## GE Consumer & Industrial
### Multilin

# EPM 9800

## ADVANCED POWER QUALITY METERING SYSTEM

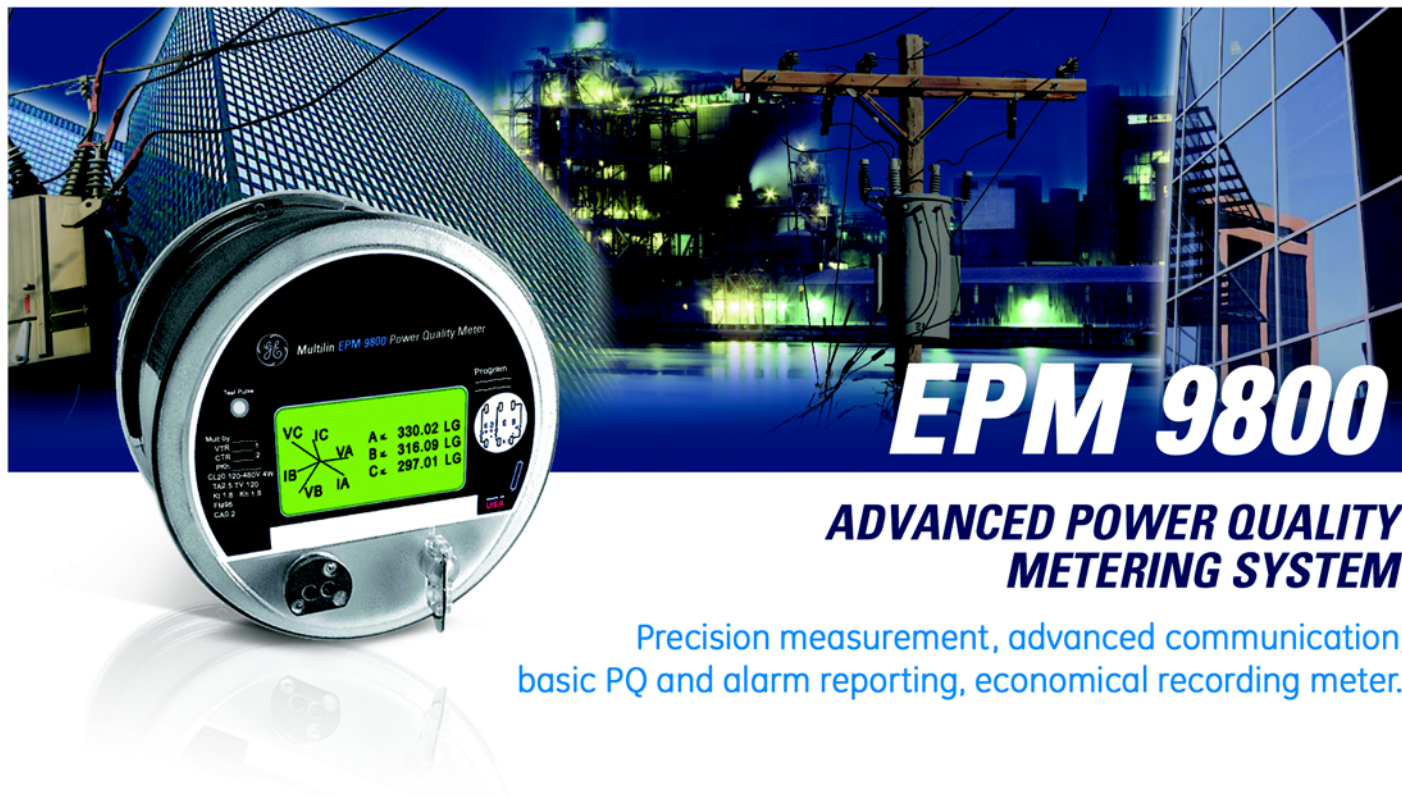Precision measurement, advanced communication, basic PQ and alarm reporting, economical recording meter.

# Instruction Manual

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*These instructions do not purport to cover all details or variations in equipment nor provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, the matter should be referred to the General Electric Company.*

*To the extent required the products described herein meet applicable ANSI, IEEE, and NEMA standards; but no such assurance is given with respect to local codes and ordinances because they vary greatly.*

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# EPM 9800 Advanced Power Quality Metering System

# Chapter 1: Overview

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## 1.1 Introduction

### 1.1.1 Description

The EPM 9800 Advanced Power Quality Metering System is a unique collection of metering technologies to fulfill advanced metering requirements. It provides high-accuracy power and energy measurements of voltage, current, and all power values, as well as data logging and power quality recording. The unit makes the data available through the display, connected systems, and historic logs.



Barcode
Example screen
Infrared test pulse
Form factor diagram
Mode (reed) switch
Test button under cover
Optical port
Reset switch

**Figure 1-1: Front view**

### 1.1.2 Theory of Operation

The advanced metering capability of the EPM 9800 is a result of the meter's high-speed sampling, measurement, and calculation functions. All voltage and current waveforms are sampled and RMS values calculated continuously every cycle. Values of voltage, current and power are produced every three cycles and every second.

The following figure illustrates the key processes operating within the EPM 9800. The meter allows for four types of inputs and can provide outputs to an integrated display, pulse outputs and several communication ports.
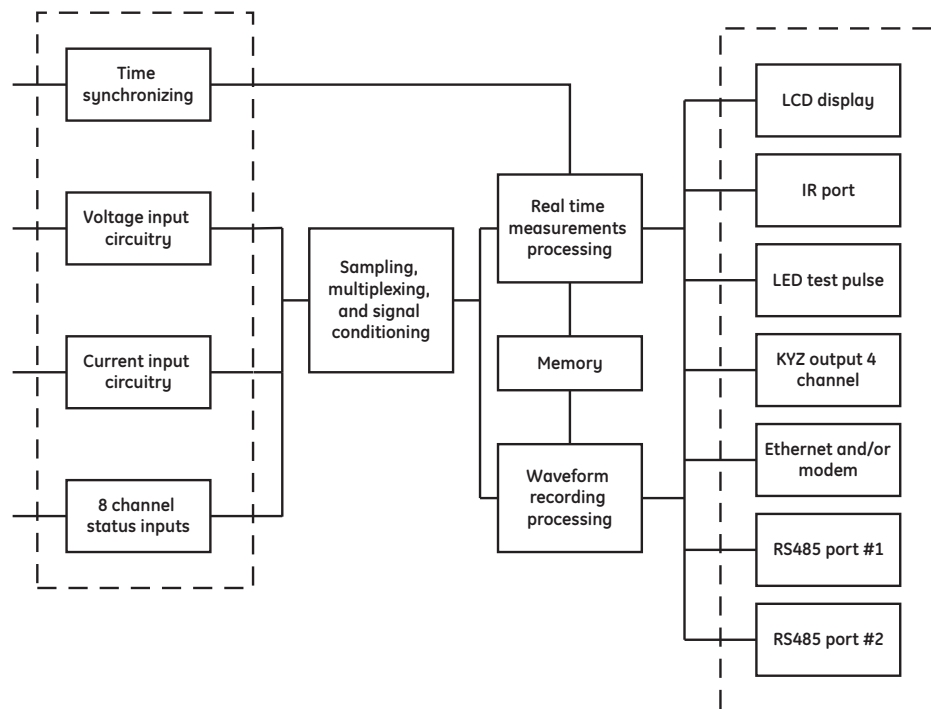


**Figure 1-2: Input processing**

Voltage and current signals are sampled at up to 256 samples per cycle. Each sample is resolved using 16-bit analog-to-digital converters. Two 16-bit analog-to-digital converters are used for the EPM 9800 – the first is for the real-time measurements and the second for the waveform recorder. The use of two analog-to-digital converters ensures that both signals have maximum resolution, accuracy and integrity. The second converter also isolates energy sampling and calculations from the waveform fault recording requirements. This provides both advanced energy and advanced waveform analysis.

The digitized signals are then passed to the appropriate processor. Real time measurements are calculated in one processor and made available for meter readings and logs. A separate processor performs waveform recording. Calculated data and logs are stored in memory for delivery to displays, external systems and download processes.

The meter includes a time synchronizing input port that accepts industry standard IRIG-B signals to synchronize meter time. If there is no IRIG-B signal, the meter uses a time synchronizing input port that uses line frequency to synchronize meter time to standard universal time. The line synchronization feature may be enabled or disabled. If it is disabled, the internal clock provides time synchronization. All readings and logs are time stamped to the nearest millisecond.

Eight status channels provide status inputs or pulse signals. Status inputs are time-stamped to the nearest millisecond and placed in the event log. Pulse inputs are multiplied by a user-supplied value and accumulated in reading registers. These accumulated values

can also be totalized. This feature makes the EPM 9800 ideal for universal metering applications. Any input channel can be selected to accept an end-of-interval pulse from another meter.

Meter parameters and all historical log data are stored in NVRAM. The meter has multiple log functionality and data is available through the front panel display (see *Display Screens* on page 1–6). Several additional communication channels operate simultaneously, including the optional Ethernet/modem combo card. External systems can be connected to either of the RS485 ports or the Ethernet/modem port. Stored data can be downloaded through the RS485 ports, the Ethernet/modem port or the optical port.

## 1.2    Functionality

### 1.2.1    Advanced Revenue Billing Capability

The EPM 9800 is a full four-quadrant power meter with an accuracy within 0.06% of reading. Measurements include delivered and received real energy (kWh), delivered and received reactive energy (kvarh), apparent energy (kVAh), real and reactive energy in each quadrant (kWh and kvarh), and total apparent energy (kVAh). It measures instantaneous power and provides multiple, simultaneous demand measurements, including time-stamped maximum and minimum readings.

The EPM 9800 time of use functionality offers the following standard capabilities:

- eight (8) time-of use (TOU) schedules
- bidirectional consumption and demand
- four (4) seasons per year with a twenty (20) year calendar
- prior month and prior season readings for each schedule
- present month and present season readings for each schedule
- total to date readings for each month and each season
- cumulative and continuous cumulative demand

Using standard pulse inputs, the EPM 9800 can count pulses from external meters and accumulate usage. The pulse inputs can be used to totalize electrical usage and utility values, such as water or gas use data. Readings include:

- eight (8) pulse inputs for load aggregation
- individual accumulating registers
- four (4) totalizing registers
- totalize with real energy (kWh) readings

The EPM 9800 simultaneously monitors four demand structures. The unit offers:

- block window demand
- rolling window demand
- predictive demand
- thermal demand
- interval length from one (1) second to many hours
- up to fifteen (15) sub-intervals
- end of interval pulse output
- end of interval pulse input

The unit gathers time-stamped minimum/maximum demands for all power values. Each of the following values is date/time stamped:

- real power (kW) demand, delivered and received, minimum/maximum
- reactive power (kvar) demand, delivered and received, minimum/maximum
- reactive power (kvar) coincident with real power (kW) demand
- apparent power (kVA) demand, minimum/maximum
- current demand, minimum/maximum

- voltage demand, minimum/maximum

A user-defined transformer loss compensation adjusts for both copper and iron losses.

### 1.2.2    Advanced Communications and Input/Output Capabilities

The EPM 9800 has advanced communication features that use multiple communication ports over open protocols. The multi-port design allows multiple simultaneous connections. The EPM 9800 provides a direct digital link to customers, allowing them to gather selected data without effecting the meter or its data. All of the advanced features of the EPM 9800 are made available through industry-standard Modbus and DNP 3.0 protocols. No proprietary or closed protocols are used.

Standard communications features include:

- ANSI type 2 optical port (infrared port)
- two (2) RS485 serial ports
- Modbus RTU/ASCII and DNP 3.0 Level 2+ protocol compatibility
- speeds up to 115 kbps

The EPM 9800 allows an additional port for one of the following uses:

- internal 56k modem with noise rejection
- internal Ethernet TCP/IP (10/100Base-T)
- combination 56 kbps modem and internal Ethernet TCP/IP (10/100Base-T)

Extensive input/output capability is available in conjunction with all metering functions.

- IRIG-B time synchronizing to GPS with 1 millisecond resolution
- eight (8) high-speed pulse/status inputs for status detect or of load aggregation/ universal metering inputs
- line frequency time synchronization

The meter comes equipped with four standard internal KYZ pulse outputs for generating energy and power signals that can be sent to external devices, such as PLCs. These can be set to pulse for any accumulated reading. One output can also be set for an end-of-interval "sync" pulse.

The user can also select from the following external input/output modules:

- analog outputs
- KYZ outputs
- relay/alarm outputs

The following control options are available:

- user-definable control outputs
- action and/or alarm on abnormal condition
- action on Boolean logic combinations of inputs or electrical conditions

### 1.2.3    Display Screens

The EPM 9800 features a back-lit LCD display with extended temperature voltage compensation. This allows viewing of energy data and the gathering of circuit diagnostic data such as voltage, current, harmonics and phasor information. This display is easily programmable. Refer to *Programmable Display* on page 4–8 for additional details.

### 1.2.4    Additional Switches

The EPM 9800 has additional switches and signals that help in using the unit (see Figure 1-2: *Input processing* on page 1–2).

- The infrared test pulse can be set to pulse for positive real energy (+Wh), negative real energy (–Wh), positive reactive energy (+varh), negative reactive energy (–varh), and apparent energy (VAh). The pulse uses a time-modulated pulse integration which allows the pulse to be accurate during short duration pulse tests. The pulse integration uses industry-accepted reference standards.
- The mode switch (magnetic reed switch) uses a magnet to switch operating modes.
- The test button.
- The reset button.

### 1.2.5    External Output Modules

A variety of optional analog or digital output modules mount externally to the EPM 9800 socket meter. The EPM 9800 does not support internal output modules. Use an auxiliary power supply, such as the PSIO, to provide output capability. See *Output Module Wiring* on page 3–37 for details on installation and usage of the external output modules.

## 1.3    EN 50160 Flicker

### 1.3.1    Description

The EPM 9800 provides EN 50160 flicker evaluation in instantaneous, short-term and long-term forms. Flicker is the sensation that is experienced by the human visual system when it is subjected to changes occurring in the illumination intensity of light sources. The primary effects of flicker are headaches, irritability and sometimes epilepsy.

IEC 61000-4-15 and former IEC 868 describe methods used to determine flicker severity. This phenomenon is strictly related to the sensitivity and the reaction of individuals. It can only be studied on a statistical basis by setting up suitable experiments among people.

### 1.3.2    Theory of Operation

Flicker can be caused by voltage variations which are caused by variable loads, such as arc furnaces, laser printers and microwave ovens. To model the eye brain change (a complex physiological process), the signal from the power network has to be processed while conforming with figure below.
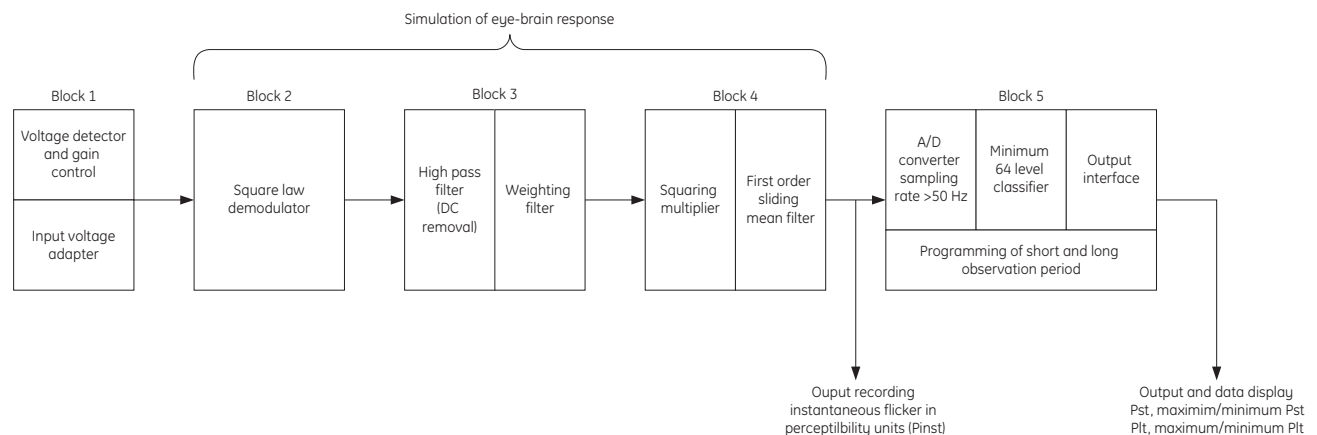
Figure 1-3: Simulation of eye-brain response

Block 1 consists of scaling circuitry and an automatic gain control function that normalizes input voltages to blocks 2, 3 and 4. For the specified 50 Hz operation, the voltage standard is 230 V RMS. Block 2 recovers the voltage fluctuation by squaring the input voltage scaled to the reference level. This simulates the behavior of a lamp.

Block 3 is composed of a cascade of two filters and a measuring range selector. In this implementation, a log classifier covers the full scale in use so the gain selection is automatic and not shown here. The first filter eliminates the DC component and the double mains frequency components of the demodulated output.

The configuration consists of a 0.05 Hz Low High Pass filter and a six-pole Butterworth low pass filter located at 35 Hz. The second filter is a weighting filter that simulates the response of the human visual system to sinusoidal voltage fluctuations of a coiled filament, gas-filled lamp (60 W at 230 V). The filter implementation of this function is as specified in IEC 61000-4-15.

Block 4 is composed of a squaring multiplier and a low pass filter. The human flicker sensation via lamp, eye and brain is simulated by the combined non-linear response of Blocks 2, 3, and 4.

Block 5 performs an online statistical cumulative probability analysis of the flicker level. Block 5 allows direct calculation of the evaluation parameters $P_{st}$ and $P_{lt}$.

Flicker is computed using the three phase-to-neutral voltages in wye configurations and the three phase-to-phase voltages when in delta. Evaluation occurs in the following forms: instantaneous, short term, or long term. Each form is detailed below.

### 1.3.3  Instantaneous Flicker Evaluation

An output of 1.00 from Block 4 corresponds to the reference human flicker perceptibility threshold for 50% of the population. This value is measured in perceptibility units (PU) and is labeled $P_{inst}$. This ia a real time value and it is continuously updated.

### 1.3.4  Short-term Flicker Evaluation

An output of 1.00 from Block 5 (corresponding to the $P_{st}$ value) corresponds to the conventional threshold of irritability per IEC 1000-3-3. To evaluate flicker severity, two parameters have been defined: one for the short term called $P_{st}$ (defined in this section) and one for the long term called $P_{lt}$ (defined in the next section).

The standard measurement time for $P_{st}$ is 10 minutes. $P_{st}$ is derived from the time at level statistics obtained from the level classifier in Block 5 of the flicker meter. The following formula is used:

$$P_{st} = \sqrt{0.0314P_{0.1} + 0.0525P_{1s} + 0.0657P_{3s} + 0.28P_{10s} + 0.08P_{50s}} \qquad \textbf{(EQ 1.1)}$$

where the percentiles $P_{0.1}, P_1, P_3, P_{10}$, and $P_{50}$ are the flicker levels exceeded for 0.1, 1, 2, 20 and 50% of the time during the observation period, respectively. The suffix "S" in the formula indicates that the smoothed value should be used. The smoothed values are obtained using the following formulas:

$$P_{1s} = \frac{P_{0.7} + P_1 + P_{1.5}}{3} \qquad \textbf{(EQ 1.2)}$$

$$P_{3s} = \frac{P_{2.2} + P_3 + P_4}{3} \qquad \textbf{(EQ 1.3)}$$

$$P_{10s} = \frac{P_6 + P_8 + P_{10} + P_{13} + P_{17}}{5} \qquad \textbf{(EQ 1.4)}$$

$$P_{50s} = \frac{P_{30} + P_{50} + P_{80}}{3} \qquad \textbf{(EQ 1.5)}$$

The 0.3 second memory time constant in the flicker meter ensures that $P_{0.1}$ cannot change abruptly and no smoothing is needed for this percentile.

### 1.3.5 Long-term Flicker Evaluation

The 10 minute period on which the short-term flicker severity is based is suitable for short duty cycle disturbances. For flicker sources with long and variable duty cycles (for example, arc furnaces) it is necessary to provide criteria for long-term assessment. For this purpose, the long-term $P_{lt}$ is derived from the short-term values over an appropriate period. By definition, this is 12 short-term values of 10 minutes each over a period of 2 hours. The following formula is used:

$$P_{lt} = \sqrt[3]{\frac{\sum_{i=1}^{n} P_{sti}^3}{N}}$$

(EQ 1.6)

where $P_{sti}$ ($i$ = 1, 2, 3,...) are consecutive readings of the short-term severity $P_{st}$.

### 1.3.6 Summary

In summary, we have:

- Flicker is the changes in the illumination of light sources due to cyclical voltage variations.
- $P_{inst}$ represents the instantaneous flicker values in perceptibility units (PU).
- $P_{st}$ represents the value based on 10 minute analysis.
- $P_{lt}$ represents the value based on 12 $P_{st}$ values.

The measurement procedure is as follows:

1. Original signal with amplitude variations.
2. Square demodulator.
3. Weighted filter.
4. Low pass filter (first order).
5. Statistical computing.

The following data is available:

- $P_{st}$ and the maximum and minimum $P_{st}$ values for long term recording
- $P_{lt}$ and the maximum and minimum $P_{lt}$ values for long term recording

# 1.4    Ordering

## 1.4.1    Order Codes

The order codes for the EPM 9800 meter are shown below:

**Table 1–1: EPM 9800 order codes**

| PL9800 – * – * – * – * – * – * | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Base unit** | PL9800 | | | | | | EPM 9800 Advanced Power Quality Metering System |
| **System frequency** | 5 | | | | | | 50 Hz AC frequency system |
| | 6 | | | | | | 60 Hz AC frequency system |
| **Power supply** | | S | | | | | Blade powered, 102 to 550 V AC auto-ranging |
| | | E | | | | | External, 102 to 275 V AC/DC auto-ranging |
| | | D | | | | | External, 18 to 60 V DC auto-ranging |
| | | L | | | | | Blade powered, 69 V AC |
| **Form** | | | 9S | | | | 0 to 277 V L-N; 3E, 4W wye |
| | | | 36S | | | | 0 to 277 V L-N; 2.5E, 4W wye |
| | | | 45S | | | | 0 to 480 V L-L; 2E, 3W delta |
| | | | 9A | | | | 0 to 277 V L-N; A-base form |
| | | | SB | | | | switchboard (power supplies E and D only) |
| **Logging options** | | | | S | | | standard (see specifications) |
| | | | | A | | | advanced (see specifications) |
| **Communications** | | | | | R | | 2 RS485 ports |
| | | | | | W | | 2 RS485 ports and 10/100Base-T Ethernet |
| | | | | | M | | 2 RS485 ports and 56 kbps dial-out modem |
| | | | | | C | | 2 RS485 ports, 56 kbps modem, Ethernet |
| **Class amps** | | | | | | 2 | 2 amps |
| | | | | | | 20 | 20 amps |

### 1.4.2 External Modules

The following external modules are available:

> **NOTE**  External modules and accessories must be ordered separately from base meters.

**Analog output modules:**

| PL9000 | * | * | * | * | * | * | * | 0 | 0 | |
|--------|---|---|---|---|---|---|---|---|---|---|
| | 1 | M | A | O | N | 4 | 0 | 0 | 0 | Four channel 0 to 1 mA analog outputs |
| | 1 | M | A | O | N | 8 | 0 | 0 | 0 | Eight channel 0 to 1 mA analog outputs |
| | 2 | O | M | A | O | N | 4 | 0 | 0 | Four channel 4 to 20 mA analog outputs |
| | 2 | O | M | A | O | N | 8 | 0 | 0 | Eight channel 4 to 20 mA analog outputs |

**Output modules:**

| PL9000 | * | * | * | 1 | 0 | 0 | 0 | 0 | 0 | |
|--------|---|---|---|---|---|---|---|---|---|---|
| | 4 | R | 0 | 1 | 0 | 0 | 0 | 0 | 0 | Four channel control relay outputs |
| | 4 | P | 0 | 1 | 0 | 0 | 0 | 0 | 0 | Four channel KYZ solid-state pulse outputs |

**Auxiliary output power supply and mounting:**

| PL9000 | * | * | I | O | 0 | 0 | 0 | 0 | 0 | |
|--------|---|---|---|---|---|---|---|---|---|---|
| | M | B | I | O | 0 | 0 | 0 | 0 | 0 | Mounting bracket (one per module group) |
| | P | S | I | O | 0 | 0 | 0 | 0 | 0 | Auxiliary power supply (>4 modules) |

**Meter display module and software:**

| PL9000 | * | * | * | * | 0 | 0 | 0 | 0 | 0 | |
|--------|---|---|---|---|---|---|---|---|---|---|
| | P | 4 | 0 | N | 0 | 0 | 0 | 0 | 0 | Three-line LED display |
| | P | 6 | 0 | N | 0 | 0 | 0 | 0 | 0 | Touch-screen LCD display |
| | N | C | M | 1 | 0 | 0 | 0 | 0 | 0 | GE Communicator EXT software, single user |
| | N | C | M | 5 | 0 | 0 | 0 | 0 | 0 | GE Communicator EXT software, five users |
| | N | C | M | S | 0 | 0 | 0 | 0 | 0 | GE Communicator EXT software, single site |

# 1.5     Specifications

## 1.5.1    Power Supply

**STANDARD POWER SUPPLY (OPTION S)**

Rating:..................................................................120 to 550 V AC auto-ranging, three-phase
Total burden:.....................................................12 VA worst-case
Source:...............................................................meter power provided by any of the monitored phase
                                                                    voltage sources
Power:................................................................blade powered

**EXTERNAL POWER SUPPLY (OPTION E)**

Rating:..................................................................102 to 275 V AC
Power consumption:......................................16 VA at 276 V AC maximum
Source:...............................................................separate power cord

**LOW VOLTAGE POWER SUPPLY (OPTION L)**

Rating:..................................................................69 V AC ±20%
Application: .......................................................low voltage supply for 69 V L-N applications

**EXTERNAL LOW VOLTAGE POWER SUPPLY (OPTION D)**

Rating:..................................................................18 to 60 V DC
Application: .......................................................low voltage supply for DC powered applications
                                                                    (switchboard meter is always separately powered)

## 1.5.2    Inputs

**INPUT CURRENT**

Current inputs:..................................................3 or 4, depending on form (IA, IB, IC, and IN)
CT rating: ...........................................................0 to 20 A, class 20
                                                                    0 to 2 A, class 2
Continuous current:.......................................120% of meter class
Overload:...........................................................500% for 1 second, non-recurring

**INPUT VOLTAGE**

Line-to-neutral: ...............................................0 to 360 V
Line-to-line:......................................................0 to 660 V

**BURDEN (SENSE INPUTS)**

Voltage inputs:..................................................0.33 VA at 576 V
Current inputs:..................................................0.012 VA at 25 A

**ISOLATION**

Inputs/outputs:................................................isolated to 2500 V
Communications ports:...............................isolated to 1000 V

**DIGITAL INPUTS**

Inputs:................................................................8
Type: ..................................................................self-excited, for dry contacts only
Internal wetting voltage:.............................12 V DC (typical)

**CLOCK**

Internal:.............................................................internal clock crystal, accuracy better than 1 minute per
                                                                    month

Line synchronization: .................................. accuracy better than 1 second per month
IRIG-B input: ..................................................... accuracy better than 1 ms per month

### 1.5.3 Outputs

**SOLID-STATE OUTPUTS (KYZ)**
Type: .................................................................. form-A or form-C
On resistance: ................................................ 25 to 35 $\Omega$
Peak voltage: ................................................... 350 V DC
Continuous load current: ........................... 120 mA
Peak load current: ......................................... 350 mA for 10 ms
Off-state leakage current: .......................... 1 µA at 350 V DC
Opto-isolation: ............................................... 3750 V RMS (60 Hz at 1 minute)

**DIGITAL DRY RELAY CONTACT OUTPUTS**
Rating: ............................................................... 5 A at 125 V AC/DC
Form: .................................................................. form-C

**DIGITAL SOLID-STATE PULSE OUTPUTS**
Form: .................................................................. form-A or form-C KYZ pulses
Maximum pulse speed: ............................... 20 pulses per second

**ANALOG TRANSDUCER SIGNAL OUTPUTS**
Modules: ........................................................... 4 channel 0 to 1 mA bi-directional analog outputs;
                                                                          8 channel 0 to 1 mA bi-directional analog outputs;
                                                                          4 channel 0 to 1 mA analog outputs;
                                                                          8 channel 0 to 1 mA analog outputs
Wiring: ............................................................... common mode
Accuracy: ......................................................... 0.1% of full-scale
Calibration: ...................................................... self-calibrating
Scaling: .............................................................. programmable

### 1.5.4 Data Logger

**STANDARD MEMORY**
Historical log 1: .............................................. 85 days (assumes 4 scaled energy readings every 15 minutes)
Historical log 2: .............................................. 133 days (assumes 4 scaled energy readings every 15 minutes)
CBEMA/ITIC: ..................................................... 512 event (assumes 14 parameters monitored)
Out-of-limit log: ............................................. 1024 events (assumes 14 parameters monitored)
Waveform log: ................................................. 63 records (each record may be 8 to 64 cycles in duration)
Flicker log: ........................................................ 1536 records
Output log: ....................................................... 256 records
Input log: .......................................................... 1024 records
System events: ................................................ 1024 events (assumes 14 parameters monitored)

**ADVANCED MEMORY**
Historical log 1: .............................................. 555 days (assumes 4 scaled energy readings every 15 minutes)
Historical log 2: .............................................. 133 days (assumes 4 scaled energy readings every 15 minutes)
SBEMA/ITIC: ..................................................... 512 event (assumes 14 parameters monitored)

Out-of-limit log: ..............................................1024 events (assumes 14 parameters monitored)

Waveform log: ................................................95 records (each record may be 8 to 64 cycles in
duration)

Flicker log:.........................................................5120 records

Output log:........................................................256 records

Input log:............................................................1024 records

System events: ...............................................1024 events (assumes 14 parameters monitored)

## 1.5.5    Communications

**STANDARD**

Display:..............................................................LCD

Ports: ...................................................................IR port, two RS485 serial ports

Protocols:...........................................................Modbus RTU, Modbus ASCII, DNP 3.0

Data rate:...........................................................up to 115 kbps

Inputs channels:...............................................8 high-speed

**OPTIONAL**

Modem: ..............................................................56K modem with dial-out capabilities

Ethernet:.............................................................internal 10/100Base-T;
internal 10/100Base-T with 56K modem combination

Protocols:...........................................................Modbus TCP, DNP LAN/WAN

## 1.5.6    Physical

**ENVIRONMENTAL**

Operating temperature:..............................–40 to 85°C

Display temperature:....................................–20 to 60°C

Seal: ....................................................................rain-tight Lexan cover (socket)

**SHIPPING**

Weight:...............................................................8 lbs (socket); 14 lbs (switchboard)

Dimensions:.......................................................10" × 11" × 13" (socket); 16" × 14" × 11" (switchboard)

## 1.5.7    Compliance

**COMPLIANCE STANDARDS**

ANSI: ...................................................................ANSI C12.20 certified

IEC:.......................................................................IEC 60687 certified

**APPROVALS**

IEC:.......................................................................IEC 60687 KEMA certified
IEC 1000-4-2 Electrostatic discharge
IEC 1000-4-3 Radiated immunity
IEC 1000-4-4 Fast transient
IEC 1000-4-5 Surge immunity
IEC 1000-4-6 Conducted immunity
IEC 60068-2-6 Vibration (sinusoidal)
IEC 60068-2-27 Shock test
IEC 695-2-1 Resistance to heat and fire

IEC 529 Dust and water
IEC 68-2-1 Cold temperature test
IEC 68-2-2 Dry heat
IEC 68-20-30 Damp heat
ANSI/IEEE:..........................................................C37.90.1 Surge withstand
C62.41 Surge immunity

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# EPM 9800 Advanced Power Quality Metering System

# Chapter 2: Electrical Background

## 2.1 Overview

### 2.1.1 Description

The EPM 9800 Advanced Power Quality Metering System can be installed in three ways:

- As a type S meter.
- As a type A meter (on an A-base)
- As a type Z meter (in a switchboard case)

The following section provides the field technician the basic steps for installation of the type S meter. These steps are described in greater in later chapters of this manual.

## 2.2    Start-up and Bench Check

### 2.2.1    Meters with Auxiliary Power

If the meter has an auxiliary power cable, apply appropriate power to the two leads of the power cable. Meter information scrolls on the display.
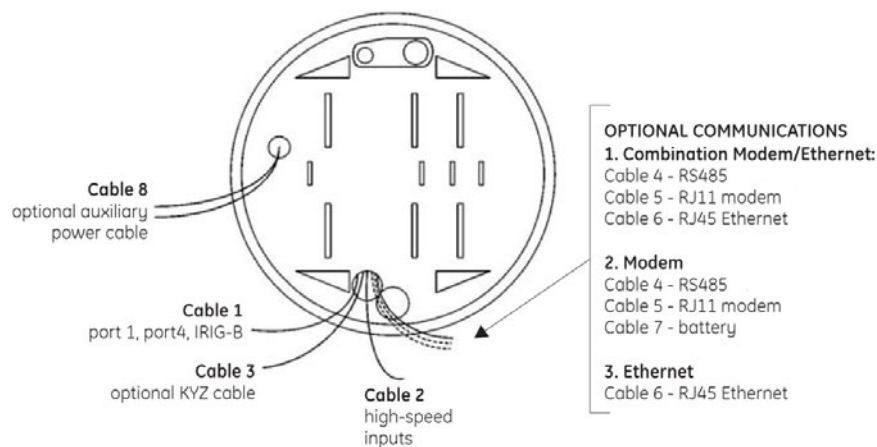


**FIGURE 2–1: EPM 9800 rear view**

### 2.2.2    Meters without Auxiliary Power

To energize meters without auxiliary power, apply appropriate power to the voltage terminals of the meter. Terminals vary by meter form. The EPM 9800 meter form (FM 9S, 36S, or 45S) is shown in the white block under the display.

Use the following figures to determine the terminals.
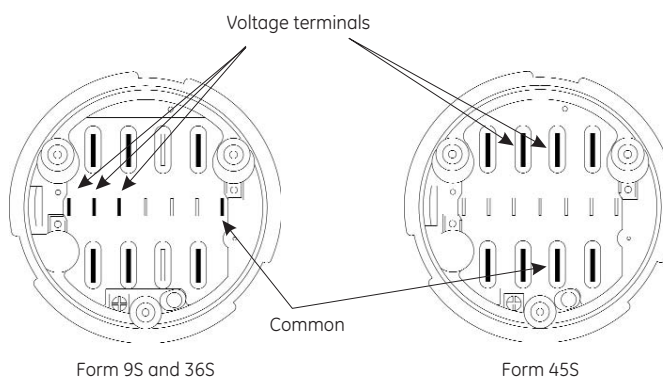


**FIGURE 2–2: EPM 9800 auxiliary terminals**

For form 9S and 36S meters, connect appropriate power to the **one of the three left-most and to the right most voltage terminals** (center row of smaller terminals). These are the small, bold terminals in the above figure (the large terminals are current terminals for these forms).

Form 45S uses only the large terminals as indicated above

When the meter is energized, the display lights up and scrolls meter information. This completes a 95% test of meter functionality.

## 2.3    Serial Communications

### 2.3.1    Optical Port

Connect with Modbus RTU at 9600 baud (initial setting). The A7Z communications interface cable requires no power supply – all power is received from the host PC serial port via circuits in the probe. Connect the A7Z interface cable at one end to the EPM 9800 optical port. At the other end, connect to the 9-pin RS232 serial port on the PC.

### 2.3.2    Serial Port

Connect with Modbus RTU at 57600 bps. Connect port 1 (or 4) of the EPM 9800 to the PC RS232 serial port via the GE Multilin F485 converter.
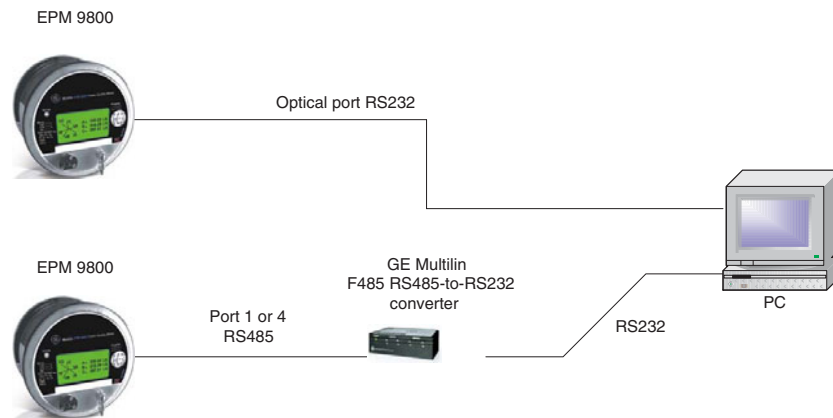


**FIGURE 2–3: Serial communications**

## 2.4 EPM 9800 Calculations

### 2.4.1 Description

The EPM 9800 Advanced Power Quality Metering System measures many different power parameters. This section illustrates the formulas used to perform calculations with samples for Wye and Delta services.

- samples for wye: Van, Vbn, Vcn, Ia, Ib, Ic, In
- samples for Delta: Vab, Vbc, Vca, Ia, Ib, Ic

### 2.4.2 Voltage

The root mean square (RMS) of phase to neutral voltages for wye connections is shown below, where *n* is the number of samples and *x* represents an, bn, and cn.

$$V_x = \sqrt{\frac{\sum_{t=1}^{n} v_{x(t)}^2}{n}} \qquad \textbf{(EQ 2.1)}$$

The root mean square (RMS) of phase to phase voltages for wye connections is shown below, where *n* is the number of samples and *x,y* represents an, bn; bn, cn; or cn, an.

$$V_{xy} = \sqrt{\frac{\sum_{t=1}^{n} (v_{x(t)} - v_{y(t)})^2}{n}} \qquad \textbf{(EQ 2.2)}$$

The root mean square (RMS) of phase to phase voltages for delta connections is shown below, where *n* is the number of samples and *xy* represents ab, bc, or ca.

$$V_{xy} = \sqrt{\frac{\sum_{t=1}^{n} v_{xy(t)}^2}{n}} \qquad \textbf{(EQ 2.3)}$$

### 2.4.3 Current

The root mean square (RMS) of currents is shown below, where *n* is the number of samples and *x* represents a, b, c, and n for wye connections, and a, b, and c for delta connections.

$$I_x = \sqrt{\frac{\sum_{t=1}^{n} i_{x(t)}^2}{n}} \qquad \textbf{(EQ 2.4)}$$

### 2.4.4    Real Power

The per-phase real power (in watts) for wye connections is shown below, where $n$ is the number of samples and $x$ represents a, b, and c.

$$P_x = \frac{\sum\limits_{t=1}^{n} (v_{xn(t)} \times i_{x(t)})}{n} \qquad \text{(EQ 2.5)}$$

The total real power (in watts) for wye connections is shown below.

$$P_T = P_A + P_B + P_c \qquad \text{(EQ 2.6)}$$

The total real power (in watts) for delta connections is shown below, where $n$ is the number of samples.

$$P_T = \frac{\sum\limits_{t=1}^{n} v_{ab(t)} \times i_{a(t)} - v_{bc(t)} \times i_{c(t)}}{n} \qquad \text{(EQ 2.7)}$$

### 2.4.5    Reactive Power

The per-phase reactive power (in vars) for wye connections is shown below, where $x$ represents a, b, and c.

$$Q_x = \sqrt{S_x^2 - P_x^2} \qquad \text{(EQ 2.8)}$$

The total reactive power (in vars) for wye connections is shown below.

$$Q_T = Q_A + Q_B + Q_C \qquad \text{(EQ 2.9)}$$

The total reactive power (in vars) for delta connections is shown below, where $n$ is the number of samples, and $V_{AB}$, $V_{BC}$, $I_A$, and $I_C$ are RMS values.

$$Q_T = \sqrt{(V_{AB} \times I_A)^2 - \left(\frac{\sum\limits_{t=1}^{n} v_{ab(t)} \times i_{a(t)}}{n}\right)^2} + \sqrt{(V_{BC} \times I_C)^2 - \left(\frac{\sum\limits_{t=1}^{n} v_{bc(t)} \times i_{c(t)}}{n}\right)^2} \qquad \text{(EQ 2.10)}$$

### 2.4.6    Apparent Power

The per-phase apparent power (in VA) for wye connections is shown below, where $x$ represents a, b, and c.

$$S_x = V_{xn(rms)} \times I_{x(rms)} \qquad \text{(EQ 2.11)}$$

The total apparent power (in VA) for wye connections is shown below.

$$S_T = S_A + S_B + S_C \qquad \text{(EQ 2.12)}$$

The total apparent power (in VA) for delta connections is shown below.

$$S_T = \sqrt{P_T^2 - Q_T^2}$$ **(EQ 2.13)**

### 2.4.7 Q per Phase and Total

The per-phase Q for wye connections is shown below, where *x* represents a, b, and c.

$$Q_x = \frac{\sqrt{3}Q_x + P_x}{2}$$ **(EQ 2.14)**

The total Q for wye connections is shown below.

$$Q_T = Q_A + Q_B + Q_C$$ **(EQ 2.15)**

The total Q for delta connections is shown below.

$$Q_T = \frac{\sqrt{3}Q_T + P_T}{2}$$ **(EQ 2.16)**

### 2.4.8 Energy

The total energy is shown below, where *X* represents real energy (in Wh), reactive energy (in varh), and apparent energy (in VAh), and Q-energy (in Qh).

$$X_T = \frac{\sum X}{3600}$$ **(EQ 2.17)**

### 2.4.9 Power Factor

The power factor is shown below, where *x* represents A, B, and C, and T for wye connections, and T for delta connections.

$$PF(x) = \frac{P_x}{S_x}$$ **(EQ 2.18)**

The total average power factor is shown below, where *x* represents quadrants 1 and 4 (for positive Wh) or quadrants 2 and 3 (for negative Wh).

$$PF_{avg}(x) = \frac{E_{real}(x)}{E_{apparent}(x)}$$ **(EQ 2.19)**

### 2.4.10 Phase Angles

Phase angles are calculated as follows, where *X* = A, B, or C.

$$\angle X = \cos^{-1}(PF(x))$$ **(EQ 2.20)**

### 2.4.11  Total Harmonic Distortion

The total harmonic distortion (THD, in %) is shown below, where $x$ represents $V_{an}$, $V_{bn}$, $V_{cn}$, $I_a$, $I_b$, and $I_c$ for wye connections, and $V_{ab}$, $V_{bc}$, $V_{ca}$, $I_a$, $I_b$, and $I_c$ for delta connections.

$$\text{THD}(x) = \frac{\sqrt{\sum_{h=2}^{127} X_{h(\text{rms})}^2}}{X_{1(\text{rms})}}$$

**(EQ 2.21)**

### 2.4.12  K-factor

The K-factor is shown below, where $x$ represents $I_a$, $I_b$, and $I_c$.

$$K(x) = \frac{\sum_{h=1}^{127} (h \times X_{h(\text{rms})})^2}{\sum_{h=1}^{127} (X_{h(\text{rms})})^2}$$

**(EQ 2.22)**

### 2.4.13  Imbalance

The voltage imbalance is shown below.

$$\text{IMB}(V) = \frac{\sqrt{\dfrac{\sum_n (v_{an} + v_{bn} + v_{cn})^2}{n}}}{V_{an(\text{rms})} + V_{bn(\text{rms})} + V_{cn(\text{rms})}}$$

**(EQ 2.23)**

The current imbalance is shown below.

$$\text{IMB}(I) = \frac{I_{Ncalc(\text{rms})}}{I_{a(\text{rms})} + I_{b(\text{rms})} + I_{c(\text{rms})}}$$

**(EQ 2.24)**

## 2.5    Demand Integrators

### 2.5.1    Description

Power utilities take into account both energy consumption and peak demand when billing customers. Peak demand, expressed in kilowatts (kW), is the highest level of demand recorded during a set period of time, called the interval. The EPM 9800 supports the following conventions for averaging demand and peak demand: thermal demand, block window demand, rolling window demand, and predictive window demand. All conventions are programmable and can be accessed via the GE Communicator EXT software.

### 2.5.2    Thermal Demand

Traditional analog watt-hour (Wh) meters use heat-sensitive elements to measure temperature rises produced by an increase in current flowing through the meter. A pointer moves in proportion to the temperature change, providing a record of demand. The pointer remains at peak level until a subsequent increase in demand moves it again, or until it is manually reset. The EPM 9800 mimics traditional meters to provide thermal demand readings.

Each second, as a new power level is computed, a recurrence relation formula is applied. This algorithm recomputes the thermal demand by averaging a small portion of the new power value with a large portion of the previous thermal demand value. The proportioning of new to previous is programmable, set by an averaging interval. The averaging interval represents a 90% change in thermal demand to a step change in power.

### 2.5.3    Block (fixed) Window Demand

Fixed window demand produces an average (arithmetic mean) of power readings over a programmed interval.

For example, a typical setting of 15 minutes produces an average value every 15 minutes (at 12:00, 12:15, 12:30, etc.) for power readings over the previous fifteen minute interval (11:45 to 12:00, 12:00 to 12:15, 12:15 to 12:30, etc.).

### 2.5.4    Rolling (sliding) Window Demand

Rolling window demand functions like multiple, overlapping block window demands. The programmable settings provided are the number and length of demand subintervals. For every subinterval, an average (arithmetic mean) of power readings over the subinterval is internally calculated. This new subinterval average is then averaged (arithmetic mean) with as many previous subinterval averages as programmed to produce the rolling window demand.

For example, with settings of three five-minute subintervals, subinterval averages are computed every five minutes (12:00, 12:05, 12:10, 12:15. etc.) for power readings over the previous five-minute interval (11:55 to 12:00, 12:00 to 12:05, 12:05 to 12:10, 12:10 to 12:15,

etc.). Further, every five minutes, the subinterval averages are averaged in groups of three (12:00, 12:05, 12:10; 12:05, 12:10, 12:15. etc.) to produce a fifteen (5 × 3) minute average every five minutes (rolling (sliding) every five minutes; 11:55 to 12:10, 12:00 to 12:15, etc.).

### 2.5.5   Predictive Window Demand

Predictive window demand expands on the above rolling window demand. Rolling window demand waits until the end of a subinterval to update the demand. Predictive window demand uses the average of the previously completed subinterval, weighted by a programmable factor, to predict the average of the upcoming subinterval During the next subinterval, as actual power readings occur, the value for the subinterval consists of the portion actually measured plus the prediction, pro-rated to the subinterval time remaining.

### Example

Using the previous settings of three 5 minute intervals, and a new setting of 120% prediction factor, the working of the predictive window demand could be described as follows.

