Allen-Bradley

PowerMonitor 1000 Unit

Catalog Numbers 1408-TR1A-485, 1408-TR2A-485, 1408-EM1A-485, 1408-EM2A-485, 1408-EM3A-485, 1408-TR1A-ENT, 1408-TR2A-ENT, 1408-EM1A-ENT, 1408-EM2A-ENT, 1408-EM3A-ENT

Important User Information

Read this document and the documents listed in the additional resources section about installation, configuration, and operation of this equipment before you install, configure, operate, or maintain this product. Users are required to familiarize themselves with installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards.

Activities including installation, adjustments, putting into service, use, assembly, disassembly, and maintenance are required to be carried out by suitably trained personnel in accordance with applicable code of practice.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

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Throughout this manual, when necessary, we use notes to make you aware of safety considerations.

WARNING: Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence.

IMPORTANT Identifies information that is critical for successful application and understanding of the product.

Labels may also be on or inside the equipment to provide specific precautions.

SHOCK HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.

BURN HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.

ARC FLASH HAZARD: Labels may be on or inside the equipment, for example, a motor control center, to alert people to potential Arc Flash. Arc Flash will cause severe injury or death. Wear proper Personal Protective Equipment (PPE). Follow ALL Regulatory requirements for safe work practices and for Personal Protective Equipment (PPE).

Safety

ATTENTION: Only qualified personnel, following accepted safety procedures, should install, wire, and service the PowerMonitor™ 1000 unit and its associated components. Before beginning any work, disconnect all sources of power and verify that they are de-energized and locked out. Failure to follow these instructions may result in personal injury or death, property damage, or economic loss.

ATTENTION: Never open a current transformer (CT) secondary circuit with primary current applied. Wiring between the CTs and the PowerMonitor 1000 unit should include a shorting terminal block in the CT secondary circuit. Shorting the secondary with primary current present allows other connections to be removed, if needed. An open CT secondary with primary current applied produces a hazardous voltage, which can lead to personal injury, death, property damage, or economic loss.

IMPORTANT The PowerMonitor 1000 unit is not designed for, nor intended for, use as a circuit protective device. Do not use this equipment in place of a motor overload relay or circuit protective relay.

About the PowerMonitor 1000 Unit

The power monitor is a compact, cost-effective, electric power and energy metering device intended for use in industrial control applications, such as distribution centers, industrial control panels, and motor control centers. It measures voltage and current in an electrical circuit, meeting revenue accuracy standards. It communicates power and energy parameters to applications such as RSEnergyMetrix®, RSPower™, and RSPowerPlus, over Ethernet or serial networks. The power monitor works with these software applications to address these key customer applications.

- Load profiling – log power parameters such as real power, apparent power, and demand, for analysis of power usage by loads over time
- Cost allocation – reporting actual energy cost by department or process to integrate energy information into management decisions
- Billing and sub-billing – charging users of energy the actual usage cost rather than allocating by square footage or other arbitrary methods
- Power system monitoring and control – display and control power flow and energy utilization

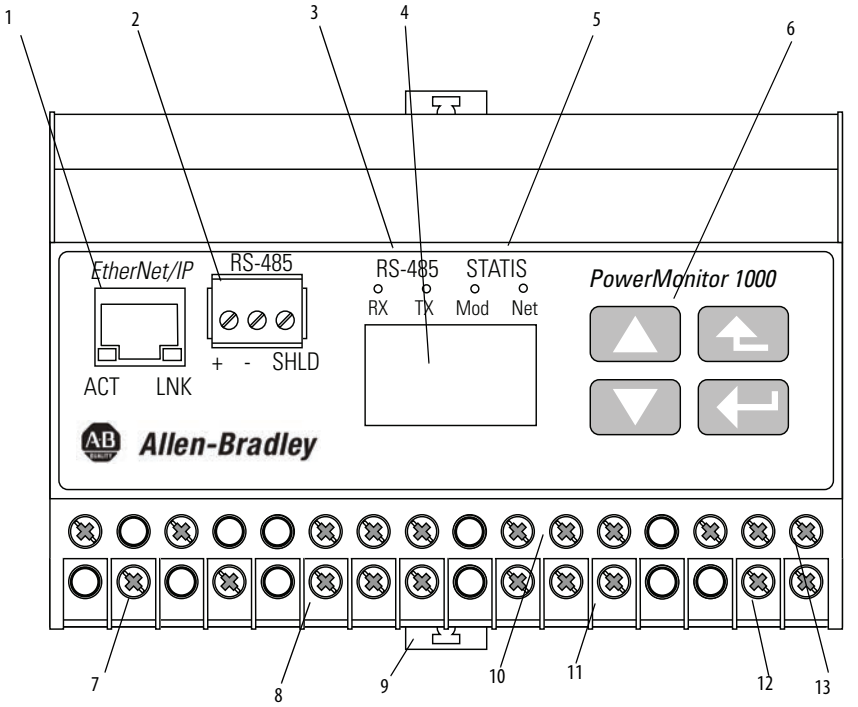
PowerMonitor 1000 Unit Features and Functions

The power monitor connects to the user's three-phase or single-phase AC power system directly or through instrument transformers (PTs and CTs). It converts instantaneous voltage and current values to digital values, and uses the resulting digital values in calculations of voltage, current, power, or energy.

The power monitor family includes five models:

- TR1 – Voltage and current transducer
- TR2 – Voltage, current, and power transducer
- EM1 – Basic real-energy monitor for sub-metering applications
- EM2 – Energy and demand monitor for main metering applications
- EM3 – Full-function power and energy monitor

Hardware Features



Feature	Description
1. Ethernet network port - standard RJ-45 jack with status indicators	Ethernet network port hardware is included on all models. The port functions only on units ordered with or upgraded to the Ethernet network. The following protocols and functions are supported. • EtherNet/IP • Modbus TCP • HTML Web page for configuration and data access • LNK indicator – Solid GREEN: IP link established – Off: no link established • ACT indicator – Flashing YELLOW: data present on Ethernet port – Off: no data activity present
2. Serial port - three-pin RS-485 connector	All models include RS-485 serial communication that support the following protocols and functions. • DF1 half-duplex slave • DF1 full-duplex • Modbus RTU slave • Configuration using the HyperTerminal communication tool • DH-485
3. Serial port status indicators	• TX indicator flashes YELLOW when data is being transmitted • RX indicator flashes YELLOW when data is being received
4. LCD	• Unit configuration • Data display
5. Module and network status indicators	• Module indicator – GREEN: Normal operation – Alternating RED/GREEN: Performing self-test – RED (solid or blinking): Initial power-up or failed self-test • Network indicator – GREEN: Ethernet connection established – Blinking GREEN: Ethernet port looking for a connection – RED: Duplicate IP address detected
6. LCD interface buttons	• Unit configuration • Data display navigation
7. Voltage-sensing wiring terminals	• Direct connect up to 600V AC three-phase line-to-line • Maximum nominal line-to-ground voltage 347V • Use potential transformers (PTs) for higher voltages
8. Current-sensing wiring terminals	• Nominal input current 5 A • Use current transformers (CTs) to connect to power system
9. DIN-rail clips	• Top and bottom clips for mounting unit on DIN rail
10. Status-input wiring terminals	• Two internally-powered inputs • S2 can be used for demand period synchronization
11. Configuration-lock wiring terminals	• Wire together to prevent configuration changes
12. KYZ-output wiring terminals	• DPDT solid-state relay for signaling use
13. Control power and ground wiring terminals	• 120…240V AC, 50…60 Hz

Functionality by Model

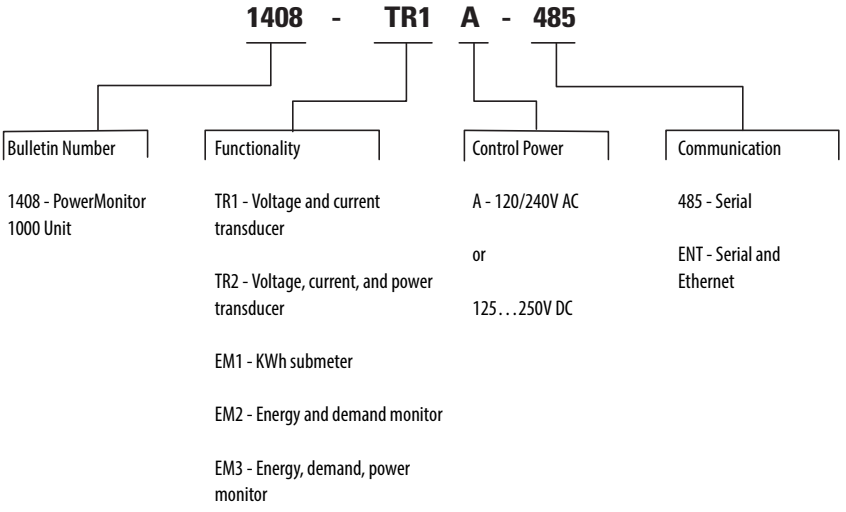
The power monitor models differ by the data sets available to client applications.

This table indicates the measurements and functions available in each model.

Measured Parameters	TR1	TR2	EM1	EM2	EM3
Voltage	•	•			•
Current	•	•			•
Frequency	•	•			•
Voltage unbalance	•	•			•
Current unbalance	•	•			•
Real power, kW		•			•
Reactive power, kVAR		•			•
Apparent power, kVA		•			•
True power factor		•			•
Real energy, kWh			•	•	•
Reactive energy, kVARh				•	•
Apparent energy, kVAh				•	•
Real power demand, kW				•	•
Reactive power demand, kVAR				•	•
Apparent power demand, kVA				•	•
Projected KW demand				•	•
Projected KVAR demand				•	•
Projected KVA demand				•	•
Demand power factor				•	•
Logs					
Energy log			•	•	•
Min / max log	•	•			•
Load factor log				•	•
Time of use logs			•	•	•
Status log	•	•	•	•	•

Troubleshooting mode lets you enter a password-protected command that promotes your PowerMonitor unit to an EM3 model. This makes all measured parameters available for troubleshooting purposes.

Catalog Number Explanation



Before You Begin

Use this document as a guide for installing, wiring, connecting, applying power, and configuring your power monitor to provide electric power and energy information to RSPower, RSPowerPlus, and RSEnergyMetrix software applications. You should already be familiar with the power monitor.

For further information about communicating with the power monitor by using other applications and controllers, refer to 1408 PowerMonitor 1000 User Manual, publication 1408-UM001.

Mount the PowerMonitor 1000 Unit

The power monitor can be mounted on a panel or a DIN rail.

Panel Mount

Follow these steps to mount the unit on a panel or any flat surface.

1. Extend the top and bottom DIN rail clips to the panel mount position.
2. Insert a small screwdriver under the spring pin to move the clip, lift it, and pull the clip forward until it extends approximately 6 mm (0.25 in.) from the enclosure.
3. Release the pin and lock the clip in the panel mount position.
4. Mount the unit by using three M4 or #8 machine screws.

DIN Rail Mount

You can mount the unit on standard 35 x 7.5 mm (EN 50 022 – 35 x 7.7) DIN rail. To mount on a DIN rail, leave the mounting clips retracted so the mounting holes are hidden behind the unit.

Install

Follow these steps to mount the unit on a DIN rail.

1. Tilt the bottom of the unit slightly away from the rail until the notches grab onto the top flange of the DIN rail.
2. Push the bottom of the enclosure forward towards the DIN rail.

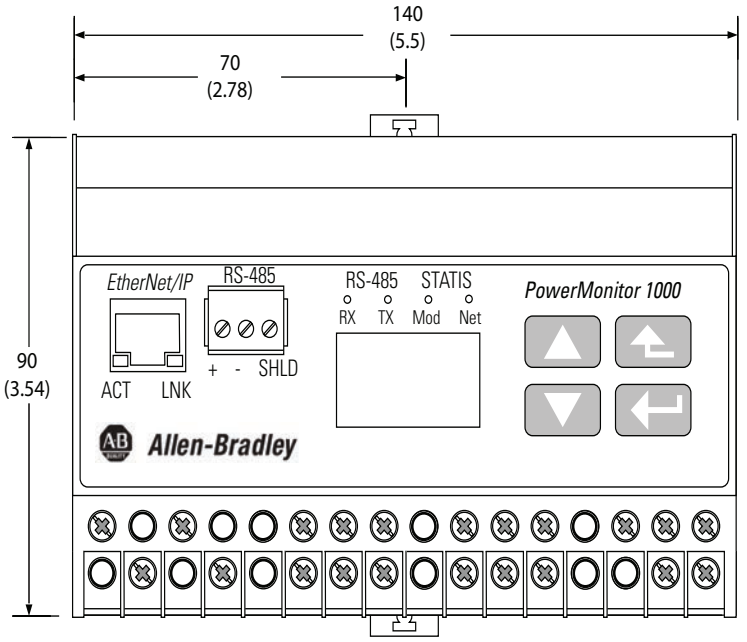
   The spring-loaded clip snaps onto the bottom of the rail and holds the unit firmly in place.

Remove

Follow these steps to remove the unit from a DIN rail.

1. Insert a small screwdriver into the exposed slot in the tab to remove the unit from the DIN rail.
2. Pull enclosure forward and remove from the rail.

Product Dimensions

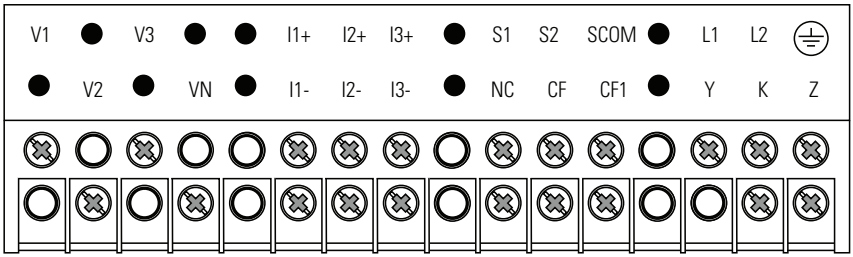


All dimensions are mm (in.).
Panel mount depth 59 mm (2.4 in.).
DIN-rail mount depth 62 mm (2.44 in.).
Hole spacing tolerance: ±0.4 mm (0.016 in.).

Wire the PowerMonitor 1000 Unit

The power monitor has finger-safe screw terminals with pressure plates for all wiring connections.

Terminal Block Layout



Wire Type	Wire Size Range	Wires per Terminal	Recommended Torque
Cu - 75 °C (167 °F)	0.33…0.21 mm^2 (22 … 14 AWG)	2 max per terminal, sol-sol or str-str only (no mixed pairs)	0.8 N•m (7 lb•in)

Voltage Sensing

The PowerMonitor 1000 unit monitors a variety of three-phase and single-phase circuits. Voltages of up to 600V AC line-to-line (347V AC line-to-ground) may be connected directly. Higher voltages require potential transformers (PTs), also known as voltage transformers (VTs).

Wiring must conform to all applicable codes and standards. In particular, you must provide suitable overcurrent protection with current and interrupting ratings selected to protect the wiring.

