GE
Grid Solutions

Multilin™ EPM 7000P

High Performance Power Quality Metering System

Instruction Manual

Software Revision: 1.0x
Manual P/N: 1601- 0248-A1
Manual Order Code: GEK-131079

imagination at work

Multilin™ EPM 7000P Instruction Manual for product revision 1.0x.

Part number: 1601-0248-A1 (November 2019)

⚠CAUTION

GENERAL SAFETY PRECAUTIONS - EPM 7000P

- This equipment is intended to be permanently Installed within a metal enclosure or panel that is protective earthed, mounted such that the exposed terminals are enclosed. Voltages are measured by connections to the branch supply only
- Failure to observe and follow the instructions provided in the equipment manual(s) could cause irreversible damage to the equipment and could lead to property damage, personal injury and/or death.
- Before attempting to use the equipment, it is important that all danger and caution indicators are reviewed.
- If the equipment is used in a manner not specified by the manufacturer or functions abnormally, proceed with caution. Otherwise, the protection provided by the equipment may be impaired and can result in Impaired operation and injury.
- Caution: Hazardous voltages can cause shock, burns or death.
- Installation/service personnel must be familiar with general device test practices, electrical awareness and safety precautions must be followed.
- Before performing visual inspections, tests, or periodic maintenance on this device or associated circuits, isolate or disconnect all hazardous live circuits and sources of electric power.
- Failure to shut equipment off prior to removing the power connections could expose you to dangerous voltages causing injury or death.
- All recommended equipment that should be grounded and must have a reliable and un-compromised grounding path for safety purposes, protection against electromagnetic interference and proper device operation.
- Equipment grounds should be bonded together and connected to the facility's main ground system for primary power.
- Keep all ground leads as short as possible.
- At all times, equipment ground terminal must be grounded during device operation and service.
- In addition to the safety precautions mentioned all electrical connections made must respect the applicable local jurisdiction electrical code.
- Before working on CTs, they must be short-circuited.
- To be certified for revenue metering, power providers and utility companies must verify that the billing energy meter performs to the stated accuracy. To confirm the meter's performance and calibration, power providers use field test standards to ensure that the unit's energy measurements are correct.

This product cannot be disposed of as unsorted municipal waste in the European Union. For proper recycling return this product to your supplier or a designated collection point. For more information go to www.recyclethis.info.

Safety words and definitions

The following symbols used in this document indicate the following conditions

DANGER

Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING

Indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION

Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE

Indicates practices not related to personal injury.

NOTE

Indicates general information and practices, including operational information, that are not related to personal injury.

For further assistance

For current manuals and software go to:

Website: https://www.gegridsolutions.com/multilin/ProductListing.htm

For product support, contact the information and call center as follows:

GE Grid Solutions
650 Markland Street
Markham, Ontario
Canada L6C 0M1
Worldwide telephone: +1 905 927 7070
Europe/Middle East/Africa telephone: +34 94 485 88 54
North America toll-free: 1 800 547 8629
Fax: +1 905 927 5098
Worldwide e-mail: multilin.tech@ge.com
Europe e-mail: multilin.tech.euro@ge.com
Website: http://www.gegridsolutions.com/multilin

Warranty

GE warrants most of its GE manufactured products for 10 years. For warranty details including any limitations and disclaimers, see our Terms and Conditions at

https://www.gegridsolutions.com/multilin/warranty.htm

Table of contents

Multilin™ EPM 7000P

Chapter 1: Meter Overview

1.1 The EPM 7000P High Accuracy Revenue Meter

The EPM 7000P is a multifunction, data-logging revenue meter for both critical meter applications and basic commercial/industrial metering applications. The EPM 7000P meter is a full four quadrant, bidirectional revenue meter that can also be used for inter-tie metering. Its metrology accuracy meets all the accuracy requirements of ANSI C12.20 Class 0.1% and IEC 62053-22 CL 0.2S. The meter has advanced revenue metering features that allow it to be used not only for measuring basic energy, but also for providing a full complement of necessary tools, such as instrument transformer compensation, CT/PT compensation, advanced test mode, perpetual TOU, and extensive logging for interval energy storage.

There is also a transducer only version of the meter, the EPM 7000PT transducer, which has the same functionality as the meter, except that it doesn't have the faceplate or the USB port.

1.1.1 Hookup Connections and Measurements

See 1.4 *EPM 7000P Meter Specifications Overview* on page 1–11.

1.1.2 Order Codes

Table 1.1: EPM 7000P Meter Order Codes

	PL7000P	*	–	*	–	*	–	*	–	*	–	*	–	*	
Base Unit	**PL7000P**			|		|		|		|		|		|	EPM 7000P Meter Power Quality Meter
Enclosure		**ENC120**		|		|		|		|		|		|	NEMA1 Rated - Indoor, Single Meter Enclosure, 120V
		ENC277		|		|		|		|		|		|	NEMA1 Rated - Indoor, Single Meter Enclosure, 277V
		ENN120		|		|		|		|		|		|	NEMA4X Rated - Indoor/Outdoor, Single Meter Enclosure, 120V
		ENN277		|		|		|		|		|		|	NEMA4X Rated - Indoor/Outdoor, Single Meter Enclosure, 277V
		ENS001		|		|		|		|		|		|	EPM Retrofit Panel Adapter - SWDGS5-E67-M
		ENS002		|		|		|		|		|		|	EPM Retrofit Panel Adapter - SWDGL9-E67-M
		EMS003		|		|		|		|		|		|	EPM Retrofit Panel Adapter - SWDGS9-E67-EPM
		XXXXXX		|		|		|		|		|		|	None
Frequency				**6**		|		|		|		|		|	60 Hz AC frequency system
				5		|		|		|		|		|	50 Hz AC frequency system
Current Input						**5A**		|		|		|		|	10 A secondary
						1A		|		|		|		|	2 A secondary
Software								**A**		|		|		|	Multimeter function only
								B		|		|		|	Data Logging, 2 MB memory
								C		|		|		|	128 Samples/cycle Waveform Recording, 10 MB Memory
								D		|		|		|	512 Samples/cycle Waveform Recording, 128 MB Memory
Power Supply										**HI**		|		|	90 to 265 VAC; 100 to 370 VDC
										LD		|		|	18 to 60 VDC
I/O Modules												**XX**		**XX**	None
												E1		**E1**	100BaseT Ethernet
												E2		**E2**	100BaseT Ethernet with IEC 61850 Protocol
												C1		**C1**	Four Channel Bi-directional 0 to 1 mA Outputs
												C2		**C2**	Four Channel Bi-directional 4 to 20 mA Outputs
												RS		**RS**	Two Relay Status Outputs / Two Status Inputs
												PS		**PS**	Four Pulse Outputs / Four Status Inputs
												F1		**F1**	Fiber Optic Interface with ST Terminations
												F2		**F2**	Fiber Optic Interface with Versatile Terminations
												S1		**S1**	Serial RS232/RS485 Communications

Table 1.2: EPM 7000PT Meter Order Codes

	PL7000P	– *	– *	– *	– *	– *	*	
Base Unit	**PL7000PT**	|	|	|	|	|	|	EPM 7000P Meter Power Quality Meter - No Display
Frequency		**6**	|	|	|	|	|	60 Hz AC frequency system
		5	|	|	|	|	|	50 Hz AC frequency system
Current Input			**5A**	|	|	|	|	10 A secondary
			1A	|	|	|	|	2 A secondary
Software				**A**	|	|	|	Multimeter function only
				B	|	|	|	Data Logging, 2 MB memory
				C	|	|	|	128 Samples/cycle Waveform Recording, 10 MB Memory
				D	|	|	|	512 Samples/cycle Waveform Recording, 128 MB Memory
Power Supply					**HI**	|	|	90 to 265 VAC; 100 to 370 VDC
					LD	|	|	18 to 60 VDC
I/O Modules						**XX**	**XX**	None
						E1	**E1**	100BaseT Ethernet
						E2	**E2**	100BaseT Ethernet with IEC 61850 Protocol
						C1	**C1**	Four Channel Bi-directional 0 to 1 mA Outputs
						C2	**C2**	Four Channel Bi-directional 4 to 20 mA Outputs
						RS	**RS**	Two Relay Status Outputs / Two Status Inputs
						PS	**PS**	Four Pulse Outputs / Four Status Inputs
						F1	**F1**	Fiber Optic Interface with ST Terminations
						F2	**F2**	Fiber Optic Interface with Versatile Terminations
						S1	**S1**	Serial RS232/RS485 Communications

1.1.3 EPM Accessories

Mounting Brackets

The following mounting brackets are available for the EPM 7000P.

Table 1.3: Mounting Brackets

Part Number	Description
PL7000P-ACC-DN	DIN Mounting Bracket

Expandable Input/Output (I/O) Cards

The following table describes the expandable communication cards available for the EPM EPM 7000P for specific slots.

Table 1.4: Input/Output (I/O) Cards

Part Number	Description	I/O Module Slot
PL7000P-ACC-E1	100BaseT Ethernet	Slot 1 or Slot 2
PL7000P-ACC-E2	61850 Communications card	Slot 1 or Slot 2
PL7000P-ACC-C1	Four Channel Bi-directional 0-1mA Outputs	Slot 1 or Slot 2
PL7000P-ACC-C2	Four Channel 4-20mA Outputs	Slot 1 or Slot 2
PL7000P-ACC-RS	Two Relay Status Outputs / Two Status Inputs	Slot 1 or Slot 2
PL7000P-ACC-PS	Four Pulse Outputs / Four Status Inputs	Slot 1 or Slot 2
PL7000P-ACC-F1	Fiber Optic Interface with ST terminations	Slot 1 or Slot 2
PL7000P-ACC-F2	Fiber Optic Interface with Versatile Terminations	Slot 1 or Slot 2
PL7000P-ACC-S1	RS232/RS485 card	Slot 1 or Slot 2

1.1.4 Software Option Technology

The EPM 7000P meter is equipped with Software Option technology, a virtual firmware-based switch that lets you enable meter features through software communication. Software Option technology allows meter upgrades after installation without removal from service.

Features	A	B	C	D
Multifunction Measurement	*	*	*	*
Programmable Display	*	*	*	*
Time of Use	*	*	*	*
System Events		*	*	*
Input Status Change	*	*	*	*
Limits	*	*	*	*
Harmonics	*	*	*	*
2 MB Memory** (3 Historical logs)		*		
10 MB Memory** (6 Historical logs)			*	
128 MB Memory** (6 Historical logs)				*
Waveform Capture - 128 Samples/Cycle			*	
Waveform Capture - 512 Smaples/Cycle				*
CT/PT Compensation	*	*	*	*
Transformer Loss Compensation (TLC)	*	*	*	*
IEC 61850 Protocol		*	*	*
DNP 3.0	*	*	*	*
Modbus Protocol***	*	*	*	*

** Note that some memory is reserved for internal operations.

*** See the *EPM 7000P Modbus Protocol and Register Map Reference Guide* for instructions on using Modbus with the meter.

Obtaining a Software Option key:

Contact GE and provide the following information:

1. Serial number(s) of the meter(s) you are upgrading. Use the number(s), with leading zeros, shown in the GE Communicator Device Status screen (from the GE Communicator Main screen, click **Tools > Device Status**).
2. Desired Software Option.
3. Purchase Order number.

   GE will issue the Software Option key.