At 12:10, we have the average of the subintervals from 11:55 to 12:00, 12:00 to 12:05 and 12:05 to 12:10. In five minutes, we will have an average of the subintervals 12:00 to 12:05 and 12:05 to 12:10 (which we know) and 12:10 to 12:15, which we do not yet know. As a guess, we will use the last subinterval (12:05 to 12:10), as an approximation for the next subinterval (12:10 to 12:15). As a further refinement, we will assume that the next subinterval might have a higher average (120%) than the last subinterval. As we progress into the subinterval, (for example, up to 12:11), the predictive window demand will be the average of the first two subintervals (12:00 to 12:05, 12:05 to 12:10), the actual values of the current subinterval (12:10 to 12:11) and the prediction for the remainder of the subinterval, 4/5 of 120% of the 12:05 to 12:10 subinterval.

Consider the following definitions:

$n$ = number of subintervals
$l$ = subinterval length
$c$ = partial subinterval length
$p$ = prediction factor

Graphically, these can be represented as follows:

| Sub(n) | Sub(n–1) | ... | Sub(1) | Sub(0) | Partial | Predict |
|--------|----------|-----|--------|--------|---------|---------|
| $l$ | $l$ | | $l$ | $l$ | $c$ | $l$ |

We have:

$$\text{Sub}(i) = \frac{\sum_{i=0}^{l-1} \text{val}(i)}{l} \qquad \textbf{(EQ 2.25)}$$

$$\text{Partial} = \frac{\sum_{i=0}^{c-1} \text{val}(i)}{c} \qquad \textbf{(EQ 2.26)}$$

The predictive window demand is:

$$D = \left( \text{Partial} + \frac{\displaystyle\sum_{i=0}^{n-2} \text{val}(i)}{n} \right) + \left( 1 - \frac{l-c}{l} \times p \right)$$

$$+ \left( \frac{\displaystyle\sum_{i=0}^{n-2} \text{Sub}(i)}{n-1} + \frac{\text{Sub}(0) - \text{Sub}(n-1)}{2(n-1)} \right) \times \left( \frac{l-c}{l} \times p \right)$$

**(EQ 2.27)**

## 2.6    Three-phase System Configurations

### 2.6.1    Description

Three-phase power is most commonly used in situations where large amounts of power will be used because it is a more effective way to transmit the power and because it provides a smoother delivery of power to the end load. There are two commonly used connections for three-phase power, a wye connection or a delta connection. Each connection has several different manifestations in actual use. When attempting to determine the type of connection in use, it is a good practice to follow the circuit back to the transformer serving the circuit. It is often not possible to conclusively determine the correct circuit connection simply by counting the wires in the service or checking voltages. Checking the transformer connection will provide conclusive evidence of the circuit connection and the relationships between the phase voltages and ground.

### 2.6.2    Wye Connection

The wye connection is so called because the phase relationships and the winding relationships between phases resemble the letter "Y". The following figure depicts the winding relationships for a wye-connected service. In a wye service the neutral (or center point of the wye) is typically grounded. This leads to common voltages of 208/120 and 480/277 (where the first number represents the phase-to-phase voltage and the second number represents the phase-to-ground voltage).
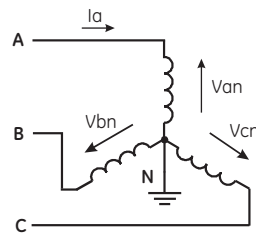


**FIGURE 2–4: Three-phase wye winding**

The three voltages are electrically separated by 120°. Under balanced load conditions with unity power factor, the currents are also separated by 120°. However, unbalanced loads and other conditions can cause the currents to depart from the ideal 120° separation.

Three-phase voltages and currents are usually represented with a phasor diagram. A phasor diagram for the typical connected voltages and currents is shown below.
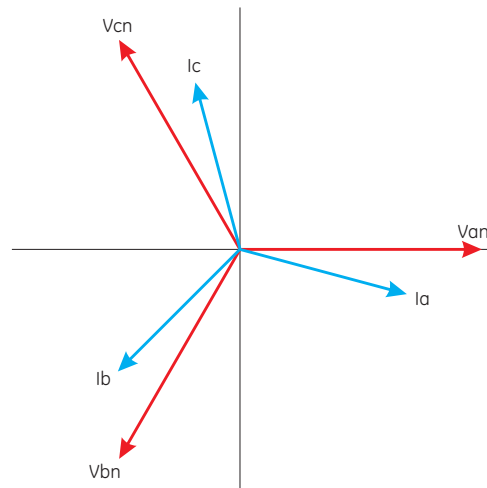
**FIGURE 2–5: Three-phase voltage and current phasors for wye winding**

The phasor diagram shows the 120° angular separation between the phase voltages. The phase-to-phase voltage in a balanced three-phase wye system is 1.732 times the phase-to-neutral voltage. The center point of the wye is tied together and is typically grounded. The following table indicates the common voltages used in the United States for wye-connected systems.

**Table 2–1: Common phase voltages on wye services**

| Phase-to-ground voltage | Phase-to-phase voltage |
|---|---|
| 120 volts | 208 volts |
| 277 volts | 480 volts |
| 2400 volts | 4160 volts |
| 7200 volts | 12470 volts |
| 7620 volts | 13200 volts |

Usually, a wye-connected service will have four wires: three wires for the phases and one for the neutral. The three-phase wires connect to the three phases. The neutral wire is typically tied to the ground or center point of the wye (refer to the *Three-phase wye winding* diagram above).

In many industrial applications the facility will be fed with a four-wire wye service but only three wires will be run to individual loads. The load is then often referred to as a delta-connected load but the service to the facility is still a wye service; it contains four wires if the circuit is traced back to its source (usually a transformer). In this type of connection the phase-to-ground voltage will be the phase-to-ground voltage indicated in the table above, even though a neutral or ground wire is not physically present at the load. The transformer is the best place to determine the circuit connection type because this is a location where the voltage reference to ground can be conclusively identified.

### 2.6.3 Delta Connection

Delta connected services may be fed with either three wires or four wires. In a three-phase delta service the load windings are connected from phase-to-phase rather than from phase-to-ground. The following figure shows the physical load connections for a delta service.
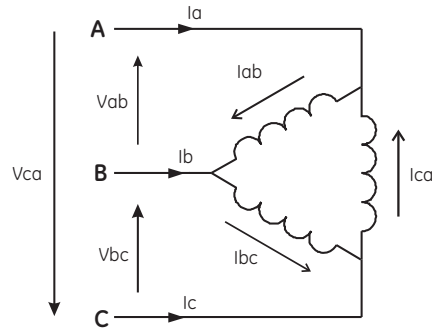


**FIGURE 2–6: Three-phase delta winding relationship**

In this example of a delta service, three wires will transmit the power to the load. In a true delta service, the phase-to-ground voltage will usually not be balanced because the ground is not at the center of the delta.

The following diagram shows the phasor relationships between voltage and current on a three-phase delta circuit.

In many delta services, one corner of the delta is grounded. This means the phase to ground voltage will be zero for one phase and will be full phase-to-phase voltage for the other two phases. This is done for protective purposes.
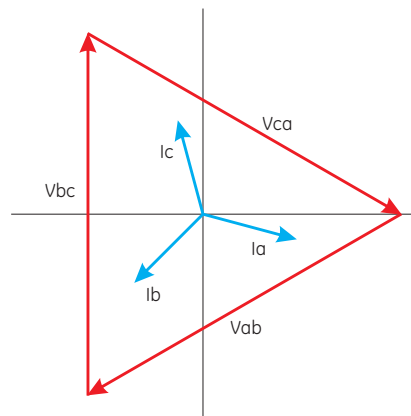


**FIGURE 2–7: Three-phase voltage and current phasors for delta winding**

Another common delta connection is the four-wire, grounded delta used for lighting loads. In this connection the center point of one winding is grounded. On a 120/240 volt, four-wire, grounded delta service the phase-to-ground voltage would be 120 volts on two phases and 208 volts on the third phase. The phasor diagram for the voltages in a three-phase, four-wire delta system is shown below.
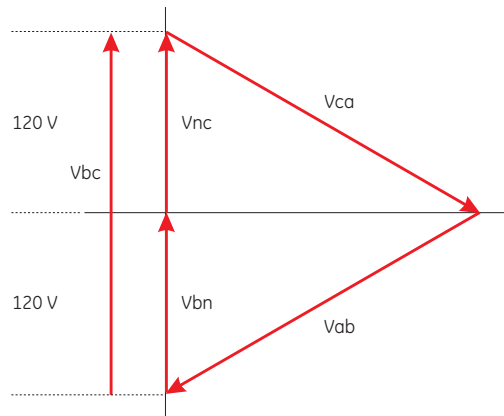
**FIGURE 2–8: Three-phase, four-wire delta phasors**

### 2.6.4    Blondell's Theorem and Three-phase Measurement

In 1893 an engineer and mathematician named Andre E. Blondell set forth the first scientific basis for poly phase metering. His theorem states:

> *If energy is supplied to any system of conductors through N wires, the total power in the system is given by the algebraic sum of the readings of N wattmeters so arranged that each of the N wires contains one current coil, the corresponding potential coil being connected between that wire and some common point. If this common point is on one of the N wires, the measurement may be made by the use of N-1 wattmeters.*

The theorem may be stated more simply, in modern language:

> *In a system of N conductors, N – 1 meter elements will measure the power or energy taken provided that all the potential coils have a common tie to the conductor in which there is no current coil.*

Three-phase power measurement is accomplished by measuring the three individual phases and adding them together to obtain the total three phase value. In older analog meters, this measurement was made using up to three separate elements. Each element combined the single-phase voltage and current to produce a torque on the meter disk. All three elements were arranged around the disk so that the disk was subjected to the combined torque of the three elements. As a result the disk would turn at a higher speed and register power supplied by each of the three wires.

According to Blondell's Theorem, it was possible to reduce the number of elements under certain conditions. For example, a three-phase, three-wire delta system could be correctly measured with two elements (two potential coils and two current coils) if the potential coils were connected between the three phases with one phase in common.

In a three-phase, four-wire wye system it is necessary to use three elements. Three voltage coils are connected between the three phases and the common neutral conductor. A current coil is required in each of the three phases.

In modern digital meters, Blondell's Theorem is still applied to obtain proper metering. The difference in modern meters is that the digital meter measures each phase voltage and current and calculates the single-phase power for each phase. The meter then sums the three phase powers to a single three-phase reading.

Some digital meters calculate the individual phase power values one phase at a time. This means the meter samples the voltage and current on one phase and calculates a power value. Then it samples the second phase and calculates the power for the second phase. Finally, it samples the third phase and calculates that phase power. After sampling all three phases, the meter combines the three readings to create the equivalent three-phase power value. Using mathematical averaging techniques, this method can derive a quite accurate measurement of three-phase power.

More advanced meters actually sample all three phases of voltage and current simultaneously and calculate the individual phase and three-phase power values. The advantage of simultaneous sampling is the reduction of error introduced due to the difference in time when the samples were taken.

Blondell's Theorem is a derivation that results from Kirchhoff's Law. Kirchhoff's Law states that the sum of the currents into a node is zero. Another way of stating the same thing is that the current into a node (connection point) must equal the current out of the node. The law can be applied to measuring three-phase loads. The figure below shows a typical connection of a three-phase load applied to a three-phase, four-wire service. Kirchhoff's Laws hold that the sum of currents A, B, C and N must equal zero or that the sum of currents into Node "n" must equal zero.
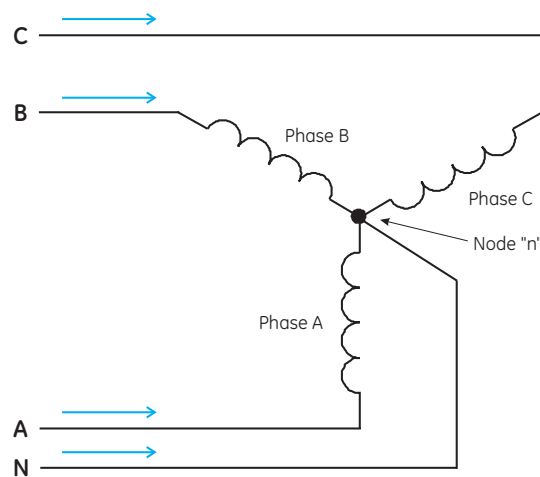


**FIGURE 2–9: Three-phase load illustrating Kirchhoff's law and Blondell's theorem**

If we measure the currents in wires A, B and C, we then know the current in wire N by Kirchhoff's Law and it is not necessary to measure it. This fact leads us to the conclusion of Blondell's Theorem that we only need to measure the power in three of the four wires if they are connected by a common node. In the circuit of Figure 1.6 we must measure the power flow in three wires. This will require three voltage coils and three current coils (a three element meter). Similar figures and conclusions could be reached for other circuit configurations involving delta-connected loads.

## 2.7 Power, Energy, and Demand

### 2.7.1 Description

It is quite common to exchange power, energy, and demand without differentiating between the three. Because this practice can lead to confusion, the differences between these three measurements will be discussed.

### 2.7.2 Power

Power is an instantaneous reading. The power reading provided by a meter is the present flow of watts. Power is measured immediately just like current. In many digital meters, the power value is actually measured and calculated over a one-second interval, since it takes some amount of time to calculate the RMS values of voltage and current. However, this time interval is kept small to preserve the instantaneous nature of power.

### 2.7.3 Energy

Energy is always based upon some time increment – it is the integration of power over a defined time increment. Energy is an important value because almost all electric bills are based, in part, on the amount of energy consumed.

Typically, electrical energy is measured in units of kilowatt-hours (kWh). A kilowatt-hour represents a constant load of 1000 watts (1 kW) for 1 hour. Stated another way, if the power delivered (instantaneous watts) is measured as 1000 W, and the load was served for a one-hour time interval, then the load would have absorbed 1 kWh of energy. A different load may have a constant power requirement of 4000 W. If this load were served for one hour, it would absorb 4 kWh of energy. Likewise, if it were served for 15 minutes, it would absorb ¼ of that total, or 1 kWh.

The following figure shows a graph of power and the resulting energy that would be transmitted as a result of the illustrated power values. For this illustration, it is assumed that the power level is held constant for each minute when a measurement is taken. Each bar in the graph represents the power load for the one-minute increment of time. In real life, the power values are continually moving.
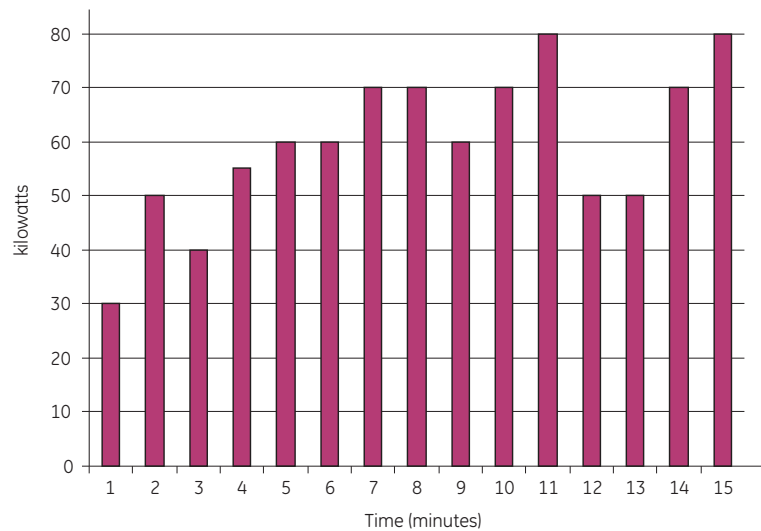
**FIGURE 2–10: Power use over time**

The data in the above figure is reproduced in the following table to illustrate the calculation of energy. Since the time increment of the measurement is one minute, and since we specified a constant load over that minute, the power reading can be converted to an equivalent consumed energy reading by multiplying the power reading by 1/60 (converting the time base from minutes to hours).

**Table 2–2: Power and energy relationship over time**

| Time Interval | Power | Energy | Accumulated Energy |
|---|---|---|---|
| 1 minute | 30 kW | 0.50 kWh | 0.50 kWh |
| 2 minutes | 50 kW | 0.83 kWh | 1.33 kWh |
| 3 minutes | 40 kW | 0.67 kWh | 2.00 kWh |
| 4 minutes | 55 kW | 0.92 kWh | 2.92 kWh |
| 5 minutes | 60 kW | 1.00 kWh | 3.92 kWh |
| 6 minutes | 60 kW | 1.00 kWh | 4.92 kWh |
| 7 minutes | 70 kW | 1.17 kWh | 6.09 kWh |
| 8 minutes | 70 kW | 1.17 kWh | 7.26 kWh |
| 9 minutes | 60 kW | 1.00 kWh | 8.26 kWh |
| 10 minutes | 70 kW | 1.17 kWh | 9.43 kWh |
| 11 minutes | 80 kW | 1.33 kWh | 10.76 kWh |
| 12 minutes | 50 kW | 0.83 kWh | 12.42 kWh |
| 13 minutes | 50 kW | 0.83 kWh | 12.42 kWh |
| 14 minutes | 70 kW | 1.17 kWh | 13.59 kWh |
| 15 minutes | 80 kW | 1.33 kWh | 14.92 kWh |

As shown in the above table, the accumulated energy for the power load profile of the data in *Power use over time* on page 2–18 is 14.92 kWh.

### 2.7.4    Demand

Demand is also a time-based value. The demand is the average rate of energy use over time. The actual label for demand is kilowatt-hours/hour but this is normally reduced to kilowatts. This makes it easy to confuse demand with power. But demand is not an instantaneous value. To calculate demand it is necessary to accumulate the energy readings (as illustrated in *Power use over time* on page 2–18) and adjust the energy reading to an hourly value that constitutes the demand.

In the above example, the accumulated energy is 14.92 kWh. But this measurement was made over a 15-minute interval. To convert the reading to a demand value, it must be normalized to a 60-minute interval. If the pattern were repeated for an additional three 15-minute intervals the total energy would be four times the measured value or 59.68 kWh. The same process is applied to calculate the 15-minute demand value. The demand value associated with the example load is 59.68 kWh/hour or 59.68 kWd. Note that the peak instantaneous value of power is 80 kW, significantly more than the demand value.

The following figure illustrates another example of energy and demand. In this case, each bar represents the energy consumed in a 15-minute interval. The energy use in each interval typically falls between 50 and 70 kWh. However, during two intervals the energy

rises sharply and peaks at 100 kWh in interval #7. This peak of usage will result in setting a high demand reading. For each interval shown the demand value would be four times the indicated energy reading. So interval 1 would have an associated demand of 240 kWh/hr. Interval #7 will have a demand value of 400 kWh/hr. In the data shown, this is the peak demand value and would be the number that would set the demand charge on the utility bill.
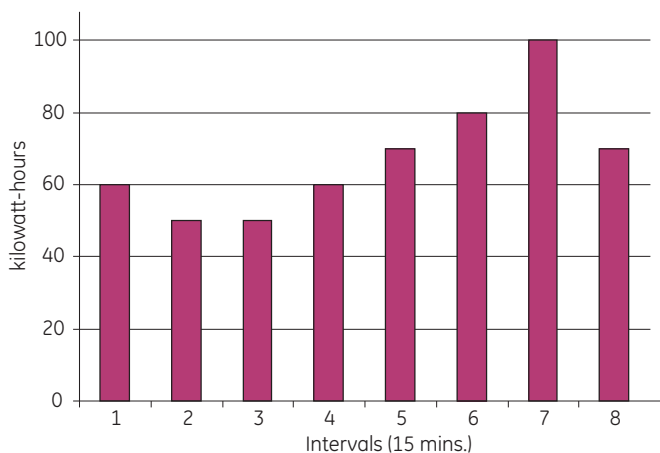


**FIGURE 2–11: Energy use and demand intervals**

As seen in this example, it is important to recognize the relationships between power, energy and demand to effectively control loads or to correctly monitor use.

## 2.8     Reactive Energy and Power Factor

### 2.8.1    Real, Reactive, and Apparent Power

The real power and energy measurements discussed in the previous section relate to the quantities that are most used in electrical systems. But it is often not sufficient to only measure real power and energy. Reactive power is a critical component of the total power picture because almost all real-life applications have an impact on reactive power. Reactive power and power factor concepts relate to both load and generation applications. However, this discussion will be limited to analysis of reactive power and power factor as they relate to loads. To simplify the discussion, generation will not be considered.

Real power (and energy) is the component of power that is the combination of the voltage and the value of corresponding current that is directly in phase with the voltage. However, in actual practice the total current is almost never in phase with the voltage. Since the current is not in phase with the voltage, it is necessary to consider both the in-phase component and the component that is at quadrature (angularly rotated 90° or perpendicular) to the voltage. The following figure shows a single-phase voltage and current and breaks the current into its in-phase and quadrature components.
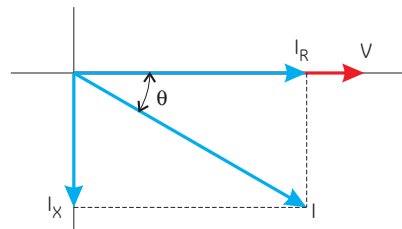


**Figure 2-1: Voltage and complex current**

The voltage (V) and the total current (I) can be combined to calculate the apparent power or VA. The voltage and the in-phase current ($I_R$) are combined to produce the real power or watts. The voltage and the quadrature current ($I_X$) are combined to calculate the reactive power.

The quadrature current may be lagging the voltage (as shown above) or it may lead the voltage. When the quadrature current lags the voltage the load is requiring both real power (watts) and reactive power (vars). When the quadrature current leads the voltage the load is requiring real power (watts) but is delivering reactive power (vars) back into the system; that is vars are flowing in the opposite direction of the real power flow.

Reactive power (vars) is required in all power systems. Any equipment that uses magnetization to operate requires vars. Usually the magnitude of vars is relatively low compared to the real power quantities. Utilities have an interest in maintaining var requirements at the customer to a low value to maximize the return on plant invested to deliver energy. When lines are carrying vars, they cannot carry as many watts. So keeping the var content low allows a line to carry its full capacity of watts. To encourage customers to keep var requirements low, most utilities impose a penalty if the var content of the load rises above a specified value.

### 2.8.2    Power Factor

A common method of measuring reactive power requirements is power factor. Power factor can be defined in two different ways. The more common method of calculating power factor is the ratio of the real power to the apparent power. This relationship is expressed in the following formula:

$$\text{Total PF} = \frac{\text{real power}}{\text{apparent power}} = \frac{\text{watts}}{\text{VA}} \qquad \textbf{(EQ 2.28)}$$

This formula calculates a power factor quantity known as total power factor. It is called total PF because it is based on the ratios of the power delivered. The delivered power quantities will include the impacts of any existing harmonic content. If the voltage or current includes high levels of harmonic distortion the power values will be affected. By calculating power factor from the power values, the power factor will include the impact of harmonic distortion. In many cases this is the preferred method of calculation because the entire impact of the actual voltage and current are included.

A second type of power factor is displacement power factor. Displacement PF is based on the angular relationship between the voltage and current. Displacement power factor does not consider the magnitudes of voltage, current or power. It is solely based on the phase angle differences. As a result, it does not include the impact of harmonic distortion. Displacement power factor is calculated using the following equation:

$$\text{Displacement PF} = \cos\theta \qquad \textbf{(EQ 2.29)}$$

where $\theta$ is the angle between the voltage and the current (see Figure 2-1: *Voltage and complex current* on page 2–21).

In applications where the voltage and current are not distorted, the total power factor will equal the displacement power factor. But if harmonic distortion is present, the two power factors will not be equal.

## 2.9    Harmonic Distortion

### 2.9.1    Harmonics of a Non-sinusoidal Waveform

Harmonic distortion is primarily the result of high concentrations of non-linear loads. Devices such as computer power supplies, variable speed drives and fluorescent light ballasts make current demands that do not match the sinusoidal waveform of AC electricity. As a result, the current waveform feeding these loads is periodic but not sinusoidal. The following figure shows a normal, sinusoidal current waveform with a period of $a$. This example has no distortion.
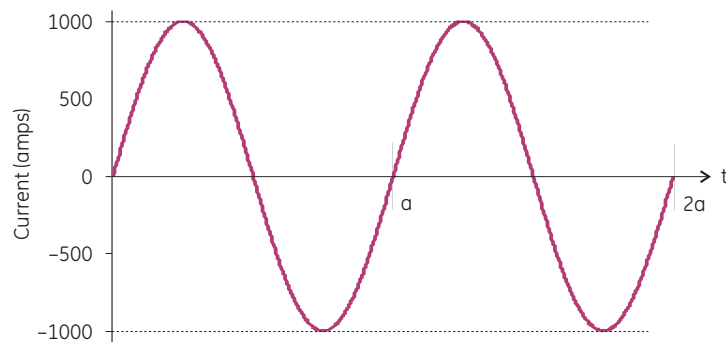
**FIGURE 2–12: Non-distorted current waveform**

The figure below shows a current waveform with a slight amount of harmonic distortion. The waveform is still periodic and is fluctuating at the normal 60 Hz frequency ($a$ = 1/60 second). However, the waveform is not the smooth sinusoidal form seen above.
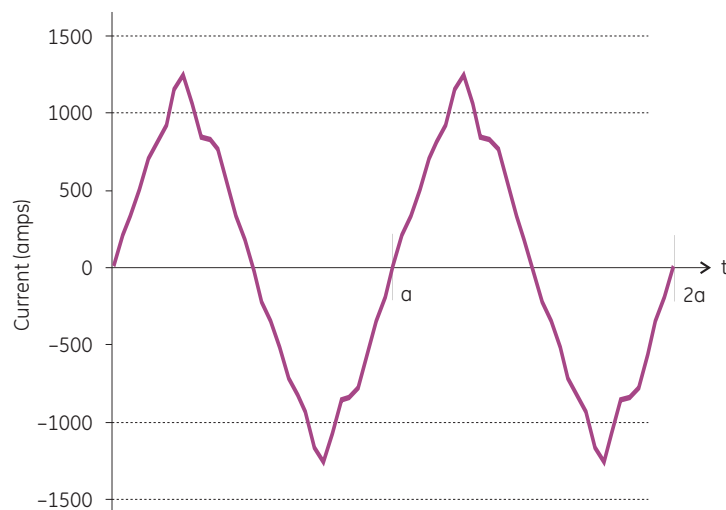
**FIGURE 2–13: Distorted current waveform**

The distortion above can be modeled as the sum of several sinusoidal waveforms of frequencies that are multiples of the fundamental 60 Hz frequency. This modeling is performed by mathematically reducing the distorted waveform into a collection of higher

frequency waveforms. These higher frequency waveforms are referred to as harmonics. The following figure shows the content of the harmonic frequencies that comprise one cycle of the distorted portion of the above waveform.
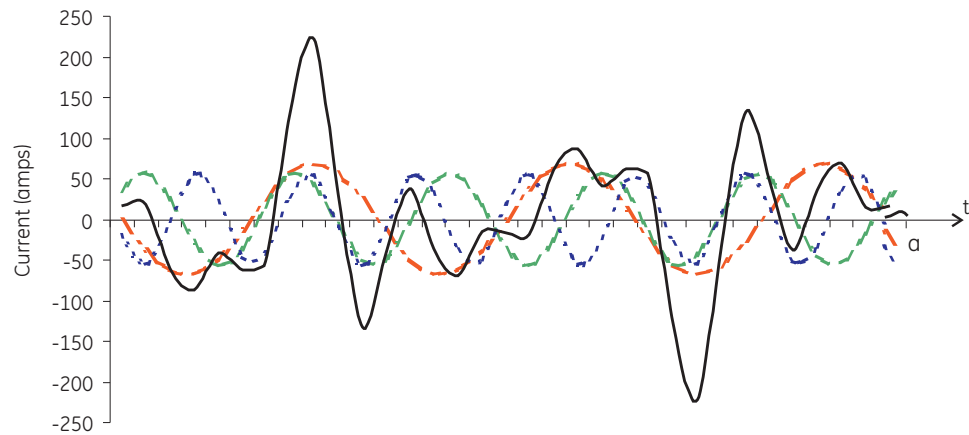


**FIGURE 2–14: Harmonics for distorted current waveform**

The waveforms above provide an indication of the impact of combining multiple harmonic frequencies together. The broken lines represent the 3rd, 5th, and 7th current harmonics. The solid line represents the sum of the three harmonics.

When harmonics are present, it is important to remember that they are operating at higher frequencies. As such, they do not always respond in the same manner as 60 Hz values.

## 2.9.2  Inductive and Capacitive Impedance

Inductive and capacitive impedance are present in all power systems. We are accustomed to thinking about these impedances as they perform at 60 Hz. However, these impedances are subject to frequency variation.

$$X_L = j\omega L \quad \text{and} \quad X_C = 1/j\omega C \quad \quad \text{(EQ 2.30)}$$

At 60 Hz, $\omega = 377$; but at 300 Hz (5th harmonic) $\omega = 1885$. As frequency changes, the impedance changes and system impedance characteristics that are normal at 60 Hz may be entirely different in the presence of higher order harmonic waves.

Traditionally, the most common harmonics have been the low order odd frequencies, such as the 3rd, 5th, 7th, and 9th. However newer, non-linear loads are introducing significant quantities of higher order harmonics.

## 2.9.3  Voltage and Current Monitoring

Since much voltage monitoring and almost all current monitoring is performed using instrument transformers, the higher order harmonics are often not visible. Instrument transformers are designed to pass 60 Hz quantities with high accuracy. These devices, when designed for accuracy at low frequency, do not pass high frequencies with high

accuracy; at frequencies above about 1200 Hz they pass almost no information. So when instrument transformers are used, they effectively filter out higher frequency harmonic distortion making it impossible to see.

However, when monitors can be connected directly to the measured circuit (such as direct connection to a 480 V bus) the user may often see higher order harmonic distortion. An important rule in any harmonics study is to evaluate the type of equipment and connections before drawing a conclusion. Not being able to see harmonic distortion is not the same as not having harmonic distortion.

### 2.9.4    Waveform Capture

It is common in advanced meters to perform a function commonly referred to as waveform capture. Waveform capture is the ability of a meter to capture a present picture of the voltage or current waveform for viewing and harmonic analysis. Typically a waveform capture will be one or two cycles in duration and can be viewed as the actual waveform, as a spectral view of the harmonic content, or a tabular view showing the magnitude and phase shift of each harmonic value. Data collected with waveform capture is typically not saved to memory. Waveform capture is a real-time data collection event.

Waveform capture should not be confused with waveform recording that is used to record multiple cycles of all voltage and current waveforms in response to a transient condition.

## 2.10  Power Quality

### 2.10.1  Description

Power quality can mean several different things. The terms *power quality* and *power quality problem* have been applied to all types of conditions. A simple definition of *power quality problem* is any voltage, current or frequency deviation that results in misoperation or failure of customer equipment or systems. The causes of power quality problems vary widely and may originate in the customer equipment, in an adjacent customer facility or with the utility.

In his book *Power Quality Primer*, Barry Kennedy provided information on different types of power quality problems. Some of that information is summarized in the following table.

**Table 2–3: Typical power quality problems**

| Cause | Disturbance Type | Source(s) |
|---|---|---|
| Impulse transient | Transient voltage disturbance, sub-cycle duration | Lightning; Electrostatic discharge; Load switching; Capacitor switching |
| Oscillatory transient with decay | Transient voltage, sub-cycle duration | Line/cable switching; Capacitor switching; Load switching |
| Sag/swell | RMS voltage, multiple cycle duration | Remote system faults |
| Interruptions | RMS voltage, multiple second or longer duration | System protection; Circuit breakers; Fuses; Maintenance |
| Undervoltage/ Overvoltage | RMS voltage, steady state, multiple second or longer duration | Motor starting; Load variations; Load dropping |
| Voltage flicker | RMS voltage, steady state, repetitive condition | Intermittent loads; Motor starting; Arc furnaces |
| Harmonic distortion | Steady-state current or voltage, long term duration | Non-linear loads; System resonance |

It is often assumed that power quality problems originate with the utility. While it is true that many power quality problems can originate with the utility system, many problems originate with customer equipment. Customer-caused problems may manifest themselves inside the customer location or they may be transported by the utility system to another adjacent customer. Often, equipment that is sensitive to power quality problems may in fact also be the cause of the problem.

If a power quality problem is suspected, it is generally wise to consult a power quality professional for assistance in defining the cause and possible solutions to the problem.

GE Consumer & Industrial
**Multilin**

# EPM 9800 Advanced Power Quality Metering System

# Chapter 3: Installation

## 3.1   Hardware Installation

### 3.1.1   Mounting the EPM 9800

The EPM 9800 Advanced Power Quality Metering System is designed to mount into a standard meter socket for forms 9S, 36S, and 45S. The EPM 9800 can be mounted outside or in an enclosed and protected environment, such as in a switchgear cabinet. A switch or circuit breaker can be installed nearby labeled as the EPM 9800 disconnecting mechanism. The dimensions for the standard meter are shown below.
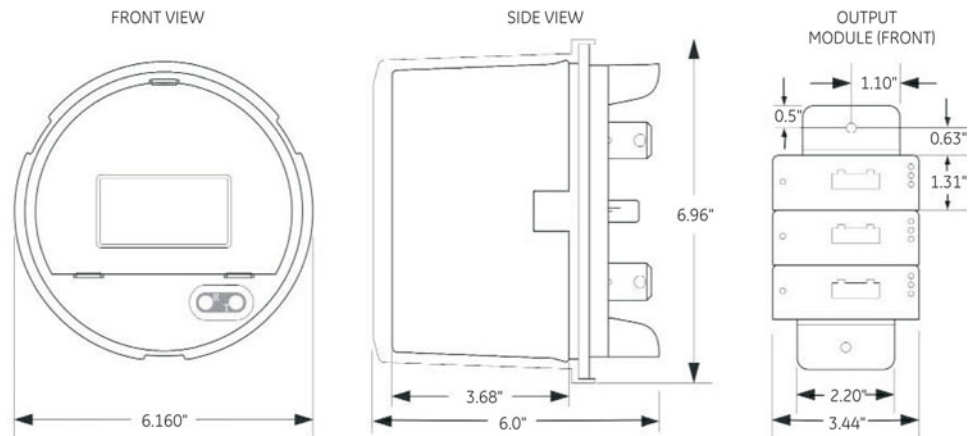


Figure 3-1: Mounting dimensions (standard meter)

The form 9A meter is designed to mount into an A-base terminal block. The dimensions for the A-base meter are shown below.

FRONT VIEW

SIDE VIEW
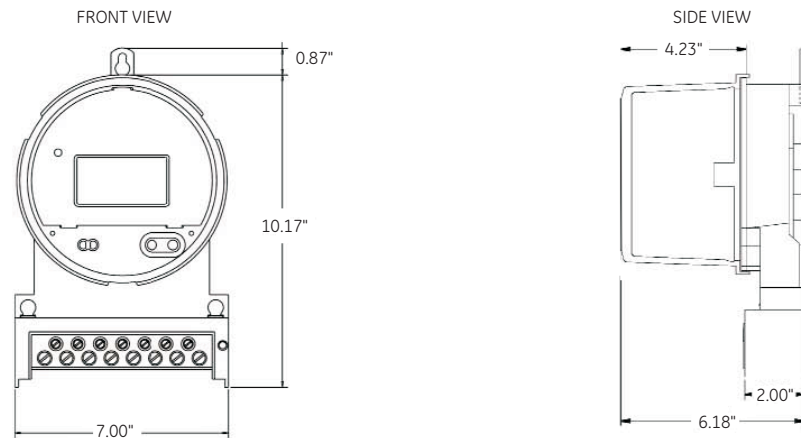


**Figure 3-2: Mounting dimensions (A-base meter)**

The form SB meter is designed to mount into an switchboard unit. The dimensions for the switchboard meter are shown below.

FRONT VIEW

REAR VIEW
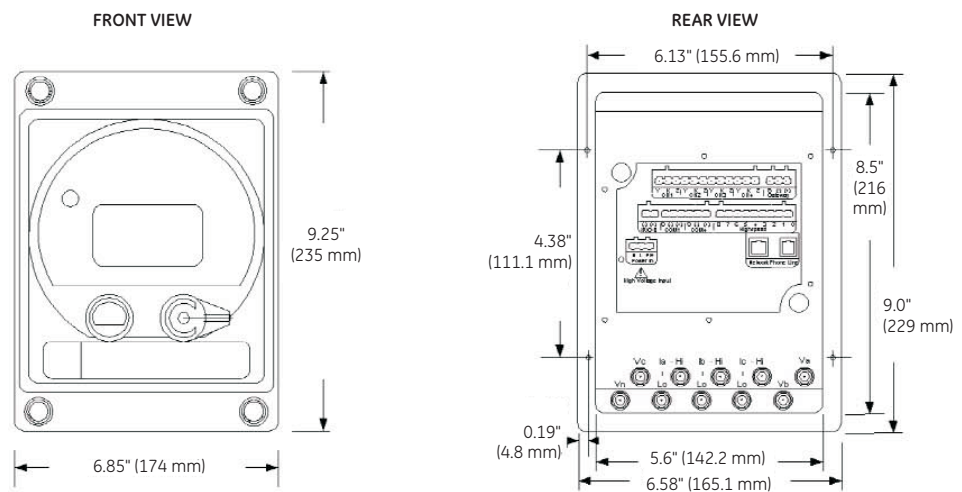


**Figure 3-3: Mounting dimensions (switchboard meter)**

### 3.1.2   Installing the Standard Meter

A summary of the EPM 9800 installation procedure is given below.

▷ Examine the labels to verify the form and service type. Ensure that the socket and meter current class ratings are compatible.

▷ Ensure that all communication and auxiliary power wiring is accessible in case disconnection is required.

▷ Before applying power to the meter, install batteries and verify the connections.
POWER MUST BE OFF TO INSTALL THE INTERNAL BATTERY!

▷ **To install the internal battery,**

- Remove the internal shroud and place the battery into its compartment with the positive terminal (+) facing UP. Replace the internal shroud. Refer to Figure 3-7: *Battery holder detail* on page 3–7.

▷ **To install the modem battery,**

- Keep the outer shroud on the meter and locate the battery cable at the back of the meter.

- Insert the cable connector into the cable and use the velcro (peel and stick) to attach the battery somewhere outside of the meter.

▷ **Measure the enclosure to ensure it accommodates the meter (if the enclosure is a standard size, this step is not necessary).**

▷ **Ensure that communications wiring from the back of the meter is fed through the appropriate openings to allow for clean connections with external devices.**

▷ **Insert the meter into the socket, making sure that the unit blades are firmly within the jaws of the socket.**

▷ **Connect external devices to the appropriate communications wiring.**
See the following figure and table for communications wiring details. RJ-11 and RJ-45 connectors will be supplied.

**Cable 8**
optional auxiliary
power cable

**Cable 1**
port 1, port4, IRIG-B

**Cable 3**
optional KYZ cable

**Cable 2**
high-speed
inputs

OPTIONAL COMMUNICATIONS
1. Combination Modem/Ethernet:
Cable 4 - RS485
Cable 5 - RJ11 modem
Cable 6 - RJ45 Ethernet

2. Modem
Cable 4 - RS485
Cable 5 - RJ11 modem
Cable 7 - battery

3. Ethernet
Cable 6 - RJ45 Ethernet
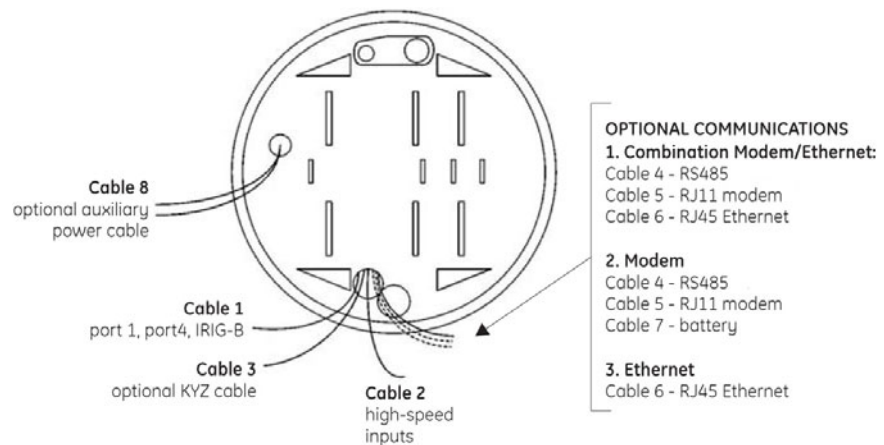
**Figure 3-4: EPM 9800 rear view with communications wiring**

**Table 3–1: Cable color key**

| Cable | Signal | Color | | Cable | Signal | Color |
|---|---|---|---|---|---|---|
| 1 | RS485 port 1 shield | Black | | 3 | KYZ normally closed 1 | Black |
| | RS485 port 1 Tx/Rx+ | Brown | | | KYZ common 1 | Brown |
| | RS485 port 1 Tx/Rx– | Red | | | KYZ normally open 1 | Red |
| | RS485 port 4 shield | Orange | | | KYZ normally closed 2 | Orange |
| | RS485 port 4 Tx/Rx+ | Yellow | | | KYZ common 2 | Yellow |
| | RS485 port 4 Tx/Rx– | Green | | | KYZ normally open 2 | Green |
| | IRIG-B + | Blue | | | KYZ normally closed 3 | Blue |
| | IRIG-B – | Purple | | | KYZ common 3 | Purple |
| 2 | High speed input 8 | Black | | | KYZ normally open 3 | Gray |
| | High speed input 7 | Brown | | | KYZ normally closed 4 | Lt. Grn |
| | High speed input 6 | Red | | | KYZ common 4 | Pink |
| | High speed input 5 | Orange | | | KYZ normally open 4 | White |
| | High speed input 4 | Yellow | | 4 | RS485 shield | Blue |
| | High speed input 3 | Green | | | RS485 Tx/Rx+ | Green |
| | High speed input 2 | Blue | | | RS485 Tx/Rx– | Red |
| | High speed input 1 | Gray | | 5 | RJ11 modem | Blue |
| | Common | Purple | | 6 | RJ45 Ethernet | Blue |
| | | | | 7 | Battery | Black |
| | | | | 8 | Auxiliary power + | Brown |
| | | | | | Auxiliary power – | Blue |

▷ Make sure the meter is functioning properly by running it through a test circuit.

**Cable colors are subject to change without notice. Refer to the cable labels for color code verification.**

### 3.1.3 Installing the Switchboard Meter

The EPM 9800 switchboard meter allows for two-step installation or disconnection.

The switchboard cases are not exactly identical. They are welded together and as such have slight variations. For this reason, a tolerance (1/16-inch or 1.5875 mm) has been added to the cutout diagram below.

Ensure that the drill holes are checked for the mounting screws. Ensure that the mounting screw fits the box tightly enough to hold the box in place. If the mounting screw is slightly smaller than the drill holes, a washer may be used.
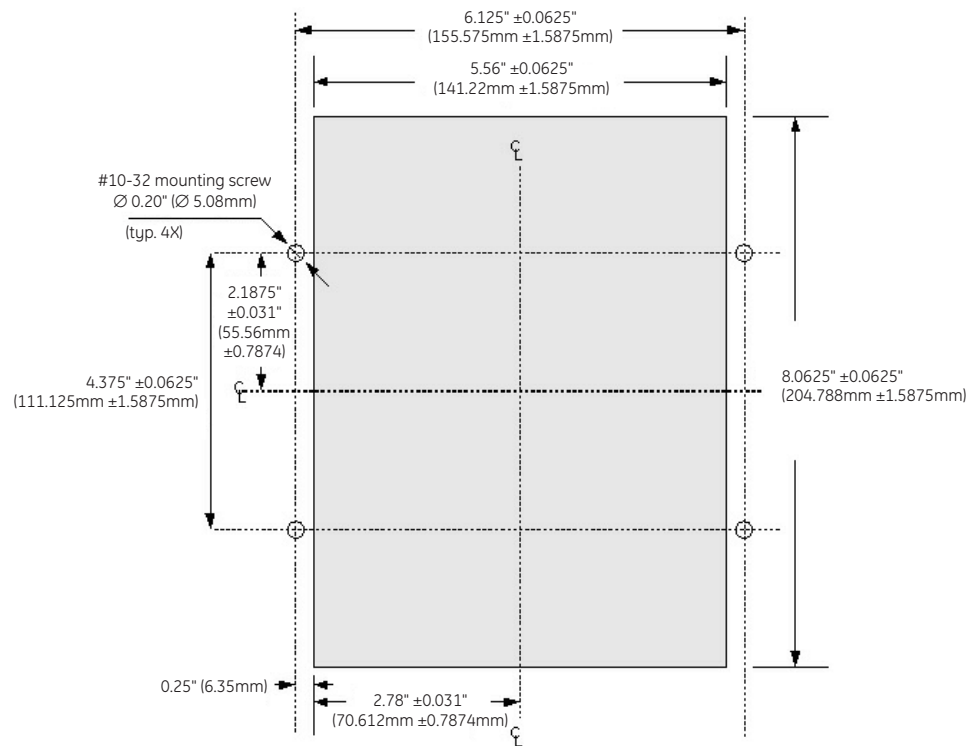
**Figure 3-5: Switchboard meter cutout**

▷ Insert the case into a prepared mounting hole for the switchboard case.

▷ Secure with mounting screws.

▷ Before installing the meter, check the battery connections (see *Battery Installation and Maintenance* on page 3–6).

▷ Slide the meter into the case.

▷ Secure by sliding the chassis levers until they snap into place.

Connectors for the following items are located on the back of the meter. The connectors will automatically plug into the available connectors on the mounting board.

Pulse outputs (four channels)
Status inputs
Phone
Line/network
Power in
COM4 - COM1 - IRIG-B
RS485 modem

▷ Position the case front against the four screw holes.

▷ Secure the front of the case by turning the four built-in screws in each of the corners.

### 3.1.4    Battery Installation and Maintenance

The internal battery is a 3 V Lithium battery (Panasonic BR2032 or equivalent) that maintains NVRAM and time during outages. It is located on one of the vertical panels inside the internal shroud (see the figure below). Under normal conditions, the battery should provide in excess of 10 years of service during storage conditions (disconnected from terminals) or when properly installed in an energized meter. The battery should provide more than one year of service during outage conditions (time on battery backup). A low battery indicator provides notification when a replacement is needed.
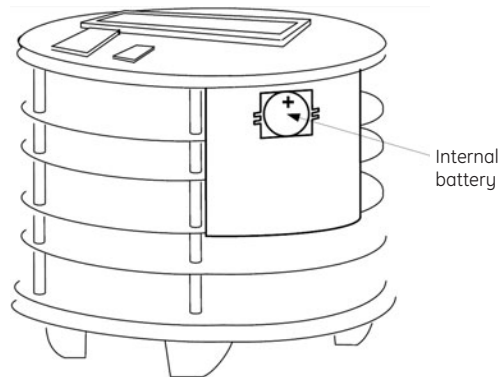


**Figure 3-6: EPM 9800 without internal shroud**

**Battery installation or replacement must be done with power off!**

The following procedure describes how to change the battery (see fig 3-7).

> ▷ Before replacing a battery, download all memory files to a local computer.
>   Note that data may be lost.

> ▷ Remove power from the meter.