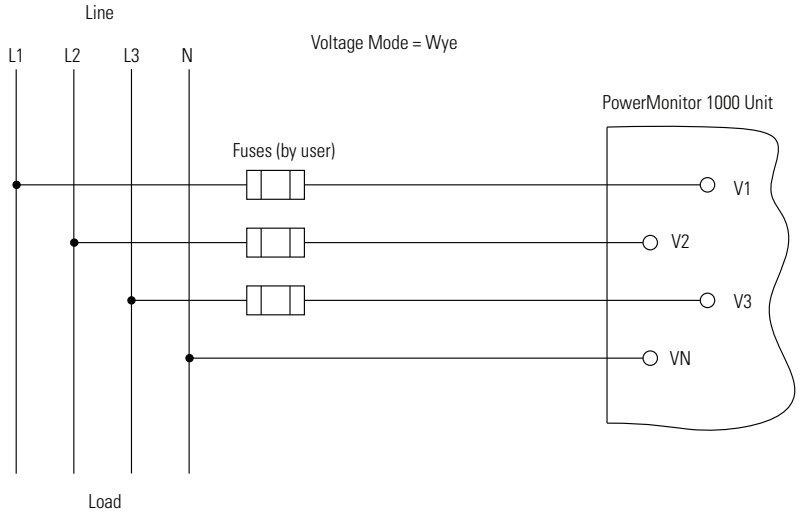
Pay particular attention to correct phasing and polarity of voltage connections. The diagrams use the dot convention to indicate transformer polarity. The dot indicates the H1 and X1 terminals on the high side and low side of the transformer respectively.

When you wire a power monitor to existing PTs and metering devices, the voltage sensing terminals of the power monitor must be connected in parallel with the voltage sensing terminals of the existing metering devices.

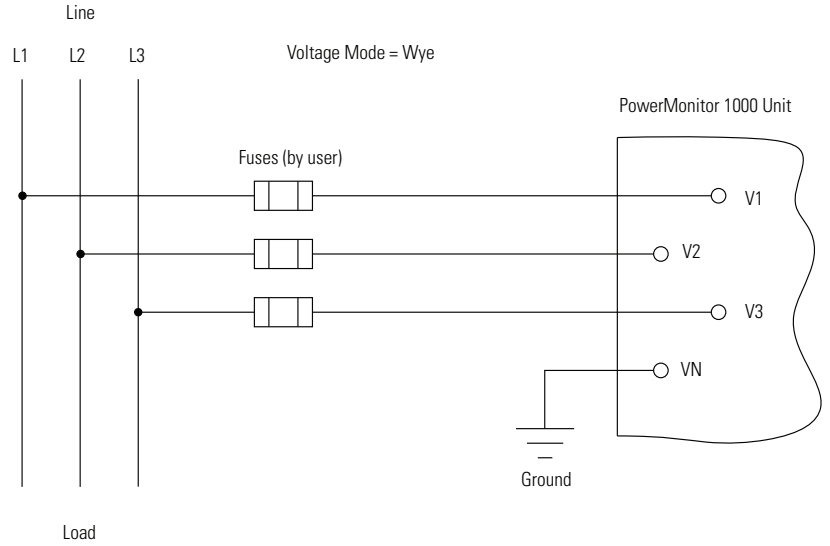
IMPORTANT Ungrounded three-wire Delta systems with line-to-line voltages between 347…600V AC may be directly connected. However, if a ground fault occurs that raises the line-to-ground voltage above 347V AC, the unit indicates a voltage over-range condition.

The following wiring diagrams indicate typical voltage sensing connections to various types of power systems.

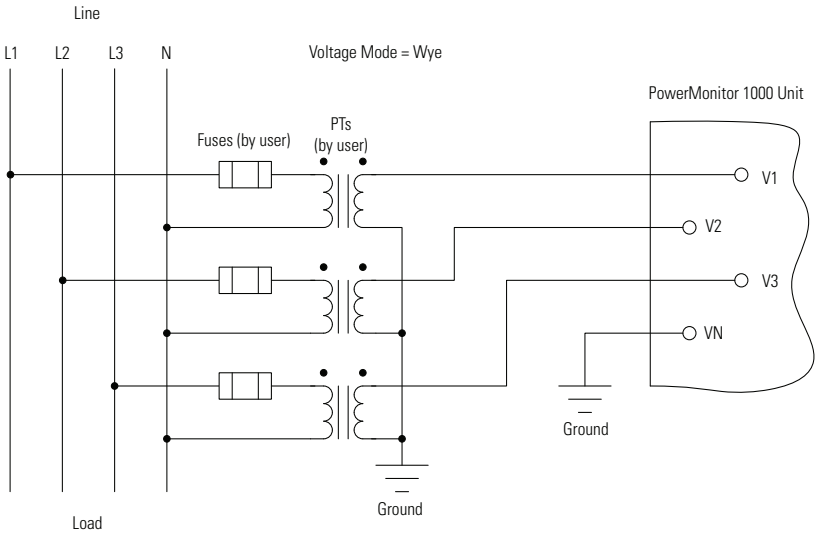
Three-phase, Four-wire Wye, Direct Connect (600V AC Line-to-line, 347V AC Line-to-neutral Maximum)



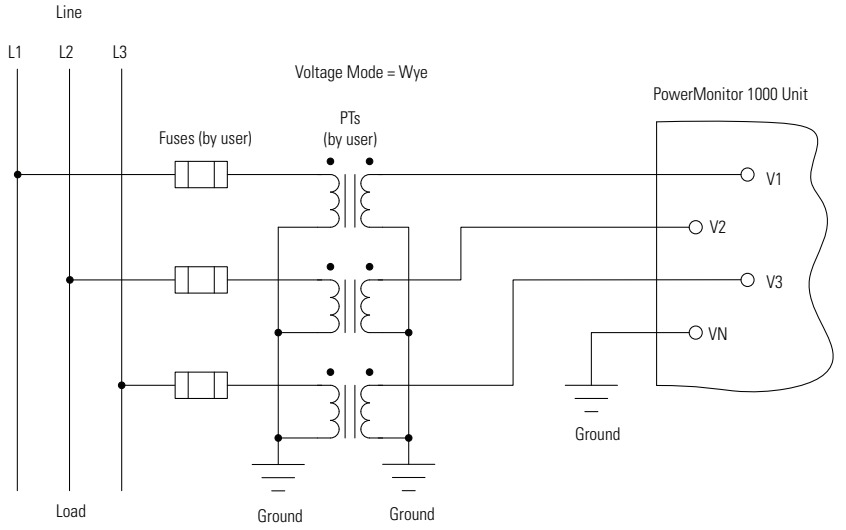
Three-phase, Three-wire Grounded Wye, Direct Connect (600V AC Line-to-line, 347V AC Line-to-neutral Maximum)



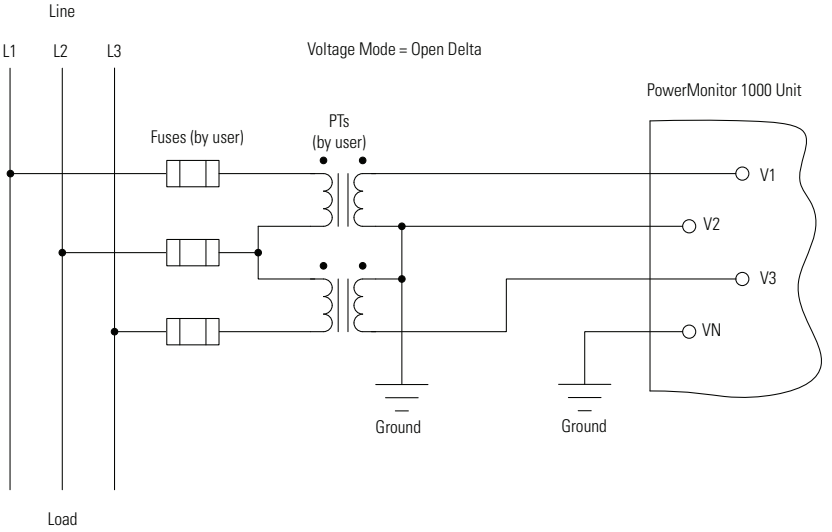
Three-phase, Four-wire Wye with Potential Transformers



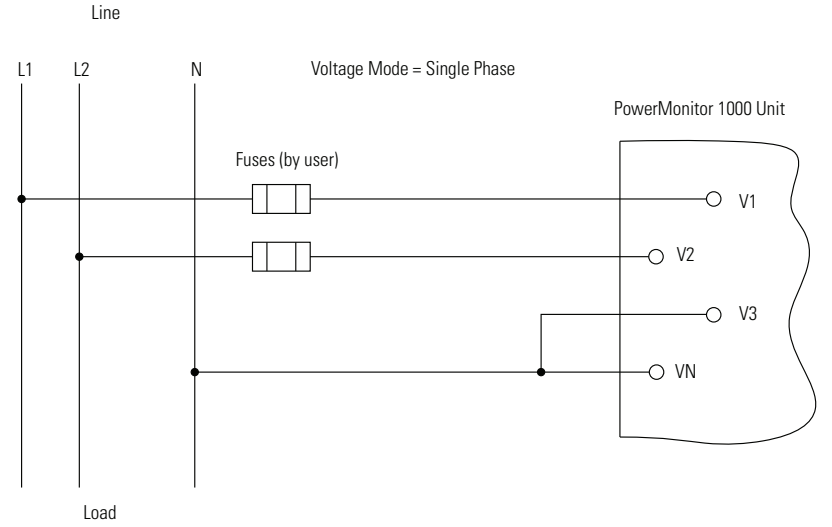
Three-phase, Three-wire Grounded Wye with Potential Transformers



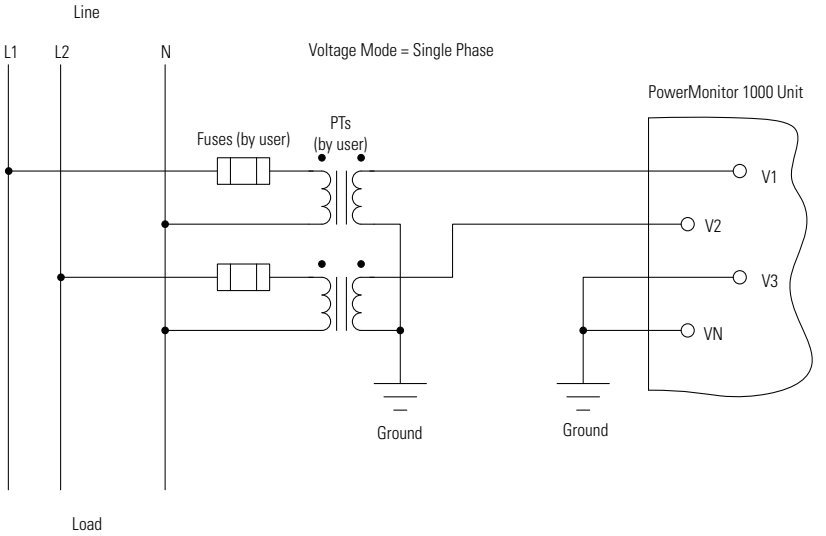
Three-phase, Three-wire Open Delta with Two Potential Transformers



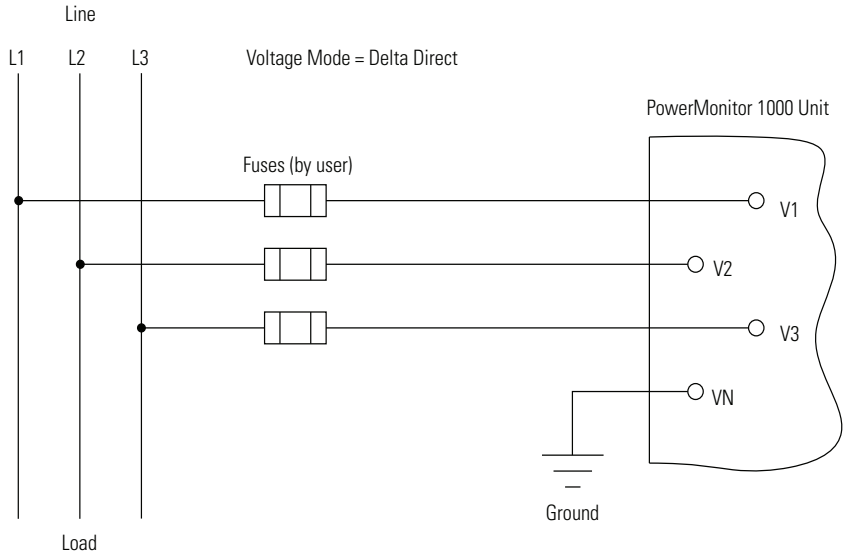
Single-phase, Direct Connect (600V AC Line-to-line, 347V AC Line-to-neutral Maximum)



Single-phase with Potential Transformers

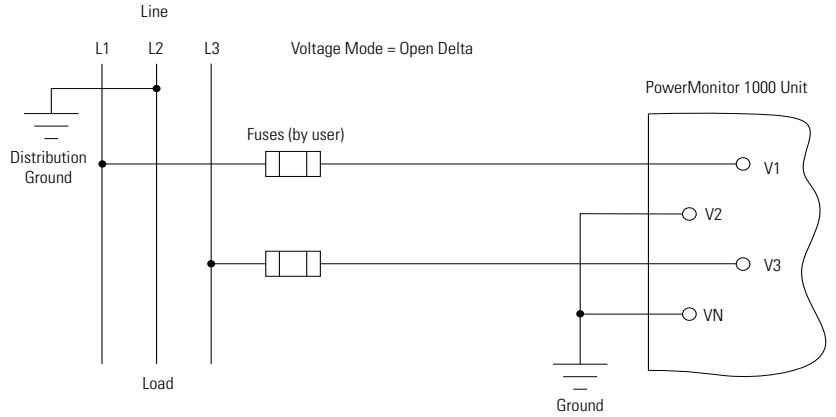


Three-phase, Three-wire Delta, Direct Connect (600V AC Line-to-line, 347V AC Line-to-ground Maximum)



Maximum line to ground voltage is 347V. If line to ground voltage exceeds 347V, then potential transformers must be used. The unit indicates voltage overrange (999.0) if an intentional or accidental ground causes line to ground voltage in excess of 347V.

Three-phase, Three-wire Grounded B-phase, Open Delta, Direct Connect (347V AC Line-to-line Maximum)



Maximum line to line voltage 347V. If line to line voltage exceeds 347V, then PTs must be used.

Current Sensing

Use a shorting terminal block, test block, or shorting switch you provide for current transformer (CT) wiring to permit safely servicing connected equipment such as the power monitor without de-energizing the power system.

Use 0.21 mm^2 (14 AWG) wiring to connect the power monitor to the shorting block. Use 0.21 mm^2 (14 AWG) or larger wire between the shorting block and the CTs depending on the length of the circuit. Longer circuits require larger wire so that the burden of the wiring does not overload the CT and reduce system accuracy.

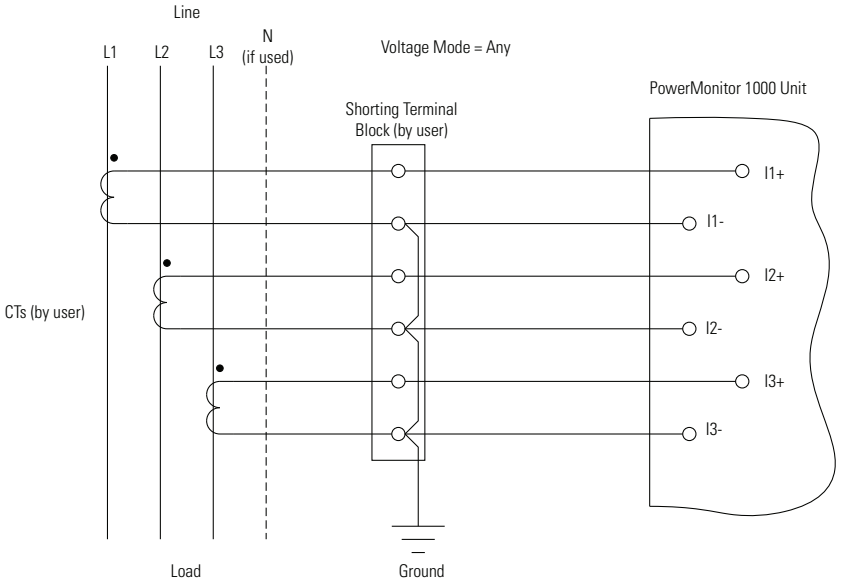
When wiring a power monitor to existing CTs and metering devices, the current sensing terminals of the power monitor must be connected in series with the CT secondary and current sensing terminals of the existing metering devices.