Enabling the Software Option:

1. Open GE Communicator software.
2. Power up your meter.

3. Connect to the EPM 7000P meter through GE Communicator software.
4. Download all meter logs and then reset them - see the *GE Communicator Instruction Manual* for instructions on doing this; you can access the manual by clicking **Help > Contents** from the Menu Bar at the top of the software Main screen.
5. Click **Tools > Change Software Option** from the Menu Bar. A screen opens, requesting the encrypted key.
6. Enter the Software Option key provided by GE.
7. Click the **Update** button. The Software Option is enabled and the meter resets.
8. Configure the log sizes - see the *GE Communicator Instruction Manual* for instructions.

1.1.5 Measured Values

The following table shows the primary measurements of the EPM 7000P meter.

Measured Values	Instantaneous	Avg	Max	Min
Voltage L-N [V]	X	X	X	X
Voltage L-L [V]	X	X	X	X
Current per Phase [A]	X	X	X	X
Current Neutral [A]	X	X	X	X
Watt (A,B,C,Total) [W]	X	X	X	X
VAR (A,B,C,Total) [VAR]	X	X	X	X
VA (A,B,C,Total) [VA]	X	X	X	X
PF (A,B,C,Total)	X	X	X	X
+Watt Hour (A,B,C,Total) [Wh]	X			
-Watt Hour (A,B,C,Total) [Wh]	X			
Watt Hour Net [Wh]	X			
+VAR-Hour (A,B,C,Total) [VARh]	X			
-VAR-Hour (A,B,C,Total) [VARh]	X			
VAR-Hour Net (A,B,C,Total) [VARh]	X			
VA-Hour (A,B,C,Total) [VARh]	X			
Frequency	X		X	X
Harmonics to the 40th Order	X			
THD	X		X	X
Voltage Angles	X			
Current Angles	X			
Waveform Scope	X			
TDD	X		X	X
K Factor	X		X	X
Q	X	X	X	X
Q-Hours	X			
Symmetrical Components	X		X	X
Voltage Unbalance	X		X	X
Current Unbalance	X		X	X

Update Rate

Instantaneous power W, VA, VARand energy Wh, VAh, VARh readings: Every 6 cycles.

All other parameters: Every 60 cycles.

1.1.6 Utility Demand

The EPM 7000P meter provides user-configured Block (Fixed) window or Rolling window Demand modes. This feature lets you set up a customized Demand profile. Block window Demand mode records the average demand for time intervals you define (usually 5, 15 or 30 minutes). Rolling window Demand mode functions like multiple, overlapping Block windows. You define the subintervals at which an average of Demand is calculated. An example of Rolling window Demand mode would be a 15-minute Demand block using 5-minute subintervals, thus providing a new Demand reading every 5 minutes, based on the last 15 minutes. Utility Demand features can be used to calculate W, VAR, VA and PF readings.

NOTICE

- If the meter loses power, average for the Demand interval is computed based on energy readings for the time the meter was online.
- If there are multiple instances of power loss during an Demand interval, Cold Load functionality is available only once for Demand computation for that interval. See page 9 for an explanation of cold Load.

1.2 Advanced Measurement Functionality

The following sections describe the EPM 7000P meter's measurement features in detail.

1.2.1 Advanced Revenue Billing Capability

The EPM 7000P device is a full four-quadrant power and energy meter that meets ANSI C12.20 0.1% Accuracy Class. Energy measurements include: kWh Delivered & Received, kVARh Delivered & Received, kVAh, kVARh, kWh in each quadrant and Total kVAh. The meter measures instantaneous power and provides multiple, simultaneous demand measurements, including time-stamped maximum and minimum readings.

Time of Use

The EPM meter's Time of Use functionality offers the following standard capabilities:

- 16 TOU schedules.
- Bidirectional consumption and Demand.
- 4 seasons/year and up to 12 months/year.
- Season may be customized for daily or weekly use.
- Perpetual calendar.
- 4 accumulation rates and a totalizer rate.
- Prior month and prior season readings for each schedule.
- Prior month and prior season for each accumulation rate, for each defined data set.
- Current month and current season readings for each schedule.
- Current month and current season for each accumulation rate, for each defined data set.
- Total-to-date readings for each month.
- Total-to-date readings for each season.
- Cumulative Demand with continuous Cumulative Demand option.
- Configurable auto self-read for season and months, or manual read.

NOTICE

If you make changes to either the current/voltage ratio, energy scaling or similar format settings in the meter's profile; or the configuration of TOU datasets, rates, schedules or day types, the data in the meter may no longer be consistent with the previous accumulated data. Any time you change these values you should reset the TOU data by performing a Master TOU reset action (see the *GE Communicator Instruction Manual* for instructions.)

Multiple Demand Windows

The EPM 7000P meter simultaneously calculates four quadrant demand with the following features:

- Block Window Demand or Rolling Window Demand averaging, divided into of up to 4 subintervals.
- Cumulative Demand.
- Continuous Cumulative Demand.
- Total Demand Distortion.

- Cold Load Pickup.
- Programmable Interval length of 5 minutes, 15 minutes, 30 minutes and 60 minutes.
- End of Interval Pulse Output (with optional PS card).
- End of Interval Pulse Input (with optional PS or RS card).

Cold Load Pickup/Demand Forgiveness

The meter offers Cold Load Pickup/Demand Forgiveness, so that in case a power system outage or excessive power system voltage drop occurs, when normal service is resumed, the customer will not be billed for the initial surge or in-rush of power to feed its "cold loads." During the initial time period immediately following the return of normal electric service, the demand is not computed in the Demand Registers if the two threshold conditions described below are met, so the customer is not billed for possible excessive demand due to "cold load pickup."

- A power system outage which drops the metering potential inputs to the meter (to below a programmed threshold) and also drops the meter's power.
- A power system outage which drops the metering potential inputs to the Meter (to below a programmed threshold), but the meter's external power remains supplied by an alternate source (e.g., station battery, station service, etc.), that is, the meter continues to operate.

Note that energy is always continuously measured and is also recorded in the Power Profile Logs, if so configured. See the *GE Communicator Instruction Manual*, for instructions.

Time Stamped Max/Min Readings

The unit gathers time stamped Max/Min Demands for all power values. Each of the following values is date/time stamped:

- W Demand, Delivered & Received, Max/Min.
- VAR Demand, Delivered & Received, Max/Min.
- VA Demand, Max/Min.
- Amps Demand, Max/Min.
- Voltage, Max/Min.

Transformer Loss Compensation (TLC)

Transformer Loss Compensation adjusts for both copper and iron losses with a simple user setup.

1.2.2 Communications and I/O Capabilities

The EPM 7000P meter features advanced communication which utilizes multiple Com ports using open protocols. The meter's multi-port design allows multiple communication connections simultaneously. The EPM 7000P meter's system provides a direct digital link, allowing selected data to be gathered without affecting the meter or your data. All of the advanced features of the EPM 7000P are made available through industry-standard Modbus or DNP3 protocols. No proprietary or closed protocols are used.

Standard Communication

- USB port, supporting Modbus ASCII, fixed at 57600 bps, 8 data bits, 1 stop bit, parity set to None.
- RS485 serial port, supporting Modbus RTU/ASCII, DNP3 Level 2, speeds from 1200 bps through 57600 bps, 8 data bits, 1 stop bit, configurable parity.

Optional Communication

The EPM 7000P meter allows you to select up to two optional cards for the following uses:

- E1 optional Ethernet Option card communicating Modbus TCP and DNP 3.0 over Ethernet.
- E2 optional Ethernet card with Modbus TCP and embedded IEC 61850 Protocol server.
- F1: Fiber Optic Output ST Terminated.
- F2: Fiber Optic Output Versatile Link Terminated.
- S1: RS485/RS232 Serial Communication Option card.

Both the E1 and the E2 cards offer enhanced security through the Exclusive Client feature. This feature lets you Whitelist an IP and/or MAC address. When that address is used to connect to the meter, all other network communication with the meter, though the same Network card, is suspended. This ensures that anything being done, e.g., updating programmable settings, while the Whitelist address is being used to communicate with the meter, is secure. You set up this feature through GE Communicator software - see the *GE Communicator Instruction Manual*l for instructions.

The E1 card also supports data push of up to 15 meter readings to cloud services using the JSON structure, such as Lucid BuildingOS® Data Push. For instructions on setting up the meter to perform data push, see *Data Push* on page 7–18.

I/O (Input and Output) capability is available in conjunction with all metering functions:

- Optional 4 high-speed status inputs for status detect or for use as load aggregation/ universal metering inputs.
- Optional pulse outputs which can be programmed to pulse for any accumulated reading. One of the pulse outputs can also be set for an End-of-Interval Sync Pulse.

Upgradeable Optional I/O

The user can select from the following optional I/O cards:

- Analog Outputs (0 +/- 1 mA or 4-20 mA).
- Pulse Outputs/Digital Inputs.
- Relay/Digital Inputs.

Control Options

Relay Control provides user-definable control outputs:

- Action and/or alarm on abnormal or other user-set conditions.

1.2.3 Meter Display

The EPM 7000P meter features a three line LED display for easy to use faceplate programming and viewing of meter readings. Refer to Chapter 2 for details on the meter's display.

1.3 EPM 7000P Meter Accuracy

For 23 °C +/- 5 °C, 3 Phase balanced Wye or Delta load, at 50 Hz or 60 Hz (as per order), Class 10 and Class 2 unit, accuracy as follows:

Parameter	Accuracy	Accuracy Input Range
Voltage L-N [V]	0.1% of reading	(57 to 480) V
Voltage L-L [V]	0.2% of reading [2]	(100 to 720) V
Current Phase [A]	0.1% of reading [1, 3]	(1 to 100)% of Current Class (CL)
Current Neutral (calculated) [A]	2% of Full Scale [1]	(1 to 100)% of CL
Active Power Total [W]	0.15% of reading [1, 2]	I: (1.25 to 50)% of CL V: (57 to 480) V PF: +/-(0.5 to 1) lag/lead
Active Energy Total [Wh]	0.15% of reading [1, 2]	I: (1.25 to 50)% of CL V: (57 to 480) V PF: +/-(0.5 to 1) lag/lead
Reactive Power Total [VAR]	0.2% of reading [1, 2]	I: (1.25 to 50)% of CL V: (57 to 480) V PF: +/-(0 to 0.8) lag/lead
Reactive Energy Total [VARh]	0.2% of reading [1, 2]	I: (1.25 to 50)% of CL V: (57 to 480) V PF: +/-(0 to 0.8) lag/lead
Apparent Power Total [VA]	0.2% of reading [1, 2]	I: (1.25 to 50)% of CL V: (57 to 480) V PF: +/-(0.5 to 1) lag/lead
Apparent Energy Total [VAh]	0.2% of reading [1, 2]	I: (1.25 to 50)% of CL V: (57 to 480) V PF: +/-(0.5 to 1) lag/lead
Power Factor	0.2% of reading [1, 2]	I: (1.25 to 50)% of CL V: (57 to 480) V PF: +/-(0.5 to 1) lag/lead
Frequency [Hz]	+/- 0.007 Hz	(45 to 65) Hz
Harmonic Distortion (1 to 99.99)% [%]	+/- 2% [1, 4]	I: (2.5 to 50)% of CL V: (57 to 480) V

1 For 2.5 element programmed units, degrade accuracy by an additional 0.5% of reading.

- For 1 A (Class 2) Nominal, degrade accuracy to 0.5% of reading for watts and energy; all other values 2 times rated accuracy.
- For 1 A (Class 2) Nominal, the input current range for accuracy specification is 20% of the values listed in the table.