> ▷ Remove the external meter cover and the internal shroud.

> ▷ Remove the old battery with a screwdriver or similar tool.

> ▷ Make sure the + on the new battery is facing *up* and outwards.

> ▷ Insert the *right side* of the battery *under* the two clips on the right side of the holder while gently pushing the battery against the *inside right wall* of the battery holder (arrow A).

> ▷ Gently push the *left side* of the battery in until it snaps into place (arrow B).
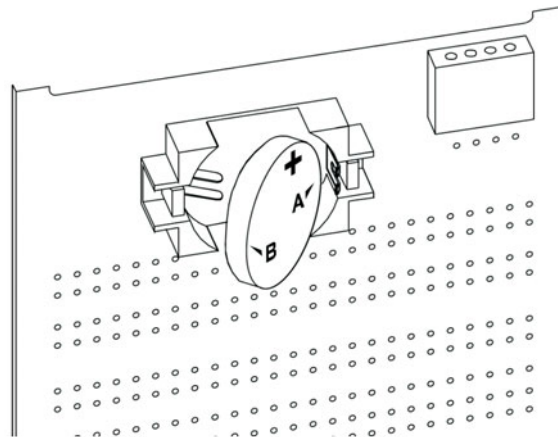
**Figure 3-7: Battery holder detail**

> **NOTE**
>
> It is very important to correctly insert the replacement battery into the holder. Otherwise proper contact will not be achieved and the meter may lose memory and time functions.

▷ Replace the internal shroud and the external meter cover.

▷ Energize the meter.

▷ Reset Time using Communicator software. If IRIG-B is connected, time is synchronized automatically.

> **NOTE**
>
> For battery safety and disposal, ensure the recommendations below are followed.
>
> • Do not expose battery to temperatures above 100°C. Do not incinerate, puncture, crush, recharge, short-circuit or over-discharge battery.
>
> • Do not expose contents of battery to water or to high humidity for extended periods of time.
>
> • Dispose of batteries in accordance with local, state and federal hazardous waste regulations.

### 3.1.5    Output Module Mounting

▷ Connect multiple output modules by inserting male RS485 side ports into female ports.

▷ Using a flathead screwdriver, screw each module into the next. Work from left to right.

▷ If multiple output modules are connected together, as shown in Figure 3-8: *Output modules mounting (overhead view)*, or an individual module is used, secure the mounting brackets to both ends of the group (or individual module) using the screws supplied (#440 pan-head screws).

▷ Secure the brackets to a flat surface using a #8 screw with a lock washer.

**NOTE**

The EPM 9800 does *not* supply power for the output modules. An external power supply, such as the PSIO (12 V output), must be used. The following figure shows the output modules mounted without a PSIO power supply; refer to Figure 3-11: *Output module with PSIO mounting (front view)* on page 3–9 for mounting with the PSIO.



1.13" (28.57mm)

0.015" (0.37mm)

3 × 1.32" (33.27mm)

mounting bracket

4.1" (104.14mm)

mounting bracket

**Figure 3-8: Output modules mounting (overhead view)**



mounting bracket (MBIO)

mounting bracket (MBIO)

1.25" (31.75mm) + Y
per module

2 × 1.10"
(27.93mm)

2.20" (55.87mm)

3.44"
(87.38mm)

Y = 1.13"
(31.37mm)
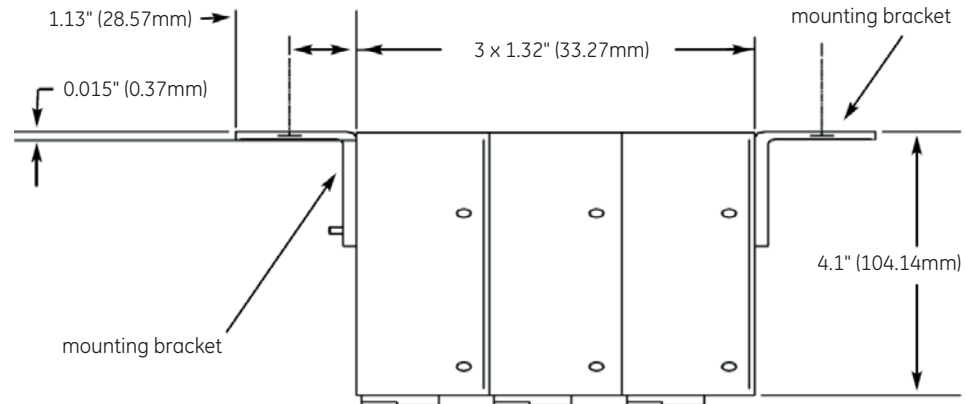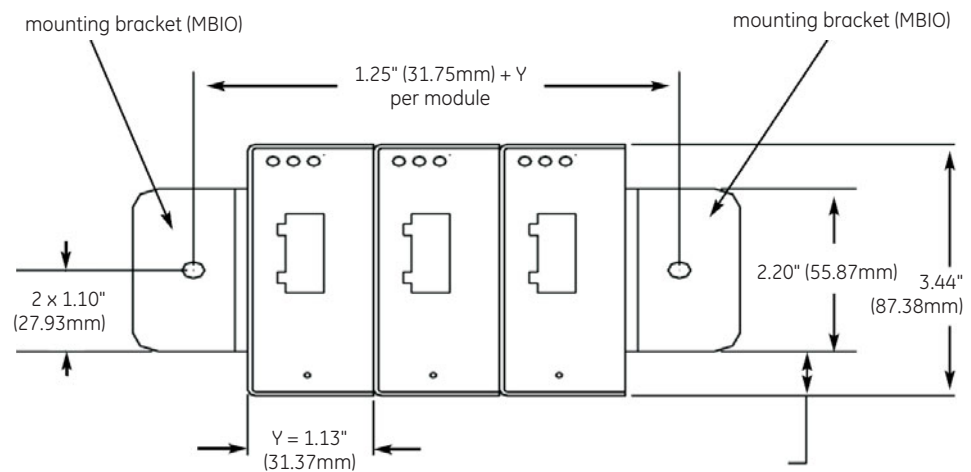
**Figure 3-9: Output modules mounting (front view)**
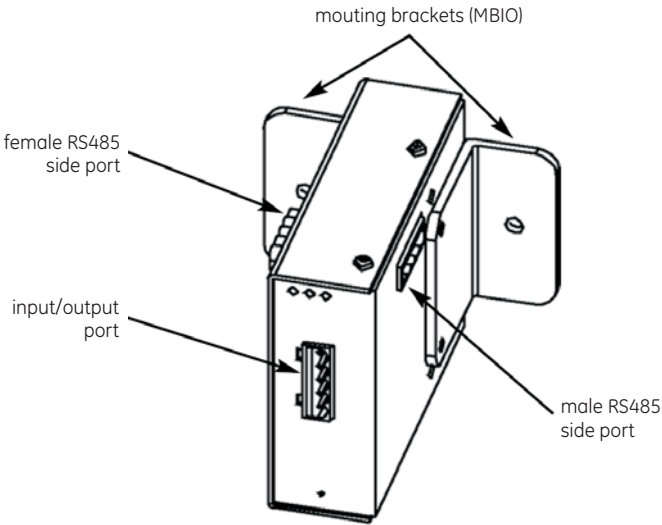
**Figure 3-10: Output module communication ports**
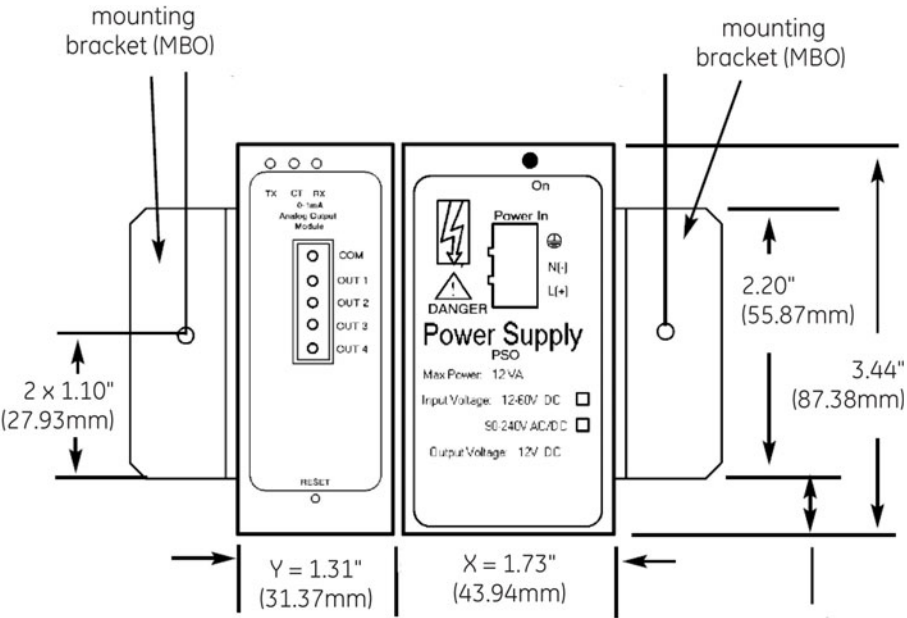


**Figure 3-11: Output module with PSIO mounting (front view)**

# 3.2    Electrical Installation

### 3.2.1    Wiring Diagrams

Corresponding wiring diagrams for the various EPM 9800 forms appear on the following pages. If the required connection is not shown, contact GE Multilin for a custom connection diagram.

**Grounding**: Industrial meters are typically grounded at the service entrance (not the meter) per NEC (1999) section 250-24(5) and 250-26.

**Auxiliary power**: Meters may be externally powered using a 120 to 230 V AC or 125 to 400 V DC power supply.

The associated forms and wiring types are shown in the following table.

**Table 3–2: EPM 9800 forms and associated wiring types**

| Form | Wiring description | Figures | | Page(s) |
|------|--------------------|---------|---|---------|
|      |                    | standard | switchboard | |
| 9S | Wye, no PTs, 3 CTs | 3-12 | 3-13 | 3–11, 3–12 |
|    | Wye, 3 PTs, 3 CTs | 3-14 | 3-15 | 3–13, 3–14 |
|    | 4-wire delta, no PTs, 3 CTs | 3-16 | 3-17 | 3–15, 3–16 |
|    | 4-wire delta, 3 PTs, 3 CTs | 3-18 | 3-19 | 3–17, 3–18 |
|    | 4-wire delta, no PTs, 2 CTs | 3-20 | 3-21 | 3–19, 3–20 |
|    | 4-wire delta, 2 PTs, 2 CTs | 3-22 | 3-23 | 3–21, 3–22 |
|    | 3-wire delta, no PTs, 2 CTs | 3-24 | 3-24 | 3–23, 3–23 |
|    | 3-wire delta, 2 PTs, 2 CTs | 3-26 | 3-27 | 3–25, 3–26 |
| 36S | 2.5 element wye, no PTs, 3 CTs | 3-28 | 3-29 | 3–27, 3–28 |
|     | 2.5 element wye, 2 PTs, 3 CTs | 3-30 | 3-31 | 3–29, 3–30 |
| 45S | Wye, no PTs, 3 CTs | 3-32 | --- | 3–31 |
|     | Wye, 2 PTs, 3 CTs | 3-33 | --- | 3–32 |
|     | 3-wire delta, no PTs, 3 CTs | 3-34 | --- | 3–33 |
|     | 3-wire delta, 2 PTs, 2 CTs | 3-35 | --- | 3–34 |
|     | 4-wire delta, no PTs, 2 CTs | 3-36 | --- | 3–35 |
|     | 4-wire delta, 2 PTs, 2 CTs | 3-37 | --- | 3–36 |

The wiring diagram for form 9S (transformer rated) wye, 4-wire, with no PTs and 3 CTs for the standard meter is shown below.

**NOTE** Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.
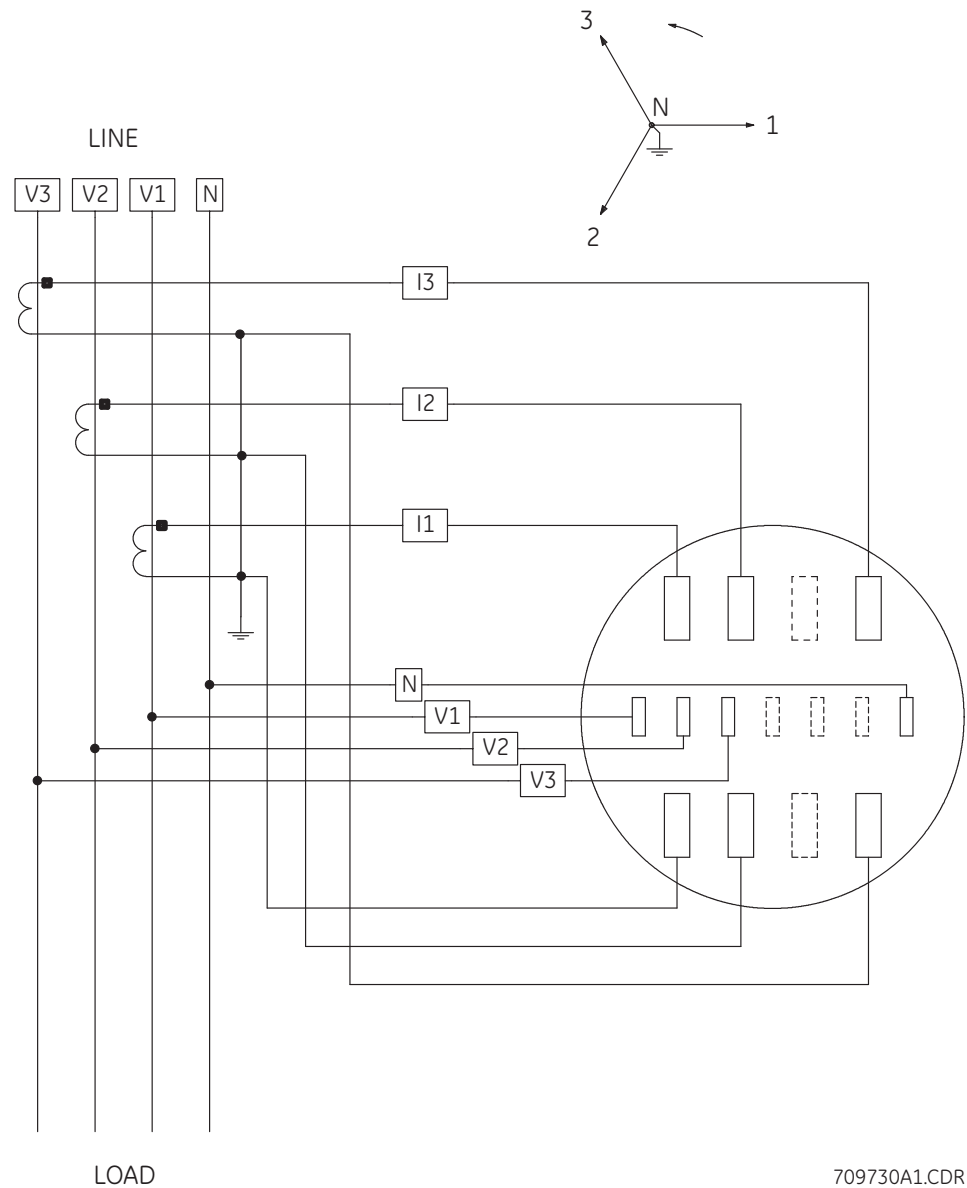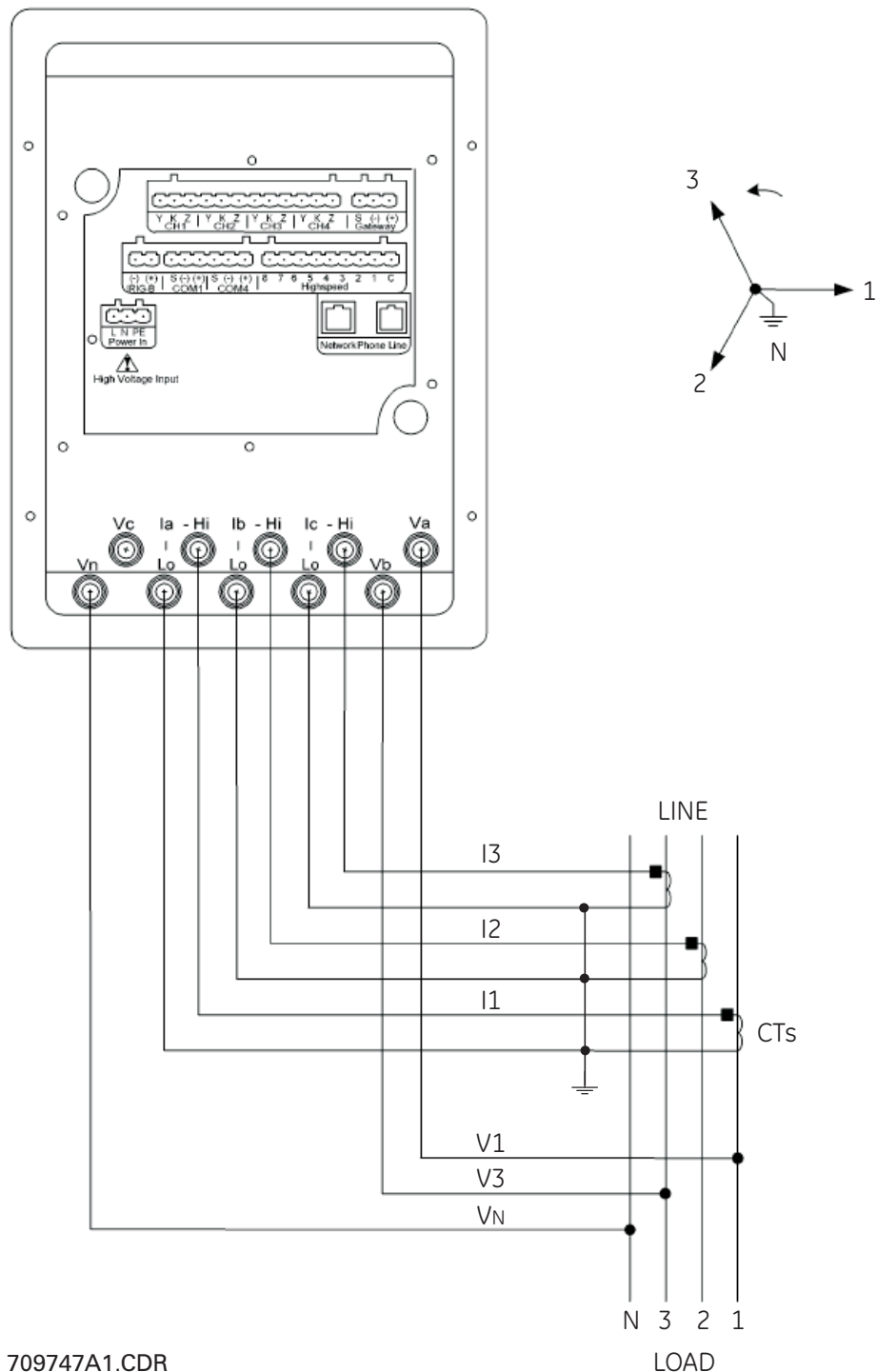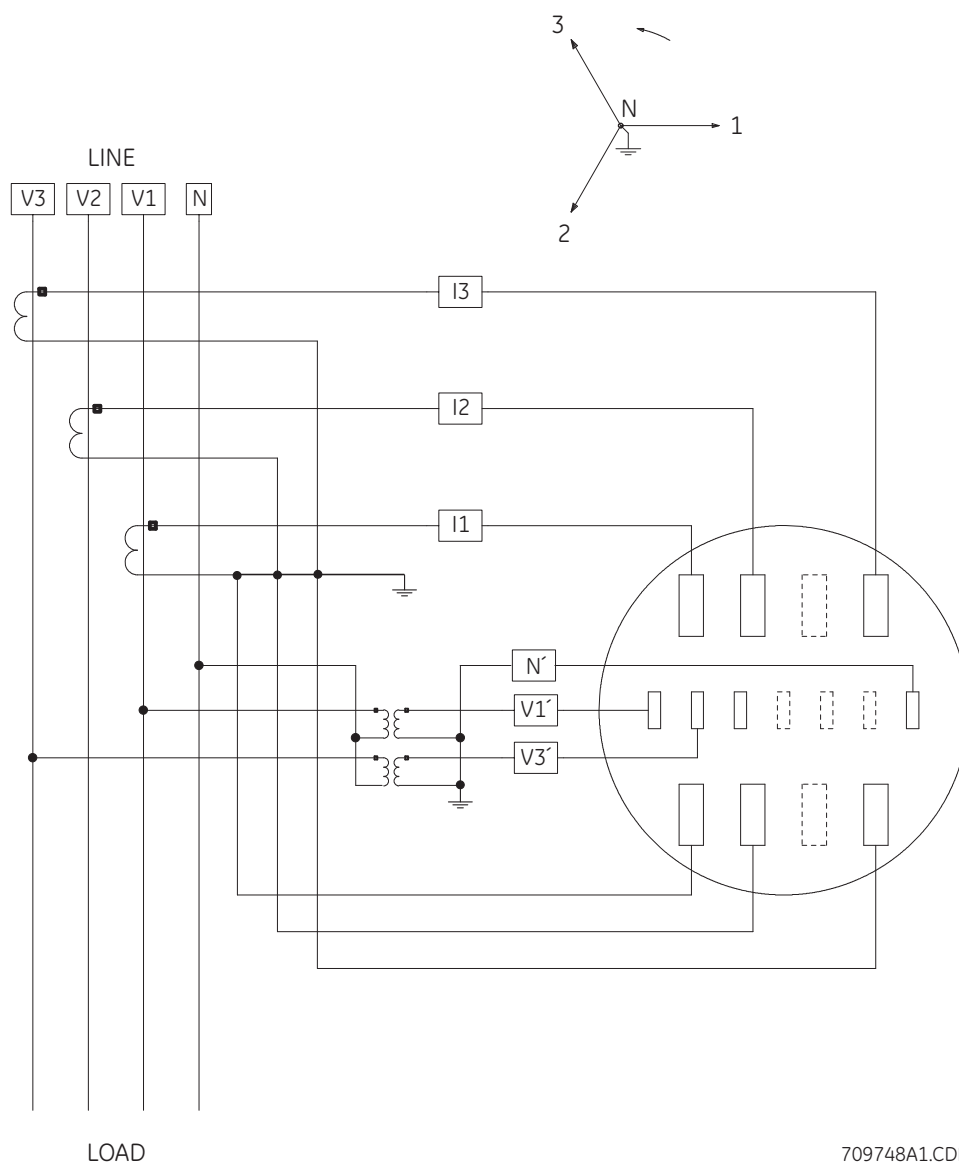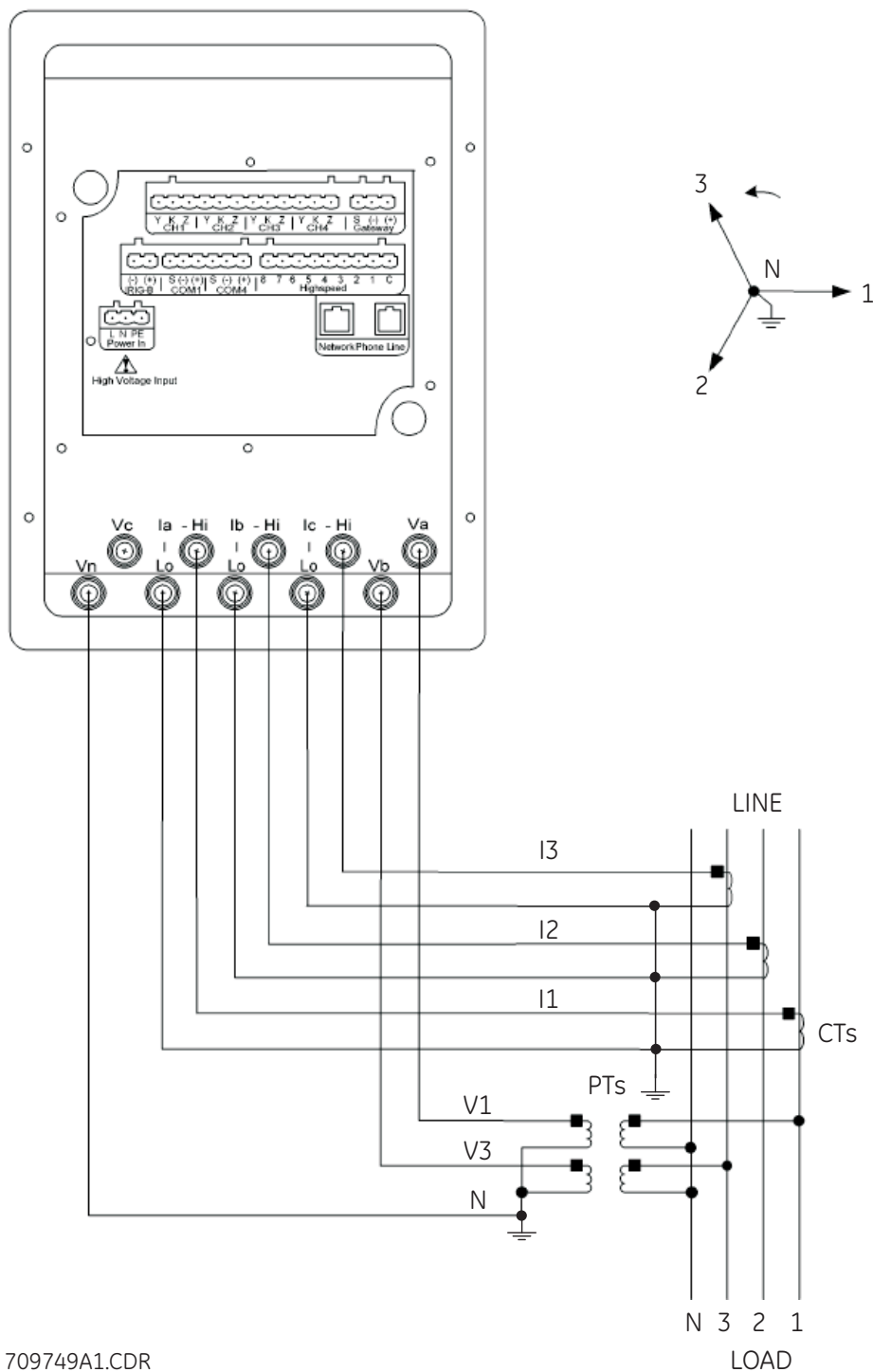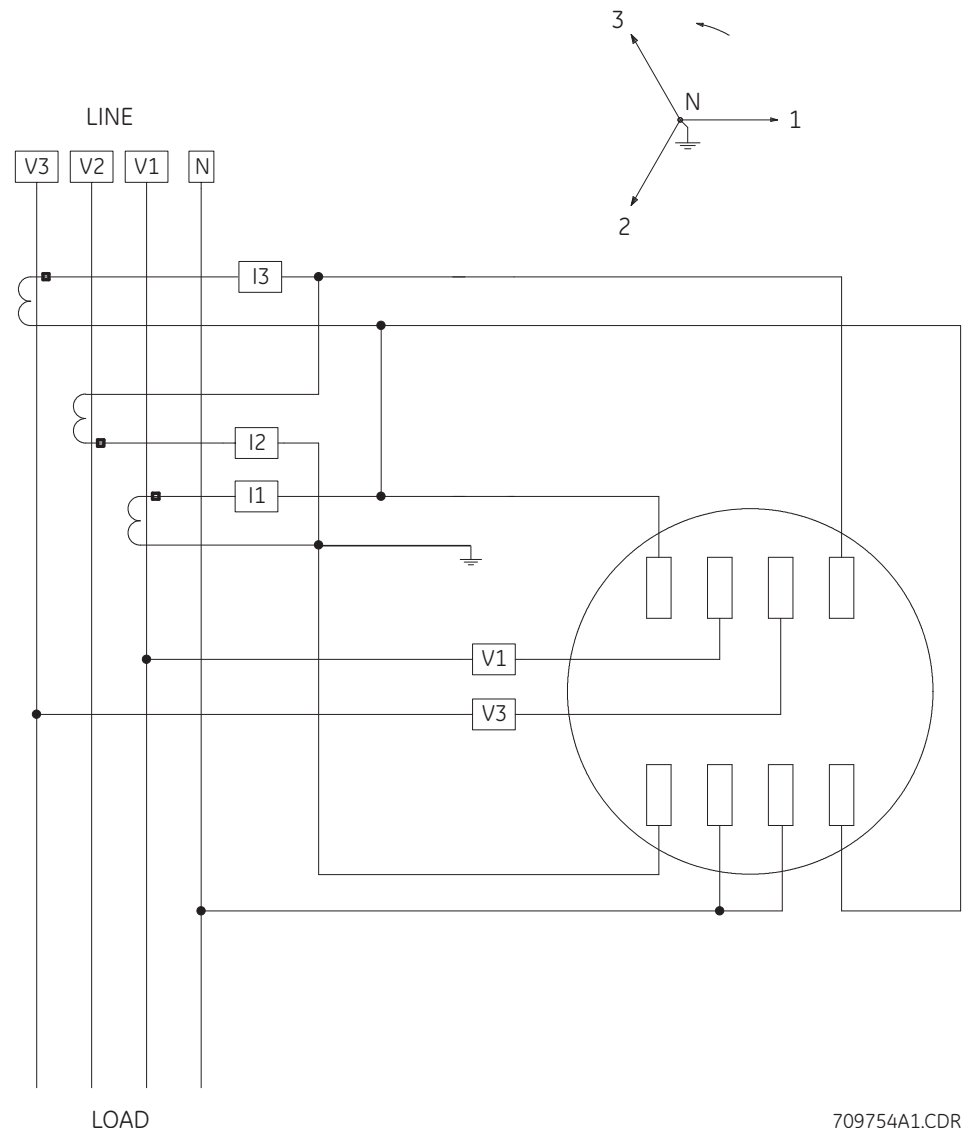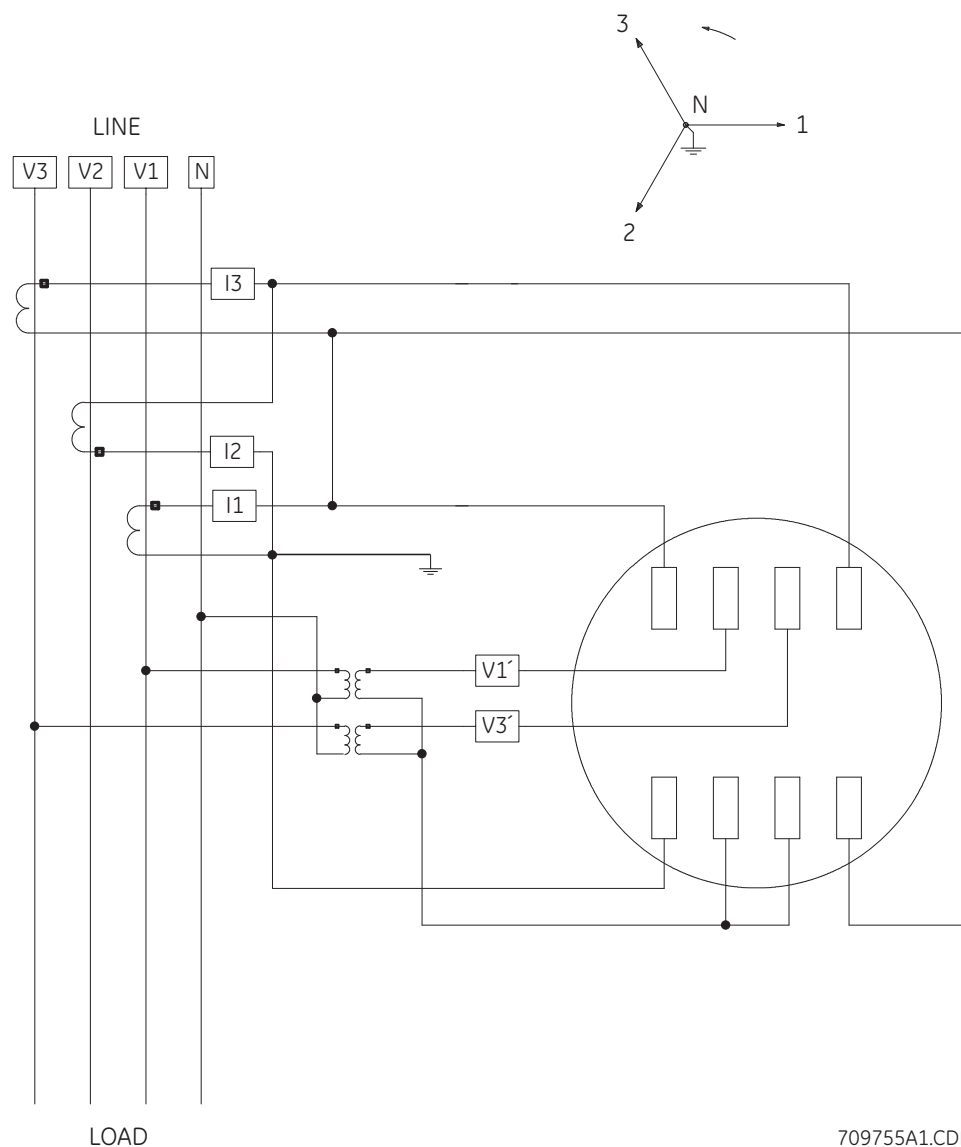


709730A1.CDR

**Figure 3-12: Form 9S wye, no PTs, 3 CTs wiring (standard meter)**

The wiring diagram for form 9S (transformer rated) wye, 4-wire, with no PTs and 3 CTs for the switchboard meter is shown below.

**NOTE** Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.
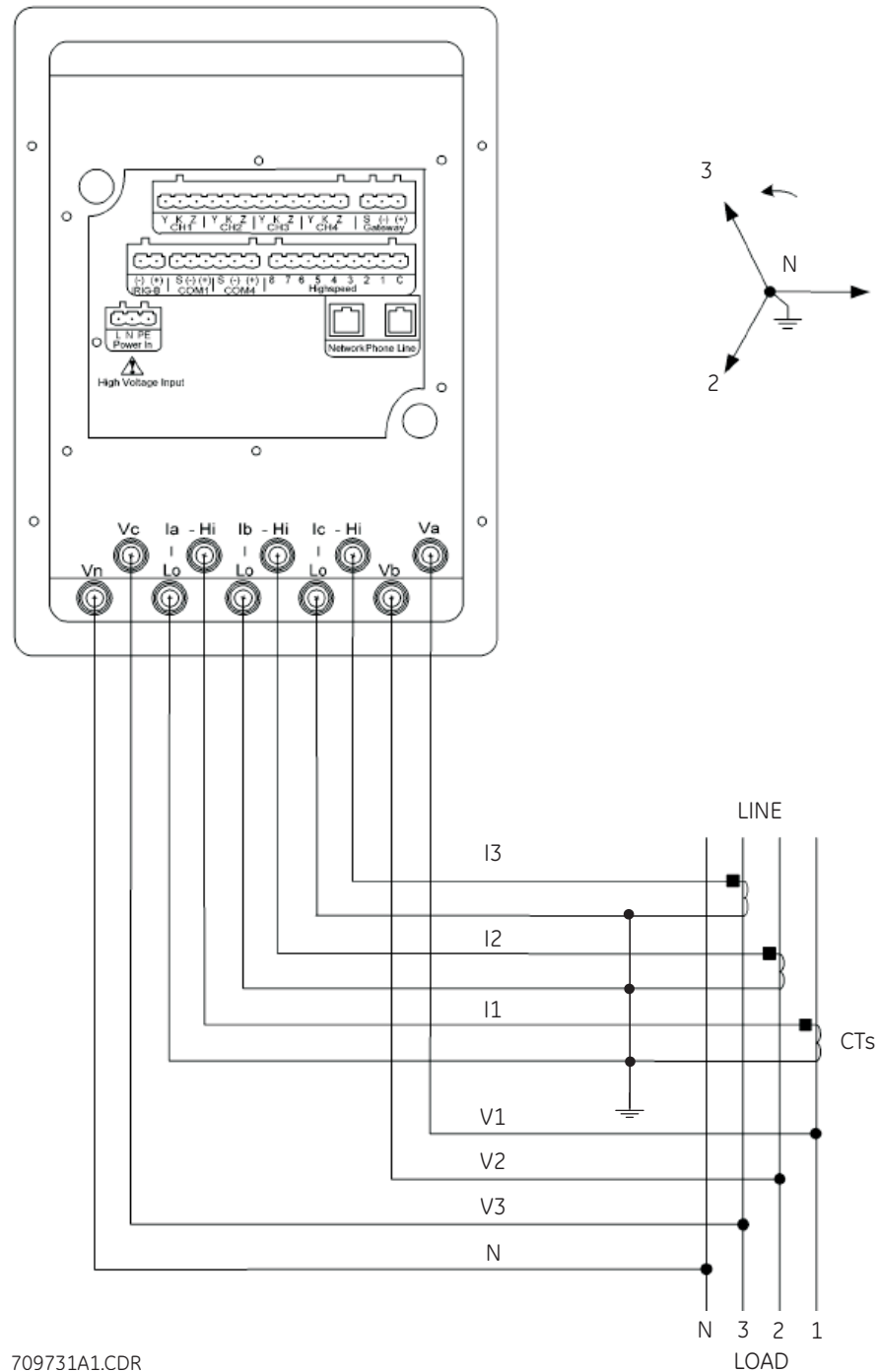


Figure 3-13: Form 9S wye, no PTs, 3 CTs wiring (switchboard meter)

The wiring diagram for form 9S (transformer rated) wye, 4-wire, with 3 PTs and 3 CTs for the standard meter is shown below.

**NOTE** Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.
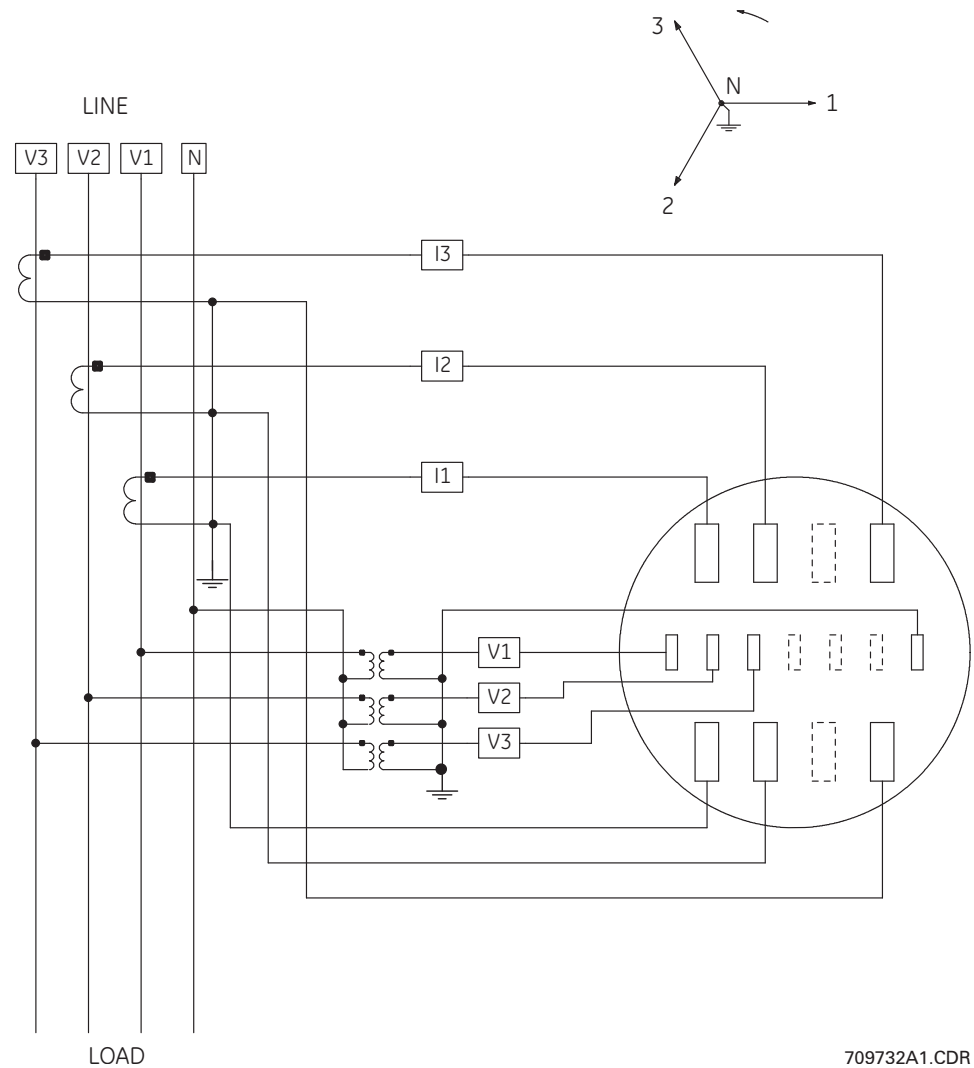
**Figure 3-14: Form 9S wye, 3 PTs, 3 CTs wiring (standard meter)**

The wiring diagram for form 9S (transformer rated) wye, 4-wire, with 3 PTs and 3 CTs for the switchboard meter is shown below.

**NOTE** Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.
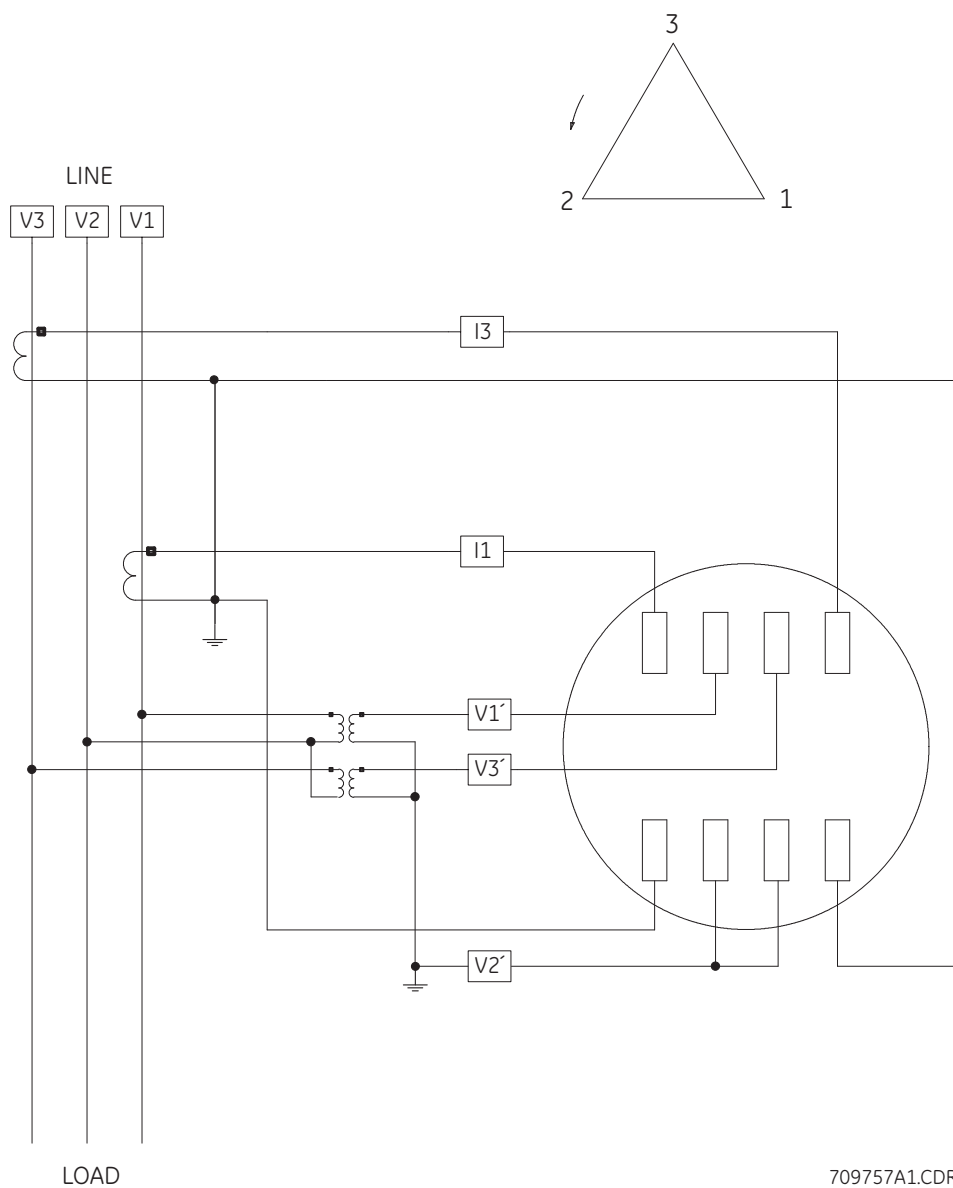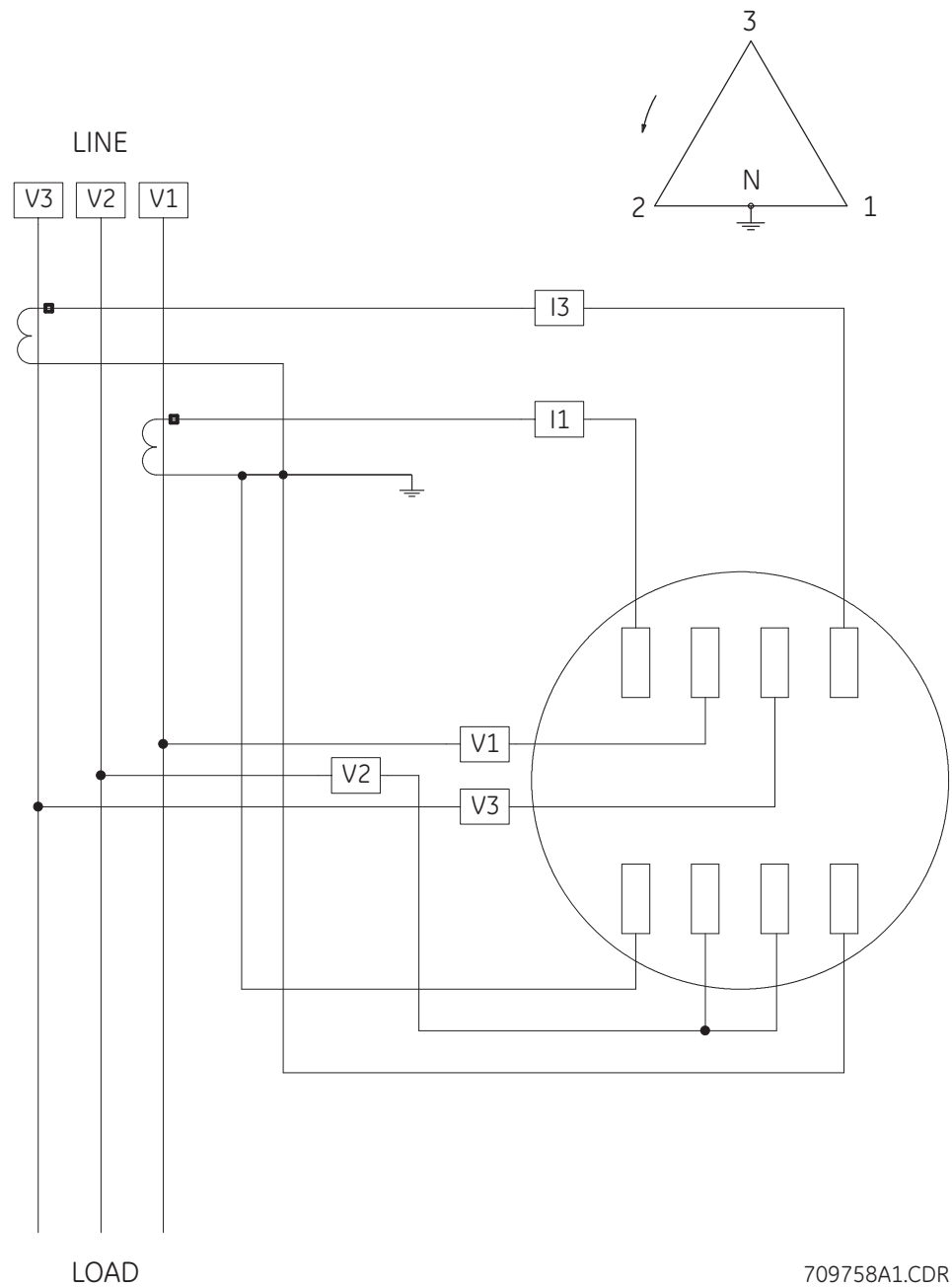


709733A1.CDR
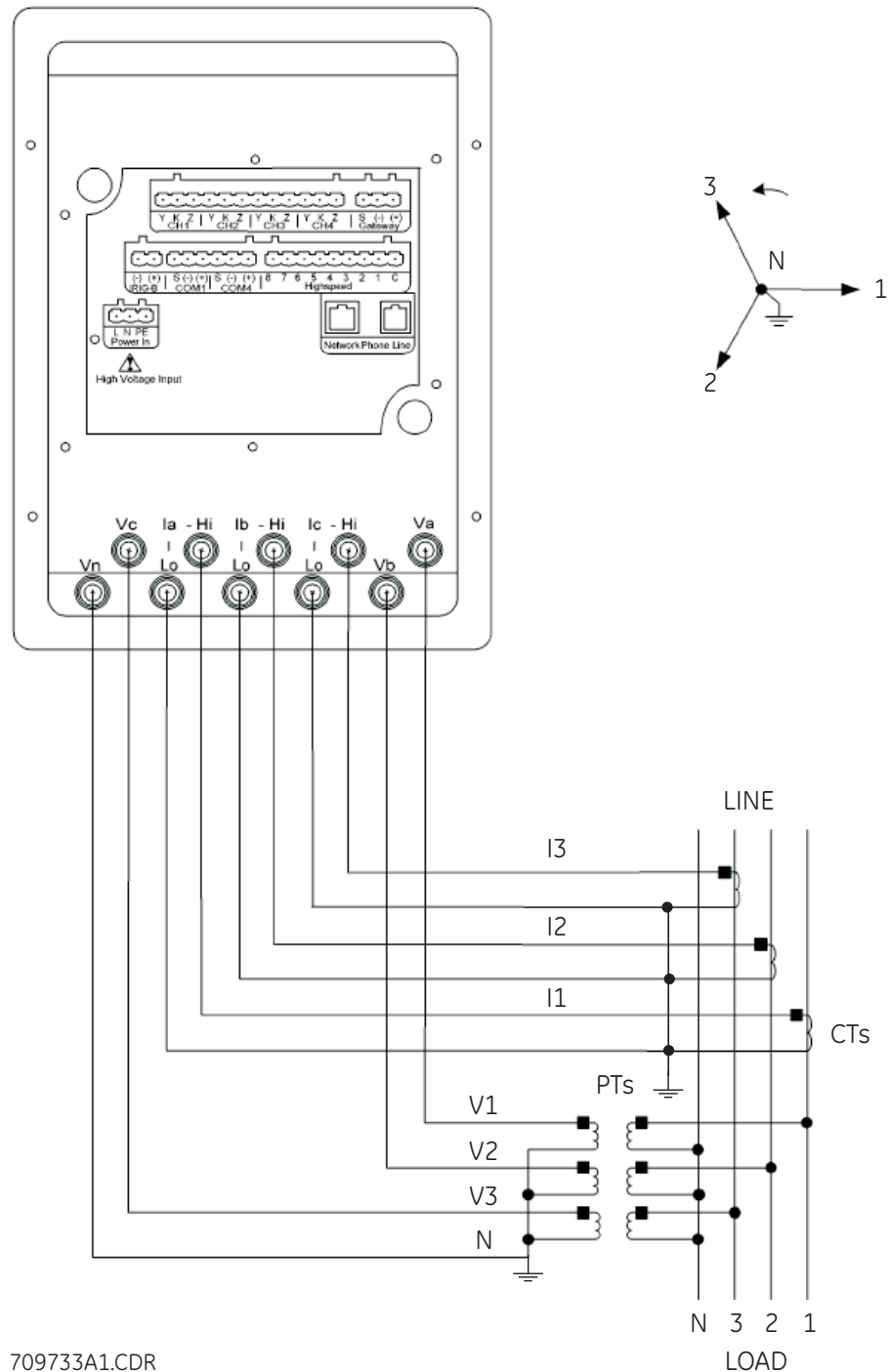
**Figure 3-15: Form 9S wye, 3 PTs, 3 CTs wiring (switchboard meter)**

The wiring diagram for form 9S (transformer rated) delta, 4-wire, with no PTs and 3 CTs for the standard meter is shown below.