Do not install overcurrent protection or non-shorting disconnecting means in CT secondary wiring. Connect the current sensing circuit to a low-impedance earth ground at only one point.

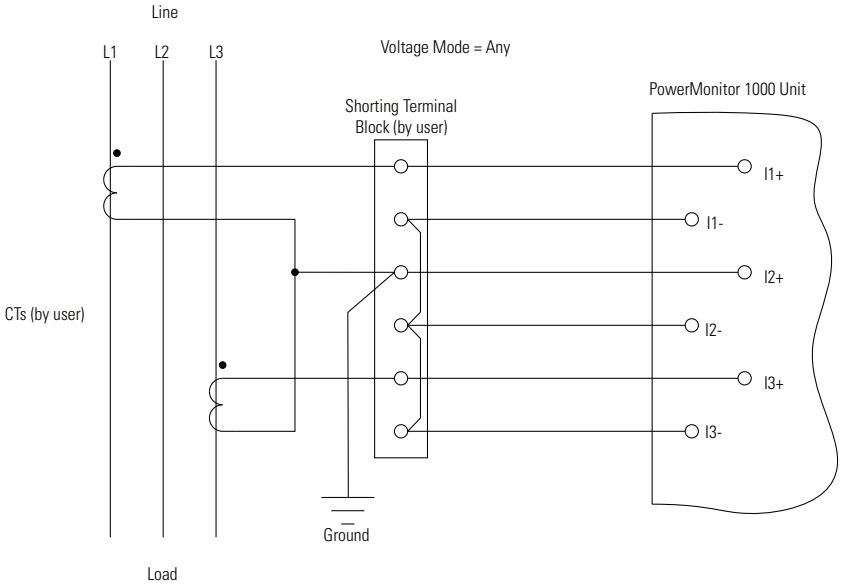
Pay particular attention to the correct phasing and polarity of current sensing connections. The diagrams use the dot convention to indicate transformer polarity. The dot indicates the H1 and X1 terminals on the primary and secondary of the CT respectively. Phasing of the CTs must correspond to the phasing of the voltage sensing connections.

The following wiring diagrams indicate typical current sensing connections to various types of power systems.

Three-phase, Three- or Four-wire, Three-current Transformers

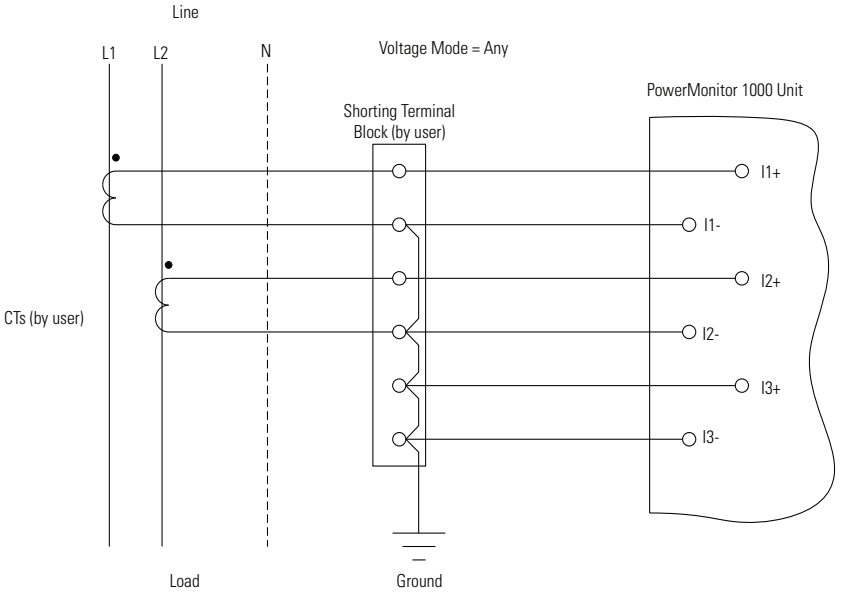


Three-phase, Three-wire, Two-current Transformers



You can use two CTs only on three-wire systems.

Single-phase, Two-current Transformers



Special Wiring Modes

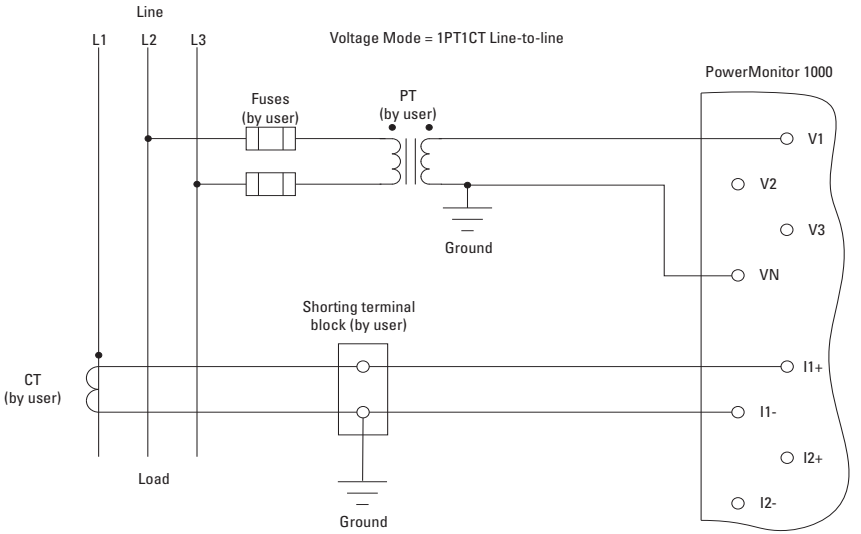
There are two special wiring modes for the power monitor.

1PT 1CT Line-to-line

This special wiring mode is designed for use in capacitor bank controllers. Traditional capacitor bank control measures VBC and IA to calculate reactive power and power factor. In this mode, the power monitor returns values as if it were configured in Delta mode. Three-phase values are estimated assuming a balanced load.

The following wiring diagram indicates the connections for the 1PT 1CT Line-to-line mode. A PT must be used. Wiring diagnostics are disabled in this mode.

1PT 1CT Line-to-line

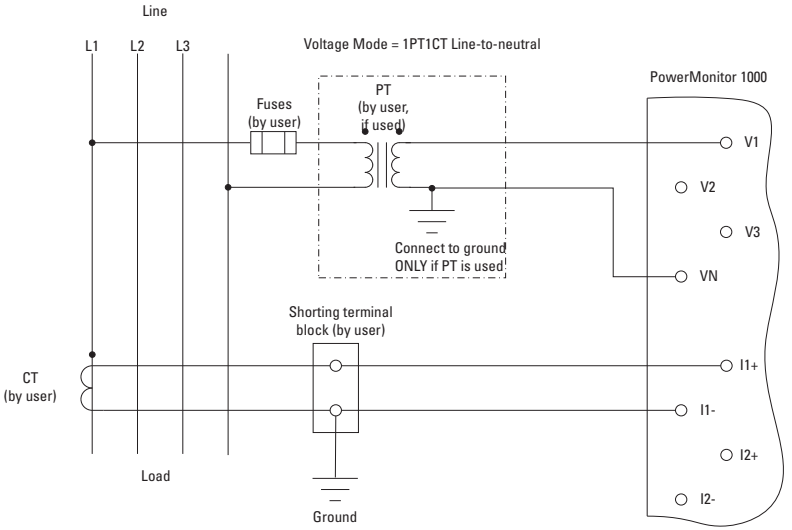


1PT 1CT Line-to-neutral

This special wiring mode is designed for use in new capacitor bank controller installations where the legacy metering connections described in the preceding section do not apply. In this mode, the power monitor returns values as if it were configured in Wye mode. Three-phase values are estimated assuming a balanced load.

The following wiring diagram indicates the connections for the 1PT 1CT Line-to-neutral mode. A PT is optional. Wiring diagnostics are disabled in this mode.

1PT and 1CT Line-to-Neutral

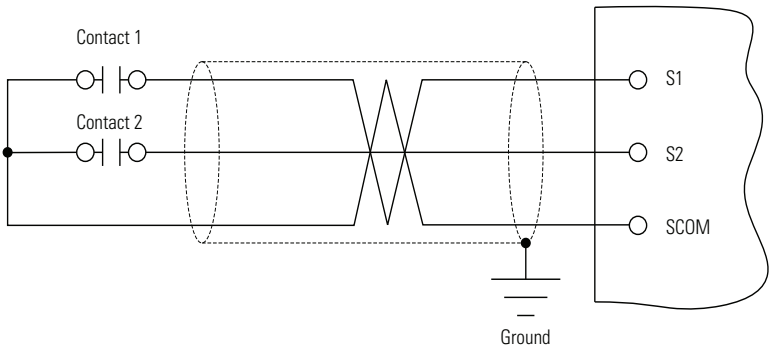


Status Inputs

One or two dry (non-powered) contacts can be connected to the power monitor status inputs. The power monitor 24V DC status input derives power from its internal power supply.

Connect status inputs by using shielded, twisted-pair cable with the shield connected to the ground bus or other low-impedance earth ground at one end only. The diagram indicates typical status input wiring.

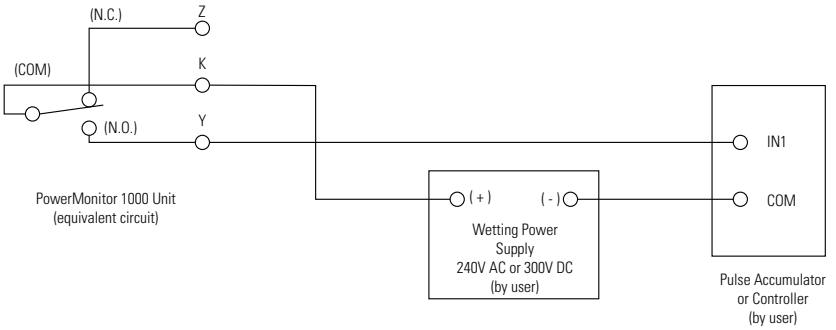
Status Inputs (S1, S2)



KYZ Output

The KYZ solid-state relay output may be connected to an external pulse accumulator or controller. Wetting voltage must be provided by the external device or circuit. The KYZ output is designed for low-current (80 mA maximum) switching at up to 240V AC or 300V DC. The diagram indicates typical KYZ wiring.

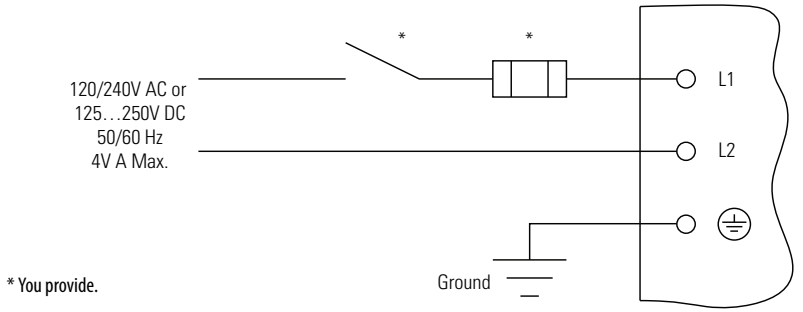
KYZ Output



Control Power

Connect the power monitor to a source of 120/240V AC or 125...250V DC control power through a user-provided disconnecting means. Provide overcurrent protection sized to protect the wiring. The power monitor is internally protected. Apply control power only after all wiring connections are made to the unit.

Control Power



Connect Communication

The following sections provide information on connecting Serial Communication and Ethernet Communication to the power monitor.

Serial Communication

Use point-to-point wiring between one power monitor and a computer or other data terminal for HyperTerminal communication and DF1 full-duplex communication. DF1 half-duplex, Modbus RTU and DH-485 protocols permit a point-to-point or multi-drop network configuration.

Multi-drop RS-485 communication wiring should be installed in a daisy-chain configuration. Up to 32 nodes may be connected together in a network. We recommend the use of Belden 9841 two-conductor shielded cable or equivalent. The maximum cable length is 1219 m (4000 ft). Use of a star or bridging topology is not recommended and may result in signal distortion unless impedance is matched for each spur (star topology) or network (bridge topology).

You must provide a RS-232 to RS-485 converter for communication between the power monitor serial port and an RS-232 port in an external device such as a computer or programmable controller. Examples of converters include the following.

- Allen-Bradley® catalog number 1761-NET-AIC
- B&B Electronics, Inc. part number 485SD9TB (DB-9 connection)

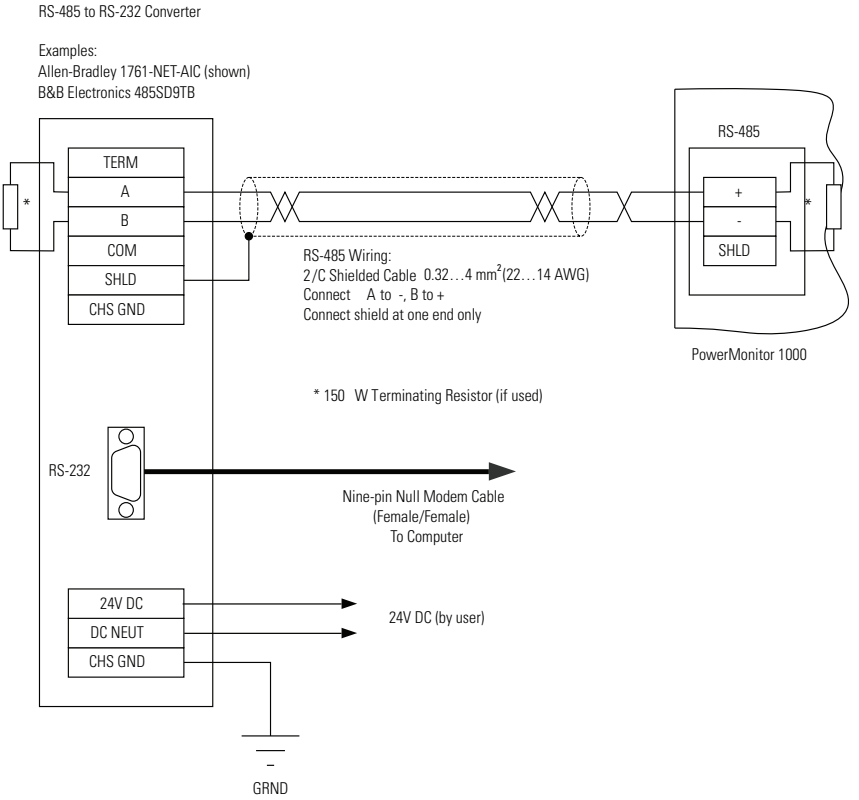
At one end of each cable segment, connect the cable shields to the SHLD terminal of the power monitor serial port or converter. The SHLD connection provides a low-impedance ground for high-frequency noise while attenuating DC or line-frequency signals.