2 For unbalanced Voltage inputs where at least one crosses the 150 V auto-scale threshold (for example, 120 V/120 V/208 V system), degrade the accuracy to 0.4% of reading.

3 With regard to current readings, reference Voltage applied (V A, V B, or V C).. Otherwise, degrade accuracy to 0.2%. See hookup diagrams in 4.8 *Electrical Connection Diagrams* on page 4–7.

4 At least one Voltage input (minimum 20 V AC) must be connected for THD measurement on current channels.

1.4 EPM 7000P Meter Specifications Overview

POWER SUPPLY

Range: **HI Option**: Universal, (90 to 265) V AC @50/60 Hz or (100 to 370) V DC.
LDC Option: (18-60) V DC.

Power Consumption: (5 to 10) VA, (3.5 to 7) W - depending on the meter's hardware configuration.

Surge withstand: see compliance section for details.

Frequency range: 45 Hz to 65 Hz or DC.

Ride through characteristics: ~33 ms at 120 V at maximum power consumption

Power consumption (burden), maximum:
8 VA/4.5 W per Phase – with 3 phase supply:

Typical burden: 3.3 VA/1.7 W per phase – at 3 phase 120 V AC (with 1 Ethernet Card installed)

VOLTAGE INPUTS

Absolute Maximum Range: Universal, Auto-ranging.
Phase to Reference (V A, V B, V C, to V ref): (57 to 480) V AC
Line to Line (V A-B, V B-C, V C-A): (100 to 480)V AC

Supported Hookups: 3 Element Wye, 2.5 Element Wye, 2 Element Delta, 4 Wire Delta

Input Impedance: 8 MΩ between any two inputs

Pickup Voltage: 20 V AC

Surge withstand: See compliance section for details

Burden: 0.0018 W at 120 V

Connection: 7 Pin 0.400" Pluggable Terminal Block;
AWG#12-26/ (0,129-3.31) mm^3

Reading: Programmable Full Scale to any PT ratio

CURRENT INPUTS

The current inputs are transformer rated and only to be connected to external CTs.

Transformer rated.

The meter will operate using 2, 2.5, or 3 element measurements.

Reading: ....Programmable current to any CT ratio.

Class 10:..(00.005 to 11) A, 5 A nominal.

Class 2:...(0.001 to 2) A, 1 A nominal.

Burden: ....0.005 VA per phase at 11 A.

Pickup Current: ....0.1% of nominal - Class 10: 5 mA; Class 2: 1 mA (0.2% of nominal is using current only mode, with no connection to the voltage inputs).

Continuous current withstand:Class 10: 20 A AC; Class 2: 5 A AC maximum ratings (for screw terminated or pass-through connections)

Overcurrent ratings as the factor of Current Class (CL):
5x - for 10 seconds, 15x - for 3 seconds, 25x - for 1 second.

Fault current withstand (at 23 ^{o}C):
100 A for 10 seconds, 300 A for 3 seconds, 500 A for 1 second.

Maximum voltage from current inputs to Earth Ground:
40 V AC.

Pass through wire diameter:....0.177" / 4.5 mm.

ISOLATION

Between human accessible I/O connections and power, voltage, current inputs: 2500 V AC.

Between power and voltage and current inputs: 2500 V AC.

Between human accessible I/O connections: 500 V AC.

Isolation is Hi-Pot test verified in factory.

MEMORY FOR STORAGE

Up to 128 Megabytes of Flash memory: dependent on Software Option.

STANDARD COMMUNICATION

USB port, supporting Modbus ASCII, fixed at 57600 bps, 8 data bits, 1 stop bit, parity set to None.

RS485 serial port, supporting Modbus RTU/ASCII, DNP3 Level 2, speeds from 1200 bps through 57600 bps, 8 data bits, 1 stop bit, configurable parity.
Modbus Address 1-247.
DNP Address: 1 to 65519.

OPTIONAL COMMUNICATION

E1: ....10/100BaseT Ethernet with Total Web Solutions and Alarm/Notification Email; Modbus TCP, DNP LAN/WAN protocols.

E2: ....Modbus TCP and IEC 61850 Protocol server.

F1: ....Fiber optic, ST terminated.

F2: ....Fiber optic, VPIN terminated.

S1: ....RS232/RS485 card.

STANDARD KYZ/RS485 CARD SPECIFICATIONS

RS485 PORT:

RS485 Transceiver: ....meets or exceeds EIA/TIA-485 Standard.

Type:...Two-wire, half duplex.

Min. input impedance:.................96 kΩ.

Max. output current: ....±60 mA.

WH PULSE

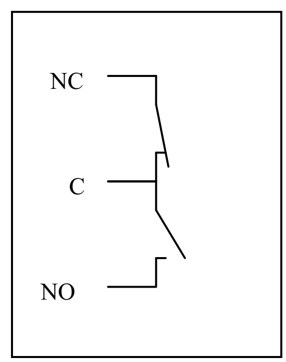
KYZ output contacts, and infrared LED light pulses through face plate (see Chapter 12 *Performing Meter Testing*, for Kh values)

Pulse Width: .... 90 ms
Full Scale Frequency: .... ~3 Hz
Contact type: .... Solid state – SPDT (NO – C – NC)
Relay type: .... Solid state
Peak switching voltage: .... DC ±350 V
Continuous load current: .... 120 mA
Peak load current: .... 350 mA for 10 ms
On resistance, max.: .... 35 Ω
Leakage current: .... 1 μA@350 V
Isolation: .... AC 3750 V
Reset state: .... (NC - C) Closed; (NO - C) Open

INFRARED LED:

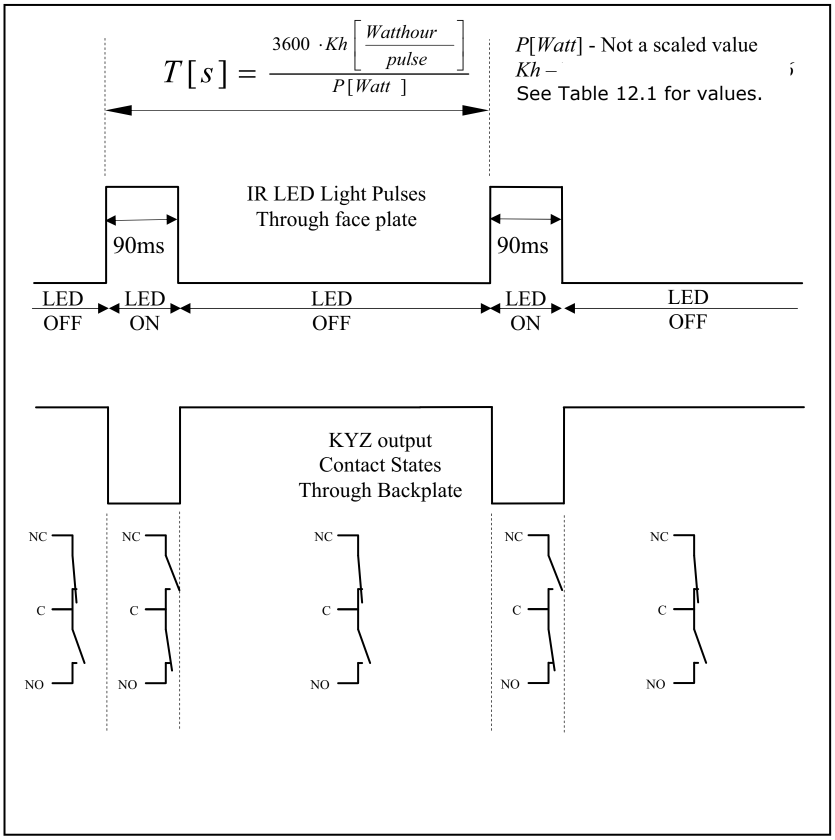
Peak Spectral wavelength: .... 940 nm
Reset state: .... Off

Figure 1-1: Internal schematic:



(De-energized state)

Figure 1-2: Output timing:



- Clock Timing and Synchronization: see 1.7 *Time Synchronization Alternatives* on page 1–17.

ENVIRONMENTAL (TEMPERATURE SPECIFICATIONS, INDIRECT SUNLIGHT)

Operating Temperature: ....(-20 to +70) °C.
Display Operating Temperature:(-20 to +70) °C.
Humidity: ....95% RH maximum, non-condensing.
Storage Temperature: ....(-20 to +70) °C.
Max Altitude: ....2000 m.
Faceplate Rating:...........................NEMA 1.
The printed circuit boards in this meter are conformal coated and compliant with IEC 61086-1/2/3, Class 2 (High Reliability). This protects against deleterious effects due to adverse environmental conditions.

SECURITY

The EPM 7000P meter has multiple security features that prevent unauthorized access to the meter's data

- One administrator name and password and up to eight user names and passwords are available. The usernames and passwords are encrypted as they are sent to the meter, to further insure meter security.
- Over 40 different privileges (for performing actions in the meter) can be customized for each of the eight users, to allow for different levels of access to the meter's data and functions.

- The password is a 30 character field that must contain at least one number. Note that only the first 28 characters are actually used by the meter as the password - the other two characters are used to randomize security processing. GE Communicator software automatically fills the password if what is entered is less than 30 characters in length. However, if you are using a third party software for password protection, you will need to create a full 30 character password, since that is what the meter will be expecting. You can use any random characters for the last two characters. Also, if you are using a third party software, your password does not need to contain a number.
- The password feature has a lockout for failed log on attempts. If an incorrect username and/or password is entered, a timer runs for 30 seconds before the user can attempt to log on again. For a second and subsequent log on failures, the lockout timer runs for five minutes.

SHIPPING DIMENSIONS

Size: .... 4.85” H x 4.85” W x 4.25” L.
Weight:.. 2 lbs./.91 kg.
Meter weight (no option cards): 1.09 lbs./0.50 kg.

1.5 Compliance

Test	Reference Standard	Level/Class
IEC62053-22 (0.2% Accuracy)		
ANSI C12.20 (0.2% Accuracy)		
Electrostatic Discharge	EN/IEC61000-4-2	Level 4
RF Immunity	EN/IEC61000-4-3	10 V/min
Fast Transient Disturbance	EN/IEC61000-4-4	Level 3
Surge Immunity	EN/IEC61000-4-5	Level 3
Conducted RF Immunity	EN/IEC61000-4-6	Level 3
Radiated and Conductive Emissions	EN/IEC61000-6-4 CISPR 11	Class A
Voltage Dip & Interruption	EN/IEC61000-4-11	0, 40, 70, 100% dips, 250/300 cycle interrupts

APPROVALS

CE Compliance	Low Voltage Directive	EN61010-1
	EMC Directive	EN61326-1 EN61000-6-2 EN61000-6-4
	ROHS Directive	
North America	cULus Listed	UL61010-1 (PICQ) C22.2. No 61010-1 (PICQ7) File E200431
KEMA	Certified	IEC 61850
ISO	Manufactured under a registered quality program	ISO9001

1.6 DNP V 3.0 Protocol Implementation

The EPM 7000P meter's version of DNP is the Distributed Network Protocol Version 3 subset 2. For complete details, see Appendix C *EPM 7000P Meter DNP Mapping*.