**NOTE** Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.
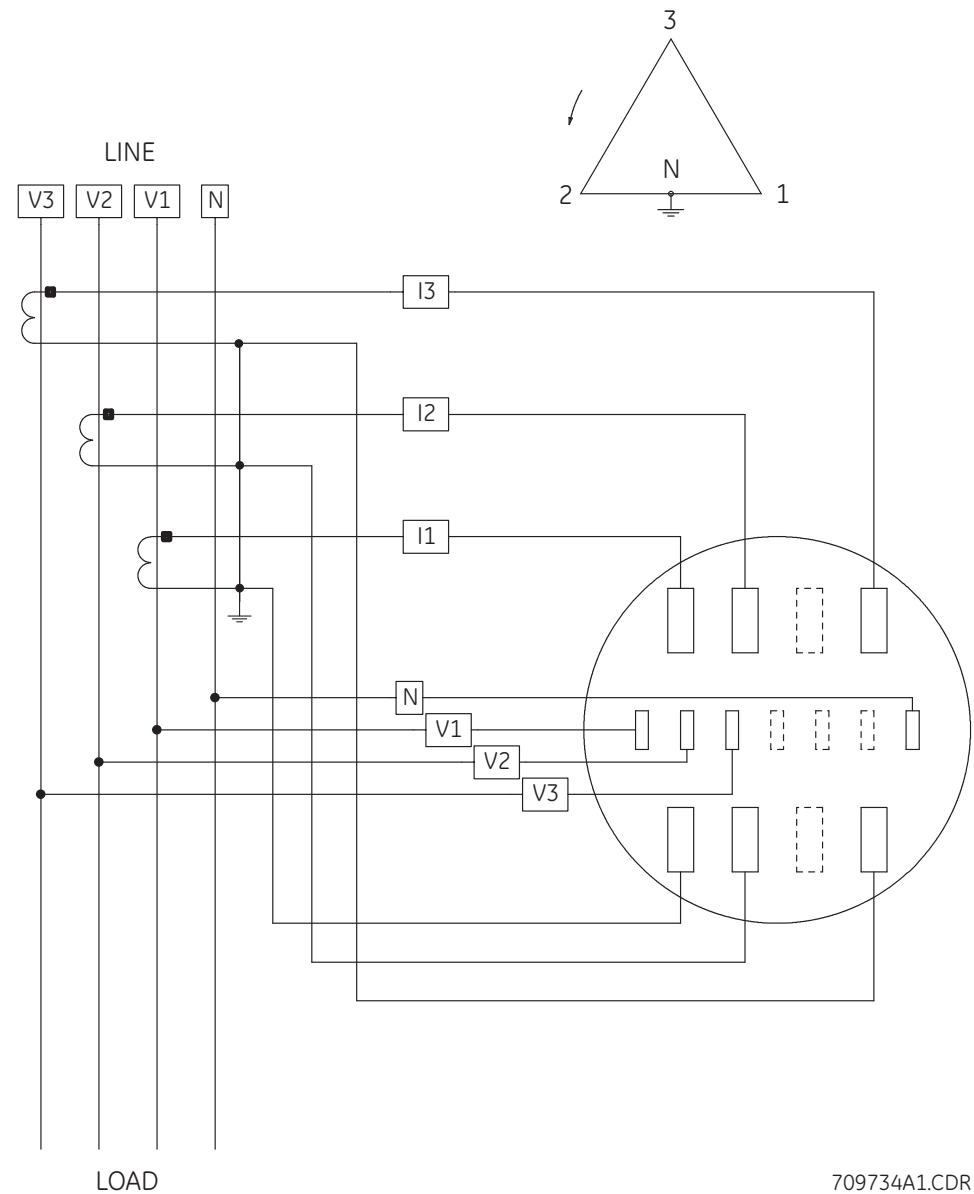


709734A1.CDR

**Figure 3-16: Form 9S 4-wire delta, no PTs, 3 CTs wiring (standard meter)**

The wiring diagram for form 9S (transformer rated) delta, 3-wire, with no PTs and 3 CTs for the switchboard meter is shown below.

**NOTE**

Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.



709735A1.CDR
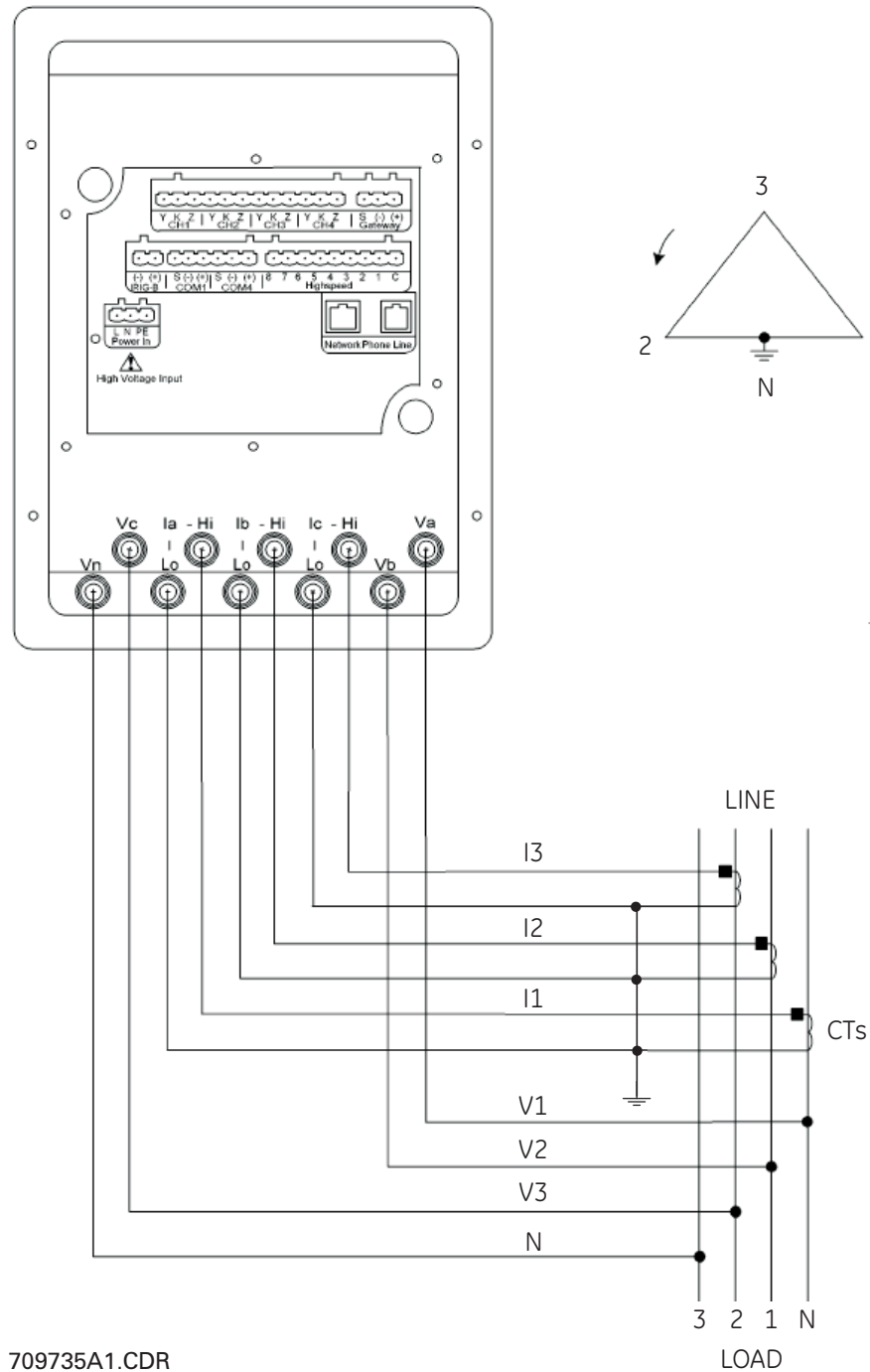
**Figure 3-17: Form 9S 3-wire delta, no PTs, 3 CTs wiring (switchboard meter)**

The wiring diagram for form 9S (transformer rated) delta, 4-wire, with 3 PTs and 3 CTs for the standard meter is shown below.

**NOTE**

Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.
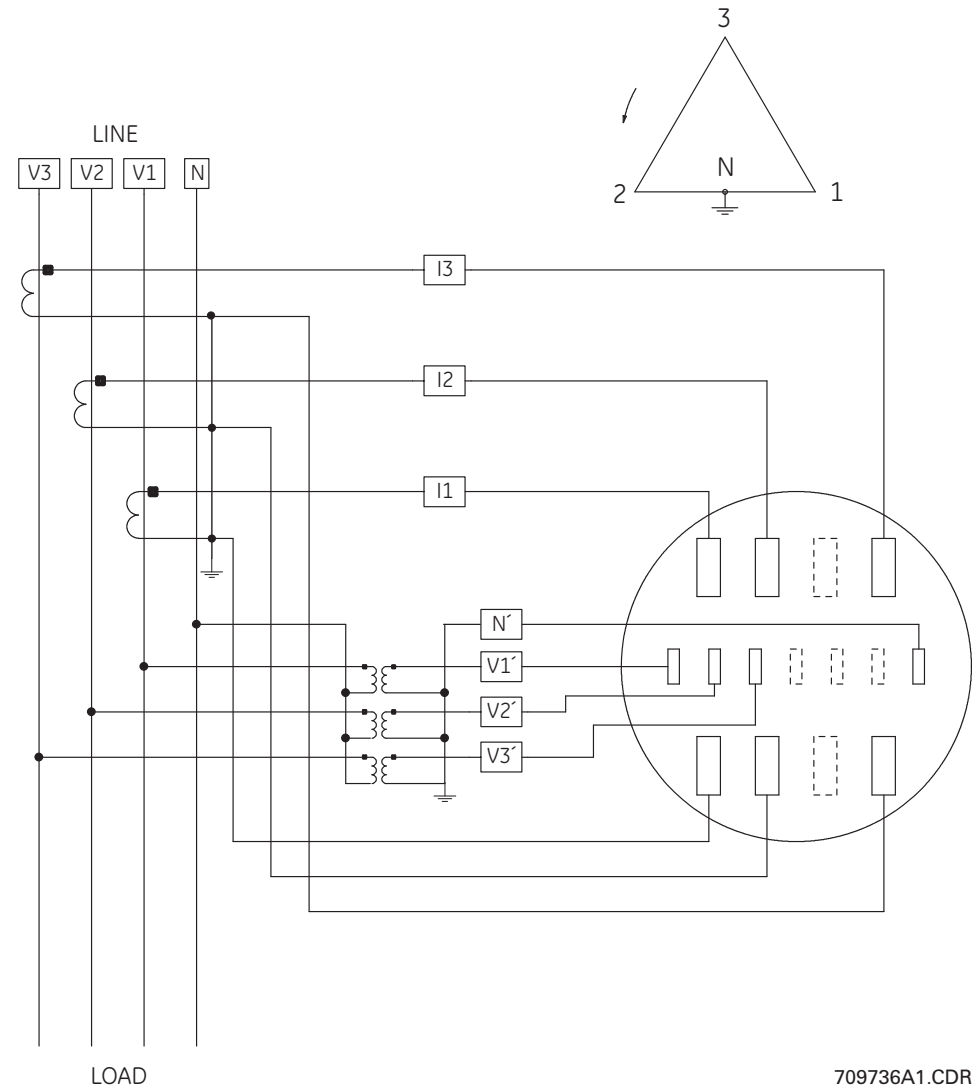


709736A1.CDR

**Figure 3-18: Form 9S 4-wire delta, 3 PTs, 3 CTs wiring (standard meter)**

The wiring diagram for form 9S (transformer rated) delta, 4-wire, with 3 PTs and 3 CTs for the switchboard meter is shown below.

**NOTE**

Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.



709737A1.CDR
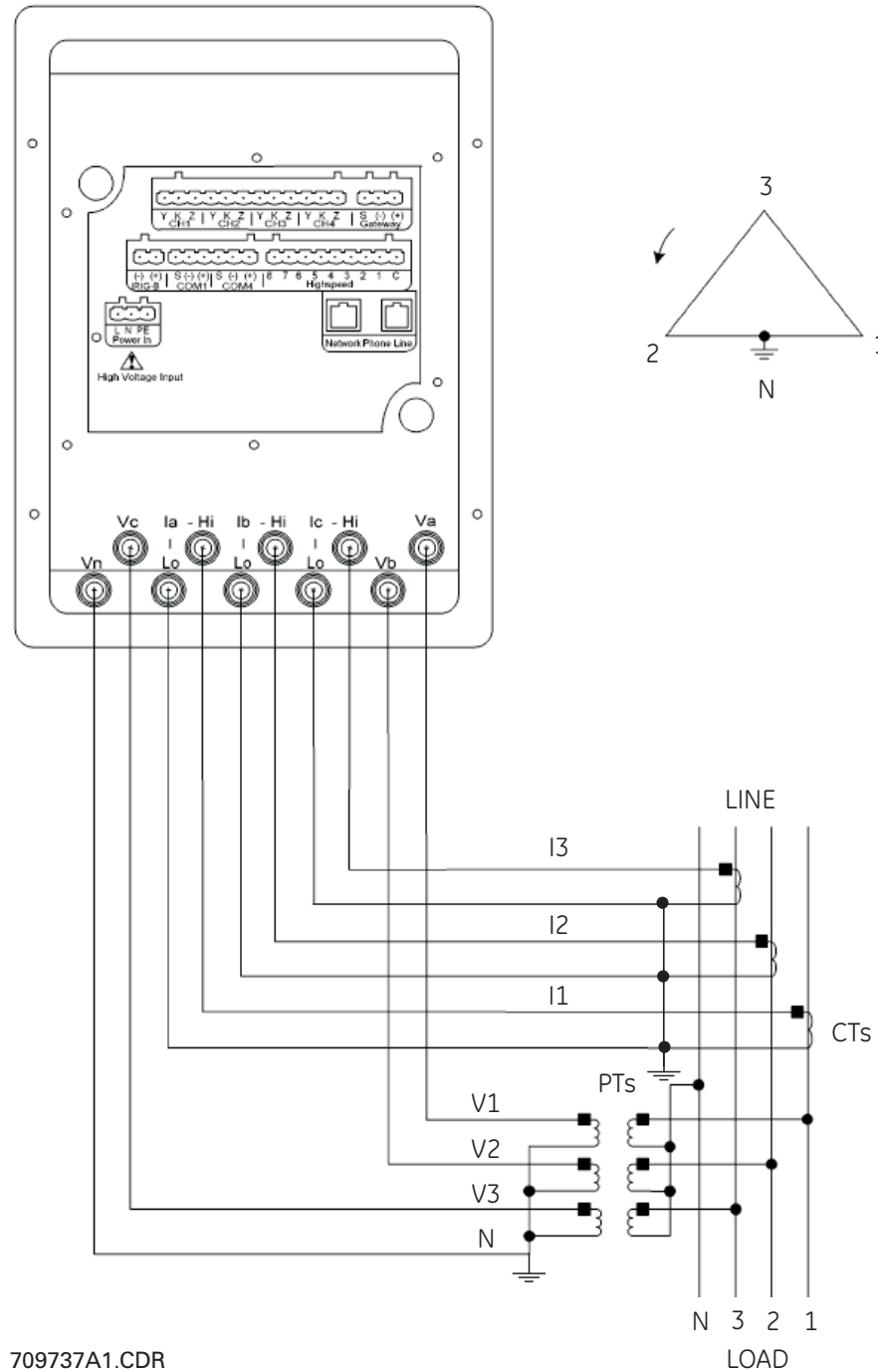
Figure 3-19: Form 9S 4-wire delta, 3 PTs, 3 CTs wiring (switchboard meter)

The wiring diagram for form 9S (transformer rated) delta, 3-wire, with no PTs and 2 CTs for the standard meter is shown below.

**NOTE**

Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.
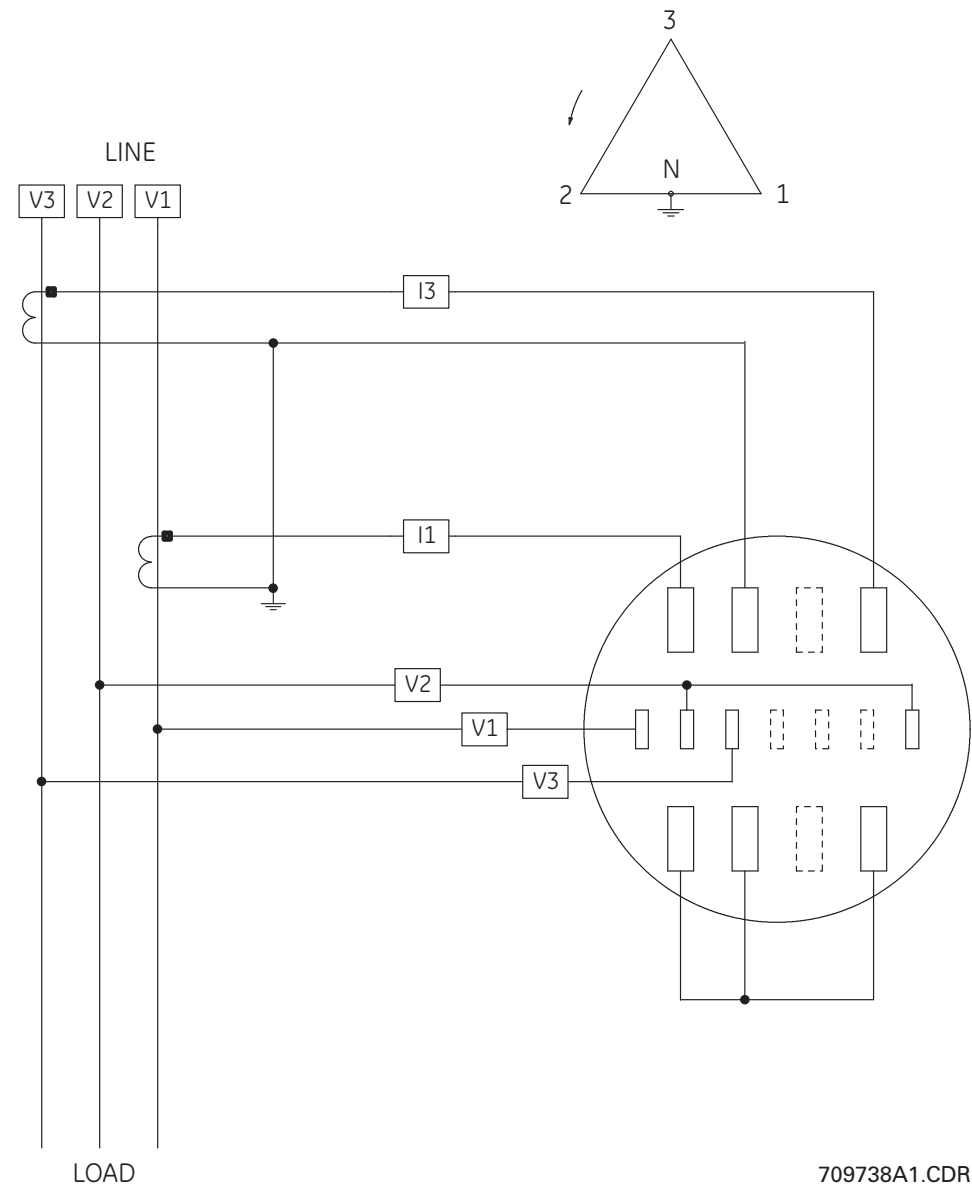
Figure 3-20: Form 9S 3-wire delta, no PTs, 2 CTs wiring (standard meter)

709738A1.CDR

The wiring diagram for form 9S (transformer rated) delta, 3-wire, with no PTs and 2 CTs for the switchboard meter is shown below.

**NOTE**

Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.
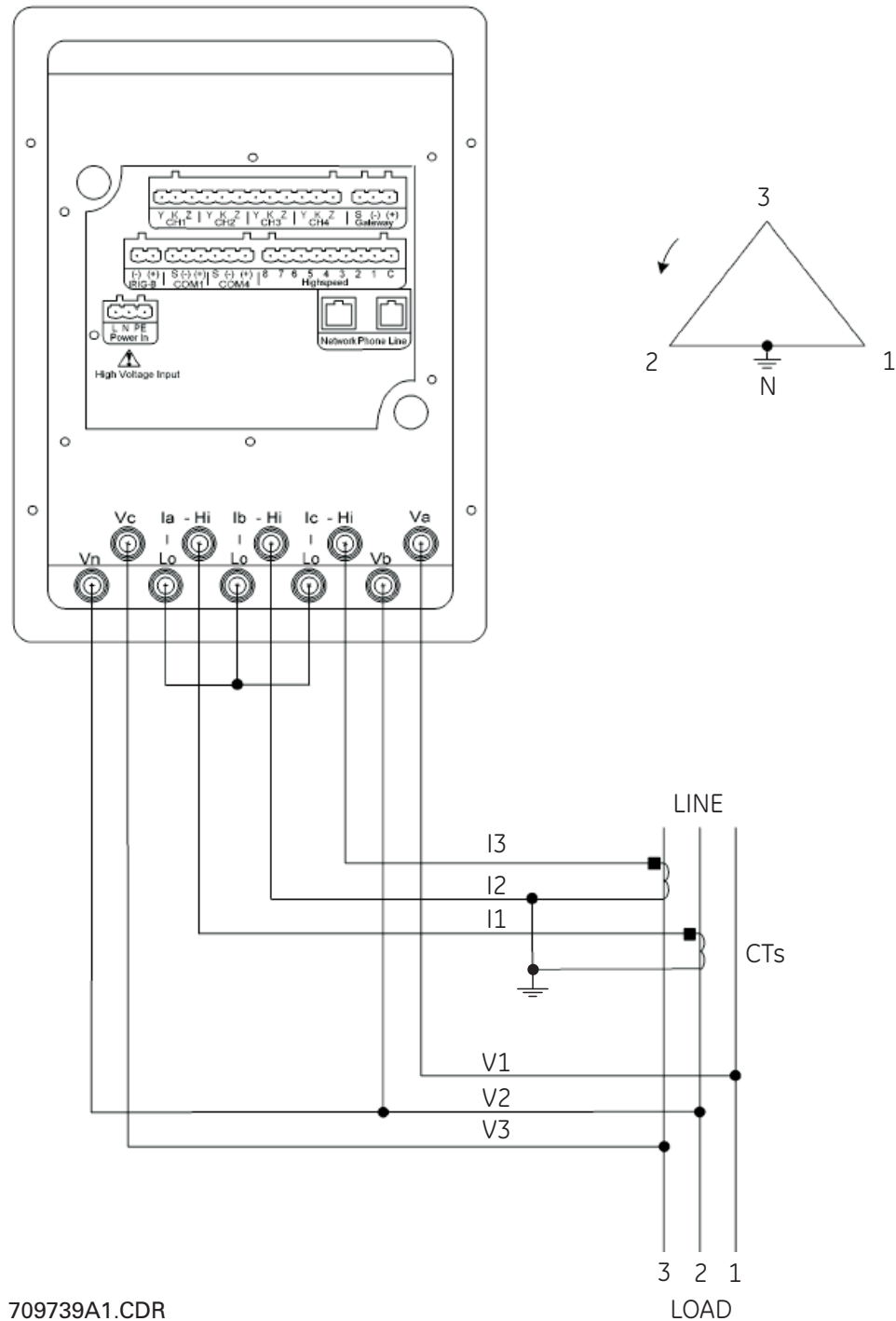


709739A1.CDR

**Figure 3-21: Form 9S 3-wire delta, no PTs, 2 CTs wiring (switchboard meter)**

The wiring diagram for form 9S (transformer rated) delta, 3-wire, with 2 PTs and 2 CTs for the standard meter is shown below.

**NOTE**

Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.

709740A1.CDR
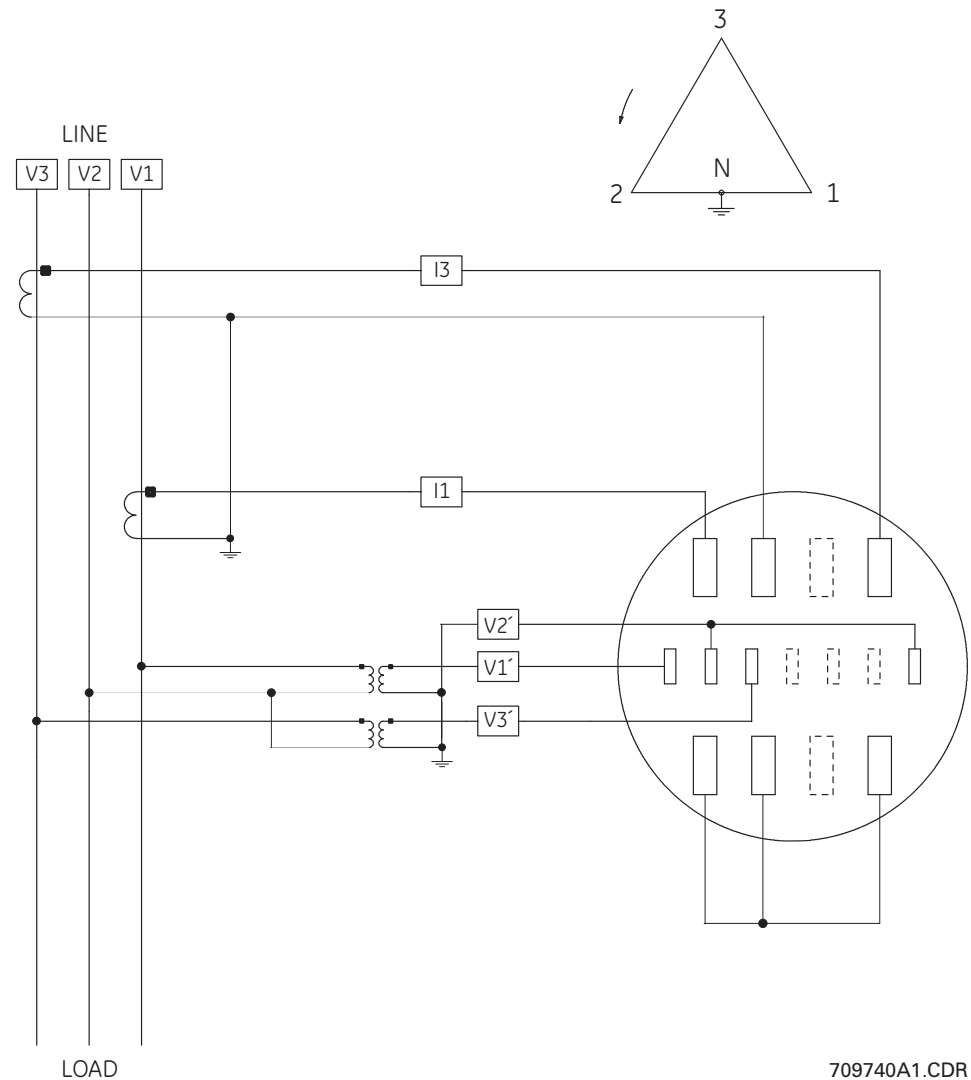
**Figure 3-22: Form 9S 3-wire delta, 2 PTs, 2 CTs wiring (standard meter)**

The wiring diagram for form 9S (transformer rated) delta, 3-wire, with 2 PTs and 2 CTs for the switchboard meter is shown below.

**NOTE** Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.



709741A1.CDR
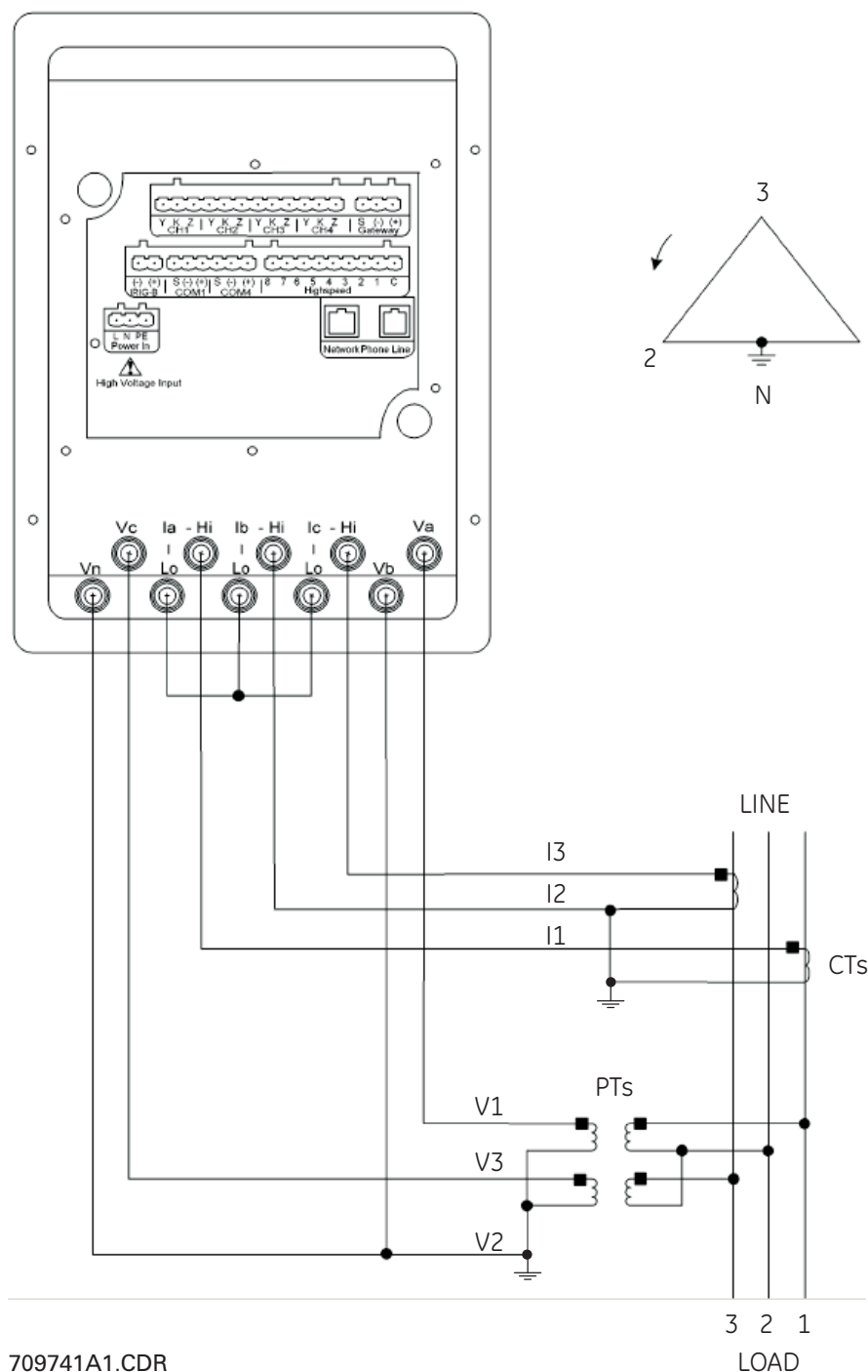
**Figure 3-23: Form 9S 3-wire delta, 2 PTs, 2 CTs wiring (switchboard meter)**

The wiring diagram for form 9S (transformer rated) delta, 3-wire, with no PTs and 2 CTs for the standard meter is shown below.

**NOTE**

Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.
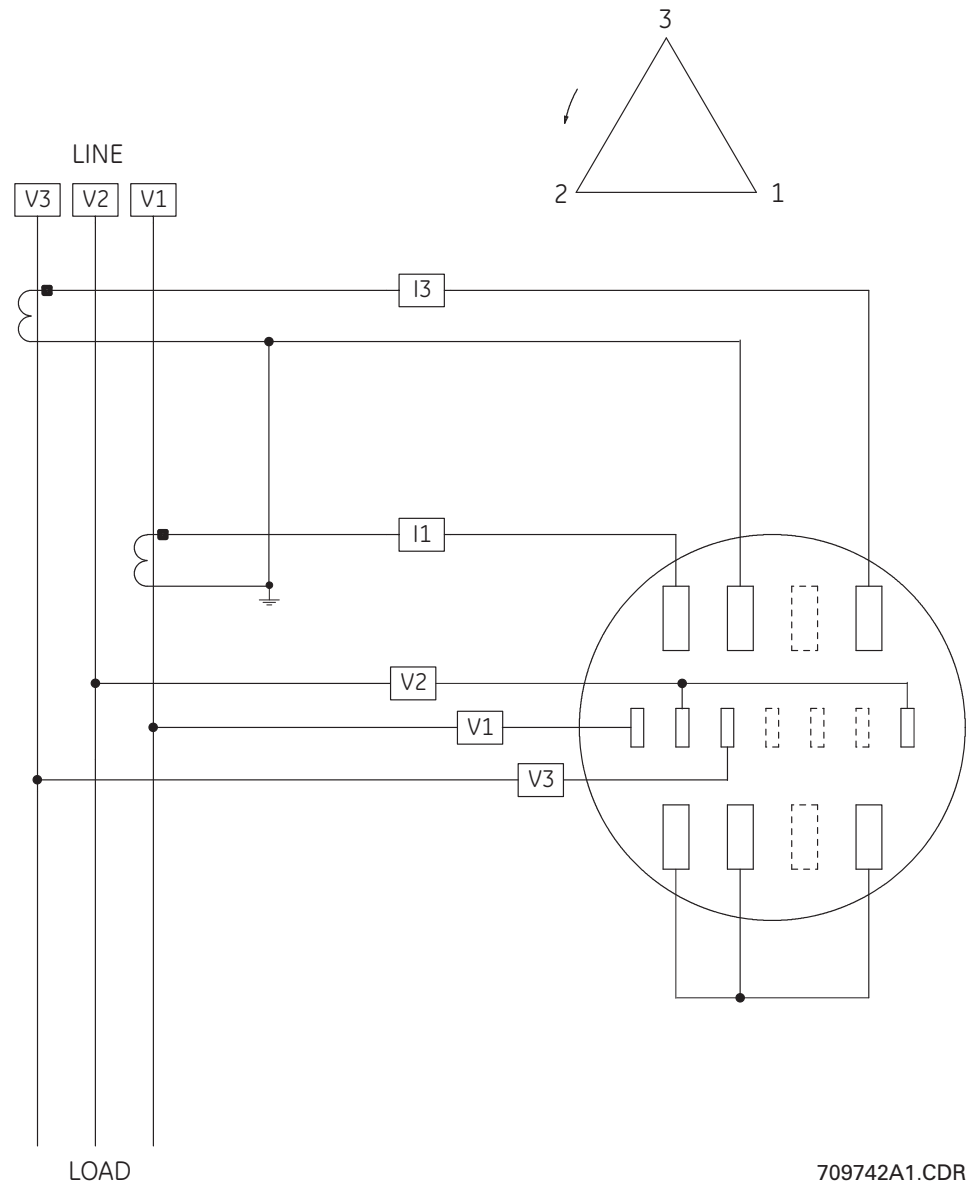


709742A1.CDR

**Figure 3-24: Form 9S 3-wire delta, no PTs, 2 CTs wiring (standard meter)**

The wiring diagram for form 9S (transformer rated) delta, 3-wire, with no PTs and 2 CTs for the switchboard meter is shown below.

**NOTE** Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.
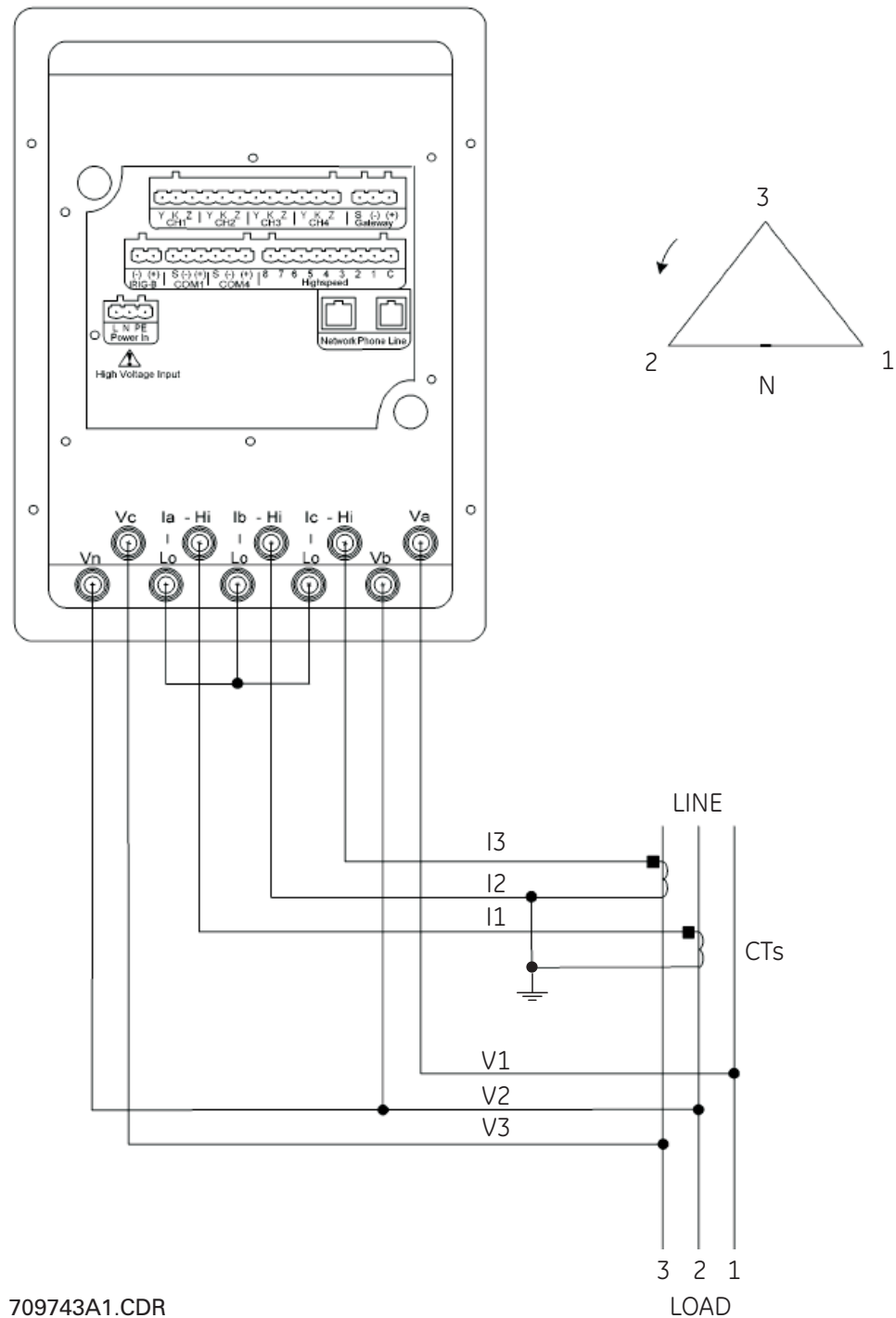


709743A1.CDR

**Figure 3-25: Form 9S 3-wire delta, no PTs, 2 CTs wiring (switchboard meter)**

The wiring diagram for form 9S (transformer rated) delta, 3-wire, with 2 PTs and 2 CTs for the standard meter is shown below.

**NOTE**

Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.
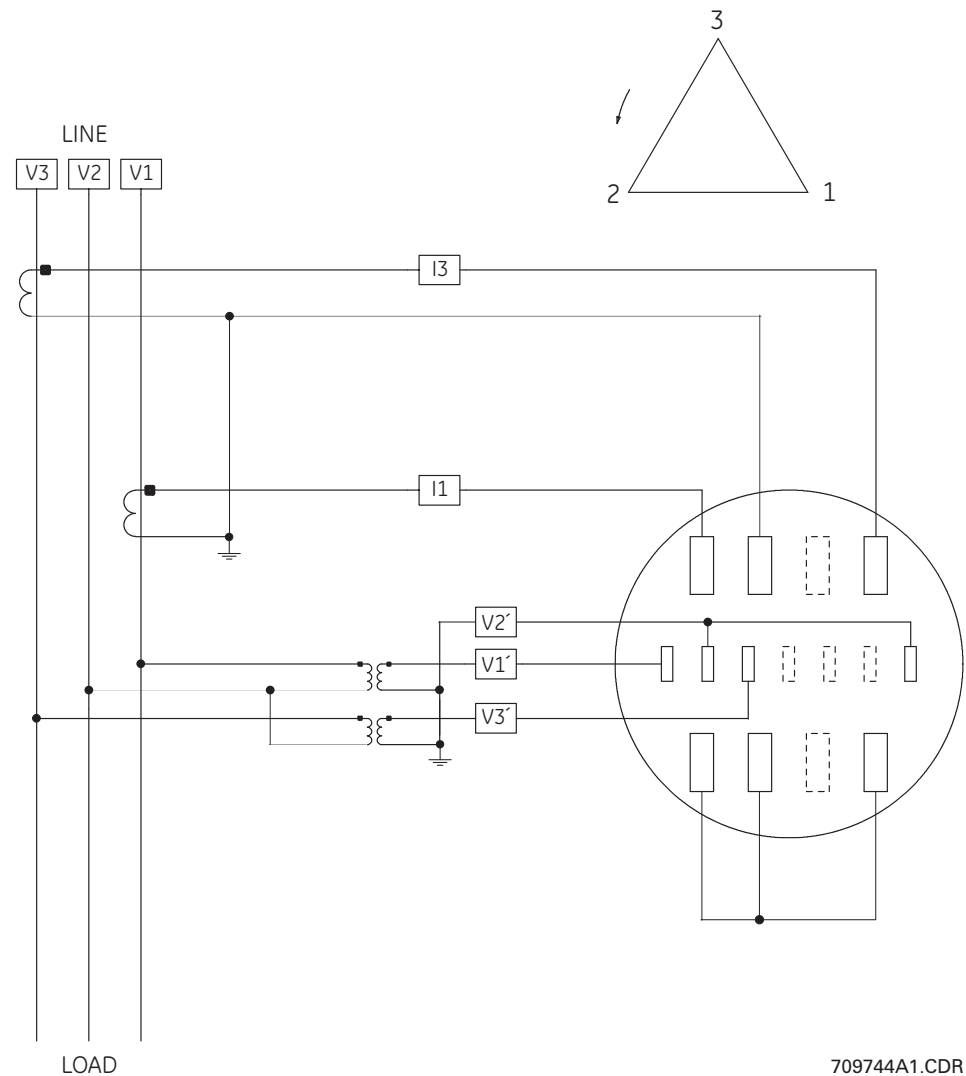


709744A1.CDR

**Figure 3-26: Form 9S 3-wire delta, 2 PTs, 2 CTs wiring (standard meter)**

The wiring diagram for form 9S (transformer rated) delta, 3-wire, with 2 PTs and 2 CTs for the switchboard meter is shown below.