If needed, install 150 Ω, ¼ W terminating resistors at the ends of the daisy-chain cable. Some RS-485 converters are equipped with internal terminating resistors. Contact the manufacturer of the converter for additional information.

TIP Wiring to the power monitor RS-485 port is the same as wiring to the PowerMonitor 3000 native RS-485 port.

See Use Communication to Set Up on page 38 for information on configuring serial communication parameters such as data rate and node addresses.

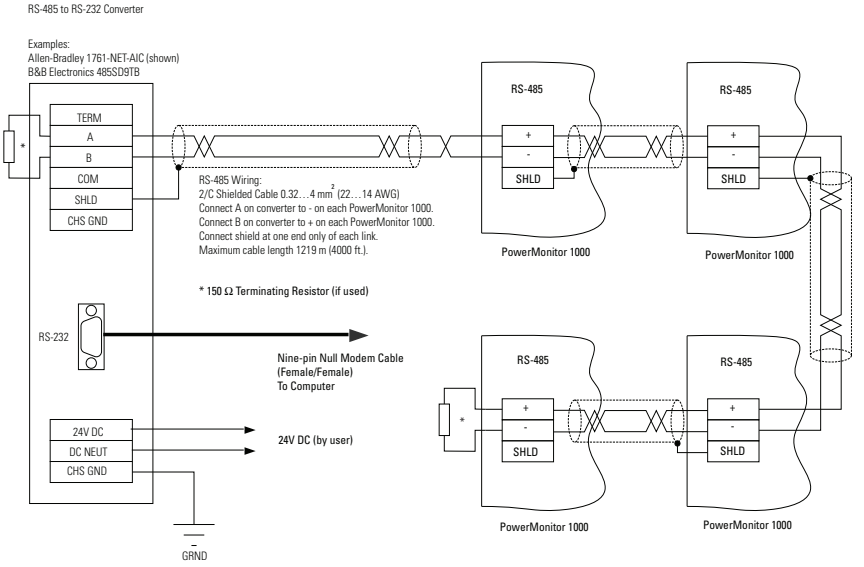
RS-485 Point-to-point Typical Wiring



Terminals	Wire Range(1)	Tightening Torque
V1, V2, V3, VN, I1+ I2+, I3+, I1-, I2-, I3-, S1, S2, SCOM, NC, CR, CF1, L1, L2, Y, K, Z	0.32…4 mm² (22…14 AWG)	0.8 N•m (7 lb•in)
RS-485 Communication	0.32…4 mm² (22…14 AWG)	0.56 N•m (5 lb•in)

(1) 75 °C Cu wire only, 1 to 2 conductors per terminal (sol-sol or str-str).

RS-485 Multi-drop Typical Wiring



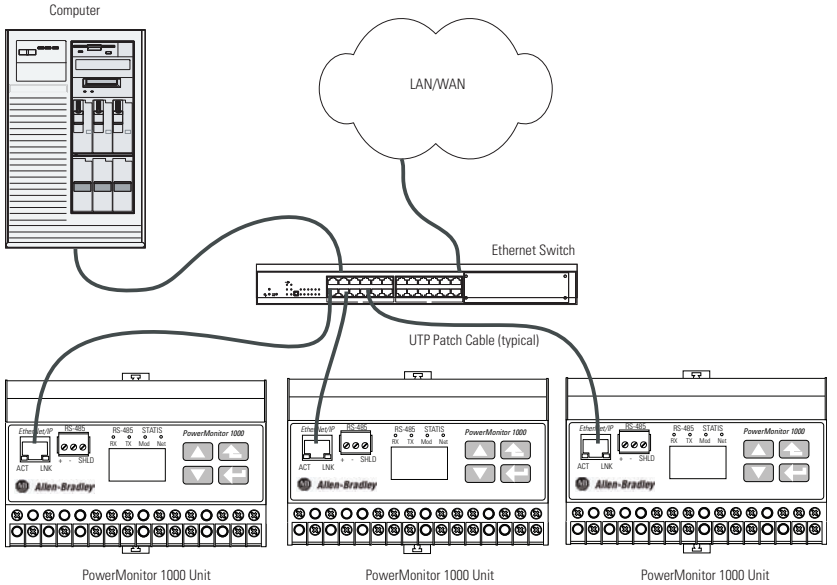
Ethernet Communication

The power monitor with optional Ethernet network communication connects easily to industry-standard Ethernet hubs and switches using standard UTP (unshielded twisted-pair) cables with RJ-45 connectors.

Terminal	Signal	Function
1	TX+	Transmit + (TX+)
2	TX-	Transmit - (TX-)
3	RX+	Receive + (RX+)
4		
5		
6	RX-	Receive - (RX-)
7		
8		

Typical Ethernet connections are shown in this diagram.

Ethernet Network Typical Connections



Ground the PowerMonitor 1000 Unit

In solid-state systems, grounding helps limit the effects of noise due to electromagnetic interference (EMI). Run the ground connection from the ground terminal of the power monitor to the ground bus or other low-impedance earth ground prior to connecting the control power or any other connections. Use 0.21 mm^2 (14 AWG) wire.

Grounding is also required in the voltage and current sensing circuits to limit the maximum voltage to ground for safety. All grounds should be made to a common ground bus or terminal.

Set Up the PowerMonitor 1000 Unit

Although the power monitor ships from the factory with default settings, you need to configure it for your particular requirements. You may configure the power monitor using the LCD, the HyperTerminal communication tool, a Web interface, or other software. This section describes, in general, methods for setting up the power monitor.

Refer to Features on page 39 for configuration specifics related to various functions.

Use Optional Software

RSPower, RSPowerPlus, and RSEnergyMetrix software (with the RT option) provide configuration interfaces for the power monitor, including the ability to upload, edit, download, and back up the unit configuration on a personal computer or server. Please refer to the applicable software user documentation or help files for information on configuring the power monitor using RSPower, RSPowerPlus, or RSEnergyMetrix software. Contact your local Allen-Bradley distributor or Rockwell Automation sales representative, or visit http://www.rockwellautomation.com/rockwellsoftware/ for more information on available software packages.

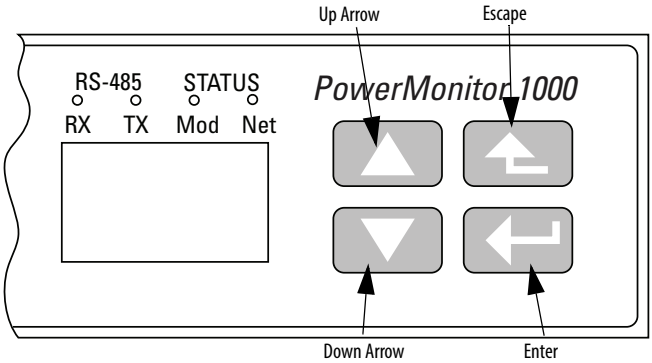
Use the LCD Screen

The power monitor has an onboard LCD for viewing and configuration. Buttons are provided to control the display. The display has three modes of operation.

- Display mode lets you select and view parameters including metering, event log, and self-test information.
- Program mode lets you change configuration parameters, with security against unauthorized configuration changes. Each power monitor is password protected.
- Edit mode lets you modify the selected parameters. In Edit mode, a highlight cursor appears under the value of the parameter being modified, starting at the right-hand (least significant) digit.

The diagram and table show the LCD interface buttons and their functions.

LCD Interface



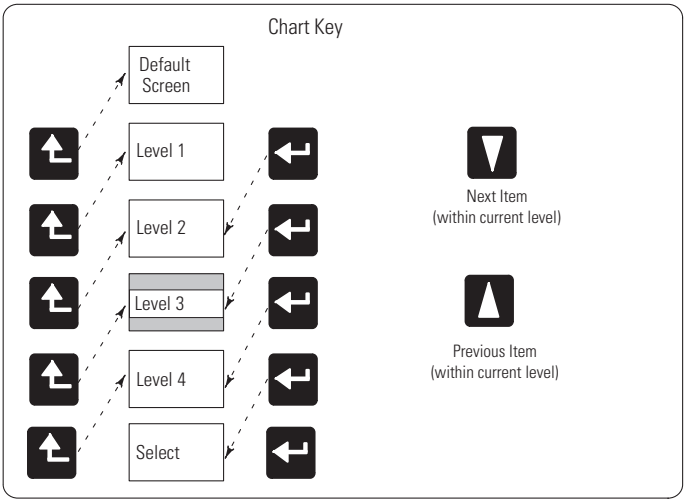
The buttons function differently in each mode. The power monitor enters into Display mode by default.

Button	Mode		
	Display	**Program**	**Edit**
Escape	Returns to parent menu At top menu, selects default screen		Cancels changes to the parameter and returns to Program mode
Up arrow	Steps back to the previous parameter or menu item		Increments the value of the highlighted digit
Down arrow	Steps forward to the next parameter or menu item		Decrements the value of the highlighted digit
Enter	Steps into a sub-menu or sets default screen	Steps into a sub-menu, selects the parameter to be modified or changes to Edit mode	Saves the parameter change and returns to Program mode
Up and down arrows together	Refreshes the display	No effect	Moves the highlight cursor one character to the left

User choices for display and configuration are organized in a hierarchical menu system within the power monitor.

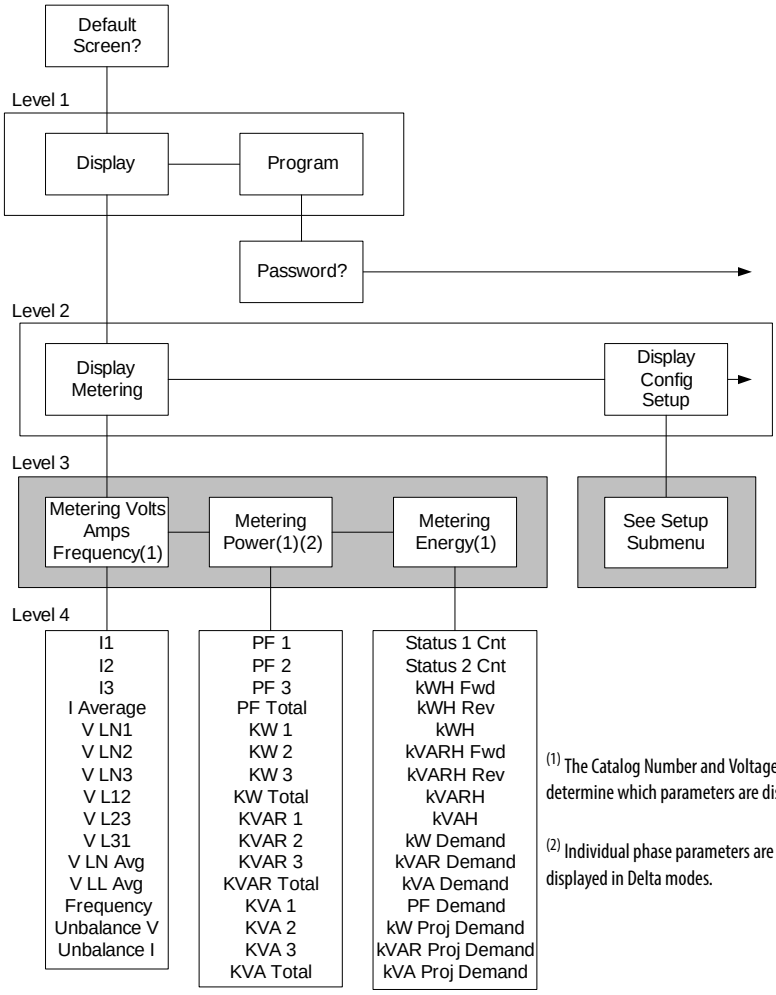
This diagram shows how to navigate in the display and configuration menu.

Menu Navigation



LCD Screen Display and Configuration Menu Map

Main Menu, Page 1



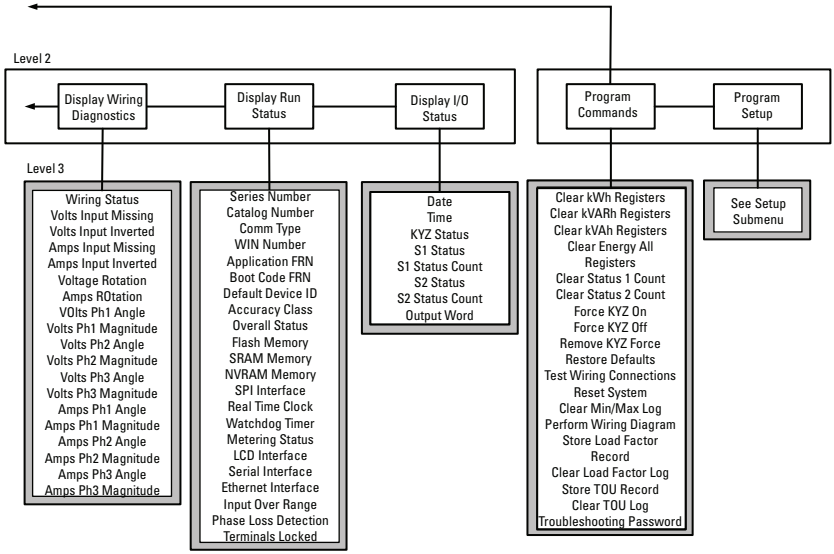
(1) The Catalog Number and Voltage mode determine which parameters are displayed.

(2) Individual phase parameters are not displayed in Delta modes.

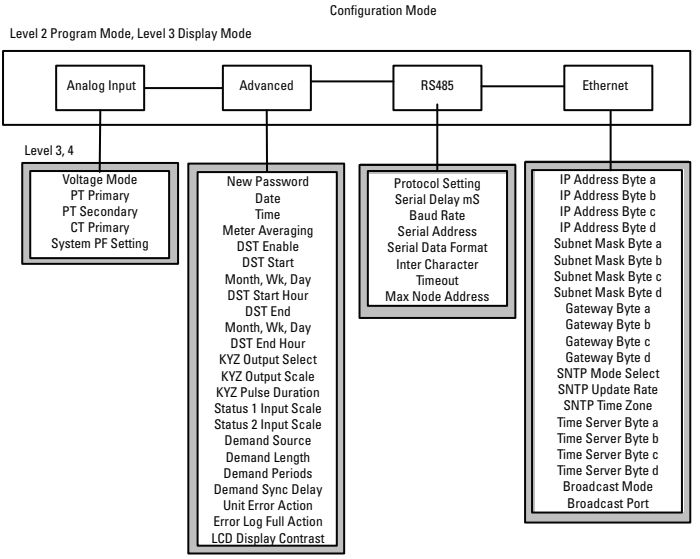
Default Screen

The power monitor lets you select and navigate to a default screen. The default screen displays at startup and is displayed after the display has been dormant for approximately 30 minutes. To set the current screen as the default, press Enter and click Yes. If you're in another menu and want to get back to the default screen, continue pressing Escape until you are prompted To Default Screen? Click Yes to display the default screen.

Main Menu, Page 2



Setup Submenu



Edit a Parameter

To edit a parameter, do the following:

- Press <up> or <down> to change the highlighted digit.
- Press <up> and <down> together to move the highlight cursor one place to the left, and press <up> or <down> to set the selected digit's value.

