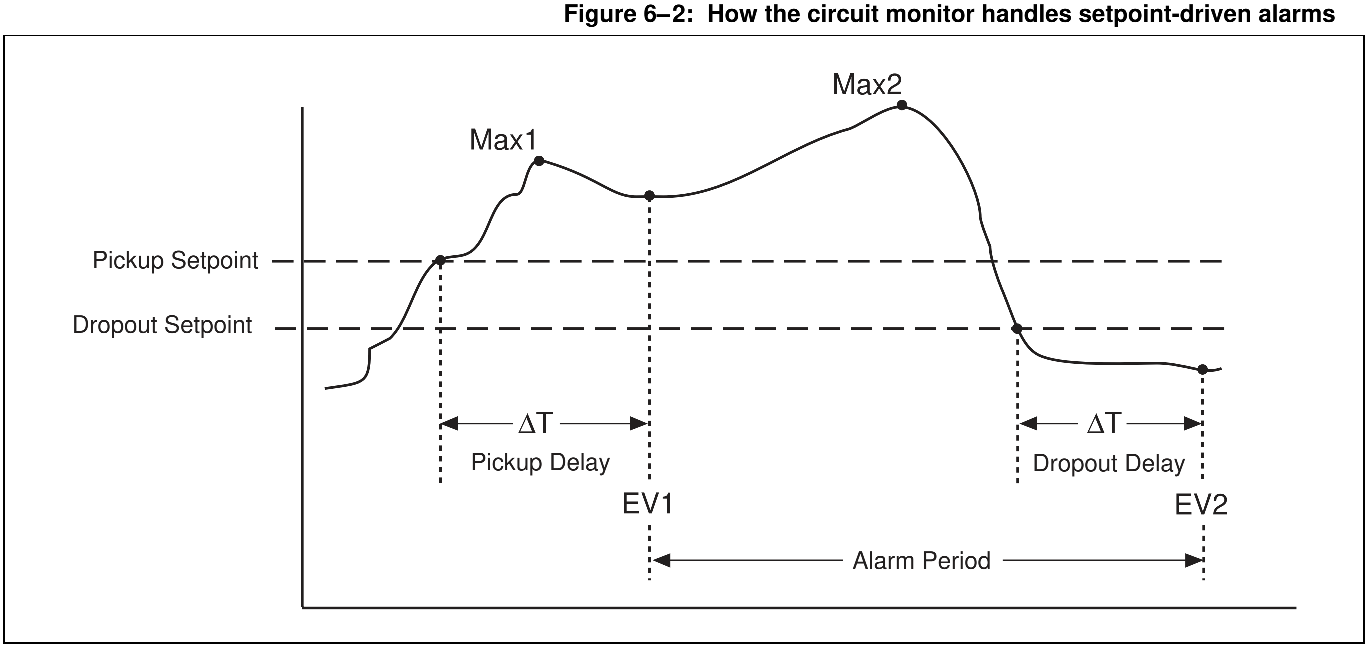


Figure 6–2: How the circuit monitor handles setpoint-driven alarms



EV1—The circuit monitor records the date and time that the pickup setpoint and time delay were satisfied, and the maximum value reached (Max1) during the pickup delay period (ΔT). Also, the circuit monitor performs any tasks assigned to the event such as waveform captures or forced data log entries.

EV2—The circuit monitor records the date and time that the dropout setpoint and time delay were satisfied, and the maximum value reached (Max2) during the alarm period.

The circuit monitor also stores a correlation sequence number (CSN) for each event (such as *Under Voltage Phase A Pickup, Under Voltage Phase A Dropout*). The CSN lets you relate pickups and dropouts in the alarm log. You can sort pickups and dropouts by CSN to correlate the pickups and dropouts of a particular alarm. The pickup and dropout entries of an alarm will have the same CSN. You can also calculate the duration of an event by looking at pickups and dropouts with the same CSN.

Priorities

Each alarm also has a priority level. Use the priorities to distinguish between events that require immediate action and those that do not require action.

- **High priority**—if a high priority alarm occurs, the display informs you in two ways: the LED on the display flashes until you acknowledge the alarm and a message displays while the alarm is active.
- **Medium priority**—if a medium priority alarm occurs, the LED flashes and a message displays only while the alarm is active. Once the alarm becomes inactive, the LED stops flashing.
- **Low priority**—if a low priority alarm occurs, the LED on the display flashes only while the alarm is active. No alarm message is displayed.
- **No priority**—if an alarm is setup with no priority, no visible representation will appear on the display. Alarms with no priority are not entered in the Alarm Log. See Logging for alarm logging information.

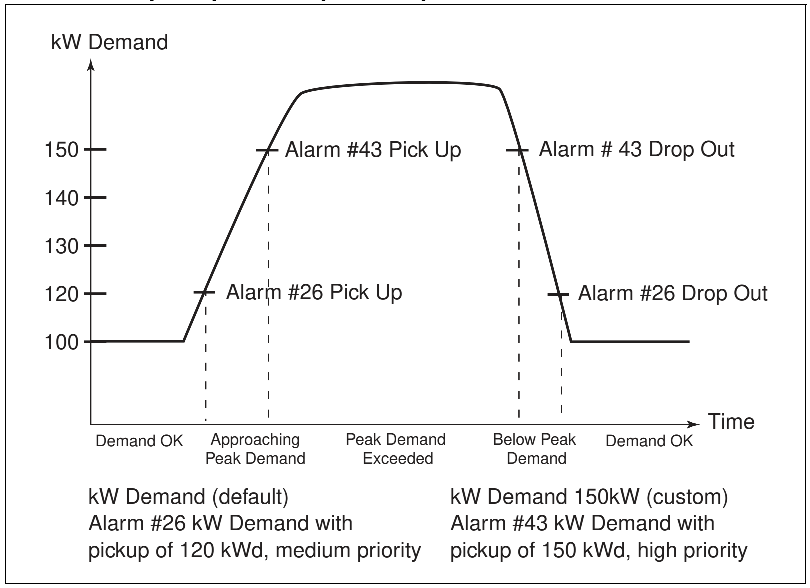
If multiple alarms with different priorities are active at the same time, the display shows the alarm message for the last alarm that occurred. For instructions on setting up alarms from the circuit monitor display, see “Setting Up and Editing Alarms” on page 22.

Alarm Levels

From the display or SMS, multiple alarms can be set up for one particular quantity (parameter) to create alarm “levels”. You can take different actions depending on the severity of the alarm.

For example, you could set up two alarms for kW Demand. A default alarm already exists for kW Demand (no. 26 in the alarm list), but you could create another custom alarm for kW Demand, selecting different pickup points for it. The custom kW Demand alarm, once created, will appear in the standard alarm list. For illustration purposes, let’s set the default kW Demand alarm to 120 kW and the new custom alarm to 150 kW. One alarm named *kW Demand*; the other *kW Demand 150kW* as shown in Figure 6–3. Note that if you choose to set up two alarms for the same quantity, use slightly different names to distinguish which alarm is active. The display can hold up to 15 characters for each name. You can create up to 10 alarm levels for each quantity.

Figure 6–3: Two alarms set up for the same quantity with different pickup and dropout set points



CUSTOM ALARMS

The circuit monitor has many pre-defined alarms, but you can also set up your own custom alarms. For example, you may need to alarm on the ON-to-OFF transition of a digital input. To create this type of custom alarm:

1. Select the appropriate alarm group (digital in this case).
2. Select the type of alarm (described in Table 6–4 on page 93).
3. Give the alarm a name.

After creating a custom alarm, you can configure it by applying priorities, setting pickups and dropouts (if applicable), and so forth. For instructions on creating custom alarms, see “Creating a New Custom Alarm” on page 21.

NOTE: The circuit monitor will automatically create alarms for the IOC44 and the IOX when the modules are identified. These are OFF-to-ON alarms.

SETPOINT-CONTROLLED RELAY FUNCTIONS

A circuit monitor can mimic the functions of certain motor management devices to detect and respond to conditions such as phase loss, undervoltage, or reverse phase relays. While the circuit monitor is not a primary protective device, it can detect abnormal conditions and respond by operating one or more Form-C output contacts. These outputs can be used to operate an alarm horn or bell to annunciate the alarm condition.

NOTE: The circuit monitor is not designed for use as a primary protective relay. While its setpoint-controlled functions may be acceptable for certain applications, it should not be considered a substitute for proper circuit protection.

If you determine that the circuit monitor’s performance is acceptable for the application, the output contacts can be used to mimic some functions of a motor management device. When deciding if the circuit monitor is acceptable for these applications, keep the following points in mind:

- Circuit monitors require control power to operate properly.
- Circuit monitors may take up to 5 seconds after control power is applied before setpoint-controlled functions are activated. If this is too long, a reliable source of control power is required.

- When control power is interrupted for more than approximately 100 milliseconds, the circuit monitor releases all energized output contacts.
- Standard setpoint-controlled functions may take 1–2 seconds to operate, in addition to the intended delay.
- A password is required to program the circuit monitor's setpoint controlled relay functions.
- Changing certain setup parameters after installation may operate relays in a manner inconsistent with the requirements of the application.

For instructions on configuring setpoint-controlled alarms or relays from the circuit monitor's display, see “Setting Up and Editing Alarms” on page 22. The types of available alarms are described in Table 6–3 on page 91.

Types of Setpoint-Controlled Relay Functions

This section describes some common motor management functions to which the following information applies:

- Values that are too large to fit into the display may require scale factors.
- Relays can be configured as normal, latched, or timed. See “Relay Output Operating Modes” on page 75 for more information.
- When the alarm occurs, the circuit monitor operates any specified relays. There are two ways to release relays that are in latched mode:
  - — Issue a command to de-energize a relay, or
  - — Acknowledge the alarm in the high priority log to release the relays from latched mode. From the main menu of the display, select View Alarms > High Priority Log to view and acknowledge unacknowledged alarms. See “Viewing Alarms” on page 45 for detailed instructions.

The list that follows shows the types of alarms available for some common motor management functions:

NOTE: Voltage base alarm setpoints depend on your system configuration. Alarm setpoints for 3-wire systems are V_{L-L} values while 4-wire systems are V_{L-N} values.

Undervoltage:

Pickup and dropout setpoints are entered in volts. The per-phase undervoltage alarm occurs when the per-phase voltage is equal to or below the pickup setpoint long enough to satisfy the specified pickup delay (in seconds). The undervoltage alarm clears when the phase voltage remains above the dropout setpoint for the specified dropout delay period.

Overvoltage:

Pickup and dropout setpoints are entered in volts. The per-phase overvoltage alarm occurs when the per-phase voltage is equal to or above the pickup setpoint long enough to satisfy the specified pickup delay (in seconds). The overvoltage alarm clears when the phase voltage remains below the dropout setpoint for the specified dropout delay period.

Unbalance Current:

Pickup and dropout setpoints are entered in tenths of percent, based on the percentage difference between each phase current with respect to the average of all phase currents. For example, enter an unbalance of 7% as 70. The unbalance current alarm occurs when the phase current deviates from the average of the phase currents, by the percentage pickup setpoint, for the specified pickup delay. The alarm clears when the percentage difference between the phase current and the average of all phases remains below the dropout setpoint for the specified dropout delay period.

Unbalance Voltage:

Pickup and dropout setpoints are entered in tenths of percent, based on the percentage difference between each phase voltage with respect to the average of all phase voltages. For example, enter an unbalance of 7% as 70. The unbalance voltage alarm occurs when the phase voltage deviates from the average of the phase voltages, by the percentage pickup setpoint, for the specified pickup delay. The alarm clears when the percentage difference between the phase voltage and the average of all phases remains below the dropout setpoint for the specified dropout delay (in seconds).

Phase Loss—Current:

Pickup and dropout setpoints are entered in amperes. The phase loss current alarm occurs when any current value (but not all current values) is equal to or below the pickup setpoint for the specified pickup delay (in seconds). The alarm clears when one of the following is true:

- All of the phases remain above the dropout setpoint for the specified dropout delay, or
- All of the phases drop below the phase loss pickup setpoint.

If all of the phase currents are equal to or below the pickup setpoint, during the pickup delay, the phase loss alarm will not activate. This is considered an under current condition. It should be handled by configuring the under current protective functions.

Phase Loss—Voltage:

Pickup and dropout setpoints are entered in volts. The phase loss voltage alarm occurs when any voltage value (but not all voltage values) is equal to or below the pickup setpoint for the specified pickup delay (in seconds). The alarm clears when one of the following is true:

- All of the phases remain above the dropout setpoint for the specified dropout delay (in seconds), OR
- All of the phases drop below the phase loss pickup setpoint.

If all of the phase voltages are equal to or below the pickup setpoint, during the pickup delay, the phase loss alarm will not activate. This is considered an under voltage condition. It should be handled by configuring the under voltage protective functions.

Reverse Power:

Pickup and dropout setpoints are entered in kilowatts or kVARS. The reverse power alarm occurs when the power flows in a negative direction and remains at or below the negative pickup value for the specified pickup delay (in seconds). The alarm clears when the power reading remains above the dropout setpoint for the specified dropout delay (in seconds).

Phase Reversal:

Pickup and dropout setpoints and delays do not apply to phase reversal. The phase reversal alarm occurs when the phase voltage rotation differs from the default phase rotation. The circuit monitor assumes that an ABC phase rotation is normal. If a CBA phase rotation is normal, the user must change the circuit monitor’s phase rotation from ABC (default) to CBA. To change the phase rotation from the display, from the main menu select

Setup > Meter > Advanced. For more information about changing the phase rotation setting of the circuit monitor, refer to “Advanced Meter Setup” on page 39.

SCALE FACTORS

A scale factor is the multiplier expressed as a power of 10. For example, a multiplier of 10 is represented as a scale factor of 1, since 10^1=10; a multiplier of 100 is represented as a scale factor of 2, since 10^2=100. This allows you to make larger values fit into the register. Normally, you do not need to change scale factors. If you are creating custom alarms, you need to understand how scale factors work so that you do not overflow the register with a number larger than what the register can hold. When SMS is used to set up alarms, it automatically handles the scaling of pickup and dropout setpoints. When creating a custom alarm using the circuit monitor’s display, do the following:

- Determine how the corresponding metering value is scaled, and
- Take the scale factor into account when entering alarm pickup and dropout settings.

Pickup and dropout settings must be integer values in the range of -32,767 to +32,767. For example, to set up an under voltage alarm for a 138 kV nominal system, decide upon a setpoint value and then convert it into an integer between -32,767 and +32,767. If the under voltage setpoint were 125,000 V, this would typically be converted to 12500 x 10 and entered as a setpoint of 12500.

Six scale groups are defined (A through F). The scale factor is preset for all factory-configured alarms. Table 6–1 lists the available scale factors for each of the scale groups. If you need either an extended range or more resolution, select any of the available scale factors to suit your need.

Table 6–1: Scale Groups

Scale Group	Measurement Range	Scale Factor
Scale Group A—Phase Current	Amperes	
	0–327.67 A	–2
	0–3,276.7 A	–1
	0–32,767 A	0 (default)
	0–327.67 kA	1
Scale Group B—Neutral Current	Amperes	
	0–327.67 A	–2
	0–3,276.7 A	–1
	0–32,767 A	0 (default)
	0–327.67 kA	1
Scale Group C—Ground Current	Amperes	
	0–327.67 A	–2
	0–3,276.7 A	–1
	0–32,767 A	0 (default)
	0–327.67 kA	1

Table 6–1: Scale Groups *(continued)*

Scale Group	Measurement Range	Scale Factor
Scale Group D—Voltage, L–L	Voltage	
	0–3,276.7 V	–1
	0–32,767 V	0 (default)
	0–327.67 kV	1
	0–3,276.7 kV	2
Scale Group E— Neutral Voltage, L–N, N–G	Voltage	
	0–3,276.7 V	–1 (default)
	0–32,767 V	0
	0–327.67 kV	1
	0–3,276.7 kV	2
Scale Group F—Power kW, kVAR, kVA	Power	
	0–32.767 kW, kVAR, kVA	–3
	0–327.67 kW, kVAR, kVA	–2
	0–3,276.7 kW, kVAR, kVA	–1
	0–32,767 kW, kVAR, kVA	0 (default)
	0–327.67 MW, MVAR, MVA	1
	0–3,276.7 MW, MVAR, MVA	2
	0–32,767 MW, MVAR, MVA	3

SCALING ALARM SETPOINTS

This section is for users who do not have SMS and must set up alarms from the circuit monitor display. It explains how to scale alarm setpoints.

When the circuit monitor is equipped with a display, the display area is 4 x 20 characters, which limits the displaying of most metered quantities to five characters (plus a positive or negative sign). The display will also show the engineering units applied to that quantity.

To determine the proper scaling of an alarm setpoint, view the register number for the associated scale group. The scale factor is the number in the Dec column for that register. For example, the register number for Scale D to Phase Volts is 3212. If the number in the Dec column is 1, the scale factor is 10 (10^1=10). Remember that scale factor 1 in Table 6–1 on page 89 for Scale Group D is measured in kV. Therefore, to define an alarm setpoint of 125 kV, enter 12.5 because 12.5 multiplied by 10 is 125. Table 6–2 lists the scale groups and their register numbers.

Table 6–2: Scale Group Register Numbers

Scale Group	Register Number
Scale Group A—Phase Current	3209
Scale Group B—Neutral Current	3210
Scale Group C—Ground Current	3211
Scale Group D—Voltage, L–L	3212
Scale Group E— Neutral Voltage, L–N, N–G	3213
Scale Group F—Power kW, kVAR, kVA	3214

ALARM CONDITIONS AND ALARM NUMBERS

This section lists the circuit monitor's predefined alarm conditions. For each alarm condition, the following information is provided.

- **Alarm No.**—a position number indicating where an alarm falls in the list.
- **Alarm Description**—a brief description of the alarm condition
- **Abbreviated Display Name**—an abbreviated name that describes the alarm condition, but is limited to 15 characters that fit in the window of the circuit monitor's display.
- **Test Register**—the register number that contains the value (where applicable) that is used as the basis for a comparison to alarm pickup and dropout settings.
- **Units**—the unit that applies to the pickup and dropout settings.
- **Scale Group**—the scale group that applies to the test register's metering value (A–F). For a description of scale groups, see "Scale Factors" on page 89**.**
- **Alarm Type**—a reference to a definition that provides details on the operation and configuration of the alarm. For a description of alarm types, refer to Table 6–4 on page 93.

Table 6–3 lists the preconfigured alarms by alarm number.

Table 6–3: List of Default Alarms by Alarm Number

Alarm Number	Alarm Description	Abbreviated Display Name	Test Register	Units	Scale Group	Alarm Type *
Standard Speed Alarms (1 Second)						
01	Over Current Phase A	Over Ia	1100	Amperes	A	010
02	Over Current Phase B	Over Ib	1101	Amperes	A	010
03	Over Current Phase C	Over Ic	1102	Amperes	A	010
04	Over Current Neutral	Over In	1103	Amperes	B	010
05	Over Current Ground	Over Ig	1104	Amperes	C	010
06	Under Current Phase A	Under Ia	1100	Amperes	A	020
07	Under Current Phase B	Under Ib	1101	Amperes	A	020
08	Under Current Phase C	Under Ic	1102	Amperes	A	020
09	Current Unbalance, Max	I Unbal Max	1110	Tenths %	—	010
10	Current Loss	Current Loss	3262	Amperes	A	053
11	Over Voltage Phase A–N	Over Van	1124	Volts	D	010
12	Over Voltage Phase B–N	Over Vbn	1125	Volts	D	010
13	Over Voltage Phase C–N	Over Vcn	1126	Volts	D	010
14	Over Voltage Phase A–B	Over Vab	1120	Volts	D	010
15	Over Voltage Phase B–C	Over Vbc	1121	Volts	D	010
16	Over Voltage Phase C–A	Over Vca	1122	Volts	D	010
17	Under Voltage Phase A	Under Van	1124	Volts	D	020
18	Under Voltage Phase B	Under Vbn	1125	Volts	D	020
19	Under Voltage Phase C	Under Vcn	1126	Volts	D	020
20	Under Voltage Phase A–B	Under Vab	1120	Volts	D	020
21	Under Voltage Phase B–C	Under Vbc	1121	Volts	D	020
22	Under Voltage Phase C–A	Under Vca	1122	Volts	D	020
23	Voltage Unbalance L–N, Max	V Unbal L-N Max	1136	Tenths %	—	010

* Alarm Types are described in Table 6–4 on page 93.

Table 6–3: List of Default Alarms by Alarm Number *(continued)*

Alarm Number	Alarm Description	Abbreviated Display Name	Test Register	Units	Scale Group	Alarm Type *
24	Voltage Unbalance L–L, Max	V Unbal L-L Max	1132	Tenths %	—	010
25	Voltage Loss (loss of A,B,C, but not all)	Voltage Loss	3262	Volts	D	052
26	Phase Reversal	Phase Rev	3228	—	—	051
27	Over kVA Demand	Over kVA Dmd	2181	kVA	F	011
28	Over kW Demand	Over kW Dmd	2151	kW	F	011
29	Over kVAR Demand	Over kVAR Dmd	2166	kVAR	F	011
30	Over Frequency	Over Freq	1180	Hundredths of Hertz	—	010
31	Under Frequency	Under Freq	1180	Hundredths of Hertz	—	020
32	Lagging true power factor	Lag True PF	1163	Thousandths	—	055
33	Leading true power factor	Lead True PF	1163	Thousandths	—	054
34	Lagging displacement power factor	Lag Disp PF	1171	Thousandths	—	055
35	Leading displacement power factor	Lead Disp PF	1171	Thousandths	—	054
36	Over Current Demand Phase A	Over Ia Dmd	1961	Amperes	A	010
37	Over Current Demand Phase B	Over Ib Dmd	1971	Amperes	A	010
38	Over Current Demand Phase C	Over Ic Dmd	1981	Amperes	A	010
39	Over THD Voltage A–N	Over THD Van	1207	Tenths %	—	010
40	Over THD Voltage B–N	Over THD Vbn	1208	Tenths %	—	010
41	Over THD Voltage C–N	Over THD Vcn	1209	Tenths %	—	010
42	Over THD Voltage A–B	Over THD Vab	1211	Tenths %	—	010
43	Over THD Voltage B–C	Over THD Vbc	1212	Tenths %	—	010
44	Over THD Voltage C–A	Over THD Vca	1213	Tenths %	—	010
45-80	Reserved for custom alarms.	—	—	—	—	—
High Speed Alarms (100 ms)						
01	Over Current A	Over Ia HS	1,000	Amperes	A	010
02	Over Current B	Over Ib HS	1001	Amperes	A	010
03	Over Current C	Over Ic HS	1002	Amperes	A	010
04	Over Current N	Over In HS	1003	Amperes	B	010
05	Over Current G	Over Ig HS	1004	Amperes	C	010
06	Over Voltage A–N	Over Van HS	1024	Volts	D	010
07	Over Voltage B–N	Over Vbn HS	1025	Volts	D	010
08	Over Voltage C–N	Over Vcn HS	1026	Volts	D	010
09	Over Voltage A-B	Over Vab HS	1020	Volts	D	010
10	Over Voltage B-C	Over Vbc HS	1021	Volts	D	010
11	Over Voltage C-A	Over Vca HS	1022	Volts	D	010
12	Over Voltage N-G	Over Vng HS	1027	Volts	E	010
13	Under Voltage A–N	Under Van HS	1024	Volts	D	020
14	Under Voltage B–N	Under Vbn HS	1025	Volts	D	020
15	Under Voltage C–N	Under Vcn HS	1026	Volts	D	020
16	Under Voltage A-B	Under Vab HS	1020	Volts	D	020
17	Under Voltage B–C	Under Vbc HS	1021	Volts	D	020
18	Under Voltage C–A	Under Vca HS	1022	Volts	D	020
19-20	Reserved for custom alarms	—	—	—	—	—

* Alarm Types are described in Table 6–4 on page 93.

Table 6–3: List of Default Alarms by Alarm Number *(continued)*

Alarm Number	Alarm Description	Abbreviated Display Name	Test Register	Units	Scale Group	Alarm Type *
Disturbance Monitoring (1/2 Cycle)						
01	Voltage Swell A	Swell Van	4	Volts	D	080
02	Voltage Swell B	Swell Vbn	5	Volts	D	080
03	Voltage Swell C	Swell Vcn	6	Volts	D	080
04	Voltage Swell N–G	Swell Vng	7	Volts	E	080
05	Voltage Swell A–B	Swell Vab	1	Volts	D	080
06	Voltage Swell B–C	Swell Vbc	2	Volts	D	080
07	Voltage Swell C–A	Swell Vca	3	Volts	D	080
08	Voltage Sag A–N	Sag Van	4	Volts	D	090
09	Voltage Sag B–N	Sag Vbn	5	Volts	D	090
10	Voltage Sag C–N	Sag Vcn	6	Volts	D	090
11	Voltage Sag A–B	Sag Vab	1	Volts	D	090
12	Voltage Sag B–C	Sag Vbc	2	Volts	D	090
13	Voltage Sag C–A	Sag Vca	3	Volts	D	090
14	Current Swell A	Swell Ia	8	Amperes	A	080
15	Current Swell B	Swell Ib	9	Amperes	A	080
16	Current Swell C	Swell Ic	10	Amperes	A	080
17	Current Swell N	Swell In	11	Amperes	B	080
18	Current Sag A	Sag Ia	8	Amperes	A	090
19	Current Sag B	Sag Ib	9	Amperes	A	090
20	Current Sag C	Sag Ic	10	Amperes	A	090
Digital						
01	End of incremental energy interval	End Inc Enr Int	N/A	—	—	070
02	End of power demand interval	End Power Dmd Int	N/A	—	—	070
03	End of 1-second update cycle	End 1s Cyc	N/A	—	—	070
04	End of 100ms update cycle	End 100ms Cyc	N/A	—	—	070
05	Power up/Reset	Pwr Up/Reset	N/A	—	—	070
06-40	Reserved for custom alarms	—	—	—	—	—

* Alarm Types are described in Table 6–4 on page 93.

Table 6–4: Alarm Types

Type	Description	Operation
Standard Speed		
010	Over Value Alarm	If the test register value exceeds the setpoint long enough to satisfy the pickup delay period, the alarm condition will be true. When the value in the test register falls below the dropout setpoint long enough to satisfy the dropout delay period, the alarm will dropout. Pickup and dropout setpoints are positive, delays are in seconds.
011	Over Power Alarm	If the absolute value in the test register exceeds the setpoint long enough to satisfy the pickup delay period, the alarm condition will be true. When the value in the test register falls below the dropout setpoint long enough to satisfy the dropout delay period, the alarm will dropout. Pickup and dropout setpoints are positive, delays are in seconds.

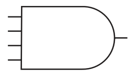
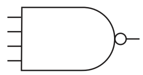
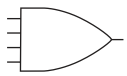
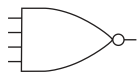
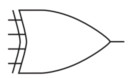
Table 6–4: Alarm Types

Type	Description	Operation
012	Over Reverse Power Alarm	If the absolute value in the test register exceeds the setpoint long enough to satisfy the pickup delay period, the alarm condition will be true. When the value in the test register falls below the dropout setpoint long enough to satisfy the dropout delay period, the alarm will dropout. This alarm will only hold true for reverse power conditions. Positive power values will not cause the alarm to occur. Pickup and dropout setpoints are positive, delays are in seconds.
020	Under Value Alarm	If the test register value is below the setpoint long enough to satisfy the pickup delay period, the alarm condition will be true. When the value in the test register rises above the dropout setpoint long enough to satisfy the dropout delay period, the alarm will dropout. Pickup and dropout setpoints are positive, delays are in seconds.
021	Under Power Alarm	If the absolute value in the test register is below the setpoint long enough to satisfy the pickup delay period, the alarm condition will be true. When the value in the test register rises above the dropout setpoint long enough to satisfy the dropout delay period, the alarm will dropout. Pickup and dropout setpoints are positive, delays are in seconds.
051	Phase Reversal	The phase reversal alarm will occur whenever the phase voltage waveform rotation differs from the default phase rotation. The ABC phase rotation is assumed to be normal. If a CBA phase rotation is normal, the user should reprogram the circuit monitor's phase rotation ABC to CBA phase rotation. The pickup and dropout setpoints and delays for phase reversal do not apply.
052	Phase Loss, Voltage	The phase loss voltage alarm will occur when any one or two phase voltages (but not all) fall to the pickup value and remain at or below the pickup value long enough to satisfy the specified pickup delay. When all of the phases remain at or above the dropout value for the dropout delay period, or when all of the phases drop below the specified phase loss pickup value, the alarm will dropout. Pickup and dropout setpoints are positive, delays are in seconds.
053	Phase Loss, Current	The phase loss current alarm will occur when any one or two phase currents (but not all) fall to the pickup value and remain at or below the pickup value long enough to satisfy the specified pickup delay. When all of the phases remain at or above the dropout value for the dropout delay period, or when all of the phases drop below the specified phase loss pickup value, the alarm will dropout. Pickup and dropout setpoints are positive, delays are in seconds.
054	Leading Power Factor	The leading power factor alarm will occur when the test register value becomes more leading than the pickup setpoint (such as closer to 0.010) and remains more leading long enough to satisfy the pickup delay period. When the value becomes equal to or less leading than the dropout setpoint, that is 1.000, and remains less leading for the dropout delay period, the alarm will dropout. Both the pickup setpoint and the dropout setpoint must be positive values representing leading power factor. Enter setpoints as integer values representing power factor in thousandths. For example, to define a dropout setpoint of 0.5, enter 500. Delays are in seconds.
055	Lagging Power Factor	The lagging power factor alarm will occur when the test register value becomes more lagging than the pickup setpoint (such as closer to –0.010) and remains more lagging long enough to satisfy the pickup delay period. When the value becomes equal to or less lagging than the dropout setpoint, that is 1.000, and remains less lagging for the dropout delay period, the alarm will dropout. Both the pickup setpoint and the dropout setpoint must be positive values representing lagging power factor. Enter setpoints as integer values representing power factor in thousandths. For example, to define a dropout setpoint of –0.5, enter 500. Delays are in seconds.
High Speed		
010	Over Value Alarm	If the test register value exceeds the setpoint long enough to satisfy the pickup delay period, the alarm condition will be true. When the value in the test register falls below the dropout setpoint long enough to satisfy the dropout delay period, the alarm will dropout. Pickup and dropout setpoints are positive, delays are in hundreds of milliseconds.
011	Over Power Alarm	If the absolute value in the test register exceeds the setpoint long enough to satisfy the pickup delay period, the alarm condition will be true. When the value in the test register falls below the dropout setpoint long enough to satisfy the dropout delay period, the alarm will dropout. Pickup and dropout setpoints are positive, delays are in hundreds of milliseconds.
012	Over Reverse Power Alarm	If the absolute value in the test register exceeds the setpoint long enough to satisfy the pickup delay period, the alarm condition will be true. When the value in the test register falls below the dropout setpoint long enough to satisfy the dropout delay period, the alarm will dropout. This alarm will only hold true for reverse power conditions. Positive power values will not cause the alarm to occur. Pickup and dropout setpoints are positive, delays are in hundreds of milliseconds.

Table 6–4: Alarm Types

Type	Description	Operation
020	Under Value Alarm	If the test register value is below the setpoint long enough to satisfy the pickup delay period, the alarm condition will be true. When the value in the test register rises above the dropout setpoint long enough to satisfy the dropout delay period, the alarm will dropout. Pickup and dropout setpoints are positive, delays are in hundreds of milliseconds.
021	Under Power Alarm	If the absolute value in the test register is below the setpoint long enough to satisfy the pickup delay period, the alarm condition will be true. When the value in the test register rises above the dropout setpoint long enough to satisfy the dropout delay period, the alarm will dropout. Pickup and dropout setpoints are positive, delays are in hundreds of milliseconds.
051	Phase Reversal	The phase reversal alarm will occur when ever the phase voltage waveform rotation differs from the default phase rotation. The ABC phase rotation is assumed to be normal. If a CBA normal phase rotation is normal, the user should reprogram the circuit monitor’s phase rotation ABC to CBA phase rotation. The pickup and dropout setpoints and delays for phase reversal do no apply.
052	Phase Loss, Voltage	The phase loss voltage alarm will occur when any one or two phase voltages (but not all) fall to the pickup value and remain at or below the pickup value long enough to satisfy the specified pickup delay. When all of the phases remain at or above the dropout value for the dropout delay period, or when all of the phases drop below the specified phase loss pickup value, the alarm will dropout. Pickup and dropout setpoints are positive, delays are in hundreds of milliseconds.
053	Phase Loss, Current	The phase loss current alarm will occur when any one or two phase currents (but not all) fall to the pickup value and remain at or below the pickup value long enough to satisfy the specified pickup delay. When all of the phases remain at or above the dropout value for the dropout delay period, or when all of the phases drop below the specified phase loss pickup value, the alarm will dropout. Pickup and dropout setpoints are positive, delays are in hundreds of milliseconds.
054	Leading Power Factor	The leading power factor alarm will occur when the test register value becomes more leading than the pickup setpoint (closer to 0.010) and remains more leading long enough to satisfy the pickup delay period. When the value becomes equal to or less leading than the dropout setpoint, that is 1.000, and remains less leading for the dropout delay period, the alarm will dropout.Both the pickup setpoint and the dropout setpoint must be positive values representing leading power factor. Enter setpoints as integer values representing power factor in thousandths. For example, to define a dropout setpoint of 0.5, enter 500. Delays are in hundreds of milliseconds.
055	Lagging Power Factor	The lagging power factor alarm will occur when the test register value becomes more lagging than the pickup setpoint (closer to –0.010) and remains more lagging long enough to satisfy the pickup delay period. When the value becomes equal to or less lagging than the dropout setpoint, that is. 1.000 and remains less lagging for the dropout delay period, the alarm will dropout. Both the pickup setpoint and the dropout setpoint must be positive values representing lagging power factor. Enter setpoints as integer values representing power factor in thousandths. For example, to define a dropout setpoint of –0.5, enter 500. Delays are in hundreds of milliseconds.
Disturbance		
080	Voltage/Current Swell	The voltage and current swell alarms will occur whenever the continuous rms calculation is above the pickup setpoint and remains above the pickup setpoint for the specified number of cycles. When the continuous rms calculations fall below the dropout setpoint and remain below the setpoint for the specified number of cycles, the alarm will dropout. Pickup and dropout setpoints are positive and delays are in cycles.
090	Voltage/Current Sag	The voltage and current sag alarms will occur whenever the continuous rms calculation is below the pickup setpoint and remains below the pickup setpoint for the specified number of cycles. When the continuous rms calculations rise above the dropout setpoint and remain above the setpoint for the specified number of cycles, the alarm will drop out. Pickup and dropout setpoints are positive and delays are in cycles.
Digital		
060	Digital Input On	The digital input transition alarms will occur whenever the digital input changes from off to on. The alarm will dropout when the digital input changes back to off from on. The pickup and dropout setpoints and delays do not apply.
061	Digital Input Off	The digital input transition alarms will occur whenever the digital input changes from on to off.The alarm will dropout when the digital input changes back to on from off. The pickup and dropout setpoints and delays do not apply.
070	Unary	This is a internal signal from the circuit monitor and can be used, for example, to alarm at the end of an interval or when the circuit monitor is reset. The pickup and dropout delays do not apply.

Table 6–4: Alarm Types

Type	Description	Operation
Boolean		
100	Logic AND 	The AND alarm will occur when *all* of the combined enabled alarms are true (up to 4).
101	Logic NAND 	The NAND alarm will occur when *any* of the combined enabled alarms is false.
102	Logic OR 	The OR alarm will occur when *any* of the combined enabled alarms are true (up to 4).
103	Logic NOR 	The NOR alarm will occur when *none* of the combined enabled alarms are true (up to 4).
104	Logic XOR 	The XOR alarm will occur when *only one* of the combined enabled alarms is different than the other three.