**NOTE** Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.
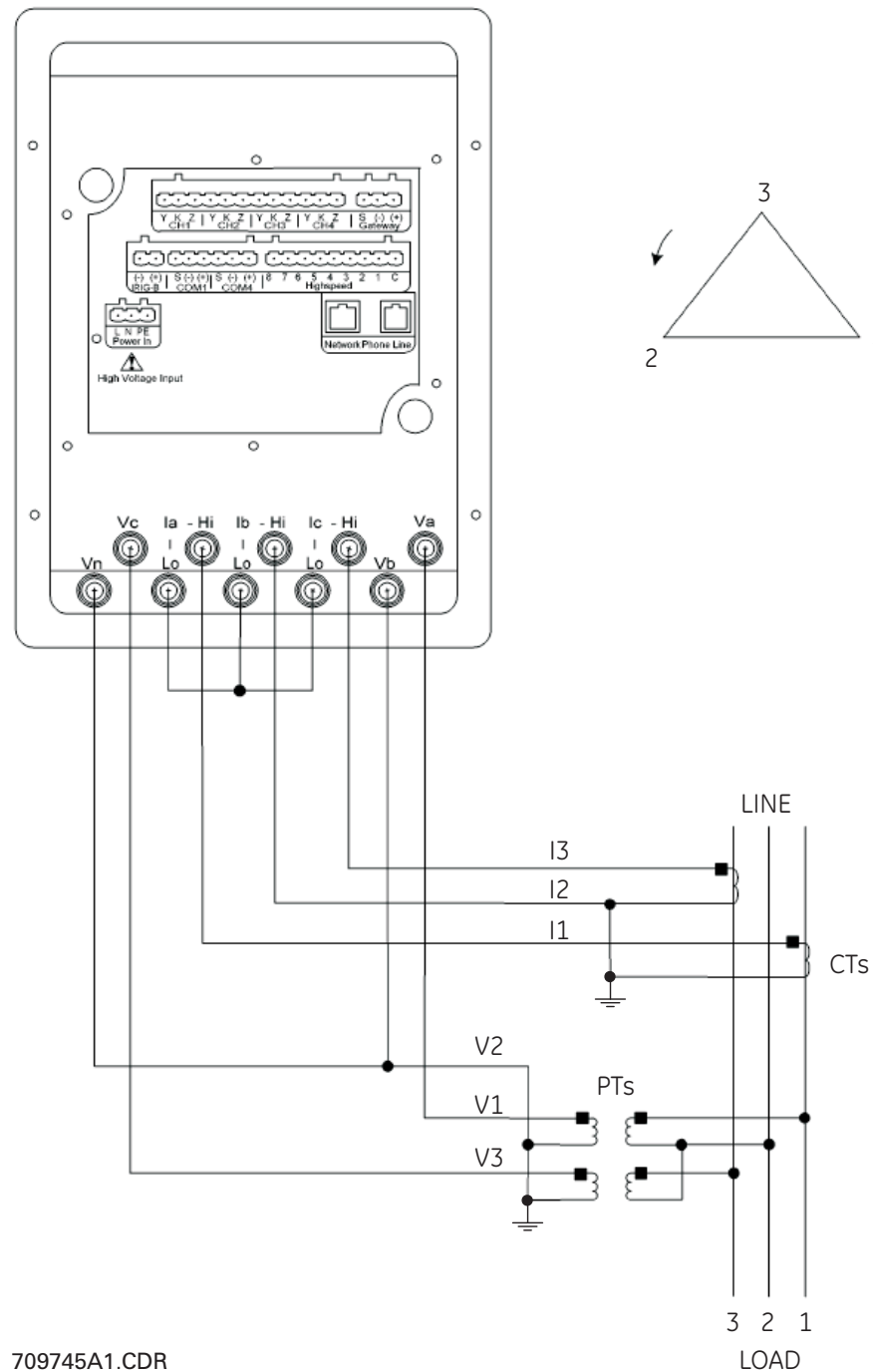


709745A1.CDR

**Figure 3-27: Form 9S 3-wire delta, 2 PTs, 2 CTs wiring (switchboard meter)**

The wiring diagram for form 36S (transformer rated) wye, 2.5-element, with no PTs and 3 CTs for the standard meter is shown below.

**NOTE**

Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.
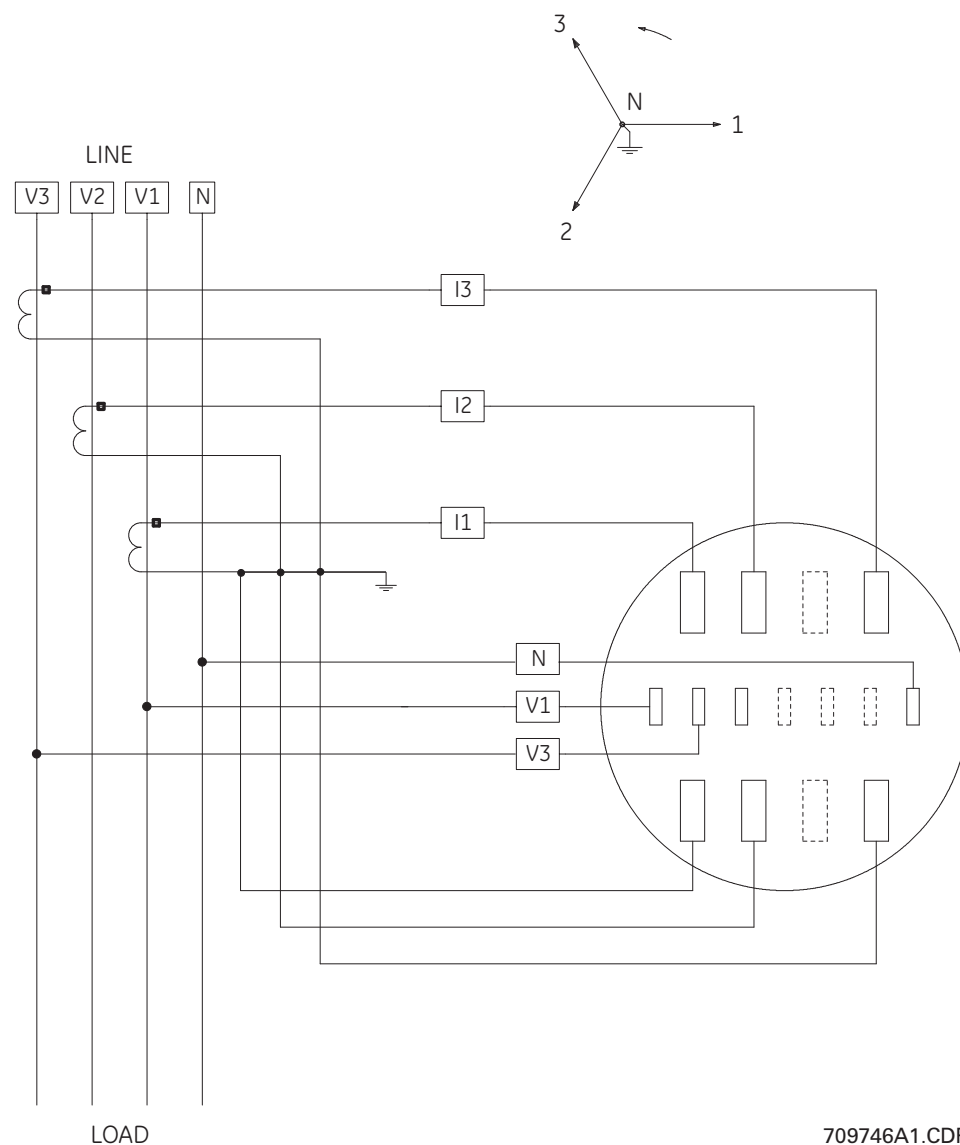


**Figure 3-28: Form 36S 2.5-element wye, no PTs, 3 CTs wiring (standard meter)**

709746A1.CDR

The wiring diagram for form 36S (transformer rated) wye, 2.5-element, with no PTs and 3 CTs for the switchboard meter is shown below.

**NOTE**

Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.



709747A1.CDR

**Figure 3-29: Form 36S 2.5-element wye, no PTs, 3 CTs wiring (switchboard meter)**

The wiring diagram for form 36S (transformer rated) wye, 2.5-element, with 2 PTs and 3 CTs for the standard meter is shown below.

**NOTE** Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.



709748A1.CDR

**Figure 3-30: Form 36S 2.5-element wye, 2 PTs, 3 CTs wiring (standard meter)**

The wiring diagram for form 36S (transformer rated) wye, 2.5-element, with 2 PTs and 3 CTs for the switchboard meter is shown below.

> **NOTE**
>
> Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.



709749A1.CDR

**Figure 3-31: Form 36S 2.5-element wye, 2 PTs, 3 CTs wiring (switchboard meter)**

The wiring diagram for form 45S (transformer rated) wye, 4-wire, with no PTs and 3 CTs for the standard meter is shown below.

**NOTE**

Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.



709754A1.CDR

**Figure 3-32: Form 45S 4-wire wye, no PTs, 3 CTs wiring (standard meter)**

The wiring diagram for form 45S (transformer rated) wye, 4-wire, with 2 PTs and 3 CTs for the standard meter is shown below.

**NOTE** Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.



709755A1.CDR

**Figure 3-33: Form 45S 4-wire wye, 2 PTs, 3 CTs wiring (standard meter)**

The wiring diagram for form 45S (transformer rated) delta, 3-wire, with no PTs and 2 CTs for the standard meter is shown below.

**NOTE**

Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.
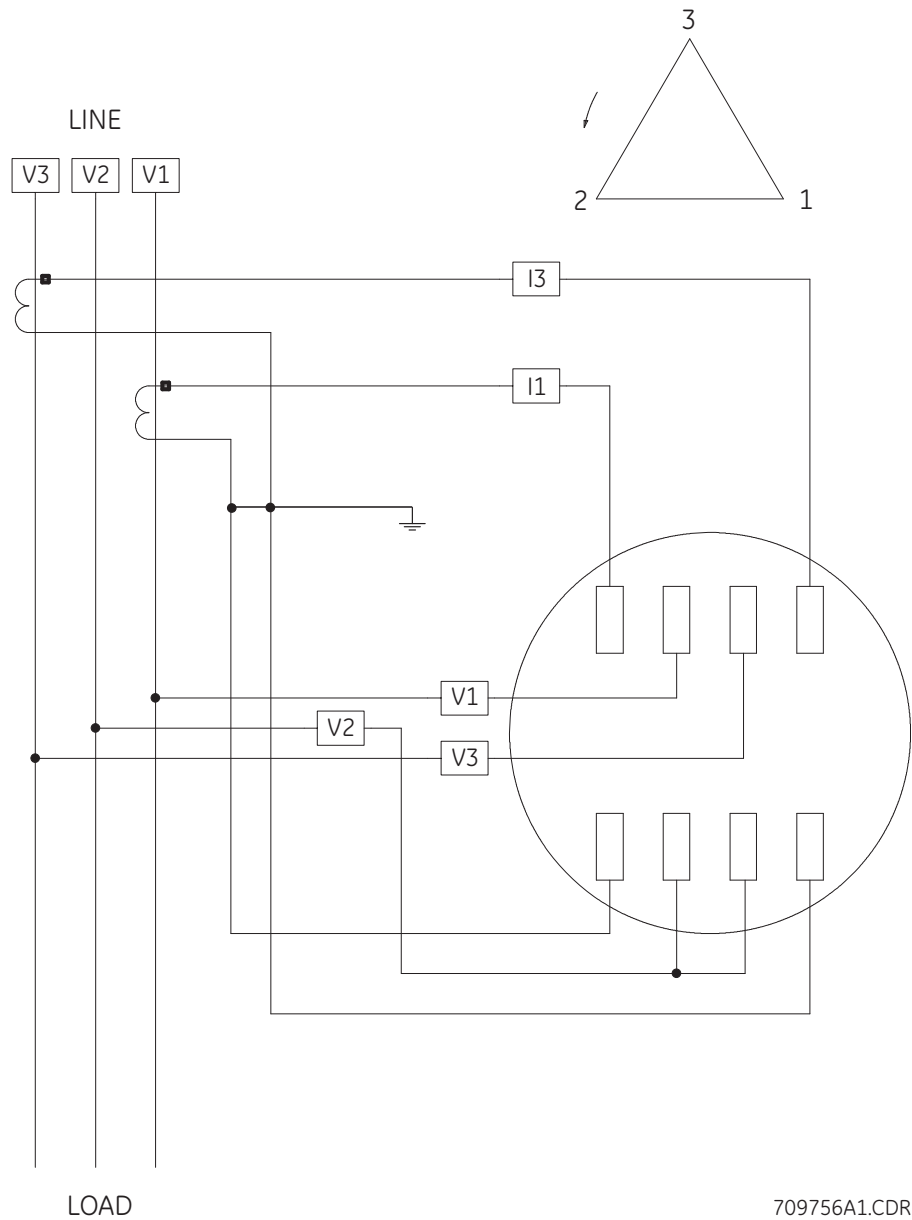


709756A1.CDR

**Figure 3-34: Form 45S 3-wire delta, no PTs, 2 CTs wiring (standard meter)**

The wiring diagram for form 45S (transformer rated) delta, 3-wire, with 2 PTs and 2 CTs for the standard meter is shown below.

**NOTE** Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.



**Figure 3-35: Form 45S 3-wire delta, 2 PTs, 2 CTs wiring (standard meter)**

709757A1.CDR

The wiring diagram for form 45S (transformer rated) delta, 4-wire, with no PTs and 2 CTs for the standard meter is shown below. Neutral is not shown for simplicity.

**NOTE**

Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.

709758A1.CDR

**Figure 3-36: Form 45S 4-wire delta, no PTs, 2 CTs wiring (standard meter)**

The wiring diagram for form 45S (transformer rated) delta, 4-wire, with 2 PTs and 2 CTs for the standard meter is shown below. Neutral is not shown for simplicity.

**NOTE**

Actual installation procedures, materials, equipment, and connections must conform to applicable codes and standards.

709759A1.CDR
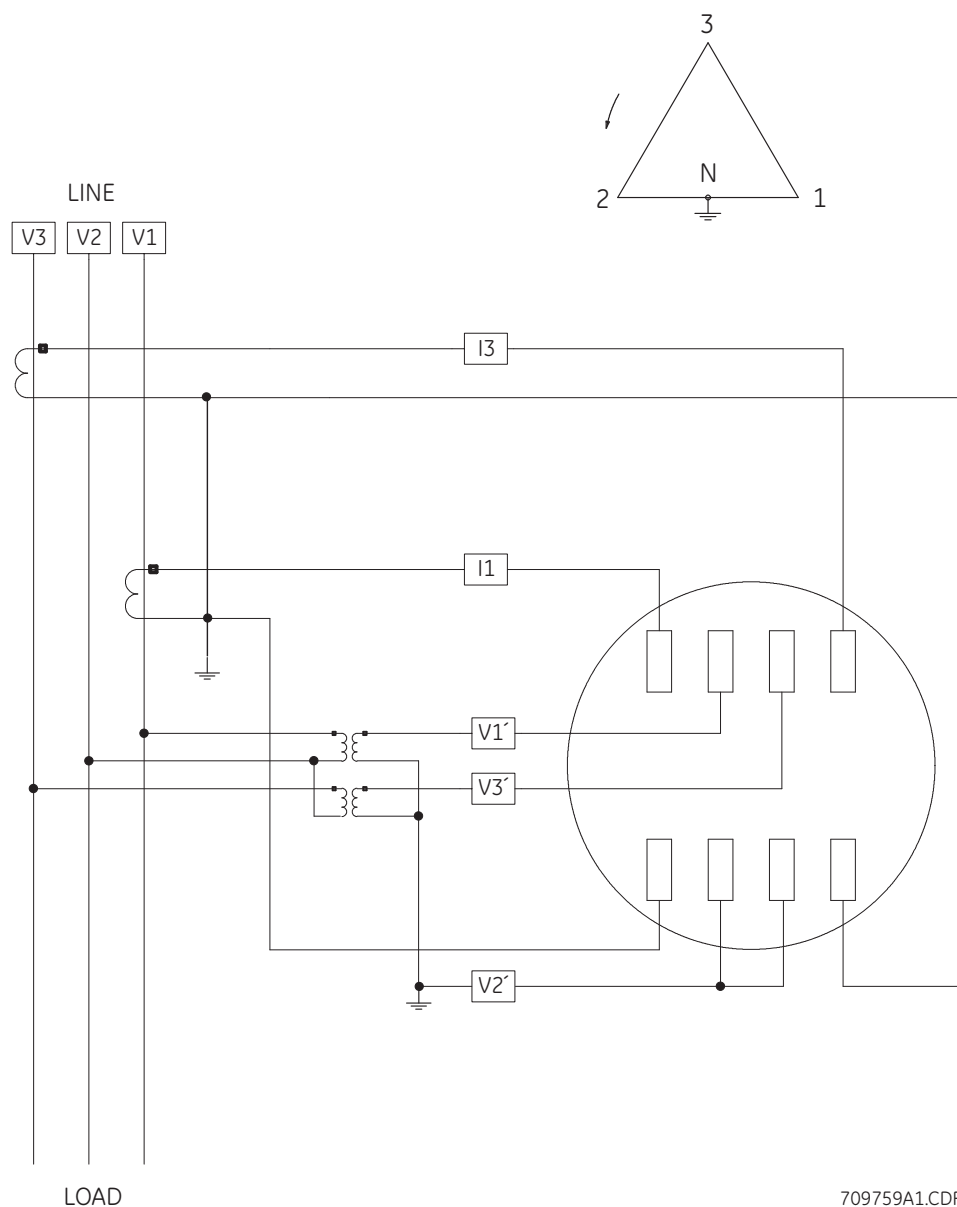
**Figure 3-37: Form 45S 4-wire delta, no PTs, 2 CTs wiring (standard meter)**

### 3.2.2    Output Module Wiring

The EPM 9800 will not supply power for the output modules. An additional power supply, such as the PSIO, must be used. The wiring is the same for all modules.



Auxiliary power is supplied through pins 4 and 5

Connection through SHIELD, B–, and A+ to the EPM 9800 port 4

PWR+
PWR–
SHIELD
B(–)
A(+)
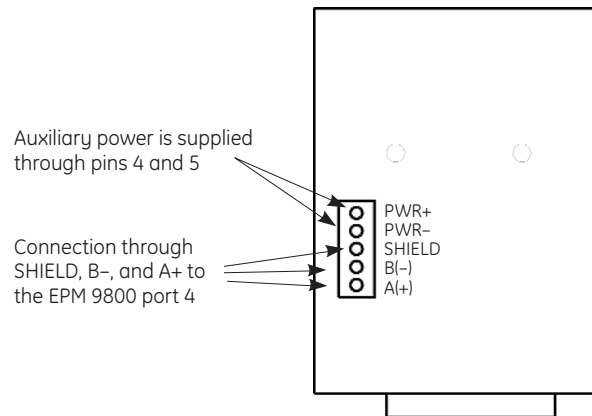
**Figure 3-38: Output pin detail**

output modules must use the EPM 9800 port 4. Six feet of RS485 cable harness is supplied. Attach one end of the cable to the port (connectors may not be supplied); insert the other end into the communication pins of the module RS485 side port (see details below).



A(+)  B(–)  S    V–   V+

Male side port on output module

$R_T$

+    External
–    power
      source

PSIO

$R_{T*}$ (for runs typically longer than 500 feet)

EPM 9800 port 4

S    A(+)  B(–)
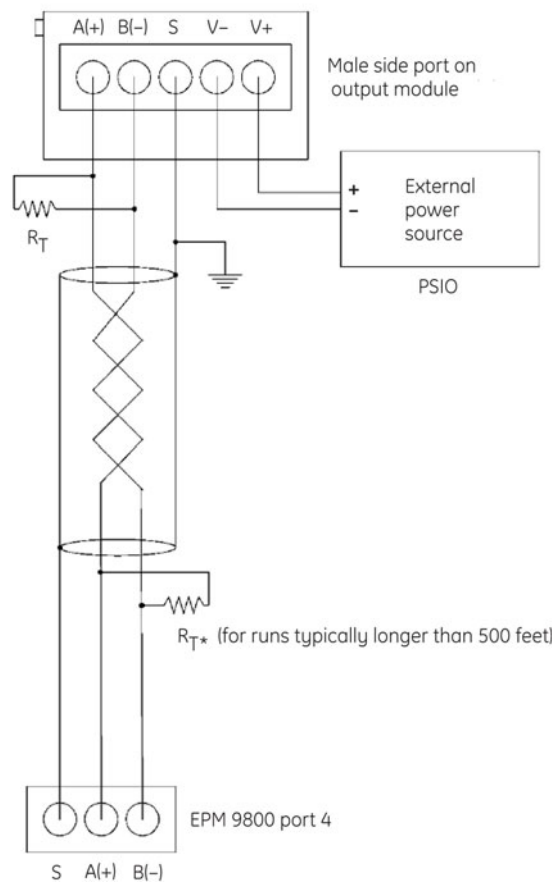
**Figure 3-39: EPM 9800 connected to output module**

### 3.2.3    High-speed Inputs Wiring

The high-speed inputs can be used in multiple ways:

1.   By attaching the KYZ pulse outputs from other meters for pulse counting and totalizing.

2.   By attaching status contacts from relays, breakers or other devices for status or waveform initiation.
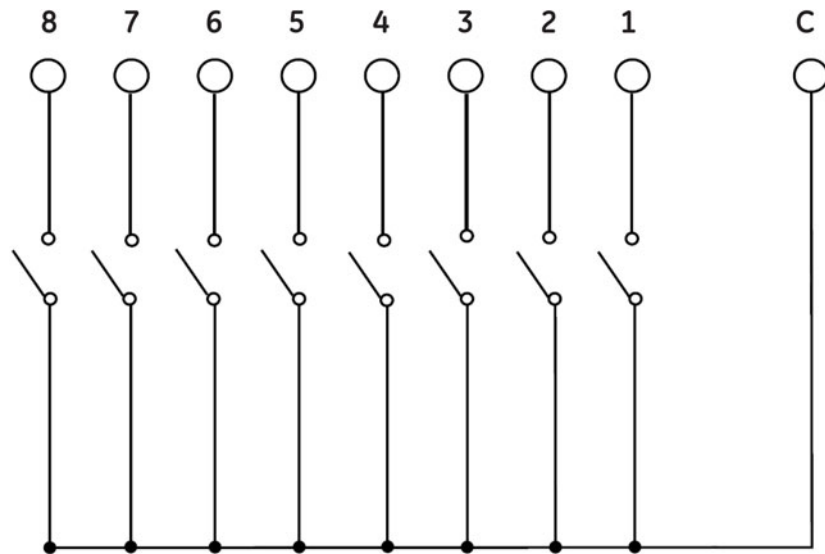


**Figure 3-40: High speed inputs connection**

### 3.2.4    IRIG-B Wiring

IRIG-B is a standard time code format that synchronizes event time stamping to within 1 ms. An IRIG-B signal-generating device connected to the GPS satellite system will synchronize EPM 9800 meters located at different geographic locations. The meter utilizes an *unmodulated* signal from a satellite-controlled clock. For details on installation, refer to the instruction manual for the satellite-controlled clock in use.
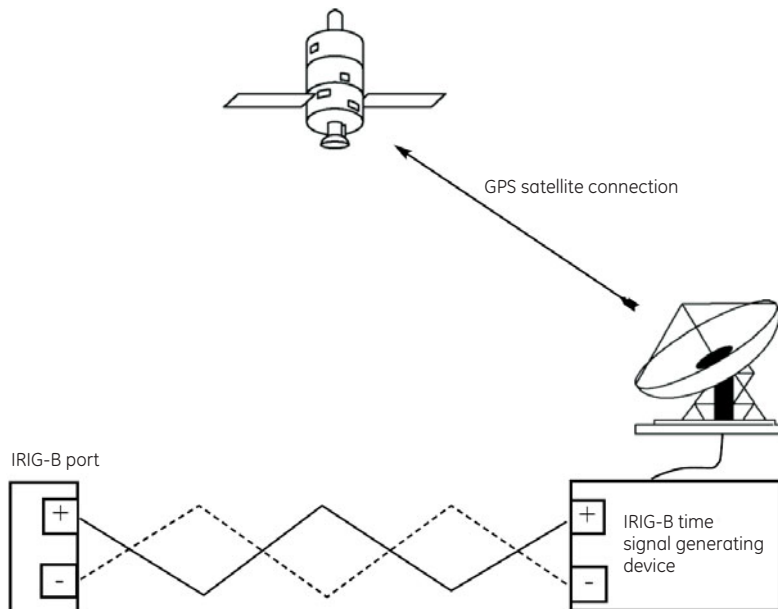


**Figure 3-41: IRIG-B connection**

Use the following procedure to install IRIG-B:

▷   Set the EPM 9800 time settings from the GE Communicator EXT software by selecting the **Time Settings** item in the device profile.

▷   Set the time zone and daylight savings time then update the device profile to save the new settings.

▷  Before connection, ensure that the date on the satellite clock is
   correct (or, within 2 months of the actual date).
   This provides the correct year for the clock (the GPS does not
   supply the year).

▷  Connect the positive (+) terminal of the meter to the positive (+)
   terminal of the signal generating device.

▷  Likewise, connect the negative (–) terminal of the meter to the
   negative (–) terminal of the signal generating device.

The most common source of problems with IRIG-B is a reversal of the positive and negative
wires. Try reversing the wires if problems occur.

# GE Consumer & Industrial
## Multilin

# EPM 9800 Advanced Power Quality Metering System

# Chapter 4: Operating Instructions

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## 4.1    Nameplate Information

### 4.1.1    Faceplate

The EPM 9800 Advanced Power Quality Metering System has operating information represented on the nameplate, located on the face of the meter. See below for details.



Form factor diagram

Ratios and constants

Mode switch

Power data

**Figure 4-1: EPM 9800 faceplate**

The ratios and constants shown on the left side of the front panel include

- multiply by constant
- voltage transformer ratio (or PT ratio)
- current transformer ratio (or CT ratio)
- primary watt-hour constant

The power data shown on the bottom of the faceplate includes

- current class
- test current
- watt-hour test constant

- ANSI C12.20 form number
- ANSI C12.20 accuracy class

### 4.1.2    Options Label

The options label is adhered to the outside of the internal shroud. It indicates the ordered options included in the meter. The label below is an example of a typical label.



**Figure 4-2: EPM 9800 options label**

## 4.2    Basic Operations

### 4.2.1    Switches and Indicators

There are two switches accessible from outside the meter cover.

1.    The **mode switch** (also called a reed switch) is used to switch from normal mode to circuit diagnostic mode or time of use mode.

2.    The **reset switch** is used to reset demand.

A third switch, the test button, is accessible only when the cover has been removed. The test button switches the meter from one of the operational modes to test mode and back to normal mode. The test button is also used to access display adjustments mode during power up mode. The display adjustments mode is discussed in the next section.

The optical port is on the lower left side of the faceplate. The optical port facilitates infrared communication with the meter. Using a SC-3 smart coupler (or other ANSI C12.13 Type II magnetic optical communications coupler) and an RS232 cable from the smart coupler to a PC, the meter can be programmed with the GE Communicator EXT software.

An infrared test pulse is located on the upper left side of the faceplate. Energy pulsing applications can be configured using GE Communicator EXT.

A phase indicator is located on the lower right side of the faceplate. "ABC" will stay illuminated if all three phases of voltage and current are present. "ACB" indicates reversed phase sequence. It will blink A, B or C if one phase is not present. If all phases are not present, the meter will turn off (unless there is an auxiliary pigtail connected to a power source).

### 4.2.2    Display Information

The EPM 9800 uses a graphical back-lit LCD programmable display with extended temperature voltage compensation. This allows viewing of energy data and the gathering of circuit diagnostic data such as voltage, current, harmonics, and phasor information.

A wide range of values can be defined for display using the user modes and screens in the programmable display and GE Communicator EXT software. Three view modes plus test mode and a select compensation screen allow tremendous flexibility in setting up the modes and the screens within the modes. View modes are user created with up to 16 screens each, which display in auto sequence every 7 seconds. Most of the screens have a status bar across the bottom which displays the date, time and phase (if there are inputs). View mode 1 is the primary mode. The other modes will automatically return to view mode 1 after a user-set amount of time from last user action.

•    Low battery: The **Lo Batt - NVRAM** (internal battery) or **Lo Batt - Modem** (modem battery) message will flash on the screen being displayed every 10 to 15 seconds *only* when the internal (or modem) battery is running low or when it is not "clicked" into place properly. If the batteries are OK, no indicator will appear.

•    Test mode: The following test modes are available.

Wh test - Same as kWh screen, except in Wh instead of kWh;

VARh test - Same as kVAR screen, except in VARh (quadrants);

VAh test - Same as kVAh screen, except in VAh (quadrants);

Watt rolling demand test (delivered and received);

Watt block demand test (delivered and received)

- Initial display screens: The EPM 9800 is shipped with initial display screens, which will scroll on the display the meter is powered up. The initial display screens are a sampling of the many screens available for the programmable display, which is detailed in *Programmable Display* on page 4–8.

- Backlight: The backlight cannot be set to stay on indefinitely. It will turn off after the amount of time selected. One hour is the maximum setting. If the backlight has timed out and is off, press the mode switch once to turn on the backlight and redirect the screen automatically.

## 4.2.3  Time Synchronization

The following time synchronization methods are available:

- **IRIG-B**: All EPM 9800 meters are equipped to use IRIG-B for time sychronization. If IRIG-B is connected, this form of time synchronization takes precedence over the internal clock. If the GPS signal is lost, the internal clock takes over time keeping at the precise moment the signal is lost.

- **Line synchronization**: All EPM 9800 meters are equipped with line synchronization, which may be enabled for use instead of IRIG-B. If line synchronization is enabled and power is lost, the internal clock takes over at the precise moment power is lost.

- **Internal clock**: All EPM 9800 meters are equipped with internal clocks, which can be used if IRIG-B is not connected and/or line synchronization is not enabled. If either of the above time sychronization tools fails, the internal clock will take over at the precise moment the synchronization tool in use fails.

## 4.2.4  Time-of-Use (TOU)

A time-of-use (TOU) usage structure takes into account the quantity of energy used and the time at which it was consumed. The EPM 9800 TOU function, available with the GE Communicator EXT software, is designed to accommodate a variety of programmable rate structures. EPM 9800 TOU accumulates data based on the time-scheme programmed into the EPM 9800 meter.

A EPM 9800 TOU calendar sets the parameters for TOU data accumulation. Up to twenty calendars can be stored in the meter, and an unlimited number of calendar files can be stored on a PC.

The EPM 9800 TOU calendar profile allows a programmable usage schedule – for example, "weekday," "weekend," "holiday" – for each day of the calendar year. Up to 16 time-of-use schedules can be created. Each TOU schedule divides the 24-hour day into fifteen-minute intervals from 00:00:00 to 23:59:59.

One of eight different programmable registers—e.g. "peak," "off peak," "shoulder peak"— may be applied to each fifteen-minute interval.

The EPM 9800 meter stores accumulations as follows:

- on a seasonal basis, up to four seasons per year;
- on a monthly basis.

Seasonal and monthly accumulations may span one year into the next. Each season and month is defined by a programmable start/billing date, which is also the end-date of the prior season or month.

- A season ends at midnight of the day before the start of the next season.
- A month ends at midnight of the month's billing day.

If the year ends and there is no new calendar, TOU accumulations will stop. If a calendar is present for the following year, TOU accumulations continue until the next monthly bill date or next start-of-season is reached. Accumulation can span into the following year. If no following year is present, the last accumulation for the year will end on 12:31:23:59:59.

The EPM 9800 stores accumulations for the prior time periods. When the end of a billing period is reached, the active period of time becomes frozen. The registers are then cleared and accumulations resume, using the next set of TOU schedules and register assignments from the stored calendar. Frozen and active accumulations are always available.

The GE Communicator EXT software retrieves TOU calendars from the EPM 9800 or from the computer's hard drive for review and edit. A maximum of twenty yearly calendars can be stored in the EPM 9800 at any given time. These may be retrieved them one at a time; a new calendar can be stored while a current calendar is in use.

Accumulations do not stop during calendar updates. If a calendar is replaced while in use, the accumulations for the current period will continue until the set end date. At that point, the current time will become the new start time and the settings of the new calendar will be used. Reset the current accumulations if a calendar in use is replaced. A reset clears only the current accumulation registers. This causes the current accumulations to use the present date as the start and accumulate to the next new end date, which will be taken from the new calendar. Once stored, prior accumulations are always available and cannot be reset. Refer to the GE Communicator EXT User Manual for details on resetting TOU accumulations.

At the end of a defined period, current accumulations are stored, the registers are cleared and accumulations for the next period begin. When the year boundary is crossed, the second calendar, if present, is used. To retain continuity, a one year period is provided to replace the old calendar with one for the following year.

If required, daylight saving time must be enabled in the **Time Settings** area of the EPM 9800 device profile.

▷ Select **Auto DST**, which sets daylight saving time automatically (for the United States ONLY).

▷ Otherwise, select **User Defined**.

▷ Manually enter the desired dates for daylight saving time. Refer to the GE Communicator EXT User Manual for additional details.
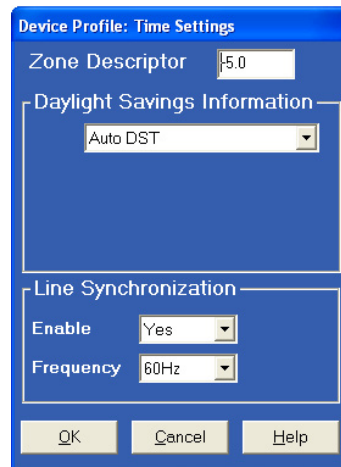
**Figure 4-3: Time settings window**

To set demand intervals,

▷ Select the **Revenue & Energy Settings > Demand Integration Intervals** item from the device profile and set the desired intervals.

▷ Click **OK** when complete.
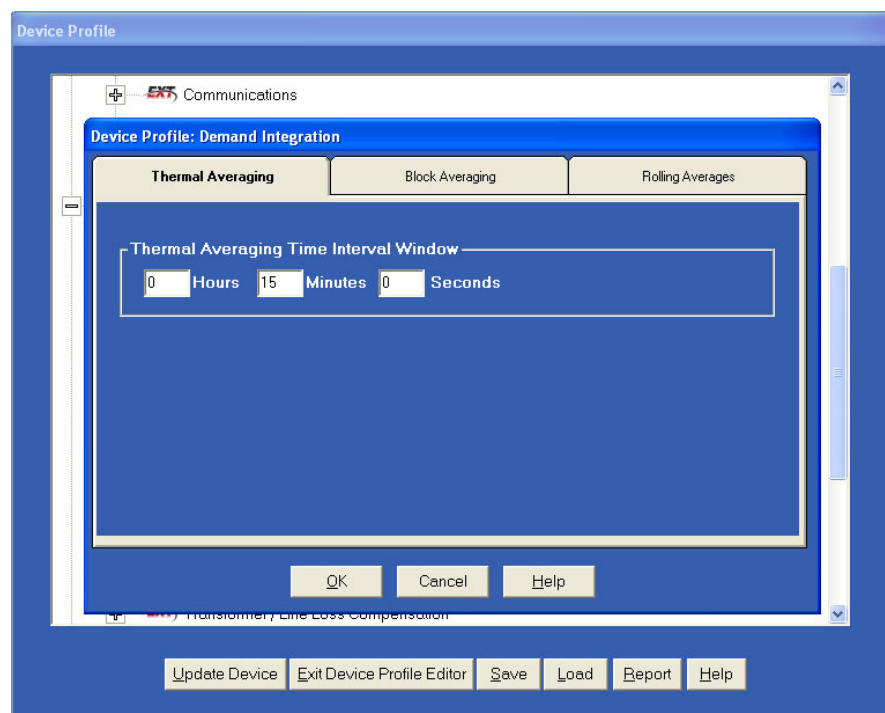


**Figure 4-4: Demand integration window**

To set the cumulative demand type,

▷ Select the **Revenue & Energy Settings > Cumulative Demand Type** item from the device profile.

▷ Select "Block Window" or "Rolling Window."

▷ Click **OK** when complete.
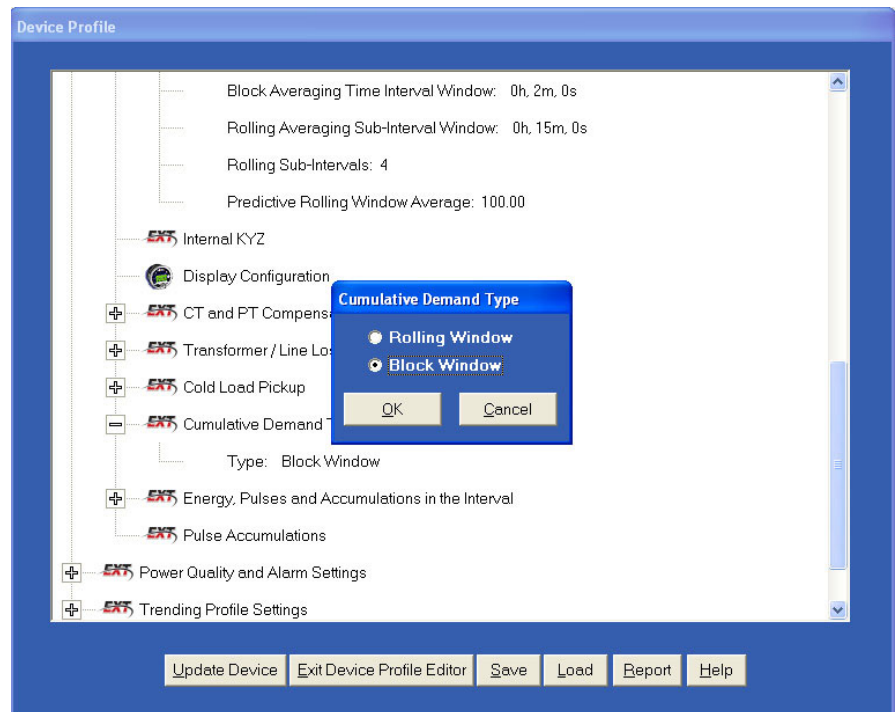


**Figure 4-5: Cumulative demand type window**

## 4.3    Programmable Display

### 4.3.1    Overview

The programmable display has three configurable user modes with up to 16 screens each. The three modes are displayed in auto sequence every 7 seconds. Using the GE Communicator EXT software, the user can assign up to 16 screens to each mode and any of the available screens can be used in any mode.The user also assigns a three-digit label that names the mode. The three modes are:

- Configurable view mode 1 - replacing normal mode
- Configurable view mode 2 - replacing circuit diagnostic mode
- Configurable View mode 3 - replacing time-of-use mode

This feature is very user-friendly and enables the user to determine what data will be displayed and in what order. This feature highlights larger (0.56-inch) digits on many of the screens so that data displayed is much easier to read.

View mode 1 is the primary mode. The other user modes (view modes 2 and 3) are accessed by swiping the mode switch twice. Test mode is accessed by removing the cover (power must be off), powering up the meter and pushing the test button at any time.

View modes 2 and 3 will automatically return to view mode 1 after a user-set amount of time after the last user action. Test mode will automatically return to view mode 1 after an amount of time after the last user action with no energy accumulation (or) an amount of time after the last user action plus the demand interval with energy accumulation. The values for the amount of time after the last user action is set on the miscellaneous screen in the user inactivity time outs section. The programmable display can be edited through GE Communicator EXT even if the meter is not connected to the computer. Simply select the **File > Open > EPM 9800 Programmable Display Profile** menu item and navigate to the programming settings files (files ending an NDS extension).

See the GE Communicator EXT instruction manual for additional details on programming the EPM 9800 and retrieving data.

The EPM 9800 programmable display navigation map is shown below.
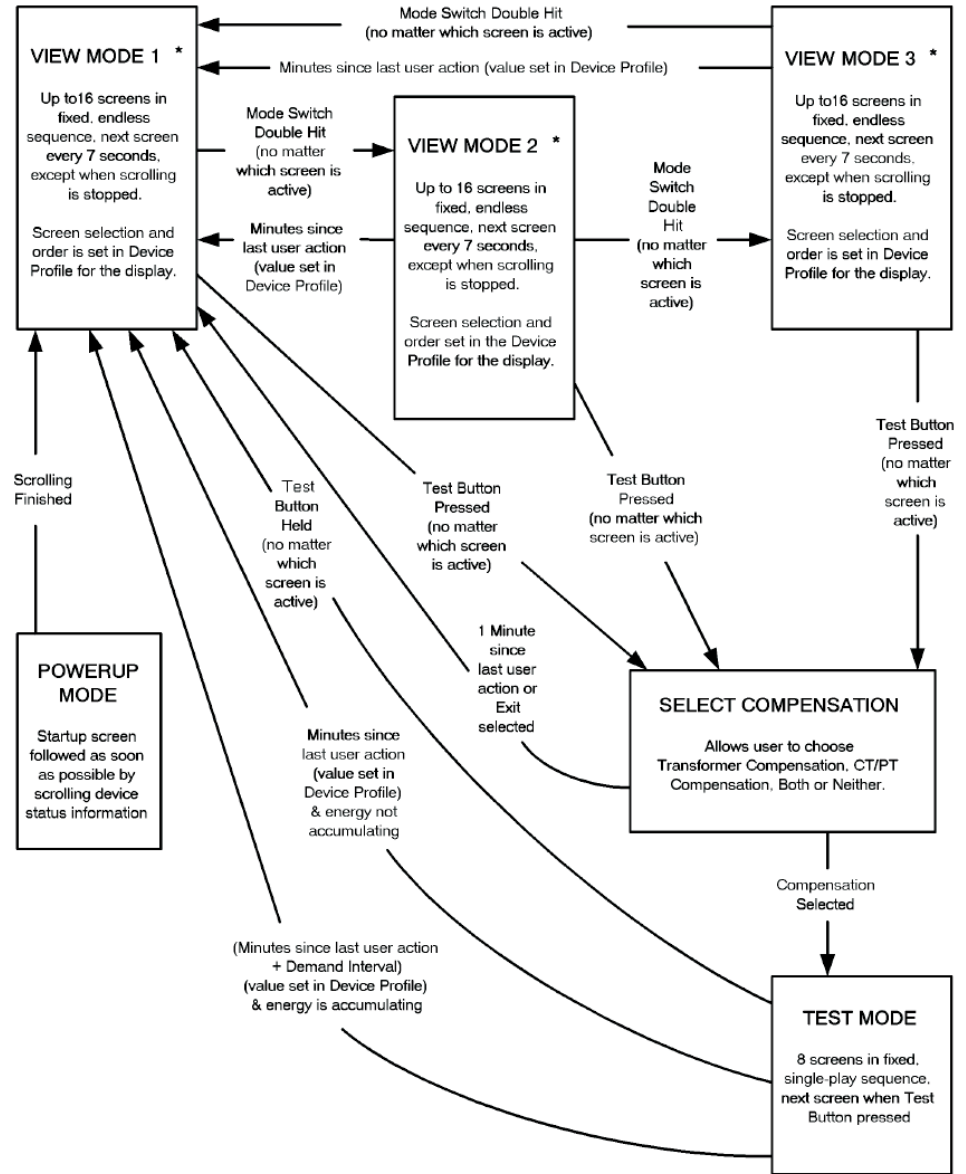


**Figure 4-6: EPM 9800 programmable display navigation map**

### 4.3.2    Programmable Display Setup

The procedure to setup the programmable display is as follows.

▷  Select the **Tools > Edit LCD Programmable Settings** menu item to open the Device Display Programmable Settings window.

▷  Click the **Meter Display Mode Names** tab.



▷  Enter a three-letter label and a description for each of the three view modes.

▷  Click the **Screen Assignments** tab then double-click on the screen the desired screen.

▷  Enter up to 16 screens under each mode.
The label for each mode will appear at the top of each column.

▷ Click on the **Power and Energy Display** tab.



▷ Enter settings for power and energy.
For the scale, select from units, kilo-units, and mega-units. In the
**Primary Power** section, select the number of digits (4 to 9) and the
decimal point location (0 to 3). Previews appear at the bottom of
the screen.

The values on this screen control the display of energy related data. Take care to
match the values on the display with those in the historical logs. These settings apply
to VA-hours, ±watthours, ±varhours and var-hours (each quadrant) in the meter.

The user-programmable scale factor determines the quantity used in the energy
registers. The scale factor applies to primary values only (secondary values are always
in units) and is set to units, kilo-units or mega-units. The scale factor takes precedence
over all other settings (i.e., all other settings are based on this setting).

The number of digits displayed can be set between 4 and 9. This setting controls the
display and storage of digits displayed and sets the register rollover for all energy
registers. For example, if the scale setting is mega-units and the number of digits
displayed is 5, the display will show up to 99999 MW-hours and associated registers
will rollover at 99999 MWhours.

▷ Click on the **Miscellaneous** tab. The screen settings replace
adjustments mode in the default profile.

▷ Enter settings in the miscellaneous screen as follows.



For the **Screen Settings** section, select:

Back Light Level: 0 (Off) to 4 (brightest)
Back Light Time (backlight shuts off): 00 min., 30 sec. to 60 min., 00 sec.
Contrast: 0 (highest) to 7 (lowest)
Scroll Stop: Enabled or Disabled
Phasor Diagram Rotation: Clockwise or Counterclockwise
Demand Shown: Cumulative or Continuous Cumulative
Time of Use Demand: Block/Rolling or Cumulative
Date Format: Month/Day/Year or Day/Month/Year

For the **Optical Port** section, set the Baud Rate to 1200, 2400, 4800, 9600, 19200, 38400 or 57600. The Optical Receive can be Normal or Inverted.