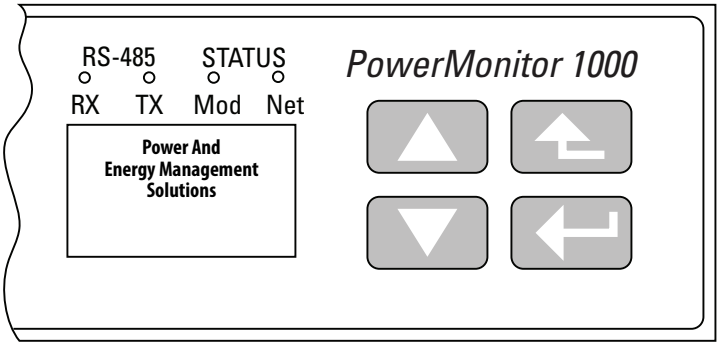
Continue in the same way until the correct value is entered then press <enter> when done.

Setup Example

This example steps through setting the unit date to demonstrate use of the display and buttons to navigate through the setup menu and make changes to parameters.

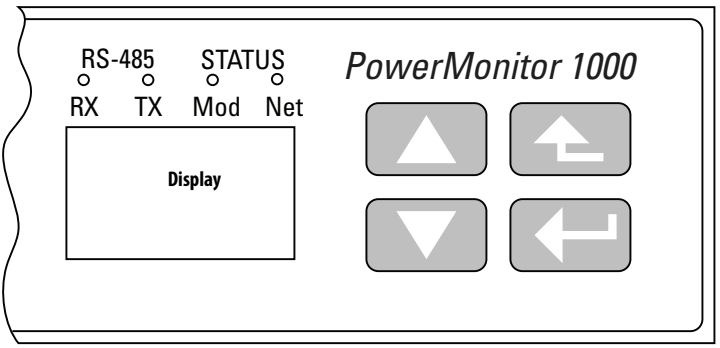
1. Navigate to the initial screen.

   The screen shown is the top level screen. If it is not present, press <escape> until it appears.



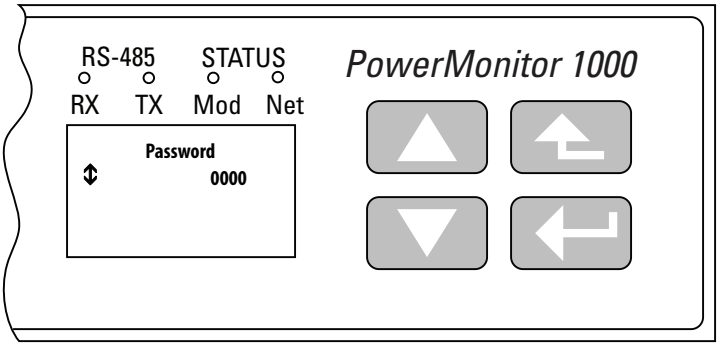
   If you press <escape> once too often, the To Default Screen? message appears. Press <escape> once more if this occurs.

2. Press <enter> and this screen appears.



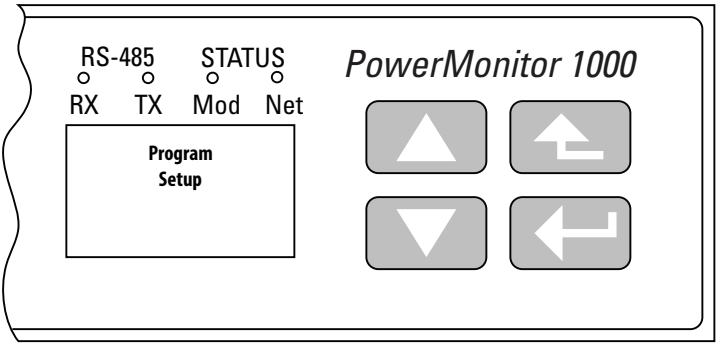
3. Press <up> or <down> once.

   Program appears in the display. Press <enter>.



4. Press <enter> if the password has not been changed from the default (0000).

   If the password has been changed, then enter the correct password.

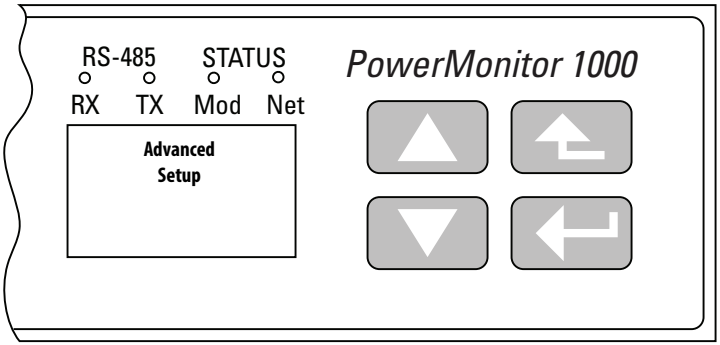


   When the correct password is entered, Program Setup appears in the display. The power monitor is now in Program mode.

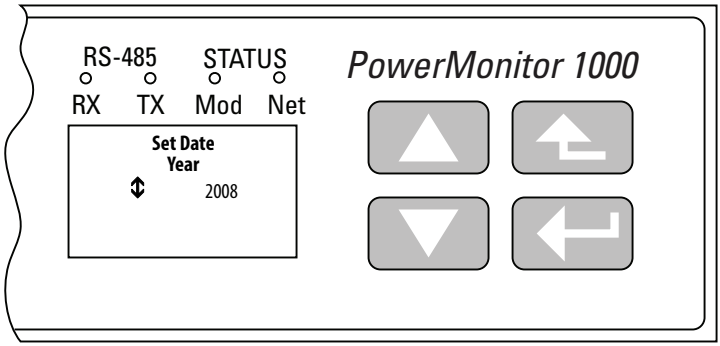
   If an incorrect password is entered, Invalid Password appears. Press any button to try again.

5. Press <enter>.

   Analog Input appears in the display. Press <down>.



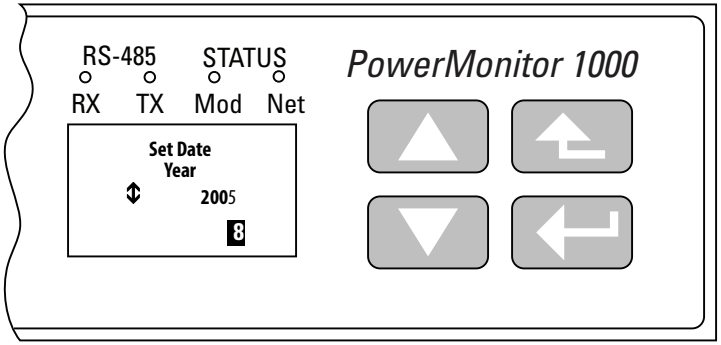
6. With Advanced Setup displayed, press <enter>, then press <down> until Set Date Year appears.



7. Press <enter> to change the value of the year.

   The power monitor is now in Edit mode, indicated by the presence of the highlight cursor. Change the year value and press <enter> to save it or <escape> to discard changes.

   See Edit a Parameter on page 30 if you need help with this.



8. Select the next item in the configuration menu by pressing <down>.

   Set the month in the same way.

Continue setting the remaining parameters in the same way.

- Navigate to the top menu display
- <enter> then <down> then <enter> to access the password screen
- Enter the correct password to access Program mode
- Navigate to the desired menu using <enter>, <up> and <down>
- <enter> selects a parameter for editing
- <up> or <down> increments or decrements the value of the highlighted digit
- <up> and <down> together move the highlight cursor
- <enter> saves your changes; <escape> discards them
- <escape> several times to the top menu to access Display mode

View Data with the Display

You may also view power monitor wiring diagnostics, metering, status and setup data using the display. To view data, select Display (instead of Setup) from the top menu and navigate through the menus as in the setup example. Press <enter> and <escape> to navigate into and out of submenus and <up> and <down> to select items within a submenu. Display mode does not permit you to change any parameter. Metering data available depends on the model of your power monitor.

Use HyperTerminal Communication Tool to Set Up

The HyperTerminal communication tool is an accessory program included with Microsoft Windows operating system. You may use the HyperTerminal communication tool to set up and view data on your power monitor as an alternative to on-device display and setup.

Follow these steps to use the HyperTerminal communication tool.

1. Connect the power monitor to your computer with a serial cable.

   Refer to Serial Communication on page 21.

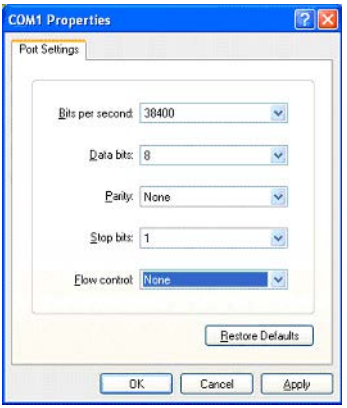
2. Launch the HyperTerminal communication tool.

   HyperTerminal communication tool is under the Start Button > Programs > Accessories > Communications > HyperTerminal.

3. When the HyperTerminal communication tool loads, enter a connection name, select COM1 (or another available port), select the data rate of the power monitor RS-485 port (default 38400 bits per second) and None as the Flow control.

   Everything else should use the defaults as shown in the Port Settings options dialog box. However, if the port has been used for DH-485 communication, the power monitor changes the parity to even.

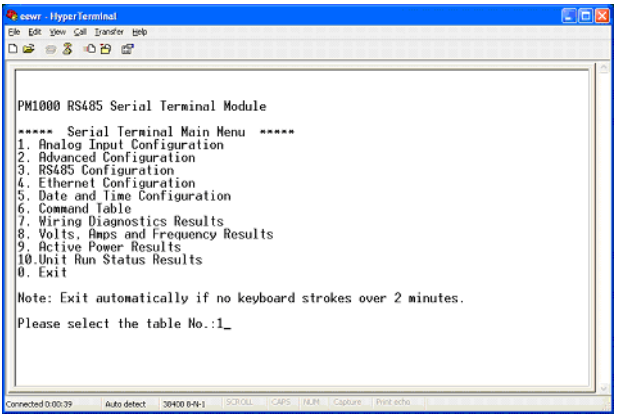
   Verify that no other application is using the selected computer communication port.



4. Click Apply and OK when finished.

5. Press the Enter key three times.

   The following menu appears.



6. To enter a menu item, backspace to delete the default value 1, type the number of the menu item, and press Enter.

   In a submenu, the HyperTerminal communication tool presents parameters one at a time. To change parameter values, enter the unit password as the first parameter. To enter the password, backspace to delete the -1 and enter the correct password (0 is the default). To view the existing settings without making changes, leave the password unchanged.

7. Press Enter to accept the password and present the next parameter.

   To change any parameter, backspace over the displayed parameter and enter the new value. Press Enter to save and move to the next parameter.

   The HyperTerminal communication tool displays a status message when all parameters are entered.

   - Write operation finished successfully

     This indicates the setup parameters have been written to the power monitor.

   - Write error occurs with element 0

     This indicates that the correct password was not entered.

   - Write error occurs with element n

     This indicates that the value entered for parameter n is outside the acceptable range of values.

   After the message, this prompt appears:

   Edit... Configuration Table again?
   Type Y for more editing, otherwise type any other key to exit.: N

8. Type Y to review or edit the selected setup parameters.

9. Type N to return to the main setup menu.

   The HyperTerminal communication tool exits the setup menu after two minutes of inactivity. To resume, press Enter three times.

Use the Web Interface

You can use an Internet browser to view data and change configuration settings on your meter.

Follow these steps to use the Web interface.

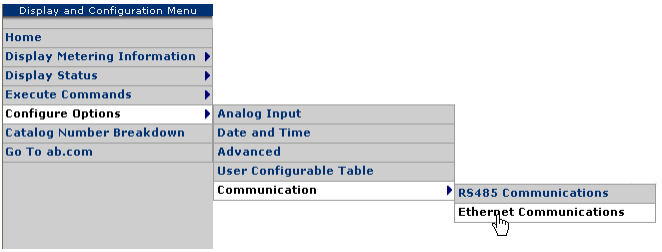
1. Use a computer that has network access to the power monitor, open your Internet browser, type the unit IP address in the address field, and press Enter.

   The power monitor's home page displays in your browser.

   The home page displays general information about the power monitor. The navigation menu is on the left.

2. Click Configure Options to access the setup menus.

EXAMPLE You can change the IP address of the power monitor by navigating to the Ethernet Communication screen.



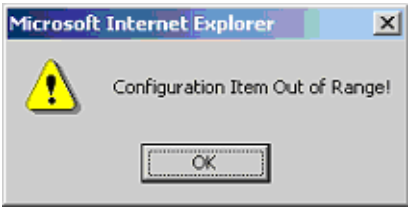
Enter the password, change the IP address, and save it by clicking Submit.

Now you can type in the new IP address in your browser and the main page refreshes using the new address.

3. Every time you change a setting or configuration you need to enter the power monitor's password (default = 0).

   If an incorrect password is entered, the following message appears.

   If the password is correct but one or more of the set-up parameter values is out of range, the following message appears.



Use Communication to Set Up

Please refer to the PowerMonitor 1000 User Manual, publication 1408-UM001, for detailed information on configuring the unit through communication with a programmable controller or custom software application.

Set-up Menus

Whichever set-up method you select, set-up parameters are organized in five set-up menus.

- Analog input setup
- Advanced setup
- RS-485 communication setup
- Optional Ethernet network communication setup
- Date and time setup

Features

This section describes in detail the functions of the power monitor. Each function includes information on set-up menus and parameters used to control its operation.

Analog Input Setup

This feature applies to all models.

Setup

The power monitor calculates metering results based on scaled voltage and current inputs. Setting up the analog inputs is necessary to obtain accurate, properly scaled metering results.

Parameter	Description	Range	Default	User Setting
Voltage mode	Should match the external electrical system and how it is wired to the PowerMonitor voltage and current input terminals. Refer to the wiring diagrams. 0 = Direct Delta 1 = Open Delta 2 = Wye 3 = Single Phase 4 = Demo, simulated results 5 = 1PT1CT-LL 6 = 1PT1CT-LN	0…4	2	
PT primary	The primary value of the PT ratio (Pri:Sec) indicating the nominal voltage present at the high-end of the transformer. For direct connect, set the PT ratio to any valid 1:1 ratio (for example, 480:480).	1.00… 50,000	480	

Parameter	Description	Range	Default	User Setting
PT secondary	The secondary value of the PT ratio (Pri:Sec) indicating the nominal voltage present at the low-end of the transformer.	1…600	480	
CT primary	The primary value of the CT ratio (Pri:5) indicating the nominal current present at the high-end of the transformer. The nominal CT rated current is 5 A.	5…50,000	5	
System PF setting	Select range corresponding to expected power factor	0 = Lead (-97…89) 1 = High (-85…98) 2 = Low (-52…-95)	2 = Low	

Related Functions

- Wiring diagnostics
- Configuration lock

Wiring Diagnostics

The power monitor performs wiring diagnostics on command to detect and report wiring errors. Wiring diagnostics operate in any wiring mode except Demo and 1PT 1CT modes, provided that measured current is at least 10% of the CT primary parameter in Analog Setup. You may select from three ranges of system power factor to improve wiring diagnostics accuracy.

This function applies to all models. Models 1408-EM1 and 1408-EM2 provide a limited results set.

Diagnostic Parameters

When a Perform wiring diagnostics command is given, the power monitor calculates and returns the results. To reduce the likelihood of erroneous or misleading wiring diagnostic data, interim results of multiple tests must agree before results are displayed. Wiring diagnostic results return to their default status approximately five minutes after the command is issued.