WAVESHAPE ALARM

The waveshape alarm in the circuit monitor alerts you to abnormalities in the power system by comparing the present waveform to preceding waveforms. This point-by-point comparison identifies waveshape changes too small to be detected by a disturbance alarm.

Use the circuit monitor display or SMS software to configure waveshape alarms to catch these subtle changes. Firmware version 12.430 and higher in the circuit monitor, and SMS version 3.32 and higher is required.

Waveshape alarms can be set up for these four measurements in any combination:

- Phase voltage
- Neutral to ground voltage
- Phase current
- Neutral current

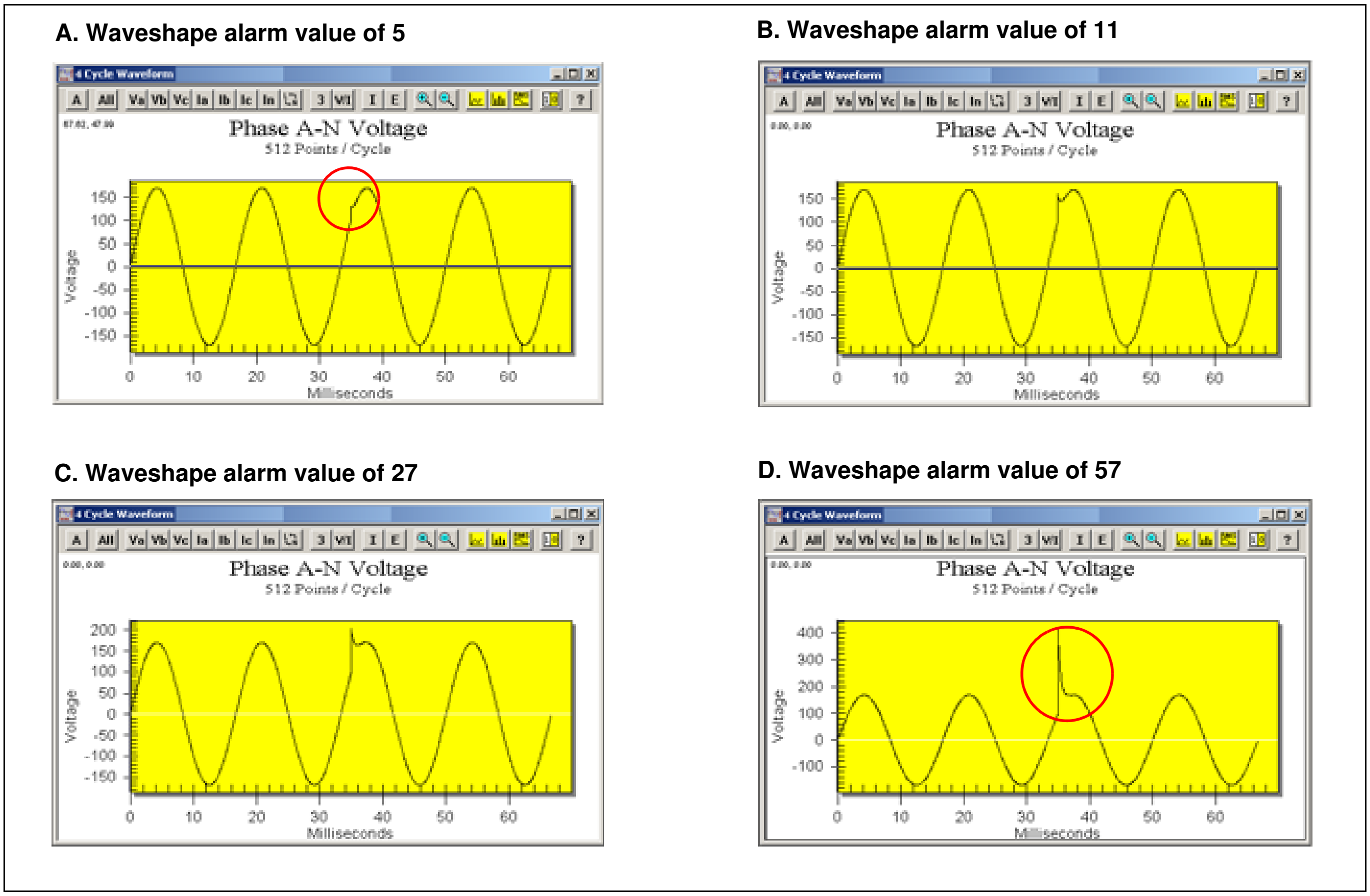
In addition, the waveshape alarms can trigger any of the following:

- Data logs
- Disturbance waveform captures
- 100 ms rms event log
- Adaptive waveform captures

During the waveshape calculations, the magnitude of the change in waveshapes is recorded as a value. Although this value has no units associated with it, a higher value indicates a greater change in the waveshape from those that occurred previously.

Consider the four waveshapes in Figure 6–4. Waveshape A shows only a small abnormality with a value of 5, but waveshape D shows a much larger change from the normal waveshape and has a value of 57. Knowing this value for your system will help you determine the setpoints for the alarm. In this example, you may choose only to monitor the most severe cases and ignore the smaller anomalies.

Figure 6–4: Example Threshold Settings



A. Waveshape alarm value of 5

B. Waveshape alarm value of 11

C. Waveshape alarm value of 27

D. Waveshape alarm value of 57

Threshold

The threshold is the value that triggers the waveshape alarm when that value is exceeded. The threshold value can range from 1–100. No units are associated with this value. The factory default value of the threshold setting is 100 (it will not detect an alarm).

If we continue using Figure 6–4 as an example and choose to alarm only on the severe cases as shown in waveshapes C and D, then the threshold value would be set to around 25.

Upper Limit

The upper limit defines the highest waveshape value that will trigger a waveshape alarm. When the upper limit is reached, values beyond that will not trigger the waveshape alarm. Values above the upper limit are expected to be detected by other alarms set up by the user.

You can set the upper limit to any whole integer in the range from 1–100. No units are associated with this value. The factory default value of the upper limit is 100.

In summary, values that fall between the threshold and upper limit will trigger a waveshape alarm. Since we set the threshold to 25 in this example, then the upper limit would be set to around 60. These setpoints would trigger alarms for waveshapes C and D, but not for waveshapes A and B.

Using Waveshape Alarms

To use the waveshape alarm feature, you need to determine the threshold and upper limit for your system.

NOTE: For setup of waveshape alarms in SMS refer to the online SMS help file.

For setup from the display, follow these steps:

1. Set up a waveshape alarm using the default setting of 100.
   Select Setup > Alarm > Create Custom > Waveshape.
2. Enable the alarm.
   Select Setup > Alarm > Edit parameters> Waveshape>(*select alarm name*)>Enable
3. Select Setup > Alarm > Edit Parameters > Waveshape.
4. While your power system is experiencing normal load conditions, view registers 2810–2813 for the highest waveshape values (collected every second). Also, view registers 2820–2823 for the maximum waveshape values since the last meter reset. You can use these values to help you select a suitable threshold and upper limit.

CHAPTER 7—LOGGING

ABOUT LOGS

Logs are files stored in the non-volatile memory of the circuit monitor and are referred to as “onboard logs.” Circuit monitor logs include the following:

- Alarm log
- User-defined data logs
- Min/Max log and Interval Min/Max/Average log
- Maintenance log

Use SMS to set up and view all the logs. See the SMS online help for information about working with the circuit monitor’s onboard logs.

Waveform captures and the 100-ms rms event recording are not logs, but the information is also saved in the circuit monitor’s memory. See “Memory Allocation” on page 105 for information about shared memory in the circuit monitor. For information about default circuit monitor settings, see “Factory Defaults” in the installation manual.

ALARM LOG

Using SMS, you can set up the circuit monitor to log the occurrence of any alarm condition. Each time an alarm occurs it is entered into the alarm log. The alarm log in the circuit monitor stores the pickup and dropout points of alarms along with the date and time associated with these alarms. You select whether the alarm log saves data as first-in-first-out (FIFO) or fill and hold. You can also view and save the alarm log to disk, and reset the alarm log to clear the data out of the circuit monitor’s memory.

NOTE: All data capture methods that are available in the CM4000 and CM4250 are also available in the CM4000T. Also, a transient alarm has a pickup entry with a duration, but it does not have a dropout entry. For information about logging with the CM4000T, refer to “Impulsive Transient Logging” on page 149.

Alarm Log Storage

The circuit monitor stores alarm log data in nonvolatile memory. You define the size of the alarm log (the maximum number of events). When determining the maximum number of events, consider the circuit monitor’s total storage capacity. See “Memory Allocation” on page 105 for additional memory considerations.

DATA LOGS

The circuit monitor records meter readings at regularly scheduled intervals and stores the data in up to 14 independent data log files in its memory. Some data log files are preconfigured at the factory. You can accept the preconfigured data logs or change them to meet your specific needs. You can set up each data log to store the following information:

- Timed Interval—1 second to 24 hours (how often the values are logged)
- First-In-First-Out (FIFO) or Fill and Hold
- Values to be logged—up to 96 registers along with the date and time of each log entry

Use SMS to clear each data log file, independently of the others, from the circuit monitor’s memory. For instructions on setting up and clearing data log files, refer to the SMS online help file.

Alarm-Driven Data Log Entries

The circuit monitor can detect over 100 alarm conditions, including over/under conditions, digital input changes, phase unbalance conditions, and more. (See **Alarms** on page 83 for more information.) Use SMS to assign each alarm condition one or more tasks, including forcing data log entries into one or more data log files.

For example, assume that you've defined 14 data log files. Using SMS, you could select an alarm condition such as "Overcurrent Phase A" and set up the circuit monitor to force data log entries into any of the 14 log files each time the alarm condition occurs.

Organizing Data Log Files

You can organize data log files in many ways. One possible way is to organize log files according to the logging interval. You might also define a log file for entries forced by alarm conditions. For example, you could set up four data log files as follows:

Data Log 5:	Log voltage every minute. Make the file large enough to hold 60 entries so that you could look back over the last hour's voltage readings.
Data Log 6:	Log voltage, current, and power hourly for a historical record over a longer period.
Data Log 7:	Log energy once every day. Make the file large enough to hold 31 entries so that you could look back over the last month and see daily energy use.
Data Log 8:	Report by exception. The report by exception file contains data log entries that are forced by the occurrence of an alarm condition. See the previous section "Alarm-Driven Data Log Entries" for more information.

NOTE: The same data log file can support both scheduled and alarm-driven entries.

Data Log Storage

Each defined data log file entry stores a date and time and requires some additional overhead. To minimize storage space occupied by dates, times, and file overhead, use a few log files that log many values, as opposed to many log files that store only a few values each.

Consider that storage space is also affected by how many data log files you use (up to 14) and how many registers are logged in each entry (up to 96) for each data log file. See "Memory Allocation" on page 105 for additional storage considerations.

MIN/MAX LOGS

There are two Min/Max logs:

- Min/Max log
- Interval Min/Max/Average log

Min/Max Log

When any real-time reading reaches its highest or lowest value, the circuit monitor saves the value in the Min/Max log.You can use SMS to view and reset this log. For instructions, refer to the SMS online help. You can also view the min/max values from the display. From the Main Menu, select Min/Max and then select the value you'd like to view, such as amperes, volts, or frequency. See "Viewing Minimum and Maximum Values from the Min/Max Menu" on page 43 in this manual for detailed instructions. The Min/Max log cannot be customized.

Interval Min/Max/Average Log

In addition to the Min/Max log, the circuit monitor has a Min/Max/Average log. The Min/Max/Average log stores 23 quantities, which are listed below. At each interval, the circuit monitor records a minimum, a maximum, and an average value for each quantity. It also records the date and time for each interval along with the date and time for each minimum and maximum value within the interval. For example, every hour the default log will log the minimum voltage for phase A over the last hour, the maximum voltage for phase A over the last hour, and the average voltage for phase A over the last hour. All 23 values are preconfigured with a default interval of 60 minutes, but you can reset the interval from 1 to 1440 minutes. To setup, view, and reset the Min/Max/Average log using SMS, see "Reading and Writing Registers" in the SMS online help. The following values are logged into the Min/Max/Average log:

- Voltage Phase A–B
- Voltage Phase B–C
- Voltage Phase C–A
- Voltage N–G
- Current Phase A
- Current Phase B
- Current Phase C
- Current Phase N
- Current Phase G
- kW 3-Phase Average
- kVAR 3-Phase Average
- kVA 3-Phase Average
- kW Demand 3-Phase Average
- kVAR Demand 3-Phase Average
- kVA Demand 3-Phase Average
- THD Voltage A–N
- THD Voltage B–N
- THD Voltage C–N
- THD Voltage A–B
- THD Voltage B–C
- THD Voltage C–A
- True Power Factor 3-Phase Total
- Displacement Power Factor 3-Phase Total

Interval Min/Max/Average Log Storage

When determining storage space among the logs, consider that storage space is affected by how often the circuit monitor is logging min/max/average values and how many entries are stored.

MAINTENANCE LOG

The circuit monitor stores a maintenance log in nonvolatile memory. Table 7–1 describes the values stored in the maintenance log. These values are cumulative over the life of the circuit monitor and cannot be reset.

Use SMS to view the maintenance log. Refer to the SMS online help for instructions.

Table 7–1: Values Stored in Maintenance Log

Value Stored	Description
Number of Demand Resets	Number of times demand values have been reset.
Number of Energy Resets	Number of times energy values have been reset.
Number of Min/Max Resets	Number of times min/max values have been reset.
Number of Output Operations	Number of times a digital output has operated. This value is stored for each digital output.
Number of Power Losses	Number of times circuit monitor has lost control power.
Number of Firmware Downloads	Number of times new firmware has been downloaded to the circuit monitor over communications.
Number of I/R Comms Sessions	Number of times the I/R communications port has been used. (Available only with VFD display.)
Highest Temperature Monitored	Highest temperature reached inside the circuit monitor.
Lowest Temperature Monitored	Lowest temperature reached inside the circuit monitor.
Number of GPS time syncs	Number of syncs received from the global positioning satellite transmitter.
Number of option card changes	Number of times the option card has been changed. Stored for both option card slots.
Number of I/O extender changes	Number of times the I/O extender has been changed.
Number of times KYZ pulse output overdriven	Number of times the KYZ pulse output is overdriven
Number of input metering accumulation resets	Number of times input pulse demand metering has been reset.

MEMORY ALLOCATION

The circuit monitor's standard, nonvolatile memory is 16 MB and can be upgraded to 32 MB and higher. See "Upgrading Memory in the Circuit Monitor" on page 136 for more information about upgrading memory.

When using SMS to set up a circuit monitor, you must allocate the total data storage capacity between the following logs and recorded information:

- Alarm log
- Steady-state waveform capture
- Disturbance waveform capture (cycles)
- Adaptive waveform capture (seconds)
- 100-ms rms event recording
- Up to 14 data logs
- Min/Max/Average log

In addition, the choices you make for the items listed below directly affect the amount of memory used:

- The number of data log files (1 to 14)
- The registers logged in each entry (1 to 96), for each data log file.
- The maximum number of entries in each data log file.
- The maximum number of events in the alarm log file.
- The maximum number of waveform captures in each of the waveform capture files. Consider that you set the maximum number for three different waveform captures: steady-state, disturbance waveform (cycles), and adaptive waveforms (seconds) plus a 100 ms rms event recording.

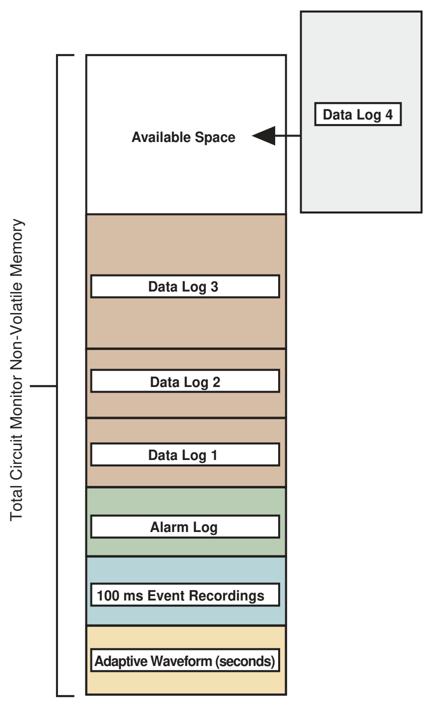
The number you enter for each of the above items depends on the amount of the memory that is still available, and the available memory depends on the numbers you've already assigned to the other items.

With a minimum of 16 MB of memory, it is unlikely that you will need to use all the circuit monitor's memory, even if you use all 14 data logs and the other recording features. However, it is important to understand that memory is shared by the alarm logs, data logs, and waveform captures. Figure 7–1, on the left, shows how the memory might be allocated.

In Figure 7–1, the user has set up an adaptive waveform (seconds), a 100 ms event recording, an alarm log, and three data logs (two small logs, and one larger log). Of the total available nonvolatile memory, about 25% is still available. If the user decided to add a fourth data log file, the file could be no larger than the space still available—25% of the circuit monitor's total storage capacity. If the fourth file had to be larger than the space still available, the user would have to reduce the size of one of the other files to free up the needed space.

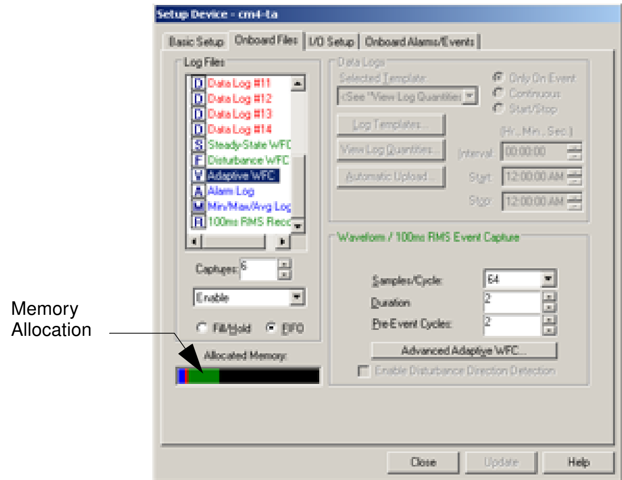
SMS displays the memory allocation statistics in the OnBoard Files dialog box shown in Figure 7–2. Color blocks on the bar show the space devoted to each type of log file, while black indicates memory still available. For instructions on setting up log files using SMS, refer to SMS online help file included with the software.

Figure 7–1: Memory allocation example



If you want to add a new log file, but the file is too large for the available space, you must either:
- reduce the size of Data Log 4 or
- reduce the size of one or more of the existing files

Figure 7–2: Memory allocation in SMS



CHAPTER 8—WAVEFORM AND EVENT CAPTURE

TYPES OF WAVEFORM CAPTURES

Using waveform captures you can monitor power sags and swells that may be produced, for example, when an X-ray machine and an elevator are used at the same time, or more commonly, when lightning strikes the distribution system that feeds the facility. The system's alarms can be programmed to detect and record such fluctuations, enabling you to determine an appropriate strategy for corrective action.

Circuit monitors use a sophisticated, high-speed sampling technique to simultaneously sample up to 512 samples per cycle on all current and voltage channels. From this sampling, the circuit monitor saves waveform data into its memory. These waveform captures can be graphically displayed using SMS. The circuit monitor has one type of waveform capture that you initiate manually; the other three event captures are associated with and triggered by an event such as a digital input transition or over/under condition. These event recordings help you understand what happened during an electrical event. Using event captures you can analyze power disturbances in detail, identify potential problems, and take corrective action. See **Disturbance Monitoring** on page 113 for more about disturbance monitoring. The types of event captures are described in the sections that follow.

Steady-State Waveform Capture

The steady-state waveform capture can be initiated manually to analyze steady-state harmonics. This waveform provides information about individual harmonics, which SMS calculates through the 255th harmonic. It also calculates total harmonic distortion (THD) and other power quality parameters. The waveform capture records one cycle at 512 samples per cycle simultaneously on all metered channels.

Initiating a Steady-state Waveform

Using SMS from a remote PC, initiate a steady-state waveform capture manually by selecting the circuit monitor and issuing the acquire command. SMS will automatically retrieve the waveform capture from the circuit monitor. You can display the waveform for all three phases, or zoom in on a single waveform, which includes a data block with extensive harmonic data. See the SMS online help for instructions.

Disturbance Waveform Capture

Use the disturbance waveform capture to record events that may occur within a short time span such as multiple sags or swells. The circuit monitor initiates a disturbance waveform capture automatically when an alarm condition occurs (if the alarm is set up to perform the waveform capture). The trigger may be from an external device such as an protective relay trip contact connected to a digital input or voltage sag alarm, or you can also initiate the waveform capture manually from SMS at any time.

In SMS, for the disturbance waveform capture, you select the sample rate and how many cycles and pre-event cycles the circuit monitor will capture (see Table 8–1).

Table 8–1: Available Resolutions for Disturbance Waveform Captures

Samples per Cycle (Resolution)	Max Duration
16	715 cycles
32	357 cycles
64	178 cycles
128	89 cycles
256	44 cycles
512	22 cycles

See the SMS online help for instructions on setting up disturbance waveform captures.

Adaptive Waveform Capture

The adaptive waveform capture is used to record longer events that cannot be recorded with the disturbance waveform capture. For example, using the adaptive waveform capture you could get a detailed view of an entire recloser sequence. Each time a sag or swell is detected, the circuit monitor triggers the waveform capture. The circuit monitor initiates an adaptive waveform capture automatically when an alarm condition occurs, or the waveform capture can also be triggered by an external device such as a protective relay. The unique feature of the adaptive waveform capture is that it can be enabled to stop recording at the dropout of the alarm, which allows you to capture data while the alarm is true. You can also initiate this waveform capture at any time.

In SMS, for the adaptive waveform capture, you select the sample rate, and how many seconds of the event the circuit monitor will capture (see Table 8–2). You can also select how many channels to record. Selecting fewer channels lets you record more seconds.

Table 8–2: Available Resolutions for Adaptive Waveform Captures

Samples per Cycle (Resolution)	Max. Duration (with per-phase current and voltage channels)
16	88 seconds
32	44 seconds
64	22 seconds
128	11 seconds
256	5 seconds
512	2 seconds

Choose fewer samples per cycle when you want to see more total seconds; choose fewer channels to see a longer duration. See the SMS online help for instructions on setting up adaptive waveform captures.

NOTE: The circuit monitor also records the status of up to 16 digital inputs that can be displayed along with the waveform capture. This is configured by default.

100MS RMS EVENT RECORDING

The 100ms rms event capture gives you a different view of an event by recording 100ms data for the amount of time you specify. Table 8–3 lists all the quantities captured. This type of event capture is useful for analyzing what happened during a motor start or recloser operation because it shows a long event without using a significant amount of memory. The circuit monitor initiates the event capture automatically when an alarm condition occurs, or an external device can also trigger the event capture. You select the duration of the event recording (up to 300 seconds) and the number of pre-event seconds (1–10) that the circuit monitor will capture.

Table 8–3: 100ms rms Event Capture Quantities

Current Per-Phase Neutral[1]
Voltage Line-to-Neutral, Per-Phase* Line-to-Line, Per-Phase
Real Power Per-Phase* 3-Phase Total
Reactive Power Per-Phase* 3-Phase Total
Apparent Power 3-Phase Total
Power Factor (True) 3-Phase Total
*4-wire systems only

CYCLE-BY-CYCLE RMS EVENT RECORDING

The circuit monitor can initiate a Cycle-by-Cycle log capture automatically when an alarm condition occurs. An external device can also trigger the capture. This log will terminate after a period of time that you designate, or upon alarm dropout (early terminate), whichever comes first. You can set the duration of the event recording (up to 3000 entries - 50 seconds for a 60 Hz system). The number of pre-event records can be from 0–100. The quantities logged in the Cycle-by-Cycle log are not user configurable. They are the rms values of eight channels (V_{ab}, V_{bc}, V_{ca}, V_{ng}, I_a, I_b, I_c, and I_n). A date-time stamp is also appended to each entry.

Setting Up Cycle-by-Cycle RMS Event Recording

To set up Cycle-by-Cycle RMS Event Recording, refer to Appendix B for instructions on using command codes and follow these steps:

1. Write **9020** in register 8000.
2. Enter the parameters in the registers as shown in Table 8–4 on page 110.

Table 8–4: Parameter Settings for Cycle-by-Cycle RMS Event

Register	Register Name	Parameter	Description
8001	Command parameters	30	File number
8002		8	Allocated records size (not user configurable)
8003		3000	Allocated file size per number of records
8017	Status pointer	8020	Register number where status will be placed
8018	Result pointer	8021	Register number where result will be placed
8019	Data pointer	8022	Register number where data will be placed
8022		(-1)	Enable file
8023		0	FIFO
8024		30	Pre-history
8025		300	Maximum per trigger

3. Write **7110** in register 8000.
4. Write **1** in register 8001.
5. Write **9021** in register 8000.

Configuring the Alarms

To trigger the Cycle-by-Cycle log, you must also configure the alarms that trigger Cycle-by-Cycle RMS Event Recording. To do so, follow these steps:

1. Write **9020** in register 8000.
2. Determine the Alarm Position Number (1–185).
3. Calculate register numbers for the Datalog Specifier.
4. 10296 + (20 x Alarm Position Number).
5. Read the Datalog Specifier register value and add 8192 to this value.
6. Write the new Datalog Specifier value to the Datalog Specifier register.
7. Repeat steps 2–5 for other alarms that are to trigger the Cycle-by-Cycle log.
8. Write **1** in register 8001.
9. Write **9021** in register 8000.

SETTING UP THE CIRCUIT MONITOR FOR AUTOMATIC EVENT CAPTURE

There are two ways to set up the circuit monitor for automatic event capture:

- Use an alarm to trigger the waveform capture.
- Use an external trigger such as a relay.

This section provides an overview of the steps you perform in SMS to setup these event captures.

Setting Up Alarm-Triggered Event Capture

To set up the circuit monitor for automatic event capture, use SMS to perform the following steps:

NOTE: For detailed instructions, refer to the SMS online help.

1. Select the type of event capture (disturbance, adaptive, or 100ms) and set up the number of samples per cycle, pre-event cycles or seconds, and duration.
2. Select an alarm condition.
3. Define the pick up and dropout setpoints of the alarm, if applicable.
4. Select the automatic waveform capture option (Capture Waveform on Event). Check the pickup-to-dropout box if you want it to use it for an adaptive waveform capture.
5. Repeat these steps for the desired alarm conditions.

Setting Up Input-Triggered Event Capture

When the circuit monitor is connected to an external device such as a protective relay, the circuit monitor can capture and provide valuable information on short duration events such as voltage sags. The circuit monitor must be equipped with digital inputs on an IOX Extender, or an IOC-44 Digital I/O Card.

To set up the circuit monitor for event capture triggered by an input, use SMS to perform the following steps:

NOTE: For detailed instructions, refer to the SMS online help.

1. Select the type of event capture (disturbance, adaptive, or 100ms) and set up the number of samples per cycle, pre-event cycles or seconds, and duration.
2. Create a digital alarm for the input if it is not already defined.
3. Select the alarm.
4. Choose the type of event recording you would like.

WAVEFORM STORAGE

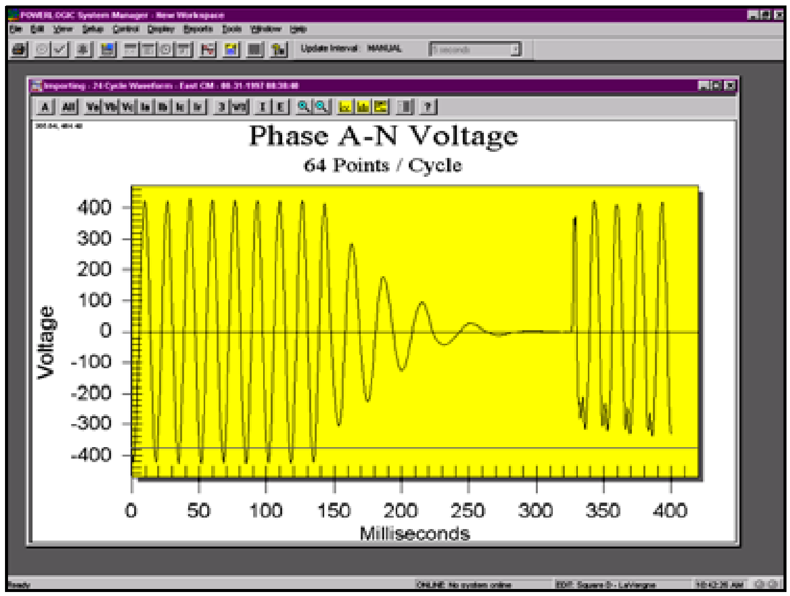
The circuit monitor can store multiple captured waveforms in its nonvolatile memory. The number of waveforms that can be stored is based on the amount of memory that has been allocated to waveform capture. However, the maximum number of stored waveforms is eighty of each type. All stored waveform data is retained on power-loss.

HOW THE CIRCUIT MONITOR CAPTURES AN EVENT

When the circuit monitor senses the trigger—that is, when the digital input transitions from OFF to ON, or an alarm condition is met—the circuit monitor transfers the cycle data from its data buffer into the memory allocated for event captures. The number of cycles or seconds it saves depends on the number of cycles or seconds you selected.

Figure 8–1 shows an event capture. In this example, the circuit monitor was monitoring a constant load when a utility fault occurred, followed by a return to normal.

Figure 8–1: Event capture initiated from a high-speed input



CHAPTER 9—DISTURBANCE MONITORING

ABOUT DISTURBANCE MONITORING

Momentary voltage disturbances are an increasing concern for industrial plants, hospitals, data centers, and other commercial facilities because modern equipment used in those facilities tends to be more sensitive to voltage sags, swells, and momentary interruptions. The circuit monitor can detect these events by continuously monitoring and recording current and voltage information on all metered channels. Using this information, you can diagnose equipment problems resulting from voltage sags or swells and identify areas of vulnerability, enabling you to take corrective action.

The interruption of an industrial process because of an abnormal voltage condition can result in substantial costs, which manifest themselves in many ways:

- labor costs for cleanup and restart
- lost productivity
- damaged product or reduced product quality
- delivery delays and user dissatisfaction

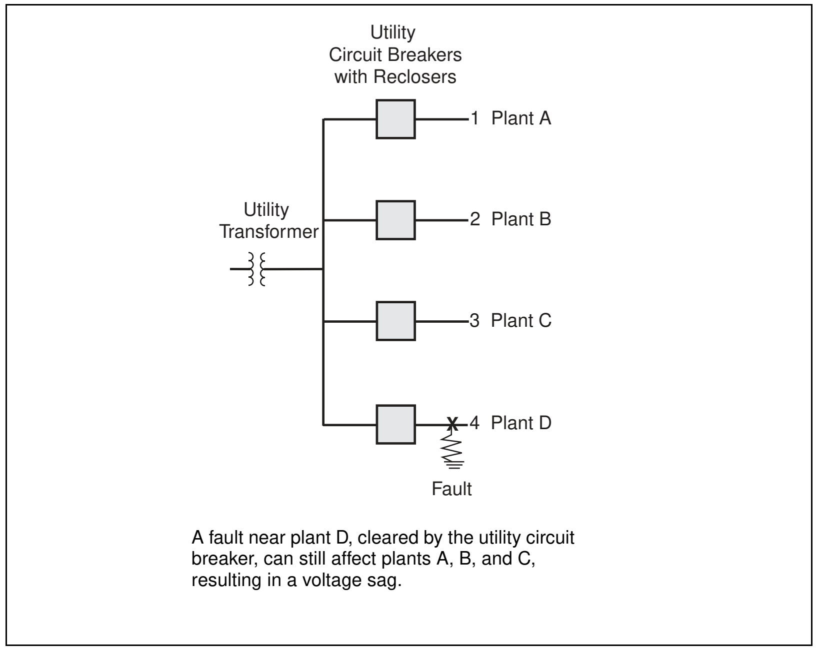
The entire process can depend on the sensitivity of a single piece of equipment. Relays, contactors, adjustable speed drives, programmable controllers, PCs, and data communication networks are all susceptible to transient and short-duration power problems. After the electrical system is interrupted or shut down, determining the cause may be difficult.

Several types of voltage disturbances are possible, each potentially having a different origin and requiring a separate solution. A momentary interruption occurs when a protective device interrupts the circuit that feeds a facility. Swells and overvoltages can damage equipment or cause motors to overheat. Perhaps the biggest power quality problem is the momentary voltage sag caused by faults on remote circuits.

A voltage sag is a brief (1/4 cycle to 1 minute) decrease in rms voltage magnitude. A sag is typically caused by a remote fault somewhere on the power system, often initiated by a lightning strike. In Figure 9–1, the utility circuit breaker cleared the fault near plant D. The fault not only caused an interruption to plant D, but also resulted in voltage sags to plants A, B, and C.

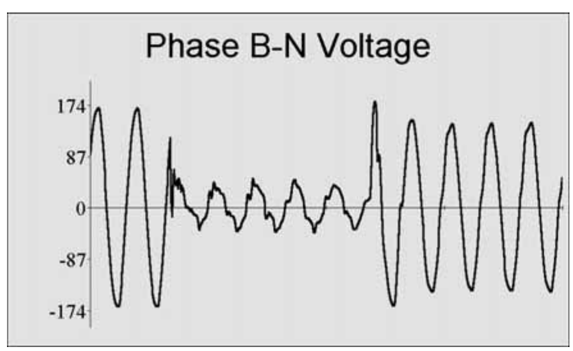
NOTE: The CM4250 is able to detect sag and swell events less than 1/4 cycle duration. However, it may be impractical to have setpoints more sensitive than 10% for voltage and current fluctuations.

Figure 9–1: A fault can cause voltage sag on the whole system.



System voltage sags are much more numerous than interruptions, since a wider part of the distribution system is affected. And, if reclosers are operating, they may cause repeated sags. The circuit monitor can record recloser sequences, too. The waveform in Figure 9–2 shows the magnitude of a voltage sag, which persists until the remote fault is cleared.

Figure 9–2: Waveform showing voltage sag, which was caused by a remote fault and lasted five cycles.



With the information obtained from the circuit monitor during a disturbance, you can solve disturbance-related problems, including the following:

- Obtain accurate measurement from your power system
  - — Identify the number of sags, swells, or interruptions for evaluation
  - — Determine the source (user or utility) of sags or swells
  - — Accurately distinguish between sags and interruptions, with accurate recording of the time and date of the occurrence
  - — Provide accurate data in equipment specification (ride-through, etc.)
- Determine equipment sensitivity
  - — Compare equipment sensitivity of different brands (contactor dropout, drive sensitivity, etc.)
  - — Diagnose mysterious events such as equipment failure, contactor dropout, computer glitches, etc.
  - — Compare actual sensitivity of equipment to published standards
  - — Use waveform capture to determine exact disturbance characteristics to compare with equipment sensitivity
  - — Justify purchase of power conditioning equipment
  - — Distinguish between equipment failures and power system related problems
- Develop disturbance prevention methods
  - — Develop solutions to voltage sensitivity-based problems using actual data
- Work with the utility
  - — Discuss protection practices with the serving utility and negotiate suitable changes to shorten the duration of potential sags (reduce interruption time delays on protective devices)
  - — Work with the utility to provide alternate “stiffer” services (alternate design practices)

CAPABILITIES OF THE CIRCUIT MONITOR DURING AN EVENT

The circuit monitor calculates rms magnitudes, based on 128 data points per cycle, every 1/2 cycle. This ensures that even sub-cycle duration rms variations are not missed.The circuit monitor is capable of measuring electromagnetic phenomena in a power system as defined in IEEE Recommended Practice for Monitoring Electric Power Quality (IEEE Standard 1159-95) for the following categories:

- Short duration variations—instantaneous, momentary, and temporary
- Long duration variations
- Voltage imbalance
- Waveform distortion
- Power frequency variations
- Voltage transients (30.72 kHz)

When the circuit monitor detects a sag or swell, it can perform the following actions:

- **Perform a waveform capture** with a resolution up to 512 samples per cycle on all channels of the metered current and voltage inputs. Three types of automatic event captures are possible: disturbance, adaptive, and 100 ms. See “Types of Waveform Captures” on page 107 in Waveform and Event Capture for more about waveform and event captures. Use SMS to setup the event capture and retrieve the waveform.