1.7 Time Synchronization Alternatives

(See the *GE Communicator Instruction Manual* for details.)

Internal Clock

The EPM 7000P meter is equipped with an internal clock crystal which is accurate to 3.5 PPM over the operating temperature range and 5 PPM over ten years of aging, and which can be used if Line Frequency Clock Synchronization is not enabled. The EPM 7000P meter's internal real time clock has a low drift: 15 seconds per month over the temperature range is the "worst case" scenario - six seconds per month is typical at -15 ^{o}C to +25 ^{o}C.

Line Frequency Clock Synchronization

The EPM 7000P meter is equipped with Line Frequency Clock Synchronization, which may be enabled or disabled for use. If Line Frequency Clock Synchronization is enabled and power is lost, the internal clock takes over at the precise moment power is lost. Line Frequency Sync uses the AC frequency as its time reference. In jurisdictions in which time is synchronized to line frequency, this is a very accurate time reference, with an accuracy better than 1 second per month.

NTP Time Synchronization

If your meter has a Network Option card (either the E1 Ethernet card, or the E2 IEC 61850 Protocol Server card), you can use the card to access a Network Time Protocol (NTP) Server for clock synchronization. See the *GE Communicator Instruction Manual,* for instructions.

Multilin™ EPM 7000P

Chapter 2: Using the EPM 7000P/ 7000PT Meter

2.1 Introduction

You can use the Elements and Buttons on the EPM 7000P meter's face to view meter readings, reset and/or configure the meter, and perform related functions. The following sections explain the Elements and Buttons and detail their use.

2.1.1 Understanding Meter Face Elements

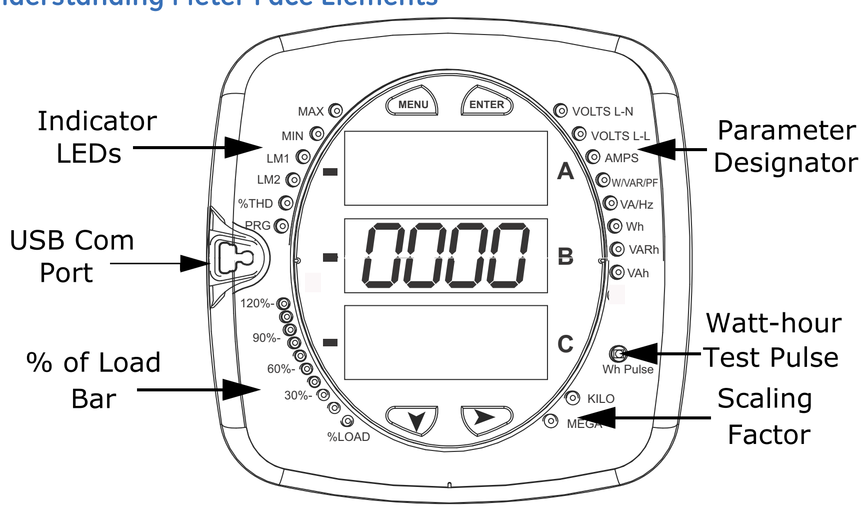


Figure 2-1: Face Plate with Elements

- The meter face features the following elements:
  - Indicator LEDs: there are six LED lights in this section of the meter face, which light when certain conditions occur:
  - MAX: this LED lights when the right arrow button is used to scroll to a secondary screen showing maximum values; e.g., Volts L-N. The LED will only light if there are

maximum values for that reading. The supported screen groups for the MAX LED are Volts L-N, Volts L-L, Amps, W/VAR/PF, and VA/Hz.

- MIN: this LED lights when the right arrow button is used to scroll to a secondary screen showing minimum values; e.g., Volts L-N. The LED will only light if there are minimum values for that reading. The supported screen groups for the MIN LED are Volts L-N, Volts L-L, Amps, W/VAR/PF, and VA/Hz.
- LM1: this LED lights when any of the 16 Above limits have been exceeded. Note that the LED lighting is not related to the data on the screen at the time.
- LM2: this LED lights when any of the 16 Below limits have been exceeded. Note that the LED lighting is not related to the data on the screen at the time.
- %THD: this LED lights when the right arrow button is used to scroll to the secondary screen showing total harmonic distortion values. The LED will only light if there are THD values for that reading. The supported screen groups for the %THD LED are Volts L-N, Amps, W/VAR/PF, and VA/Hz.
- PRG: this LED lights when the meter is in front panel edit mode and a configuration value has changed.

- Parameter designator: e.g., Volts L-N.
- Watt-hour test pulse: Energy pulse output to test accuracy.
- Scaling factor: Kilo or Mega multiplier of displayed readings.
- % of Load bar: Graphic Display of Amps as % of the load (see 2.3 *Understanding the % of Load Bar* on page 2–13, for additional information).
- USB Communication port: Com 1 port for USB to serial communication.

2.1.2 Understanding Meter Face Buttons

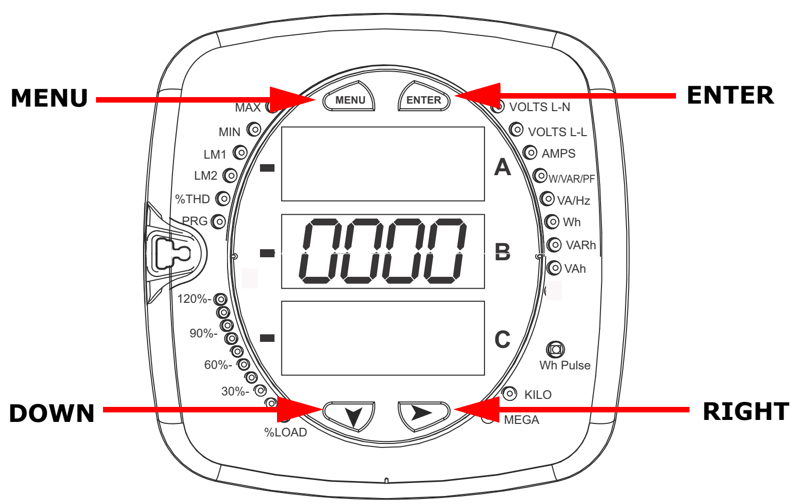


Figure 2-2: Faceplate with Buttons

The meter face has **Menu**, **Enter**, **Down** and **Right** buttons, which let you perform the following functions:

- View meter information.
- Enter display modes.
- Configure parameters (may be Password protected).

- Perform resets (may be Password protected).
- Change settings.
- View parameter values.
- Scroll parameter values.
- View Limit states.

2.2 Using the Front Panel

You can access four modes using the EPM 7000P meter's front panel buttons:

- Operating mode (Default).
- Reset mode.
- Configuration mode.
- Information mode - Information mode displays a sequence of screens that show model information, such as Frequency, Amps, Software Options, etc.

Use the **Menu**, **Enter**, **Down** and **Right** buttons to navigate through each mode and its related screens.

NOTICE

- See Appendix A *EPM 7000P Meter Navigation Maps*, for the display's Navigation maps.
- The meter can also be configured using software; see Chapter 28 in the *GE Communicator Instruction Manual* for instructions.
- Access to Reset Demand Mode, Reset Energy Mode, and Configuration Mode can be password protected or disabled in the meter's security configuration. If access is password protected, the user must enter the correct password in order to perform the function. If access is disabled, a message is shown, stating that the function is denied. See the *GE Communicator Instruction Manual* for details on meter security.

2.2.1 Understanding Startup and Default Displays

Upon powering up, the meter displays a sequence of screens:

- Lamp Test screen where all LEDs are lit.
- Lamp Test screen where all digits are lit.
- Firmware screen showing the build number.
- Error screen (if an error exists).

After startup, if auto-scrolling is enabled, the EPM 7000P meter scrolls the parameter readings on the right side of the front panel. The Kilo or Mega LED lights, showing the scale for the Wh, VARh and VAh readings. Figure 2.3 shows an example of a Wh reading.

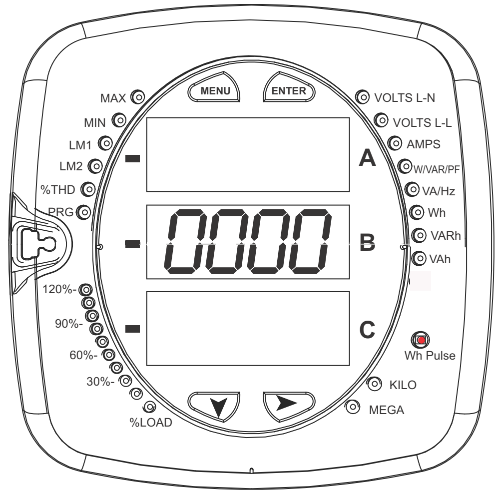


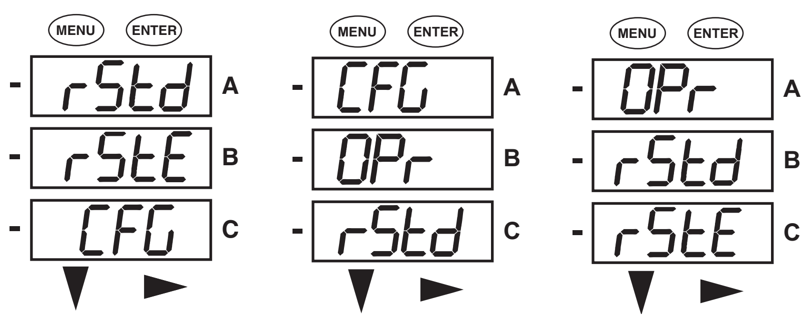
Figure 2-3: Display Showing Watt-hour Reading

The EPM 7000P meter continues to provide scrolling readings until one of the buttons on the front panel is pressed, causing the meter to enter one of the other Modes.

2.2.2 Using the Main Menu

1. Press the **Menu** button. The Main Menu screen appears.
   - The Reset: Demand mode (rStd) appears in the A window. Use the Down button to scroll, causing the Reset: Energy (rStE), Configuration (CFG), Operating (OPr), and Information (InFo) modes to move to the A window.
   - The mode that is currently flashing in the A window is the “Active” mode, which means it is the mode that can be configured.

   For example: Press Down Twice - CFG moves to A window. Press Down Twice - OPr moves to the A window.



2. Press the **Enter** button from the Main Menu to view the Parameters screen for the mode that is currently active.

2.2.3 Using Reset Mode

Reset Mode has two options:

- Reset: Demand (rStd): resets the Max and Min values
- Reset: Energy (rStE): resets the energy accumulator fields

1. Press the Enter button while either rStd or rStE is in the A window. The Reset Demand No or Reset Energy No screen appears.
    - If you press the **Enter** button again, the Main Menu appears, with the next mode in the A window. (The **Down** button does not affect this screen.)
    - If you press the **Right** button, the Reset Demand YES or Reset Energy YES screen appears. Press **Enter** to perform a reset.

CAUTION

Reset Demand YES resets **all** Max and Min values.

2. Once you have performed a reset, the screen displays either “rSt dMd donE” or “rSt EnEr donE”and then resumes auto-scrolling parameters.