Wiring status:

- Pass - system wiring is correct for the voltage mode and power factor selections.
- Failed - system wiring is incorrect. Refer to voltage and current input status for additional information.
- Input Low - measured current is below 10% of full scale.
- Disabled - the power monitor is in Demo or 1PT 1CT wiring mode.

- Waiting Command - five minutes have elapsed since the most recent command.
- Out of Range - measured phase angles are outside the range of the selected system power factor.
- Voltage or current input missing (input below the metering threshold) or inverted (reverse polarity, 180 degrees out of phase)
  - -1 — Test not run; see wiring status for reason.
  - 0 — Pass, all inputs present / correct polarity.
  - 1 — Phase 1 missing / inverted.
  - 2 — Phase 2 missing / inverted.
  - 3 — Phase 3 missing / inverted.
  - 12 — Phase 1 and 2 missing / inverted.
  - 13 — Phase 1 and 3 missing / inverted.
  - 23 — Phase 2 and 3 missing / inverted.
  - 123 — All 3 phases missing / inverted.
- Voltage rotation
  - -1 — Test not run; see wiring status for reason.
  - 123 — Forward phase rotation (ABC).
  - 132 — Reverse phase rotation (ACB).
  - 4 — Invalid phase rotation (2 inputs wired with same phase).
- Current rotation, referenced to voltage Phase 1
  - -1 — Test not run; see wiring status for reason.
  - 123 — Forward rotation (ABC).
  - 231 — Forward rotation, 120 degrees displaced (BCA).
  - 312 — Forward rotation, 240 degrees displaced (CAB).
  - 132 — Reverse rotation (ACB).
  - 213 — Reverse rotation, 120 degrees displaced (BAC).
  - 321 — Reverse rotation, 240 degrees displaced (CBA).
  - 4 — Invalid phase rotation (2 inputs wired with same phase).

Forward phase rotation is not required to pass wiring diagnostics. Before changing wiring connections, refer to both the voltage / current rotation and voltage / current inverted status to select the correct analog input.

Magnitude and Phase Angle

The power monitor continually returns voltage and current magnitude and phase angle data. This data may be used to construct a phasor diagram, and in addition to the diagnostics parameters, to troubleshoot wiring issues. The following exceptions apply.

- Magnitude data is not returned by models 1408-EM1 and -EM2
- Current phase angle 2 always returns 0 in open-delta wiring mode

TIP The Troubleshooting mode of the power monitor lets you view magnitude data.

Please refer to Troubleshooting Mode on page 43.

Phase angles are consistent with the four-quadrant power metering diagram.

Refer to Power Metering on page 50.

Setup

Basic analog setup is required. In addition, a system power factor should be selected. The ranges are as follows:

- Low (52...95% lag, default setting)
- High (85 lag ...98% lead)
- Leading (97 lag ...89% lead)

Results

Wiring diagnostics results may be viewed using the following methods:

- Web interface
- LCD screen
- Communication
- HyperTerminal communication tool

Commands

- Perform wiring diagnostics
- Test wiring connections (LCD screen menu)

Troubleshooting Mode

Troubleshooting mode lets you enter a password-protected command that makes available all metered parameters for troubleshooting purposes. Troubleshooting mode does not change the data log support.

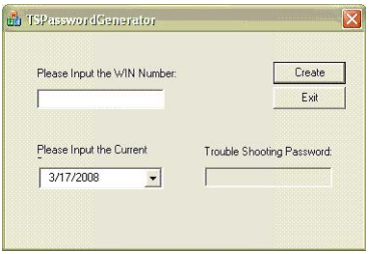
You may command your power monitor into Troubleshooting mode by using the LCD screen, the web page, the HyperTerminal interface, or via communication.

You must enter a unique password to enter Troubleshooting mode. The password is provided by a software utility program that you can obtain from the Rockwell Automation knowledgebase or by contacting Rockwell Automation technical support.

Setup

Follow these steps to enter Troubleshooting mode.

1. Open the password generator program TSPasswordGenerator.exe.



2. Enter the Warranty Identification (WIN) number of the power monitor.
3. Enter the current date.

   If the date in the power monitor is not set to the current date, enter the date in the power monitor.
4. Click Create and write down or copy the troubleshooting password.
5. Exit the password generator program.
6. Using your selected configuration means, select the Troubleshooting mode command, and when prompted, enter the password.

Troubleshooting mode remains in effect for 24 hours. You can access Troubleshooting mode a maximum of 30 times during the life of the power monitor.

Commands

- Troubleshooting mode enable

RS-485 Communication

This function applies to all models.

Setup

Your power monitor is set up to communicate via its RS-485 port using a default set of parameters when you first apply power.

Parameter	Description	Range	Default	User Setting
Protocol Setting		DF1 Half-duplex Slave DF1 Full-duplex Modbus RTU Slave Auto Sense DH485	DF1 Full-duplex	
Delay(1)	Time between receiving a request and transmitting a response	0…75 ms	10 ms	
Baud Rate	Communication bit rate per second	1200, 2400, 4800, 9600(2), 19.2k(2), 38.4k, 57.6k	38.4k	
RS-485 Address	Uniquely identifies the power monitor on a multi-drop network	1…247 0…31(3)	Unit ID number	
Data Format	Data bits / stop bits / parity	8 / 1 / none 8 / 1 / even(3) 8 / 1 / odd	8 / 1 / none	
Inter Character Timeout(1)	Minimum delay between characters that indicates the end of a Modbus message packet	0…6553 ms	0 = 3.5 character times	
Max Node Address(3)		1…31	31	

(1) Delay, Inter Character Timeout parameters have no effect on DH485 protocol

(2) The baud-rate setting for DH485 should be 9600 or 19.2 k

(3) DH485

DH-485 protocol is supported in firmware FRN 2.0 and higher. If DH-485 is selected, the data format is automatically set to 8 / 1 / even. Recommended data rates for DH-485 are 9600 and 19.2k.

Error checking method is Cyclic Redundancy Check (CRC). All devices on a multi-drop RS-485 network must be set at the same data rate and each must be assigned a unique network address.

Optional Ethernet Network Communication

The power monitor supports simultaneous operation of the optional Ethernet network and serial ports.

This feature applies to all models with catalog numbers ending in -ENT.

The Ethernet network port supports 10 or 100 Mbps data rate, half-duplex, or full-duplex.

Setup

The Ethernet network port is set up with a default IP address and gateway using a common auto-configuration addressing scheme. The default address simplifies the task of making an initial connection to the unit from a personal computer with a compatible Class B IP address.

Parameter	Description	Range	Default	User Setting
IP address bytes 1…4	Unit IP address in format aaa.bbb.ccc.ddd	0…255	192.168.254.x (x is the unit's ID)	
Subnet mask bytes 1…4	Subnet mask in format aaa.bbb.ccc.ddd	0…255	255.255.0.0	
Gateway IP address bytes 1…4	Gateway IP address in format aaa.bbb.ccc.ddd	0…255	128.1.1.1	
SNTP setup	See Date and Time Functions setup. Includes: SNTP mode Update interval Time zone Time server IP address			

The power monitor operates with a fixed IP address that uniquely identifies it on the network. An IP address of 255.255.255.255 is not permitted. The power monitor does not support BOOTP or DHCP auto-addressing.

IMPORTANT	The IP address for your power monitor must not conflict with the IP address of any other device on the network. Contact your network administrator to obtain a unique IP address, subnet mask, and default gateway address for your unit.

Ethernet Network Addressing

The IP address is a 32-bit binary number, which consists of the network address (NetID) and the machine address (HostID). The Subnet mask defines the boundary between the NetID and HostID and each 0 represents the HostID.

Ethernet Network Addressing Example

IP address	(decimal):	192	1	1	207
	(binary):	11000000	00000001	00000001	11001111
Subnet mask	(decimal):	255	255	255	0
	(binary):	11111111	11111111	11111111	00000000
		----	Net ID	----	-Host ID-

In this example, the NetID is 192.1.1.0 and the HostID is 0.0.0.207. The relationship between NetID and HostID depends on the IP address class, the discussion of which is beyond the scope of this document (the example uses a Class C IP address). Devices on the same subnet can communicate directly; devices on different subnets may communicate with each other only through a gateway or router.

The Gateway IP address defines the address of the gateway or router on the unit's subnet that is used to route messages to other subnets for wide-area networking. The default is 128.1.1.1.

Energy Metering

This function applies to catalog numbers 1408-EM1, 1408-EM2, and 1408-EM3.

Metered Parameters

The power monitor calculates and returns the totalized energy values including the following:

- GWh forward, GWh reverse, and GWh net
- kWh forward, kWh reverse, and kWh net
- GVARh forward, GVARh reverse, and GVARh net
- kVARh forward, kVARh reverse, and kVARh net
- GVAh and kVAh

Each time the kWh value rolls over to zero the GWh value increments by one. The other pairs of values operate in the same way.

EXAMPLE A large energy value could be displayed as 123,456,789,234.567 kWh where 123,456 is the GWh metering result and 789,234.567 is the kWh metering result.

Energy results (kWh, kVARh, and kVAh) roll over to 0 at a value of 9,999,999,999,999 or 10^{12}-1.

Setup

Only basic analog input setup is required for energy metering.

Results

Energy metering results may be viewed using the following methods:

- Web interface
- LCD screen
- Communication

Energy results are not available via the HyperTerminal communication tool.

Commands

The following commands are supported by the power monitor:

- Set GWh/kWh register
- Set GVARh/kVARh register
- Set GVAh/kVAh register
- Clear all energy registers

Related Functions

- KYZ output
- Energy log
- Configuration lock

Demand Metering

Demand is an electric power term that expresses the average energy usage over a period of time. The power monitor may be configured to measure demand using a fixed demand period or a sliding window. The demand period may be timed internally, synchronized to an external demand end-of-interval contact connected to the S2 status input, or synchronized using communication.

This function applies to catalog numbers 1408-EM2 and 1408-EM3.

Metered Parameters

The power monitor calculates and returns the following demand values:

- Real power demand, kW
- Reactive power demand, kVAR
- Apparent power demand, kVA
- Demand power factor, percent lagging (-) or leading (+)
- Projected kW, kVAR, and kVA demand
- Demand interval elapsed time, minutes

Projected demand calculates a linear projection of demand at the end of a demand interval.

Demand power factor is calculated using the following formula.

kW Demand / kVA Demand

Setup

Demand metering requires basic analog input setup as well as demand calculation setup. Basic demand set-up parameters are found in the Advanced Setup menu. Network demand synchronization is available on units connected to an Ethernet network. Network-demand synchronization set-up parameters are found in the Ethernet communication set-up menu.

Parameter	Description	Range	Default	User Setting
Demand Source (advanced setup)	Selects the source of the demand end-of-interval (EOI) signal. 0 = Internal Timer 1 = Status Input 2 2 = Controller Command 3 = Ethernet Demand Broadcast Network-demand synch options are available only on units with an optional Ethernet network installed. • If Demand Broadcast Master Select is set to master then a Demand Source value of 0…2 selects the EOI source that is used to trigger the demand-synch master broadcast. • If Demand Broadcast Master Select is set to slave then a Demand Source value of 0…3 selects the EOI source.	0…3	0	
Demand Period Length (advanced setup)	Specifies the period for demand calculations. The following include special cases. Demand source = 0 (internal time) and demand period length = 0 then demand metering is disabled Demand source 0 and demand period length = 0 then projected demand is disabled Demand source 0 and demand period length 0 then projected demand is calculated using the unit's internal clock	0… 99 min	15 min	
Number of Demand Periods (advanced setup)	Specifies the number of demand periods to average together for demand measurement. This parameter is used for sliding window demand calculations. For example, for a 30 minute sliding-window, demand period length = 2 minutes and number of demand periods = 15.	1…15	1	
Forced Demand Sync Delay (advanced setup)	If demand source 0 and demand period length 0 then this parameter determines how long the unit waits for an EOI pulse, command, or broadcast after the expected control pulse has not been received. If the EOI signal is not received before the waiting period expires, a new demand period starts and a record is entered in the status log. Special case: 0 = Wait forever	0…900 s	10	
Demand Broadcast Master Select (Ethernet setup)	0 = Slave, the unit uses its selected demand source to calculate demand. If demand source = 3 (Ethernet demand broadcast) the unit will listen to the selected-broadcast port number for a broadcast from the demand-sync master unit. 1 = Master, the unit broadcasts an EOI broadcast to the selected-UDP port number when the selected demand source detects an EOI event.	0…1	0	
Broadcast Port Number (Ethernet setup)	Specifies the listening or broadcast port for the UDP Ethernet-demand broadcast message.	300… 400	300	

Results

Demand metering results may be viewed using the following methods:

- Web interface
- LCD display
- Communication

Demand results are not available via the HyperTerminal communication tool.

Commands

- Controller command (EOI signal)

Related Functions

- Status inputs
- Time of use log
- Configuration lock

Power Metering

This function applies to catalog numbers 1408-TR1 (power factor only), 1408-TR2, and 1408-EM3.

Metered Parameters

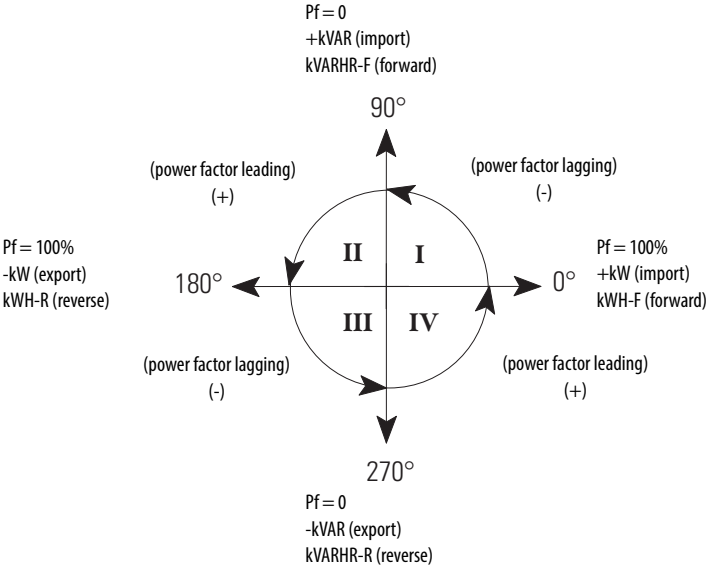
The power monitor calculates and returns four-quadrant power measurements including these:

- L1, L2, L3 and Total True Power Factor, percent lagging (-) and leading (+)
- L1, L2, L3 and Total Real Power, kW
- L1, L2, L3 and Total Reactive Power, kVAR
- L1, L2, L3 and Total Apparent Power, kVA

Only total three-phase power results are provided when Direct Delta or Open Delta wiring modes are selected.

The Magnitude and Direction of Power Quantities chart indicates the relationship between the magnitude and direction of the power quantities and the numeric signs used by the power monitor.

Magnitude and Direction of Power Quantities



Setup

Only basic analog-input setup is required for power metering.

Results

Power metering results may be viewed using the following methods:

- Web interface
- LCD screen
- Communication
- HyperTerminal communication tool

Related Functions

- Metering result averaging
- Configuration lock

Voltage, Current, and Frequency Metering

This function applies to catalog numbers 1408-TR1, 1408-TR2, and 1408-EM3.

Metered Parameters

The power monitor calculates and returns voltage, current, and frequency measurements including these:

- L1, L2, L3, and Average Current, A
- L1-N, L2-N, L3-N, and Average L-N Voltage, V
- L1-L2, L2-L3, L3-L1, and Average L-L Voltage, V
- Frequency
- Percent Current Unbalance
- Percent Voltage Unbalance

Line-to-neutral voltage results are not provided for Delta and Open Delta wiring modes.