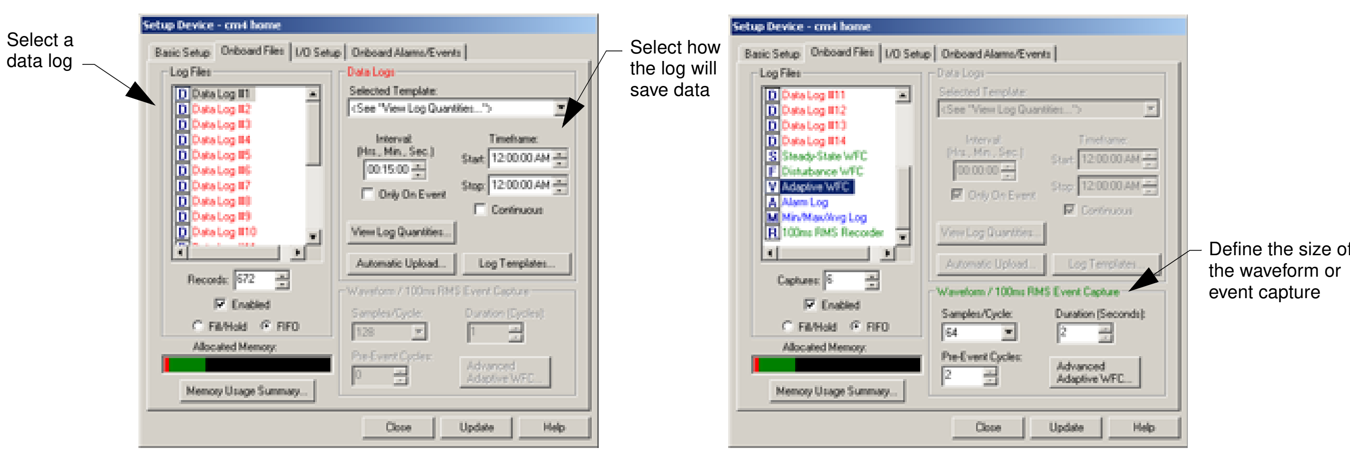
- **Record the event in the alarm log**. When an event occurs, the circuit monitor updates the alarm log with an event date and time stamp with 1 millisecond resolution for a sag or swell pickup, and an rms magnitude corresponding to the most extreme value of the sag or swell during the event pickup delay. Also, the circuit monitor can record the sag or swell dropout in the alarm log at the end of the disturbance. Information stored includes: a dropout time stamp with 1 millisecond resolution and a second rms magnitude corresponding to the most extreme value of the sag or swell. Use SMS to view the alarm log.
- **Force a data log entry** in up to 14 independent data logs. Use SMS to set up and view the data logs.
- **Operate any output relays** when the event is detected.
- **Indicate the alarm** on the display by flashing the alarm LED to show that a sag or swell event has occurred. From the circuit monitor's display, a list of up to 10 of the previous alarms in the high priority log is available. You can also view the alarms in SMS.

USING THE CIRCUIT MONITOR WITH SMS TO PERFORM DISTURBANCE MONITORING

The following procedure provides an overview of the steps to set up the circuit monitor for disturbance monitoring. For detailed instructions, see the SMS online help. In SMS under Setup > Devices Routing, the Device Setup dialog box contains the tabs for setting up disturbance monitoring. After you have performed basic set up of the circuit monitor, perform three setup steps:

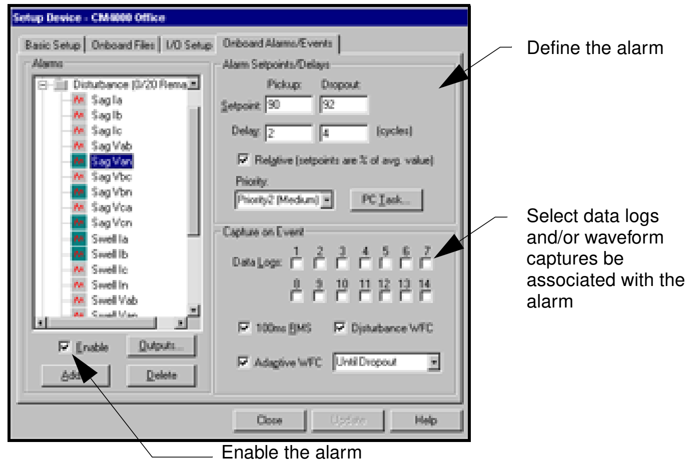
1. Define the storage space for the alarm log, waveform capture, and any forced data logs using the Onboard Files tab in SMS. This sets up the amount of circuit monitor memory that the logs and waveform capture will use.

Figure 9–3: Onboard Files tab



2. Associate an alarm with data logs and waveform/event captures using the Onboard Alarms/Events tab.

Figure 9–4: Onboard Alarms/Events tab



3. In addition, you can set up a relay to operate upon an event using the I/O tab in SMS.

   NOTE: For the I/O Extender, you must define the relay from the display before SMS can recognize it. See "Setting Up I/Os" on page 25 of this bulletin for instructions.

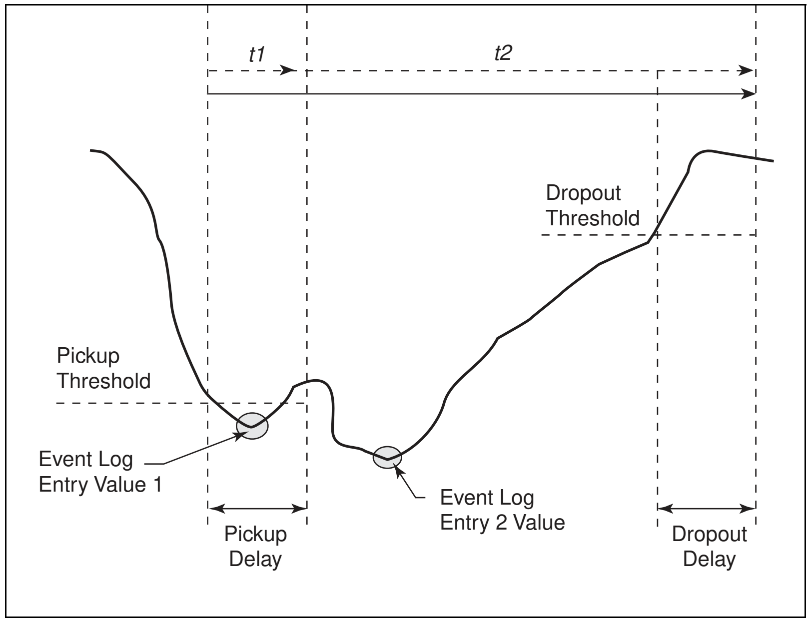
UNDERSTANDING THE ALARM LOG

Pickups and dropouts of an event are logged into the onboard alarm log of the circuit monitor as separate entries. Figure 9–5 on page 118 illustrates an alarm log entry sequence. In this example, two events are entered into the alarm log:

- Alarm Log Entry 1—The value stored in the alarm log at the end of the pickup delay is the furthest excursion from normal during the pickup delay period *t1*. This is calculated using 128 data point rms calculations.
- Alarm Log Entry 2—The value stored in the alarm log at the end of the dropout delay is the furthest excursion from normal during period *t2* from the end of the pickup delay to the end of the dropout delay.

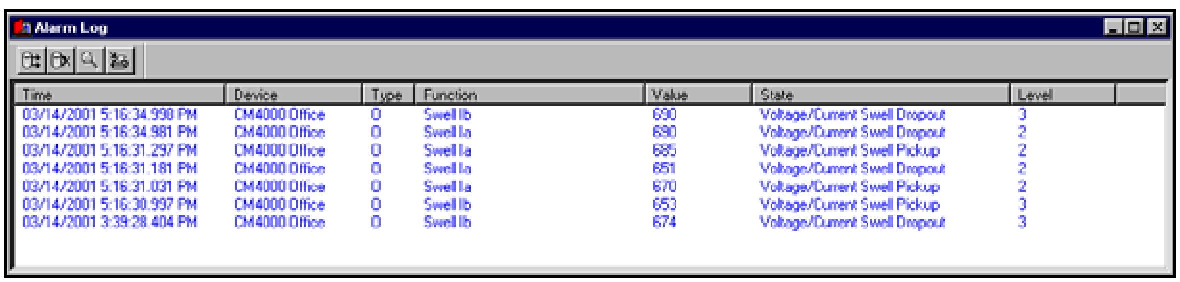
The time stamps for the pickup and dropout reflect the actual duration of these periods.

Figure 9–5: Event log entries example



Once the alarm has been recorded, you can view the alarm log in SMS. A sample alarm log entry is shown in Figure 9–6. See SMS online help for instructions on working with the alarm log.

Figure 9–6: Sample alarm log entry



Alarm Log

Time	Device	Type	Function	Value	State	Level
03/14/2001 5:16:34.998 PM	CM4000 Office	0	Swell Ib	690	Voltage/Current Swell Dropout	3
03/14/2001 5:16:34.981 PM	CM4000 Office	0	Swell Ia	690	Voltage/Current Swell Dropout	2
03/14/2001 5:16:31.297 PM	CM4000 Office	0	Swell Ia	685	Voltage/Current Swell Pickup	2
03/14/2001 5:16:31.181 PM	CM4000 Office	0	Swell Ia	651	Voltage/Current Swell Dropout	2
03/14/2001 5:16:31.031 PM	CM4000 Office	0	Swell Ia	670	Voltage/Current Swell Pickup	2
03/14/2001 5:16:30.997 PM	CM4000 Office	0	Swell Ib	653	Voltage/Current Swell Pickup	3
03/14/2001 3:39:28.404 PM	CM4000 Office	0	Swell Ib	674	Voltage/Current Swell Dropout	3

USING EN50160 EVALUATION

This section describes how the circuit monitor operates when the European standard EN50160 evaluation feature is enabled. For instructions on how to enable this evaluation, see “Setting Up EN50160 Evaluation” on page 130.

Overview

This overview summarizes the EN50160 standard.

EN50160:2000 “Voltage characteristics of electricity supplied by public distribution systems” is a European standard that defines the quality of the voltage a customer can expect from the electric utility. Although this is a European standard, it can be applied in the U.S.

The circuit monitor evaluates the following electrical characteristics in accordance with EN50160:

- Frequency
- Magnitude of the supply voltage
- Supply voltage variations
- Rapid voltage changes – voltage magnitude and flicker
- Supply voltage dips
- Short interruptions of the supply voltage
- Long interruptions of the supply voltage
- Temporary power frequency overvoltages
- Transient overvoltages
- Supply voltage unbalance
- Harmonic voltage

The EN50160 evaluations can be divided into two categories—those based on metering data during normal operation and those based on abnormal events. Much of this data is available from the circuit monitor standard data and alarms; however, evaluation of flicker and transient overvoltages requires a CM4000T.

The standard sets limits for some of the evaluations. These limits are built into the circuit monitor firmware. You can configure registers for other evaluations and change them from the default values. These configuration registers are protected while revenue security is active. (Revenue security is a circuit monitor feature that restricts access to certain configuration registers and reset commands related to revenue metering.)

How Results of the Evaluations Are Reported

The circuit monitor reports evaluation data in register entries and alarm log entries. Table 9–1 describes the register entries for the evaluation data.

Table 9–1: Register Entries

Register Number	Description
3910	Summary bitmap of **active evaluations** that reports which areas of evaluation are active in the circuit monitor.
3911	Summary bitmap of **evaluation status** that reports the pass/fail status of each **area** of evaluation.
Portal registers	Detail bitmap of evaluation status that reports the pass/fail status of the evaluation of each individual data item. Detailed data summary information is also available for each of the evaluations for the present interval and for the previous interval. You can access this data over a communications link using Modbus block reads of “portal” registers. Refer to “EN50160 Evaluation of Meter Data” on page 124 for additional information.

Log entries for the evaluation data include:

- Onboard alarm log entry for diagnostic alarms. When the status of an area of evaluation is outside the range of acceptable values, an entry is made in the on-board alarm log. This entry provides notification of the exception for a specific area of evaluation. This notification is reported only in SMS and does not appear on the local display.

- Onboard alarm log entry for alarms. Circuit monitor alarms are used to perform some of the evaluations. If an onboard alarm log is enabled, an entry will be made in the on-board alarm log when any of these alarms pick up or drop out.

NOTE: Enabling EN50160 evaluation does not guarantee that the onboard alarm log is enabled or properly configured to record these events. Also, when you enable EN50160 evaluation, you do not automatically configure onboard data logging or waveform capture files. You should consider your requirements and configure these files and the event captures triggered by the various alarms to provide any additional data that would be helpful to diagnose or document an exception to this standard.

Possible Configurations Through Register Writes

This section describes the changes you can make to configurations for the EN50160 evaluation through register writes in the circuit monitor. Refer to “System Configuration and Status Registers” on page 125 for register assignments.

- **Select the first day of the week for evaluations**. You can define the first day of the week to be used for the EN50160 evaluations in register 3905.
- **Define the voltage interruption.** The standard defines an interruption as voltage less than 1% of nominal voltage. Because some locations require a different definition, you can configure this value in register 3906.
- **Define allowable range of slow voltage variations.** The standard defines the allowable range of slow voltage variations to be ±10% of nominal voltage. Because some locations require a different definition, you can configure this value in register 3907.

Evaluation of Abnormal Events

Count of Rapid Voltage Changes

The standard does not specify the rate of change of the voltage for this evaluation. For this evaluation, the circuit monitor counts a change of ≥5% nominal and ≤10% nominal from one one-second meter cycle to the next one-second meter cycle. It counts rapid voltage decreases and increases separately. The interval for accumulation of these events is one week.

You can configure the number of allowable events per week in register 3917. (Default = -32768 = Pass/Fail evaluation disabled.)

Detection and classification of Supply Voltage Dips

According to EN50160, voltage dips are generally caused by faults in installations or the electrical utility distribution system. Under normal operating conditions, the number of voltage dips expected may be anywhere from less than a hundred to nearly a thousand. The majority of voltage dips last less than one second with a depth less than 60%. However, voltage dips of greater depth and duration can occasionally occur. In some regions, voltage dips with depths between 10% and 15% of the nominal voltage are common because of the switching of loads at a customer’s installation.

Supply voltage dips are under-voltage events that last from 10 ms to 1 minute. Magnitudes are the minimum rms values during the event. Disturbance alarms are used to detect events ≤ 11 seconds. The register-based disturbance event log is used to capture the events. Standard speed undervoltage alarms are used to detect events having a duration greater than 11 seconds. The register-based event log is used to capture the events. The EN50160 function watches these logs for new entries and classifies these events. The standard does not specifically address how to classify supply voltage dips or how many are allowable. The circuit monitor detects and classifies the dips for each phase voltage as follows:

	Duration (t) seconds											
Depth (D) % Nominal	0.01 ≤ t < 0.02	0.02 ≤ t < 0.05	0.05 ≤ t < 0.1	0.1 ≤ t < 0.2	0.2 ≤ t < 0.5	0.5 ≤ t < 1	1 ≤ t < 3	3 ≤ t < 10	10 ≤ t < 20	20 ≤ t < 60	60 ≤ t < 180	Total
10 ≤ D < 15												
15 ≤ D < 30												
30 ≤ D < 45												
45 ≤ D < 60												
60 ≤ D < 75												
75 ≤ D < 90												
90 ≤ D < 99												
Total												

You can configure the number of allowable events per week for each range of Depth in registers 3920 – 3927. (Default = -32768 = Pass/Fail evaluation disabled.)

Detection of Interruptions of the Supply voltage

The standard defines an interruption as voltage less than 1% of nominal voltage. Because some locations require a different definition, you can configure this value in register 3906. Interruptions are classified as “short” if duration ≤ 3 minutes or “long” otherwise. The circuit monitor classifies interruptions as shown in the following table.

You can configure the number of allowable short interruptions per year in register 3918 (Default = -32768 = Pass/Fail evaluation disabled). You can configure the number of allowable long interruptions per year in register 3919. (Default = -32768 = Pass/Fail evaluation disabled.)

	Duration (t) seconds									
	t < 1	1 ≤ t < 2	2 ≤ t < 5	5 ≤ t < 10	10 ≤ t < 20	20 ≤ t < 60	60 ≤ t < 180	180 ≤ t < 600	600 ≤ t < 1200	1200 ≤ t
Total										

Detecting and Classifying Temporary Power Frequency Overvoltages

As stated in EN50160, a temporary power frequency overvoltage generally appears during a fault in the electrical utility power distribution system or in a customer’s installation, and disappears when the fault is cleared. Usually, the overvoltage may reach the value of phase-to-phase voltage because of a shift of the neutral point of the three-phase voltage system.

Under certain circumstances, a fault occurring upstream from a transformer will produce temporary overvoltages on the low voltage side for the time during which the fault current flows. Such overvoltages will generally not exceed 1.5 kV rms.

The circuit monitor detects and classifies the overvoltages for each phase voltage as follows:

Duration (t) seconds												
Magnitude (M) % Nominal	0.01 ≤ t < 0.02	0.02 ≤ t < 0.05	0.05 ≤ t < 0.1	0.1 t < 0.2	0.2 ≤ t < 0.5	0.5 ≤ t < 1	1 ≤ t < 3	3 ≤ t < 10	10 ≤ t < 20	20 ≤ t < 60	60 ≤ t < 180	Total
110 < M ≤ 115												
115 < M ≤ 130												
130 < M ≤ 145												
145 < M ≤ 160												
160 < M ≤ 175												
175 < M ≤ 200												
M > 200												
Total												

You can configure the number of allowable events per week for each range of Magnitude in registers 3930 – 3937. (Default = -32768 = Pass/Fail evaluation disabled.)

Detecting Transient Overvoltages

The impulsive transient alarm is used to detect transient overvoltages between live conductors and earth. (This feature is available only in the CM4000T model.) The register-based transient event log is used to capture the events. The log is configured to capture all transient events. The EN50160 function watches this log for new entries and classifies the overvoltages for each phase voltage as follows:

	Duration (t) microseconds							
Magnitude (M) % Nominal	t < 20	20 ≤ t < 50	50 ≤ t < 100	100 ≤ t < 200	200 ≤ t < 500	500 ≤ t < 1000	1000 ≤ t < 2000	Total
200 < M ≤ 300								
300 < M ≤ 400								
400 < M ≤ 500								
500 < M ≤ 600								
600 < M ≤ 700								
700 < M ≤ 800								
800 < M ≤ 900								
900 < M ≤ 1000								
M > 1000								
Total								

You can configure the number of allowable number of events per week for each range of Magnitude in registers 3940 – 3949. (Default = -32768 = Pass/Fail evaluation disabled.)

Circuit Monitor Operation with EN50160 Enabled

This section describes how circuit monitor operation is affected when EN50160 evaluation is enabled.

Resetting Statistics

You can reset statistics for the EN50160 evaluations with the command 11100. A parameter value of 9999 will reset all items. A timestamp is provided in registers for each item indicating when the last reset was performed. This command is disabled when revenue security is active.

NOTE: You should reset statistics when you enable EN50160 for the first time and also whenever you make any changes to the basic meter setup such as changing the nominal voltage. See “Setting Up EN50160 Evaluation” on page 130.

Standard Alarms Allocated for Evaluations

To accomplish some of the evaluations required and to provide a record of events in the on-board alarm log, the circuit monitor uses standard alarms. When the evaluation is enabled, certain alarm positions will be claimed for use in the evaluation. You cannot use these alarms for other purposes while the evaluation is enabled. These alarms include:

- Over Voltage: Standard speed alarm positions 75-77
- Under Voltage: Standard speed alarm positions 78-80
- Disturbance (voltage sags and swells): Disturbance alarm positions 1-3 and 5-13
- Transient Overvoltages: Impulsive transient alarm

“EN50160” is included in the alarm label for alarms being used by this evaluation.

Flicker Monitoring

When EN50160 evaluation is enabled, you can configure flicker monitoring. (This feature is available only in the CM4000T model.) The settings specified in the standard are:

- Pst duration = 10 minutes
- Plt duration 12 x Pst.

Harmonic Calculations

When EN50160 evaluation is enabled, the harmonic calculations will be set to update every 10 seconds. You can select the format of the harmonic calculations to be %Nominal, %Fundamental, or %RMS.

Time Intervals

Time intervals are synchronized with the Trending and Forecasting feature. Refer to the *POWERLOGIC Web Pages instruction bulletin 63230-304-207*. Weekly values will be posted at midnight of the morning of the “First Day of Week” configured in register 3905. Yearly values will be based on the calendar year.

All of the EN50160 data is stored in non volatile memory once per hour or when an event occurs. In the event of a meter reset, up to one hour of routine meter evaluation data will be lost.

EN50160 Evaluation of Meter Data[1]

When the EN50160 evaluation is enabled, the circuit monitor evaluates metered data under normal operating conditions, “excluding situations arising from faults or voltage interruptions.” For this evaluation, normal operating conditions are defined as all phase voltages greater than the definition of interruption. The standard specifies acceptable ranges of operation for these data items.

This section describes how the EN50160 standard addresses metered data.

Power Frequency

EN50160 states that the nominal frequency of the supply voltage shall be 50 Hz. Under normal operating conditions the mean value of the fundamental frequency measured over ten seconds shall be within the following range:

- for systems with synchronous connection to an interconnected system:
  - 50 Hz ±1% during 99.5% of a year
  - 50 Hz +4 to -6% for 100% of the time
- for systems with no synchronous connection to an interconnected system (for example, power systems on some islands):
  - 50 Hz ±2% during 95% of a week
  - 50 Hz ±15% for 100% of the time

NOTE: The same range of percentages are used for 60 Hz systems.

Supply Voltage Variations

EN50160 states that under normal operating conditions, excluding situations arising from faults or voltage interruptions,

- during each period of one week 95% of the ten minute mean rms values of the supply voltage shall be within the range of U_n ±10%.
- all ten minute mean rms values of the supply voltage shall be within the range of U_n +10% to -15%.

Flicker Severity

EN50160 states that under normal operating conditions, in any period of one week, the long-term flicker severity caused by voltage fluctuation should be $P_n \leq 1$ for 95% of the time. (This feature is available only in the CM4000T model.)

1 BS EN 50160:2000, Voltage characteristics of electricity supplied by public distribution systems, BSi.

Supply Voltage Unbalance

EN50160 states that under normal operating conditions, during each period of one week, 95% of the ten minute mean rms values of the negative phase sequence component of the supply voltage shall be within the range 0–2% of the positive phase sequence component.

Harmonic Voltage

EN50160 states that under normal operating conditions, during each period of one week, 95% of the ten minute mean rms values of each individual harmonic voltage shall be less than or equal to the value given in Table 9–2. Additionally, the THD of the supply voltage shall be less than 8%.

Table 9–2: Values of individual harmonic voltages at the supply terminals for orders up to 25 in % of nominal voltage

Odd Harmonics				Even Harmonics	
Not Multiples of 3		Multiples of 3			
Order h	Relative Voltage	Order h	Relative Voltage	Order h	Relative Voltage
5	6%	3	5%	2	2%
7	5%	9	1.5%	4	1%
11	3.5%	15	0.5%	6...24	0.5%
13	3%	21	0.5%		
17	2%				
19	1.5%				
23	1.5%				
25					

NOTE: No values are given for harmonics of order higher than 25, as they are usually small, but largely unpredictable because of resonance effects.

System Configuration and Status Registers

Table 9–3 lists registers for system configuration and status evaluation.

Table 9–3: System Configuration and Status Registers

Register	Number	Description
3900	1	Enable/Disable EN50160 Evaluation 0 = Disable (default) 1 = Enable
3901	1	Nominal Voltage, (copied from register 3234 for reference) Default = 230
3902	1	Voltage Selection for 4-Wire Systems 0 = Line-to-Neutral (default) 1 = Line-to-Line
3903	1	Nominal Frequency, Hz (copied from register 3208 for reference) Default = 60
3904	1	Frequency configuration 0 = system with synchronous connection to interconnected system (default) 1 = system without synchronous connection to interconnected system

Table 9–3: System Configuration and Status Registers *(continued)*

Register	Number	Description
3905	1	First Day of Week 1 = Sunday 2 = Monday (default) 3 = Tuesday 4 = Wednesday 5 = Thursday 6 = Friday 7 = Saturday
3906	1	Definition of Interruption 0 – 10% Nominal (default = 1)
3907	1	Allowable Range of Slow Voltage Variations 1 – 20% Nominal (default = 10)
3908	1	Reserved
3909	1	Reserved
3910	1	Bitmap of active evaluations Bit 00 – Summary bit – at least one EN50160 evaluation is active Bit 01 – Frequency Bit 02 – Supply voltage variations Bit 03 – Magnitude of rapid voltage changes Bit 04 – Flicker Bit 05 – Supply voltage dips Bit 06 – Short interruptions of the supply voltage Bit 07 – Long interruptions of the supply voltage Bit 08 – Temporary power frequency overvoltages Bit 09 – Transient overvoltages Bit 10 – Supply voltage unbalance Bit 11 – Harmonic voltage Bit 12 – THD Bit 13 – Not used Bit 14 – Not used Bit 15 – Not used
3911	1	Bitmap of evaluation status summary Bit 00 – Summary bit – at least one EN50160 evaluation has failed. Bit 01 – Frequency Bit 02 – Supply voltage variations Bit 03 – Magnitude of rapid voltage changes Bit 04 – Flicker Bit 05 – Supply voltage dips Bit 06 – Short interruptions of the supply voltage Bit 07 – Long interruptions of the supply voltage Bit 08 – Temporary power frequency overvoltages Bit 09 – Transient overvoltages Bit 10 – Supply voltage unbalance Bit 11 – Harmonic voltage Bit 12 – THD Bit 13 – Not used Bit 14 – Not used Bit 15 – Not used
3912	2	Count of 10-second intervals present year
3914	2	Count of 10-second intervals this week
3916	1	Count of 10-minute intervals this week

Table 9–3: System Configuration and Status Registers *(continued)*

Register	Number	Description
3917	1	Number of allowable rapid voltage changes per week Default = -32768 = Pass/Fail evaluation disabled
3918	1	Number of allowable short interruptions per year Default = -32768 = Pass/Fail evaluation disabled
3919	1	Number of allowable long interruptions per year Default = -32768 = Pass/Fail evaluation disabled
3920	8	Number of allowable voltage dips per week for each range of Depth Default = -32768 = Pass/Fail evaluation disabled
3930	8	Number of allowable overvoltages per week for each range of Magnitude Default = -32768 = Pass/Fail evaluation disabled
3940	10	Number of allowable transient overvoltages per week for each range of Magnitude Default = -32768 = Pass/Fail evaluation disabled

Evaluation Data Available Over a Communications Link

Portal Registers

Evaluation data is available over communications via “portal” register reads. Each data item is assigned a portal register number. A block read of the specified size at that address will return the data for that item. In general, if the block size is smaller than specified, the data returned will be 0x8000 (-32768) to indicate the data is invalid. If the block size is larger than specified, the data for the item will be returned and the remaining registers will be padded with 0x8000. Refer to Table 9–4 for portal register descriptions.

Table 9–4: Portal Register Descriptions

Portal	Description	Size	Data
38270	Evaluation Summary Bitmap	18	Register 1 – Bitmap of active evaluations (same as register 3910) Bit set when evaluation is active Bit 00 – Summary bit – at least one EN50160 evaluation is active Bit 01 – Frequency Bit 02 – Supply voltage variations Bit 03 – Magnitude of rapid voltage changes Bit 04 – Flicker Bit 05 – Supply voltage dips Bit 06 – Short interruptions of the supply voltage Bit 07 – Long interruptions of the supply voltage Bit 08 – Temporary power frequency overvoltages Bit 09 – Transient overvoltages Bit 10 – Supply voltage unbalance Bit 11 – Harmonic voltage Bit 12 – THD Bit 13 – Not used Bit 14 – Not used Bit 15 – Not used

Table 9–4: Portal Register Descriptions *(continued)*

Portal	Description	Size	Data
			Register 3 (Range 1)/Register 11 (Range 2) – Bitmap of evaluation status of individual evaluations Bit 00 – Frequency Bit 01 – Va Bit 02 – Vb Bit 03 – Vc Bit 04 – Flicker Va Bit 05 – Flicker Vb Bit 06 – Flicker Vc Bit 07 – Voltage Unbalance Bit 08 – THD Va Bit 09 – THD Vb Bit 10 – THD Vc Bit 11 – Va H2 Bit 12 – Va H3 Bit 13 – Va H4 Bit 14 – Va H5 Bit 15 – Va H6
			Register 5 (Range 1)/Register 13 (Range 2) – Bitmap of evaluation status of individual evaluations Bit 00 – Va H23 Bit 01 – Va H24 Bit 02 – Va H25 Bit 03 – Vb H2 Bit 04 – Vb H3 Bit 05 – Vb H4 Bit 06 – Vb H5 Bit 07 – Vb H6 Bit 08 – Vb H7 Bit 09 – Vb H8 Bit 10 – Vb H9 Bit 11 – Vb H10 Bit 12 – Vb H11 Bit 13 – Vb H12 Bit 14 – Vb H13 Bit 15 – Vb H14
			Register 7 (Range 1)/Register 15 (Range 2) – Bitmap of evaluation status of individual evaluations Bit 00 – Vc H7 Bit 01 – Vc H8 Bit 02 – Vc H9 Bit 03 – Vc H10 Bit 04 – Vc H11 Bit 05 – Vc H12 Bit 06 – Vc H13 Bit 07 – Vc H14 Bit 08 – Vc H15 Bit 09 – Vc H16 Bit 10 – Vc H17 Bit 11 – Vc H18 Bit 12 – Vc H19 Bit 13 – Vc H20 Bit 14 – Vc H21 Bit 15 – Vc H22

Table 9–4: Portal Register Descriptions *(continued)*

Portal	Description	Size	Data
			Register 9 (Range 1)/Register 17 (Range 2) – Bitmap of evaluation status of individual evaluations Bit 00 – Ib H7 Bit 01 – Ic H7 Bit 02 – Ia H9 Bit 03 – Ib H9 Bit 04 – Ic H9 Bit 05 – Ia H11 Bit 06 – Ib H11 Bit 07 – Ic H11 Bit 08 – Ia H13 Bit 09 – Ib H13 Bit 10 – Ic H13 Bit 11 – Reserved Bit 12 – Reserved Bit 13 – Reserved Bit 14 – Reserved Bit 15 – Reserved
38271 – 38390	Summary of Meter Data Evaluations by Item	33	Register number of Metered Quantity (can be used to confirm data item being reported) Register value (present metered value) Average value (at end of last completed averaging time period) Minimum value during the last completed averaging time period Maximum value during the last completed averaging time period Minimum value during this interval Maximum value during this interval Minimum value during the last interval Maximum value during the last interval Percent in Evaluation Range 1 this interval Percent in Evaluation Range 2 this interval (when applicable) Percent in Evaluation Range 1 last interval Percent in Evaluation Range 2 last interval (when applicable) Count of average values in Evaluation Range 1 (MOD10L2) Count of average values in Evaluation Range 2 (MOD10L2) Count of total valid averages for Evaluation of Range 1 (MOD10L2) Count of total valid averages for Evaluation of Range 2 (MOD10L2) Date/Time Last Excursion Range 1 (4-register format) Date/Time Last Excursion Range 2 (4-register format) Date/Time Last Reset (4-register format)
38391 – 38393	Summary of Rapid Voltage Changes by Phase	12	Count of rapid voltage increases this week Count of rapid voltage decreases this week Count of rapid voltage increases last week Count of rapid voltage decreases last week Date/Time last rapid voltage change (4-register format) Date/Time last reset (4-register format)
38394 – 38396	Summary of Voltage Dips by Phase This Week	104	Count of dips by magnitude & duration this week (96 values) [See “Detection and classification of Supply Voltage Dips” on page 120.] Date/Time last voltage dip (4-register format) Date/Time last reset (4-register format)
38397 – 38399	Summary of Voltage Dips by Phase Last Week	104	Count of dips by magnitude & duration last week (96 values) [See “Detection and classification of Supply Voltage Dips” on page 120. Date/Time last voltage dip (4-register format) Date/Time last reset (4-register format)

Table 9–4: Portal Register Descriptions *(continued)*

Portal	Description	Size	Data
38400 – 38403	Summary of Supply Voltage Interruptions 3-Phase and by Phase	34	Flag indicating interruption is active Elapsed seconds for interruption in progress Count of short interruptions this year Count of long interruption this year Count of short interruptions last year Count of long interruptions last year Count of interruptions by duration this year (10 values) [See “Detection of Interruptions of the Supply voltage” on page 121.] Count of interruptions by duration last year (10 values) [See “Detection of Interruptions of the Supply voltage” on page 121.] Date/Time of last interruption (4-register format) Date/Time of last reset (4-register format)
38404 – 38406	Temporary Power Frequency Overvoltages by Phase This Week	104	Count of overvoltages by magnitude & duration this week (96 values) [See “Detecting and Classifying Temporary Power Frequency Overvoltages” on page 121.] Date/Time last overvoltage (4-register format) Date/Time last reset (4-register format)
38407 – 38409	Temporary Power Frequency Overvoltages by Phase Last Week	104	Count of overvoltages by magnitude & duration last week (96 values) [See “Detecting and Classifying Temporary Power Frequency Overvoltages” on page 121.] Date/Time last overvoltage (4-register format) Date/Time last reset (4-register format)
38410 – 38412	Transient Overvoltages by Phase This Week	88	Count of transients by magnitude & duration this week (80 values) [See “Detecting Transient Overvoltages” on page 123.] Date/Time last transient overvoltage (4-register format) Date/Time last reset (4-register format)
38413 – 38415	Transient Overvoltages by Phase Last Week	88	Count of transients by magnitude & duration last week (80 values) [See “Detecting Transient Overvoltages” on page 123.] Date/Time last transient overvoltage (4-register format) Date/Time last reset (4-register format)

Viewing EN50160 Evaluations Web Pages

You can view EN50160 Evaluations on web pages. Refer to the *POWERLOGIC Web Pages instruction bulletin 63230-304-207*.

Setting Up EN50160 Evaluation

In order to set up the EN50160 evaluation in the circuit monitor, you must complete the following tasks:

1. **Enable the EN50160 evaluation.**

   By default, the EN50160 evaluation is disabled. For instructions on enabling, see “Enabling the EN50160 Evaluation” on page 131.

2. **Select the nominal voltage** of your system.

   The EN50160 standard defines nominal voltage for low-voltage systems to be 230V line-to-line for 3-wire systems or 230V line-to-neutral for 4-wire systems. Therefore, the default value for Nominal Voltage is 230. If the application is a medium-voltage system or if you want the evaluations to be based on some other nominal voltage, you can configure this value using the display only. System Manager Software does not allow configuration of nominal voltage.

3. **Change the nominal frequency** of your system if you are evaluating a 50 Hz system.

   The EN50160 standard defines nominal frequency as 50 Hz, but the circuit monitor can also evaluate 60 Hz systems. It cannot evaluate nominal frequency for 400 Hz systems. The default nominal frequency in the circuit monitor is 60 Hz. To change the default, from the display Main

Menu, select Setup > Meter > Frequency. From SMS software, see the online help file.

4. **Reset the EN50160 Statistics**.
   a. Write **9999** in register 8001.
   b. Write **11100** in register 8000.