NOTICE

- If password protection is enabled for reset for the display, you must enter the four digit password before you can reset the meter. To enter a password, follow the instructions in 2.2.4 *Entering a Password* on page 2–5.
- The following two situations may cause Reset Demand to be blocked:
    - TOU (Time of Use) blocks the Reset Demand command from the front panel when the TOU system is running and there are self-read dates defined in the TOU calendar, i.e., TOU is running in self-read mode.
    - DNP blocks the front panel Reset Demand if DNP is enabled for any port, the DNP Auto Freeze function is enabled, and the Reset Min/Max option within Auto Freeze is also enabled.
- If Reset Demand is blocked by either TOU or DNP Freeze, the display will show **Deny** instead of **Done**.

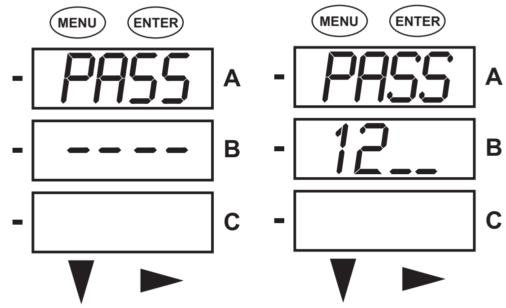
2.2.4 Entering a Password

If password protection has been enabled in the software for the front panel display, a screen appears requesting a password when you try to perform a restricted function, i.e., one that requires a password to perform (see Chapter 6 in the *GE Communicator Instruction Manual* for instructions on setting up password protection for the meter).

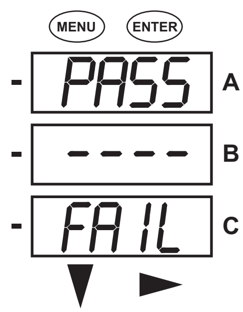
- PASS appears in the A window and 4 dashes appear in the B window; the left-most dash is flashing.

1. Press the **Down** button to scroll numbers from 0 to 9 for the flashing dash. When the correct number appears for that dash, use the **Right** button to move to the next dash.

Example: The left screen, below, shows four dashes. The right screen shows the display after the first two digits of the password have been entered.



2. When all 4 digits of the password have been selected, press the **Enter** button.
   - If you are in Reset mode and you enter the correct password, "rSt dMd donE" or "rSt EnEr donE"appears and the screen resumes auto-scrolling parameters.
   - If you are in Configuration mode and you enter the correct password, the display returns to the screen that required a password.
   - If you enter an incorrect Password, "PASS ---- FAIL" appears and:



- The previous screen is redisplayed, if you are in Reset mode.
- The previous Operating mode screen is redisplayed, if you are in Configuration mode.

2.2.5 Using Configuration Mode

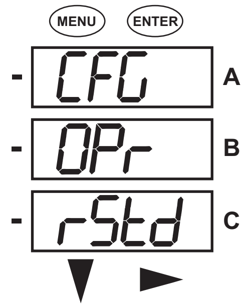
Configuration mode follows Reset: Energy on the Main Menu.

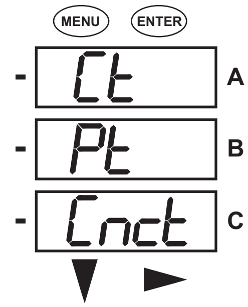
To access Configuration mode:

1. Press the **Menu** button while the meter is auto-scrolling parameters.
2. Press the **Down** button until the Configuration mode option (CFG) is in the A window.
3. Press the **Enter** button. The configuration Parameters screen appears.
4. Press the **Down** button to scroll through the configuration parameters: Scroll (SCrL), CT, PT, Connection (Cnct) and Port. The parameter currently 'Active," i.e., configurable, flashes in the A window.
5. Press the **Enter** button to access the Setting screen for the currently active parameter.

NOTICE

You can use the **Enter** button to scroll through all of the configuration parameters and their Setting screens, in order.





Press **Enter** when CFG is in A window -

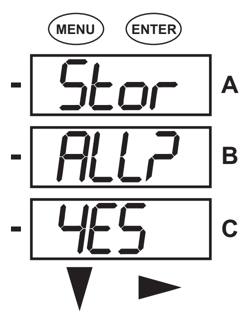
Parameter screen appears - Press **Down**- Press **Enter** when the Parameter you want is in A window

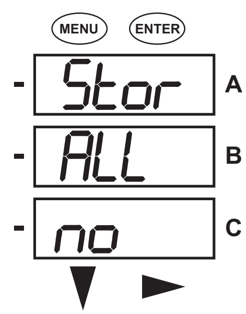
6. The parameter screen appears, showing the current settings. To change the settings:
   - Use either the **Down** button or the **Right** button to select an option.
   - To enter a number value, use the **Down** button to select the number value for a digit and the **Right** button to move to the next digit.

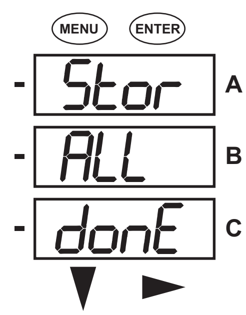
NOTICE

When you try to change the current setting and Password protection is enabled for the display, the Password screen appears. See 2.2.4 *Entering a Password* on page 2–5, for instructions on entering a password.

7. Once you have entered the new setting, press the **Menu** button twice.
8. The Store ALL YES screen appears. You can either:
   - Press the **Enter** button to save the new setting.
   - Press the **Right** button to access the Store ALL no screen; then press the **Enter** button to cancel the Save.
9. If you have saved the settings, the Store ALL done screen appears and the meter resets.







Press the **Enter** button to save the settings. Press the **Right** button for Stor All no screen.

Press the **Enter** button to Cancel the Save.

The settings have been saved.

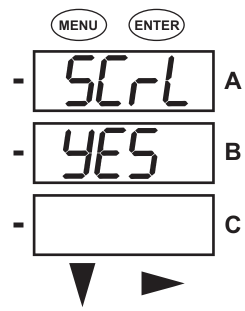
Configuring the Scroll Feature

When in auto-scrolling mode, the meter performs a scrolling display, showing each parameter for 7 seconds, with a 1 second pause between parameters. The parameters that the meter displays are determined by the following conditions:

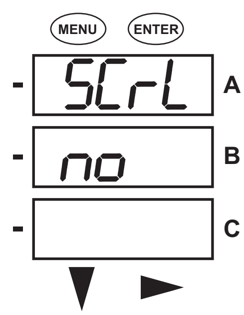
- They have been selected through software (see the *GE Communicator Instruction Manual* for instructions).
- They are enabled by the installed Software Option (see 1.1.4 *Software Option Technology* on page 1–4).

To enable or disable auto-scrolling:

1. Press the **Enter** button when SCrl is in the A window. The Scroll YES screen appears.



2. Press either the **Right** or **Down** button if you want to access the Scroll no screen. To return to the Scroll YES screen, press either button.
3. Press the **Enter** button on either the Scroll YES screen (to enable auto-scrolling) or the Scroll no screen (to disable auto-scrolling).



4. The CT- n screen appears (this is the next Configuration mode parameter).

NOTICE

- To exit the screen without changing scrolling options, press the **Menu** button.
- To return to the Main Menu screen, press the **Menu** button twice.
- To return to the scrolling (or non-scrolling) parameters display, press the **Menu** button three times.

Configuring CT Setting

CT Setting has two parts: Ct-n (numerator) and Ct-d (denominator).

1. Press the **Enter** button when Ct is in the A window. The Ct-n screen appears. You can either:
   - Change the value for the CT numerator.

- Access the Ct-d screen by pressing the **Enter** button.

NOTICE

The Ct-d screen is preset to a 5 Amp or 1 Amp value at the factory and cannot be changed.

2. To change the value for the CT numerator, from the Ct-n screen:
   - Use the **Down** button to select the number value for a digit. CT-n can be up to 5 digits, with a maximum value of 65535.
   - Use the **Right** button to move to the next digit.

NOTICE

If you are prompted to enter a password, see 2.2.4 *Entering a Password* on page 2–5, for instructions on doing so.

3. When the new setting is entered, press the **Menu** button twice.
4. The Store ALL YES screen appears. Press **Enter** to save the new CT setting.

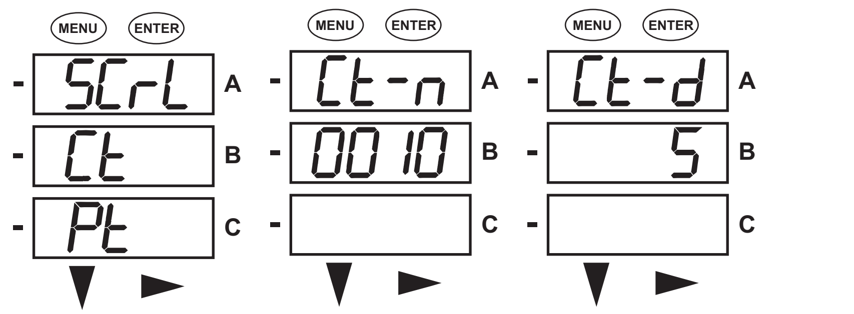
Example CT Settings:

200/5 Amps: Set the Ct-n value for 200.

2,000/5 Amps: Set the Ct-n value for 2000.

NOTICE

Ct-n is dictated by primary current; Ct-d is secondary current.



Press ENTER   Use buttons to set Ct-n   Ct-d cannot be changed

Configuring PT Setting

PT Setting has two parts: Pt-n (numerator) and Pt-d (denominator).

1. Press the **Enter** button when Pt is in the A window. The PT-n screen appears. You can either:
   - Change the value for the PT numerator (can be up to 8 digits, with a maximum value of 99999999).
   - Access the Pt-d screen by pressing the **Enter** button (can be up to 5 digits, with a maximum value of 65535).
2. To change the value for the PT numerator or denominator:
   From the Pt-n or Pt-d screen:
   - Use the **Down** button to select the number value for a digit.
   - Use the **Right** button to move to the next digit.

NOTICE

If you are prompted to enter a password, see 2.2.4 *Entering a Password* on page 2–5, for instructions on doing so.

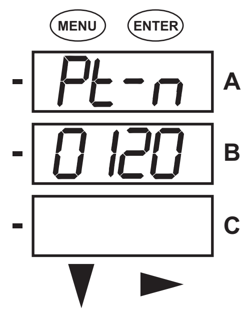
3. When the new setting is entered, press the **Menu** button twice.
4. The STOR ALL YES screen appears. Press **Enter** to save the new PT setting.

Example PT Setting:

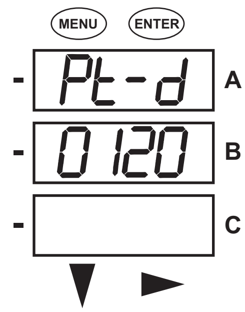
277/277 Volts: Pt-n value is 277, Pt-d value is 277.

NOTICE

Pt-n is dictated by primary voltage; Pt-d is secondary voltage.



Use buttons to set Pt-n



Use buttons to set Pt-d

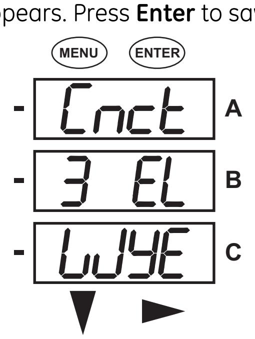
Configuring Connection Setting

1. Press the **Enter** button when Cnct is in the A window. The Cnct screen appears.
2. Press the **Right** button or **Down** button to select a configuration. The choices are:
   - 3 Element Wye (3 EL WYE)
   - 2.5 Element Wye (2.5EL WYE)
   - 2 CT Delta (2 Ct dEL)

NOTICE

If you are prompted to enter a password, refer to Section 2.2.4 for instructions on doing so.