Voltage and current unbalance are calculated according to the following formula.

$$\frac{\text{Maximum Deviation from Average} \times 100}{\text{Average}}$$

Setup

Only basic analog-input setup is required for power metering.

Results

Voltage, current, and frequency metering results may be viewed using the following methods:

- Web interface
- LCD screen
- Communication
- HyperTerminal communication tool

Related Functions

- Metering result averaging
- Configuration lock

Date and Time Functions

The power monitor internal clock and calendar is used in demand metering and data logging functions. A number of user-selectable options are available for synchronizing and controlling the internal clock and calendar.

This function applies to all models.

Date and Time Parameters

- Date: Year, Month, Day
- Time: Hour, Minute, Seconds, Hundredths

Basic Setup

Basic setup is done using the date and time setup menu.

TIP In the LCD screen, date and time are included in the Advanced Setup menu.

Parameter	Range	Default
Date: Year	2001…2100	2005
Date: Month	1…12	1
Date: Day	1…31	1
Time: Hour	0…23	0
Time: Minute	0…59	0
Time: Seconds	0…59	0
Time: Hundredths	0…99	0

Daylight-savings Time Setup

Daylight-savings time (DST) setup is done in the Advanced Setup menu. If DST is enabled, the power monitor internal clock advances by one hour on the start date and hour specified, and is set back by one hour on the return date and hour specified. The defaults represent the common DST start and return date/times in use in the United States in 2006. The DST function also adjusts the network-time synch offset when used.

Parameter	Description	Range	Default	User Setting
Use DST Correction	0 = Disables DST 1 = Enables DST	0…1	0	
DST Month/ Week/Day Start	Format: MMWWDD Month: 01 = January…12 = December Week: 01 = 1st week…05 = Last Week Day of Week: 01 = Sunday…07 = Saturday	010101… 120507	030201 March, 2nd, Sunday	
Hour of Day Start		0…23	2 (2 am)	
Return from DST Month/ Week/Day	Format same as start date	010101… 120507	110101 November, First, Sunday	
Hour of Day End		0…23	2 (2 am)	

Network Time Synchronization

Network time synchronization is available only on units equipped with the optional Ethernet network. Set-up parameters are found in the Ethernet communication set-up menu. The power monitor updates its time from a simple network time protocol (SNTP) server or an anycast group of SNTP servers, depending on setup parameter values. Network-time synchronization set-up parameters are found in the Ethernet communication set-up menu.

Parameter	Description	Range	Default	User Setting
SNTP Mode Select	0 = Disable 1 = Unicast – Specify the IP address of a unicast SNTP server. 2 = Anycast mode – Specify the broadcast IP address of a SNTP anycast group.	0…2	0	
SNTP Update Interval	Defines how often the time is updated from the SNTP server.	1…32766 minutes	300	
Time Zone Select	There are 32 available time zones.	0…32	7 (Eastern Time)	
Time Server IP Address	Unicast server or anycast group IP address in format aaa.bbb.ccc.ddd.	0.0.0.0… 255.255.255.255	0.0.0.0	

Related Functions

- Demand metering
- Data logging

Time Zones

These are the available time zones. Choose the one for your region.

Value	Offset from GMT	Time Zone Name	Areas in Time Zone
0	GMT-12:00	Dateline Standard Time	Eniwetok, Kwajalein
1	GMT-11:00	Samoa Standard Time	Midway Island, Samoa
2	GMT-10:00	Hawaiian Standard Time	Hawaii
3	GMT-09:00	Alaskan Standard Time	Alaska
4	GMT-08:00	Pacific Standard Time	Pacific Time (U.S. & Canada; Tijuana)
5	GMT-07:00	Mountain Standard Time	Mountain Time (U.S. & Canada)
		U.S. Mountain Standard Time	Arizona
6	GMT-06:00	Canada Central Standard Time	Saskatchewan
		Central America Standard Time	Central America
		Central Standard Time	Central Time (U.S. & Canada)
		Mexico Standard Time	Mexico City
7	GMT-05:00	Eastern Standard Time	Eastern Time (U.S. & Canada)
		SA Pacific Standard Time	Bogota, Lima, Quito
		U.S. Eastern Standard Time	Indiana (East)
8	GMT-04:00	Atlantic Standard Time	Atlantic Time (Canada)
		Pacific SA Standard Time	Santiago
		SA Western Standard Time	Caracas, La Paz
9	GMT-03:30	Newfoundland Standard Time	Newfoundland
10	GMT-03:00	E. South America Standard Time	Brasilia
		Greenland Standard Time	Greenland
		SA Eastern Standard Time	Buenos Aires, Georgetown
11	GMT-02:00	Mid-Atlantic Standard Time	Mid-Atlantic
12	GMT-01:00	Azores Standard Time	Azores
		Cape Verde Standard Time	Cape Verde Is.
13	GMT	Standard Time	Greenwich Mean Time: Dublin, Edinburgh, Lisbon, London
		Greenwich Standard Time	Casablanca, Monrovia

Value	Offset from GMT	Time Zone Name	Areas in Time Zone
14	GMT+01:00	Central Europe Standard Time	Belgrade, Bratislava, Budapest, Ljubljana, Prague
		Central European Standard Time	Sarajevo, Skopje, Sofija, Vilnius, Warsaw, Zagreb
		Romance Standard Time	Brussels, Copenhagen, Madrid, Paris
		W. Central Africa Standard Time	West Central Africa
		W. Europe Standard Time	Amsterdam, Berlin, Bern, Rome, Stockholm, Vienna
15	GMT+02:00	E. Europe Standard Time	Bucharest
		Egypt Standard Time	Cairo
		FLE Standard Time	Helsinki, Riga, Tallinn
		GTB Standard Time	Athens, Istanbul, Minsk
		Israel Standard Time	Jerusalem
		South Africa Standard Time	Harare, Pretoria
16	GMT+03:00	Arab Standard Time	Kuwait, Riyadh
		Arabic Standard Time	Baghdad
		E. Africa Standard Time	Nairobi
		Russian Standard Time	Moscow, St. Petersburg, Volgograd
17	GMT+03:30	Iran Standard Time	Tehran
18	GMT+04:00	Arabian Standard Time	Abu Dhabi, Muscat
		Caucasus Standard Time	Baku, Tbilisi, Yerevan
19	GMT+04:30	Afghanistan Standard Time	Kabul
20	GMT+05:00	Ekaterinburg Standard Time	Ekaterinburg
		West Asia Standard Time	Islamabad, Karachi, Tashkent
21	GMT+05:30	India Standard Time	Calcutta, Chennai, Mumbai, New Delhi
22	GMT+05:45	Nepal Standard Time	Kathmandu
23	GMT+06:00	Central Asia Standard Time	Astana, Dhaka
		N. Central Asia Standard Time	Almaty, Novosibirsk
		Sri Lanka Standard Time	Sri Jayawardenepura
24	GMT+06:30	Myanmar Standard Time	Rangoon
25	GMT+07:00	North Asia Standard Time	Krasnoyarsk
		SE Asia Standard Time	Bangkok, Hanoi, Jakarta

Value	Offset from GMT	Time Zone Name	Areas in Time Zone
26	GMT+08:00	China Standard Time	Beijing, Chongqing, Hong Kong, Urumqi
		North Asia East Standard Time	Irkutsk, Ulaan Bataar
		Singapore Standard Time	Kuala Lumpur, Singapore
		Taipei Standard Time	Taipei
		W. Australia Standard Time	Perth
27	GMT+09:00	Korea Standard Time	Seoul
		Tokyo Standard Time	Osaka, Sapporo, Tokyo
		Yakutsk Standard Time	Yakutsk
28	GMT+09:30	AUS Central Standard Time	Darwin
		Cen. Australia Standard Time	Adelaide
29	GMT+10:00	AUS Eastern Standard Time	Canberra, Melbourne, Sydney
		E. Australia Standard Time	Brisbane
		Tasmania Standard Time	Hobart
		Vladivostok Standard Time	Vladivostok
		West Pacific Standard Time	Guam, Port Moresby
30	GMT+11:00	Central Pacific Standard Time	Magadan, Solomon Is., New Caledonia
31	GMT+12:00	Fiji Standard Time	Fiji, Kamchatka, Marshall Is.
		New Zealand Standard Time	Auckland, Wellington
32	GMT+13:00	Tonga Standard Time	Nuku'alofa

Energy Log

The energy log is one of five data logs where the power monitor records metering and status data. Data logging setup is performed using optional RSPower or RSEnergyMetrix RT software via communication.

Refer to RSPower Getting Results Guide, publication RSPWR-GR002 and RSEnergyMetrix Getting results guide, publication ENEMTX-GR001 for information on the software.

For details on the communication interface for data logging setup and record access, refer to the PowerMonitor 1000 Communication Reference Manual, publication 1408-UM001.

This function applies to catalog numbers 1408-EM1, 1408-EM2, and 1408-EM3.

Logged Parameters

Energy log records contain a date/time stamp and the metering parameters listed below.

Metering Parameter	EM1	EM2	EM3
Status Input 1 Scaled Count	•	•	•
Status Input 2 Scaled Count	•	•	•
Real Energy Net, GWh / kWh	•	•	•
Reactive Energy Net, GVARH / kVARh		•	•
Apparent Energy Net, GVAh / kVAh		•	•
Real Power Demand, kW		•	•
Reactive Power Demand, kVAR		•	•
Apparent Power Demand, kVA		•	•
Demand PF, percent		•	•

Results

Energy log records can be accessed only via communication.

Commands

- Clear energy log

Related Functions

- Energy metering, Demand metering
- Configuration lock

Min/Max Log

The power monitor records time-stamped minimum and maximum values for all real-time metering data (except for energy data).

This feature applies to catalog numbers 1408-TR1, 1408-TR2, and 1408-EM3.

Logged Parameters

The min/max log contains a record for each of the metering parameters listed below along with a date/time stamp corresponding to the minimum and maximum value recorded.

Metering Parameter	TR1	TR2	EM3
L1, L2, L3 and Average Current	•	•	•
L1-N, L2-N, L3-N and Average L-N Voltage	•	•	•
L1-L2, L2-L3, L3-L1 and Average L-L Voltage	•	•	•
Frequency	•	•	•
Percent Current Unbalance	•	•	•
Percent Voltage Unbalance	•	•	•
L1, L2, L3 and Total True Power Factor		•	•
L1, L2, L3 and Total Real Power, kW		•	•
L1, L2, L3 and Total Reactive Power, kVAR		•	•
L1, L2, L3 and Total Apparent Power, kVA		•	•
Real Power Demand, kW			•
Reactive Power Demand, kVAR			•
Apparent Power Demand, kVA			•
Demand PF, percent			•

Results

Min/max log records can be accessed only via communication.

Commands

- Clear single min/max log record
- Clear min/max log

Related Functions

- Energy metering
- Demand metering
- Voltage, current and frequency metering
- Power metering

Load Factor Log

The power monitor maintains a 12-month record of demand and load factor. Load factor is average demand divided by peak demand and is a measure of load variability.

This function applies to catalog numbers 1408-EM2 and 1408-EM3.

Logged Parameters

The load factor log consists of 13 records, an in-process record for the current month, and one record for the previous 12 months. The monthly records operate in a circular or FIFO fashion. On a user-selected day each month, the current record is pushed into the monthly record stack and cleared. Each record contains the following data:

- Real power demand, peak and average, kW
- Real power load factor, percent
- Reactive power demand, peak and average, kVAR
- Reactive power load factor in percent
- Apparent power demand, peak and average, kVA
- Apparent power load factor in percent

Results

Load factor log records can be accessed only via communication.

Commands

- Store and clear current Load Factor Record
- Clear Load Factor Log

Related Functions

- Demand metering

Time of Use Logs

The power monitor maintains records of energy and demand organized by times of use you define. These records may be used for billing and cost allocation by RSPowerPlus software.

There are up to three time-of-use (TOU) logs, one for real energy and demand, one for reactive energy and demand, and one for apparent energy and demand. Within each log, energy consumption and peak demand are recorded into off-peak, mid-peak, and on-peak categories. The days and times that define the mid- and on-peak periods are user selectable. All times of use not defined as mid- or on-peak are considered off-peak.

This function applies to catalog numbers 1408-EM1 (one TOU log, real energy only), 1408-EM2 (three TOU logs, energy, and demand), and 1408-EM3 (three TOU logs, energy, and demand).

Logged Parameters

Each TOU log consists of 13 records, an in-process record for the current month, and one record each for the previous 12 months. The monthly records operate in a circular or FIFO fashion. On a user-selected day each month, the current record is pushed into the monthly record stack and cleared. Each record contains the following data:

- Net energy: off-peek, mid-peek, and on-peak
- Peak demand: off-peek, mid-peek, and on-peak
- Start and end date/time of the record
- Record number

Results

Time of use log records can be accessed only via communication.

Commands

- Store and clear current TOU Record
- Clear TOU Log

Related Functions

- Energy metering
- Demand metering

Status Log

The Status log records the date and time of changes made to the device and of external events. The status log consists of 50 records and operates in a circular or FIFO fashion. The status log may not be cleared.

This function applies to all models.

Logged Events

- Configuration changed
- Clock set
- Relay output forced on or off
- Status input activated or deactivated (may be disabled)
- Status input counter 1 or 2 rollover or set
- Missed external sync pulse
- Energy register rollover or set
- Device power-up or power-down
- Self-test status

Results

Status log records can be accessed only via communication.

Related Functions

- Log status input changes

I/O Functions

The I/O functions include Relay KYZ Output, Status Inputs, and Configuration Lock Input.

Relay KYZ Output

The KYZ output is a solid-state relay designed for low-power, long-life signaling operation. Its typical use is to provide a pulse output proportional to energy consumption to an external totalizer.

This function applies to catalog numbers 1408-EM1, 1408-EM2, and 1408-EM3 for energy pulse.

This function applies to all models for forced operation.

Operation

The KYZ output can operate in any of the following modes:

- Energy pulse operation with fixed pulse width or toggle
- Forced operation

Setup

KYZ-output set-up parameters are found in the Advanced Setup menu and are summarized in the table.

Parameter	Description	Range	Default	User Setting	Model				
					TR 1	TR 2	EM 1	EM 2	EM 3
KYZ Output Parameter	0 = Disable 1 = Wh Fwd 2 = Wh Rev	0…2	0				●	●	●
	3 = VARh Fwd 4 = VARh Rev 5 = VAh	0…5						●	●
KYZ Output Scale	The increase in value of the selected parameter that caused the output to change state	1… 100,000	1000				●	●	●
KYZ Pulse Duration Setting	0 = toggle output 50…1000 = duration of output pulse, rounded to 10 ms	0 or 50… 1000	250 ms				●	●	●

Commands

- Force KYZ Output On
- Force KYZ Output Off
- Remove Force from KYZ

Related Functions

- Configuration lock

Status Inputs

The power monitor has two self-powered (24V DC) status inputs. Two typical uses for status inputs are to totalize external pulse meters and to synchronize the demand end of interval (EOI).

This function applies to catalog numbers 1408-EM1 (except demand EOI synch), 1408-EM2, and 1408-EM3.