   Refer to “Resetting Statistics” on page 123.

Enabling the EN50160 Evaluation

Enabling the EN50160 Evaluation is performed using the Power Quality menu (see below). Table 9–5 shows the available options.

Table 9–5: Options for Enabling EN50160 Evaluation

Option	Available Values	Selection Description	Default
EN50160 Enable	Y or N	Set to enable or disable the EN50160 Evaluation.	N
Nom. Voltage	0-1.5 * PT Primary	Set power system nominal line-to-line voltage	230
IEC61000 Enable	Y or N	Set to enable or disable the IEC Mode	N

To enable the EN50160 evaluation from the display, follow these steps:

1. From the Main Menu, select Setup > Meter > Power Quality.

```
POWER QUALITY
 EN50160 Enable    N
 Nom. Voltage    230
 IEC61000 Enable   N
```

CM4250

```
POWER QUALITY
 EN50160 Enable    N
 Nom. Voltage    230
 Flicker
```

CM4000T

```
POWER QUALITY
 EN50160 Enable    N
 Nom. Voltage    230
```

CM4000

2. EN50160 is selected. Press the enter button. “N” begins to blink. Use the up arrow button to scroll change from “N” to “Y.” Then, press the enter button.
3. Use the arrow button to select the other option on the menu, or if you are finished, press the menu button to save.

Selecting Nominal Voltage

To set up Nominal Voltage from the display, follow these steps:

1. From the Main Menu, select Setup > Meter > Power Quality.

   The POWER QUALITY screen displays.

```
POWER QUALITY
 EN50160 Enable    N
 Nom. Voltage    230
 IEC61000 Enable   N
```

CM4250

```
POWER QUALITY
 EN50160 Enable    N
 Nom. Voltage    230
 Flicker
```

CM4000T

```
POWER QUALITY
 EN50160 Enable    N
 Nom. Voltage    230
```

CM4000

2. Use the arrow buttons to scroll to the Nominal Voltage option.

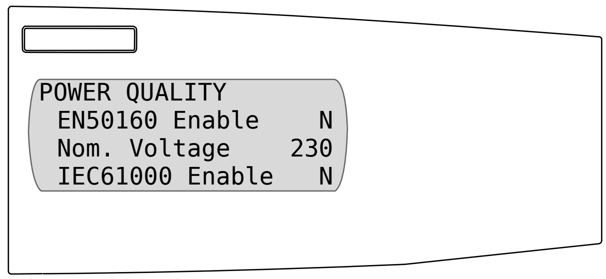
3. Press the enter button to select the value. The value begins to blink. Use the arrow buttons to set the nominal voltage value. Then, press the enter button to select the new value.
4. Use the arrow buttons to select the other option on the menu, or if you are finished, press the menu button to save.

Selecting IEC61000 Mode (CM4250 only)

To set up IEC61000 mode from the display, follow these steps:

1. From the Main Menu, select Setup > Meter > Power Quality.

   The POWER QUALITY screen displays.



2. Use the arrow buttons to scroll to the IEC 61000 option.
3. Press the enter button. “N” begins to blink. Use the up arrow button to scroll change from “N” to “Y.” Then, press the enter button.
4. Use the arrow button to select the other option on the menu, or if you are finished, press the menu button to save.

NOTE: IEC61000 mode requires firmware version 14.000 or later.

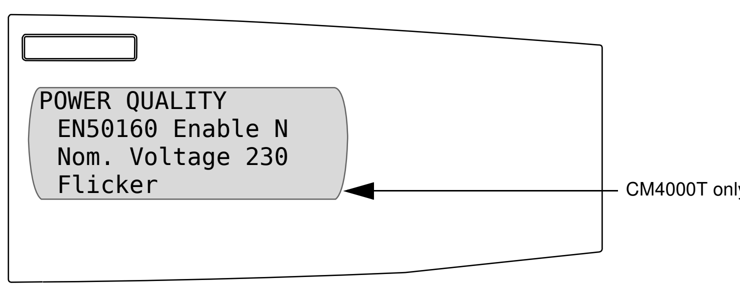
NOTE: Remember to change the circuit monitor’s nominal frequency, if necessary, and to reset the registers for EN50160 statistics. See “Setting Up EN50160 Evaluation” on page 130 for details.

Selecting Flicker (CM4000T only)

To set up Flicker from the display, follow these steps:

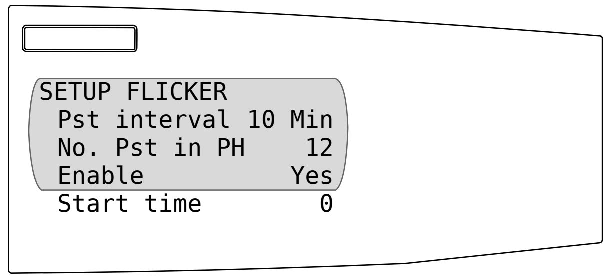
1. From the Main Menu, select Setup > Meter > Power Quality.

   The POWER QUALITY screen displays.



2. Use the arrow buttons to scroll to the Flicker option.

3. Press the enter button to select the value. The Setup Flicker screen is displayed.



4. Each value begins to blink when it is selected. Use the arrow buttons to set new values. Then, press the enter button to select the new value.
5. When you are finished, press the menu button to save.

CHAPTER 10—MAINTENANCE AND TROUBLESHOOTING

CIRCUIT MONITOR MAINTENANCE

The circuit monitor does not require regular maintenance, nor does it contain any user-serviceable parts. If the circuit monitor requires service, contact your local sales representative. Do not open the circuit monitor. Opening the circuit monitor voids the warranty.

DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

Do not attempt to service the circuit monitor. CT and PT inputs may contain hazardous currents and voltages. Only authorized service personnel from the manufacturer should service the circuit monitor.

Failure to follow this instruction will result in death or serious injury.

⚠ CAUTION

HAZARD OF EQUIPMENT DAMAGE

Do not perform a Dielectric (Hi-Pot) or Megger test on the circuit monitor. High voltage testing of the circuit monitor may damage the unit. Before performing Hi-Pot or Megger testing on any equipment in which the circuit monitor is installed, disconnect all input and output wires to the circuit monitor.

Failure to follow this instruction can result in injury or equipment damage.

CIRCUIT MONITOR MEMORY

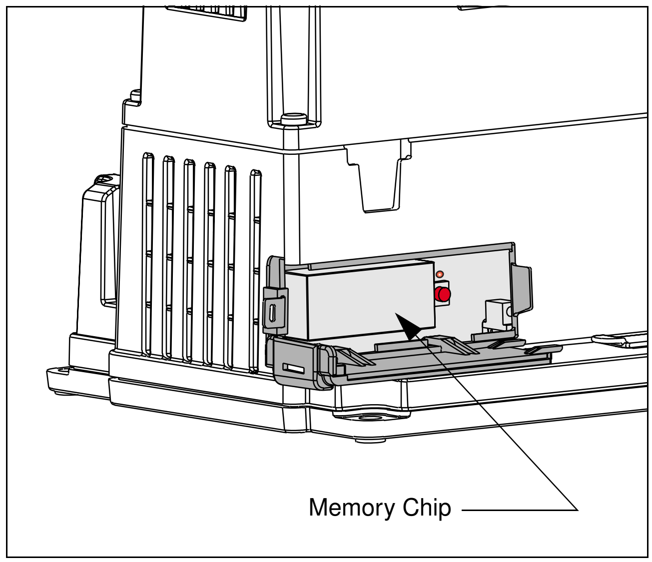
The circuit monitor uses its nonvolatile memory (RAM) to retain all data and metering configuration values. Under the operating temperature range specified for the circuit monitor, this nonvolatile memory has an expected life of up to 100 years. The circuit monitor stores its data logs on a memory chip, which has a life expectancy of up to 20 years under the operating temperature range specified for the circuit monitor. The life of the circuit monitor's internal battery-backed clock is over 20 years at 25°C.

NOTE: Life expectancy is a function of operating conditions; this does not constitute any expressed or implied warranty.

Upgrading Memory in the Circuit Monitor

The circuit monitor standard memory is 16 MB, but can be easily expanded to 32 MB. Contact your local Square D/Schneider Electric representative for availability of the memory upgrade chips. The memory chip is accessible through the access door on the side of the circuit monitor as illustrated in Figure 10–1. See the instruction bulletin provided with the memory expansion kit for instructions on removal and installation of the memory chip.

Figure 10–1:Memory chip location in the circuit monitor



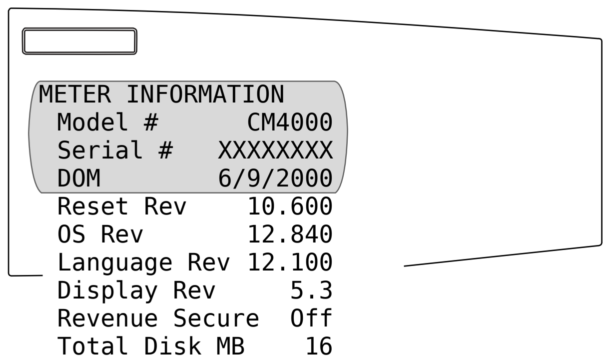
IDENTIFYING THE FIRMWARE VERSION

You can upgrade the circuit monitor’s firmware through any of these ports:

- RS-485 port
- RS-232 port
- Infrared ports on the VFD display
- Ethernet communications card

To determine the firmware version of the circuit monitor’s operating system from the remote display, do this:

From the main menu, select Diagnostics > Meter Information. The information about your meter displays on the Meter Information screen. Your screen may vary slightly.



To determine the firmware version over the communication link, use SMS to perform a System Communications Test. The firmware version is listed in the firmware revision (F/ W Revision) column.

VIEWING THE DISPLAY IN DIFFERENT LANGUAGES

The circuit monitor can be configured to display text in various languages. Language files are installed using the DLF-3000 software application. To obtain and use language files, refer to the DLF-3000 documentation.

CALIBRATION OF THE CURRENT/VOLTAGE MODULE

Contact your local sales representative for information on calibration of the current/voltage module on the circuit monitor.

GETTING TECHNICAL SUPPORT

Please refer to the *Technical Support Contacts* provided in the circuit monitor shipping carton for a list of support phone numbers by country.

TROUBLESHOOTING

The information in Table 10–1 describes potential problems and their possible causes. It also describes checks you can perform or possible solutions for each. After referring to this table, if you cannot resolve the problem, contact the your local Square D/Schneider Electric sales representative for assistance.

DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH

- This equipment must be installed and serviced only by qualified personnel.
- Qualified persons performing diagnostics or troubleshooting that require electrical conductors to be energized must comply with NFPA 70 E - Standard for Electrical Safety Requirements for Employee Workplaces and OSHA Standards - 29 CFR Part 1910 Subpart S - Electrical.
- Carefully inspect the work area for tools and objects that may have been left inside the equipment.
- Use caution while removing or installing panels so that they do not extend into the energized bus; avoid handling the panels, which could cause personal injury.

Failure to follow these instructions will result in death or serious injury.

Table 10–1: Troubleshooting

Potential Problem	Possible Cause	Possible Solution
The red maintenance LED is illuminated on the circuit monitor.	When the red maintenance LED is illuminated, it indicates a potential hardware or firmware problem in the circuit monitor.	When the red maintenance LED is illuminated, “Maintenance LED” is added to the menu under “Diagnostics.” Error messages display to indicate the reason the LED is illuminated. Note these error messages and call Technical Support or contact your local sales representative for assistance.
The green control power LED is not illuminated on the circuit monitor.	The circuit monitor is not receiving the necessary power.	Verify that the circuit monitor line (L) and neutral (N) terminals (terminals 25 and 27) are receiving the necessary power.
The display is blank after applying control power to the circuit monitor.	The display is not receiving the necessary power or communications signal from the circuit monitor.	Verify that the display cable is properly inserted into the connectors on the display and the circuit monitor.

Table 10–1: Troubleshooting *(continued)*

The data being displayed is inaccurate or not what you expect.	Circuit monitor is grounded incorrectly.	Verify that the circuit monitor is grounded as described in "Grounding the Circuit Monitor" in the installation manual.
	Incorrect setup values.	Check that the correct values have been entered for circuit monitor setup parameters (CT and PT ratings, System Type, Nominal Frequency, and so on). See "Setting Up the Metering Functions of the Circuit Monitor" on page 17 for setup instructions.
	Incorrect voltage inputs.	Check circuit monitor voltage input terminals (9, 10, 11,12) to verify that adequate voltage is present.
	Circuit monitor is wired improperly.	Check that all CTs and PTs are connected correctly (proper polarity is observed) and that they are energized. Check shorting terminals. See "Wiring CTs, PTs, and Control Power to the Circuit Monitor" in the installation manual for wiring diagrams. Initiate a wiring check from the circuit monitor display.
Cannot communicate with circuit monitor from a remote personal computer.	Circuit monitor address is incorrect.	Check to see that the circuit monitor is correctly addressed. See "RS-485, RS-232, and Infrared Port Communications Setup" on page 12 for instructions.
	Circuit monitor baud rate is incorrect.	Verify that the baud rate of the circuit monitor matches the baud rate of all other devices on its communications link. See "RS-485, RS-232, and Infrared Port Communications Setup" on page 12 for instructions.
	Communications lines are improperly connected.	Verify the circuit monitor communications connections. Refer to **Chapter 6—Communications** in the installation manual for more information.
	Communications lines are improperly terminated.	Check to see that a multipoint communications terminator is properly installed. See "Terminating the Communications Link" in the installation manual for instructions.
	Incorrect route statement to circuit monitor.	Check the route statement. Refer to the SMS online help for instructions on defining route statements.

CHAPTER 11—TRANSIENT CIRCUIT MONITOR (CM4000T)

TRANSIENT CIRCUIT MONITOR DESCRIPTION

The CM4000T circuit monitor has most of the same metering capabilities as the CM4250. However, it also has the ability to detect and capture sub-microsecond voltage transients up to a peak voltage of 10,000 volts (L-L). It accomplishes this by using the transient version of the current/voltage module.

The transient detection module, or CVMT, contains the entire front end of the meter necessary to perform both standard metering, as defined by the CM4250, and the high-speed data acquisition necessary to perform high-speed impulsive voltage transient detection.

The CM4000T also has the ability to measure voltage fluctuations (flicker) based on IEC 61000-4-15 (2003) standards (230 V, 50 Hz systems and 120 V, 60 Hz systems). See “Flicker” later in this chapter for more information.

Attaching the CVMT module allows the capture, storage, and viewing of sub-microsecond voltage events. Additionally, it allows for the logging of voltage transient peaks, average voltage, rise time, and duration.

WHAT ARE TRANSIENTS?

A transient is defined as a disturbance in the electrical system lasting less that one cycle. There are two types of transients: impulsive and oscillatory. An impulsive transient is defined as a sudden, non-power frequency change in the steady state condition of voltage or current that is unidirectional in polarity. Lightning strikes are a common cause of impulsive transients. Oscillatory (also known as switching) transients include both positive and negative polarity values. Energizing capacitor banks will typically result in an oscillatory transient on one or more phases.

Each type of transient is divided into three sub-categories related to the frequencies. Table 11–1 lists the transients and their three categories.

Table 11–1: Transient Categories and Sub-Categories

Transient Categories	Spectral Components	Duration
Impulsive		
Millisecond (Low Frequency)	0.1 ms rise	> 1 ms
Microsecond (Medium Frequency)	1 µs rise	50 ns to 1 ms
Nanosecond (High Frequency)	5 ns rise	< 50 ns
Oscillatory		
Low Frequency	< 5 kHz	0.3 to 50 ms
Medium Frequency	5 to 500 kHz	5 µs to 20 µs
High Frequency	0.5 to 5 MHz	5 µs

NOTE: Impulsive transients are characterized by their rise time, amplitude, and duration. Oscillatory transients are characterized by their frequency duration.

Low frequency transients are the most common, followed by medium frequency transients. While damage can be immediate in cases such as lightning, the CM4000T monitors and alerts you to the lower-to-medium frequency transients which can slowly damage components. Early detection of repetitive transients can allow you (in many instances) to take action before your components are damaged.

IMPULSIVE TRANSIENT ALARMS

The CM4000T provides an additional alarm group for detecting impulsive transients on the voltage inputs. The Impulsive Transient alarm operates differently than the other alarms, yet it provides extensive information about impulsive transients in an electrical system. The Impulsive Transient alarm does not prevent the use of any other alarms. All alarm groups will function concurrently and can trigger concurrent data records.

Detection and capture of high-speed transients are in the nanosecond to microsecond range with a total capture duration of up to 2 milliseconds. Slower events can be recorded using the standard disturbance event-capture capabilities of the meter.

There is only one alarm to configure to detect impulsive and oscillatory transients on the three-phase voltage channels in the CM4000T circuit monitor. The transient alarm is in Alarm Position 185 (registers 13980 – 13999). Each transient that is detected forces an entry in the alarm log and forces a transient and disturbance waveform capture if waveform capture is enabled (refer to “Logging” on page 101 and “Waveform and Event Capture” on page 107 for more information about alarm logs and disturbance captures). The table below is an addendum to Table 6–4 on page 93 in this manual to include the transient alarm.

Table 11–2: Transient Alarm Type Description

Type	Description	Operation
185	Impulsive Transient - Voltage	The impulsive transient voltage alarm will occur whenever the peak voltage is above the pickup setpoint and remains above the pickup setpoint for the specified duration.

Configuring a Transient Alarm

To configure a transient alarm, you must select the voltage inputs to monitor. The impulsive transient alarm allows you to enter a custom label, enable or disable the alarm, select the alarm’s priority, enter the voltage pickup threshold, and input the minimum pulse width.

The CM4000T automatically selects the voltage transient monitoring method based on the type of system it is connected to, so there is no need to configure the system type. For example, if the CM4000T is connected to a 4-wire wye system, the detection method changes to single-ended (L-N) with a maximum voltage range of 5 kV peak (3536 V rms). If the CM4000T is connected to a 3-wire delta system, the detection method changes to differential (L-L) with a maximum voltage range of 10 kV peak (7072 V rms).

Recording and Analyzing Data

After each occurrence of an impulsive transient, data is entered into the circuit monitor’s alarm log using SMS as long as the alarm priority is set to Low, Medium, or High. The alarm log contains the following information:

- Alarm position
- Unique alarm ID
- Entry type
- Peak Magnitude
- Start time and date
- Correlation sequence number
- File association

- Waveform capture association
- Average magnitude
- Transient duration
- Rise time

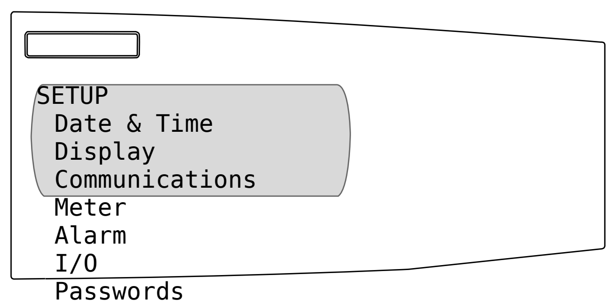
For more information on logging impulsive transient date, see **Logging** on page 101. For more information on alarm logging features in SMS, refer to the SMS online help.

Creating an Impulsive Transient Alarm

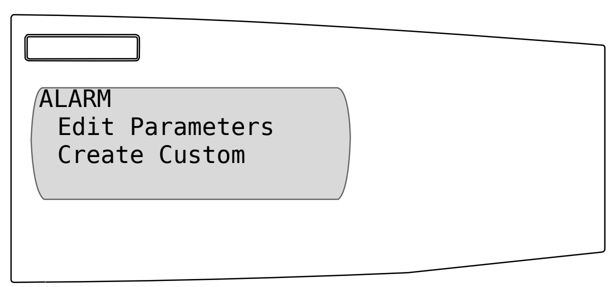
Using the display, perform the steps below to configure the impulsive transient alarm:

NOTE: There is a default transient alarm that enables detection on all phases. If the label and phases are acceptable, you can skip this section and go directly to "Setting Up and Editing Transient Alarms" on page 146.

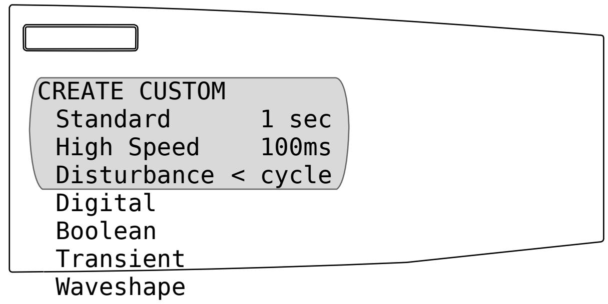
1. From the Main Menu, select Setup. The password prompt appears.
2. Select your password. The default password is 0. The Setup menu is displayed.



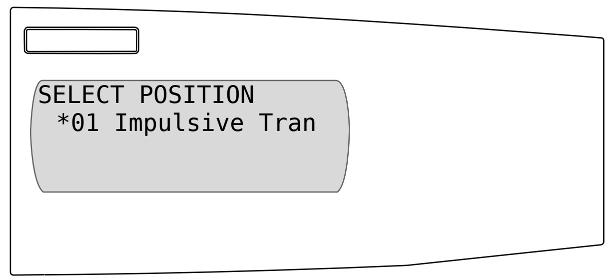
3. Select Alarm. The Alarm menu displays.



4. Select Create Custom. The Create Custom menu appears.



5. Select Transient. The Select Position menu appears.



6. Select the position of the new transient alarm. The Alarm Parameters menu displays. Table 11–3 describes the options on this menu.

Table 11–3: Options for Creating a Transient Alarm

Option	Available Values	Selection Description	Default
Lbl	Alphanumeric Up to 15 characters	Label - name of the alarm. Press the down arrow button to scroll through the alphabet. The lower-case letters are presented first, then upper-case, then numbers and symbols. Press the enter button to select a letter and move to the next character field. To move to the next option, press the menu button.	Impulsive Trans
Type	The alarm type is configured by default and cannot be changed.		Imp. Voltage

Table 11–3: Options for Creating a Transient Alarm *(continued)*

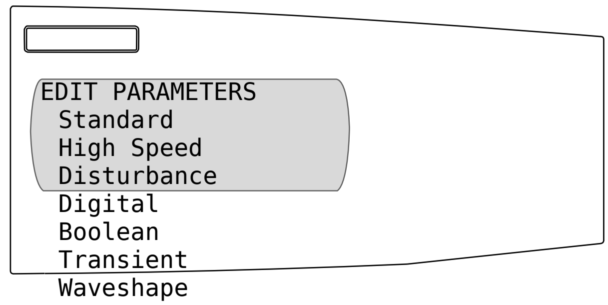
Option	Available Values	Selection Description	Default
Qty	All Phases Ph. A Ph. B Ph. A&B Ph. C Ph. A&C Ph. B&C	For transient alarms, this is the value to be evaluated. While selected, press the arrow buttons to scroll through quantity options. Pressing the enter button while an option is displayed will activate that option's list of values. Use the arrow buttons to scroll through the list of options. Select an option by pressing the enter button. For 3-wire systems, selecting Phase A will configure the transient alarm to monitor V_{A-B}. If you select Phases A&B, the transient alarm will monitor V_{A-B} and V_{B-C}.	All Phases

7. Press the menu button until "Save Changes? No" flashes on the display. Select Yes with the arrow button, then press the enter button to save the changes. Now you are ready to set up and edit the newly-created transient alarm.

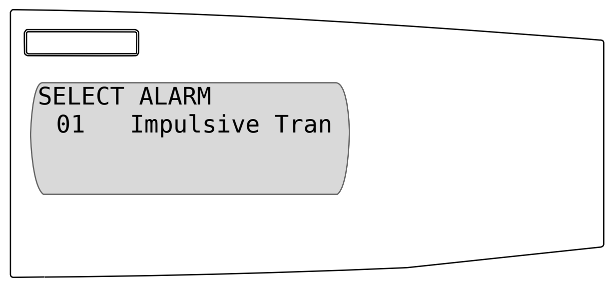
Setting Up and Editing Transient Alarms

Follow the instructions below to set up and edit a transient alarm:

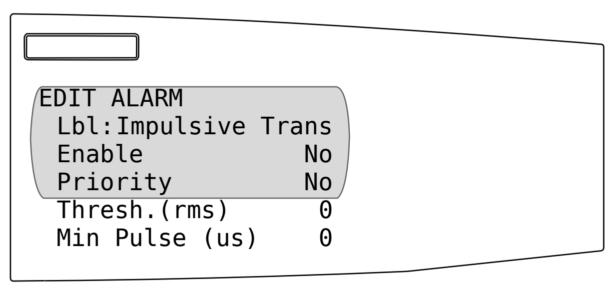
1. From the Main Menu, select Setup > Alarm > Edit Parameters. The Edit Parameters menu displays.



2. Select Transient. The Select Alarm menu displays.



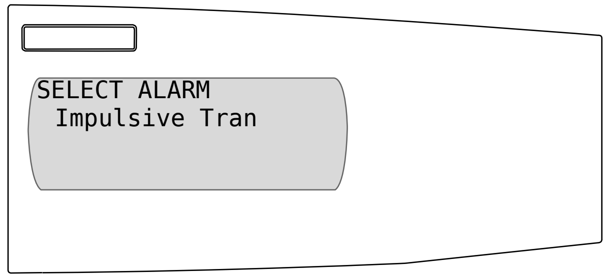
3. Select the transient alarm. The Edit Alarm menu displays. Table 11–4 on page 148 describes the options on this menu.



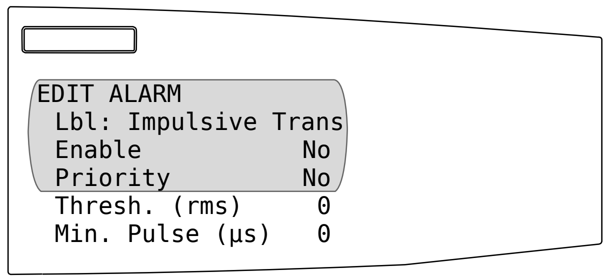
4. Use the arrow buttons to scroll to the menu option you want to change, then edit the following alarms: Lbl., Priority, Thresh. (rms), and Min. Pulse (µs). See Table 11–4 for a description of the alarm options.

NOTE: Do not *enable the alarm during this step. The alarm must be enabled* after *all changes have been saved.*

5. When you are finished with all changes, press the menu button until “Save Changes? No” flashes on the display. Select Yes with the arrow button, then press the enter button to save the changes.
6. From the Main Menu, select Setup > Alarm > Edit Parameters > Transients. The Select Alarm menu displays.



7. Select the transient alarm. The Edit Alarm menu displays. Table 11–5 on page 148 describes the options on this menu.



8. Verify that the Priority, Thresh. (rms), and Min. Pulse (µs) alarm options are set to the values you entered earlier.
9. Use the arrow buttons to scroll to the Enable options, then select Yes to enable the alarm. Verify that Yes is selected before proceeding.
10. Press the menu button until “Save Changes? No” flashes on the display. Select Yes with the arrow button, then press the enter button to save the changes.

NOTE: The Impulsive Transient alarm will be automatically disabled if invalid setpoints (threshold and minimum pulse width) are entered. If you are unable to enable the alarm, check your system configuration (system type, connection, VT ratio) and your alarm setpoints to ensure that the transient circuit monitor operates as intended. Refer to Table 11–5 for minimum and maximum setpoint information.

Table 11–4: Options for Editing a Transient Alarm

Option	Available Values	Selection Description	Default
Lbl	Alphanumeric	Label - name of the alarm. Press the down arrow button to scroll through the alphabet. The lower case letters are presented first, then uppercase, then numbers and symbols. Press the enter button to select a letter and move to the next character field. To move to the next option, press the menu button.	Name of the alarm
Enable	Yes No	Select Y to make the alarm available for use by the circuit monitor. On pre-configured alarms, the alarm may already be enabled. Select N to make the alarm function unavailable to the circuit monitor.	N (not enabled)
Priority	None High Med Low	Low the lowest priority alarm. High is the highest priority alarm and also places the active alarm in the list of high priority alarms. To view this list from the Main Menu, select Alarms > High Priority Alarms.	None
Thresh. (rms)	0 - 23,173	The transient alarm threshold or pickup value is set in rms and bounded by system configuration. The minimum value for the transient alarm threshold (pickup) is dependent on the system type and connection	3430 V (rms) 4850 V (peak)
Min. Pulse (µs)	0 - 40 µs	To ensure accurate detection, this value can range from 0 to 40 µs. A transient pulse width must meed the minimum pulse width requirements to trigger the alarm and capture waveforms.	0

Table 11–5: Minimum and Maximum Setpoints for System Wiring Types

System Wiring	System Connection	Minimum Threshold (Setpoint), RMS	Maximum Threshold (Setpoint), RMS
4-wire Wye	Direct connect (L-N)	0 V	3430 V
3-wire Delta	Direct connect (L-L)	0 V	5940 V
4-wire Wye	VTs	0 V	Primary ratio x 3430 Example: 288:120 = 2.4 2.4 x 3430 = 8232 maximum setpoint
3-wire Delta	VTs	0V	Primary ratio x 5940 Example: 288:120 = 2.4 2.4 x 6860 = 16,464 maximum setpoint

IMPULSIVE TRANSIENT LOGGING

Each time an impulsive transient occurs, the transient alarm forces an entry in the CM4000T alarm log, a transient and disturbance waveform capture is generated when waveform capture is enabled, and register-based data in non-volatile memory is recorded. The register-based data in the alarm log consists of the following:

- Date/Time
- Unique ID
- Peak voltage magnitude
- Duration of the peak in tenths of a microsecond
- Rise-time in tenths of a microsecond
- Average voltage

The data can be viewed by selecting View Alarm > Active Alarm List, then selecting the transient alarm. See **Operation** on page 7 for information on how to view the alarm log data using the display.

Transient Analysis Information

Register-based transient analysis information is also generated each time an impulsive transient occurs. This data consists of the number of transients for each phase, the date and time of the last register-based transient alarm log reset, number of alarms in the register-based transient alarm log, stress on circuit indication for each phase in volt-seconds, magnitude, and duration. The following list contains the transient analysis information.

- Number of transients on Phase A
- Number of transients on Phase B
- Number of transients on Phase C
- Number of transients on all phases
- Date/time of the last register-based alarm log reset
- Number of alarms in the register-based transient alarm log
- Stress on the circuit indication for Phase A (volt-seconds)
- Stress on the circuit indication for Phase B (volt-seconds)
- Stress on the circuit indication for Phase C (volt-seconds)
- Transient categorization – Magnitude 1 and Duration 1
- Transient categorization – Magnitude 1 and Duration 2
- Transient categorization – Magnitude 1 and Duration 3
- Transient categorization – Magnitude 2 and Duration 1
- Transient categorization – Magnitude 2 and Duration 2
- Transient categorization – Magnitude 2 and Duration 3
- Transient categorization – Magnitude 3 and Duration 1
- Transient categorization – Magnitude 3 and Duration 2
- Transient categorization – Magnitude 3 and Duration 3

NOTE: Data log entries and adaptive waveform captures cannot be triggered by an impulsive transient event because transient occur too rapidly for these data capture tools to be effective. However, high-speed alarms and sag/swell alarms can still be configured to trigger if the transient event duration is within the detection criteria for the alarm.

To utilize all of the transient analysis features of the CM4000T you should configure the transient categorization magnitude and duration setpoints. The CM4000T provides nine accumulators that evaluate each captured transient and assigns it to a category based on magnitude and duration. For example, a 480 V Wye system might have a Transient Alarm Threshold (pick-up) setpoint of 600 V rms (848 V peak). Transient captures for L-N connected systems is 5 kV (peak). Therefore, all captured transient magnitudes will be between 848 V peak and 5 k V peak. The Magnitude #1 (register 9226) and Magnitude #3 (register 9227) parameters for the Transient Categories might be configured as 1471 V peak (5 kV – 848) * 15% + 848) which would include transients in the lower 15% in magnitude. Magnitude #3 might be configured as 2509 V peak (5 kV – 848) * 40% + 848) which includes transients in the upper 60% in magnitude. Magnitude #2 is implied as those transients > 15% of the range to < 40% of the range.

Much like Magnitude #1 and Magnitude #3, values for Duration #1 (register 9228) and Duration #3 (register 9229) must be configured. We recommend that Duration #1 is set to 32 µs and Duration #3 is set to 130 µs. This implies that all transients with duration ≤ 32 µs will be considered Duration #1 and transients with duration ≥ 130 µs will be Duration #3. Duration #2 is implied as those transients with a duration > 32 µs, but < 130 µs. See

Writing Transient Register Values

The following is a list of the steps necessary to enter the transient register values. For more information on reading and writing registers, refer to “Reading and Writing Registers” on page 48.

1. Write 9020 to register 8000 to enter Setup mode.
2. Write the desired value into the following registers (these values are in Peak, not rms):
    - 9226 for Magnitude #1
    - 9227 for Magnitude #3
    - 9228 for Duration #1
    - 9229 for Duration #3
3. Write 1 to register 8001.
4. Write 9021 to register 8000 to exit Setup and save changes.

TRANSIENT WAVEFORM CAPTURES

Using waveform captures you can view each detected transient. Each time an impulsive transient event is detected, the CM4000T records two waveform captures when waveform capture is enabled. The first waveform capture is a transient waveform capture that records the signal on each of the three voltage inputs at a rate of 83,333 samples per cycle. The transient waveform capture will display voltage transients up to 5 kV peak magnitude for a 4-wire configuration and up to 10 kV for a L-L, 3-wire configuration when direct connected.

The second waveform capture is a disturbance waveform capture that is configured using the display or SMS. SMS will indicate all transient captures that are contained within each disturbance waveform capture. The disturbance waveform capture can range from seven channels at a rate of 512 samples per cycle for 28 cycles to seven channels at a rate of 16 samples per cycle for 915 cycles (see Table 11–6). It is recommended that the disturbance waveform capture in a CM4000T be configured for 512 samples per cycle, which is one data point every 32 µs. This maximizes the available data for analysis of the transient event.