The **User Inactivity Time Outs** section refers to the number of minutes since last user action when mode reverts to view mode 1. The settings range from 5 to 60 minutes with 1 minute intervals and are as follows:

Leave Test Mode After: reverts with or without energy accumulation.;
Leave View Mode 2 After: reverts automatically;
Leave View Mode 3 After: reverts automatically.

Use buttons for functions below:

- **Update Display**: Click to send the new settings to the display (after settings have been updated, view mode 1 is displayed).

- **Retrieve From Display**: Click to Retrieve existing settings.

- **Cancel**: Click to cancel any new settings changes.

- **Save**: Click to save new settings to a file.

- **Load**: Click to load saved settings from a file.

- **Help**: Click to get help for this set of screens.

▷ When finished with the changes, select **Update Display** to send the new settings to the display.
Pop-up windows will appear to indicate that the changes have been made and the software will return to the main GE Communicator EXT screen.

## 4.4    Transformer Loss Compensation

### 4.4.1    Introduction

The Edison Electric Institute's *Handbook for Electricity Metering (Ninth Edition)* defines loss compensation as:

> *A means for correcting the reading of a meter when the metering point and point of service are physically separated, resulting in measurable losses including $I^2R$ losses in conductors and transformers and iron-core losses. These losses may be added to or subtracted from the meter registration.*

Loss compensation may be used in any instance where the physical location of the meter does not match the electrical location where change of ownership occurs. Most often this appears when meters are connected on the low-voltage side of power transformers when the actual ownership change occurs on the high-voltage side of the transformer. This condition is shown below.
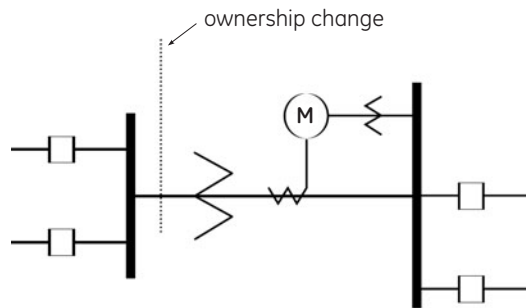


**Figure 4-7: Low voltage metering installation requiring loss compensation**

It is generally less expensive to install metering equipment on the low-voltage side of a transformer and in some conditions other limitations may also impose the requirement of low-side metering even though the actual ownership change occurs on the high-voltage side.

The need for loss compensated metering may also exist when the ownership changes several miles along a transmission line where it is simply impractical to install metering equipment. Ownership may change at the midway point of a transmission line where there are no substation facilities. In this case, power metering must again be compensated. This condition is shown below.
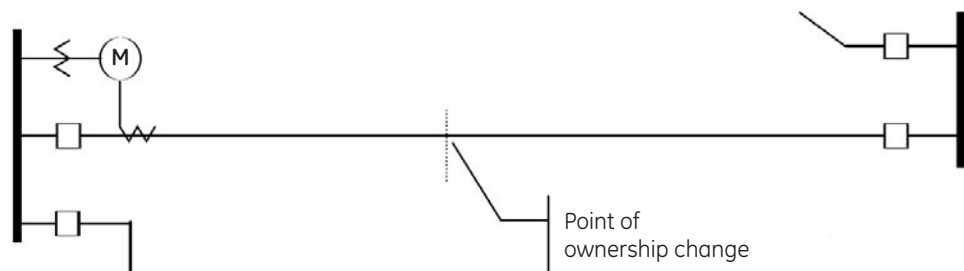


**Figure 4-8: Joint ownership line metering requiring loss compensation**

A single meter cannot measure the losses in a transformer or transmission line directly. It can, however, include computational corrections to calculate the losses and add or subtract those losses to the power flow measured at the meter location. This is the method used for loss compensation in the EPM 9800 meter.

The computational corrections used for transformer and transmission line loss compensation are similar. Generically, no-load losses and full-load losses are evaluated and a correction factor for each loss level is calculated. However, the calculation of the correction factors that must be programmed into the meter differ for the two different applications. For this reason, the two methodologies will be treated separately.

In the EPM 9800, loss compensation is a technique that computationally accounts for active and reactive power losses. The meter calculations are based on the formulas below. These equations describe the amount of active (watts) and reactive (vars) power lost due to both iron and copper effects (reflected to the secondary of the instrument transformers). The total secondary watt loss $P_{loss}$ is shown below.

$$P_{loss} = \left( \left( \frac{V_m}{V_c} \right)^2 \times \%LWFE \right) + \left( \left( \frac{I_m}{I_c} \right)^2 \times \%LWCU \right) \times S_{full} \qquad \textbf{(EQ 4.1)}$$

The total secondary var loss $Q_{loss}$ is shown below:

$$Q_{loss} = \left( \left( \frac{V_m}{V_c} \right)^2 \times \%LVFE \right) + \left( \left( \frac{I_m}{I_c} \right)^2 \times \%LVCU \right) \times S_{full} \qquad \textbf{(EQ 4.2)}$$

Where $V_m$ is the measured voltage, $V_c$ is the calculated point voltage, $I_m$ is the measured current, $I_c$ is the calculated point current, and $S_{full}$ is the full-scale secondary VA. The values for %LWFE, %LWCU, %LVFE, and %LVCU are derived from the transformer and meter information, as demonstrated in following sections.

The calculated loss compensation values are added to or subtracted from the measured watts and vars. The selection of adding or subtracting losses is made through the meter profile when programming the meter. The meter uses the combination of the add/subtract setting and the directional definition of power flow (also in the profile) to determine how to handle the losses. Losses will be "added to" or "subtracted from" (depending on whether add or subtract is selected) the received power flow. For example, if losses are set to "add to" and received power equals 2000 kW and losses are equal to 20 kW then the total metered value with loss compensation would be 2020 kW; for these same settings if the meter measured 2000 kW of delivered power the total metered value with loss compensation would be 1980 kW.

Since transformer loss compensation is the more common loss compensation method, the meter has been designed for this application. Line loss compensation is calculated in the meter using the same terms but the percent values are calculated by a different methodology as described in a subsequent section below.

In summary, the EPM 9800 transformer loss compensation:

- Performs calculations on each phase of the meter for every measurement taken. Unbalanced loads are accurately handled.
- Calculates numerically, eliminating the environmental affects that cause inaccuracies in electromechanical compensators.
- Performs bi-directional loss compensation.
- Requires no additional wiring; the compensation occurs internally.

- Imposes no additional electrical burden when performing loss compensation.

Loss compensation is applied to 1 second per phase watt/var readings and, because of this, affects all subsequent readings based on 1 second per phase watt/var readings. This method results in loss compensation be applied to the following quantities:

- Total power.
- Demands, per phase and total (thermal, block (fixed) window, rolling (sliding) window and predictive window).
- Maximum and minimum demands.
- Energy accumulations.
- KYZ output of energy accumulations.

**NOTE** Loss Compensation is disabled when the meter is placed in test mode.

### 4.4.2  Transformer Loss Compensation in the EPM 9800

The EPM 9800 meter provides compensation for active and reactive power quantities by performing the numerical calculations using factors derived by clicking the **TLC Calculator** button on the Transformer Loss screen of the device profile or by manually figuring values (refer to *Transformer Loss Compensation Worksheet* on page 4–17). Enter the derived values in the Device Profile screen of the GE Communicator EXT software (values will automatically be entered from the TLC calculator button).

The GE Communicator EXT software can enable transformer loss compensation for losses due to copper and iron, individually or simultaneously. Losses can either be added to or subtracted from measured readings.

Loss compensation values must be calculated based on the meter installation. As a result transformer loss values must be normalized to the meter by converting the base voltage and current and taking into account the number of elements used in the metering installation. For three element meters, the installation must be normalized to the phase-to-neutral voltage and the phase current; in two element meters the installation must be normalized to the phase-to-phase voltage and the phase current. This process is described in the following sections.

### 4.4.3  Loss Compensation in Three Element Installations

Loss compensation is based on the loss and impedance values provided on the transformer manufacturer's test report. A typical test report will include at least the following information:

- Manufacturer
- Unit serial number
- Transformer MVA rating (self-cooled)
- Test voltage
- No load loss watts
- Load loss watts (or full load loss watts)

- Percent of exciting current at 100% voltage
- Percent impedance

The transformer MVA rating is generally the lowest MVA rating (the self-cooled or OA rating) of the transformer winding. The test voltage is generally the nominal voltage of the secondary or low voltage winding. For three phase transformers these values will typically be the three-phase rating and the phase-to-phase voltage. All of the test measurements are based on these two numbers. Part of the process of calculating the loss compensation percentages is converting the transformer loss values based on the transformer ratings to the base used by the meter.

Correct calculation of loss compensation also requires knowledge of the meter installation. To calculate the loss compensation settings, the following information is required:

- Number of meter elements
- Potential transformer ratio (PTR)
- Current transformer ratio (CTR)
- Meter base voltage
- Meter base current

This section is limited to application of EPM 9800 meters to three-element metering installations. As a result, we know that:

- Number of metering elements = 3
- Meter base voltage = 120 V
- Meter base current = 5 A

The loss compensation values can be calculated by clicking the **TLC Calculator** button on the transformer loss screen of the EPM 9800 device profile. This will open the transformer loss calculation spreadsheet (in Excel format).

### 4.4.4    Transformer Loss Compensation Worksheet

A copy of the transformer loss calculation spreadsheet with example numbers is available from the EPM 9800 support documents section of the GE multilin website (http://www.GEmultilin.com) as GET-8501.xls.

GE Consumer & Industrial
**Multilin**

# EPM 9800 Advanced Power Quality Metering System

# Chapter 5: Testing the Meter

## 5.1   Overview

### 5.1.1   Warnings

⚠ CAUTION

The information contained within this chapter is intended to be an aid to qualified metering personnel.  It is not intended to replace the extensive training necessary to install or remove meters from service.  Any work on or near energized meters, meter sockets or other metering equipment presents the danger of electrical shock, personal injury or death.  All work on these products must be performed by qualified industrial electricians and metering specialists only!

⚠ CAUTION

All work must be done in accordance with local utility safety practices and the procedures outlined in the current edition of the *Handbook for Electricity Metering*. The handbook is available from the Edison Electric Institute (http://www.eei.org), 701 Pennsylvania Avenue N.W., Washington D.C. 20004-2696.

## 5.2    Testing Tools

### 5.2.1    Description

The EPM 9800 is equipped with a light-emitting diode (LED) for calibration and a liquid crystal display with test screens. These two standard features provide user interface and equipment interface points for meter testing.

### 5.2.2    Test Pulse LED

The test pulse LED is located in the upper left-hand portion of the meter faceplate. This LED continuously emits calibration pulses (infrared light). It can be used for a variety of pulses including individual quadrants for watt-hour, VAhour, varhour and watt demand pulses. Each calibration pulse is equal to the value assigned to $K_t$ (watthours per pulse) in the meter's device profile. The millisecond duration of each output pulse is also programmable in the meter's device profile.

To program the test pulse LED, launch the device profile in GE Communicator EXT software and click on **KYZ Outputs**, then click on any of test LED pull-down menus to configure the following settings:

- Assigned channel - choose from settings.
- Watt-hour per pulse - enter the value in the secondary.
- Pulse width - can be set from 5 to 635 ms.
- Mode - can be enabled or disabled.
- Form - can be selected between form-A and form-C.

Click **OK** then click **Update Device** to send the new settings to the meter.

The unit for the calibration pulses is watt-hours. The initial value of each pulse ($K_t$) is 1.800 secondary watt-hours per pulse.

### 5.2.3    LCD Display

In test mode, the LCD display provides user access to accumulated real, reactive and apparent energy as well as block demand for real power. There are eight screens in test mode: **Wh - Del**, **Wh - Rec**, **VARh - Q1 & Q2**, **VARh - Q3 & Q4**, **VAh - Q1 & Q4**, **VAh - Q2 & Q3**, **Watt Demand Test Rolling** and **Watt Demand Test Block**. See *Using Test Mode* on page 5–3 for additional detail.

The LCD display also includes three phase voltage annunciators. These annunciators are labeled A, B, and C to indicate the presence of voltage on the indicated phase. If voltage is not present on one phase, its indicator will not be displayed. These indicators also show whether current is flowing on the indicated phase. If no current is flowing on a phase, the annunciator will blink. When current is flowing, it will show a continuously illuminated digit. This annunciator indicates phase sequence.

## 5.3    Test mode

### 5.3.1    Description

Test mode allows the meter to be tested without disturbing billing data or setting a new maximum demand. Test mode performs the same function as setting the pointers back on an electromechanical meter after testing.

While operating in test mode, the meter uses the same measurement and calculation processes that are used in normal mode. the only difference is that the billing numbers stored in the meter are not updated with the real-time reading. This preserves the billing numbers while testing is performed.

### 5.3.2    Entering Test Mode

To enter test mode, the user must pass the meter security system. In most instances, this requires the user to remove power from the meter, break the meter seal, remove the Lexan cover, and then re-power the meter.

The test button is one of two pushbuttons in the lower right hand side of the meter faceplate.

> ▷    **Press the test button (on the right) to display the Select Transformer Loss screen.**

> ▷    **Press the test button again to scroll through the following transformer loss screens:**

> - Transformer loss only
> - Both CTPT and transformer loss
> - No compensation
> - CTPT only

> ▷    **Select the desired screen.**

> ▷    **Push the test button for 2 to 3 seconds.**
> **The test mode screens appear and the display changes to indicate the user has entered test mode (the word test appears in the upper right corner of the screen).**

Upon entering test mode, the following processes occur:

1. All energy, demand and TOU values are stored in the EPM 9800 nonvolatile memory.

2. Meter log recording is suspended; however, historical logging continues and entries to historical logs reflect that test mode is in effect during the effected interval(s).

### 5.3.3    Using Test Mode

The same selected measurement profile quantities (data accumulations) that are calculated during normal operation are calculated in test mode. Display quantities (watt-hours, varhours, VAhours, and block demand quantities) are displayed in units rather than

kilo-units (i.e. the data is displayed as Wh, varh, VAh and Watts rather than kWh, kvarh, kVAh and kW). The same demand values calculated during normal operation are also calculated in test mode. The display formats in test mode are changed to provide greater resolution during test operations.

The display does not scroll while in test mode. Each item remains displayed until the test mode button is pressed. At that time, the next test mode screen is shown.

The following table shows the display screens available in test mode and the data displayed on each screen and the pulse source for each screen:

### Table 5–1: Test mode displayed data and pulse source

| Test mode | Displayed data | Pulse source |
|---|---|---|
| Wh - del | Delivered energy in Wh | kWh, Del |
| Wh - rec | Received energy in Wh | kWh, Rec |
| VARh - Q1 & Q2 | Reactive energy (varh) in quadrants 1 and 2 | kvarh, Del |
| VARh -Q3 & Q4 | Reactive energy (varh) in quadrants 3 and 4 | kvarh, Rec |
| VAh - Q1 & Q4 | Apparent energy (VAh) in quadrants 1 and 4 | kVAh, Q1 |
| VAh - Q2 & Q3 | Apparent energy (VAh) in quadrants 2 and 3 | kVAh, Q3 |
| Watt Demand Rolling | Power block demand delivered (watts) | kWh, Del |
| Watt Demand Block | Power block demand delivered (watts) | kWh, Del |

Adjacent to the test mode button (T) is the reset button (R). A test reset is initiated by pressing the reset button while in test mode. A test mode reset causes all test quantities to be reset to zero and a new block interval to be started. The item displayed when the reset occurred remains in the display but the value will be initialized. The reset occurs when the reset button is released.

While in test mode, the test pulse LED will pulse at the rate programmed for the meter $K_t$. The value of the meter $K_t$ can be verified from the device profile. The meter quantity assigned to the test pulse LED changes as the user moves from one test screen to another. The assigned values are defined in the pulse source column of the table above.

Changing the $K_t$ value does not effect EPM 9800 performance or accuracy. The $K_t$ value only effects the rate at which the test pulse LED blinks. Smaller $K_t$ values produce more pulses for a given load and shorter test time. The tester should ensure that the allowed test time is long enough to reduce variability that may be introduced in the starting and stopping of the test procedure.

Individual quadrant tests for varhours can be completed by proper test design. To test strictly varhours, limit the test parameters to one quadrant during testing.

In the event of a power outage, data for test mode energy, demand and power factor are not saved. Upon power-up, the meter returns to normal mode. The test data is lost and all registers are restored to their pretest values.

While in test mode, the infrared port and communications port 1 are available for communication with the meter.

In test mode, the user can preset the values of the energy readings that will be restored to the meter when test mode is exited. This is accomplished via the GE Communicator EXT software (see *Test Mode Preset Accumulators* on page 5–5).

### 5.3.4    Test Mode Exit Delay Setting

Use the following procedure to set the exit delay time.

▷ From the device profile screen, click the **Test Mode** icon or double-click on the **Test Mode Settings** line.
The Test Mode Settings window appears:
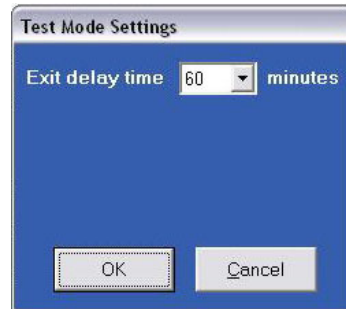


The **Test Mode** icon and screen appear only if the display firmware is less than 40. If the display firmware is greater than 40, this setting will appear in the programmable settings.

▷ Use the pull-down menu to select the delay time in minutes (from 1 to 255 minutes).
This is the time in which GE Communicator EXT will exit test mode if there is no activity.

▷ Click **OK** to return to the main device profile screen.

▷ For the changes to take effect, click on the **Update Device** button. This sends the new profile to the EPM 9800.

### 5.3.5    Test Mode Preset Accumulators

There are two reasons why a user might want to use the preset accumulators screens:

1. A monitor in test mode is out of service and is therefore not monitoring accumulations. The new value can be used to adjust for the values not monitored while in test mode.

2. When replacing an old meter that has accumulations with a new meter that has no accumulations, the new value can be set with the value of the accumulations of the old meter.

To set the test mode preset accumulators:

▷ Select the **Tools > Test Mode > Preset Accumulators** menu item.
The set of screens shown here (Test Mode Preset) appears.



Each screen has a current value, new value and preset box for each accumulator. A new meter will have zeros for current values.

▷ **Click the tabs at the top of the window to access the individual screens.**
Settings can be preset for the following sets of values: primary energy, secondary energy, primary energy (quadrants), secondary energy (quadrants), internal input accumulators, KYZ output accumulators, Q hours, current and voltage squared T accumulators, cumulative demand (secondary), and uncompensated energy.

▷ Select the **Preset** boxes for values to set.

▷ Click **Set** or **Cancel**.

### 5.3.6    Exiting Test Mode

Test mode is exited in one of three ways:

1. By pressing and holding the test button for more than 3 seconds.

2. By the test mode time-out timer, if no load is present.

3. By the extended test mode time-out timer, if load is present.

Pressing the test mode button for more than three seconds will immediately exit test mode.

The test mode time-out timer has two modes of operation, depending on whether the meter sees measurable load.

- **If the meter does not recognize measureable load**: The meter watches for user interaction by monitoring activity on the test button and the reset button.  If neither button is pushed within the programmed exit delay time, the meter will automatically exit test mode and return to normal mode.  Each time the test or reset button is pressed, the meter starts the exit delay timer again.  The exit delay time is programmed in the EPM 9800 device profile.

- **If the meter recognizes measurable load**: It watches the test and reset buttons for activity but uses a different time limit.  When load is present, it uses an extended time consisting of the exit delay time plus the programmed block interval time.  This insures that the meter can complete a full block demand test without interruption.

All test mode data is lost when test mode is exited. Upon exiting test mode, a new (possibly partial) demand interval and subinterval are started. The past subinterval as well as the current subinterval are zeroed. Upon returning to normal operating mode, a time-of-use meter or demand meter with load profiling will complete the time remaining in the current partial subinterval such that subsequent subintervals will be synchronized with the hourly boundary.

Maximum demand values for each demand integration type are not modified while in test mode. The previously recorded maximums will be restored when test mode is exited. If the user desires to reset demand data during testing operations, this action can be completed after test mode is exited by pressing the Reset Button after the meter has reset to normal mode.

Normal billing and historical log data accumulation is suspended during test mode operation. Upon exiting test mode, accumulation of billing and historical log quantities will:

1. Resume from the values in place when test mode was entered, or
2. Continue from the values preset while in test mode.

# EPM 9800 Advanced Power Quality Metering System

# Chapter 6: Communications

## 6.1 Communications Wiring

### 6.1.1 Overview

RS232 communication is used to connect a single EPM 9800 with another device, such as a computer, RTU, or PLC. The link is viable for up to 50 feet (15.2 meters) and is available only through the EPM 9800 optical port with a communication interface (optical port to RS232 converter).

RS485 communication allows multiple meters to communicate with another device at a local or remote site. The input/output modules use RS485 to communicate with the meter. All RS485 links are viable for up to 4000 feet (1220 meters). The EPM 9800 ports 1 and 4 are two-wire, RS485 connections (up to 115200 bps). Optional communication interfaces for internal modem with dial in/dial out, 10/100Base-T Ethernet, combination modem and Ethernet are available.
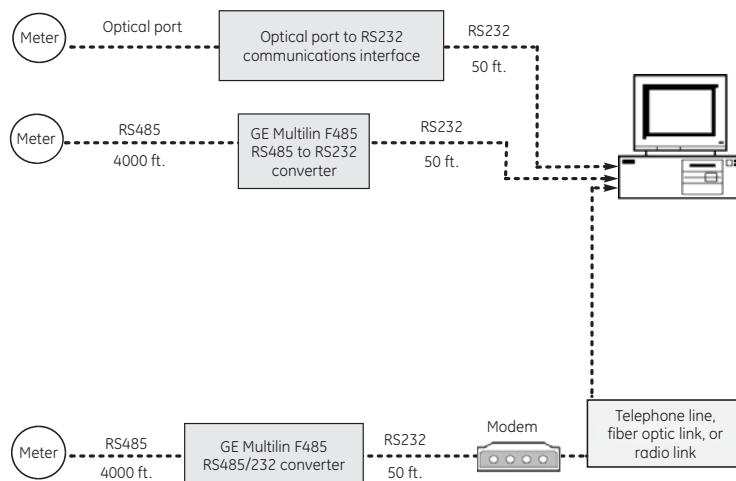
**Figure 6-1: Communications overview**

### 6.1.2    ANSI Type II Optical Port

Use the ANSI type II optical port on the face of the EPM 9800 for RS232 communications. The optical port is compatible with the A7Z communication interface and other ANSI type II magnetic communication interfaces.



**Figure 6-2: A7Z communications interface**

One end of the magnetic interface simply snaps onto the optical port and is kept in place by the magnet; the other end is an RS232 connection. Insert the RS232 end into a 9-pin serial port on a computer or other device. The A7Z requires no power supply – all power is received from the host computer serial port using transmitter and receiver circuits within the probe.

The RS232 standard limits the cable length to 50 feet (15.2m).

### 6.1.3    RS485 Serial Communication

RS485 communications allow multiple devices to communicate on a bus. Ports 1 and 4 of the EPM 9800 are RS485 terminals, viable for a distance of up to 4000 feet (1219 meters). A detail of a two-wire RS485 port is shown below.
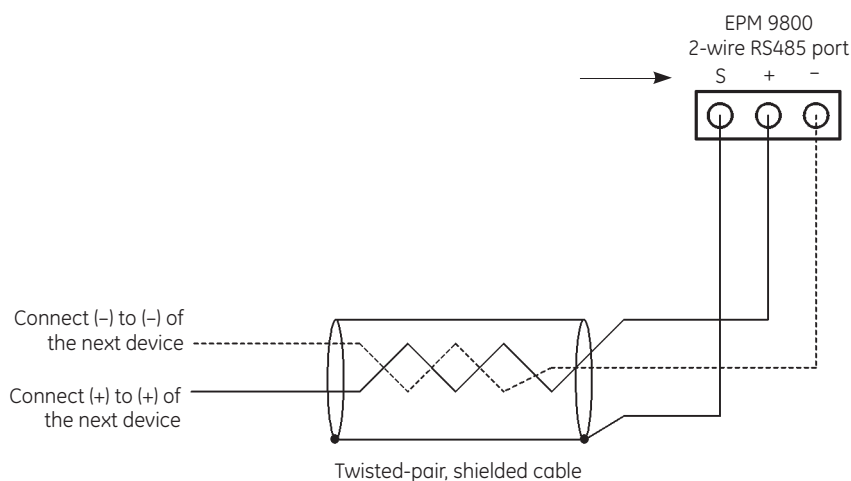


**Figure 6-3: Two-wire RS485 port (detail)**

The RS485 shield is not an earth-ground connection – the shield must be connected to earth-ground at one point. Do not connect the shield to ground at multiple points as it interferes with communication. For the A+ and B– two-wire RS485 communication terminals, connect the A+ terminal of the meter to the positive (+) terminal of the device. Likewise, connect the B– terminal of the meter to the negative (–) terminal of the device.

For all RS485 connections:

- Use a shielded twisted pair cable 22 AWG (0.33 mm$^2$) or larger, grounding the shield at one end only.

- Establish point-to-point configurations for each device on an RS485 bus. Connect positive (+) terminals to positive (+) terminals, and connect negative (–) terminals to negative (–) terminals.

- Protect cables from sources of electrical noise.

- Avoid both "star" and "tee" connections (see Figure 6-5: *Incorrect "T" and "star" topologies* on page 6–4). No more than two cables should be connected at any one point on an RS485 network, whether the connections are for devices, converters, or terminal strips.

- Include all segments when calculating the total cable length of a network. If there is no RS485 repeater, the maximum length for cable connecting all devices is 4000 feet (1219 meters).

A typical two-wire RS485 connection is shown below.
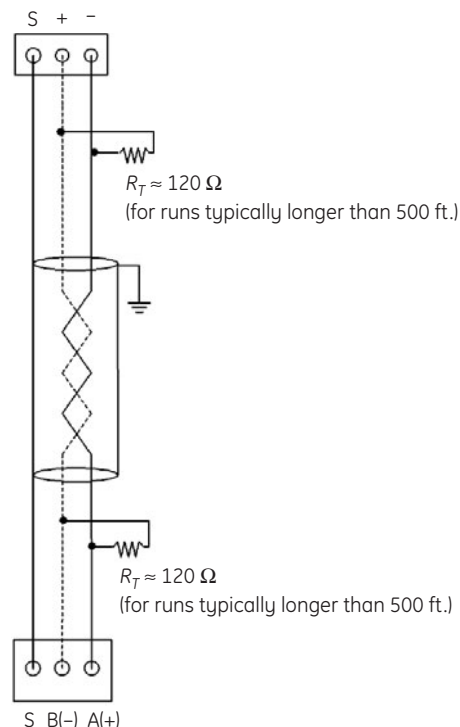


**Figure 6-4: Typical two-wire RS485 connection**

Termination resistors ($R_T$) are generally used on both ends of longer length transmission lines. The value of the termination resistors is determined by the electrical parameters of the cable.

**NOTE**

The EPM 9800 meter may be shipped with connectors on the ends of cables or they may be shipped as pigtails (no connectors). In this case, a generic terminal block will be shipped with the meter. The terminal block has up to 12 connectors and can be cut into smaller sections with a utility knife. Please refer to the Table 3–1: *Cable color key* on page 3–4 if using pigtails or for information about connector identities.

**NOTE**

Termination resistors are only needed with runs typically more than 500 feet. The meter has some level of termination internally and usually resistors are not needed.

"Star" and "tee" connections must be avoided. These are illustrated in the following figure.

**INCORRECT "T" CONNECTION**

**"Tee" connection incorrect**

The three wires connected in a "T" shape on both the (–) and (+) terminals will cause interference problems

**INCORRECT "STAR" CONNECTION**

**"Star" connection incorrect**

The three wires connected in a "star" shape on both the (+) and (–) terminals will cause interference problems
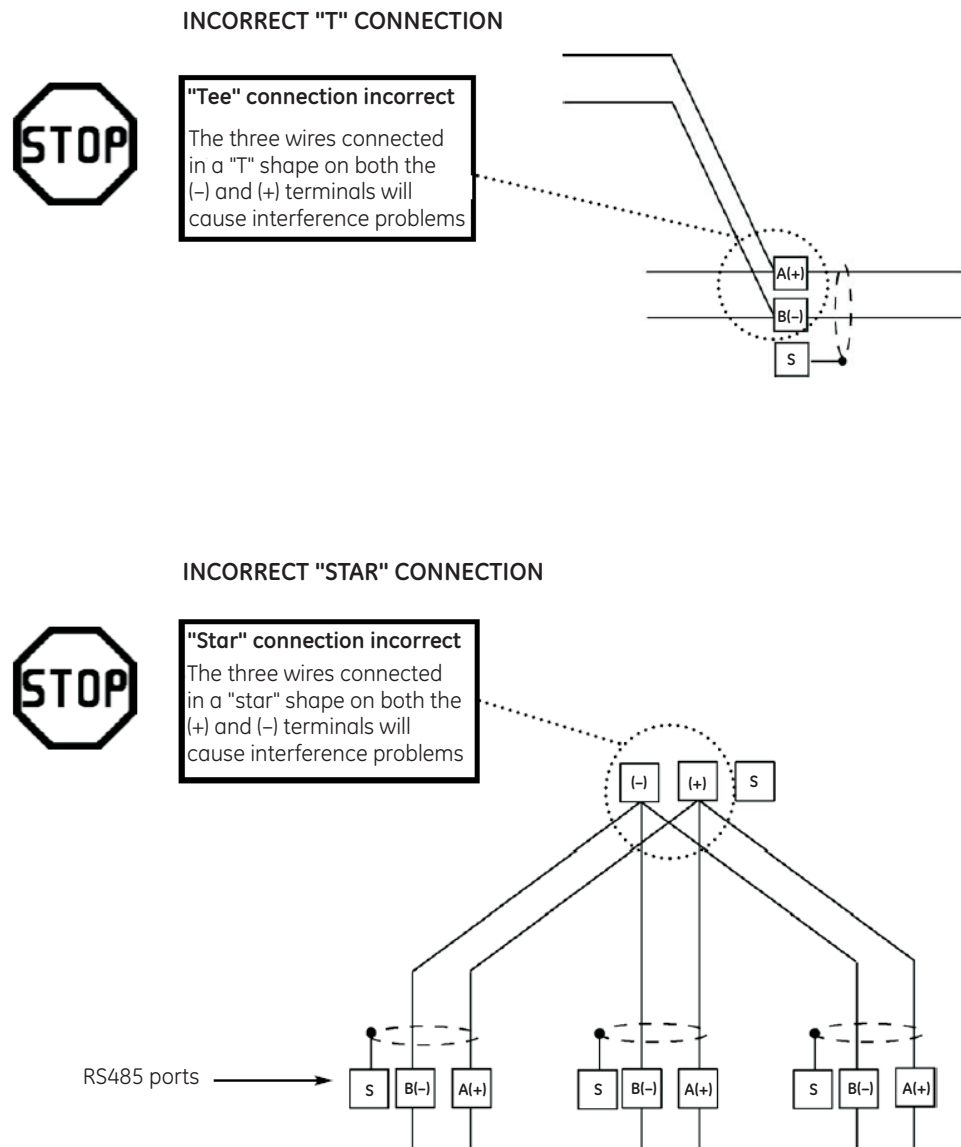
**Figure 6-5: Incorrect "T" and "star" topologies**

## 6.2 RS485 Serial Connections

### 6.2.1 Connection to an RS485 Master

Use port 1 or port 4 to connect to an RS485 master. For information on connecting the EPM 9800 to a modem, see *Programming Modems for Remote Communications* on page 6–11. The RS485 link is viable for up to 4000 feet (1219 meters). An RS485 to RS232 converter may be required (such as the GE Multilin F485 or similar devices).

To establish communication between a meter and any RS485 master, use a shielded, twisted pair cable.

Connect the cable to an RS485 port (port 1 or port 4) on the EPM 9800. Connect the A(+) and B(-) terminals on the EPM 9800 to the positive (+) and negative (–) terminals on the master, respectively. Provide jumpers only on a four-wire master, linking its two negative terminals and two positive terminals. An RS485 communication is reliable up to 4000 feet (1219 meters).

Connect the shield to the ground (G) terminal on the master. The shield must also be connected to earth-ground at one point. Provide resistors at each end, connected to the positive (+) and negative (–) lines. The termination resistance $R_T$ is approximately 120 ohms.

**NOTE**

Termination resistors are only needed with runs typically greater than 500 feet. The EPM 9800 has some level of internal termination and resistors are not generally not required for lengths less than 500 feet.
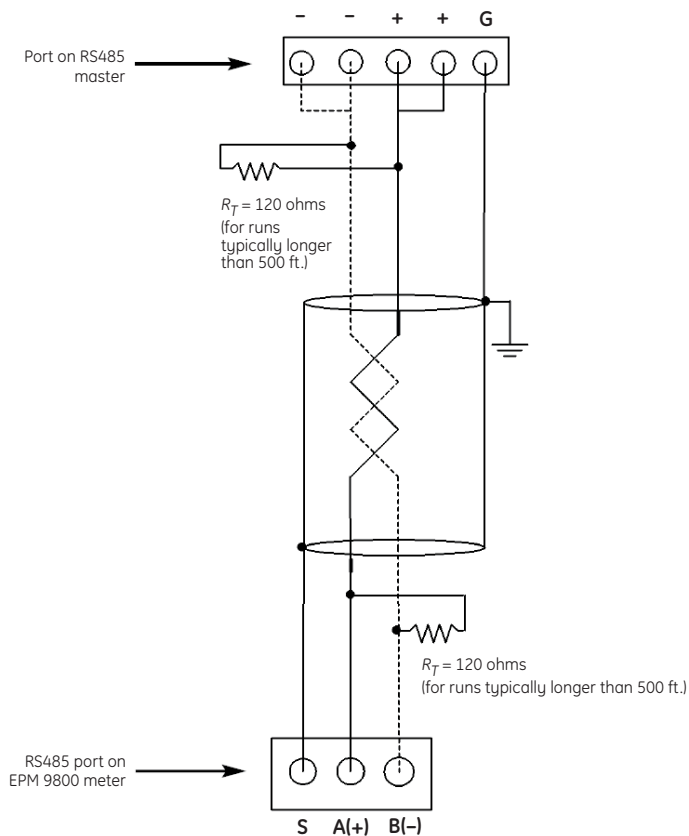


**Figure 6-6: EPM 9800 connected to an RS485 master**

### 6.2.2   Connection to Output Modules via RS485

Output modules can also be connected to the EPM 9800 with an RS485 cable harness (supplied with the purchase of the MBIO mounting brackets). Insert one end of the cable into port 4 of the meter and the other end of the cable into the communication pins of the input/output module male RS-485 side port (see *EPM 9800 connected to an RS485 master* on page 6–6).

The EPM 9800 power supply will not supply power to any external output modules. An external 12 V power source (such as the PSIO) must be used. RS485 communication is reliable for up to 4000 feet (1219 meters).

The following figure illustrates the output modules connection via RS485.
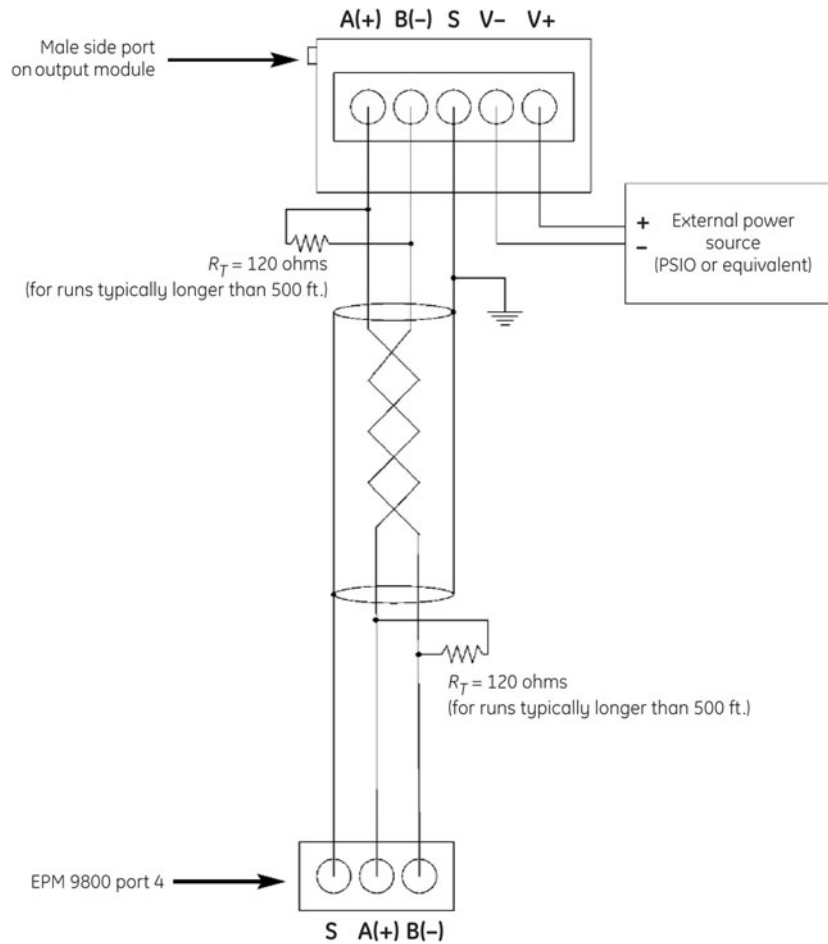
**Figure 6-7: EPM 9800 connected to output module via RS485**

Connect the A(+) and B(–) terminals on the EPM 9800 to the A(+) and B(–) terminals of the female RS485 port. Connect the shield to the shield (S) terminal. The (S) terminal is used to reference the meter port to the same potential as the source. It is not an earth ground connection – the shield must be connected to earth-ground at one point.

Provide termination resistors at each end (see note below), connected to the A(+) and B(–) lines. The resistance of $R_T$ is approximately 120 ohms.

> **NOTE**
>
> Termination resistors are only needed with runs typically more than 500 feet. The EPM 9800 has some level of internal termination and resistors are not generally not required for lengths less than 500 feet.

### 6.2.3    Linking Multiple Devices

A total of 31 meters may be connected in series on a single bus using RS485. The cable length may not exceed 4000 feet (1219 meters). Before assembling the bus, each meter must be assigned a unique address.

Connect the A(+) and B(–) terminals of each device. Break the shield between the RS485 master and between device segments as shown below. It is not an earth ground connection. The shield must be connected to earth-ground at one point. Connect resistors at each end to the (+) and (–) lines. The resistance of $R_T$ is approximately 120 ohms.
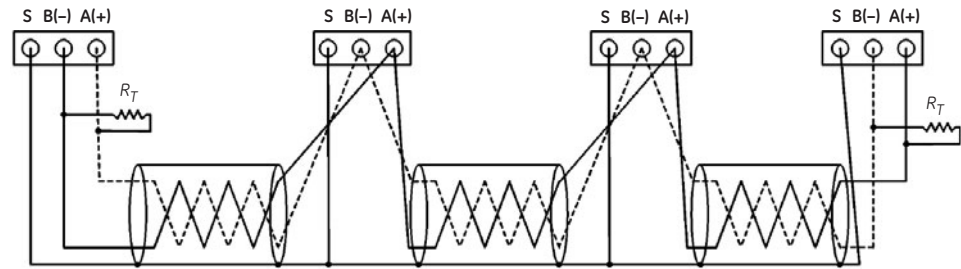


**Figure 6-8: Linking multiple meters**

### 6.2.4    Remote Communications over Telephone Lines

The use of modems (dedicated or dial-up) is recommended when devices are at great distances. For units without the built-in modem option, RS485 wiring with a GE Multilin F485 converter is recommended.
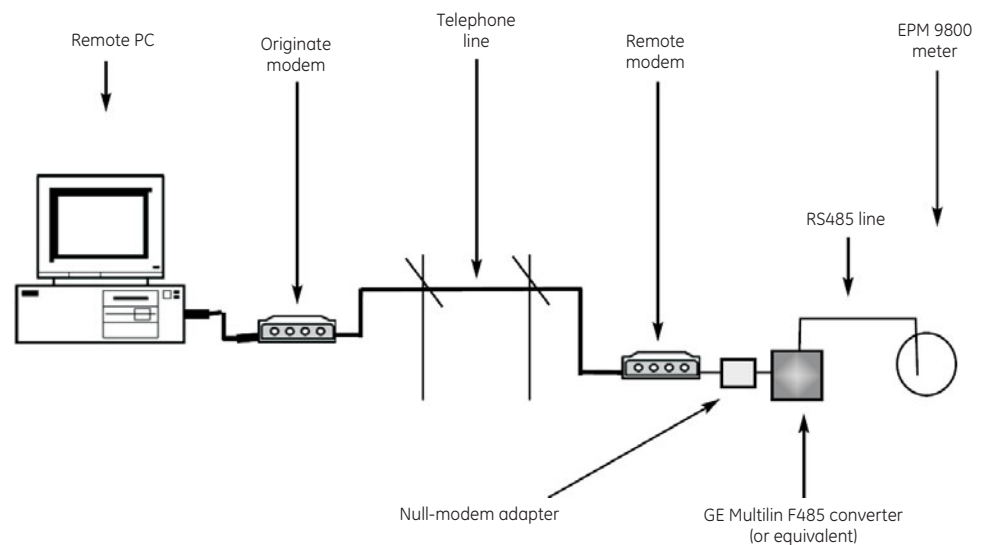


**Figure 6-9: RS485 remote connections**

Use port 1 or port 4 for RS485 communication. The RS485 link is reliable up to 4000 feet (1219 meters). Set an appropriate baud rate and enable the Modbus ASCII protocol.

An RS485 to RS232 converter is also required. GE recommends the GE Multilin F485 converter. See *Programming Modems for Remote Communications* on page 6–11 for additional details.

## 6.3    RJ11 Modem Connections

### 6.3.1    Description

The internal modem option for the EPM 9800 provides a direct connection to a standard telephone line. No additional hardware is required to establish a communication connection between the meter and a remote computer.

The modem operates at speeds up to 56 kbps. The internal connection between the modem and the meter includes a memory buffer. This enables the modem to connect to the phone line at any speed and to change speed during the communication connection to the remote PC. The buffer between the meter and the modem allows the meter to communicate into the modem at a constant speed while the modem telephone line speed can vary. This eliminates the synchronizing problems that are common with other devices. It also increases the effective throughput of the communication channel. This, in turn, decreases connection time and connection costs.

The modem supports both incoming calls (from a remote computer) and automatic dial-out calls when a defined event must be automatically reported.

### 6.3.2    Hardware Connection

Units with an internal modem contain two RJ11 jacks that pigtail from the back of the meter: one is a line connection for the outside line; the other is a connection for a phone. A standard telephone RJ11 plug can connect the meter to a standard PSTN (public switched telephone network). The phone jack is the override of the modem function when the phone is in use.

### 6.3.3    Dial-in Function

The modem continuously monitors the telephone line to detect an incoming call. When an incoming call is detected, the modem will wait for user-defined number of rings and answer the call.

The modem can be programmed to check for a password on an incoming call. In this case, the modem will hang up on the incoming call if the correct password is not provided. If several unsuccessful incoming call attempts are received in a set time period, the modem will lock-out future incoming calls for a user-defined number of hours.

When an incoming call is successfully connected, the control of communications is passed to the calling software. The modem will respond to computer commands to download data or other actions authorized by the meter passwords. Refer to *Programming Modems for Remote Communications* on page 6–11 for programming details.

### 6.3.4    Dial-out Function

The dial-out function allows the EPM 9800 to automatically report certain conditions without user intervention. The modem normally polls the meter to determine if any abnormal or reportable conditions exist. The modem checks the following meter conditions and programmed events to determine if a call should be placed.

- Are any meter setpoint limits exceeded?
- Has the status of the high-speed inputs changed?
- Has a waveform been recorded?
- Has a power quality event been recorded?
- Has a control output changed?
- Has the meter experienced a loss of control power?
- Is either the history log approaching a full condition?
- Is the event log approaching a full condition?
- Is any other log approaching a full condition?
- Has the modem password failed?
- Has communication with the meter failed?

If any of the monitored events exist, the internal modem will automatically initiate a call to a specified location to make a report or perform some other function. For log full conditions, the EPM 9800 will automatically download the log(s) that are nearing the full state. The modem can be programmed to call two different numbers to make the required reports, primary and backup.

The internal modem can be programmed with an ASCII string for identification purposes. If this string in present the modem will play the string to the host computer upon connection to identify the meter to the host software.

The internal modem includes a connection for an external 3 V Lithium battery (with custom leads and velcro mounting) to power the modem if the meter loses control power. Using the battery, the modem will be able to complete a reporting call even if power to the meter has been disconnected. This feature allows the meter to report power outage conditions. Under normal conditions, the battery should provide in excess of 10 years of service during storage conditions (disconnected from terminals) or when properly installed in an energized meter. The battery should provide more than one year of service during outage conditions (on battery backup). A low battery indicator will appear on the display screen when there is a low battery.

Replacement of the battery is simple. The battery is attached to a cable (if ordered) which pigtails from the back of the meter with a connector (see below and *Battery Installation and Maintenance* on page 3–6).

Installation steps:

▷ **Remove the old battery by disconnecting it at the connector.**

▷ **Install the new battery by snapping it into the connector.**

▷ **Peel and stick the velcro adhesive somewhere outside the meter (or use the old adhesive to fasten the battery in place).**

**NOTE**

Custom leads and velcro mounting are not included in some earlier versions of the switchboard meter. Contact GE Multilin for details.

### 6.3.5    Programming Modems for Remote Communications

When a modem speaks to most RS485 or RS232-based devices, it must be programmed to certain settings for the communication to work. This task is often quite complicated. The steps below illustrate how to communicate with the remote meter(s).

For the modem connected to a remote PC (the originate modem):

▷ Restore the modem to factory settings to erase all previously programmed settings.

▷ Set the modem to display result codes.
These will be used by the remote PC.

▷ Set the modem to verbal result codes.
These will be used by the remote PC.

▷ Set the modem to use the DTR signal.
This is necessary for the remote PC to ensure proper connection with the originate modem.

▷ Set the modem to enable flow control.
This is necessary to communicate with remote modem connected to the EPM 9800.

▷ Set the modem to write the new settings to activate the profile.
This places the settings into nonvolatile memory; they will take effect after the modem powers up.

For the modem connected to the EPM 9800 (the remote modem):

▷ Restore the modem to factory settings to erase all previously programmed settings.

▷ Set the modem to auto answer on *N* rings.

▷ Set modem to ignore the DTR signal.
This is necessary to ensure connection with originate modem.

▷ Set modem to disable flow control; RS232 communication does not support this feature.

▷ Set the modem to write the new settings to activate the profile.
This places the settings into nonvolatile memory; they will take effect after the modem powers up.