3. When you have made your selection, press the **Menu** button twice.
4. The STOR ALL YES screen appears. Press **Enter** to save the setting.



Use buttons to select configuration

Configuring the RS485 Communication Port Setting

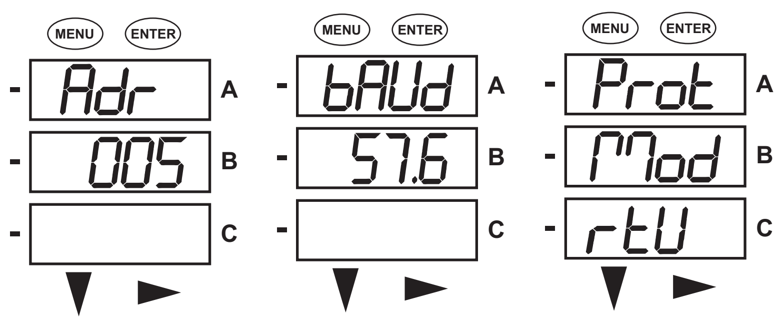
Port configuration consists of: Address (a three digit number), Baud Rate (9600; 19200; 38400; or 57600), and Protocol (DNP 3.0; Modbus RTU; or Modbus ASCII).

1. Press the **Enter** button when POrt is in the A window. The Adr (address) screen appears. You can either:
   - Enter the address.
   - Access one of the other Port screens by pressing the **Enter** button: press **Enter** once to access the bAUd screen (Baud Rate), twice to access the Prot screen (Protocol).
2. To enter the Address:
   From the Adr screen:
   - Use the **Down** button to select the number value for a digit.
   - Use the **Right** button to move to the next digit.
     NOTE: Using the faceplate you can enter addresses between 1 and 247; if you want to enter a DNP address over 247, you need to enter the address through software settings. Refer to Section 5.2.2.
3. To select the Baud Rate:
   From the bAUd screen, use the **Right** button or the **Down** button to select the setting you want.
4. To select the Protocol:
   From the Prot screen, press the **Right** button or the **Down** button to select the setting you want.

NOTICE

If you are prompted to enter a password, refer to Section 2.2.4 for instructions on doing so.

5. When you have finished making your selections, press the **Menu** button twice.
6. The STOR ALL YES screen appears. Press **Enter** to save the settings.



Use buttons to enter Address   Use buttons to select Baud Rate   Use buttons to select Protocol

2.2.6 Using Operating Mode

Operating mode is the EPM 7000P meter's default mode, that is, the standard front panel display. After starting up, the meter automatically scrolls through the parameter screens, if scrolling is enabled. Each parameter is shown for 7 seconds, with a 1 second pause between parameters. Scrolling is suspended for 3 minutes after any button is pressed.

1. Press the **Down** button to scroll all the parameters in Operating mode. The currently "Active," i.e., displayed, parameter has the Indicator light next to it, on the right face of the meter.
2. Press the **Right** button to view additional readings for that parameter. The table below shows possible readings for Operating Mode. Sheet 2 in Appendix A shows the Operating mode Navigation map.

NOTICE

Readings or groups of readings are skipped if not applicable to the meter type or hookup, or if they are disabled in the programmable settings.

OPERATING MODE PARAMETERS	POSSIBLE READINGS				
Voltage Line to Neutral Display	voltage line to neutral	voltage line to neutral max	voltage line to neutral min	voltage line to neutral THD (V3)	
Voltage Line to Line Display	voltage line to line	voltage line to line max	voltage line to line min	voltage line to line THD (V3)	
Current Display	current	neutral current	current max	current min	current THD (V3)
Power Display	watt VAR PF	watt max Q1,4 VAR max Q1,2 PF max Q1,4	watt min Q1,4 VAR min Q1,2 PF min Q1,4	watt max Q2,3 VAR max Q3,4 PF max Q2,3	watt min Q2,3 VAR min Q3,4 PF min Q2,3
Apparent Power/ Frequency Display	VA frequency	VA max frequency max	VA min frequency min		
Active Energy Display	watt hour Q1.4	watt hour Q2,3	watt hour net	watt hour total	
Reactive Energy Display	VAR hour Q1,2	VAR hour Q3,4	VAR hour net	VAR hour total	
Apparent Energy Display	VA hour				

2.3 Understanding the % of Load Bar

The 10-segment LED bar graph at the bottom left of the EPM 7000P meter's front panel provides a graphic representation of Amps. The segments light according to the load, as shown in the table below.

When the load is over 120% of Full Load, all segments flash "On" (1.5 secs) and "Off" (0.5 secs).

Segments	Load >= % Full Load
none	no load
1	1%
1-2	15%
1-3	30%
1-4	45%
1-5	60%
1-6	72%
1-7	84%
1-8	96%
1-9	108%
1-10	120%
All Blink	>120%

The % of Load bar can be programmed through GE Communicator software - see the *GE COmmunicator Instruction Manual* for instructions.

2.4 EPM 7000PT Transducer Communication and Programming Overview

The EPM 7000PT transducer does not include a display on the front face of the meter; there are no buttons or USB port on the face of the meter. Programming and communication utilize the RS485 connection on the back of the meter. See 5.1.2 *RS485 / KYZ Output (Com 2)* on page 5–4, for RS485 communication details. Once a connection is established, GE Communicator software can be used to program the meter and communicate to EPM 7000PT transducer slave devices.

Meter Connection

To provide power to the meter, attach an Aux cable to GND, L(+) and N(-). Refer to Section 4.8 *Electrical Connection Diagrams* on page 4–7.

The RS485 cable attaches to SH, - and + as shown in Figure 5-1: *Connecting the USB Cable to the Meter* on page 5–2.

2.4.1 Accessing the Meter in Default Communication Mode

You can connect to the EPM 7000PT in Default Communication mode. This feature is useful in debugging or if you do not know the meter's programmed settings and want to find them. For 5 seconds after the EPM 7000PT is powered up, you can use the RS485 port with Default Communication mode to poll the Meter Name register (decimal address registers 1-8 in the meters Modbus Registers map). You do this by connecting to the meter with the following default settings (see Section 2.4.3, for instructions):

Baud Rate: 9600

Address: 1

Protocol: Modbus RTU

Parity: None

1 Stop bit*

8 Data bits*

The meter continues to operate with these default settings for 5 minutes. During this time, you can access the meter's Device Profile to ascertain/change meter information. Every time the Meter Name register is read, the timeout is extended by 5 minutes. After 5 minutes of no activity, the meter reverts to the programmed Device Profile settings.

CAUTION

IMPORTANT! In Normal operating mode the initial factory communication settings are:

Baud Rate: 57600

Address: 1

Protocol: Modbus RTU

Parity: None

1 Stop bit*

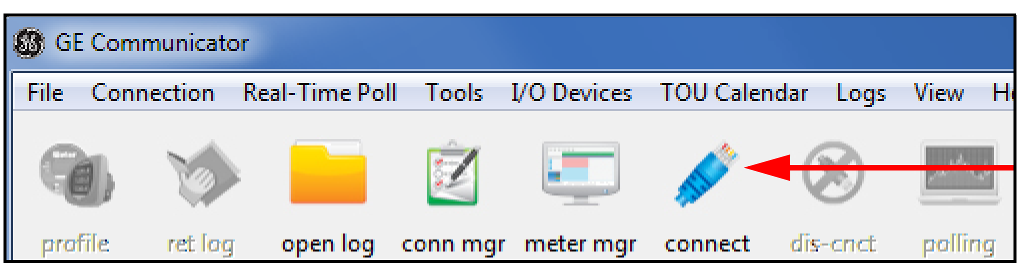
8 Data bits*

*1 Stop bit and 8 Data bits is the default for the GE Communicator application's RS485 port connection, so those settings aren't shown in the Connect screen. They are included here in case you are connecting to the meter with other software.

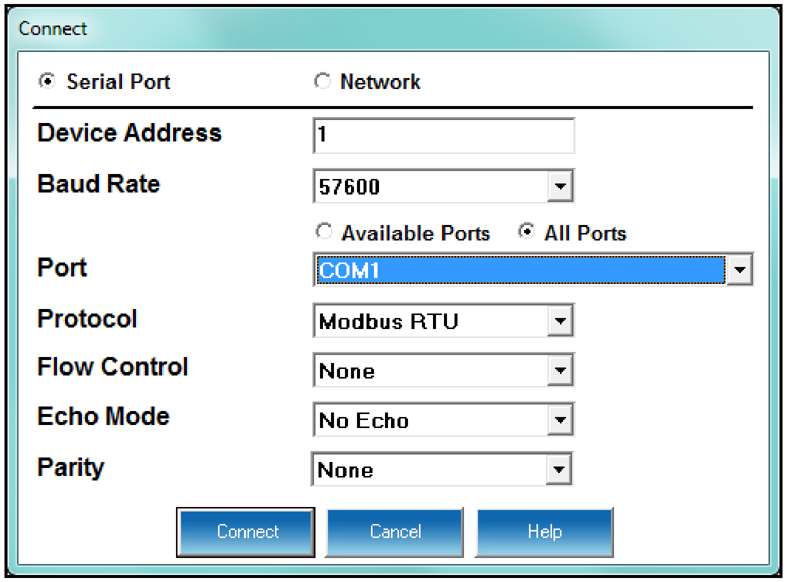
2.4.2 Connecting to the Meter through GE Communicator Software

How to Connect:

1. Open the GE Communicator software.
2. Click the **Connect** icon in the Icon bar.

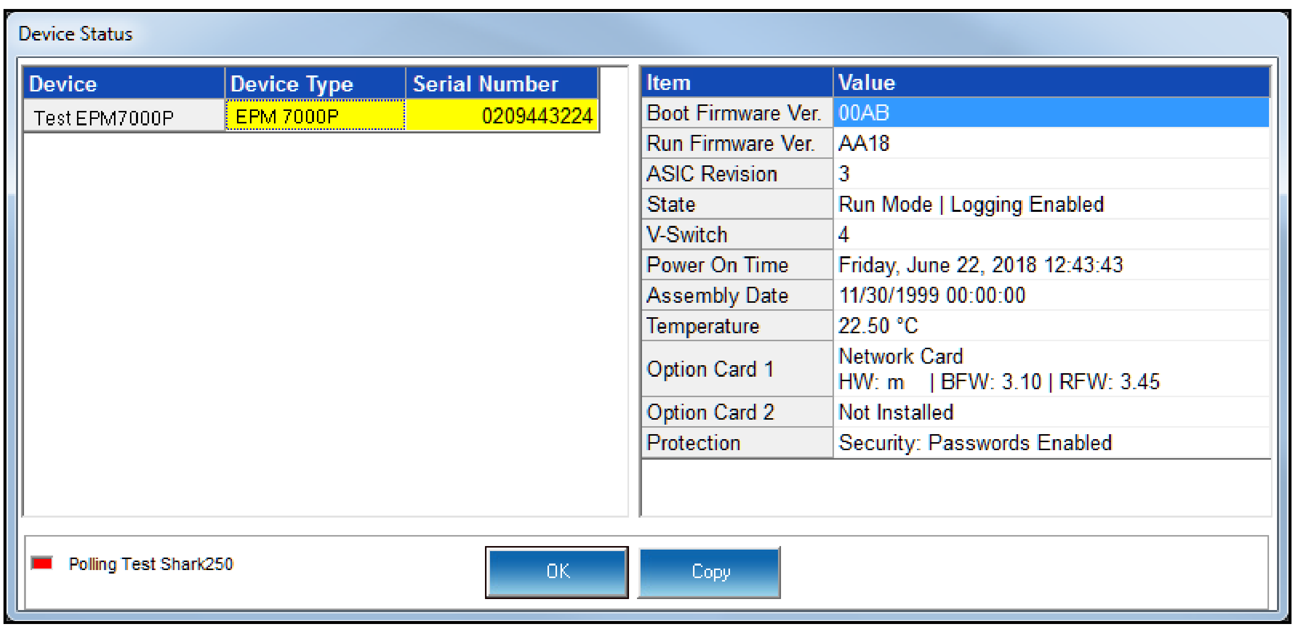


3. The Connect screen opens, showing the Default settings. Make sure your settings are the same as shown here. Use the pull-down menus to make any necessary changes to the settings.