Table 11–6: Disturbance Waveform Capture Maximum Duration for the Number of Samples Per Cycle

Samples per Cycle	Max Duration
16	715 cycles
32	357 cycles
64	178 cycles
128	89 cycles
256	44 cycles
512	22 cycles

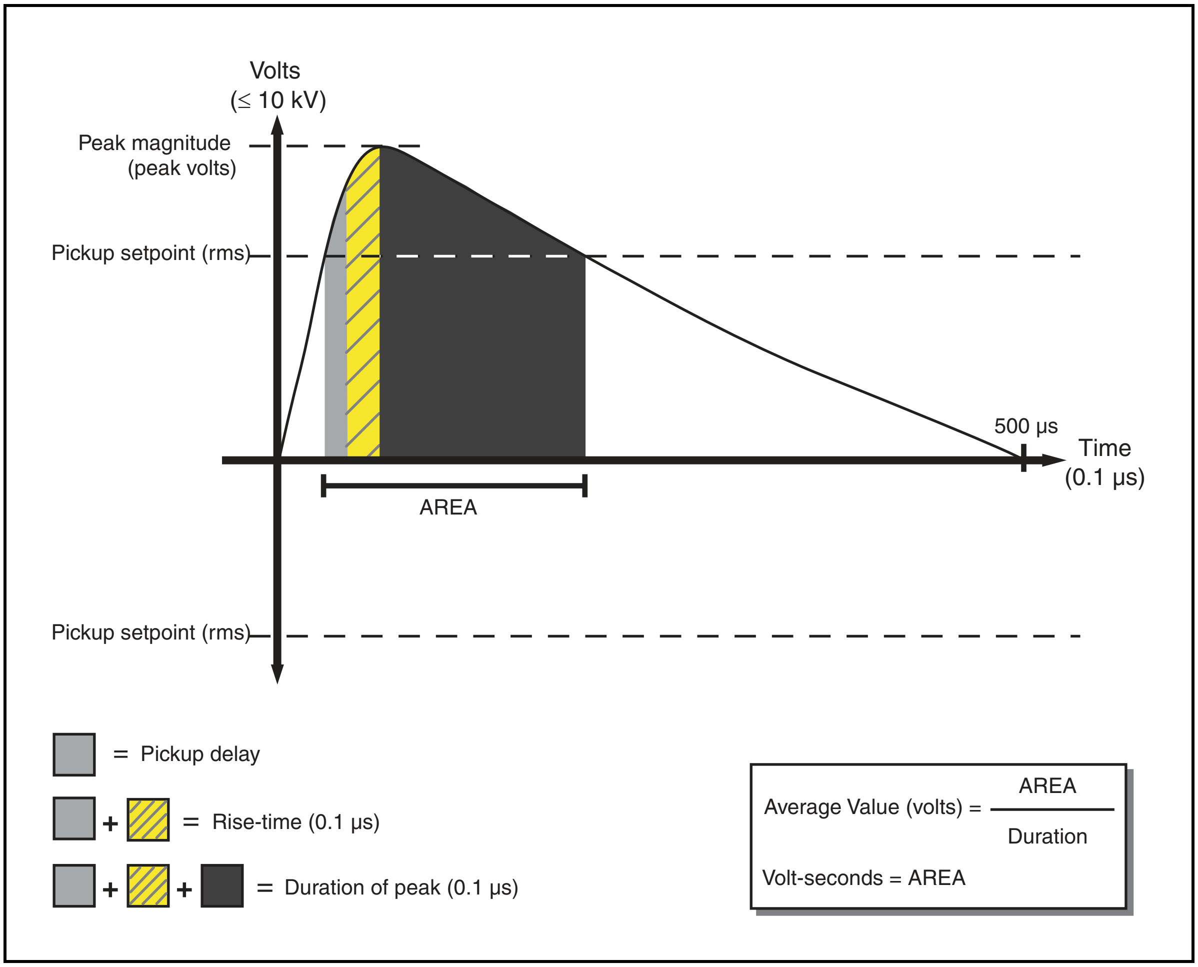
Table 11–7: Transient Waveform Capture Maximum Duration for the Number of Samples Per Cycle

Samples per Cycle	Max Duration
100,000 (50 Hz system)	2 millisecond (1/10 of a cycle)
83,333 (60 Hz system)	2 millisecond (1/8 of a cycle)

Transient Waveform Capture Example

The following figure is an example of a transient waveform capture. Below the figure is an explanation of the waveform capture.

Figure 11–1: Impulsive Transient



The CM4000T provides analysis data for each transient captured. Methods used to characterize transients include:

- Peak Voltage
- Energy (AREA)
- Rise-time
- Duration

Data provided by the CM4000T facilitates analysis using each of these methods. The meter reports a pickup date/time, rise-time, duration of the peak, peak magnitude, and average voltage of the transient. The CM4000T also provides an accumulated value per phase captured to indicate the severity of the transients in volt-seconds. For example, Figure 11–1 illustrates an impulsive transient. The average voltage of the impulsive transient is calculated by taking the AREA, which includes the product of the voltage and duration within the transient curve bound by the threshold (pickup and drop-out) setpoints, and dividing it by the duration of the peak.

FLICKER

Using the transient module (CVMT) of a circuit monitor, you can detect and measure the modulation of electric light (called “flicker”). Under certain conditions, some individuals’ eyes are sensitive to flicker. Flicker occurs when electric light fluctuates because of variation in line voltage at certain frequencies. Interaction among varying loads and impedance of the electrical distribution system contribute to the line voltage variation that produces flicker.

Flicker can be a problem in a work environment such as a factory where large, cycling loads are present. It can also be a problem for residential customers of electric utilities, particularly residences located between an electrical substation and large commercial users of electrical power. As the commercial establishments cycle their large loads, the voltage supplied to the residences may vary markedly, causing the lights to flicker in the residences.

Minimum Requirements

Flicker monitoring is available if you are using a circuit monitor equipped with a CVMT module (CM4000T). To measure flicker, the circuit monitor firmware must be version 12.32 or higher, and the CVMT firmware must be version 11.000 or higher.

You can find the latest firmware on our website at www.powerlogic.com. If you are not familiar with upgrading the firmware, contact your local Schneider Electric representative for support.

Standards

The measurement of flicker in the circuit monitor is structured around the IEC standards for flicker described in Table 11–8.

Table 11–8: Standards

Standard	Description
IEC 61000-4-15 (2003)	The circuit monitor is designed to measure flicker based on this standard for 230 V, 50 Hz systems or for 120 V, 60 Hz systems.

How the Circuit Monitor Handles Flicker

The circuit monitor detects and measures flicker on the electrical system based on the IEC 61000-4-15 standard. Two quantities are measured:

- short-term flicker (P_{st})
- long-term flicker (P_{lt})

The circuit monitor displays both of these quantities for each phase. In 4-wire systems, it measures flicker line-to-neutral voltage, but in 3-wire systems, the circuit monitor measures line-to-internal meter reference, *not line-to-line voltage.*

Short-term flicker is measured over a period of minutes. You can select the number of minutes that the circuit monitor will use to update short-term flicker (P_{st}). The default setting is 10 minutes, which is a generally accepted setting for the short-term flicker (P_{st}).

Long-term flicker (P_{lt}) is based on an integer multiple of the short-term flicker (P_{st}) interval. Long-term flicker (P_{lt}) is recorded each time a specified number of short-term flicker (P_{st}) updates occur. For example, if short-term flicker (P_{st}) is set to 10 minutes and long-term flicker (P_{lt}) is set to 12 (short-term updates), then the long-term flicker (P_{lt}) is recorded every two hours (10 minutes x 12 short-term intervals = 120 minutes). The default setting for long-term flicker (P_{lt}) is 12 (120 minutes based on a short-term flicker (P_{st}) interval of 10 minutes), which is a generally accepted value.

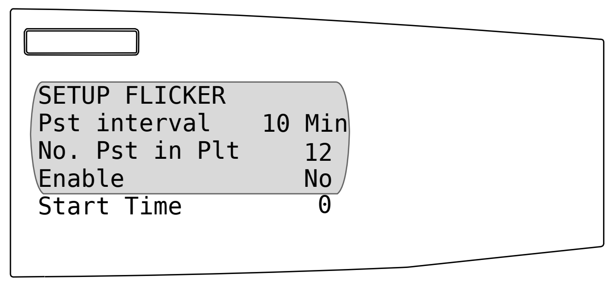
Short-term and long-term flicker data are backed up hourly to the memory of the circuit monitor. Consequently, in the event of control power loss to the circuit monitor, a maximum of one hour of data would be lost.

Setting Up Flicker from the Display

To setup flicker from the display, follow these steps:

1. From the Main Menu, select Setup > Meter > Flicker.

The Setup Flicker screen displays. Table 11–9 describes the options for flicker setup.



2. Use the arrow buttons to scroll to the menu option you want to change.
3. Press the enter button to select the value. The value begins to blink. Use the arrow buttons to scroll through the available values. Then, press the enter button to select the new value.
4. Use the arrow buttons to scroll through the other options on the menu, or if you are finished, press the menu button to save. When you save the settings for flicker, the circuit monitor performs a reset. If flicker is enabled at power up, it takes the circuit monitor two minutes to begin populating the data on the display. The asterisks (*) will be replaced when data begins to populate the registers.

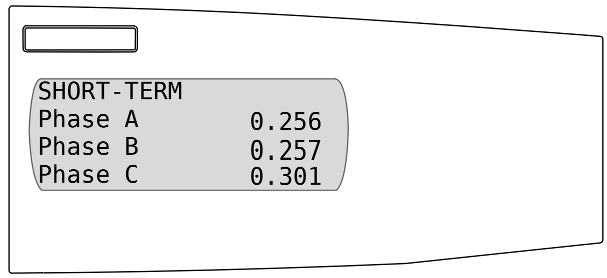
Table 11–9: Options for Flicker Setup

Option	Available Values	Selection Description	Default
Pst Interval	1, 5, 10, or 15	The number of *minutes* in which the short-term update is performed.	10
No. Pst in Plt	2–1000	The *number* of short-term updates (P_{st}) required in a long-term update (P_{lt}). The combination of possible short-term intervals and the number of short-term intervals for long-term updates can create a long-term interval range from two minutes to approximately 10.5 days.	12
Enable	Yes or No	Yes enables the circuit monitor to begin updating the flicker measurements at the specified start time. No disables flicker. The circuit monitor will not measure flicker, even if a start time and intervals are set up.	No
Start time	0–1439	The start time is minutes from midnight and will begin at the specified start time if flicker is enabled. Note that zero (0) starts immediately and that the start time is relative to today. For example, if the time is currently 1:00 pm and the desired start time is 2:00 am, then you would enter 120. Measurement will start immediately rather than tomorrow morning at 2:00 am because this time has passed for today. Changing the start time causes a reset only if the start time is after the present time of the circuit monitor.	0

Viewing Flicker Readings

After you have set up flicker and enabled it, you can view the flicker readings from the display. To do this, follow this step:

1. From the Main Menu, select Meters > Flicker. The Flicker screen displays.



The values display for short-term flicker level for all three phases. Use the arrow buttons to scroll and view the short-term and long-term flicker values.

Viewing Flicker Data Web Pages

You can view flicker data on web pages. Refer to the *POWERLOGIC Web Pages instruction bulletin 63230-304-207*.

Flicker Register List

The data registers and time stamps for the flicker registers are FIFO buffers. The Master Register List is available for download at www.powerlogic.com.

NOTE: The CM4250 does not measure high-speed transients or flicker as described in this chapter.

APPENDIX A—USING THE COMMAND INTERFACE

OVERVIEW OF THE COMMAND INTERFACE

The circuit monitor provides a command interface, which you can use to issue commands that perform various operations such as controlling relays. Table A–2 on page 158 lists the available commands. The command interface is located in memory at registers 8000–8149. Table A–1 lists the definitions for the registers.

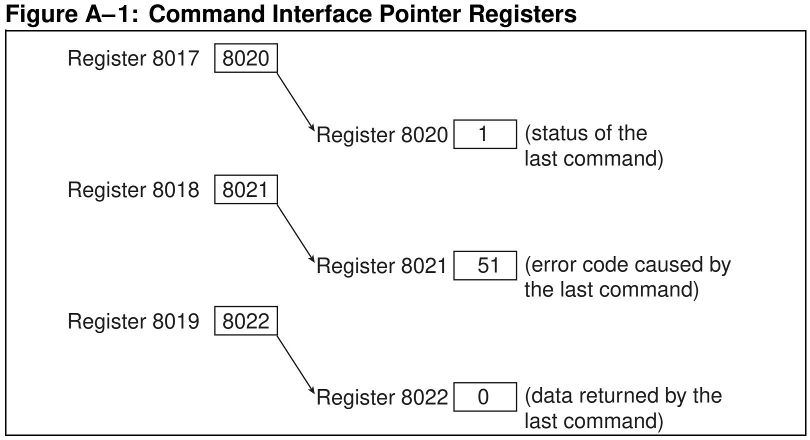
Table A–1: Location of the command interface

Register	Description
8000	This is the register where you write the commands.
8001–8015	These are the registers where you write the parameters for a command. Commands can have up to 15 parameters associated with them.
8017	Status pointer to the user area. The status of the last command processed is placed in this register.
8018	Results pointer to the user area. When an error occurs, the error code is placed in this register.
8019	I/O data pointer to the user area. Use this register to point to data buffer registers where you can send additional data or return data.
8020–8149	These registers are for you (the user) to write information. Depending on which pointer places the information in the register, the register can contain status (from pointer 8017), results (from pointer 8018), or data (from pointer 8019). The registers will contain information such as whether the function is enabled or disabled, set to fill and hold, start and stop times, logging intervals, and so forth. By default, return data will start at 8020 unless you specify otherwise.

When registers 8017–8019 are set to zero, no values are returned. When any or all of these registers contain a value, the value in the register "points" to a target register, which contains the status, error code, or I/O data (depending on the command) when the command is executed. Figure A–1 shows how these registers work.

NOTE: You determine the register location where results will be written. Therefore, take care when assigning register values in the pointer registers; values may be corrupted when two commands use the same register.

Figure A–1: Command Interface Pointer Registers



Issuing Commands

To issue commands using the command interface, follow these general steps:

1. Write the related parameter(s) to the command parameter registers 8001–15.
2. Write the command code to command interface register 8000.

If no parameters are associated with the command, then you need only to write the command code to register 8000. Table A–2 lists the command codes that can be written to the command interface into register 8000. Some commands have an associated registers where you write parameters for that command. For example, when you write the parameter 9999 to register 8001 and issue command code 3351, all relays will be energized if they are set up for external control.

Table A–2: Command Codes

Command Code	Command Parameter Register	Parameters	Description
1110	None	None	Causes soft reset of the unit (re-initializes the circuit monitor).
1210	None	None	Clears the communications counters.
1310	 8001 8002 8003 8004 8005 8006	 Month Day Year Hour Minute Second	Sets the system date and time. Values for the registers are: Month (1–12) Day (1–31) Year (4-digit, for example 2000) Hour (Military time, for example 14 = 2:00pm) Minute (1–59) Second (1–59)
1410	None	None	Disables the revenue security switch.
1411	None	None	Enables the revenue security switch.
Relay Outputs			
3310	8001	Relay Output Number ①	Configures relay for external control.
3311	8001	Relay Output Number ①	Configures relay for internal control.
3320	8001	Relay Output Number ①	De-energizes designated relay.
3321	8001	Relay Output Number ①	Energizes designated relay.
3330	8001	Relay Output Number ①	Releases specified relay from latched condition.
3340	8001	Relay Output Number ①	Releases specified relay from override control.
3341	8001	Relay Output Number ①	Places specified relay under override control.
3350	8001	9999	De-energizes all relays.
3351	8001	9999	Energizes all relays.
3361	8001	Relay Output Number ①	Resets operation counter for specified relay.
3362	8001	Relay Output Number ①	Resets the turn-on time for specified relay.
3363	8001	None	Resets the operation counter for all relays.
3364	8001	None	Resets the turn-on time for all relays.
3365	8001	Input Number ①	Resets the operation counter for specified input.
3366	8001	Input Number ①	Resets turn-on time for specified input.
3367	8001	None	Resets the operation counter for all inputs.
3368	8001	None	Resets turn-on time for all inputs.
3369	8001	None	Resets all counters and timers for all I/Os.
3370	8001	Analog Output Number ①	Disables specified analog output.
3371	8001	Analog Output Number ①	Enables specified analog output.

Table A–2: Command Codes *(continued)*

Command Code	Command Parameter Register	Parameters	Description
3380	8001	9999	Disables all analog outputs.
3381	8002	9999	Enables all analog outputs.
Resets			
4110	None	None	Resets min/max.
4210	8001	1 = Voltage 2 = Current 3 = Both	Resets the register-based alarm logs.
5110	None	None	Resets all demand registers.
5111	None	None	Resets current demand.
5112	None	None	Resets voltage demand.
5113	None	None	Resets power demand.
5114	None	None	Resets input demand.
5115	None	None	Resets generic 1 demand for first group of 10 quantities.
5116	None	None	Resets generic 2 demand for second group of 10 quantities.
5210	None	None	Resets all min/max demand.
5211	None	None	Resets current min/max demand.
5212	None	None	Resets voltage min/max demand.
5213	None	None	Resets power min/max demand.
5214	None	None	Resets input min/max demand.
5215	None	None	Resets generic 1 min/max demand.
5216	None	None	Resets generic 2 min/max demand.
5910	8001	Bitmap	Start new demand interval. Bit0 = Power Demand 1 = Current Demand 2 = Voltage Demand 3 = Input Metering Demand 4 = Generic Demand Profile 1 5 = Generic Demand Profile 2
6209	8019	I/O Data Pointer ②	Preset Accumulated Energies Requires the IO Data Pointer to point to registers where energy preset values are entered. All Accumulated energy values must be entered in the order in which they occur in registers 1700 to 1727.
6210	None	None	Clears all energies.
6211	None	None	Clears all accumulated energy values.
6212	None	None	Clears conditional energy values.
6213	None	None	Clears incremental energy values.
6214	None	None	Clears input metering accumulation.
6320	None	None	Disables conditional energy accumulation.
6321	None	None	Enables conditional energy accumulation.
6910	None	None	Starts a new incremental energy interval.
Files			
7510	8001	Files 1–16 to trigger	Triggers data log entry. Bitmap where Bit 0 = Data Log 1, Bit 1 = Data Log 2, Bit 2 = Data Log 3, etc.
7511	8001	File Number	Triggers single data log entry.
Setup			
9020	None	None	Enter into setup mode.

Table A–2: Command Codes *(continued)*

Command Code	Command Parameter Register	Parameters	Description
9021	8001	1 = Save 2 = Do not save	Exit setup mode and save all changes.
11100	8001	9999 = Password	Reset EN50160 Statistics

① You must write to register 8001 the number that identifies which output you would like to use. To determine the identifying number, refer to "I/O Point Numbers" on page 160 for instructions.
② Data buffer location (register 8019) is the pointer to the first register where data will be stored. By default, return data begins at register 8020, although you can use any of the registers from 8020–8149. *Take care when assigning pointers. Values may be corrupted if two commands are using the same register.*

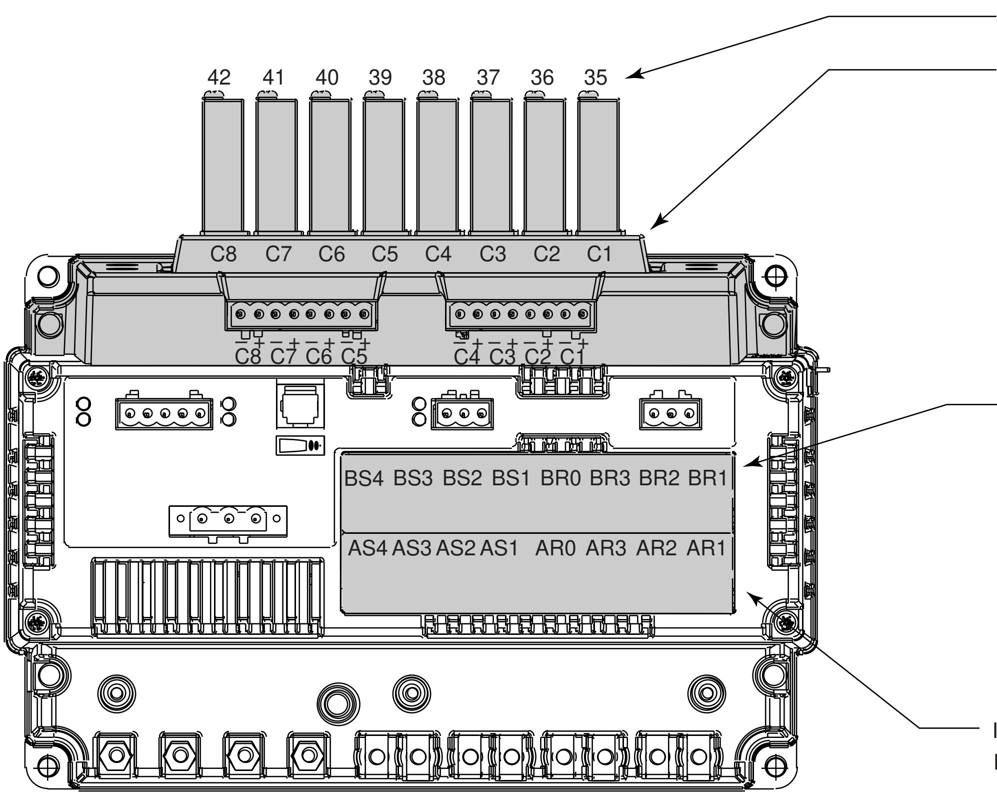
I/O POINT NUMBERS

All inputs and outputs of the circuit monitor have a reference number and a label that correspond to the position of that particular input or output.

- The reference number is used to manually control the input or output with the command interface.
- The label is the default identifier that identifies that same input or output. The label appears on the display, in SMS, on the option card, and on the I/O extender.

Figure A–2 on page 161 shows the reference number and its label equivalent.

Figure A–2: Identifying I/Os for the command interface



IOC44 in Option Slot B

Point No.	Label
19 =	B-S1
20 =	B-S2
21 =	B-S3
22 =	B-S4
23 =	B-R1
24 =	B-R2
25 =	B-R3
26 =	B-R0

IOC44 in Option Slot A

Point No.	Label
3 =	A-S1
4 =	A-S2
5 =	A-S3
6 =	A-S4
7 =	A-R1
8 =	A-R2
9 =	A-R3
10 =	A-R0

OPERATING OUTPUTS FROM THE COMMAND INTERFACE

To operate an output from the command interface, first identify the relay using the *I/O point number*. Then, set the output to external control. For example, to energize the last output on Option Card B, write the commands as follows:

1. Write number 26 to register 8001.
2. Write command code 3310 to register 8000 to set the relay to external control.
3. Write command code 3321 to register 8000.

If you look in Table A–2 on page 158, you'll see that command code 3310 sets the relay to external control and command code 3321 is listed as the command used to energize a relay. Command codes 3310–3381 are for use with inputs and outputs.

USING THE COMMAND INTERFACE TO CHANGE CONFIGURATION REGISTERS

You can also use the command interface to change values in selected metering-related registers, such as synchronizing the time of day of the clock or resetting generic demand.

Two commands, 9020 and 9021, work together as part of the command interface procedure when you use it to change circuit monitor configuration. You must first issue command 9020 to enter into setup mode, change the register, and then issue 9021 to save your changes and exit setup mode.

Only one setup session is allowed at a time. While in this mode, if the circuit monitor detects more than two minutes of inactivity, that is, if you do not write any register values or press any buttons on the display, the circuit monitor will timeout and restore the original configuration values. All changes will be lost. Also, if the circuit monitor loses power or communications while in setup mode, your changes will be lost.

The general procedure for changing configuration registers using the command interface is as follows:

1. Issue command 9020 in register 8000 to enter into the setup mode.
2. Make changes to the appropriate register by writing the new value to that register. Perform register writes to all registers that you want to change. For instructions on reading and writing registers, see “Reading and Writing Registers” on page 48.
3. To save the changes, write the value 1 to register 8001.

   NOTE: Writing any other value except 1 to register 8001 lets you exit setup mode without saving your changes.
4. Issue command 9021 in register 8000 to initiate the save and reset the circuit monitor.

For example, the procedure to change the demand interval for current is as follows:

1. Issue command code 9020.
2. Write the new demand interval to register 1801.
3. Write 1 to register 8001.
4. Issue command code 9021.

CONDITIONAL ENERGY

Circuit monitor registers 1728–1744 are conditional energy registers.

Conditional energy can be controlled in one of two ways:

- Over the communications link, by writing commands to the circuit monitor's command interface, or
- By a digital input—for example, conditional energy accumulates when the assigned digital input is on, but does not accumulate when the digital input is off.

The following procedures tell how to set up conditional energy for command interface control, and for digital input control. The procedures refer to register numbers and command codes. For a listing of command codes, see Table A–2 on page 158 in this chapter.

Command Interface Control

Set Control—To *set control* of conditional energy to the command interface:

1. Write command code 9020 to register 8000.
2. In register 3227, set bit 6 to 1 (preserve other bits that are ON).
3. Write 1 to register 8001.
4. Write command code 9021 to register 8000.

Start—To *start* conditional energy accumulation, write command code 6321 to register 8000.

Verify Setup—To *verify proper setup*, read register 1794. The register should read 1, indicating conditional energy accumulation is ON.

Stop—To *stop* conditional energy accumulation, write command code 6320 to register 8000.

Clear—To *clear* all conditional energy registers (1728-1747), write command code 6212 to register 8000.

Digital Input Control

Set Control—To configure conditional energy for digital input control:

1. Write command code 9020 to register 8000.
2. In register 3227, set bit 6 to 0 (preserve other bits that are ON).
3. Configure the digital input that will drive conditional energy accumulation. For the appropriate digital input, write 3 to the *Base +9* register.
4. Write 1 to register 8001.
5. Write command code 9021 to register 8000.

Clear—To clear all conditional energy registers (1728–1747), write command code 6212 to register 8000.

Verify Setup—To *verify proper setup*, read register 1794. The register should read 0 when the digital input is off, indicating that conditional energy accumulation is off. The register should read 1 when conditional energy accumulation is on.

INCREMENTAL ENERGY

The circuit monitor's incremental energy feature allows you to define a start time, end time, and time interval for incremental energy accumulation. At the end of each incremental energy period, the following information is available:

- Wh IN during the last completed interval (reg. 1748–1750)
- VARh IN during the last completed interval (reg. 1751–1753)
- Wh OUT during the last completed interval (reg. 1754–1756)
- VARh OUT during the last completed interval (reg. 1757–1759)
- VAh during the last completed interval (reg. 1760–1762)
- Date/time of the last completed interval (reg. 1763–1766)
- Peak kW demand during the last completed interval (reg. 1940)
- Date/Time of Peak kW during the last interval (reg. 1941–1944)
- Peak kVAR demand during the last completed interval (reg. 1945)
- Date/Time of Peak kVAR during the last interval (reg. 1946–1949)
- Peak kVA demand during the last completed interval (reg. 1950)
- Date/Time of Peak kVA during the last interval (reg. 1951–1954)

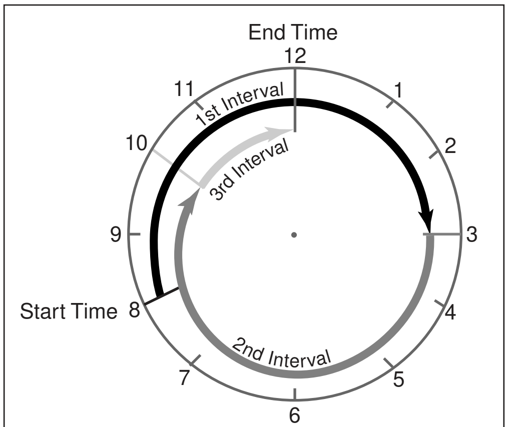
The circuit monitor can log the incremental energy data listed above. This logged data provides all the information needed to analyze energy and power usage against present or future utility rates. The information is especially useful for comparing different time-of-use rate structures.

When using the incremental energy feature, keep the following points in mind:

- Peak demands help minimize the size of the data log in cases of sliding or rolling demand. Shorter incremental energy periods make it easier to reconstruct a load profile analysis.
- Since the incremental energy registers are synchronized to the circuit monitor clock, it is possible to log this data from multiple circuits and perform accurate totalizing.

Using Incremental Energy

Figure A–3: Increment Energy Example



1st Interval (7 hours) = 8:00 a.m. to 3:00 p.m.
2nd Interval (7 hours) = 3:00 p.m. to 10:00 p.m.
3rd Interval (2 hours) = 10:00 p.m. to 12:00 a.m.

Incremental energy accumulation begins at the specified start time and ends at the specified end time. When the start time arrives, a new incremental energy period begins. The start and end time are specified in minutes from midnight. For example:

Interval: 420 minutes (7 hours)
Start time: 480 minutes (8:00 a.m.)
End time = 1440 minutes (12:00 a.m.)

The first incremental energy calculation will be from 8:00 a.m. to 3:00 p.m. (7 hours) as illustrated in Figure A–3. The next interval will be from 3:00 p.m. to 10:00 p.m., and the third interval will be from 10 p.m. to 12:00 a.m. because 12:00 a.m. is the specified end time. A new interval will begin on the next day at 8:00 a.m. Incremental energy accumulation will continue in this manner until the configuration is changed or a new interval is started by a remote master.

Set up—To set up incremental energy:

1. Write command code 9020 to register 8000.
2. In register 3230, write a start time (in minutes-from-midnight).
3. For example, 8:00 am is 480 minutes.
4. In register 3231, write an end time (in minutes-from-midnight).

5. Write the desired interval length, from 0–1440 minutes, to register 3229.
6. If incremental energy will be controlled from a remote master, such as a programmable controller, write 0 to the register.
7. Write 1 to register 8001.
8. Write command code 9021 to register 8000.

Start—To start a new incremental energy interval from a remote master, write command code 6910 to register 8000.

SETTING UP INDIVIDUAL HARMONIC CALCULATIONS

The circuit monitor can perform harmonic magnitude and angle calculations for each metered value and for each residual value. The harmonic magnitude can be formatted as either a percentage of the fundamental (THD) or as a percentage of the rms values (thd). The harmonic magnitude and angles are stored in a set of registers: 28,672–30,719. During the time that the circuit monitor is refreshing harmonic data, the circuit monitor posts a value of 0 in register 3245. When the set of harmonic registers is updated with new data, the circuit monitor posts a value of 1 in register 3245. The circuit monitor can be configured to hold the values in these registers for up to 60 metering update cycles once the data processing is complete.

The circuit monitor has three operating modes for harmonic data processing: disabled, magnitude only, and magnitude and angles. Because of the extra processing time necessary to perform these calculations, the factory default operating mode is magnitudes only.

To configure the harmonic data processing, write to the registers described in Table A–3.

Table A–3: Registers for Harmonic Calculations

Reg No.	Value	Description
3240	0, 1, 2	Harmonic processing; 0 = disabled 1 = magnitudes only enabled 2 = magnitudes and angles enabled
3241	0, 1, 2, 3, 4	Harmonic magnitude formatting; 0 = % of fundamental (default) 1 = % of rms 2 = Engineering units (Volts/Amperes) 3 = Volts % Nominal/Amperes 4 = Volts % Fundamental/current in Amperes
3242	10–60 seconds	Harmonics Refresh Interval Default = 30 seconds
3243	10–60 seconds	This register shows the time remaining before the next update (of harmonic data).
3245	0,1	This register indicates whether harmonic data processing is complete: 0 = processing incomplete 1 = processing complete

CHANGING SCALE FACTORS

The circuit monitor stores instantaneous metering data in 16-bit single registers. A value held in each register must be an integer between –32,767 and +32,767. Because some values for metered current, voltage, and power readings fall outside this range, the circuit monitor uses multipliers, or scale factors. This enables the circuit monitor to extend the range of metered values that it can record.

The circuit monitor stores these multipliers as scale factors. A scale factor is the multiplier expressed as a power of 10. For example, a multiplier of 10 is represented as a scale factor of 1, since 10^1=10; a multiplier of 100 is represented as a scale factor of 2, since 10^2=100.

You can change the default value of 1 to other values such as 10, 100, or 1,000. However, these scale factors are automatically selected when you set up the circuit monitor, either from the display or by using SMS.

If the circuit monitor displays "overflow" for any reading, change the scale factor to bring the reading back into a range that fits in the register. For example, because the register cannot store a number as large as 138,000, a 138 kV system requires a multiplier of 10. 138,000 is converted to 13,800 x 10. The circuit monitor stores this value as 13,800 with a scale factor of 1 (because 10^1=10).

Scale factors are arranged in scale groups.

You can use the command interface to change scale factors on a group of metered values. However, be aware of these important points if you choose to change scale factors:

Notes:

- We **strongly recommend** that you do not change the default scale factors, which are automatically selected by *POWERLOGIC* hardware and software.
- When using custom software to read circuit monitor data over the communications link, you must account for these scale factors. To correctly read any metered value with a scale factor other than 0, multiply the register value read by the appropriate power of 10.
- As with any change to basic meter setup, when you change a scale factor, all min/max and peak demand values should be reset.

APPENDIX B—SPECIFICATIONS

This appendix contains specifications for the circuit monitor and display.

CM4250 SPECIFICATIONS

NOTE: Specifications given for the CM4250 are valid at 25 degrees centigrade.

Table B–1: Specifications for CM4250

METERING SPECIFICATIONS	
Current Inputs (Each Channel)	
Current Range	0–10 A①
Nominal Current CT sec	5 , 1 A
Voltage Inputs (Each Channel)	
Voltage Range	1–690 Line to Line, 400 Line to Neutral
Nominal Voltage PT sec	100, 110, 115, 120 V
Frequency Range	45–67 Hz, 350–450 Hz
Harmonic Response—Phase Voltages and Currents	
Frequency 45–67 Hz	Up to 255th Harmonic
Frequency 350–450 Hz	Up to 31st Harmonic
Data Update Rate	Approximately 1-second update of all real-time readings for demand and energy calculations (100 ms update for some real-time readings).
Accuracy ②	
Current (measured) ③	
Phase Amperes and Neutral Amperes	±(0.04% of reading + 0.025% full scale) (full scale = 10 A)
Voltage	±(0.04% of reading + 0.025% full scale) (full scale = 690 V)
Total Power	
Real, Reactive, and Apparent Power	0.075% of reading + 0.025% of full scale
True Power Factor	±0.002 from 0.500 leading to 0.500 lagging
Energy and Demand	ANSI C12.20 0.2 Class, IEC 62053-22 0.2 Class
Frequency	
50/60Hz	±0.01 Hz at 45–67 Hz
400 Hz	±0.10 Hz at 350–450 Hz
Time of Day Clock/Calendar (at 25°C) ④	Less than ±1.5 seconds in 24 hours (1 ms resolution)
METERING INPUT ELECTRICAL SPECIFICATIONS	
Current Inputs	
Nominal	5.0 A rms
Metering Over-range	400% (20 A maximum)
Overcurrent Withstand	40 A rms Continuous 100 A rms 10 seconds in 1 hour 500 A rms 1 second in 1 hour
Input Impedance	Less than 0.1 Ohm
Burden	Less than 0.15 VA
Analog-to-Digital Converter Resolution	16 bits
Anti-aliasing Filters	50 dB attenuation at 1/2 sample rate

Table B–1: Specifications for CM4250 *(continued)*

Voltage Inputs ⑤	
Nominal Full Scale	400 Vac Line to Neutral, 690 Line to Line
Metering Over-range	50%
Input Impedance	Greater than 5 MegaOhm
Measurement overvoltage category	CATIV - up to 2000 m
	CATIII - from 2000-3000 m
CONTROL POWER INPUT SPECIFICATIONS	
AC Control Power	
Operating Input Range	90–305 Vac
Burden, maximum	50 VA
Frequency Range	45–67 Hz, 350–450 Hz
Isolation	2400 V, 1 minute
Ride-through on Power Loss	0.1 second at 120 Vac
DC Control Power	
Operating Input Range	100–300 Vdc
Burden	30 W maximum
Isolation	3400 Vdc, 1 minute
Ride-through on Power Loss	0.1 second at 120 Vdc
Overvoltage Category	II per IEC 1010-1, second edition
ENVIRONMENTAL SPECIFICATIONS	
Operating Temperature	
Meter and Optional Modules	–25° to +70°C maximum (See information about operating temperature of the circuit monitor in the installation guide.)
Remote Display	VFD model is –20 to +70°C LCD model is –20 to +60°C
Storage Temperature	
Meter and Optional Modules	–40 to +85°C (ADD Standard)
Remote Display	VFD model is –40 to +85°C LCD model is –30 to +80°C
Humidity Rating	5–95% Relative Humidity (non-condensing) at 40°C
Pollution Degree	II per IEC 1010-1
Altitude Range	0 to 3,000 m (10,000 ft)
Physical Specifications	
Weight (approximate, without add-on modules)	4.2 lb (1.90 kg)
Dimensions	See circuit monitor dimensions in the Series 4000 installation manual.
REGULATORY/STANDARDS COMPLIANCE	
Electromagnetic Interference	
Radiated Emissions	FCC Part 15 Class A/EN550 II Class A
Conducted Emissions	FCC Part 15 Class A/EN550 II Class A
Electrostatic Discharge (Air Discharge)	IEC 1000-4-2 level 3
Immunity to Electrical Fast Transient	IEC 1000-4-4 level 3
Immunity to Surge (Impulse Wave)	IEC 1000-4-5 level 4 (up to 6 kv) on voltage inputs
Voltage dips and interrupts	IEC 1000-4-11
Conducted immunity	IEC 1000-4-6
Dielectric Withstand	UL 508, CSA C22.2-14-M1987, EN 61010
Immunity to Radiated Fields	IEC 61000-4-3

Table B–1: Specifications for CM4250 *(continued)*

Accuracy	ANSI C12.20, IEC 687 Class 0.2, IEC62053-22 Class 0.2
IEC 61000-4-8	Magnetic fields 30 A/m
Product Standards	
USA	UL 508, IEC61000-4-7
Canada	CSA C22.2-2-4-M1987
Europe	CE per low voltage directive EN 61010, IEC61000-4-30
Listings	CUL and UL Listed 18X5 Ind Cont. Eq.
KYZ SPECIFICATIONS	
Load voltage	240 Vac, 300 Vdc maximum
Load current	100 mA maximum at 25°C ⑥
ON resistance	35 ohms maximum
Leakage current	0.03 µA (typical)
Turn ON/OFF time	3 ms
Input or output isolation	3750 V rms

①All values are in rms unless otherwise noted.
②Based on 1-second update rate. Does not apply to 100ms readings.
③Any CT secondary currents less than 5 mA fundamental are reported as zero.
④If higher precision is required, a GPS option is available. See “Digital Inputs” in the reference manual for more information.
⑤Any voltage input to the meter that is below 1.0 V fundamental is reported as zero.
⑥Derate load current 0.56 mA/°C above 25°C.