▷ When programming the remote modem with a terminal program, ensure the baud rate of the terminal program matches the meter baud rate.

Selected modem strings/settings are shown below.

**Table 6–1: Modem strings/settings**

| Modem | String/setting |
|---|---|
| Cardinal modem | AT&FE0F8&K0N0S37=9 |
| Zoom/Faxmodem VFX V.32BIS(14.4K) | AT&F0&K0S0=1&W0&Y0 |
| Zoom/Faxmodem 56Kx Dual Mode | AT&F0&K0&C0S0=1&W0&Y0 |
| US Robotics Sportster 33.6 Faxmodem | AT&F0&N6&W0Y0 (for 9600 baud)<br>DIP switch setting: up-up-down-down-up-up-up-down |
| US Robotics Sportster 56K Faxmodem | AT&F0&W0Y0<br>DIP switch setting: up-up-down-down-up-up-up-down |

## 6.4    RJ45 Ethernet Connections

### 6.4.1    Overview

The Ethernet RJ45 option conforms to the IEEE 802.3, 10/100Base-T specification using unshielded twisted pair (UTP) wiring. This allows the use of inexpensive RJ45 connectors and CAT 3 or better cabling. The RJ45 connector is supplied with the meter (cable 6).

Using this LAN connection allows multiple PCs to concurrently access the EPM 9800. The RJ45 line is inserted into the RJ45 connector on cable 6 from the back of the EPM 9800. The RJ45 connection into the meter connects the EPM 9800 to a network via the Modbus/TCP protocol.

### 6.4.2    Hardware Connection

The EPM 9800 with the 10/100Base-T Ethernet option has all the components of the standard EPM 9800 plus the capability of connection to a network.

The internal network option is an extremely versatile communication tool with the following features:

- Adheres to IEEE 802.3 Ethernet standard using TCP/IP.
- Utilizes simple and inexpensive 10/100Base-T wiring and connections.
- Connects to networks using standard built-in RJ45 jack.
- Programmable to any IP address, subnet mask, and gateway requirements.
- Communicates using the industry standard Modbus/TCP protocol.

## 6.5    Simultaneous Modem/Ethernet Connections

### 6.5.1    Overview

The combination modem/Ethernet option is an extension of the regular Ethernet option. It has all the features of the Ethernet option with a built-in modem. The modem and Ethernet capabilities can be used simultaneously.

The protocol supported by the modem is Modbus ASCII. The protocol supported by the RS485 ethernet/modem is Modbus RTU. The combination modem/Ethernet option converts all incoming modem Modbus ASCII requests to Modbus RTU for internal and communication. It then converts all response Modbus RTU messages into Modbus ASCII protocol before it sends the responses to the modem.

The fixed parameters for the Ethernet/modem are: 8 data bits, even parity, and 1 stop bit. The Ethernet/modem's baud rate and delay time are configurable.

## 6.6    DNP Communications

### 6.6.1    Features

The EPM 9800 Advanced Power Quality Metering System supports DNP V3.00 level 2. The following features are supported:

- Up to 136 measurements (64 binary inputs, 8 binary counters, 64 analog inputs) can be mapped to DNP static points (over 3000) in the customizable DNP point map.
- Up to 16 relays and 8 resets can be controlled through DNP level 2.
- Report-by-exception processing (DNP events) deadbands can be set on a per-point basis.
- 250 events of combination of four events (binary input change, frozen counter, counter change, analog change).
- Freeze commands: Freeze, Freeze/No-Ack, Freeze4 with Time, Freeze with Time/ No-Ack.
- Freeze with time commands enable the EPM 9800 meter to have internal time-driven frozen and frozen event data. The data is created when the meter receives the time and interval.

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# EPM 9800 Advanced Power Quality Metering System

# Chapter 7: Miscellaneous

## 7.1 Revision History

### 7.1.1 Release Dates

**Table 7–1: Release dates**

| Publication | GE part number | EPM 9800 revision | Release date |
|---|---|---|---|
| GEK-113198 | 1601-224-A1 | 1.0x | 20 January 2005 |
| GEK-11319C | 1601-224-A2 | 1.0x | 1 May 2007 |

### 7.1.2 Changes to the Manual

**Table 7–2: Revision A1 to A2**

| Section | Description |
|---|---|
| Ch. 8 | Add Chapter 8 - GE Communicator Software |
| General | Manual revised to A2 |
| General | New formatting including new cover graphics |
| Cover | Remove reference to UL #A3775 |

## 7.2    Warranty

### 7.2.1    GE Multilin Warranty

General Electric Multilin (GE Multilin) warrants each device it manufactures to be free from defects in material and workmanship under normal use and service for a period of 24 months from date of shipment from factory.

In the event of a failure covered by warranty, GE Multilin will undertake to repair or replace the device providing the warrantor determined that it is defective and it is returned with all transportation charges prepaid to an authorized service centre or the factory. Repairs or replacement under warranty will be made without charge.

Warranty shall not apply to any device which has been subject to misuse, negligence, accident, incorrect installation or use not in accordance with instructions nor any unit that has been altered outside a GE Multilin authorized factory outlet.

GE Multilin is not liable for special, indirect or consequential damages or for loss of profit or for expenses sustained as a result of a device malfunction, incorrect application or adjustment.

For complete text of Warranty (including limitations and disclaimers), refer to GE Multilin Standard Conditions of Sale.

# GE Consumer & Industrial
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# EPM 9800 Advanced Power Quality Metering System

# Chapter 8: GE Communicator EXT

## 8.1    Overview

EPM 9800 Advanced Power Quality Metering System enables you to configure an EPM 9800 Socket Meter's programmable settings, which are stored in the unit's Device Profile. The Device Profile has four sections (below) plus Output Modules.
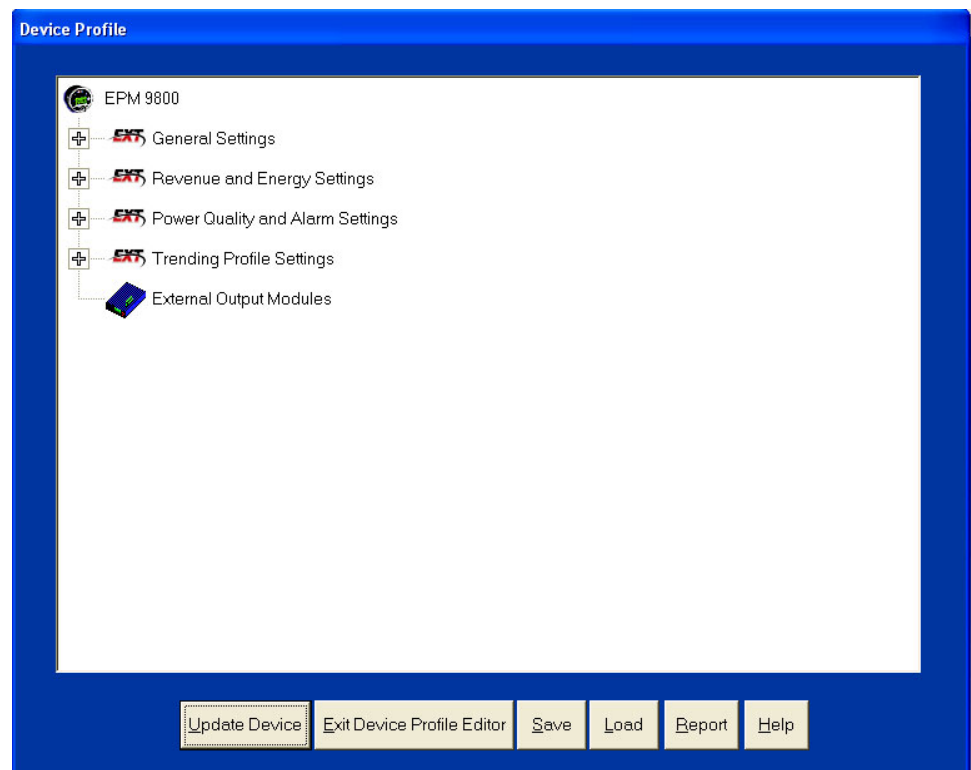


Following is an overview of the procedure for configuring an EPM 9800 Meter:

1. **Retrieve** the meter's Device Profile (section 8.2)

2. **Configure** the programmable settings stored in the Device Profile (sections 8.3–8.7)

3. **Send** the new Device Profile back to the Meter (section 8.2).

If you click the **Save**, **Load** or **Update** buttons, you **MUST** have a unique meter Destination Label so that the file is saved, loaded or updated to the intended device.

This chapter also covers:

- Resetting Meter Information (section 8.9)
- Setting and Retrieving Meter Time (section 8.10)
- Test Mode Preset Accumulators (section 8.14) and Options (section 8.15)

Actual programming screens may vary depending on the options ordered with your meter.

The settings shown are for the **EPM 9800, which supports DNP Level 2.** For a Feature Comparison of GE models, refer to section 1.6 of the GE Communicator EXT Guide. For details on DNP Level 2, see Chapter 17 of the GE Communicator EXT Guide. The External Devices section of the Device Profile is covered in Chapter 11 of this same guide.

## 8.2    Retrieve and Send Device Profiles

▷   Click on the **Profile** button, or select **Tools > Edit Current Device Profile**. EPM 9800 Advanced Power Quality Metering System retrieves the programmable settings from the currently connected meter.
The following screen appears:
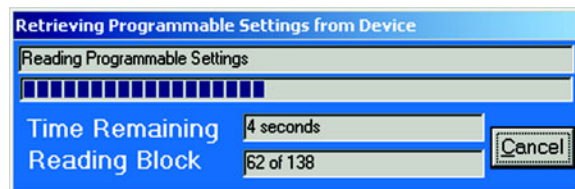


When the settings have been retrieved successfully, the Device Profile screen appears. This screen contains all the programmable settings currently stored in the connected meter.

▷   Configure each of the programmable settings by clicking on the **+/-** icon and then double-clicking on the selected parameter.
(See sections 8.3–8.25 for details on editing each setting.)
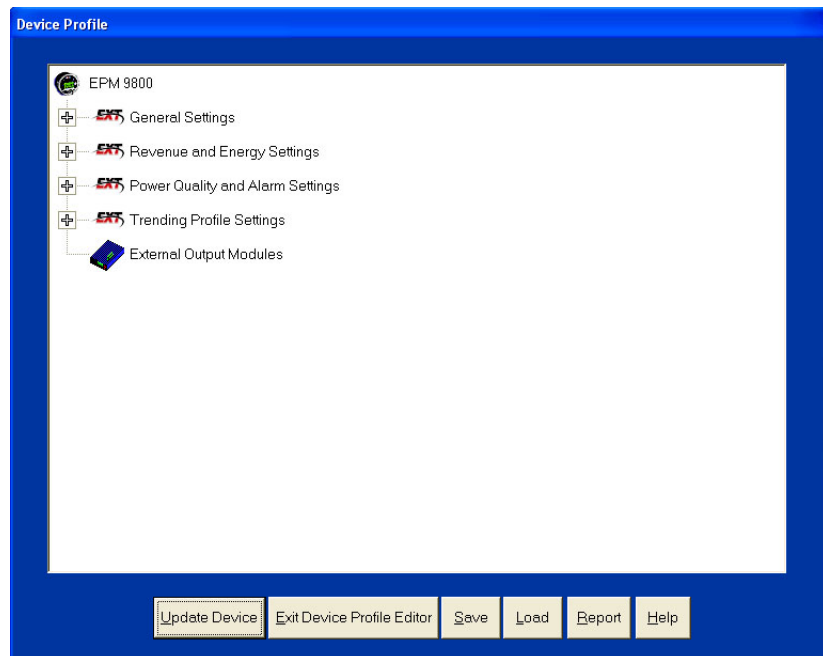


After you have finished configuring any or all of the programmable settings, use the BUTTONS at the bottom of the screen as follows:

▷   Click on the settings you would like to save, then proceed with the Update.

▷   Implement the changes by clicking on the **Update Device button**. This sends the new, edited Device Profile to the meter.

You must update the Meter Device profile for any of the programmable settings to take effect.

A **Warning** will appear asking you if you want to Save Connected Device Settings.

▷ Store the profile for later use by clicking on the **Save** button.
A dialogue box will ask where you would like to save the profile.

▷ Open a previously saved profile by clicking on the **Load** button.
A dialogue box will ask for the location of the saved profile.

▷ Print a copy of the profile by clicking on the **Report** button.
The Report screen will appear as shown here:



## Using the Report Page:

**Page Arrows:** Select a page to view.

**Zoom:** Adjusts the Viewing Magnification.

**Print Range:** Adjusts the Range of Pages to be printed at 100%.

## Buttons:

**Copies:** How many copies do you want to print?

**Print Pages:** Select individual pages to print. Separate Page Numbers by Commas.

**Print:** This button sends you to Print Setup screen where you select printer, properties, paper and page orientation. Click OK to Print.

**Save:** Save these selections for future use.

**Done:** Exit the screen and return to the Device Profile screen.

If you change the Com settings for the meter, you will not be able to communicate with the meter. You will have to sign off and sign on again with the new settings.

## 8.3    General Settings

"General Settings" is the first group of settings in the Device Profile.

▷ From the Device Profile screen (see section 8.2), click on the (**+/-**) button or double-click on the "General Settings" line.
All of the settings in the General Settings Group are listed.
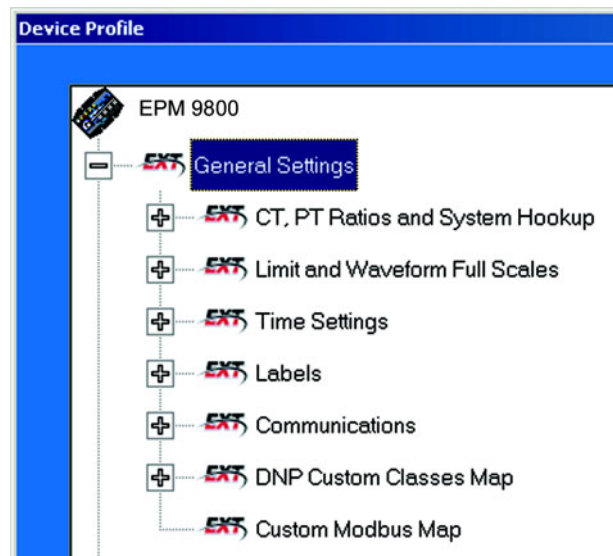


▷ Click on the particular Programmable Setting you would like to configure.
The settings will be detailed in the order they appear on the Device Profile screen.

### 8.3.1    CT and PT Ratios and System Hookup

▷ From the Device Profile screen (see section 8.2), click on **General Settings**

▷ Double-click on the **CT, PT Ratios and System Hookup** line.
The following submenu appears:
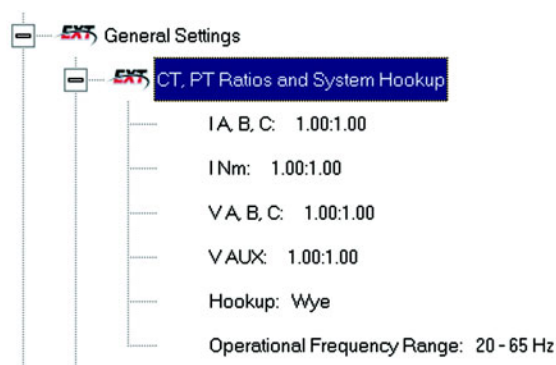
This screen displays the current Device Profile's settings for CT, PT ratios and the meter form used for hookup. The values shown are for example only.

▷ **Double-click on any of the settings.**
**The CT and PT Ratios screen appears:**



Make changes to this screen according to the requirements of your application.

- When you change a PT or CT ratio, EPM 9800 Advanced Power Quality Metering System updates the corresponding Full Scale value entered in the Limits and Waveforms Full Scale setting.

- Using the pull-down menu, choose the hook up service that matches the connection you have to the EPM 9800. Selections may include: 9S 4-Wire Wye or Delta, 36S 4-Wire Wye, 39S 4-Wire Wye and 45S 3-Wire Delta or 4-Wire Wye. The Device Profile screen, including the Form above the connection window, will reflect your selection.

Changes to the Operational Frequency Range do not change the Full Scale Value for Frequency. Changes must be made in the "Limits and Waveform Full Scale Settings" screen. Like Voltage and Current, the nominal value should be used. For example, 50 for 50Hz circuits.

▷ Click **OK**.
The following screen asks you to verify the Kh/Ke Ratio for the Test Pulse Setting. Kh/Ke Ratio is Secondary Watthour Constant over kWh (the energy).
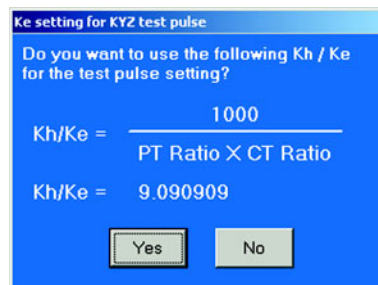


▷ Click **Yes**, or Click **No**, and re-enter values in the CT & PT Ratio screen.

▷ When all changes are entered, click **OK** to return to the main Device Profile screen.

▷ Click on the **Update Device** button.
This sends the new profile to the Meter.

▷ **Reset** Logs, clearing logs and accumulations.

Be sure to capture needed meter information before updating the device. Data will no longer be available after the Reset. The meter will be prepared for new installation.

## 8.3.2    Limit and Waveform Full Scales

All Limit and Waveform settings (sections 8.5.1 and 8.5.3, respectively) are based on a percentage of the Full Scale. Full Scales are based on the CT and PT ratios (see section 8.3.1).

▷ **Be sure to set the CT and PT ratios first**
EPM 9800 Advanced Power Quality Metering System automatically recalculates the Full Scales every time the CT and PT ratios change and should be verified every time CT and PT Ratios are changed.

Changing the CT and PT Ratios will reset the meter, clearing logs and stored data. This action prepares the meter for placement in a new installation or changing of the Instrument Transformers.

▷ From the Device Profile screen (see section 8.2), click on the **+/-** button beside **General Settings**

▷ Click on the **Limit and Waveform Full Scales** line.
The following submenu appears:
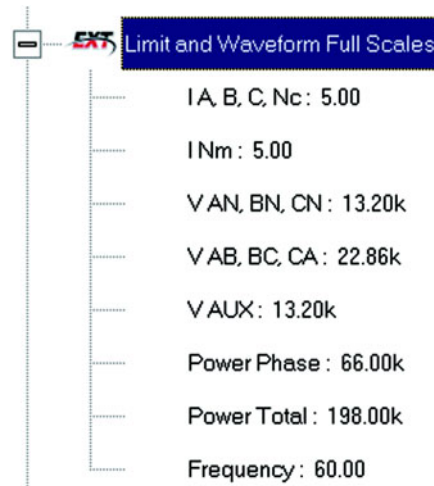


The EPM 9800 screen displays the Device Profile's settings for the Limit and Waveform Full Scales.

Frequency and Voltage values are nominal values. The Phase Powers are computed using nominal voltage and rated maximum current.

▷ Double-click on any of the settings.
The Limit and Waveform Full Scales screen appears.
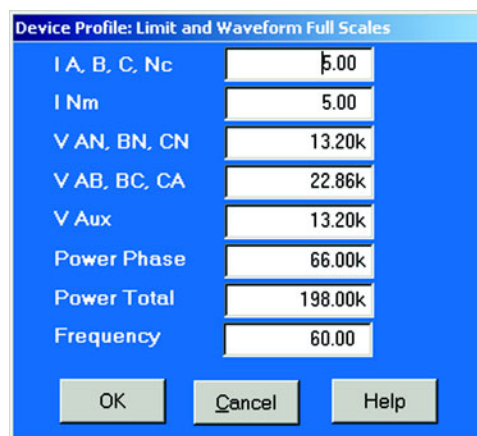


▷ Enter the Full Scale for each parameter:

• The Limit and Waveform settings (section 8.5.1 and 8.5.3, respectively) will be based on a percentage of the Full Scales entered here.

• EPM 9800 Advanced Power Quality Metering System automatically recalculates the Full Scales Voltages, Currents and

Power every time the CT and PT Ratios change. Frequency is not changed, even if the Range

• Selection is changed. Frequency must be changed on the Limits screen. ï Power Phase is the amount of power per each phase.

• Power Total is the power of all phases combined.

▷ When all changes are entered, click **OK** to return to the main Device Profile screen.

▷ For these changes to take effect, you must click on the **Update Device** button.
This sends the new profile to the meter.

▷ To **Reset** Logs, see section 8.26

### 8.3.3    Time Settings

#### To edit a Device Profile's time settings:

▷ From the Device Profile screen (see section 8.2), click on the **+/-** button or double-click on the **Time Settings** line.
The following submenu appears:
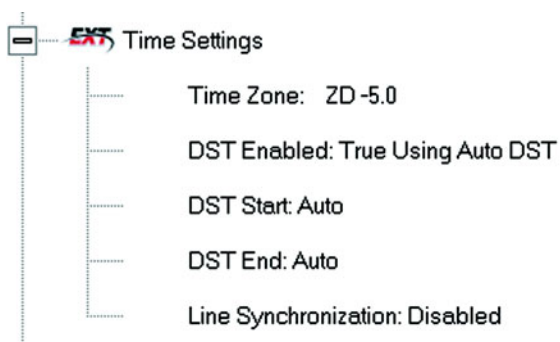


This screen displays the current Device Profile's time settings. (DST=Daylight Savings Time.)

▷ Double-click on a programmable setting (eg: **Time Zone**).
The Time Settings screen appears.



▷ Make changes to this screen according to the requirements of your
application:

- **Zone Descriptor**:
  Sets the Time Zone for the Meter. (0=Greenwich Mean Time).

**Table 8–1: Greenwich Mean Time (GMT) Table (Dublin, London)**

| -1:00 | Azores | +1:00 | Brussels, Paris, Warsaw |
|---|---|---|---|
| -2:00 | Mid-Atlantic | +2:00 | Athens, Cairo, Helsinki |
| -3:00 | Buenos Aires, Georgetown | +3:00 | Baghdad, Kuwait, Moscow, Teheran |
| -4:00 | Atlantic Time (Canada), Santiago | +4:00 | Kabul, Baku |
| -5:00 | Eastern Time (US & Canada), Lima | +5:00 | Karachi |
| -6:00 | Central Time (US & Can), Mx City | +6:00 | Daka |
| -7:00 | Mountain Time (US & Canada) | +7:00 | Bankok, Hanoi, Jakarta |
| -8:00 | Pacific Time (US & Can), Tijuana | +8:00 | Beijing, Hong Kong, Singapore |
| -9:00 | Alaska | +9:00 | Osaka, Sapporo, Seoul |

Table 8–1: Greenwich Mean Time (GMT) Table (Dublin, London)

| -10:00 | Hawaii | +10:00 | Brisbane, Melbourne, Guam, Hobart |
|--------|--------|--------|-----------------------------------|
| -11:00 | Midway Island | +11:00 | Magadan, Solomon Islands |
| -12:00 | Eniwetok | +12:00 | Auckland, Fiji |

- **Daylight Savings Information**:

   **Enable:** Enables an automatic adjustment for daylight savings.

   **Disable:** Disables an automatic adjustment for daylight savings.

   **Auto DST:** Sets Daylight Savings Time automatically for the **United States only**. Time changes automatically occur at 2:00 AM (your local time), on the first Sunday in April and the last Sunday in October.

   **User Defined:** Allows you to set the Daylight Savings Time manually.

   **Start:** Set the Month, Day and Hour when the adjustment for Daylight Savings will commence.

   **End:** Set the month, day and hour when the adjustment for Daylight Savings will conclude.

- **Line Synchronization**: Set Enable or Disable and Frequency.

   The basic function of Line Synchronization is to adjust the real time clock to track the time based on the power line frequency. For this purpose, Phase A voltage ONLY is used. Line Sync is disabled if a GPS signal is present.

- **How Time is Adjusted**:

   After the clock is synchronized to the line, the meter periodically checks the cumulative difference between the real time clock in cycles and the line cycle count. If the absolute difference is greater that 50 (60) cycles, the clock is adjusted ±1 second accordingly.

▷ To set the meter on-board clock, use **Set Meter Time** from the Tools menu. (see section 8.26).

▷ When all changes are entered, click **OK** to return to the main Device Profile screen.

▷ For these changes to take effect, you must click on the **Update Device** button.
This sends the new profile to the Meter.

▷ To **Reset** Logs, see later sections.

### 8.3.4    Labels

**Labels are user-defined names for the Meter, the Auxiliary Voltage terminal and the I N Measured terminal.**

It is important to label the meter (under **Meter Designation** because the label given will become the name of the file for any logs retrieved from that meter; see Chapter 8 of the GE Communicator EXT Guide for details on viewing stored logs.

▷ From the Device Profile screen (section xxx), click on the **+/-** button beside **General Settings**, then click on **Labels**.
The following submenu appears:



▷ Double-click on any of the designation names.
The following screen appears.



▷ Enter the labels in the appropriate fields.
Meter Designation MUST be set for Partial Log Retrieval.

When all changes are entered,

▷ Click **OK** to return to the main Device Profile screen.

▷ Click on the **Update Device** button to effect changes.
This sends the new profile to the meter.

For meter designations, you can use any character allowed by Windows Operating System for a File Name (since that meter designation will be used as the File Name).
In English versions the following characters will **not** work:
**\ / : * ? " < > |**.
For meters used internationally by multilingual users, it is recommended that you use ONLY alphanumeric characters allowed by your Operating System.

### 8.3.5    Communications

▷   From the Device Profile screen (see section 8.2), click on the **+/-** button next to **General Settings**, then click on **Communications Ports**.
The following submenu appears:
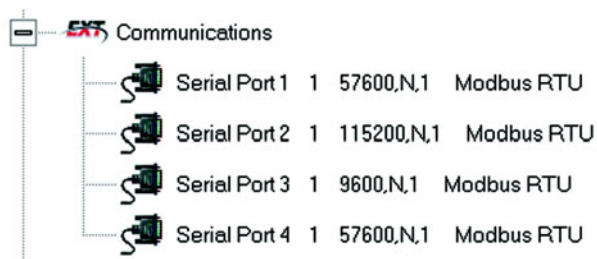
▷ Double-click on the port you would like to change.
The Communications Settings screen appears:



This screen displays the Device Profile's settings for the meter's two programmable Communications Ports: Address, Baud Rate, Data Bits, Parity, Stop Bits, Transmit Delay, Communication Protocol, Network Option and Internal Modem Option.

You may use the on-board display or one of the meter's External Displays to learn the current baud rate, address and communication protocol of each meter port. **The settings for the Optical Port are fixed and cannot be changed.** Port 1 and Port 4 are the meter's RS-485 ports and are used for RS- 485 communication with a variety of devices. Port 3 is an internal modem or Ethernet. Ports 1 and 4 are factory set at 115200 and 9600 baud rates, port 3, is 38,400 maximum.

▷ **Make changes to this screen according to the requirements of your application, by clicking on the box or pull-down menu of any of the following settings:**

• **Address**: Assign an address to each port to communicate with other devices. Multiple Meters on an RS-485 bus must each have a unique address set for the port that is connected to the bus. Type in unique address.

• **Baud Rate**: The baud rate entered in this field must match the baud rate of the device that will be connected to the Meter at this

port. Use 9600 for modem connections. From the pull-down menu, select 4800, 9600, 19200, 38400, 57600, or 115200.

- **Data Bits**: for Modbus RTU and ASCII, leave the Data Bits at 8. Other protocols may require a different setting. Use the pull-down menu to select from: 5, 6, 7 or 8.

- **Parity**: for Modbus RTU and ASCII, leave the Parity at None. Other protocols may require a different setting. Use the pull-down menu to select from: None, Even, Odd, Mark or Space.

- **Stop Bits**: for Modbus RTU and ASCII, leave the Stop Bits at 1. Other protocols may require a different setting. Use the pull-down menu to select from: 1, 1.5 or 2.

- **TxDelay (Transmit Delay)**: leave the TxDelay at 0ms unless you are using equipment that requires a delay in the response time, such as a radio modem. Use the pull-down menu to select from: 0ms, 10ms, 20ms, 30ms, 40ms, 50ms, 60ms, 60ms or 70ms.

- **Protocol**: Direct Connections made through EPM 9800 Advanced Power Quality Metering System must use either Modbus RTU or Modbus ASCII protocol (Modbus RTU is recommended). Modem Connections made through EPM 9800 Advanced Power Quality Metering System must use Modbus ASCII only. Use the pull-down menu to select from: Modbus RTU, Modbus ASCII or DNP 3.0. See Chapter 2 of the GE Communicator EXT Guide for details.

- **Mode (Port 4 only)**: If you are using Output modules, set this port to Output Module mode. Set the port to operate at 57600 baud. To change the setting, use the pull-down menu to select Slave or Output Module. Make other changes for your application.

- **Internal Network Option**: If your Meter has the Internal Network Option, see your Network Administrator for the correct settings. Settings will vary from network to network.

If your meter has the INP200 Option (10/100BaseT) and you click on the Advanced Settings button, the following set of screens will appear. The meter is shipped with initial settings, or you can fully configure the settings using these screens. The process is detailed in Chapter 6 of the GE Communicator EXT Guide.

This screen is **not** supported by meters with the INP10 Option

.
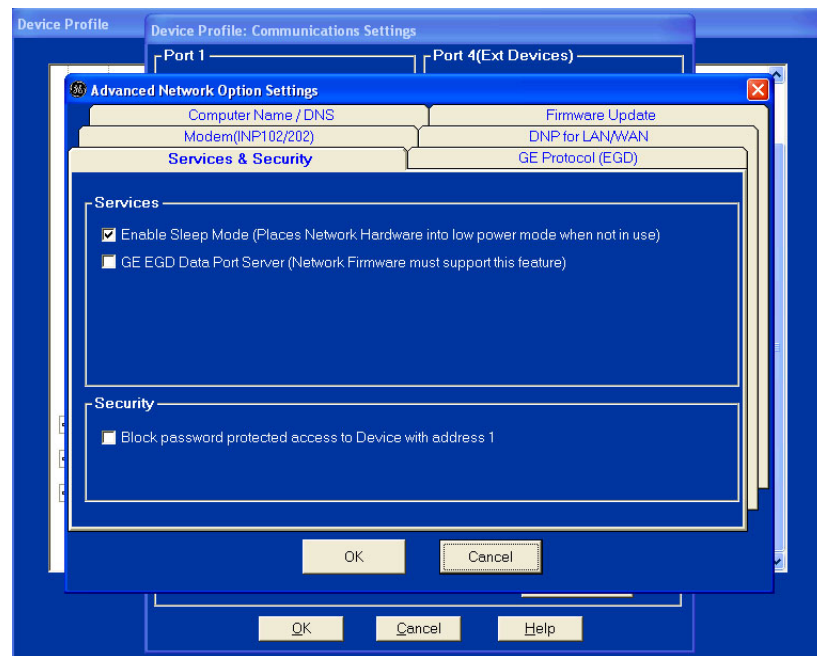


- **Internal Modem Option**: If your meter has this option, set the number of Rings to Answer from the pull-down menu. Set the Baud Rate to 57600, or to match your system baud rate.
- **Dial Out Profile**: Click the Dial Out Profile button and the following screen appears. Details on programming this screen

and on the Modem Dial In/Dial Out Function are in Chapter 9 of this manual. This feature is ordered as INP 2.



> Any changes you make here may adversely affect communications. For example, if you change the baud rate of the port connected to a computer, be sure to make the same change to the computer port's baud rate. If you change a port's address, be sure to update the address settings of any device that communicates with the port. The baud rate of the port used by the Meter's External Display should always be set to **9600** and the address set to **1**.

- **Edit Gateway Port Devices**: The Edit Gateway Port Devices button at the bottom of the screen is used to Enable up to 8 devices that are connected the gateway and are to be monitored.

When the user clicks the Edit Gateway Port Devices button, this screen is displayed:



▷ Click on the box next to the Device to be monitored.
A Device Address will appear next to the Enabled Device.

▷ Change the **Device Address**, if needed, to any address except **1**.
The Number 1 is always reserved for the Primary Device.

▷ Click **OK** to return to the Modem Programming screen.

▷ When all changes are entered, click **OK** to return to the main Device Profile screen.

▷ Click on the **Update Device** button.
This sends the new profile to the EPM 9800 Meter.

▷ **Reset** Logs.

### 8.3.6    DNP Custom Classes Map

The DNP Custom Class Map is a useful tool for prioritizing the readings in your system and the frequency of the readings. The DNP Custom Class Map also keeps your system free from thousands of unwanted readings.

▷ From the Device Profile screen (section 8.2), click on the **+/-** button beside **DNP Custom Class Map**.

▷ Double-click on a **DNP Custom Class Map** parameter.
The following set of screens appears. (EPM 9800 meters support
DNP V3.00 Level 2. **See Chapter 16** of the GE Communicator EXT
Guide **for details.)**
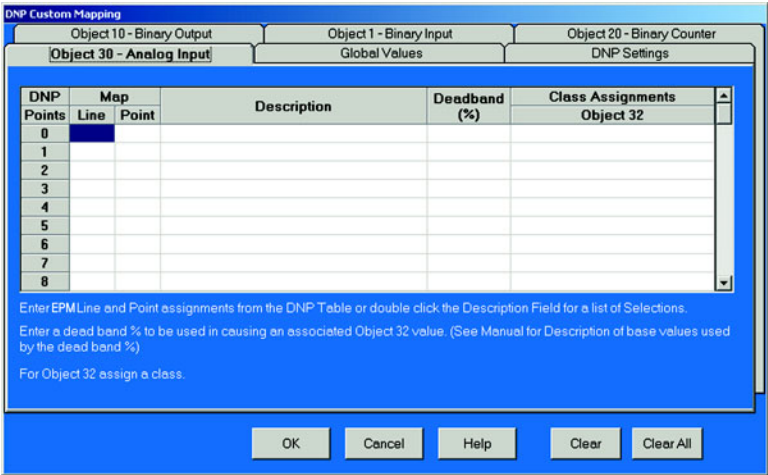


### 8.3.7 Custom Modbus Map

#### EPM 9800 Custom Modbus Map

You can select up to 256 Registers (or the equivalent of 2K, whichever is lower) to provide
the functionality you want from your Meter. In addition, you can customize selected values
for Format Type, Scaling, Byte Order, Data Size, etc.

▷ From the Device Profile screen (section 8.2), click on the **+/-** button
beside **Custom Modbus Map** or double-click on the **Custom
Modbus Map** line.
The screen appears:
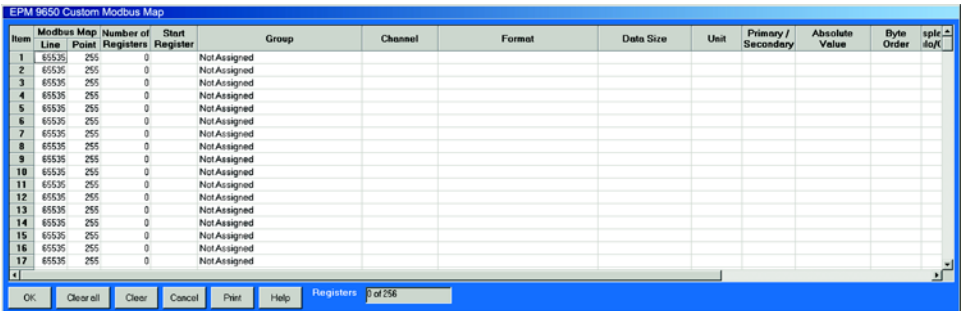


Data entry is straightforward. Each type of data is described below. Note that not all
selections will appear on the screen at the same time. You have to **scroll the screen from
right to left** to reach some of the functions. Certain entries (such as Format, Data Size, etc.)
have different allowable selections depending on the data point used. The pull-down menu
will automatically adjust to provide the appropriate selections for that data point.

Table of the Most Commonly Used Modbus Map Readings on page 8-18.

## Data Point Selection
(There are two different ways to select a Data Point.)

▷ **Refer to the Modbus Map and find the associated Line and Point for the value you want.**
When you enter those values into the table, the software will complete the associated Group and Channel.

OR

▷ Double-click the **Group** field.

▷ From the pull-down menus, select a **Group and Associated Channel** value.
The software will complete the Map and Line values.

- **Number of Registers**
The number of registers polled for this Data Point is automatically computed. The number is dependent on the Data Size selected in the Data Size column.

- **Start Register**
Start Register numbers are automatically assigned. The registers are assigned and adjusted automatically to take into account previous entries and data sizes. This is the Start Number for the first register to use in polling.

- **Format**
From the pull-down menu, select a type of Format for a value such as Floating, Integer, etc.

- **Data Size**
From the pull-down menu, select the Number of Bytes you want to represent the Data Point.

- **Unit**
If the polled value is viewed as an integer, the Unit field tells you where to place the decimal point.
**Example**: If you select .01, a polling value 1234 would be interpreted as 12.34.
**Example**: If you select 100, a polling value 1234 would be interpreted as 123400.

- **Pri/Sec**
The meter normally computes values in secondary units. Where applicable, you may select primary or secondary. If Primary is selected, the value is multiplied by the appropriate CT and/or PT values.

- **Sign/Abs**
Where appropriate, you may have the option of having the data point computed as a signed or absolute value.

- **Byte Order**
For most of the Data Points, the user can select the polling order of the number of bytes selected by the Data Size field. Example: For a four-byte Data Point, the bytes can be arranged in any order for polling purposes.

- **Display/Modulo/Offset**
  Depending on the Data Point selected, you may select one or more additional options with the appropriate subselections.
  **Display:** For certain Data Points, interpretation and display options are offered.
  **Example**: For An Angle values, you can represent and display as 0 to 360 degrees or -180 to +180 degrees, etc. Selections will appear in a pull-down menu for the associated point.
  **Modulo:** Certain values are cumulative and can roll over and start recounting from zero. For those values, where required, you can enter a point at which the rollover will occur.
  **Offset:** Where allowed, you can enter a value (offset) which will be added to the data point when it is computed.

**Table 8–2: Custom Modbus Readings**

| Line | Point | Description |
|------|-------|-------------|
| 34 | 0 | One Second Phase to Neutral Volts: Volts AN |
| 34 | 1 | One Second Phase to Neutral Volts: Volts BN |
| 34 | 2 | One Second Phase to Neutral Volts: Volts CN |
| 35 | 0 | One Second Auxiliary Volts: V Aux |
| 36 | 0 | One Second (A, B, C): 1A |
| 36 | 1 | One Second (A, B, C): 1B |
| 36 | 2 | One Second (A, B, C): 1C |
| 37 | 0 | One Second Measured N Current: 1Nm |
| 38 | 0 | One Second Calculated N Current: 1Nc |
| 39 | 0 | One Second Phase to Phase Volts: Volts AB |
| 39 | 1 | One Second Phase to Phase Volts: Volts BC |
| 39 | 2 | One Second Phase to Phase Volts: Volts CA |
| 40 | 0 | One Second VA (A, B, C): VA A |
| 40 | 1 | One Second VA (A, B, C): VA B |
| 40 | 2 | One Second VA (A, B, C): VA C |
| 41 | 0 | One Second VA Total: VA Total |
| 42 | 0 | One Second One Second VAR (A, B, C): VAR A |
| 42 | 1 | One Second One Second VAR (A, B, C): VAR A |
| 42 | 2 | One Second One Second VAR (A, B, C): VAR A |
| 43 | 0 | One Second VAR Total: VAR Total |
| 44 | 0 | One Second One Second Watts (A, B, C): Watts A |
| 44 | 1 | One Second One Second Watts (A, B, C): Watts B |

**Table 8–2: Custom Modbus Readings**

| 44 | 2 | One Second One Second Watts (A, B, C): Watts C |
|---|---|---|
| 45 | 0 | One Second Watts Total: Watts Total |
| 46 | 0 | One Second Frequency: Frequency |
| 47 | 0 | One Second Power Factor (A, B, C): PF A |
| 47 | 1 | One Second Power Factor (A, B, C): PF B |
| 47 | 2 | One Second Power Factor (A, B, C): PF C |
| 48 | 0 | One Second Power Factor Total: PF Total |
| 49 | 0 | One Second Imbalance: Voltage |
| 49 | 1 | One Second Imbalance: Current |
| 216 | 2 | Block Window Average Watt |
| 217 | 3 | Maximum Block Window Positive Watt |
| 217 | 4 | Maximum Block Window Negative Watt |
| 218 | 3 | Minimum Block Window Positive Watt |
| 218 | 4 | Minimum Block Window Negative Watt |
| 194 | 4 | Phase A-N/Phase A-B Voltage THD |
| 195 | 0 | Phase B-N/Phase B-C Voltage THD |
| 196 | 0 | Phase C/Phase C-A Voltage THD |
| 197 | 0 | Phase A Current THD |
| 198 | 0 | Phase B Current THD |
| 199 | 0 | Phase C Current THD |

▷ Use the buttons at the bottom of the screen to **Clear All**, **Clear**, **Cancel** or **Print** your selections.

▷ When all changes are entered, click **OK** to return to the main Device Profile screen.

▷ For these changes to take effect, you MUST click the **Update Device** button to send the new profile to the meter.

## 8.4     Revenue and Energy Settings

**"Revenue and Energy Settings" is the second group of settings in the Device Profile.**

▷ From the Device Profile screen (see section 8.2), click on the **+/-** button or double-click on the **Revenue and Energy Settings** line. All of the settings in the Revenue and Energy Settings Group are listed.
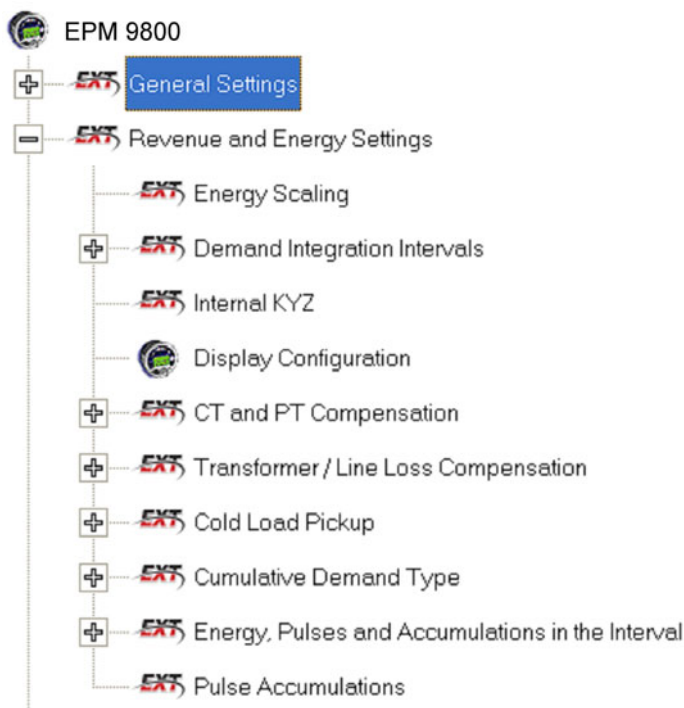


▷ Click on the particular programmable setting you would like to configure.
The settings will be detailed in the order they appear on the Device Profile screen.

### 8.4.1    Energy Scaling

▷ From the Device Profile screen (see section 8.2), click on the **+/-** button or double-click on the **Energy Scaling** line.
The following set of screens appears:



▷ Using the EPM 9800 Energy Scale Setting screens, the user can select the Number of Digits, Decimal Point Placement and Energy Unit for displayed readings.

▷ Click on the tabs to navigate between screens, except for Global Settings.  Click on **Global Settings** to access that screen.

- Energy

    Watt Hour (Above)

    VA Hour

    VAR Hour

- Uncompensated Energy

    VA, Watt and VAR readings not adjusted by Transformer Loss Compensation.

- Test Mode Energy

  Energy Readings while in Test Mode.



- Pulse Accumulation

  Accumulators

  Aggregators

- I and V Squared T Readings

  $I^2T$: Data will not accumulate until Current reaches programmed level.

  $V^2T$: Data stops accumulating when Voltage falls below programmed level.



- Q Hours

  Q Hours are obtained by lagging the applied voltage to a wattmeter by 60 degrees.

- Global Settings

  Settings configured on one screen apply to screens associated with filled-in rows. If a row is left blank, the associated screen is not modified.



▷ When all changes are entered, click **OK** to return to the main Device Profile screen.

▷ Click on the **Update Device** button.
This sends the new profile to the EPM 9800 Meter.

### 8.4.2 Program Demand Integration Intervals (Demand Intervals)

**See *EPM 9800 Installation and Operation Manual* for details on Demand Integration.**

▷ From the Device Profile screen (see section 8.2), click on the **+/-** button or double-click on the **Demand Integration Intervals** line. The following submenu appears:
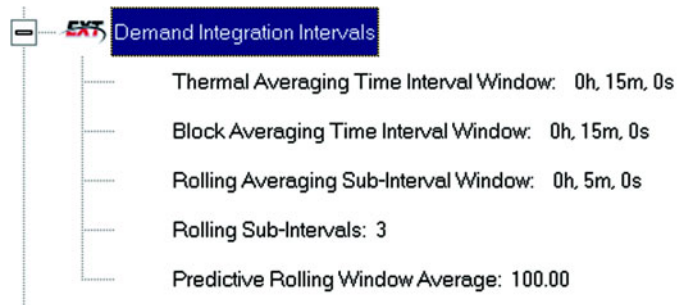


▷ Double-click on any of the settings and the Demand Integration Programming screens appear:
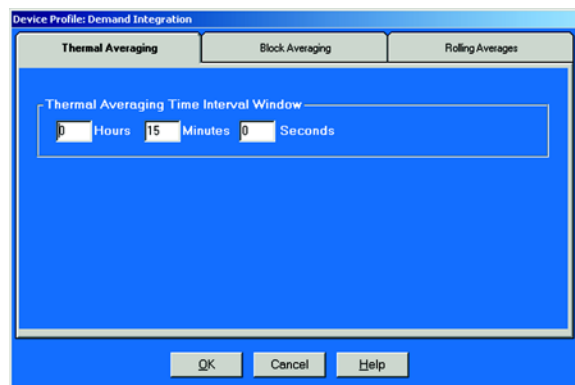


▷ Click on the tabs at the top of the screens to navigate from one screen to the others.

▷ Make changes to the screens according to the requirements of your application.

**Following is a brief description of each setting and its function.**

• **Thermal Averaging Time Interval Window** (above): Allows you to set hours, minutes and seconds for a precise thermal window of demand data.

- **Block Averaging Time Interval Window**: Sets the length of the Block Interval used for Demand Calculation and other Interval-based functions.



- **Block Window Sync**: Synchronizes the meter with pulses from a High Speed Input connected to another meter.

  ▷ Click **Generate End of Interval Pulse** on the lower section of the above screen (not shown) to produce a synchronizing output and select a Relay and Pulse Width for the output.

- **Rolling Average Subinterval Window**: Sets the length of the Demand Subinterval when Rolling Demand is used. (Subinterval Length X Number of Subintervals = Length of Demand Interval Window)



- **Rolling Subintervals**: Sets the number of Rolling Demand Subintervals in the Rolling Demand Window. (Subinterval Length X Number of Subintervals = Length of Demand Interval Window)

- **Predictive Rolling Window Average**: Increasing the length of the Predictive Demand Window increases the accuracy of the prediction by including more of the Current Demand Window (up to 100%). Decreasing the length of the Prediction Window gives earlier warnings of high demands.