Operation

Each time status input 1 sees an off-to-on transition, the status input 1 scale factor is added to the status input 1 count. The count continues to increase, rolling over to zero at a value of 9,999,999,999,999 ($10^{12} - 1$). Status input 2 operates in the same fashion. Status input 2 counter operates whether or not the input is used for demand EOI synchronization.

Setup

The set-up parameters for pulse totalizing and scaling are in the Advanced Setup menu and are summarized in this table.

Parameter	Description	Range	Default	User Setting	Model				
					TR1	TR2	EM1	EM2	EM3
Status Input 1 Input Scale	When a status input sees an off to on transition, the status input count is increased by the scale factor.	1… 1,000,000	1				•	•	•
Status Input 2 Input Scale		1… 1,000,000	1				•	•	•

Setup for demand EOI synchronization is described in the Demand Metering section.

Metering Parameters

- Status 1 Count x1,000,000 and x1
- Status 2 Count x1,000,000 and x1

Commands

The following commands may be used to preset or reset the status input counters:

- Set Status 1 Count
- Set Status 2 Count

Related Functions

- Log status input changes
- Configuration lock

Configuration Lock Input

Unauthorized changes to the power monitor setup are prevented when the configuration-lock input terminals, CF and CF1, are connected together.

This feature applies to all models.

Operation

The following set-up parameters and commands are locked when the configuration lock is applied:

- Analog input setup menu: all parameters
- Advanced setup menu
- Metering result averaging
- Log status input changes
- KYZ setup
- Status input 1 and 2 input scale
- Demand setup
- Ethernet communication set-up menu
- Network demand setup

The following commands are prohibited when the configuration lock is applied:

- Set kWh, kVARh, kVAh register
- Clear all energy registers
- Set status 1 or 2 count
- Clear energy log
- Force KYZ output on, off, or clear force
- Restore factory defaults
- Reset power monitor system

Setup

No setup is needed.

Miscellaneous Functions

The power monitor includes a small number of miscellaneous functions that you can select. Set-up parameters of these functions are in the Advanced Configuration set-up menu.

Parameter	Description	Range	Default	User Setting
New Password	Select a new password if desired to help prevent unauthorized changes to the unit setup.	0…9999	0	
Metering Result Averaging	If enabled, metering results are averaged by using the previous eight cycles to smooth the results.	0 = Off 1 = On	1	
Log Status Input Changes(1)	If disabled, prevents routine status input changes from filling up the status log. Useful when a status input is used for pulse counting or demand EOI synch.	0 = Disable 1 = Enable	0	
Unit Error Action	Determines the unit's response to a hardware or firmware error. 0 = Halt, make status indicator solid red 1 = Reset the unit	0…1	1	
Software Error Log Full Action	Determines the unit response when a firmware failure is detected and the error log is full. 0 = Halt on error and wait for clear log command, make status indicator solid red 1 = Perform a firmware reset	0…1	1	

(1) Log status input changes parameter is not accessible from the LCD screen.

Commands

The power monitor offers the following commands. The power monitor Commands table can be accessed using the LCD screen, the HyperTerminal communication tool, the Web interface, or via communication.

Commands that do not apply to the power monitor model are ignored.

Command	Parameters	Action
Set kWh register	GWh / kWh forward GWh / kWh reverse	Presets forward and reverse energy values, resets if parameters = 0
Set kVARh register	GVARh / kVARh forward GVARh / kVARh reverse	
Set kVAh register	GVAh / kVAh forward GVAh / kVAh reverse	
Clear all energy registers	-	Resets all energy values
Set Status 1 count	New status 1 count	Presets or resets status input count
Set Status 2 count	New status 2 count	
Clear energy log	-	Clears all data from energy log
Force KYZ output on	-	Forces the KYZ output state, over-rides automatic action
Force KYZ output off	-	
Remove force from KYZ	-	Restores automatic action of KYZ output as configured
Restore factory defaults	-	Clears all user-configured values from the setup menus to their factory default settings
Reset system	-	Warm reboot: Performs a power-on self test of the power monitor
Test wiring connections	-	Perform wiring diagnostics
Clear min/max records	Min/max record number	Clears selected min/max record or all records if parameter = 0
Store and clear current load factor record	-	Simulates end-of-month push of in-process current month into the monthly load factor record stack
Clear load factor log		Clears all load factor log records
Store and clear current TOU record		Simulates end-of-month push of in-process current month into the monthly TOU record stack
Clear TOU log		Clears all TOU log records
Clear error log		Clears the error log

Related Functions

- Configuration lock

Certifications

The power monitor adheres to these certifications.

EtherNet/IP Network Conformance Testing

All power monitor products equipped with an EtherNet/IP network communication port bear the mark shown. This mark indicates the power monitor has been tested at an Open Device Vendor Association (ODVA) independent test lab and has passed the EtherNet/IP network conformance test. This test provides a level of assurance that the power monitor will interoperate with other conformance tested EtherNet/IP network devices (including devices from other vendors). One representative device from the power monitor EtherNet/IP network family of devices, the 1408-EM3-ENT, has been tested by ODVA by using EtherNet/IP Conformance Test, version A2.8. The ODVA website http://www.odva.org maintains a list of products that have passed the conformance test at one of their test labs.

UL/C-UL

UL 508 listed, File E56639, for Industrial Control Equipment and C-UL Certified.

CE Certification

If this product bears the CE marking, it is approved for installation within the European Union and EEA regions. It has been designed to meet the following directives.

EMC Directive

This product is tested to meet Council Directive 89/336/EEC Electromagnetic Compatibility (EMC) and the following standards, in whole, documented in a technical construction file.

EN55011 – Radiated Electromagnetic Emissions

EN55011 – Conducted Emissions

ENV50204 – RF 900MHz Keyed Carrier

EN61000 – Immunity

This product is intended for use in an industrial environment.

Low Voltage Directive

This product is tested to meet Council Directive 73/23/EEC Low Voltage, by applying the safety requirements of EN61010-1.

This equipment is classified as open equipment and must be installed (mounted) in an enclosure during operation as a means of providing safety protection.

International Standard IEC 529 / NEMA / UL 508 Degree of Protection

The Bulletin 1408 PowerMonitor 1000 unit is rated as IP10 degree of protection per International Standard IEC 529. It is considered an open device per NEMA and UL 508.

Follow the recommended installation guidelines to maintain these ratings.

ANSI/IEEE Tested

Meets or exceeds the Surge Withstand Capability (SWC) C37.90.1 - 2002 for protective relays and relay systems on all power-connection circuit terminations.

Specifications

Parameter	Accuracy in % of Reading at 25 °C (77 °F) 50/60 Hz Unity Power Factor						Nominal / Range
		Applies to					
		TR1	TR2	EM1	EM2	EM3	
Voltage Sense Inputs: V1, V2, V3	±0.5%	X	X			X	Line-neutral rms: 347V / 15…399V Line-line rms: 600V / 26…691V
Current Sense Input: I1, I2, I3	±0.5%	X	X			X	5A / 0.05…10.0 A rms
Frequency	±0.05 Hz	X	X			X	50 or 60 Hz / 40…75 Hz
Power Functions: kW, kVA, kVAR	EN62053-21:2003 Accuracy Requirement Class 1(1)		X			X	
Demand Functions: kW, kVA					X	X	
Energy Functions: kWH, kVAH				kWh only	X	X	
Metering Update Rates	100 ms V, I, Hz 200 ms Power	X	X	X	X	X	

(1) Fast transient external influence tested at 2 kV.

Parameter	Rating
Control Power	85…264V AC 47…63 Hz 125…250V DC 4 VA max
Voltage Sense Inputs: V1, V2, V3	Input impedance: 5 MΩ min Input current: 2 mA max
Current Sense Inputs: I1, I2, I3	Overload withstand: 15 A continuous, 200 A for 1/2 s Burden: 0.05V A Impedance: 0.002 Ω Max crest factor at 5 A is 3.0 Starting current: 5 mA
Status Inputs	Contact closure (internal 24V DC)
KYZ Output	80 mA at 240V AC / 300V DC

Attribute	Value	
Dielectric withstand	Control power	2500V
	Voltage inputs	2500V
	Current inputs	2500V
	Status inputs	2500V
	KYZ output	2500V
Terminal blocks	0.34…2.5 mm^2 (22…14 AWG), 75 °C (167 °F) min, copper wire only Recommended torque 0.8 N•m (7 lb•in)	
Operating temperature	-10…60 °C (14…140 °F)	
Storage temperature	-40…85 °C (-40…185 °F)	

Attribute	Value
Humidity	5…95%, noncondensing
Vibration	2.0 g 10…500 Hz
Shock	30 g peak each axis (operating) 50 g peak each axis (nonoperating)

Glossary

ampere. A unit of electrical current or rate of flow of electrons. One volt across one ohm of resistance causes a current flow of one ampere.

apparent power. The product of voltage magnitude and current magnitude in a circuit. Units are VA or some multiple thereof.

balanced load. An alternating, current power system consisting of more than two current carrying conductors in which these current-carrying conductors all carry the same current.

baud. A rate at which data transmission occurs, where one baud equals one bit per second.

billing demand. The demand level that a utility uses to calculate the demand charges on the current month's bill. Various methods may be used to determine the value, such as minimum demand, peak demand, or a ratchet clause. It can be based on Watt demand, VA demand, VAR demand, or some combination of these.

burden. The electrical load placed on source of VA or the load an instrument or meter places on a current or potential transformer. All current and potential transformers have a rated burden that should not be exceeded or else transformer transformation accuracy deteriorates.

capacitor. A device consisting essentially of two conducting surfaces separated by an insulating material or dielectric. A capacitor stores electrical energy, blocks the flow of direct current, and permits the flow of alternating current to a degree dependent upon the capacitance and frequency. They may also be used to adjust the power factor in a system.

connected load. The total load that you can impose on the electrical system if everything was connected at one time. Connected loads can be measured in horsepower, watts or volt-amperes. Some rate schedules establish a minimum demand charge by imposing a fee per unit of connected load.

current transformer (CT). A transformer, intended for measuring or control purposes, designed to have its primary winding connected in series with a conductor carrying the current to be measured or controlled. CT's step down high currents to lower values that can be used by measuring instruments.

current transformer ratio. The ratio of primary amperes divided by secondary amperes.

data table. The power monitor data is organized in data tables similar to those found in an SLC 5/03 programmable controller. The detailed data-table definitions are covered in the PowerMonitor 1000 Communication Reference Manual, publication 1408-UM001.

demand interval. Demand charges are based on peak demand over a utility-specified time interval, not on the instantaneous demand (or connected load) at any given moment. Typical demand intervals are 15, 20, and 30 minutes.

frequency. The number of recurrences of a periodic phenomenon in a unit of time. In electrical terms, frequency is specified as so many Hertz (Hz) where one Hz equals one cycle per second.

impedance. The total opposition (that is, resistance and reactance) a circuit offers to the flow of alternating current at a given frequency. It is measured in ohms.

inductor. A device consisting of one or more windings with or without a magnetic core. Motors are largely inductive.

KYZ pulse. Contact closure generated utility revenue meters. Each pulse indicates the consumption of a specific number of watts. These pulses can be used to measure energy consumption and demand.

lagging current. The current flowing in an AC circuit that is mostly inductive. If a circuit contains only inductance, the current lags the applied voltage by 90°. Lagging current means lagging power.

leading current. The current flowing in a circuit which is mostly capacitive. If a circuit contains only capacitance, the current leads the applied voltage by 90°. Leading current means leading power factor.

load. Any device or circuit consuming power in an electrical system.

load shedding. The removal of load from the line-to-limit load and control demand level.

load restoring. The energizing of loads that were previously removed from the line-to-limit load and control demand level.

neutral. The conductor chosen as the return path for the current from the load to the source. It is also a voltage reference point in a power system.

ohm. The unit of electrical resistance. One ohm is the value of resistance through which a potential difference of one volt will maintain a current flow of one ampere.

peak demand. The highest average load over a utility-specified time interval during a billing period. If there is no ratchet clause in the rate schedule, then the peak demand is also the billing demand.

polyphase. Having or utilizing several phases. A polyphase power circuit has several (typically three) phases of alternating current with a fixed phase angle between phases.

potential transformer (PT). A transformer with the primary winding connected in parallel with the circuit whose voltage is to be measured or controlled. PT's are normally used to step down high-voltage potentials to lower levels acceptable to measuring instruments. Also known as voltage transformer (VT).

potential transformer ratio. The ratio of primary voltage divided by secondary voltage.

power factor. The ratio of real power in watts of an alternating current circuit to the apparent power in volt-amperes. Also expressed as the cosine of the phase angle between the fundamental voltage applied to a load and the current passing through it.

power factor correction. Steps taken to raise the power factor by closely aligning the current to be in phase with the applied voltage. Most frequently this consists of added capacitance to increase the lagging power factor of inductive circuits.

power factor penalty. The charge utilities impose for operating at power factor below some rate schedule-specified level. This level ranges from a lagging power factor of 0.80 to unity. There are innumerable ways by which utilities calculate power factor penalties.

ratchet clause. A rate schedule clause that states that billing demand may be based on current-month peak demand or on historical peak demand, depending on relative magnitude. Usually the historical period is the past 11 months, although it can be for the life of the contract.

reactance. The opposition to the flow of alternating current. Capacitive reactance is the opposition offered by capacitors and inductive reactance is the opposition offered by an inductive load. Both reactances are measured in ohms.

real power. The component of apparent power that represents real work in an alternating current circuit. It is expressed in watts and is equal to the apparent power times the power factor.

resistance. The property of a substance that impedes current flow and results in the dissipation of power in the form of heat. The unit of resistance is the ohm. One ohm is the resistance through which a difference of potential of one volt will produce a current of one ampere.

revenue meter. A meter used by a utility to generate billing information. Many types of meters fall in this category depending on the rate structure.

root mean square (rms). The effective value of alternating current or voltage. The rms values of voltage and current can be used for the accurate computation of power in watts. The rms value is the same value as if continuous direct current were applied to a pure resistance.

sliding-window demand interval. A method of calculating average demand by averaging the average demand over several successive short time intervals, advancing one short-time interval each time. Updating average demand at short-time intervals gives the utility a much better measure of true demand and makes it difficult for you to obscure high short-term loads.

unbalanced load. A situation existing in a three-phase alternating current system using more than two current carrying conductors where the current is not due to uneven loading of the phases.

volt-ampere (VA). The unit of apparent power. It equals volts times amperes regardless of power factor.

volt-ampere demand. Where peak average demand is measured in volt-amperes rather than watts. The average VA during a predefined interval. The highest average, that is, Peak VA demand, is sometimes used for billing.

voltage (V). The force that causes current to flow through a conductor. One volt equals the force required to produce a current flow of one ampere through a resistance of one ohm.

watt (W). A measure of real power. The unit of electrical power required to do work at the rate of one joule per second. It is the power expended when one ampere of direct current flows through a resistance of one ohm. Equal to apparent power VA times the power factor.

watt demand. Power during a predetermined interval. The highest average, that is, Peak demand, is commonly used for billing.

watt hour (Wh). The number of watts used in one hour. Since the power usage varies, it is necessary to integrate this parameter over time. Power flow can be either forward or reverse.

wattmeter. An instrument for measuring the real power in an electric circuit. Its scale is usually graduated in watts, kilowatts, or megawatts.

volt-ampere reactive hours (VARh). The number of VARs used in one hour. Since the value of this parameter varies, it is necessary to integrate it over time. VARs can be forward or reverse.

W

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Publication 1408-IN001E-EN-P - September 2013

Supersedes Publication 1408-IN001D-EN-P - April 2011