CM4000T SPECIFICATIONS

Table B–2: Specifications for CM4000T

METERING SPECIFICATIONS	
Current Inputs (Each Channel)	
Current Range	0–10 A ac
Nominal Current	5 A ac
Voltage Inputs (Each Channel)	
Voltage Range	0–600 Vac Line to Line, 347 Line to Neutral
Nominal Voltage (typical)	120 Vac
Impulsive Voltage	
Impulse Sampling Frequency	15 MHz, 5 MHz per channel (3 voltage channels)
Impulse Range	0 to 5,000 volts (peak) L-N
	0 to 10,000 volts (peak) L-L
Impulse Resolution	12 bits, 2.0 volts
Impulse Accuracy	±5% of reading
Frequency Range	45–67 Hz, 350–450 Hz
Harmonic Response—Phase Voltages and Currents	
Frequency 45–67 Hz	255th Harmonic
Frequency 350–450 Hz	31st Harmonic
Data Update Rate	Approximately 1-second update of all real-time readings for demand and energy calculations (100 ms update for some real-time readings).
Accuracy ①	
Current (measured) ②	
• Phase Amperes and Neutral Amperes	Current = 0.04% of reading + 0.025% full scale
Voltage	0.04% of reading + 0.025% full scale
Power	
• Real, Reactive, and Apparent Power	0.075% of reading + 0.025% of full scale
True Power Factor	±0.002 from 0.500 leading to 0.500 lagging
Energy and Demand	ANSI C12.20 0.2 Class, IEC 687 0.2 Class
Frequency	
• 50/60Hz	±0.01 Hz at 45–67 Hz
• 400 Hz	±0.10 Hz at 350–450 Hz
Time of Day Clock/Calendar (at 25°C)	Less than ±1.5 seconds in 24 hours (1 ms resolution)
METERING INPUT ELECTRICAL SPECIFICATIONS	
Current Inputs	
Nominal	5.0 A rms
Metering Over-range	100% (10 A maximum)
Overcurrent Withstand	15 A rms Continuous 50 A rms 10 seconds in 1 hour 500 A rms 1 second in 1 hour
Input Impedance	Less than 0.1 Ohm
Burden	Less than 0.15 VA
Voltage Inputs④	
Nominal Full Scale	347 Vac Line to Neutral, 600 Line to Line
Metering Over-range	50%
Input Impedance	Greater than 2 Megohm (L-L), 1 Megohm (L-N)

Table B–2: Specifications for CM4000T *(continued)*

CONTROL POWER INPUT SPECIFICATIONS	
120/240 Vac Nominal	
Operating Input Range	90–305 Vac
Burden, maximum	50 VA
Frequency Range	45–67 Hz, 350–450 Hz
Isolation	2300 V, 1 minute
Ride-through on Power Loss	0.1 second at 120 Vac
125/250 Vdc Nominal	
Operating Input Range	100–300 Vdc
Burden	30 W maximum
Isolation	3250 Vdc, 1 minute
Ride-through on Power Loss	0.1 second at 120 Vdc
Mains Supply Voltage Fluctuations	not to exceed ±10%
ENVIRONMENTAL SPECIFICATIONS	
Operating Temperature	
Meter and Optional Modules	–25° to +65°C maximum (See information about operating temperature in the *PowerLogic Circuit Monitor Installation Manual*.)
Remote Display	VFD model is –20 to +70°C LCD model is –20 to +60°C
Storage Temperature	
Meter and Optional Modules	–40 to +85°C
Remote Display	VFD model is –40 to +85°C LCD model is –30 to +80°C
Humidity Rating	5–95% Relative Humidity (non-condensing) at 40°C
Pollution Degree	UL840, IEC 1010-1 (Class 2)
Installation Category	UL508, IEC 1010-1 (Class 2)
Altitude Range	0 to 2,000 m (6,561.68 ft)
Physical Specifications	
Weight (approximate, without add-on modules)	4.2 lb (1.90 kg)
Dimensions	See the *PowerLogic Circuit Monitor Installation Manual*..
REGULATORY/STANDARDS COMPLIANCE	
Electromagnetic Interference	
Radiated Emissions	FCC Part 15 Class A/CE heavy industrial
Conducted Emissions	FCC Part 15 Class A/CE heavy industrial
Electrostatic Discharge (Air Discharge)	IEC pub 1,000-4-2 level 3
Immunity to Electrical Fast Transient	IEC pub 1,000-4-4 level 3
Immunity to Surge (Impulse Wave)	IEC pub 1,000-4-5 level 4
Dielectric Withstand	UL 508, CSA C22.2-14-M1987, EN 61010
Immunity to Radiated Fields	IEC pub 61000-6-2
Accuracy	ANSI C12.20 and IEC 687 Class 0.2
Safety	
USA	UL 508
Canada	CSA C22.2-2-4-M1987
Europe	CE per low voltage directive EN 61010, IEC61000-4-15
Listings	cUL and UL Listed 18X5 Ind Cont. Eq.

Table B–2: Specifications for CM4000T *(continued)*

KYZ SPECIFICATIONS	
Load voltage	240 Vac, 300 Vdc maximum
Load current	96 mA maximum
ON resistance	50 ohms maximum
Leakage current	0.03 µA (typical)
Turn ON/OFF time	3 ms
Input or output isolation	3750 V rms

① Based on 1-second update rate. Does not apply to 100ms readings.
② Any CT secondary currents less than 5 mA are reported as zero.
③ If higher precision is required, see “Digital Inputs” in the reference manual for more information.
④ Any voltage input to the meter that is below 1.0 V is reported as zero.

CM4000 SPECIFICATIONS

Table B–3: Specifications for CM4000

METERING SPECIFICATIONS	
Current Inputs (Each Channel)	
Current Range	0–10 A ac
Nominal Current	5 A ac
Voltage Inputs (Each Channel)	
Voltage Range	0–600 Vac Line to Line, 347 Line to Neutral
Nominal Voltage (typical)	120 Vac
Frequency Range	45–67 Hz, 350–450 Hz
Harmonic Response—Phase Voltages and Currents	
Frequency 45–67 Hz	255th Harmonic
Frequency 350–450 Hz	31st Harmonic
Data Update Rate	Approximately 1-second update of all real-time readings for demand and energy calculations (100 ms update for some real-time readings).
Accuracy ①	
Current (measured) ②	
Phase Amperes and Neutral Amperes	±(0.04% of reading + 0.025% full scale)
Voltage	±(0.04% of reading + 0.025% full scale)
Power	
Real, Reactive, and Apparent Power	0.075% of reading + 0.025% of full scale
True Power Factor	±0.002 from 0.500 leading to 0.500 lagging
Energy and Demand	ANSI C12.20 0.2 Class, IEC 687 0.2 Class
Frequency	
50/60Hz	±0.01 Hz at 45–67 Hz
400 Hz	±0.10 Hz at 350–450 Hz
Time of Day Clock/Calendar (at 25°C) ③	Less than ±1.5 seconds in 24 hours (1 ms resolution)
METERING INPUT ELECTRICAL SPECIFICATIONS	
Current Inputs	
Nominal	5.0 A rms
Metering Over-range	100% (10 A maximum)
Overcurrent Withstand	15 A rms Continuous 50 A rms 10 seconds in 1 hour 500 A rms 1 second in 1 hour
Input Impedance	Less than 0.1 Ohm
Burden	Less than 0.15 VA
Voltage Inputs ④	
Nominal Full Scale	347 Vac Line to Neutral, 600 Line to Line
Metering Over-range	50%
Input Impedance	Greater than 2 MegaOhm

Table B–3: Specifications for CM4000 *(continued)*

CONTROL POWER INPUT SPECIFICATIONS	
120/240 Vac Nominal	
Operating Input Range	90–305 Vac
Burden, maximum	50 VA
Frequency Range	45–67 Hz, 350–450 Hz
Isolation	2300 V, 1 minute
Ride-through on Power Loss	0.1 second at 120 Vac
125/250 Vdc Nominal	
Operating Input Range	100–300 Vdc
Burden	30 W maximum
Isolation	3250 Vdc, 1 minute
Ride-through on Power Loss	0.1 second at 120 Vdc
Mains Supply Voltage Fluctuations	not to exceed ±10%
ENVIRONMENTAL SPECIFICATIONS	
Operating Temperature	
Meter and Optional Modules	–25° to +70°C maximum (See information about operating temperature in the *PowerLogic Circuit Monitor Installation Manual*.)
Remote Display	VFD model is –20 to +70°C LCD model is –20 to +60°C
Storage Temperature	
Meter and Optional Modules	–40 to +85°C
Remote Display	VFD model is –40 to +85°C LCD model is –30 to +80°C
Humidity Rating	5–95% Relative Humidity (non-condensing) at 40°C
Pollution Degree	II per IEC 1010-1
Installation Category	II per IEC 1010-1
Altitude Range	0 to 3,048 m (10,000 ft)
Physical Specifications	
Weight (approximate, without add-on modules)	4.2 lb (1.90 kg)
Dimensions	See the *PowerLogic Circuit Monitor Installation Manual*..
REGULATORY/STANDARDS COMPLIANCE	
Electromagnetic Interference	
Radiated Emissions	FCC Part 15 Class A/EN550 II Class A
Conducted Emissions	FCC Part 15 Class A/EN550 II Class A
Electrostatic Discharge (Air Discharge)	IEC 1000-4-2 level 3
Immunity to Electrical Fast Transient	IEC 1000-4-4 level 3
Immunity to Surge (Impulse Wave)	IEC 1000-4-5 level 4
Voltage dips and interrupts	IEC 1000-4-11
Conducted immunity	IEC 1000-4-6
Dielectric Withstand	UL 508, CSA C22.2-14-M1987, EN 61010
Immunity to Radiated Fields	IEC 61000-4-3
Accuracy	ANSI C12.20 and IEC 687 Class 0.2
Product Standards	
USA	UL 508
Canada	CSA C22.2-2-4-M1987
Europe	CE per low voltage directive EN 61010
Listings	cUL and UL Listed 18X5 Ind Cont. Eq.

Table B–3: Specifications for CM4000 *(continued)*

KYZ SPECIFICATIONS	
Load voltage	240 Vac, 300 Vdc maximum
Load current	100 mA maximum at 25°C ⑤
ON resistance	35 ohms maximum
Leakage current	0.03 µA (typical)
Turn ON/OFF time	3 ms
Input or output isolation	3750 V rms

①Based on 1-second update rate. Does not apply to 100ms readings.

②Any CT secondary currents less than 5 mA are reported as zero.

③If higher precision is required, see “Digital Inputs” in the reference manual for more information.

④Any voltage input to the meter that is below 1.0 V is reported as zero.

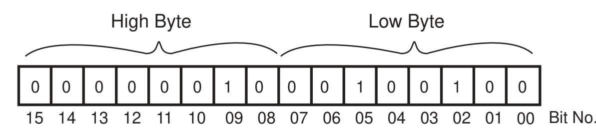
⑤Derate load current 0.56 mA/°C above 25°C.

APPENDIX C—ABBREVIATED REGISTER LISTING

ABOUT REGISTERS

For registers defined in bits, the rightmost bit is referred to as bit 00. Figure C–1 shows how bits are organized in a register.

Figure C–1: Bits in a register



The circuit monitor registers can be used with MODBUS or JBUS protocols. Although the MODBUS protocol uses a zero-based register addressing convention and JBUS protocol uses a one-based register addressing convention, the circuit monitor automatically compensates for the MODBUS offset of one. Regard all registers as holding registers where a 30,000 or 40,000 offset can be used. For example, Current Phase A will reside in register 31,000 or 41,000 instead of 1,000.

Table C–3 on page 180 contains the following ranges of registers:

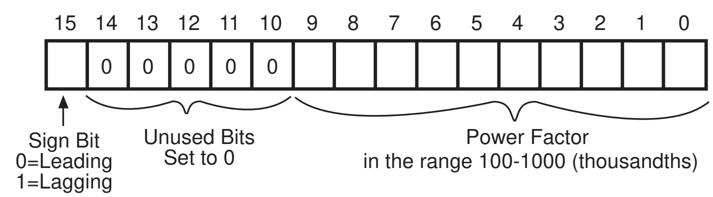
- 1000 – 1067—100 ms data
- 1080 – 1299—Real Time 1 second data
- 1300 – 1499—Real Time Minimums
- 1500 – 1794—Real Time Maximums
- 1700 – 1794—Energy Readings
- 2150 – 2193—Demand Readings
- 3000 – 3999—System Configurations

For a more complete register listing, visit the www.powerlogic.com web site.

HOW POWER FACTOR IS STORED IN THE REGISTER

Each power factor value occupies one register. Power factor values are stored using signed magnitude notation (see Figure C–2 below). Bit number 15, the sign bit, indicates leading/lagging. A positive value (bit 15=0) always indicates leading. A negative value (bit 15=1) always indicates lagging. Bits 0–9 store a value in the range 0–1,000 decimal. For example the circuit monitor would return a leading power factor of 0.5 as 500. Divide by 1,000 to get a power factor in the range 0 to 1.000.

Figure C–2: Power factor register format



When the power factor is lagging, the circuit monitor returns a high negative value—for example, -31,794. This happens because bit 15=1 (for example, the binary equivalent of -31,794 is 1000001111001110). To get a value in the range 0 to 1,000, you need to mask bit 15. You do this by adding 32,768 to the value. An example will help clarify.

Assume that you read a power factor value of -31,794. Convert this to a power factor in the range 0 to 1.000, as follows:

-31,794 + 32,768 = 974

974/1,000 = .974 lagging power factor

HOW DATE AND TIME ARE STORED IN REGISTERS

The date and time are stored in a four-register compressed format. Each of the four registers, such as registers 1810 to 1813, contain a high and low byte value to represent the date and time in hexadecimal. Table C–1 lists the register and the portion of the date or time it represents.

Table C–1: Date and Time Format

Register	Hi Byte	Lo Byte
Register 1	Month (1-12)	Day (1-31)
Register 2	Year (0-199)	Hour (0-23)
Register 3	Minute (0-59)	Second (0-59)
Register 4	Milliseconds	

For example, if the date was 01/25/00 at 11:06:59.122, the Hex value would be 0119, 640B, 063B, 007A. Breaking it down into bytes we have the following:

Table C–2: Date and Time Byte Example

Hexadecimal Value	Hi Byte	Lo Byte
0119	01 = month	19 = day
640B	64 = year	0B = hour
063B	06 = minute	3B = seconds
007A	007A = milliseconds	

HOW ENERGY VALUES ARE STORED IN REGISTERS

Energy values are stored in a four-register format. Each of the four registers can have a value ranging from 0 to 9,999. A specific multiplier acts on each individual register and that value is added together for the 4 registers for the total value of the energy topic.

Register 4	Register 3	Register 2	Register 1
0 - 9,999	0 - 9,999	0 - 9,999	0 - 9,999

Energy Value = (Register 4 X 1,000,000,000,000) +
(Register 3 X 100,000,000) +
(Register 2 X 10,000) +
(Register 1)

ABBREVIATED REGISTER LISTING

Table C–3 contains an abbreviated register list for the circuit monitor.

Table C–3: Abbreviated Register List

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
100 ms Metering—Current									
1000	Current, Phase A	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	RMS
1001	Current, Phase B	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	RMS
1002	Current, Phase C	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	RMS
1003	Current, Neutral	1	Integer	RO	N	B	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	RMS 4-wire system only
1004	Current, Ground	1	Integer	RO	N	C	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	RMS 4-wire system only
1005	Current, 3-Phase Average	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	Calculated mean of Phases A, B & C
1006	Current, Apparent RMS	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	Peak instantaneous current of Phase A, B or C divided by $\sqrt{2}$
100 ms Metering—Voltage									
1020	Voltage, A-B	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	Fundamental RMS Voltage measured between A & B
1021	Voltage, B-C	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	Fundamental RMS Voltage measured between B & C
1022	Voltage, C-A	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	Fundamental RMS Voltage measured between C & A
1023	Voltage, L-L Average	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	Fundamental RMS 3 Phase Average L-L Voltage
1024	Voltage, A-N	1	Integer	RO	N	D	Volts/Scale	0 – 32,767 (-32,768 if N/A)	Fundamental RMS Voltage measured between A & N 4-wire system only
1025	Voltage, B-N	1	Integer	RO	N	D	Volts/Scale	0 – 32,767 (-32,768 if N/A)	Fundamental RMS Voltage measured between B & N 4-wire system only
1026	Voltage, C-N	1	Integer	RO	N	D	Volts/Scale	0 – 32,767 (-32,768 if N/A)	Fundamental RMS Voltage measured between C & N 4-wire system only
1027	Voltage, N-G	1	Integer	RO	N	E	Volts/Scale	0 – 32,767 (-32,768 if N/A)	Fundamental RMS Voltage measured between N & G 4-wire system with 4 element metering only
1028	Voltage, L-N Average	1	Integer	RO	N	D	Volts/Scale	0 – 32,767 (-32,768 if N/A)	Fundamental RMS 3-Phase Average L-N Voltage 4-wire system only
100 ms Metering—Power									
1040	Real Power, Phase A	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	Real Power (PA) 4-wire system only
1041	Real Power, Phase B	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	Real Power (PB) 4-wire system only
1042	Real Power, Phase C	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	Real Power (PC) 4-wire system only
1043	Real Power, Total	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767	4-wire system = PA+PB+PC 3 wire system = 3-Phase real power
1044	Reactive Power, Phase A	1	Integer	RO	N	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	Reactive Power (QA) 4-wire system only
1045	Reactive Power, Phase B	1	Integer	RO	N	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	Reactive Power (QB) 4-wire system only

RO = Read only.
R/CW = Read configure writeable if in a setup session.
NV = Nonvolatile.
①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1046	Reactive Power, Phase C	1	Integer	RO	N	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	Reactive Power (QC) 4-wire system only
1047	Reactive Power, Total	1	Integer	RO	N	F	kVAr/Scale	-32,767 – 32,767	4-wire system = QA+QB+QC 3 wire system = 3-Phase real power
1048	Apparent Power, Phase A	1	Integer	RO	N	F	kVA/Scale	-32,767 – 32,767 (-32,768 if N/A)	Apparent Power (SA) 4-wire system only
1049	Apparent Power, Phase B	1	Integer	RO	N	F	kVA/Scale	-32,767 – 32,767 (-32,768 if N/A)	Apparent Power (SB) 4-wire system only
1050	Apparent Power, Phase C	1	Integer	RO	N	F	kVA/Scale	-32,767 – 32,767 (-32,768 if N/A)	Apparent Power (SC) 4-wire system only
1051	Apparent Power, Total	1	Integer	RO	N	F	kVA/Scale	-32,767 – 32,767	4-wire system = SA+SB+SC 3 wire system = 3-Phase real power
100 ms Metering—Power Factor									
1060	True Power Factor, Phase A	1	Integer	RO	N	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using the complete harmonic content of real and apparent power. 4-wire system only
1061	True Power Factor, Phase B	1	Integer	RO	N	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using the complete harmonic content of real and apparent power. 4-wire system only
1062	True Power Factor, Phase C	1	Integer	RO	N	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using the complete harmonic content of real and apparent power. 4-wire system only
1063	True Power Factor, Total	1	Integer	RO	N	xx	0.001	1,000 -100 to 100 ①	Derived using the complete harmonic content of real and apparent power
1064	Alternate True Power Factor, Phase A	1	Integer	RO	N	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using the complete harmonic content of real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1065	Alternate True Power Factor, Phase B	1	Integer	RO	N	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using the complete harmonic content of real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1066	Alternate True Power Factor, Phase C	1	Integer	RO	N	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using the complete harmonic content of real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1067	Alternate True Power Factor, Total	1	Integer	RO	N	xx	0.001	0 – 2,000	Derived using the complete harmonic content of real and apparent power. Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
100 ms Metering—Frequency									
1080	Frequency	1	Integer	RO	N	xx	0.01Hz 0.10Hz	(50/60Hz) 4,500 – 6,700 (400Hz) 3,500 – 4,500 (-32,768 if N/A)	Frequency of circuits being monitored. If the frequency is out of range, the register will be -32,768. Value is measured only if configured in register 3239.

RO = Read only.
R/CW = Read configure writeable if in a setup session.
NV = Nonvolatile.
①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1 s Metering—Current									
1100	Current, Phase A	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	RMS
1101	Current, Phase B	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	RMS
1102	Current, Phase C	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	RMS
1103	Current, Neutral	1	Integer	RO	N	B	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	RMS 4-wire system only
1104	Current, Ground	1	Integer	RO	N	C	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	RMS 4-wire system only
1105	Current, 3-Phase Average	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	Calculated mean of Phases A, B & C
1106	Current, Apparent RMS	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	Peak instantaneous current of Phase A, B or C divided by $\sqrt{2}$
1107	Current, Unbalance, Phase A	1	Integer	RO	N	xx	0.10%	0 – 1,000	
1108	Current, Unbalance, Phase B	1	Integer	RO	N	xx	0.10%	0 – 1,000	
1109	Current, Unbalance, Phase C	1	Integer	RO	N	xx	0.10%	0 – 1,000	
1110	Current, Unbalance, Max	1	Integer	RO	N	xx	0.10%	0 – 1,000	Percent Unbalance, Worst
1 s Metering—Voltage									
1120	Voltage, A-B	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	Fundamental RMS Voltage measured between A & B
1121	Voltage, B-C	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	Fundamental RMS Voltage measured between B & C
1122	Voltage, C-A	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	Fundamental RMS Voltage measured between C & A
1123	Voltage, L-L Average	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	Fundamental RMS 3 Phase Average L-L Voltage
1124	Voltage, A-N	1	Integer	RO	N	D	Volts/Scale	0 – 32,767 (-32,768 if N/A)	Fundamental RMS Voltage measured between A & N 4-wire system only
1125	Voltage, B-N	1	Integer	RO	N	D	Volts/Scale	0 – 32,767 (-32,768 if N/A)	Fundamental RMS Voltage measured between B & N 4-wire system only
1126	Voltage, C-N	1	Integer	RO	N	D	Volts/Scale	0 – 32,767 (-32,768 if N/A)	Fundamental RMS Voltage measured between C & N 4-wire system only
1127	Voltage, N-G	1	Integer	RO	N	E	Volts/Scale	0 – 32,767 (-32,768 if N/A)	Fundamental RMS Voltage measured between N & G 4-wire system with 4 element metering only
1128	Voltage, L-N Average	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	Fundamental RMS 3-Phase Average L-N Voltage
1129	Voltage, Unbalance, A-B	1	Integer	RO	N	xx	0.10%	0 – 1,000	Percent Voltage Unbalance, Phase A-B
1130	Voltage, Unbalance, B-C	1	Integer	RO	N	xx	0.10%	0 – 1,000	Percent Voltage Unbalance, Phase B-C
1131	Voltage, Unbalance, C-A	1	Integer	RO	N	xx	0.10%	0 – 1,000	Percent Voltage Unbalance, Phase C-A

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NV = Nonvolatile.
① See “How Power Factor is Stored in the Register” on page 178.
② See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1132	Voltage, Unbalance, Max L-L	1	Integer	RO	N	xx	0.10%	0 – 1,000	Percent Voltage Unbalance, Worst L-L
1133	Voltage, Unbalance, A-N	1	Integer	RO	N	xx	0.10%	0 – 1,000 (-32,768 if N/A)	Percent Voltage Unbalance, Phase A-N 4-wire system only
1134	Voltage, Unbalance, B-N	1	Integer	RO	N	xx	0.10%	0 – 1,000 (-32,768 if N/A)	Percent Voltage Unbalance, Phase B-N 4-wire system only
1135	Voltage, Unbalance, C-N	1	Integer	RO	N	xx	0.10%	0 – 1,000 (-32,768 if N/A)	Percent Voltage Unbalance, Phase C-N 4-wire system only
1136	Voltage, Unbalance, Max L-N	1	Integer	RO	N	xx	0.10%	0 – 1,000 (-32,768 if N/A)	Percent Voltage Unbalance, Worst L-N 4-wire system only
1 s Metering—Power									
1140	Real Power, Phase A	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	Real Power (PA) 4-wire system only
1141	Real Power, Phase B	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	Real Power (PB) 4-wire system only
1142	Real Power, Phase C	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	Real Power (PC) 4-wire system only
1143	Real Power, Total	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767	4-wire system = PA+PB+PC 3-wire system = 3-Phase real power
1144	Reactive Power, Phase A	1	Integer	RO	N	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	Reactive Power (QA) 4-wire system only
1145	Reactive Power, Phase B	1	Integer	RO	N	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	Reactive Power (QB) 4-wire system only
1146	Reactive Power, Phase C	1	Integer	RO	N	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	Reactive Power (QC) 4-wire system only
1147	Reactive Power, Total	1	Integer	RO	N	F	kVAr/Scale	-32,767 – 32,767	4-wire system = QA+QB+QC 3 wire system = 3-Phase reactive power
1148	Apparent Power, Phase A	1	Integer	RO	N	F	kVA/Scale	-32,767 – 32,767 (-32,768 if N/A)	Apparent Power (SA) 4-wire system only
1149	Apparent Power, Phase B	1	Integer	RO	N	F	kVA/Scale	-32,767 – 32,767 (-32,768 if N/A)	Apparent Power (SB) 4-wire system only
1150	Apparent Power, Phase C	1	Integer	RO	N	F	kVA/Scale	-32,767 – 32,767 (-32,768 if N/A)	Apparent Power (SC) 4-wire system only
1151	Apparent Power, Total	1	Integer	RO	N	F	kVA/Scale	-32,767 – 32,767	4-wire system = SA+SB+SC 3-wire system = 3-Phase apparent power
1 s Metering—Power Factor									
1160	True Power Factor, Phase A	1	Integer	RO	N	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using the complete harmonic content of real and apparent power. 4-wire system only
1161	True Power Factor, Phase B	1	Integer	RO	N	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using the complete harmonic content of real and apparent power. 4-wire system only
1162	True Power Factor, Phase C	1	Integer	RO	N	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using the complete harmonic content of real and apparent power. 4-wire system only
1163	True Power Factor, Total	1	Integer	RO	N	xx	0.001	1,000 -100 to 100 ①	Derived using the complete harmonic content of real and apparent power

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①See "How Power Factor is Stored in the Register" on page 178.
②See "How Date and Time Are Stored in Registers" on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1164	Alternate True Power Factor, Phase A	1	Integer	RO	N	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using the complete harmonic content of real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1165	Alternate True Power Factor, Phase B	1	Integer	RO	N	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using the complete harmonic content of real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1166	Alternate True Power Factor, Phase C	1	Integer	RO	N	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using the complete harmonic content of real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1167	Alternate True Power Factor, Total	1	Integer	RO	N	xx	0.001	0 – 2,000	Derived using the complete harmonic content of real and apparent power. Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1168	Displacement Power Factor, Phase A	1	Integer	RO	N	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using only fundamental frequency of the real and apparent power. 4-wire system only
1169	Displacement Power Factor, Phase B	1	Integer	RO	N	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using only fundamental frequency of the real and apparent power. 4-wire system only
1170	Displacement Power Factor, Phase C	1	Integer	RO	N	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using only fundamental frequency of the real and apparent power. 4-wire system only
1171	Displacement Power Factor, Total	1	Integer	RO	N	xx	0.001	1,000 -100 to 100 ①	Derived using only fundamental frequency of the real and apparent power
1172	Alternate Displacement Power Factor, Phase A	1	Integer	RO	N	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using only fundamental frequency of the real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1173	Alternate Displacement Power Factor, Phase B	1	Integer	RO	N	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using only fundamental frequency of the real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1174	Alternate Displacement Power Factor, Phase C	1	Integer	RO	N	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using only fundamental frequency of the real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.

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NV = Nonvolatile.
①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1175	Alternate Displacement Power Factor, Total	1	Integer	RO	N	xx	0.001	0 – 2,000	Derived using only fundamental frequency of the real and apparent power. Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1 s Metering—Frequency and Temperature									
1180	Frequency	1	Integer	RO	N	xx	0.01Hz 0.10Hz	(50/60Hz) 4,500 – 6,700 (400Hz) 3,500 – 4,500 (-32,768 if N/A)	Frequency of circuits being monitored. If the frequency is out of range, the register will be -32,768.
1181	Temperature	1	Integer	RO	N	xx	0.1°C	-1,000 – 1,000	Internal unit temperature
1 s Metering—Analog Inputs									
1190	Auxiliary Analog Input Value, User-Selected Input 1	1	Integer	RO	N	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	Present value of user-selected auxiliary analog input. This value will be included in Min/Max determinations.
1191	Auxiliary Analog Input Value, User-Selected Input 2	1	Integer	RO	N	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	Present value of user-selected auxiliary analog input. This value will be included in Min/Max determinations.
1192	Auxiliary Analog Input Value, User-Selected Input 3	1	Integer	RO	N	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	Present value of user-selected auxiliary analog input. This value will be included in Min/Max determinations.
1193	Auxiliary Analog Input Value, User-Selected Input 4	1	Integer	RO	N	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	Present value of user-selected auxiliary analog input. This value will be included in Min/Max determinations.
1194	Auxiliary Analog Input Value, User-Selected Input 5	1	Integer	RO	N	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	Present value of user-selected auxiliary analog input. This value will be included in Min/Max determinations.
1195	Auxiliary Analog Input Value, User-Selected Input 6	1	Integer	RO	N	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	Present value of user-selected auxiliary analog input. This value will be included in Min/Max determinations.
1196	Auxiliary Analog Input Value, User-Selected Input 7	1	Integer	RO	N	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	Present value of user-selected auxiliary analog input. This value will be included in Min/Max determinations.
1197	Auxiliary Analog Input Value, User-Selected Input 8	1	Integer	RO	N	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	Present value of user-selected auxiliary analog input. This value will be included in Min/Max determinations.
1198	Auxiliary Analog Input Value, User-Selected Input 9	1	Integer	RO	N	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	Present value of user-selected auxiliary analog input. This value will be included in Min/Max determinations.
1199	Auxiliary Analog Input Value, User-Selected Input 10	1	Integer	RO	N	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	Present value of user-selected auxiliary analog input. This value will be included in Min/Max determinations.
Power Quality—THD									
1200	THD/thd Current, Phase A	1	Integer	RO	N	xx	0.10%	0 – 32,767	Total Harmonic Distortion, Phase A Current Expressed as % of fundamental

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① See “How Power Factor is Stored in the Register” on page 178.
② See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1201	THD/thd Current, Phase B	1	Integer	RO	N	xx	0.10%	0 – 32,767	Total Harmonic Distortion, Phase B Current Expressed as % of fundamental
1202	THD/thd Current, Phase C	1	Integer	RO	N	xx	0.10%	0 – 32,767	Total Harmonic Distortion, Phase C Current Expressed as % of fundamental
1203	THD/thd Current, Phase N	1	Integer	RO	N	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Total Harmonic Distortion, Phase N Current Expressed as % of fundamental 4-wire system only
1204	THD/thd Current, Ground	1	Integer	RO	N	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Total Harmonic Distortion, Ground Current Expressed as % of fundamental
1207	THD/thd Voltage, Phase A-N	1	Integer	RO	N	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Total Harmonic Distortion Expressed as % of fundamental 4-wire system only
1208	THD/thd Voltage, Phase B-N	1	Integer	RO	N	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Total Harmonic Distortion Expressed as % of fundamental 4-wire system only
1209	THD/thd Voltage, Phase C-N	1	Integer	RO	N	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Total Harmonic Distortion Expressed as % of fundamental 4-wire system only
1210	THD/thd Voltage, Phase N-G	1	Integer	RO	N	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Total Harmonic Distortion Expressed as % of fundamental 4-wire system only
1211	THD/thd Voltage, Phase A-B	1	Integer	RO	N	xx	0.10%	0 – 32,767	Total Harmonic Distortion Expressed as % of fundamental
1212	THD/thd Voltage, Phase B-C	1	Integer	RO	N	xx	0.10%	0 – 32,767	Total Harmonic Distortion Expressed as % of fundamental
1213	THD/thd Voltage, Phase C-A	1	Integer	RO	N	xx	0.10%	0 – 32,767	Total Harmonic Distortion Expressed as % of fundamental
1215	THD/thd Voltage, 3-Phase Average L-N	1	Integer	RO	N	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Total Harmonic Distortion Expressed as % of fundamental 4-wire system only
1216	THD/thd Voltage, 3-Phase Average L-L	1	Integer	RO	N	xx	0.10%	0 – 32,767	Total Harmonic Distortion Expressed as % of fundamental
Transformer Heating									
1218	K-Factor, Current, Phase A	1	Integer	RO	N	xx	0.10	0 – 10,000	Updated with spectral components.
1219	K-Factor, Current, Phase B	1	Integer	RO	N	xx	0.10	0 – 10,000	Updated with spectral components.
1220	K-Factor, Current, Phase C	1	Integer	RO	N	xx	0.10	0 – 10,000	Updated with spectral components.
1221	Crest Factor, Current, Phase A	1	Integer	RO	N	xx	0.01	0 – 10,000	Transformer Crest Factor
1222	Crest Factor, Current, Phase B	1	Integer	RO	N	xx	0.01	0 – 10,000	Transformer Crest Factor
1223	Crest Factor, Current, Phase C	1	Integer	RO	N	xx	0.01	0 – 10,000	Transformer Crest Factor
1224	Crest Factor, Current, Neutral	1	Integer	RO	N	xx	0.01	0 – 10,000 (-32,768 if N/A)	Transformer Crest Factor 4-wire system only
1225	Crest Factor, Voltage, A-N/A-B	1	Integer	RO	N	xx	0.01	0 – 10,000	Transformer Crest Factor Voltage A-N (4-wire system) Voltage A-B (3-wire system)