▷ When all changes are entered, click **OK** to return to the main Device Profile screen.

▷ For these changes to take effect, you MUST click on the **Update Device** button to send the new profile to the meter.

### 8.4.3    Internal KYZ Outputs (and Test LED Settings)

The Internal KYZ Outputs Settings allow you to assign channels to the KYZ Outputs and to the Test LED Test. The Channel Selection sets the type of pulse that will be generated.

For example, the **Test LED** can generate Energy Pulses for conventional testing or Reactive (VARh) Pulses for complex testing and approvals. The settings also allow you to determine the frequency and the duration of the pulse for each output and for the Test LED.

▷ From the Device Profile screen (section 8.2), click on the **+/-** button beside **Internal KYZ Settings** or double- click on the **Internal KYZ Settings** line.
The screen appears:



▷ Click on the arrow of the pull-down menu next to KYZ Output to which you would like to assign a channel.

▷ Make changes to:

Watt Hour per Pulse,

Pulse Width,

Mode and Form,

for each output and for the Test LED.
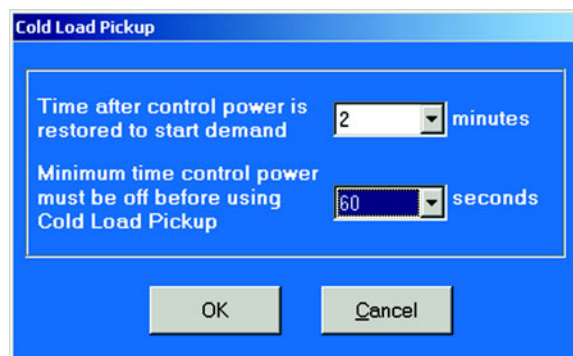
Note on Form: Form A = Transition. Form C = Pulse.

▷ When all changes are entered, click **OK** to return to the main Device Profile screen.

▷ For these changes to take effect, you MUST click on the **Update Device** button.
This sends the new profile to the EPM 9800 Meter.

If your EPM 9800 meter is equipped with the **KYZ Output** Option, the KYZ Output Settings will appear. Otherwise, only the Test LED will appear on the screen.

### 8.4.4   Display Configuration

▷ From the Device Profile screen (section 8.2), click on the **+/-** button beside **Display Configuration** or double-click on the **Display Configuration** line.
The following set of screens (Meter Display Programmable Settings) appears:

▷ Click tabs at the top of the screens to access the Programmable Settings.



- Display Modes:

  ▷ Enter a three-letter Label for each of the three View Modes. Enter a Description for each View Mode using the Line 1 and 2 Description windows.



- Screen Assignments:

▷ Enter up to 16 screens for each View Mode.
Your label for each View Mode appears at the top of each column.



• Power and Energy Display:

▷ Set **Scale**, **Digits** and **Decimal Point**.
Previews appear at the bottom of the screen.

Settings on this screen control the display of energy related numbers. Care should be given to match the values on the display with those in historical logs. These settings apply to VA-hours, Watt-hours (**+/-**), VARhours (**+/-**) and VAR-hours (quadrants) in the meter.

Scale factor is the user-programmable setting that determines how measurements made by the meter will be displayed. In most applications, the measurements made in the metering circuit on the secondary side on the Instrument Transformers are displayed as Primary Values using the Scale Factor.

The Scale Factor (Primary Value = Secondary Value X Scale Factor) and the Transformer Factor (TF = Voltage Transformer Ratio X Current Transformer Ratio) are the same for energy measurements.

For display of voltage and current measurements, VTR and CTR are used.

**NOTE**

**Scale Factor takes precedence over all other settings**, i.e. - all other settings are based on this setting.
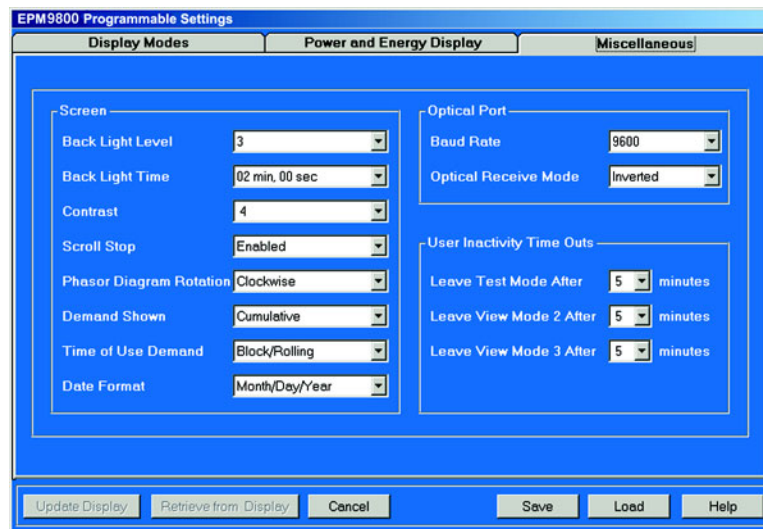
- Miscellaneous:

    ▷ **Set Screen Settings, Optical Port and User Inactivity Time-outs.**
    The Screen Settings replace Adjustments Mode in the default profile.

  - **Screen Settings**:

    ▷ Set Back Light Level (brightness), Back Light Time (when Back Light shuts off), Contrast, Scroll Stop, Phasor Rotation and  Cumulative Demand.

  - **Cumulative Demand Settings**:

    ▷ Set to:
    Regular: Running Total
    Continuous: Running Total + Current Max/Min.

  - **Optical Port**:

    ▷ Set Baud Rate and Optical Receive (Normal or Inverted).
    Inverted Operation is used with the Smart Coupler.

- **User Inactivity Time Outs:** (number of minutes since last user action when Mode reverts to View Mode 1).

  - **Settings are:**
    5 - 60 minutes.
    Leave Test Mode After_ Minutes: Reverts with or without energy accumulation.
    Leave View Mode 2 or 3 After _ Minutes: Reverts Automatically.

- Use Buttons for Functions below:

  - **Update Display:**

    ▷ Must click to update the display. After settings update, View Mode 1 is displayed.

  - **Retrieve from Display:**

    ▷ Click to retrieve existing settings.

- **Cancel:**

  ▷ Cancel any new settings and return to main EPM 9800 Advanced Power Quality Metering System screen.

- **Save:**

  ▷ Save new settings to a file.

- **Load:**

  ▷ Load saved settings from a file.

  ▷ Click **Update Display** to send new display settings and return to main EPM 9800 Advanced Power Quality Metering System screen.

> **NOTE**  See the *EPM 9800 Installation and Operation Manual* for further details.

## 8.4.5    CT and PT Compensation

▷ From the Device Profile screen (see section 8.2), click on the **+/-** button beside **CT and PT Compensation** or double-click on the **CT and PT Compensation** line.
The following screen appears:
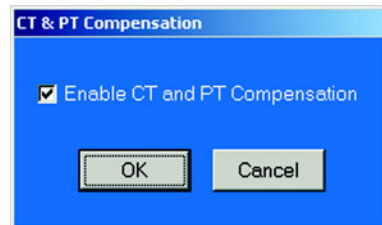


▷ Check the **Enable CT** box to Enable CT and PT Compensation. (Leave unchecked to Disable. )

▷ Click **OK** to close the screen and return to the main EPM 9800 Advanced Power Quality Metering System screen.

> **NOTE**  The term "Potential Transformer" was changed to "Voltage Transformer" by the IEEE in 1982. Most Instrument Transformers now use the term Voltage Transformer.

### 8.4.6    Transformer/Line Loss Compensation

▷ From the Device Profile screen (see section 8.2), click on the **+/-** button beside **Transformer / Line Loss Compensation** or double-click on the **Transformer / Line Loss Compensation** line.
The following submenu appears:
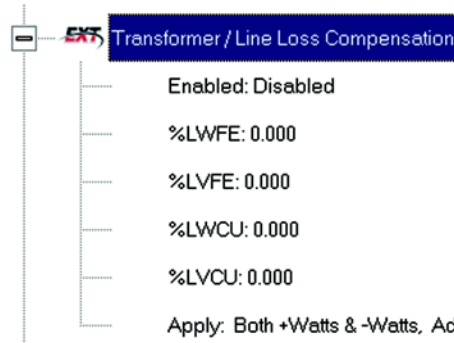


This screen displays the current values for the meter's Transformer Loss Compensation.

- %LWFE = Percent Loss of Watts due to Iron ï
- %LVFE = Percent Loss of Vars due to Iron ï
- %LWCU = Percent Loss of Watts due to Copper
- %LVCU = Percent Loss of Vars due to Copper

▷ Consult **Appendix B** of the GE Communicator EXT Guide, **on Transformer Loss Compensation in the appendix pages of this manual.**

▷ **Double-click on any of the loss values,"%LWFE" etc.**
The Transformer and Line Loss Compensation screen appears (see next page).

▷ Click on **TLC Calculator** to find the values to enter into the Percent Loss windows.
The Calculator button will launch an Excel Spreadsheet which will do the calculations for you once the required data is entered. A copy of the Excel Spreadsheet with example numbers is in **Appendix B** of the GE Communicator EXT Guide.

EPM 9800 Advanced Power Quality Metering System will automatically launch the Excel Spreadsheet as part of its software package. But, for the TLC Button to work, you must have the Excel program in your system. If you do not have Excel software or if the spreadsheet file is not in the GE Communicator directory, a Warning will be displayed instead of the worksheet. You can do your own calculations using the hardcopy Transformer Loss Compensation Worksheet in Appendix B of the GE Communicator EXT Guide.

For most Excel users, this spreadsheet will not run until permission is given to run the Macros contained in the sheet. This is done by changing the Excel Security Setting from High to Medium.

## The Excel Command

▷ From Excel Toolbar, select **Tools > Security > Options**.

▷ On the Security Tab Pag, click on the **Macro Security** button.

▷ Select **Medium Security**.
This setting allows Excel to run in EPM 9800 Advanced Power Quality Metering System.

▷ Enter the percent Loss of Watts and Vars for copper and iron in the appropriate fields.

▷ Enable Transformer Loss Compensation by selecting **Iron** only, **Copper Only** or **Both Iron and Copper** from the pull-down menu at the bottom of the screen.

▷ With the second pull-down menu, select from the following:

- Add to Watts and Subtract from VAR
- Subtract from Watts and Add to VAR.
- Add to Watts and VAR.
- Subtract from Watts and VAR.

▷ With a third pull-down menu, apply the loss based on the power flow direction. From the menu select one of the following:

- Both +Watts and -Watts.
- -Watts only.
- +Watts only.

Do NOT use the last settings if you do not have the appropriate firmware. Check with Technical Support if you have a question.

▷ When all settings are complete, click **OK** to return to the main Device Profile screen.

▷ For these changes to take effect, you MUST click on the **Update Device** button.
This sends the new profile to the EPM 9800 Meter.

### 8.4.7    Cold Load Pickup

▷ From the Device Profile screen (see section 8.2), click on the **+/-** button beside **Cold Load Pickup** or double-click on the **Cold Load Pickup** line.
The following submenu appears, showing the current settings for Cold Load Pickup.
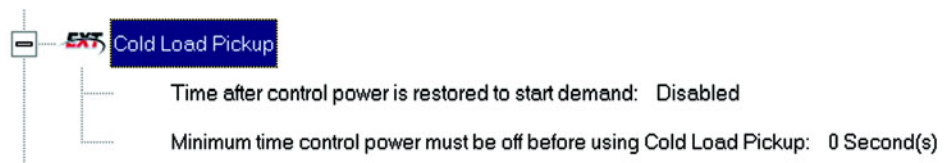


▷ Double-click on one of the parameters and the following screen appears:



- **Cold Load Pickup:** Delay can be 1 to 60 minutes or Disabled. This value is the delay from the time control power is restored to the time when the user wants to resume demand accumulation.
- Minimum time control power must be off before using Cold Load Pickup: Value is set from 0 to 255 seconds.

▷ When all changes are entered, click **OK** to return to the main Device Profile screen.

For these changes to take effect, you must click on the Update Device button to send the new profile to the Meter

### 8.4.8    Cumulative Demand Type

▷ From the Device Profile screen (see section 8.2), click on the **+/-** button beside **Cumulative Demand Type** or double-click on the **Cumulative Demand Type** line.
This window appears:
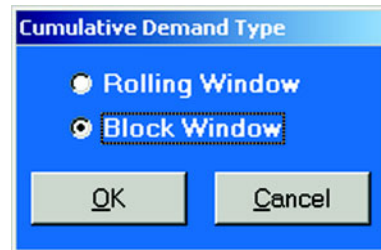


▷ Click the radio button in front of Rolling (sliding) Window or Block (fixed) Window to select Cumulative Demand Type.

▷ Click **OK** to exit the screen and return to the main EPM 9800 Advanced Power Quality Metering System screen.

### 8.4.9    Energy, Pulses and Accumulations in the Interval

▷ From the Device Profile screen (see section 8.2), click on the **+/-** button beside **Energy, Pulses and Accumulations in the Interval** or double-click on the **Energy, Pulses and Accumulations in the Interval** line.
This window appears:
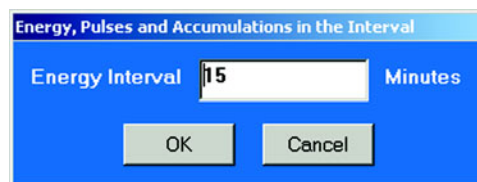


▷ Set the number of minutes for the Energy Interval.
This the Demand and Accumulation Interval Duration.

▷ Click **OK** to close the window and return to the main EPM 9800 Advanced Power Quality Metering System screen.

### 8.4.10   Pulse Accumulations

This section of the Device Profile displays a series of eight running totals available on Meter. Each total can be added to (or subtracted from) other totals. This allows you to set the high speed inputs located directly on the meter to pulse accumulate.

**NOTE**

If you use these inputs for pulse accumulations, do not set them to record waveforms. If you do, endless waveforms record.

▷ From the Device Profile screen (see section 8.2), click on the **+/-** button or double-click on the **Pulse Accumulations** line. The following screen will appear:



## Purpose of Pulse Accumulations

Pulse Accumulators are used to accumulate pulse information from external devices. These devices may be gas, water or electricity meters, energy management systems, SCADA devices or any pulse-generating device. Pulse accumulation is a very flexible way to accumulate information from external devices. Using the meter's pulse accumulator, pulses from other meters can be algabraically combined with the host meter's accumulations to generate one reading for a set of meters in a complex arrangement.

• **Source:** This is the particular input on the meter which will be accumulated.

**Units/Pulse:** This is the scale factor which normalizes the pulses so that they can be aggregated, if desired. Pulses are stored in primary values.

**Accumulator:** This allows you to place the pulse register into a separate accumulation register, which can aggregate or net values.

**User assigned label:** This window allows a user to enter a label designation so that when reading the Aggregator, the meter will display the source.

▷ To add or subtract data, use pull down menu in each window of Accumulator column(s).

**NOTE**

EPM 9800 supports **Negative** Averaging for Total Values.

▷  When all data has been entered, click **OK** to return to the main Device Profile screen.

▷  For these changes to take effect, you MUST click on the **Update Device** button. This sends the new profile to the meter.

# 8.5    Power Quality and Alarm Settings

This is the third group of settings in the Device Profile.

▷ From the Device Profile screen (see section 8.2), click on the **+/–** button or double-click on the **Power Quality and Alarm Settings** line.
All of the settings in this group are listed.
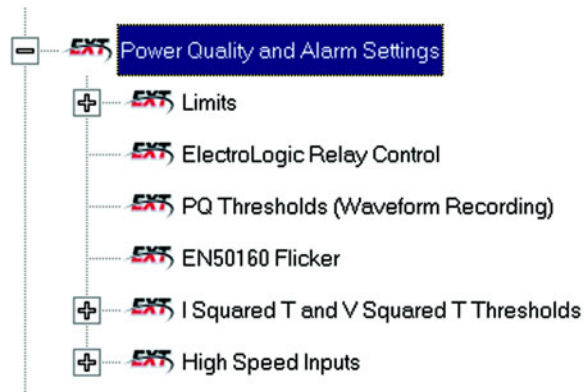


▷ Click on the particular Programmable Setting you would like to configure.
The settings will be detailed in the order they appear on the Device Profile screen.

## 8.5.1    Limits

Limit settings are based on a percentage of the Full Scales (% of FS), which are set in the Limit and Waveform Full Scales section of the Device Profile (section 8.3.2). Full Scales are based on CT and PT ratios set in the CT, PT Ratios and System Hookup section of the Device Profile (section 8.3.1) (120V L-N, 208V L-L and 5A).

▷ Before programming Limits, set the CT and PT ratios first.

▷ **Then, set the Limit and Waveform Full Scales**.
The software automatically updates the Full Scale. However, you can set it separately from the **CT and PT Ratios**.

▷ From the Device Profile screen (see section 8.2), click on the **+/-** button beside **Limits** or double click on the **Limits** line.
The following submenu appears:
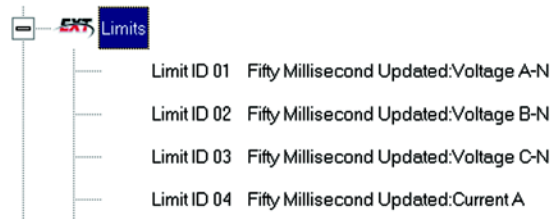


This screen displays the current Device Profile's settings for Limits. Not all limits are shown above; "Limit ID" extends to 32.

▷ Double-click on any of the settings ("Limit ID 01:", etc.)
The Limits screen appears.

## Percentage of Full Scale settings

The limits are set in % of full scale (% of FS) so that when a user creates a profile, he can keep his settings. This is true, even though the CT and PT Ratios change when the meter (or a new meter) is placed in a different location. Changing the CT and PT Ratios will not effect the % of full scale limits previously set. This is useful when using large numbers at meters



Make changes to this screen according to the requirements of your application:

▷ To set the type of limit and the channel assigned to it, double-click in either the **Type** or **Channel** column.

▷ From the pop-up menu, choose the desired settings and click **OK**.

▷ To designate the limit as either Above or Below a percentage of the Full Scale, click once in each **Settings** column and select the desired setting from the pull-down menu.

▷ **To set the percentage of the Full Scale at which the limit will trip, enter the value in the % of FS column.**
**EPM 9800 Advanced Power Quality Metering System automatically calculates the Primary value.**

The Combination Limit 3 is the logical combination of Limit 1's state and Limit 2's state.

**Example 1**:

Limit I D:

Type: 1 Second Readings

Channel: Volts AN

Limit 1 Setting: Limit exceeded if Volts AN is below 12V.

Limit 2 Setting: Limit exceeded if Volts AN is above 132V.

Combination Limit 3 Setting: **AND** If Limit 1 **AND** Limit 2 are exceeded then Limit 3 is exceeded.

**Example 2**:

Limit I D:

Type: 1 Second Readings

Channel: Volts AN

Limit 1 Setting: Limit exceeded if Volts AN is below 12V.

Limit 2 Setting: Limit exceeded if Volts AN is above 132V.

Combination Limit 3 Setting: **OR** If Limit 1 **OR** Limit 2 are exceeded then Limit 3 is exceeded.

To combine Limits of different Limit IDs, use the Relay Logic Diagrams.

Full Scale settings are shown in the lower left of the screen. These values are set in the Limits and Waveform Full Scales section of the Device Profile (section 8.4).

▷ **To set the Power Factor Limits, double click on any of the Power Factor settings in the Limit 1 or Limit 2 column.**
**The Power Factor Programming Screen will appear:**
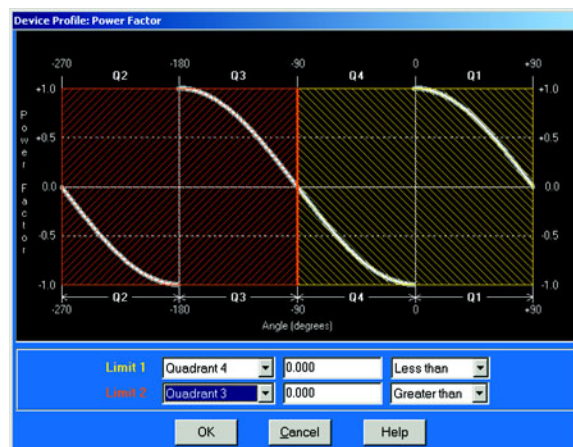


Power Factor is broken into four quadrants. The screen lets you set a limit in two of the four quadrants.

▷ To set a limit from the pull-down menus, select a Quadrant and Less Than or Greater Than (Full Scales).

▷ Type in the Power Factor Number.
The graph will illustrate your selections by shading the Out of Limit bands. The area of the graph not covered by shading is within **Normal Operational Range**. **Method 1 Quadrants**: Q1 +Lag, Q2 -Lag, Q3 -Lead, Q4 +Lead.

▷ To display a graph of **Method 2 Quadrants**: Q1 +Lag, Q2 -Lead, Q3 +Lag, Q4 -Lead, go to the Programming Labels screen (section 8.19) of the Device Profile.
In the lower drop down menu, click on Method 2.

▷ Return to the Limits screen.

▷ Click on any PF setting in the Limit 1 or Limit 2 column.
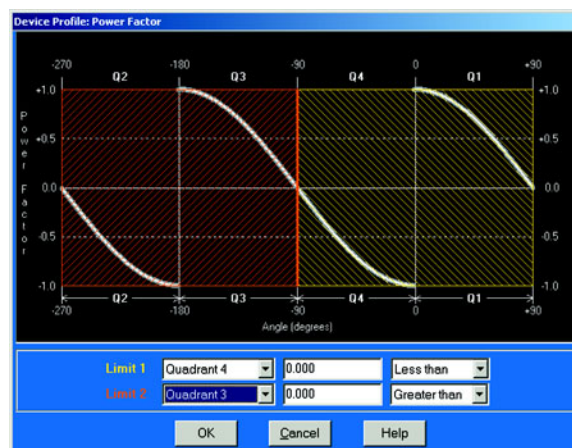


This meter is a real four quadrant meter. Therefore, limits can be set for capacitive and inductive PF when generating or consuming power.

▷ When all settings are complete, click **OK** to return to the main Device Profile screen.

▷ For these changes to take effect, you MUST click on the **Update Device** button.
This sends the new profile to the Meter.

▷ You may **Reset Logs** after updating the device. See section 8.26.

### 8.5.2    ElectroLogic Relay Control

To edit a Device Profile's ElectroLogic Relay settings:

▷ From the Device Profile screen (see section 8.2), click on the **+/-** button or double-click on the **GE Relay** line.



The following screen appears. This screen displays the current Device Profile's settings:



To assign an item to the RelayLogic Tree:

▷ Select an Input for the tree by clicking on a bullet next to numbers **1** through **8**.

▷ Choose Limits or Digital Inputs by clicking on the bullet in front of the word.

▷ Select the Limit or Input you want to assign to the RelayLogic Tree Input you selected.

▷ Press **Set** to confirm your selection and the software will place the selection in the appropriate window in the screen.

▷ After you have assigned all the RelayLogic Inputs, select the gates that will be used to combine the logic to trigger the relay.

▷ To select a gate, click on the gate or choose one from the dropdown menu below the gate.

To change items on the RelayLogic Tree, use the following steps:

▷ To change the selected relay and/or relay modules, select from the drop-down menu at the upper right hand corner of the screen.

▷ To change the relay Set Delay, select from the drop-down menu to the right of the Set Delay Label.

▷ To change the Relay Reset Delay, select from the drop-down menu to the right of the Reset Delay Label.

▷ To clear an item from the Relay Tree, click on that item then click the **Clear** button.

▷ To clear ALL ITEMS from the Relay Tree, click the **Clear Assigned Items** button.

> In order to use this screen, you must have purchased at least one External Relay Out module. For more details on External Modules, see Chapter 11 of the GE Communicator EXT Guide.

### 8.5.3    PQ Thresholds (Waveform Recording)

The Power Quality (PQ) and Waveform Thresholds setting determines at what point the Meter will execute a waveform capture and/or record a power quality event. See Chapter 8 of the GE Communicator EXT Guide for how to view logs.

PQ and waveform thresholds are given as a percentage of the Full Scales (% of FS). Set the Full Scales in the Limits and Waveform Full Scales section of the Device Profile (section 8.4). Full Scales are based on the CT and PT ratios set in the CT, PT Ratios and System Hookup.

> Before programming the PQ and Waveform Thresholds, set the CT and PT ratios. Then, set the Limits and Waveform Full Scales.

> **CAUTION:** Changing the CT and PT Ratios will Reset the meter and clear all logs and accumulations. Be sure to capture needed meter information before changing CT and PT Ratios.

#### Note on Sampling Rate

A higher sampling rate allows for transients to be monitored. Generally, users will set the monitor to 128 samples per cycle for this purpose. Lower sampling rates have advantages because they allow you to record more cycles of information per event screen. Low sampling rates are better for long duration events, like motor starts or distribution faults. The meter enables users to tailor the recording for both these applications. For more information on Sampling Rate, see the graph on page 8-39.

▷ From the Device Profile screen (see section 8.2), double-click on the
**PQ Thresholds (Waveform Recording** line;
The Waveform—CBEMA Profile screen appears:



1. **Software Triggers:**

▷ To set the threshold for a PQ event and waveform capture, enter
the desired percentage of Full Scale in the Value(%) column of the
Above Setpoint and Below Setpoint sections.
Full Scales are shown in the lower right corner of the screen.

## Note on CBEMA

The CBEMA plotting is a power quality standard known world-wide for recording the
amount of damage voltage transient conditions have done to the equipment being
monitored. The meter automatically records this information. For CBEMA purposes,
the user programs internal set points for voltage below 90% and above 110% of full
scale (+/- 10% from the nominal voltage). These setpoints are defined by the ITI
(CBEMA) specification. The ITI (CBEMA) Curve is published by Information Technology
Industry Council (ITI).

A user can set a recording with tighter voltage limits to trigger a waveform recording.
However, CBEMA plotting will be based only on the limits internally set.

## Note on Setting the Meter to Record Current Faults

As discussed, the voltage setpoints are used to record voltage type events, such as
voltage surges, sags and transients. The current settings are used to record faults on
the line or in-rush currents from devices such as motors. Typically, to catch these
events, set the limit to above 200% of full scale.

2. **Waveform Clipping Threshold:** EPM 9800 Standard Hardware - 91.0924A Peak before
clipping.

3. **Hardware Triggers:**

▷ To enable a Waveform or PQ recording for any of the 8 High Speed Inputs, click in the appropriate box.
This will trigger a recording based on a contact trigger. This is useful to monitor an open device and to capture the waveform during that operation.

4. **Samples per Cycle:**

▷ To choose the Samples per Cycle to be recorded at 60 Hz, click on the **Sampling Rate** pull down menu.

▷ Choose from 16, 32, 64, 128, 256 and 512 samples per cycle. The number of samples per cycle you choose will inversely affect the number of cycles per capture. ?

- If you select 256, a Capture Only pop up screen will ask you to select Volts A, B, C or I A, B, C.
- If you select 512, a Capture Only pop up screen will ask you to select one of the individual channels.

As you increase the number of samples, you will record more detailed information. The Table below illustrates the "Effects of Sampling Rate" on the number of cycles captured. Increasing the Sampling Rate increases Waveform Definition but reduces the length of the observed window. The approximate length of the observed window is shown in the last column.
For example, to observe events of approximately 1/2 Second, a Sampling Rate of 32 Samples per Cycle or less should be used.

**Table 8–3: Effects of Sampling Rates**

| Samples per Cycle | Channels | | Samples per Channel | Cycles per Capture | Time (Approx.) |
|---|---|---|---|---|---|
| | Analog | HSI | | | |
| 16 | 7 | 8 | 1024 | 64 | 1 second |
| 32 | 7 | 8 | 1024 | 32 | 1/2 second |
| 64 | 7 | 8 | 1024 | 16 | 1/4 second |
| 128 | 7 | 8 | 1024 | 8 | 1/8 second |
| 256 | 3 | 8 | 2048 | 8 | 1/8 second |
| 512 | 1 | 8 | 4096 | 8 | 1/8 second |

**Note on Waveform Event Captures**

A screen of data is one capture. If you set Total Captures to 3 and you are recording at 16 samples per cycle, you will record:

16 Samples: 3 × 64= 192 cycles of recorded waveforms

128 Samples: 3 × 8= 24 cycles of recorded waveforms

With the 2 MB module, you have a total of 64 total captures. With the 4 MB module, you have a total of 96 captures. You can partition the memory in any fashion required for the specific application. There is no limitation on the amount of cycles that can be recorded per event.

▷ To choose the total amount of captures, click on the **Total Captures** pull down menu.

▷ Select from **0** to **96** captures.
The higher the number, the more information you will be "stringing together".

▷ When all changes are entered, click **OK** to return to the main Device Profile screen.

▷ For these changes to take effect, you MUST click on the **Update Device** button.
This sends the new profile to the Meter.

### 8.5.4    EN 50160 Flicker

With the Flicker Settings screen, the user can set the test times for the Flicker function.

▷ From the Device Profile screen (section 8.2), click on the **+/-** button beside **EN50160 Flicker** or double- click on the **Flicker Settings** line.
This screen appears



▷ From the pull-down menus, select a Short Term test time and a Long Term test time.
Typical values for PST and PLT are 10 minutes and 120 minutes.

▷ From the Frequency pull-down menu, select 50 or 60 Hz.

▷ When all changes are entered, click **OK** to return to the main Device Profile screen.

▷ For these changes to take effect, you MUST click on the **Update Device** button.
This sends the new profile to the EPM 9800 Meter.

Flicker is discussed in detail in Chapter 16 of the GE Communicator EXT Guide.

### 8.5.5    I Squared T and V Squared T Thresholds

With the I Squared T and V Squared T Thresholds screen, the user can set at what point the Current and Voltage should accumulate.

▷ From the Device Profile screen (section 8.2), click on the **+/-** button beside **I Squared T and V Squared T** or double-click on the **I Squared T and V Squared T** line.
This screen appears:



▷ Input the desired thresholds.

▷ Click **OK** to exit the screen and return to the EPM 9800 Advanced Power Quality Metering System main screen.

### 8.5.6    High Speed Inputs

This section of the Device Profile enables you to label the eight High Speed Inputs. Using this storage field allows a user to label the inputs so that when the data is later analyzed, the user knows the source of the status change.

▷ From the Device Profile screen (see section 8.2), click on the **+/-** button or double-click on the **Digital Inputs** line.

▷ Double-click on **High Speed Inputs**.
The following submenu appears:

▷ Double-click on any of the **Input #** lines.
   The High Speed Digital Input Assignments screen appears.



▷ Double-click on the Input you would like to label.

▷ Enter text in each field.

▷ Click **OK** to return to the main Device Profile screen.

▷ For these changes to take effect, you MUST click on the **Update Device** button.
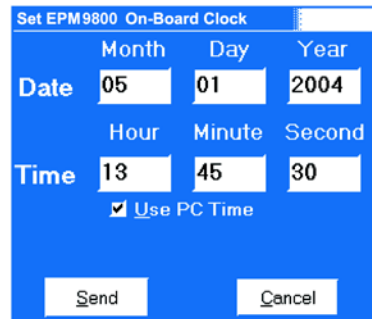   This sends the new profile to the EPM 9800 Meter.

## 8.6    Trending Profile Settings and Load Profile Recording

This section of the Device Profile enables you to set the Trending Profiles for historical logs.

▷  From the Device Profile screen (see section 8.2), click on the **+/-** button or double-click on the **Trending Profile Settings** line. This submenu appears:



▷  Double-click on one of the Trending topics to access the programming screens.

### Load Profile Recording - Definition

Load Profile Recording is a subset of the Meter's more general Logging and Trending capability. The same screens are used for setup but Load Profile Recording only deals with Accumulated Values; Energy (Wh), Reactive Energy (VARh) and Apparent Power (VAh).

Historically, Load Profile Recording referred to recording of Quadrant 1 Energy (Wh) because electromechanical meters only measured energy and were detented to prevent reverse rotation outside of Quadrant 1.

### 8.6.1    Trending Log Time Intervals

Trending Log Time Intervals determine the interval at which Historical Logs 1 and 2 will take a snapshot. To set the parameters for the logs, see section 8.6.2.

See Chapter 8 of the GE Communicator EXT Guide for how to view and retrieve logs.

▷  From the Device Profile screen (see section 8.2), click on the **+/-** button beside **Trending Log Time Intervals** or doubleclick on the **Trending Log Time Intervals** line. This submenu appears:
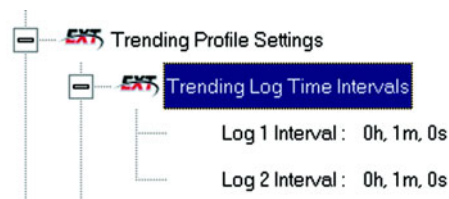


This screen displays the current Device Profile's Trending Log TimeIntervals. The values shown are for example only.

▷ Double-click on either **Log 1 Interval** or **Log 2 Interval**.
The Interval Log Setting screen appears:
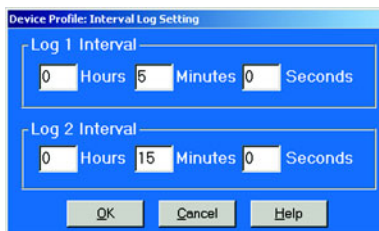


▷ Enter the hours, minutes and seconds for each log.
The logs will be time-stamped based on the meter's time, which is set using the Tools menu. See section 8.10.

▷ When all changes are entered, click **OK** to return to the main Device Profile screen.

▷ For these changes to take effect, you MUST click on the **Update Device** button.
This sends the new profile to the meter.

▷ It is recommended that you **Reset Logs** (see section 8.11) when changing settings that effect the logs.

### 8.6.2    Trending Setup

The Trending Setup controls the channel assignments for Historical Logs 1 and 2. To set the Time Intervals for these Logs, see section 8.6.1. See Chapter 8 of the GE Communicator EXT Guide for how to view logs.

▷ From the Device Profile screen (see section 8.2), click on the **+/-** button beside **Trending Setup** or double-click on the **Trending Setup** line.
The following submenu appears:



▷ To change the settings for Log 1 double-click on **Log 1**. To change the settings for Log 2 click on **Log 2**. The Snapshot Channel Assignment Log 1 or 2 screen appears:

Make changes to this screen according to the requirements of your application:

▷ **Type**: Using pull down menu, select the type of snapshot.

▷ ?**Channel**: Using pull down menu, select a channel for the snapshot.

▷ Click on **Add** to include the selections in the Log; click on **Remove** to delete.

▷ To Remove multiple items, hold **Control** while clicking items to be removed and click Remove.

▷ To Remove a range of items, click the first item, hold **Shift**, then click the last item, then click **Remove**.

▷ When all changes are entered, click **OK** to return to the main Device Profile screen.

▷ Click on the **Update Device** button to effect changes.

▷ **Resetting Logs** is recommended (see section 8.9).

Total Bytes Used and Bytes Remaining screens display the memory status for that particular file. The Meter assumes 256 bytes of memory for each file. Total memory is determined at time of purchase.

### 8.6.3    Pad Missing Records for Historical Logs

When the meter is not in normal operation, it will not record any data for Log 1 and Log 2. For example, during firmware updates or loss of power, data will not be saved. Some applications may require data logs to contain those missing records.

To remedy this problem, you can Enable the feature in **View > Options > Log Retrieval**.

▷ Click the **Pad Meter Log File** box in front of the feature.

▷ Click **OK.**
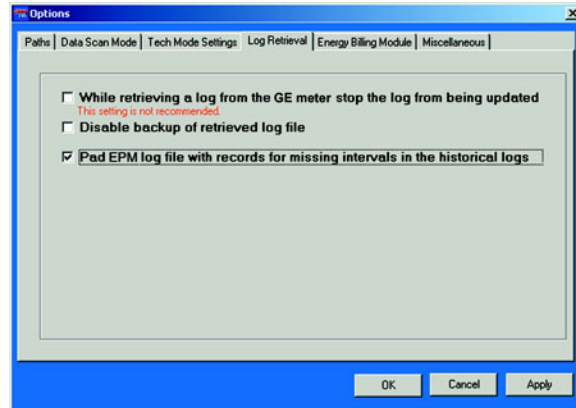


This feature pads missing records for Log 1 and Log 2. The software causes the Log Converter program to automatically pad the missing records with a value of 0 for each log retrieval process and stores them in the Log DB file.

By default, if the Meter Trending Interval is set for Greater than 1 Hour, the meter will always save a record on the hour in the Trending Logs.

## 8.7    External Devices

This setting of the Device Profile configures the Meter's External Devices, a variety of Ouput Modules.



▷ From the Device Profile screen (see section 8.2), double-click on the **External Output Modules** line.
The following screen appears.



▷ Click in the **Type** column and use the pull down menu to select the specific Ouput Module you wish to add

▷ Enter a unique address for each.

▷ Use the **Edit** buttons to configure each module further.

▷ Click **OK** to return to the main Device Profile screen.

▷ For these changes to take effect, you MUST click on the **Update Device** button.
This sends the new profile to the EPM 9800 Meter.

## 8.8    Set and Retrieve Meter Time

The EPM 9800 uses its on-board clock for time-stamping any logs it is recording.

### To set the meter's clock:

▷ Select **Tools > Set Meter Time**.
The meter's On-board Clock screen appears:
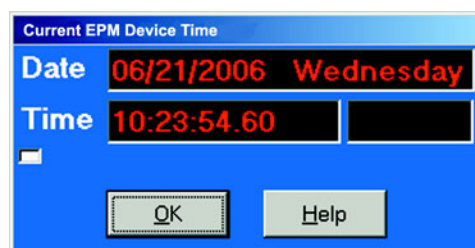


▷ To synchronize the meter and your computer, leave the **Use PC Time** box checked.

▷ To set the date and time to be independent from the PC, deselect the **Use PC Time** box and enter the time and date settings.

▷ Click the **Send** button to update the meter's time settings.

### To retrieve the Meter device's current time and date settings:

▷ Select **Tools > Retrieve Meter Time**.
This screen appears. Date and running time display in LEDs.



▷ Click **OK** to return to the main EPM 9800 Advanced Power Quality Metering System screen.

## 8.9    Reset Meter Information

▷ From the menu bar select **Tools > Reset Meter Information**. The following set of screens appears:
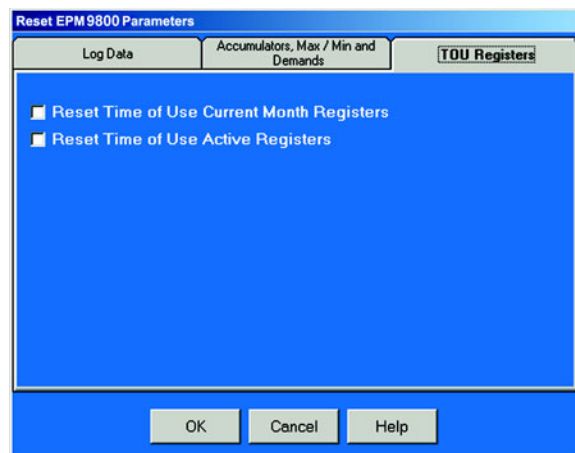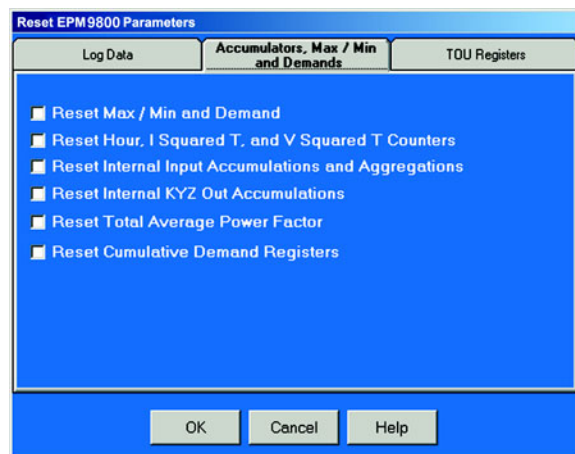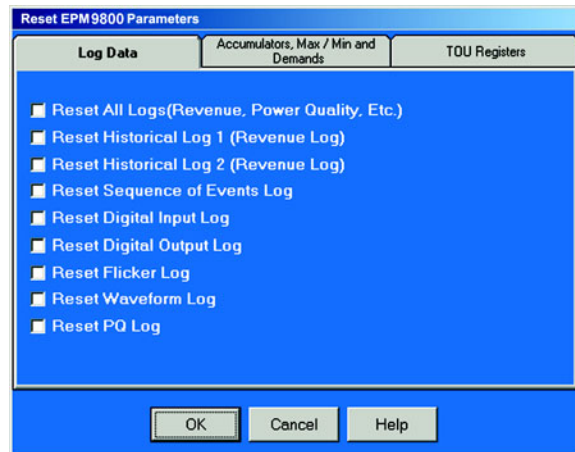
▷ Click on the tabs to navigate between screens.

▷ Click on the box beside the value(s) you would like to reset.

▷ Click **OK**.

NOTE

If you click Reset Logs, a **Warning** will appear asking you if you want to **Save Connected Device Settings**. Click on the settings you would like to save, then proceed with the Update. If you do not save the settings, they will be overwritten.

For each box you select, a window will appear which states that the "Reset is Completed".

▷ Click **OK**.
    The reset is completed.

You can password protect this feature by enabling the Password feature of the meter. (See Chapter 12 of the GE Communicator EXT Guide for details).

## 8.10  Manual Waveform Capture

▷ From the Menu bar, click on **Tools > Manual Waveform Capture**.
The Manual Waveform Capture screen (shown here) appears, if the
connected device is an EPM 9800.



This screen displays the Waveform Log Statistics of the logs that have possible
Waveform Triggers.

▷ Click the **Trigger Now** button at the bottom of the screen to create
a waveform.
EPM 9800 Advanced Power Quality Metering System creates a
Waveform in Meter memory.
The Records on the screen will increase by 1.

▷ To retrieve the Waveform, from the Menu Toolbar, click **Logs >
Retrieve Log** from the device

▷ Click **OK** to return to the main Device Profile screen.

## 8.11 Test Mode Preset Accumulators

There are two reasons why a user might want to use the Preset Accumulators screens:

1. A meter in Test Mode is out of service and is therefore not monitoring accumulations. The New Value can be used to adjust for the values not monitored while in Test Mode.

2. When replacing an old meter, that has accumulations, with a new meter that has no accumulations, the New Value can be set with the value of the accumulations of the old meter.

### Setting Test Mode Preset Accumulators for EPM 9800

▷ From the menu bar select **Tools > Test Mode > Preset Accumulators**.
The set of screens shown here appears.

Each screen has a Current Value, New Value and Preset Box for each accumulator. A new meter will have zeros for Current Values.

▷ **Click Tabs at the top of the screens to access the individual screens.**

Settings can be preset for the following sets of values:

- Primary Energy
- Secondary Energy
- Primary Energy (Quadrants)
- Secondary Energy (Quadrants)
- Internal Input  Accumulators
- KYZ Output Accumulators
- I & V Squared T Accumulators
- Cumulative Demand (Secondary)
- Uncompensated Energy and Q Hours

▷ **Click the Preset Boxes for the values you want to set.**

▷ **Click Set or Cancel.**

## 8.12   CT and PT Compensation

The CT and PT Compensation feature allows users to remove the error caused by the CTs (external to unit) and PTs that are connected to the unit.

### Enable CT and PT Compensation:

The steps:

▷ From the Device Profile (Revnue and Energy Settings), click **CT & PT Compensation > State**.

▷ Enable **CT & PT Compensation**.
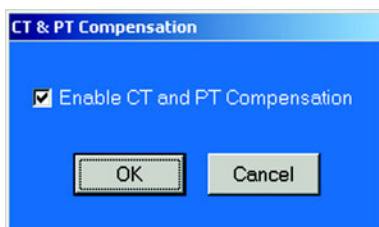


▷ To send the new profile to the meter click **OK** and click **Update Device Profile**.

▷ Exit Device Profile.

▷ Click **Tools > CT & PT Compensation > Calibration Table Status**
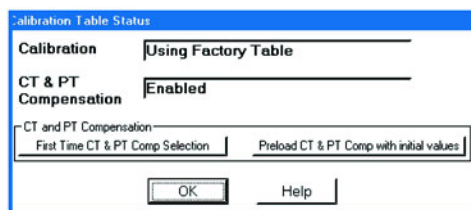


▷ Click the **First Time CT & PT Comp Selection**.

▷ Click **Preload CT & PT Comp with Initial Values**.

▷ Click **OK**.

▷ Click **Tools > CT & PT Compensation > View Callibration Tables**.



| EPM Calibration Point | Factory Table | | | | CT & PT Compensation Table | | | |
|---|---|---|---|---|---|---|---|---|
| | Phase A | Phase B | Phase C | Aux N | Phase A | Phase B | Phase C | Aux N |
| Voltage | 40065 | 39976 | 40043 | -2070 | 36059 | 35978 | 36039 | -2070 |
| 0.15A | 38184 | 38173 | 38228 | 1586466935 | 38184 | 38173 | 38228 | 1586466935 |
| 0.25A | 38168 | 38150 | 38219 | 289354719 | 38168 | 38150 | 38219 | 289354719 |
| 0.50A | 38165 | 38143 | 38201 | 289354719 | 38165 | 38143 | 38201 | 289354719 |
| 1.00A | 38189 | 38163 | 38221 | 289354719 | 38189 | 38163 | 38221 | 289354719 |
| 2.50A | 38192 | 38168 | 38228 | 17606926 | 38192 | 38168 | 38228 | 17606926 |
| 5.00A | 38198 | 38173 | 38231 | 17606926 | 38198 | 38173 | 38231 | 17606926 |
| 0.50A @60 | 19 | 19 | 18 | | 19 | 19 | 18 | |
| 1.00A @60 | 19 | 19 | 18 | | 19 | 19 | 18 | |
| 2.50A @60 | 17 | 18 | 18 | | 17 | 18 | 18 | |
| 5.00A @60 | 16 | 16 | 16 | | 16 | 16 | 16 | |
| 10.00A @60 | 13 | 13 | 13 | | 13 | 13 | 13 | |

Factory Table Blk Time 07/30/2004 09:38:40.22   CTPT Table Blk Time 07/30/2004 09:38:39.14
Factory Table Cal Time 02/18/2004 14:31:46.79   CTPT Table Cal Time 05/20/2004 15:50:52.00

▷ Click **Copy Factory Table to CT & PT Comp Table**.

▷ Click **OK**.

CT & PT Compensation is now Enabled and ready for corrections.

▷ Collect data to determine the correction required.

## Compensate CTs & PTs:

▷ Click **Tools > CT & PT Comp > Compensate CTs & PTs**.

▷ Follow direction on screens. Click tabs to make additional corrections.



▷ Click **OK.**

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## V

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