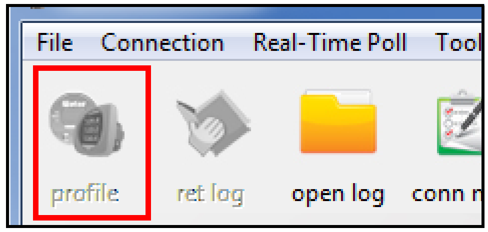
4. Click the **Connect** button. If you have a problem connecting, you may have to disconnect power to the meter, then reconnect power and click the Connect button, again.

5. You will see the Device Status screen, confirming connection to your meter.

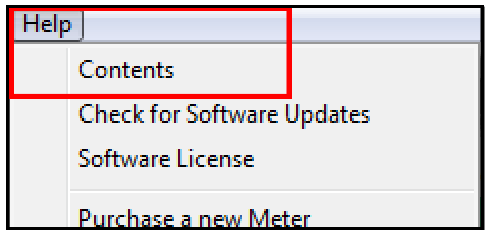


6. Click **OK** to close the Device Status screen. You will see the software Main screen.

7. Click the Profile icon in the Menu Bar to open the meter's Device Profile screen, which is where you make configuration settings for the meter.



8. See the *GE Communicator Instruction Manual* for detailed information on all of the settings. You can access the manual by clicking **Help > Contents** from the software's Main screen.



Multilin™ EPM 7000P

Chapter 3: Mechanical Installation

3.1 Introduction

The EPM 7000P meter can be installed using a standard ANSI C39.1 (4" round) or an IEC 92mm DIN (square) form. In new installations, simply use existing DIN or ANSI punches. For existing panels, pull out old analog meters and replace them with the EPM 7000P meter. See 3.4 *Transducer Installation* on page 3–5, for EPM 7000PT transducer installation. See 4.8 *Electrical Connection Diagrams* on page 4–7, for wiring diagrams.

NOTE: The drawings shown below and on the next page give you the meter dimensions in inches and centimeters [cm shown in brackets]. Tolerance is +/- 0.1" [.25 cm].

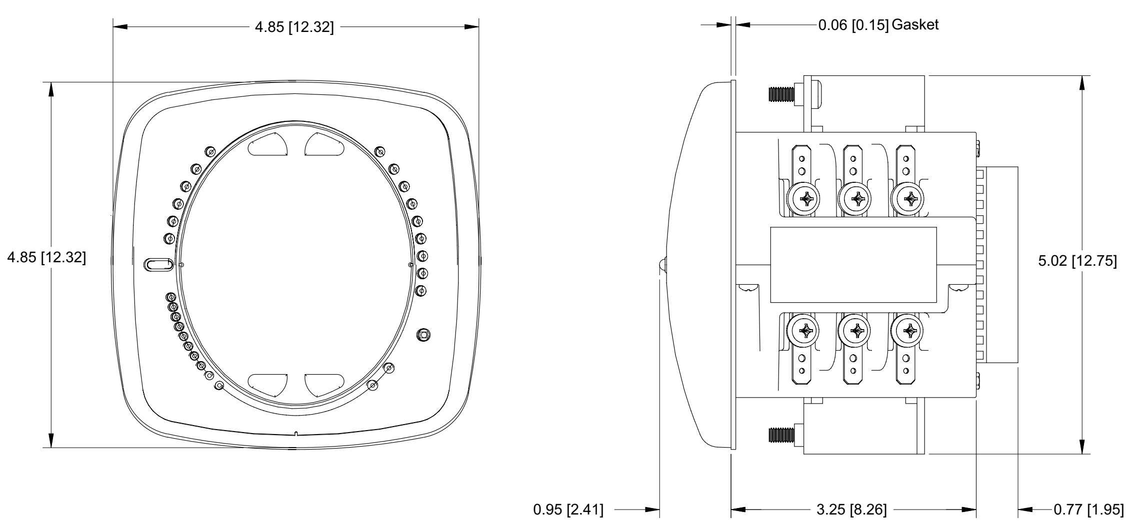


Figure 3-1: Meter Front and Side Dimensions

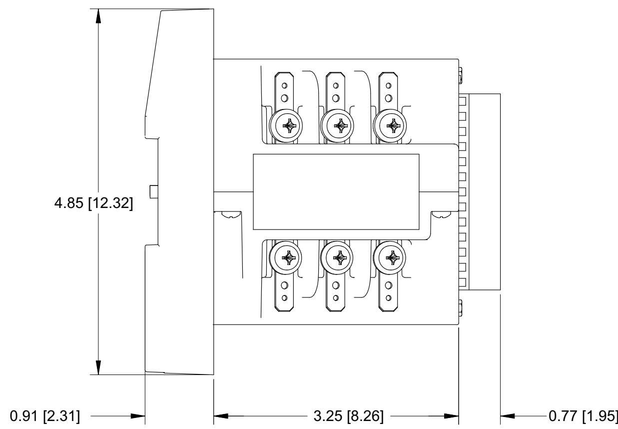


Figure 3-2: EPM 7000PT Dimensions

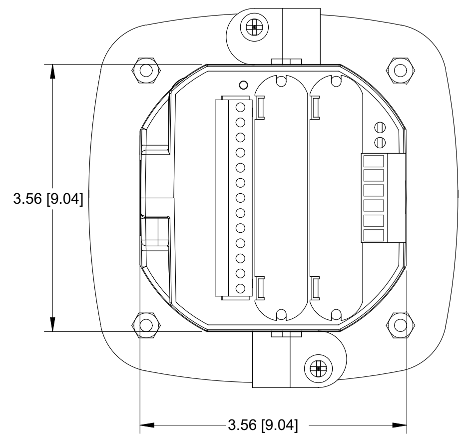


Figure 3-3: Meter Back Dimensions

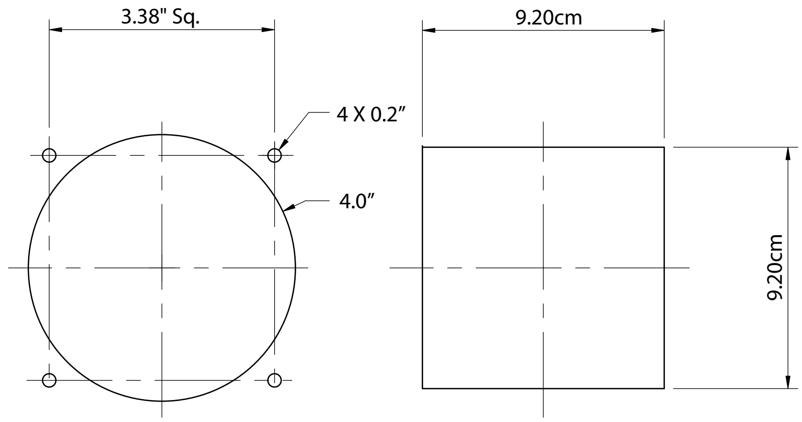


Figure 3-4: ANSI and DIN Cutout Dimensions

RECOMMENDED TOOLS FOR EPM 7000P METER INSTALLATION:

- #2 Phillips screwdriver
- Small adjustable wrench

The EPM 7000P meter is designed to withstand harsh environmental conditions; however it is recommended you install it in a dry location, free from dirt and corrosive substances (see Environmental specifications in 1.4 *EPM 7000P Meter Specifications Overview* on page 1–11).

3.2 ANSI Installation Steps

1. Slide meter with Mounting Gasket into panel.
2. Secure from back of panel with flat washer, lock washer and nut on each threaded rod. Use a small wrench to tighten. Do not overtighten. The maximum installation torque is 0.4 Newton-Meter.

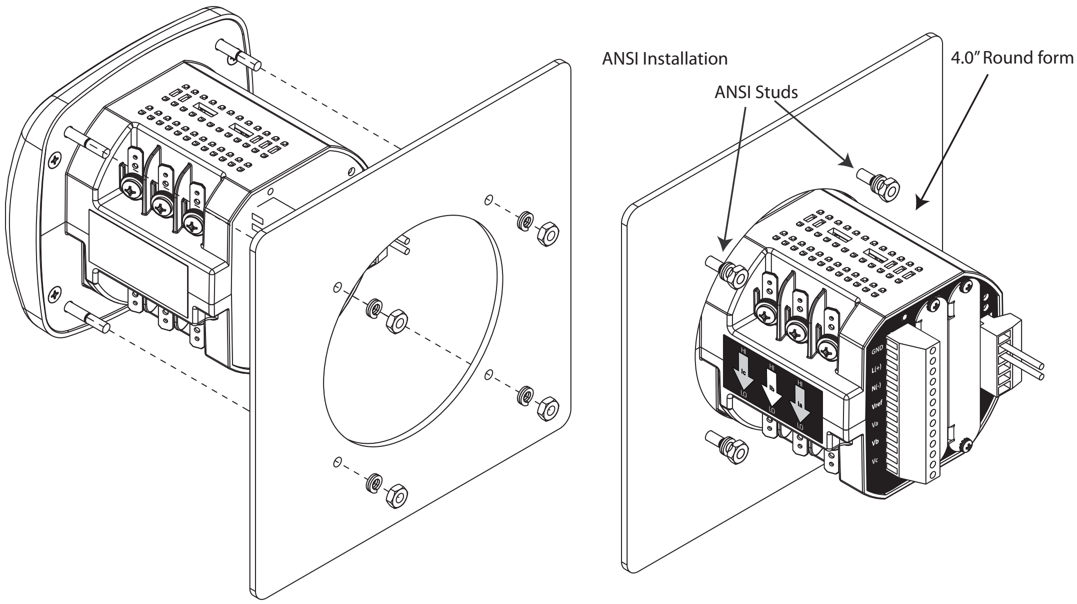


Figure 3-5: ANSI Installation

3.3 DIN Installation Steps

1. Slide meter with NEMA 12 Mounting Gasket into panel (remove ANSI Studs, if in place).
2. From back of panel, slide 2 DIN Mounting Brackets into grooves in top and bottom of meter housing. Snap into place.
3. Secure meter to panel by using a #2 Phillips screwdriver to tighten the screw on each of the two mounting brackets. Do not overtighten: the maximum installation torque is 0.4 Newton-Meter.