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②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1226	Crest Factor, Voltage, B-N/B-C	1	Integer	RO	N	xx	0.01	0 – 10,000	Transformer Crest Factor Voltage B-N (4-wire system) Voltage B-C (3-wire system)
1227	Crest Factor, Voltage, C-N/C-A	1	Integer	RO	N	xx	0.01	0 – 10,000	Transformer Crest Factor Voltage C-N (4-wire system) Voltage C-A (3-wire system)
Fundamental Magnitudes and Angles—Current									
1230	Current Fundamental RMS Magnitude, Phase A	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	
1231	Current Fundamental Coincident Angle, Phase A	1	Integer	RO	N	xx	0.1°	0 – 3,599	Referenced to A-N/A-B Voltage Angle
1232	Current Fundamental RMS Magnitude, Phase B	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	
1233	Current Fundamental Coincident Angle, Phase B	1	Integer	RO	N	xx	0.1°	0 – 3,599	Referenced to A-N/A-B Voltage Angle
1234	Current Fundamental RMS Magnitude, Phase C	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	
1235	Current Fundamental Coincident Angle, Phase C	1	Integer	RO	N	xx	0.1°	0 – 3,599	Referenced to A-N/A-B Voltage Angle
1236	Current Fundamental RMS Magnitude, Neutral	1	Integer	RO	N	B	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	4-wire system only
1237	Current Fundamental Coincident Angle, Neutral	1	Integer	RO	N	xx	0.1°	0 – 3,599 (-32,768 if N/A)	Referenced to A-N 4-wire system only
1238	Current Fundamental RMS Magnitude, Ground	1	Integer	RO	N	C	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	
1239	Current Fundamental Coincident Angle, Ground	1	Integer	RO	N	xx	0.1°	0 – 3,599 (-32,768 if N/A)	Referenced to A-N
Fundamental Magnitudes and Angles—Voltage									
1244	Voltage Fundamental RMS Magnitude, A-N/A-B	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	Voltage A-N (4-wire system) Voltage A-B (3-wire system)
1245	Voltage Fundamental Coincident Angle, A-N/A-B	1	Integer	RO	N	xx	0.1°	0 – 3,599	Referenced to A-N (4-wire) or A-B (3-wire)
1246	Voltage Fundamental RMS Magnitude, B-N/B-C	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	Voltage B-N (4-wire system) Voltage B-C (3-wire system)

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①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1247	Voltage Fundamental Coincident Angle, B-N/B-C	1	Integer	RO	N	xx	0.1°	0 – 3,599	Referenced to A-N (4-wire) or A-B (3-wire)
1248	Voltage Fundamental RMS Magnitude, C-N/C-A	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	Voltage C-N (4-wire system) Voltage C-A (3-wire system)
1249	Voltage Fundamental Coincident Angle, C-N/C-A	1	Integer	RO	N	xx	0.1°	0 – 3,599	Referenced to A-N (4-wire) or A-B (3-wire)
1250	Voltage Fundamental RMS Magnitude, N-G	1	Integer	RO	N	E	Volts/Scale	0 – 32,767 (-32,768 if N/A)	4-wire system only
1251	Voltage Fundamental Coincident Angle, N-G	1	Integer	RO	N	xx	0.1°	0 – 3,599 (-32,768 if N/A)	Referenced to A-N 4-wire system only
Fundamental Power									
1255	Fundamental Real Power, Phase A	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1256	Fundamental Real Power, Phase B	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1257	Fundamental Real Power, Phase C	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1258	Fundamental Real Power, Total	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767	
1259	Fundamental Reactive Power, Phase A	1	Integer	RO	N	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1260	Fundamental Reactive Power, Phase B	1	Integer	RO	N	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1261	Fundamental Reactive Power, Phase C	1	Integer	RO	N	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1262	Fundamental Reactive Power, Total	1	Integer	RO	N	F	kVAr/Scale	-32,767 – 32,767	
Distortion Power and Power Factor									
1264	Distortion Power, Phase A	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1265	Distortion Power, Phase B	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1266	Distortion Power, Phase C	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1267	Distortion Power, Total	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767	
1268	Distortion Power Factor, Phase A	1	Integer	RO	N	xx	0.10%	0 – 1,000 (-32,768 if N/A)	4-wire system only
1269	Distortion Power Factor, Phase B	1	Integer	RO	N	xx	0.10%	0 – 1,000 (-32,768 if N/A)	4-wire system only

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①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1270	Distortion Power Factor, Phase C	1	Integer	RO	N	xx	0.10%	0 – 1,000 (-32,768 if N/A)	4-wire system only
1271	Distortion Power Factor, Total	1	Integer	RO	N	xx	0.10%	0 – 1,000	
Harmonic Current and Voltage									
1274	Harmonic Current, Phase A	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	
1275	Harmonic Current, Phase B	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	
1276	Harmonic Current, Phase C	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	
1277	Harmonic Current, Neutral	1	Integer	RO	N	B	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	4-wire system only
1278	Harmonic Voltage, A-N/A-B	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	Voltage A-N (4-wire system) Voltage A-B (3-wire system)
1279	Harmonic Voltage, B-N/B-C	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	Voltage B-N (4-wire system) Voltage B-C (3-wire system)
1280	Harmonic Voltage, C-N/C-A	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	Voltage C-N (4-wire system) Voltage C-A (3-wire system)
1281	Total Demand Distortion	1	Integer	RO	N	xx	0.1%	0 – 1,000	Calculated based on Peak Current Demand Over Last Year entered by user in register 3233
1282	Harmonic Power Flow	1	Bitmap	RO	N	xx	xxxxxxx	0x0000 – 0x0F0F	Describes harmonic power flow per phase and total 0 = into load, 1 = out of load Bit 00 = kW Phase A Bit 01 = kW Phase B Bit 02 = kW Phase C Bit 03 = kW Total Bit 04 = reserved Bit 05 = reserved Bit 06 = reserved Bit 07 = reserved Bit 08 = kVAr Phase A Bit 09 = kVAr Phase B Bit 10 = kVAr Phase C Bit 11 = kVAr Total Bit 12 = reserved Bit 13 = reserved Bit 14 = reserved Bit 15 = reserved
Sequence Components									
1284	Current, Positive Sequence, Magnitude	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	
1285	Current, Positive Sequence, Angle	1	Integer	RO	N	xx	0.1	0 – 3,599	
1286	Current, Negative Sequence, Magnitude	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	
1287	Current, Negative Sequence, Angle	1	Integer	RO	N	xx	0.1	0 – 3,599	
1288	Current, Zero Sequence, Magnitude	1	Integer	RO	N	A	Amperes/Scale	0 – 32,767	

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②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1289	Current, Zero Sequence, Angle	1	Integer	RO	N	xx	0.1	0 – 3,599	
1290	Voltage, Positive Sequence, Magnitude	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	
1291	Voltage, Positive Sequence, Angle	1	Integer	RO	N	xx	0.1	0 – 3,599	
1292	Voltage, Negative Sequence, Magnitude	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	
1293	Voltage, Negative Sequence, Angle	1	Integer	RO	N	xx	0.1	0 – 3,599	
1294	Voltage, Zero Sequence, Magnitude	1	Integer	RO	N	D	Volts/Scale	0 – 32,767	
1295	Voltage, Zero Sequence, Angle	1	Integer	RO	N	xx	0.1	0 – 3,599	
1296	Current, Sequence, Unbalance	1	Integer	RO	N	xx	0.10%	0 – 32,767	
1297	Voltage, Sequence, Unbalance	1	Integer	RO	N	xx	0.10%	0 – 32,767	
1298	Current, Sequence Unbalance Factor	1	Integer	RO	N	xx	0.10%	0 – 1,000	Negative Sequence / Positive Sequence
1299	Voltage, Sequence Unbalance Factor	1	Integer	RO	N	xx	0.10%	0 – 1,000	Negative Sequence / Positive Sequence
Minimum—Current									
1300	Minimum Current, Phase A	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	RMS
1301	Minimum Current, Phase B	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	RMS
1302	Minimum Current, Phase C	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	RMS
1303	Minimum Current, Neutral	1	Integer	RO	Y	B	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	RMS 4-wire system only
1304	Minimum Current, Ground	1	Integer	RO	Y	C	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	Minimum calculated RMS ground current
1305	Minimum Current, 3-Phase Average	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	Minimum calculated mean of Phases A, B & C
1306	Minimum Current, Apparent RMS	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	Minimum peak instantaneous current of Phase A, B or C divided by $\sqrt{2}$
1307	Minimum Current Unbalance, Phase A	1	Integer	RO	Y	xx	0.10%	0 – 1,000	

RO = Read only.
R/CW = Read configure writeable if in a setup session.
NV = Nonvolatile.
①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1308	Minimum Current Unbalance, Phase B	1	Integer	RO	Y	xx	0.10%	0 – 1,000	
1309	Minimum Current Unbalance, Phase C	1	Integer	RO	Y	xx	0.10%	0 – 1,000	
1310	Minimum Current Unbalance, Max	1	Integer	RO	Y	xx	0.10%	0 – 1,000	
Minimum—Voltage									
1320	Minimum Voltage, A-B	1	Integer	RO	Y	D	Volts/Scale	0 – 32767	Minimum fundamental RMS Voltage between A & B
1321	Minimum Voltage, B-C	1	Integer	RO	Y	D	Volts/Scale	0 – 32767	Minimum fundamental RMS Voltage between B & C
1322	Minimum Voltage, C-A	1	Integer	RO	Y	D	Volts/Scale	0 – 32767	Minimum fundamental RMS Voltage between C & A
1323	Minimum Voltage, L-L Average	1	Integer	RO	Y	D	Volts/Scale	0 – 32767	Minimum fundamental RMS Average L-L Voltage
1324	Minimum Voltage, A-N	1	Integer	RO	Y	D	Volts/Scale	0 – 32767 (-32,768 if N/A)	Minimum fundamental RMS Voltage between A & N 4-wire system only
1325	Minimum Voltage, B-N	1	Integer	RO	Y	D	Volts/Scale	0 – 32767 (-32,768 if N/A)	Minimum fundamental RMS Voltage between B & N 4-wire system only
1326	Minimum Voltage, C-N	1	Integer	RO	Y	D	Volts/Scale	0 – 32767 (-32,768 if N/A)	Minimum fundamental RMS Voltage between C & N 4-wire system only
1327	Minimum Voltage, N-G	1	Integer	RO	Y	E	Volts/Scale	0 – 32767 (-32,768 if N/A)	Minimum fundamental RMS Voltage between N & G 4-wire system with 4-element metering only
1328	Minimum Voltage, L-N Average	1	Integer	RO	Y	D	Volts/Scale	0 – 32767 (-32,768 if N/A)	Minimum fundamental RMS L-N Voltage 4-wire system only
1329	Minimum Voltage Unbalance, A-B	1	Integer	RO	Y	xx	0.10%	0 – 1,000	
1330	Minimum Voltage Unbalance, B-C	1	Integer	RO	Y	xx	0.10%	0 – 1,000	
1331	Minimum Voltage Unbalance, C-A	1	Integer	RO	Y	xx	0.10%	0 – 1,000	
1332	Minimum Voltage Unbalance, Max L-L	1	Integer	RO	Y	xx	0.10%	0 – 1,000	Minimum percent Voltage Unbalance, Worst L-L Depends on absolute value
1333	Minimum Voltage Unbalance, A-N	1	Integer	RO	Y	xx	0.10%	0 – 1,000 (-32,768 if N/A)	
1334	Minimum Voltage Unbalance, B-N	1	Integer	RO	Y	xx	0.10%	0 – 1,000 (-32,768 if N/A)	
1335	Minimum Voltage Unbalance, C-N	1	Integer	RO	Y	xx	0.10%	0 – 1,000 (-32,768 if N/A)	
1336	Minimum Voltage Unbalance, Max L-N	1	Integer	RO	Y	xx	0.10%	0 – 1,000 (-32,768 if N/A)	Minimum percent Voltage Unbalance, Worst L-N Depends on absolute value 4-wire system only
Minimum—Power									
1340	Minimum Real Power, Phase A	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	Minimum Real Power (PA) 4-wire system only

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NV = Nonvolatile.
①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1341	Minimum Real Power, Phase B	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	Minimum Real Power (PB) 4-wire system only
1342	Minimum Real Power, Phase C	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	Minimum Real Power (PC) 4-wire system only
1343	Minimum Real Power, Total	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767	4-wire system = PA+PB+PC 3 wire system = 3-Phase real power
1344	Minimum Reactive Power, Phase A	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	Minimum Reactive Power (QA) 4-wire system only
1345	Minimum Reactive Power, Phase B	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	Minimum Reactive Power (QB) 4-wire system only
1346	Minimum Reactive Power, Phase C	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	Minimum Reactive Power (QC) 4-wire system only
1347	Minimum Reactive Power, Total	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767	4-wire system = QA+QB+QC 3-wire system = 3-Phase reactive power
1348	Minimum Apparent Power, Phase A	1	Integer	RO	Y	F	kVA/Scale	-32,767 – 32,767 (-32,768 if N/A)	Minimum Apparent Power (SA) 4-wire system only
1349	Minimum Apparent Power, Phase B	1	Integer	RO	Y	F	kVA /Scale	-32,767 – 32,767 (-32,768 if N/A)	Minimum Apparent Power (SB) 4-wire system only
1350	Minimum Apparent Power, Phase C	1	Integer	RO	Y	F	kVA /Scale	-32,767 – 32,767 (-32,768 if N/A)	Minimum Apparent Power (SC) 4-wire system only
1351	Minimum Apparent Power, Total	1	Integer	RO	Y	F	kVA /Scale	-32,767 – 32,767	4-wire system = SA+SB+SC 3-wire system = 3-Phase apparent power
Minimum—Power Factor									
1360	Minimum True Power Factor, Phase A	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using the complete harmonic content of real and apparent power. 4-wire system only
1361	Minimum True Power Factor, Phase B	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using the complete harmonic content of real and apparent power. 4-wire system only
1362	Minimum True Power Factor, Phase C	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using the complete harmonic content of real and apparent power. 4-wire system only
1363	Minimum True Power Factor, Total	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 ①	Derived using the complete harmonic content of real and apparent power
1364	Minimum Alternate True Power Factor, Phase A	1	Integer	RO	Y	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using the complete harmonic content of real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1365	Minimum Alternate True Power Factor, Phase B	1	Integer	RO	Y	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using the complete harmonic content of real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.

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NV = Nonvolatile.
①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1366	Minimum Alternate True Power Factor, Phase C	1	Integer	RO	Y	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using the complete harmonic content of real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1367	Minimum Alternate True Power Factor, Total	1	Integer	RO	Y	xx	0.001	0 – 2,000	Derived using the complete harmonic content of real and apparent power. Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1368	Minimum Displacement Power Factor, Phase A	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using only fundamental frequency of the real and apparent power. 4-wire system only
1369	Minimum Displacement Power Factor, Phase B	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using only fundamental frequency of the real and apparent power. 4-wire system only
1370	Minimum Displacement Power Factor, Phase C	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using only fundamental frequency of the real and apparent power. 4-wire system only
1371	Minimum Displacement Power Factor, Total	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 ①	Derived using only fundamental frequency of the real and apparent power
1372	Minimum Alternate Displacement Power Factor, Phase A	1	Integer	RO	Y	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using only fundamental frequency of the real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1373	Minimum Alternate Displacement Power Factor, Phase B	1	Integer	RO	Y	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using only fundamental frequency of the real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1374	Minimum Alternate Displacement Power Factor, Phase C	1	Integer	RO	Y	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using only fundamental frequency of the real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1375	Minimum Alternate Displacement Power Factor, Total	1	Integer	RO	Y	xx	0.001	0 – 2,000	Derived using only fundamental frequency of the real and apparent power. Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.

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R/CW = Read configure writeable if in a setup session.
NV = Nonvolatile.
①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
Minimum—Frequency and Temperature									
1380	Minimum Frequency	1	Integer	RO	Y	xx	0.01Hz 0.10Hz	(50/60Hz) 4,500 – 6,700 (400Hz) 3,500 – 4,500 (-32,768 if N/A)	Minimum frequency of circuits being monitored. If the frequency is out of range, the register will be -32,768.
1381	Minimum Temperature	1	Integer	RO	Y	xx	0.1°C	-1,000 – 1,000	Minimum internal unit temperature
Minimum—Analog Inputs									
1390	Minimum Auxiliary Analog Input Value, User-Selected Input 1	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1391	Minimum Auxiliary Analog Input Value, User-Selected Input 2	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1392	Minimum Auxiliary Analog Input Value, User-Selected Input 3	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1393	Minimum Auxiliary Analog Input Value, User-Selected Input 4	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1394	Minimum Auxiliary Analog Input Value, User-Selected Input 5	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1395	Minimum Auxiliary Analog Input Value, User-Selected Input 6	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1396	Minimum Auxiliary Analog Input Value, User-Selected Input 7	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1397	Minimum Auxiliary Analog Input Value, User-Selected Input 8	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1398	Minimum Auxiliary Analog Input Value, User-Selected Input 9	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1399	Minimum Auxiliary Analog Input Value, User-Selected Input 10	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	

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R/CW = Read configure writeable if in a setup session.
NV = Nonvolatile.
①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
Minimum—THD									
1400	Minimum THD/thd Current, Phase A	1	Integer	RO	Y	xx	0.10%	0 – 32,767	Minimum Total Harmonic Distortion, Phase A Current Expressed as % of fundamental
1401	Minimum THD/thd Current, Phase B	1	Integer	RO	Y	xx	0.10%	0 – 32,767	Minimum Total Harmonic Distortion, Phase B Current Expressed as % of fundamental
1402	Minimum THD/thd Current, Phase C	1	Integer	RO	Y	xx	0.10%	0 – 32,767	Minimum Total Harmonic Distortion, Phase C Current Expressed as % of fundamental
1403	Minimum THD/thd Current, Phase N	1	Integer	RO	Y	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Minimum Total Harmonic Distortion, Phase N Current Expressed as % of fundamental 4-wire system only
1404	Minimum THD/thd Current, Ground	1	Integer	RO	Y	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Minimum Total Harmonic Distortion, Ground Current Expressed as % of fundamental
1407	Minimum THD/thd Voltage, Phase A-N	1	Integer	RO	Y	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Minimum Total Harmonic Distortion Expressed as % of fundamental 4-wire system only
1408	Minimum THD/thd Voltage, Phase B-N	1	Integer	RO	Y	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Minimum Total Harmonic Distortion Expressed as % of fundamental 4-wire system only
1409	Minimum THD/thd Voltage, Phase C-N	1	Integer	RO	Y	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Minimum Total Harmonic Distortion Expressed as % of fundamental 4-wire system only
1410	Minimum THD/thd Voltage, Phase N-G	1	Integer	RO	Y	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Minimum Total Harmonic Distortion Expressed as % of fundamental 4-wire system only
1411	Minimum THD/thd Voltage, Phase A-B	1	Integer	RO	Y	xx	0.10%	0 – 32,767	Minimum Total Harmonic Distortion Expressed as % of fundamental
1412	Minimum THD/thd Voltage, Phase B-C	1	Integer	RO	Y	xx	0.10%	0 – 32,767	Minimum Total Harmonic Distortion Expressed as % of fundamental
1413	Minimum THD/thd Voltage, Phase C-A	1	Integer	RO	Y	xx	0.10%	0 – 32,767	Minimum Total Harmonic Distortion Expressed as % of fundamental
1415	Minimum THD/thd Voltage, 3-Phase Average L-N	1	Integer	RO	Y	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Minimum Total Harmonic Distortion Expressed as % of fundamental 4-wire system only
1416	Minimum THD/thd Voltage, 3-Phase Average L-L	1	Integer	RO	Y	xx	0.10%	0 – 32,767	Minimum Total Harmonic Distortion Expressed as % of fundamental
Minimum—Transformer Heating									
1418	Minimum Current K-Factor, Phase A	1	Integer	RO	Y	xx	0.10	0 – 10,000	
1419	Minimum Current K-Factor, Phase B	1	Integer	RO	Y	xx	0.10	0 – 10,000	
1420	Minimum Current K-Factor, Phase C	1	Integer	RO	Y	xx	0.10	0 – 10,000	

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NV = Nonvolatile.
①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1421	Minimum Crest Factor, Current, Phase A	1	Integer	RO	Y	xx	0.01	0 – 10,000	Minimum Transformer Crest Factor
1422	Minimum Crest Factor, Current, Phase B	1	Integer	RO	Y	xx	0.01	0 – 10,000	Minimum Transformer Crest Factor
1423	Minimum Crest Factor, Current, Phase C	1	Integer	RO	Y	xx	0.01	0 – 10,000	Minimum Transformer Crest Factor
1424	Minimum Crest Factor, Current, Neutral	1	Integer	RO	Y	xx	0.01	0 – 10,000 (-32,768 if N/A)	Minimum Transformer Crest Factor 4-wire system only
1425	Minimum Crest Factor, Voltage A-N/A-B	1	Integer	RO	Y	xx	0.01	0 – 10,000	Minimum Transformer Crest Factor Voltage A-N (4-wire system) Voltage A-B (3-wire system)
1426	Minimum Crest Factor, Voltage B-N/B-C	1	Integer	RO	Y	xx	0.01	0 – 10,000	Minimum Transformer Crest Factor Voltage B-N (4-wire system) Voltage B-C (3-wire system)
1427	Minimum Crest Factor, Voltage C-N/C-A	1	Integer	RO	Y	xx	0.01	0 – 10,000	Minimum Transformer Crest Factor Voltage C-N (4-wire system) Voltage C-A (3-wire system)
Minimum—Fundamental Magnitudes and Angles—Current									
1430	Minimum Current Fundamental RMS Magnitude, Phase A	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1431	Minimum Current Fundamental Coincident Angle, Phase A	1	Integer	RO	Y	xx	0.1°	0 – 3,599	Angle at the time of magnitude minimum Referenced to A-N/A-B Voltage Angle
1432	Minimum Current Fundamental RMS Magnitude, Phase B	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1433	Minimum Current Fundamental Coincident Angle, Phase B	1	Integer	RO	Y	xx	0.1°	0 – 3,599	Angle at the time of magnitude minimum Referenced to A-N/A-B Voltage Angle
1434	Minimum Current Fundamental RMS Magnitude, Phase C	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1435	Minimum Current Fundamental Coincident Angle, Phase C	1	Integer	RO	Y	xx	0.1°	0 – 3,599	Angle at the time of magnitude minimum Referenced to A-N/A-B Voltage Angle
1436	Minimum Current Fundamental RMS Magnitude, Neutral	1	Integer	RO	Y	B	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	4-wire system only
1437	Minimum Current Fundamental Coincident Angle, Neutral	1	Integer	RO	Y	xx	0.1°	0 – 3,599 (-32,768 if N/A)	Angle at the time of magnitude minimum Referenced to A-N 4-wire system only
1438	Minimum Current Fundamental RMS Magnitude, Ground	1	Integer	RO	Y	C	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	

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①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1439	Minimum Current Fundamental Coincident Angle, Ground	1	Integer	RO	Y	xx	0.1°	0 – 3,599 (-32,768 if N/A)	Angle at the time of magnitude minimum Referenced to A-N
Minimum—Fundamental Magnitudes and Angles—Voltage									
1444	Minimum Voltage Fundamental RMS Magnitude, A-N/A-B	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	Voltage A-N (4-wire system) Voltage A-B (3-wire system)
1445	Minimum Voltage Fundamental Coincident Angle, A-N/A-B	1	Integer	RO	Y	xx	0.1°	0 – 3,599	Angle at the time of magnitude minimum Referenced to itself)
1446	Minimum Voltage Fundamental RMS Magnitude, B-N/B-C	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	Voltage B-N (4-wire system) Voltage B-C (3-wire system)
1447	Minimum Voltage Fundamental Coincident Angle, B-N/B-C	1	Integer	RO	Y	xx	0.1°	0 – 3,599	Angle at the time of magnitude minimum Referenced to A-N (4-wire) or A-B (3-wire)
1448	Minimum Voltage Fundamental RMS Magnitude, C-N/C-A	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	Voltage C-N (4-wire system) Voltage C-A (3-wire system)
1449	Minimum Voltage Fundamental Coincident Angle, C-N/C-A	1	Integer	RO	Y	xx	0.1°	0 – 3,599	Angle at the time of magnitude minimum Referenced to A-N (4-wire) or A-B (3-wire)
1450	Minimum Voltage Fundamental RMS Magnitude, N-G	1	Integer	RO	Y	E	Volts/Scale	0 – 32,767 (-32,768 if N/A)	
1451	Minimum Voltage Fund. Coincident Angle, N-G	1	Integer	RO	Y	xx	0.1°	0 – 3,599 (-32,768 if N/A)	Angle at the time of magnitude minimum Referenced to A-N
Minimum—Fundamental Power									
1455\	Minimum Fundamental Real Power, Phase A	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1456	Minimum Fundamental Real Power, Phase B	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1457	Minimum Fundamental Real Power, Phase C	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1458	Minimum Fundamental Real Power, Total	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767	
1459	Minimum Fundamental Reactive Power, Phase A	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1460	Minimum Fundamental Reactive Power, Phase B	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only

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R/CW = Read configure writeable if in a setup session.
NV = Nonvolatile.
①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1461	Minimum Fundamental Reactive Power, Phase C	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1462	Minimum Fundamental Reactive Power, Total	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767	
Minimum—Distortion Power and Power Factor									
1464	Minimum Distortion Power, Phase A	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1465	Minimum Distortion Power, Phase B	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1466	Minimum Distortion Power, Phase C	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1467	Minimum Distortion Power, Total	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767	
1468	Minimum Distortion Power Factor, Phase A	1	Integer	RO	Y	xx	0.10%	0 – 1,000 (-32,768 if N/A)	4-wire system only
1469	Minimum Distortion Power Factor, Phase B	1	Integer	RO	Y	xx	0.10%	0 – 1,000 (-32,768 if N/A)	4-wire system only
1470	Minimum Distortion Power Factor, Phase C	1	Integer	RO	Y	xx	0.10%	0 – 1,000 (-32,768 if N/A)	4-wire system only
1471	Minimum Distortion Power Factor, Total	1	Integer	RO	Y	xx	0.10%	0 – 1,000	
Minimum—Harmonic Current and Voltage									
1474	Minimum Harmonic Current, Phase A	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1475	Minimum Harmonic Current, Phase B	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1476	Minimum Harmonic Current, Phase C	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1477	Minimum Harmonic Current, Neutral	1	Integer	RO	Y	B	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	4-wire system only
1478	Minimum Harmonic Voltage, A-N/A-B	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	Voltage A-N (4-wire system) Voltage A-B (3-wire system)
1479	Minimum Harmonic Voltage, B-N/B-C	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	Voltage B-N (4-wire system) Voltage B-C (3-wire system)
1480	Minimum Harmonic Voltage, C-N/C-A	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	Voltage C-N (4-wire system) Voltage C-A (3-wire system)
1481	Minimum Total Demand Distortion	1	Integer	RO	Y	xx	0.01%	0 – 10,000	

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NV = Nonvolatile.
① See "How Power Factor is Stored in the Register" on page 178.
② See "How Date and Time Are Stored in Registers" on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
Minimum—Sequence Components									
1484	Minimum Current, Positive Sequence, Magnitude	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1485	Minimum Current, Positive Sequence, Angle	1	Integer	RO	Y	xx	0.1	0 – 3,599	
1486	Minimum Current, Negative Sequence, Magnitude	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1487	Minimum Current, Negative Sequence, Angle	1	Integer	RO	Y	xx	0.1	0 – 3,599	
1488	Minimum Current, Zero Sequence, Magnitude	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1489	Minimum Current, Zero Sequence, Angle	1	Integer	RO	Y	xx	0.1	0 – 3,599	
1490	Minimum Voltage, Positive Sequence, Magnitude	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	
1491	Minimum Voltage, Positive Sequence, Angle	1	Integer	RO	Y	xx	0.1	0 – 3,599	
1492	Minimum Voltage, Negative Sequence, Magnitude	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	
1493	Minimum Voltage, Negative Sequence, Angle	1	Integer	RO	Y	xx	0.1	0 – 3,599	
1494	Minimum Voltage, Zero Sequence, Magnitude	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	
1495	Minimum Voltage, Zero Sequence, Angle	1	Integer	RO	Y	xx	0.1	0 – 3,599	
1496	Minimum Current, Sequence, Unbalance	1	Integer	RO	Y	xx	0.10%	-1,000 – 1,000	
1497	Minimum Voltage, Sequence, Unbalance	1	Integer	RO	Y	xx	0.10%	-1,000 – 1,000	
1498	Minimum Current, Sequence Unbalance Factor	1	Integer	RO	N	xx	0.10%	0 – 1,000	Negative Sequence / Positive Sequence

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②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1499	Minimum Voltage, Sequence Unbalance Factor	1	Integer	RO	N	xx	0.10%	0 – 1,000	Negative Sequence / Positive Sequence
Maximum—Current									
1500	Maximum Current, Phase A	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	RMS
1501	Maximum Current, Phase B	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	RMS
1502	Maximum Current, Phase C	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	RMS
1503	Maximum Current, Neutral	1	Integer	RO	Y	B	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	RMS 4-wire system only
1504	Maximum Current, Ground	1	Integer	RO	Y	C	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	Maximum calculated RMS ground current
1505	Maximum Current, 3 Phase Average	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	Maximum calculated mean of Phases A, B & C
1506	Maximum Current, Apparent RMS	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	Maximum peak instantaneous current of Phase A, B or C divided by √2
1507	Maximum Current Unbalance, Phase A	1	Integer	RO	Y	xx	0.10%	0 – 1,000	
1508	Maximum Current Unbalance, Phase B	1	Integer	RO	Y	xx	0.10%	0 – 1,000	
1509	Maximum Current Unbalance, Phase C	1	Integer	RO	Y	xx	0.10%	0 – 1,000	
1510	Maximum Current Unbalance, Max	1	Integer	RO	Y	xx	0.10%	0 – 1,000	
Maximum—Voltage									
1520	Maximum Voltage, A-B	1	Integer	RO	Y	D	Volts/Scale	0 – 32767	Maximum fundamental RMS Voltage between A & B
1521	Maximum Voltage, B-C	1	Integer	RO	Y	D	Volts/Scale	0 – 32767	Maximum fundamental RMS Voltage between B & C
1522	Maximum Voltage, C-A	1	Integer	RO	Y	D	Volts/Scale	0 – 32767	Maximum fundamental RMS Voltage between C & A
1523	Maximum Voltage, L-L Average	1	Integer	RO	Y	D	Volts/Scale	0 – 32767	Maximum fundamental RMS Average L-L Voltage
1524	Maximum Voltage, A-N	1	Integer	RO	Y	D	Volts/Scale	0 – 32767 (-32,768 if N/A)	Maximum fundamental RMS Voltage between A & N 4-wire system only
1525	Maximum Voltage, B-N	1	Integer	RO	Y	D	Volts/Scale	0 – 32767 (-32,768 if N/A)	Maximum fundamental RMS Voltage between B & N 4-wire system only
1526	Maximum Voltage, C-N	1	Integer	RO	Y	D	Volts/Scale	0 – 32767 (-32,768 if N/A)	Maximum fundamental RMS Voltage between C & N 4-wire system only

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①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1527	Maximum Voltage, N-G	1	Integer	RO	Y	E	Volts/Scale	0 – 32767 (-32,768 if N/A)	Maximum fundamental RMS Voltage between N & G 4-wire system with 4-element metering only
1528	Maximum Voltage, L-N Average	1	Integer	RO	Y	D	Volts/Scale	0 – 32767 (-32,768 if N/A)	Maximum fundamental RMS L-N Voltage 4-wire system only
1529	Maximum Voltage Unbalance, A-B	1	Integer	RO	Y	xx	0.10%	0 – 1,000	
1530	Maximum Voltage Unbalance, B-C	1	Integer	RO	Y	xx	0.10%	0 – 1,000	
1531	Maximum Voltage Unbalance, C-A	1	Integer	RO	Y	xx	0.10%	0 – 1,000	
1532	Maximum Voltage Unbalance, Max L-L	1	Integer	RO	Y	xx	0.10%	0 – 1,000	Maximum percent Voltage Unbalance, Worst L-L Depends on absolute value
1533	Maximum Voltage Unbalance, A-N	1	Integer	RO	Y	xx	0.10%	0 – 1,000 (-32,768 if N/A)	
1534	Maximum Voltage Unbalance, B-N	1	Integer	RO	Y	xx	0.10%	0 – 1,000 (-32,768 if N/A)	
1535	Maximum Voltage Unbalance, C-N	1	Integer	RO	Y	xx	0.10%	0 – 1,000 (-32,768 if N/A)	
1536	Maximum Voltage Unbalance, Max L-N	1	Integer	RO	Y	xx	0.10%	0 – 1,000 (-32,768 if N/A)	Maximum percent Voltage Unbalance, Worst L-N Depends on absolute value (4-wire system only)
Maximum—Power									
1540	Maximum Real Power, Phase A	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	Maximum Real Power (PA) 4-wire system only
1541	Maximum Real Power, Phase B	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	Maximum Real Power (PB) 4-wire system only
1542	Maximum Real Power, Phase C	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	Maximum Real Power (PC) 4-wire system only
1543	Maximum Real Power, Total	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767	4-wire system = PA+PB+PC 3 wire system = 3-Phase real power
1544	Maximum Reactive Power, Phase A	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	Maximum Reactive Power (QA) 4-wire system only
1545	Maximum Reactive Power, Phase B	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	Maximum Reactive Power (QB) 4-wire system only
1546	Maximum Reactive Power, Phase C	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	Maximum Reactive Power (QC) 4-wire system only
1547	Maximum Reactive Power, Total	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767	4-wire system = QA+QB+QC 3 wire system = 3-Phase reactive power
1548	Maximum Apparent Power, Phase A	1	Integer	RO	Y	F	kVA /Scale	-32,767 – 32,767 (-32,768 if N/A)	Maximum Apparent Power (SA) 4-wire system only

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①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1549	Maximum Apparent Power, Phase B	1	Integer	RO	Y	F	kVA /Scale	-32,767 – 32,767 (-32,768 if N/A)	Maximum Apparent Power (SB) 4-wire system only
1550	Maximum Apparent Power, Phase C	1	Integer	RO	Y	F	kVA /Scale	-32,767 – 32,767 (-32,768 if N/A)	Maximum Apparent Power (SC) 4-wire system only
1551	Maximum Apparent Power, Total	1	Integer	RO	Y	F	kVA /Scale	-32,767 – 32,767	4-wire system = SA+SB+SC 3-wire system = 3-Phase apparent power
Maximum—Power Factor									
1560	Maximum True Power Factor, Phase A	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using the complete harmonic content of real and apparent power (4-wire system only)
1561	Maximum True Power Factor, Phase B	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using the complete harmonic content of real and apparent power (4-wire system only)
1562	Maximum True Power Factor, Phase C	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using the complete harmonic content of real and apparent power (4-wire system only)
1563	Maximum True Power Factor, Total	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 ①	Derived using the complete harmonic content of real and apparent power
1564	Maximum Alternate True Power Factor, Phase A	1	Integer	RO	Y	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using the complete harmonic content of real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1565	Maximum Alternate True Power Factor, Phase B	1	Integer	RO	Y	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using the complete harmonic content of real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1566	Maximum Alternate True Power Factor, Phase C	1	Integer	RO	Y	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using the complete harmonic content of real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1567	Maximum Alternate True Power Factor, Total	1	Integer	RO	Y		0.001	0 – 2,000	Derived using the complete harmonic content of real and apparent power. Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1568	Maximum Displacement Power Factor, Phase A	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using only fundamental frequency of the real and apparent power. 4-wire system only
1569	Maximum Displacement Power Factor, Phase B	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using only fundamental frequency of the real and apparent power. 4-wire system only
1570	Maximum Displacement Power Factor, Phase C	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Derived using only fundamental frequency of the real and apparent power. 4-wire system only

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①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1571	Maximum Displacement Power Factor, Total	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 ①	Derived using only fundamental frequency of the real and apparent power
1572	Maximum Alternate Displacement Power Factor, Phase A	1	Integer	RO	Y	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using only fundamental frequency of the real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1573	Maximum Alternate Displacement Power Factor, Phase B	1	Integer	RO	Y	xx	0.001	0 – 2,000 (-32,768 if N/A)	Derived using only fundamental frequency of the real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1574	Maximum Alternate Displacement Power Factor, Phase C	1	Integer	RO	Y		0.001	0 – 2,000 (-32,768 if N/A)	Derived using only fundamental frequency of the real and apparent power (4-wire system only). Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
1575	Maximum Alternate Displacement Power Factor, Total	1	Integer	RO	Y	xx	0.001	0 – 2,000	Derived using only fundamental frequency of the real and apparent power. Reported value is mapped from 0-2000, with 1000 representing unity, values below 1000 representing lagging, and values above 1000 representing leading.
Maximum—Frequence and Temperature									
1580	Maximum Frequency	1	Integer	RO	Y	xx	0.01Hz 0.10Hz	(50/60Hz) 4,500 – 6,700 (400Hz) 3,500 – 4,500 (-32,768 if N/A)	Frequency of circuits being monitored. If the frequency is out of range, the register will be –32,768.
1581	Maximum Temperature	1	Integer	RO	Y	xx	0.1°C	-1,000 – 1,000	Internal unit temperature
Maximum—Analog Inputs									
1590	Maximum Auxiliary Analog Input Value, User-Selected Input 1	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1591	Maximum Auxiliary Analog Input Value, User-Selected Input 2	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1592	Maximum Auxiliary Analog Input Value, User-Selected Input 3	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1593	Maximum Auxiliary Analog Input Value, User-Selected Input 4	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	

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①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1594	Maximum Auxiliary Analog Input Value, User-Selected Input 5	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1595	Maximum Auxiliary Analog Input Value, User-Selected Input 6	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1596	Maximum Auxiliary Analog Input Value, User-Selected Input 7	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1597	Maximum Auxiliary Analog Input Value, User-Selected Input 8	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1598	Maximum Auxiliary Analog Input Value, User-Selected Input 9	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
1599	Maximum Auxiliary Analog Input Value, User-Selected Input 10	1	Integer	RO	Y	xx	Refer to Analog Input Setup	-32,767 – 32,767 (-32,768 if N/A)	
Maximum—THD									
1600	Maximum THD/thd Current, Phase A	1	Integer	RO	Y	xx	0.10%	0 – 32,767	Maximum Total Harmonic Distortion, Phase A Current Expressed as % of fundamental
1601	Maximum THD/thd Current, Phase B	1	Integer	RO	Y	xx	0.10%	0 – 32,767	Maximum Total Harmonic Distortion, Phase B Current Expressed as % of fundamental
1602	Maximum THD/thd Current, Phase C	1	Integer	RO	Y	xx	0.10%	0 – 32,767	Maximum Total Harmonic Distortion, Phase C Current Expressed as % of fundamental
1603	Maximum THD/thd Current, Phase N	1	Integer	RO	Y	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Maximum Total Harmonic Distortion, Phase N Current Expressed as % of fundamental 4-wire system only
1604	Maximum THD/thd Current, Ground	1	Integer	RO	Y	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Maximum Total Harmonic Distortion, Ground Current Expressed as % of fundamental
1607	Maximum THD/thd Voltage, Phase A-N	1	Integer	RO	Y	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Maximum Total Harmonic Distortion Expressed as % of fundamental 4-wire system only
1608	Maximum THD/thd Voltage, Phase B-N	1	Integer	RO	Y	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Maximum Total Harmonic Distortion Expressed as % of fundamental 4-wire system only
1609	Maximum THD/thd Voltage, Phase C-N	1	Integer	RO	Y	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Maximum Total Harmonic Distortion Expressed as % of fundamental 4-wire system only
1610	Maximum THD/thd Voltage, Phase N-G	1	Integer	RO	Y	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Maximum Total Harmonic Distortion Expressed as % of fundamental 4-wire system only

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②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1611	Maximum THD/thd Voltage, Phase A-B	1	Integer	RO	Y	xx	0.10%	0 – 32,767	Maximum Total Harmonic Distortion Expressed as % of fundamental
1612	Maximum THD/thd Voltage, Phase B-C	1	Integer	RO	Y	xx	0.10%	0 – 32,767	Maximum Total Harmonic Distortion Expressed as % of fundamental
1613	Maximum THD/thd Voltage, Phase C-A	1	Integer	RO	Y	xx	0.10%	0 – 32,767	Maximum Total Harmonic Distortion Expressed as % of fundamental
1615	Maximum THD/thd Voltage, 3-Phase Average L-N	1	Integer	RO	Y	xx	0.10%	0 – 32,767 (-32,768 if N/A)	Maximum Total Harmonic Distortion Expressed as % of fundamental 4-wire system only
1616	Maximum THD/thd Voltage, 3-Phase Average L-L	1	Integer	RO	Y	xx	0.10%	0 – 32,767	Maximum Total Harmonic Distortion Expressed as % of fundamental
Maximum—Transformer Heating									
1618	Maximum Current K-Factor, Phase A	1	Integer	RO	Y	xx	0.10	0 – 10,000	
1619	Maximum Current K-Factor, Phase B	1	Integer	RO	Y	xx	0.10	0 – 10,000	
1620	Maximum Current K-Factor, Phase C	1	Integer	RO	Y	xx	0.10	0 – 10,000	
1621	Maximum Crest Factor, Current, Phase A	1	Integer	RO	Y	xx	0.01	0 – 10,000	Maximum Transformer Crest Factor
1622	Maximum Crest Factor, Current, Phase B	1	Integer	RO	Y	xx	0.01	0 – 10,000	Maximum Transformer Crest Factor
1623	Maximum Crest Factor, Current, Phase C	1	Integer	RO	Y	xx	0.01	0 – 10,000	Maximum Transformer Crest Factor
1624	Maximum Crest Factor, Current, Neutral	1	Integer	RO	Y	xx	0.01	0 – 10,000 (-32,768 if N/A)	Maximum Transformer Crest Factor 4-wire system only
1625	Maximum Crest Factor, Voltage A-N/A-B	1	Integer	RO	Y	xx	0.01	0 – 10,000	Maximum Transformer Crest Factor Voltage A-N (4-wire system) Voltage A-B (3-wire system)
1626	Maximum Crest Factor, Voltage B-N/B-C	1	Integer	RO	Y	xx	0.01	0 – 10,000	Maximum Transformer Crest Factor Voltage B-N (4-wire system) Voltage B-C (3-wire system)
1627	Maximum Crest Factor, Voltage C-N/C-A	1	Integer	RO	Y	xx	0.01	0 – 10,000	Maximum Transformer Crest Factor Voltage C-N (4-wire system) Voltage C-A (3-wire system)
Maximum—Fundamental Magnitudes and Angles—Current									
1630	Maximum Current Fundamental RMS Magnitude, Phase A	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1631	Maximum Current Fundamental Coincident Angle, Phase A	1	Integer	RO	Y	xx	0.1°	0 – 3,599	Angle at the time of magnitude Maximum Referenced to A-N/A-B Voltage Angle

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②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1632	Maximum Current Fundamental RMS Magnitude, Phase B	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1633	Maximum Current Fundamental Coincident Angle, Phase B	1	Integer	RO	Y	xx	0.1°	0 – 3,599	Angle at the time of magnitude Maximum Referenced to A-N/A-B Voltage Angle
1634	Maximum Current Fundamental RMS Magnitude, Phase C	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1635	Maximum Current Fundamental Coincident Angle, Phase C	1	Integer	RO	Y	xx	0.1°	0 – 3,599	Angle at the time of magnitude Maximum Referenced to A-N/A-B Voltage Angle
1636	Maximum Current Fundamental RMS Magnitude, Neutral	1	Integer	RO	Y	B	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	4-wire system only
1637	Maximum Current Fundamental Coincident Angle, Neutral	1	Integer	RO	Y	xx	0.1°	0 – 3,599 (-32,768 if N/A)	Angle at the time of magnitude Maximum Referenced to A-N 4-wire system only
1638	Maximum Current Fundamental RMS Magnitude, Ground	1	Integer	RO	Y	C	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	
1639	Maximum Current Fundamental Coincident Angle, Ground	1	Integer	RO	Y	xx	0.1°	0 – 3,599 (-32,768 if N/A)	Angle at the time of magnitude Maximum Referenced to A-N
Maximum—Fundamental Magnitudes and Angles—Voltage									
1644	Maximum Voltage Fundamental RMS Magnitude, A-N/A-B	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	Voltage A-N (4-wire system) Voltage A-B (3-wire system)
1645	Maximum Voltage Fundamental Coincident Angle, A-N/A-B	1	Integer	RO	Y	xx	0.1°	0 – 3,599	Angle at the time of magnitude Maximum Referenced to itself
1646	Maximum Voltage Fundamental RMS Magnitude, B-N/B-C	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	Voltage B-N (4-wire system) Voltage B-C (3-wire system)
1647	Maximum Voltage Fundamental Coincident Angle, B-N/B-C	1	Integer	RO	Y	xx	0.1°	0 – 3,599	Angle at the time of magnitude Maximum Referenced to A-N (4-wire) or A-B (3-wire)

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NV = Nonvolatile.
①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1648	Maximum Voltage Fundamental RMS Magnitude, C-N/C-A	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	Voltage C-N (4-wire system) Voltage C-A (3-wire system)
1649	Maximum Voltage Fundamental Coincident Angle, C-N/C-A	1	Integer	RO	Y	xx	0.1°	0 – 3,599	Angle at the time of magnitude Maximum Referenced to A-N (4-wire) or A-B (3-wire)
1650	Maximum Voltage Fundamental RMS Magnitude, N-G	1	Integer	RO	Y	E	Volts/Scale	0 – 32,767 (-32,768 if N/A)	
1651	Maximum Voltage Fund. Coincident Angle, N-G	1	Integer	RO	Y	xx	0.1°	0 – 3,599 (-32,768 if N/A)	Angle at the time of magnitude Maximum Referenced to A-N
Maximum—Fundamental Power									
1655	Maximum Fundamental Real Power, Phase A	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1656	Maximum Fundamental Real Power, Phase B	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1657	Maximum Fundamental Real Power, Phase C	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1658	Maximum Fundamental Real Power, Total	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767	
1659	Maximum Fundamental Reactive Power, Phase A	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1660	Maximum Fundamental Reactive Power, Phase B	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1661	Maximum Fundamental Reactive Power, Phase C	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1662	Maximum Fundamental Reactive Power, Total	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767	
Maximum—Distortion Power and Power Factort									
1664	Maximum Distortion Power, Phase A	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1665	Maximum Distortion Power, Phase B	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only

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NV = Nonvolatile.
①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1666	Maximum Distortion Power, Phase C	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767 (-32,768 if N/A)	4-wire system only
1667	Maximum Distortion Power, Total	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767	
1668	Maximum Distortion Factor, Phase A	1	Integer	RO	Y	F	0.10	0 – 1,000 (-32,768 if N/A)	4-wire system only
1669	Maximum Distortion Factor, Phase B	1	Integer	RO	Y	F	0.10	0 – 1,000 (-32,768 if N/A)	4-wire system only
1670	Maximum Distortion Factor, Phase C	1	Integer	RO	Y	F	0.10	0 – 1,000 (-32,768 if N/A)	4-wire system only
1671	Maximum Distortion Factor, Total	1	Integer	RO	Y	F	0.10	0 – 1,000	
Maximum—Harmonic Current and Voltage									
1674	Maximum Harmonic Current, Phase A	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1675	Maximum Harmonic Current, Phase B	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1676	Maximum Harmonic Current, Phase C	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1677	Maximum Harmonic Current, Neutral	1	Integer	RO	Y	B	Amperes/Scale	0 – 32,767 (-32,768 if N/A)	4-wire system only
1678	Maximum Harmonic Voltage A	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	Voltage A-N (4-wire system) Voltage A-B (3-wire system)
1679	Maximum Harmonic Voltage B	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	Voltage B-N (4-wire system) Voltage B-C (3-wire system)
1680	Maximum Harmonic Voltage C	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	Voltage C-N (4-wire system) Voltage C-A (3-wire system)
1681	Maximum Total Demand Distortion	1	Integer	RO	Y	xx	0.01%	0 – 10,000	
Maximum—Sequence Components									
1684	Maximum Current, Positive Sequence, Magnitude	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1685	Maximum Current, Positive Sequence, Angle	1	Integer	RO	Y	xx	0.1°	0 – 3,599	
1686	Maximum Current, Negative Sequence, Magnitude	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	

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①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1687	Maximum Current, Negative Sequence, Angle	1	Integer	RO	Y	xx	0.1°	0 – 3,599	
1688	Maximum Current, Zero Sequence, Magnitude	1	Integer	RO	Y	A	Amperes/Scale	0 – 32,767	
1689	Maximum Current, Zero Sequence, Angle	1	Integer	RO	Y	xx	0.1°	0 – 3,599	
1690	Maximum Voltage, Positive Sequence, Magnitude	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	
1691	Maximum Voltage, Positive Sequence, Angle	1	Integer	RO	Y	xx	0.1°	0 – 3,599	
1692	Maximum Voltage, Negative Sequence, Magnitude	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	
1693	Maximum Voltage, Negative Sequence, Angle	1	Integer	RO	Y	xx	0.1°	0 – 3,599	
1694	Maximum Voltage, Zero Sequence, Magnitude	1	Integer	RO	Y	D	Volts/Scale	0 – 32,767	
1695	Maximum Voltage, Zero Sequence, Angle	1	Integer	RO	Y	xx	0.1°	0 – 3,599	
1696	Maximum Current, Sequence, Unbalance	1	Integer	RO	Y	xx	0.10%	-1,000 – 1,000	
1697	Maximum Voltage, Sequence, Unbalance	1	Integer	RO	Y	xx	0.10%	-1,000 – 1,000	
1698	Maximum Current, Sequence Unbalance Factor	1	Integer	RO	N	xx	0.10%	0 – 1,000	Negative Sequence / Positive Sequence
1699	Maximum Voltage, Sequence Unbalance Factor	1	Integer	RO	N	xx	0.10%	0 – 1,000	Negative Sequence / Positive Sequence
Energy									
1700	Energy, Real In	4	Mod10	RO	Y	xx	WH	(1)	3-Phase total real energy into the load
1704	Energy, Reactive In	4	Mod10	RO	Y	xx	VArH	(1)	3-Phase total reactive energy into the load
1708	Energy, Real Out	4	Mod10	RO	Y	xx	WH	(1)	3-Phase total real energy out of the load
1712	Energy, Reactive Out	4	Mod10	RO	Y	xx	VArH	(1)	3-Phase total reactive energy out of the load

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①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1716	Energy, Real Total (signed/absolute)	4	Mod10	RO	Y	xx	WH	(2)	Total Real Energy In, Out or In + Out
1720	Energy, Reactive Total (signed/absolute)	4	Mod10	RO	Y	xx	VArH	(2)	Total Reactive Energy In, Out or In + Out
1724	Energy, Apparent	4	Mod10	RO	Y	xx	VAH	(1)	3-Phase total apparent energy
1728	Energy, Conditional Real In	4	Mod10	RO	Y	xx	WH	(1)	3-Phase total accumulated conditional real energy into the load
1732	Energy, Conditional Reactive In	4	Mod10	RO	Y	xx	VArH	(1)	3-Phase total accumulated conditional reactive energy into the load
1736	Energy, Conditional Real Out	4	Mod10	RO	Y	xx	WH	(1)	3-Phase total accumulated conditional real energy out of the load
1740	Energy, Conditional Reactive Out	4	Mod10	RO	Y	xx	VArH	(1)	3-Phase total accumulated conditional reactive energy out of the load
1744	Energy, Conditional Apparent	4	Mod10	RO	Y	xx	VAH	(1)	3-Phase total accumulated conditional apparent energy
1748	Energy, Incremental Real In, Last Complete Interval	3	Mod10	RO	Y	xx	WH	(3)	3-Phase total accumulated incremental real energy into the load
1751	Energy. Incremental Reactive In, Last Complete Interval	3	Mod10	RO	Y	xx	VArH	(3)	3-Phase total accumulated incremental reactive energy into the load
1754	Energy, Incremental Real Out, Last Complete Interval	3	Mod10	RO	Y	xx	WH	(3)	3-Phase total accumulated incremental real energy out of the load
1757	Energy, Incremental Reactive Out, Last Complete Interval	3	Mod10	RO	Y	xx	VArH	(3)	3-Phase total accumulated incremental reactive energy out of the load
1760	Energy, Incremental Apparent, Last Complete Interval	3	Mod10	RO	Y	xx	VAH	(3)	3-Phase total accumulated incremental apparent energy
1763	DateTime Last Complete Incremental Energy Interval	4	DateTime	RO	Y	xx	See Template ②	See Template ②	
1767	Energy, Incremental Real In, Present Interval	3	Mod10	RO	Y	xx	WH	(3)	3-Phase total accumulated incremental real energy into the load
1770	Energy. Incremental Reactive In, Present Interval	3	Mod10	RO	Y	xx	VArH	(3)	3-Phase total accumulated incremental reactive energy into the load

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①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
1773	Energy, Incremental Real Out, Present Interval	3	Mod10	RO	Y	xx	WH	(3)	3-Phase total accumulated incremental real energy out of the load
1776	Energy, Incremental Reactive Out, Present Interval	3	Mod10	RO	Y	xx	VArH	(3)	3-Phase total accumulated incremental reactive energy out of the load
1779	Energy, Incremental Apparent, Present Interval	3	Mod10	RO	Y	xx	VAH	(3)	3-Phase total accumulated incremental apparent energy
1782	Energy, Reactive, Quadrant 1	3	Mod10	RO	Y	xx	VArH	(3)	3-Phase total accumulated incremental reactive energy – quadrant 1
1785	Energy, Reactive, Quadrant 2	3	Mod10	RO	Y	xx	VArH	(3)	3-Phase total accumulated incremental reactive energy – quadrant 2
1788	Energy, Reactive, Quadrant 3	3	Mod10	RO	Y	xx	VArH	(3)	3-Phase total accumulated incremental reactive energy – quadrant 3
1791	Energy, Reactive, Quadrant 4	3	Mod10	RO	Y	xx	VArH	(3)	3-Phase total accumulated incremental reactive energy – quadrant 4
1794	Conditional Energy Control Status	1	Integer	RO	Y	xx	xx	0 – 1	0 = Off (default) 1 = On
Note: (1) 0 – 9,999,999,999,999,999 (2) -9,999,999,999,999,999 – 9,999,999,999,999,999 (3) 0 – 999,999,999,999									
Demand—Power Demand Channels									
2150	Last Demand Real Power, 3-Phase Total	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767	3-Phase total present real power demand for last completed demand interval – updated every sub-interval
2151	Present Demand Real Power, 3-Phase Total	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767	3-Phase total present real power demand for present demand interval
2152	Running Average Demand Real Power, 3-Phase Total	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767	Updated every second
2153	Predicted Demand Real Power, 3-Phase Total	1	Integer	RO	N	F	kW/Scale	-32,767 – 32,767	Predicted real power demand at the end of the present interval
2154	Peak Demand Real Power, 3-Phase Total	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767	
2155	Peak Demand DateTime Real Power, 3-Phase Total	4	DateTime	RO	Y	xx	See Template ②	See Template ②	
2159	Cumulative Demand Real Power, 3-Phase Total	2	Long	RO	Y	F	kW/Scale	-2147483648 – 2147483647	

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①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
2161	Power Factor, Average @ Peak Demand, Real Power	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Average True Power Factor at the time of the Peak Real Demand
2162	Power Demand, Reactive @ Peak Demand, Real Power	1	Integer	RO	Y	F	kVAr/Scale	-32,767 – 32,767	Reactive Power Demand at the time of the Peak Real Demand
2163	Power Demand, Apparent @ Peak Demand, Real Power	1	Integer	RO	Y	F	kVA/Scale	0 – 32,767	Apparent Power Demand at the time of the Peak Real Demand
2165	Last Demand Reactive Power, 3-Phase Total	1	Integer	RO	N	F	kVAr /Scale	-32,767 – 32,767	3-Phase total present reactive power demand for last completed demand interval – updated every sub-interval
2166	Present Demand Reactive Power, 3-Phase Total	1	Integer	RO	N	F	kVAr /Scale	-32,767 – 32,767	3-Phase total present real power demand for present demand interval
2167	Running Average Demand Reactive Power, 3-Phase Total	1	Integer	RO	N	F	kVAr /Scale	-32,767 – 32,767	3-Phase total present reactive power demand, running average demand calculation of short duration – updated every second
2168	Predicted Demand Reactive Power, 3-Phase Total	1	Integer	RO	N	F	kVAr /Scale	-32,767 – 32,767	Predicted reactive power demand at the end of the present interval
2169	Peak Demand Reactive Power, 3-Phase Total	1	Integer	RO	Y	F	kVAr /Scale	-32,767 – 32,767	
2170	Peak Demand DateTime Reactive Power, 3-Phase Total	4	DateTime	RO	Y	xx	See Template ②	See Template ②	
2174	Cumulative Demand Reactive Power, 3-Phase Total	2	Long	RO	Y	F	kVAr /Scale	-2147483648 – 2147483647	
2176	Power Factor, Average @ Peak Demand, Reactive Power	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Average True Power Factor at the time of the Peak Reactive Demand
2177	Power Demand, Real @ Peak Demand, Reactive Power	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767	Real Power Demand at the time of the Peak Reactive Demand
2178	Power Demand, Apparent @ Peak Demand, Reactive Power	1	Integer	RO	Y	F	kVA/Scale	0 – 32,767	Apparent Power Demand at the time of the Peak Reactive Demand
2180	Last Demand Apparent Power 3-Phase Total	1	Integer	RO	N	F	kVA /Scale	-32,767 – 32,767	3-Phase total present apparent power demand for last completed demand interval – updated every sub-interval
2181	Present Demand Apparent Power, 3-Phase Total	1	Integer	RO	N	F	kVA /Scale	-32,767 – 32,767	3-Phase total present apparent power demand for present demand interval
2182	Running Average Demand Apparent Power, 3-Phase Total	1	Integer	RO	N	F	kVA /Scale	-32,767 – 32,767	3-Phase total present apparent power demand, running average demand calculation of short duration – updated every second

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NV = Nonvolatile.
①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
2183	Predicted Demand Apparent Power, 3-Phase Total	1	Integer	RO	N	F	kVA /Scale	-32,767 – 32,767	Predicted apparent power demand at the end of the present interval
2184	Peak Demand Apparent Power, 3-Phase Total	1	Integer	RO	Y	F	kVA /Scale	-32,767 – 32,767	3-Phase total peak apparent power demand peak
2185	Peak Demand DateTime Apparent Power, 3-Phase Total	4	DateTime	RO	Y	xx	See Template ②	See Template ②	Date/Time of 3-Phase peak apparent power demand
2189	Cumulative Demand Apparent Power, 3-Phase Total	2	Long	RO	Y	F	kVA /Scale	-2,147,483,648 – 2,147,483,647	Cumulative Demand, Apparent Power
2191	Power Factor, Average @ Peak Demand, Apparent Power	1	Integer	RO	Y	xx	0.001	1,000 -100 to 100 (-32,768 if N/A) ①	Average True Power Factor at the time of the Peak Apparent Demand
2192	Power Demand, Real @ Peak Demand, Apparent Power	1	Integer	RO	Y	F	kW/Scale	-32,767 – 32,767	Real Power Demand at the time of the Peak Apparent Demand
2193	Power Demand, Reactive @ Peak Demand, Apparent Power	1	Integer	RO	Y	F	kVAr/Scale	0 – 32,767	Reactive Power Demand at the time of the Peak Apparent Demand
System Configuration									
3000	Circuit Monitor Label	2	Character	R/CW	Y	xx	xxxxxxx	xxxxxxx	
3002	Circuit Monitor Nameplate	8	Character	R/CW	Y	xx	xxxxxxx	xxxxxxx	
3014	Circuit Monitor Present Operating System Firmware Revision Level	1	Integer	RO	N	xx	xxxxxxx	0x0000 – 0xFFFF	
3034	Present Date/Time	4	DateTime	RO	N	xx	See Template ②	See Template ②	
3039	Last Unit Restart Date Time	4	DateTime	RO	Y	xx	See Template ②	See Template ②	
3043	Number of Metering System Restarts	1	Integer	RO	Y	xx	1	0 – 32,767	
3044	Number of Control Power Failures	1	Integer	RO	Y	xx	1	0 – 32,767	
3045	Date/Time of Last Control Power Failure	4	DateTime	RO	Y	xx	See Template ②	See Template ②	

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②See “How Date and Time Are Stored in Registers” on page 178.

Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
3050	Self-Test Results	1	Bitmap	RO	N	xx	xxxxxxx	0x0000 – 0xFFFF	0 = Normal; 1 = Error Bit 00 = Is set to "1" if any failure occurs Bit 01 = RTC failure Bit 02 = MCF UART #1 failure Bit 03 = MCF UART #2 failure Bit 04 = PLD UART failure Bit 05 = Metering Collection overrun failure Bit 06 = Metering Process 0.1 overrun failure Bit 07 = Metering Process 1.0 overrun failure Bit 08 = Disk-on-Chip failure Bit 09 = Display failure Bit 10 = CV Module failure Bit 11 = Aux Plug EEPROM failure Bit 12 = Flash Memory failure Bit 13 = Dram Memory failure Bit 14 = Simtek Memory failure Bit 15 = RTC Memory failure
3051	Self Test Results	1	Bitmap	RO	N	xx	xxxxxxx	0x0000 – 0xFFFF	0 = Normal; 1 = Error Bit 00 = Aux IO failure Bit 01 = Option Slot A module failure Bit 02 = Option Slot B module failure Bit 03 = IOX module failure Bit 04 = Not used Bit 05 = Bit 06 = Bit 07 = Bit 08 = OS Create failure Bit 09 = OS Queue overrun failure Bit 10 = Not used Bit 11 = Not used Bit 12 = Bit 13 = Systems shut down due to continuous reset Bit 14 = Unit in Download, Condition A Bit 15 = Unit in Download, Condition B
3052	Configuration Modified	1	Integer	RO	Y	xx	xxxxxxx	0x0000 – 0xFFFF	Used by sub-systems to indicate that a value used within that system has been internally modified 0 = No modifications; 1 = Modifications Bit 00 = Summary bit Bit 01 = Metering System Bit 02 = Communications System Bit 03 = Alarm System Bit 04 = File System Bit 05 = Auxiliary IO System Bit 06 = Display System
3053	Installed Log Memory	1	Integer	RO	Y	xx	Clusters	0 – 65,535	
3054	Free Log Memory	1	Integer	RO	Y	xx	Clusters	0 – 65,535	
3055	Log Memory Cluster Size	1	Integer	RO	Y	xx	Bytes	0 – 65,535	
3056	Programmed Disk On Chip Version Number	1	Integer	R/W	N	xx	xxxxxxx	0x0000 – 0xFFFF	
3058	Real Time Clock Factory Calibration	1	Integer	RO	Y	xx	ppm	-63 – 126	(-) = Slow down (+) = Speed up

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Table C–3: Abbreviated Register List *(continued)*

Reg	Name	Size	Type	Access	NV	Scale	Units	Range	Notes
3059	Real Time Clock Field Calibration	1	Integer	R/CW	Y	xx	ppm	-63 – 126	(-) = Slow down (+) = Speed up
3061	Installed Log Memory	1	Integer	RO	Y	xx	Mbytes	0 – 65,535	
3073	Installed Option – Slot A	1	Integer	RO	N	xx	xxxxxxx	0 – 16	0 = Not Installed 1 = IOC44 2 = Reserved 3 = Reserved 4 = Reserved 5 = Reserved 6 = Ethernet Option Module
3074	Installed Option – Slot B	1	Integer	RO	N	xx	xxxxxxx	0 – 7	0 = Not Installed 1 = IOC44 2 = Reserved 3 = Reserved 4 = Reserved 5 = Reserved 6 = Ethernet Option Module 7 = Production Test Load Board
3075	Installed Option – IO Extender	1	Integer	RO	N	xx	xxxxxxx	0, 5	0 = Not Installed 5 = Installed
3093	Present Month	1	Integer	RO	N	xx	Months	1 – 12	
3094	Present Day	1	Integer	RO	N	xx	Days	1 – 31	
3095	Present Year	1	Integer	RO	N	xx	Years	2,000 – 2,043	
3096	Present Hour	1	Integer	RO	N	xx	Hours	0 – 23	
3097	Present Minute	1	Integer	RO	N	xx	Minutes	0 – 59	
3098	Present Second	1	Integer	RO	N	xx	Seconds	0 – 59	
3099	Day of Week	1	Integer	RO	N	xx	1.0	1 – 7	Sunday = 1

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①See “How Power Factor is Stored in the Register” on page 178.
②See “How Date and Time Are Stored in Registers” on page 178.

GLOSSARY

accumulated energy—energy can accumulate in either signed or unsigned (absolute) mode. In signed mode, the direction of power flow is considered and the accumulated energy magnitude may increase and decrease. In absolute mode, energy accumulates as a positive regardless of the power flow direction.

address—see *device address*. See also *Ethernet address*.

ANSI—American National Standards Institute.

baud rate—specifies how fast data is transmitted across a network port.

block interval demand—power demand calculation method for a block of time and includes three ways to apply calculating to that block of time using the sliding block, fixed block, or rolling block method.

coincident readings—two readings that are recorded at the same time.

command interface—used to issue commands such as reset commands and to manually operate relays contained in registers 8000–8149.

communications link—a chain of devices such as circuit monitors and power meters that are connected by a communications cable to a communications port.

conditional energy—energy accumulates only when a certain condition occurs.

control power—provides power to the circuit monitor.

control power transformer (CPT)—transformer to reduce control power voltage to the meter.

crest factor (CF)—crest factor of voltage or current is the ratio of peak values to rms values.

current transformer (CT)—current transformer for current inputs.

current unbalance—percentage difference between each phase voltage with respect to the average of all phase currents.

current/voltage module—an interchangeable part of the circuit monitor where all metering data acquisition occurs.

default—a value loaded into the circuit monitor at the factory that you can configure.

demand—average value of a quantity, such as power, over a specified interval of time.

device address—defines where the circuit monitor (or other devices) reside in the power monitoring system.

displacement power factor (dPF)—cosine of the angle between the fundamental components of current and voltage, which represents the time lag between fundamental voltage and current.

EN50160—a European standard that defines the quality of the voltage a customer can expect to receive from the electric utility.

Ethernet address—a unique number that identifies the device in the Ethernet network and is always written as combination of eleven numbers such as 199.186.195.23.

event—the occurrence of an alarm condition, such as *Undervoltage Phase A*, configured in the circuit monitor.

firmware—operating system within the circuit monitor.

frequency—number of cycles in one second.

fundamental—value of voltage or current corresponding to the portion of the signal at the power frequency (50, 60, or 400 Hz).

generic demand profile—up to 10 quantities on which any of the demand calculations can be performed (thermal demand, block interval demand, or synchronized demand). Two generic demand profiles can be set up in the circuit monitor.

harmonic power—difference between total power and fundamental power. A negative value indicates harmonic power flow out of the load. A positive value indicates harmonic power flow into the load.

harmonics—the circuit monitor stores in registers the magnitude and angle of individual harmonics up to the 63rd harmonic. Distorted voltages and currents can be represented by a series of sinusoidal signals whose frequencies are multipliers of some fundamental frequency, such as 60 Hz.

holding register—register that holds the next value to be transmitted.

IEC—International Electrotechnical Commission.

incremental energy—accumulates energy during a user-defined timed interval.

IOX—input/output extender that is an optional part of the circuit monitor where up to eight analog or digital I/O modules can be added to expand the I/O capabilities of the circuit monitor.

K-factor—a numerical rating used to specify power transformers for non linear loads. It describes a transformer's ability to serve nonlinear loads without exceeding rated temperature rise limits.

KYZ output—pulse output from a metering device where each pulse has a weight assigned to it which represents an amount of energy or other value.

LCD—liquid crystal display.

line-to-line voltages—measurement of the rms line-to-line voltages of the circuit.

line-to-neutral voltages—measurement of the rms line-to-neutral voltages of the circuit.

logging—recording data at user-defined intervals in the circuit monitor's nonvolatile memory.

maximum value—highest value recorded of the instantaneous quantity such as Phase A Current, Phase A Voltage, etc., since the last reset of the minimums and maximums.

minimum value—lowest value recorded of the instantaneous quantity such as Phase A Current, Phase A Voltage, etc., since the last reset of the minimums and maximums.

nominal—typical or average.

onboard—refers to data stored in the circuit monitor.

option cards—optional, field-installable accessories for the circuit monitor that expand the I/O and Ethernet communications capabilities because they can be inserted into slots in the circuit monitor.

overvoltage—increase in effective voltage to greater than 110 percent for longer than one minute.

parity—refers to binary numbers sent over the communications link. An extra bit is added so that the number of ones in the binary number is either even or odd, depending on your configuration). Used to detect errors in the transmission of data.

partial interval demand—calculation of energy thus far in a present interval. Equal to energy accumulated thus far in the interval divided by the length of the complete interval.

peak demand current—highest demand current measured in amperes since the last reset of demand. See also *peak value*.

peak demand real power—highest demand real power measured since the last rest of demand.

peak demand voltage—highest demand voltage measured since the last reset of demand voltage. See also *peak value*.

peak demand—highest demand measured since the last reset of peak demand.

peak value—of voltage or current is the maximum or minimum crest value of a waveform.

phase currents (rms)—measurement in amperes of the rms current for each of the three phases of the circuit. See also *peak value*.

phase rotation—phase rotations refers to the order in which the instantaneous values of the voltages or currents of the system reach their maximum positive values. Two phase rotations are possible: A-B-C or A-C-B.

potential transformer (PT)—also known as a voltage transformer.

power factor (PF)—true power factor is the ratio of real power to apparent power using the complete harmonic content of real and apparent power. Calculated by dividing watts by volt amperes. Power factor is the difference between the total power your utility delivers and the portion of total power that does useful work. Power factor is the degree to which voltage and current to a load are out of phase. See also *displacement power factor*.

predicted demand—the circuit monitor takes into account the energy consumption thus far in the present interval and the present rate of consumption to predict demand power at the end of the present interval.

quantity—a parameter that the circuit monitor can measure or calculate such as current, voltage, power factor, etc.

real power—calculation of the real power (3-phase total and per-phase real power calculated) to obtain kilowatts.

recloser sequence—a series of voltage sags caused by a utility breaker opening a number of consecutive times in an effort to clear a fault. See also *sag*/*swell*.

rms—root mean square. Circuit monitors are true rms sensing devices. See also *harmonics (rms*).

sag/**swell**—fluctuation (decreasing or increasing) in voltage or current in the electrical system being monitored. See also, *voltage sag* and *voltage swell*.

scale factor—multipliers that the circuit monitor uses to make values fit into the register where information is stored.

SMS—see System Manager Software.

synchronized demand—demand intervals in the circuit monitor that can be synchronized with another device using an external pulse, a command sent over communications, or the circuit monitor's internal real-time clock.

System Manager Software (SMS)—software designed by PowerLogic for use in evaluating power monitoring and control data.

system type—a unique code assigned to each type of system wiring configuration of the circuit monitor.

thermal demand—demand calculation based on thermal response.

TIF/IT—telephone influence factor used to assess the interference of power distribution circuits with audio communications circuits.

Total Harmonic Distortion (THD or thd)—indicates the degree to which the voltage or current signal is distorted in a circuit.

total power factor—*see power factor*.

transient—sudden change in the steady-state condition of voltage or current.

troubleshooting—evaluating and attempting to correct problems with the circuit monitor's operation.

true power factor—see *power factor*.

undervoltage—decrease in effective voltage to less than 90% for longer than one minute.

VAR—volt ampere reactive.

VFD—vacuum fluorescent display.

voltage interruption—complete loss of power where no voltage remains in the circuit.

voltage sag—a brief decrease in effective voltage lasting more than one minute.

voltage swell—increase in effective voltage for up to one minute in duration.

voltage transformer (VT)—see *potential transformer*.

voltage unbalance—percentage difference between each phase voltage with respect to the average of all phase voltages.

waveform capture—can be done for all current and voltage channels in the circuit monitor.

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