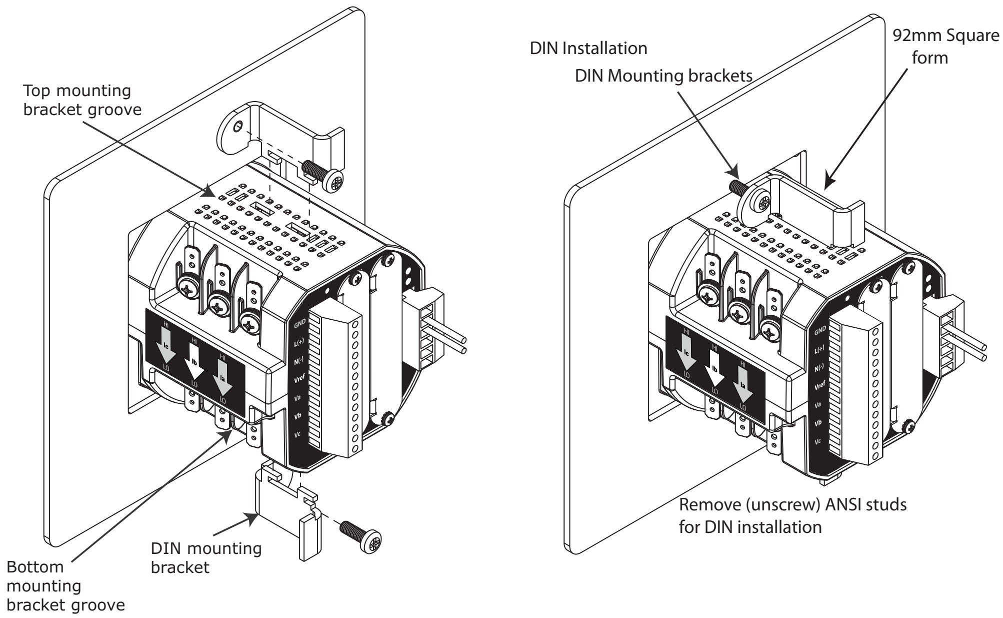


Figure 3-6: DIN Installation

3.4 Transducer Installation

Use DIN Rail mounting to install the EPM 7000PT transducer.

Specs for DIN Rail Mounting

International Standards DIN 46277/3

DIN Rail (Slotted) Dimensions

0.297244” x 1.377953” x 3” /.755cm x 3.5cm x 7.62cm

1. Slide top groove of meter onto the DIN Rail.
2. Press gently until the meter clicks into place.

NOTICE

- To remove the meter from the DIN Rail, pull down on the Release Clip to detach the unit from the rail (see Figure 3.7).
- If mounting with the DIN Rail provided, use the black rubber stoppers, also provided (see Figure 3.8).

NOTE ON DIN RAILS: DIN Rails are commonly used as a mounting channel for most terminal blocks, control devices, circuit protection devices and PLCs. DIN Rails are made of electrolytically plated cold rolled steel and are also available in aluminum, PVC, stainless steel and copper.

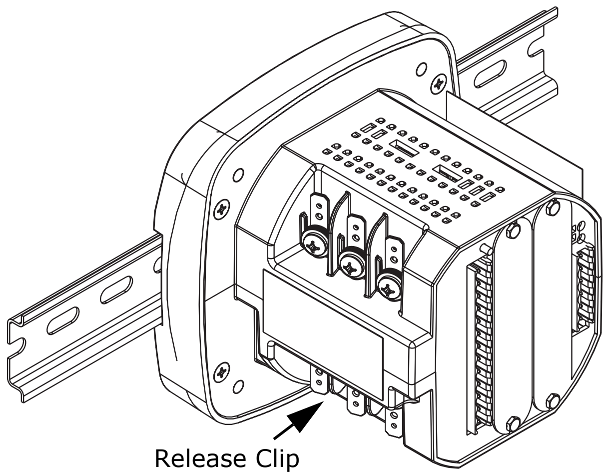


Figure 3-7: Transducer on DIN Rail

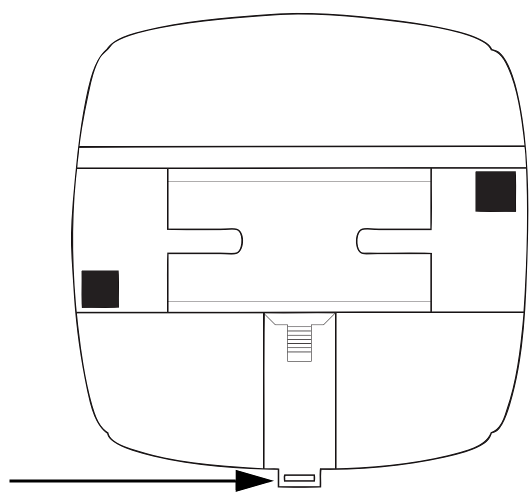


Figure 3-8: DIN Rail Detail

Multilin™ EPM 7000P

Chapter 4: Electrical Installation

4.1 Safety Considerations When Installing Meters

⚠CAUTION

- Installation of the EPM 7000P meter must be performed only by qualified personnel who follow standard safety precautions during all procedures. Those personnel should have appropriate training and experience with high voltage devices. Appropriate safety gloves, safety glasses and protective clothing are recommended.
- During normal operation of the EPM 7000P meter, dangerous voltages are present in many parts of the meter, including: Terminals and any connected CTs (Current Transformers) and PTs (Potential Transformers), all I/O (Inputs and Outputs) and their circuits. All Primary and Secondary circuits can, at times, produce lethal voltages and currents. Avoid contact with any current-carrying surfaces.
- **Do not use the meter or any I/O device for primary protection or in an energy-limiting capacity. The meter can only be used as secondary protection.**
- Do not use the meter for applications where failure of the meter may cause harm or death.
- Do not use the meter for any application where there may be a risk of fire.
- All meter terminals should be inaccessible after installation.
- Do not apply more than the maximum voltage that the meter or any attached device can withstand. Refer to meter and/or device labels and to the Specifications for all devices before applying voltages.
- Do not HIPOT/Dielectric test any Outputs, Inputs or Communications terminals.
- To prevent hazardous voltage conditions, the use of fuse branch circuit protection for voltage leads and the power supply are required.
- To prevent CT damage and potential injuries, shorting blocks for CT circuits are required if the meter needs to be removed from service. One side of the CT must be grounded.

NOTICE

The current inputs are only to be connected to external current transformers provided by the installer. The CTs shall be Approved or Certified and rated for the current of the meter used.

⚠CAUTION

- **IF THE EQUIPMENT IS USED IN A MANNER NOT SPECIFIED BY THE MANUFACTURER, THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED.**

NOTICE

- **THERE IS NO REQUIRED PREVENTIVE MAINTENANCE OR INSPECTION NECESSARY FOR SAFETY. HOWEVER, ANY REPAIR OR MAINTENANCE SHOULD BE PERFORMED BY THE FACTORY.**

⚠CAUTION

- **DISCONNECT DEVICE: The following part is considered the equipment disconnect device. A SWITCH OR CIRCUIT-BREAKER SHALL BE INCLUDED IN THE END-USE EQUIPMENT OR BUILDING INSTALLATION. THE SWITCH SHALL BE IN CLOSE PROXIMITY TO THE EQUIPMENT AND WITHIN EASY REACH OF THE OPERATOR. THE SWITCH SHALL BE MARKED AS THE DISCONNECTING DEVICE FOR THE EQUIPMENT.**

4.2 CT Leads Terminated to Meter

The EPM 7000P meter is designed to have current inputs wired in one of three ways. Figure 4.1 shows the most typical connection where CT Leads are terminated to the meter at the current gills. This connection uses nickel-plated brass studs (current gills) with screws at each end. This connection allows the CT wires to be terminated using either an "O" or a "U" lug. Tighten the screws with a #2 Phillips screwdriver. The maximum installation torque is 1 Newton-Meter.

Other current connections are shown in figures 4.2 and 4.3. Voltage and RS485/KYZ connections are shown in Figure 4.4.

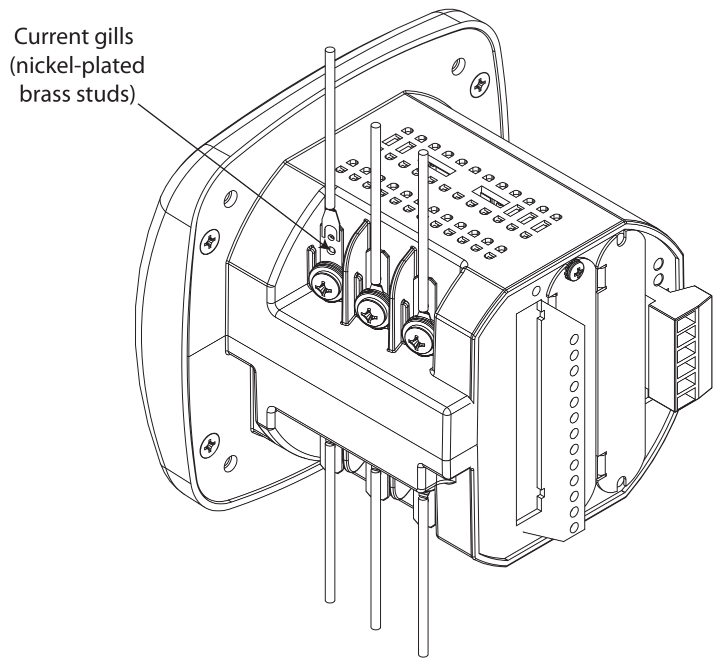


Figure 4-1: CT Leads Terminated to Meter, #8 Screw for Lug Connection

Wiring Diagrams are shown in 4.8 *Electrical Connection Diagrams* on page 4–7.

Communications connections are detailed in Chapter 5 *Communication Installation*.

4.3 CT Leads Pass Through (No Meter Termination)

The second method allows the CT wires to pass through the CT inputs without terminating at the meter. In this case, remove the current gills and place the CT wire directly through the CT opening. The opening accommodates up to 0.177" / 4.5mm maximum diameter CT wire.

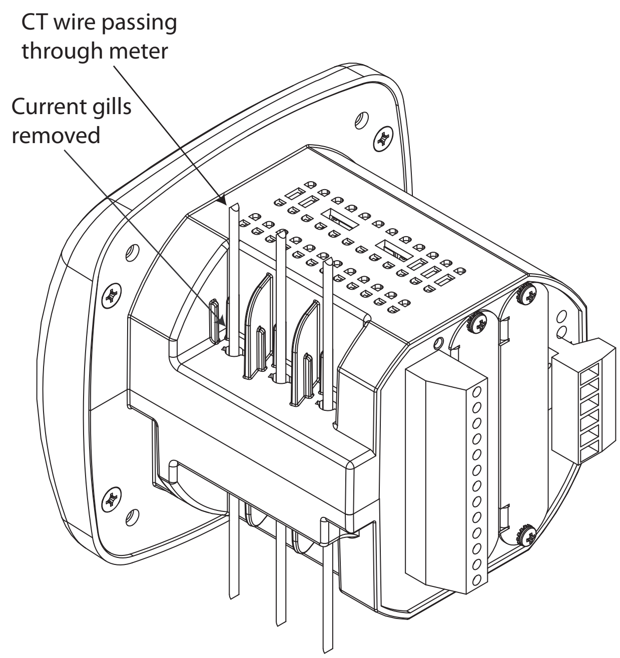


Figure 4-2: Pass Through Wire Electrical Connection

4.4 Quick Connect Crimp-on Terminations

For quick termination or for portable applications, 0.25” quick connect crimp-on connectors can also be used

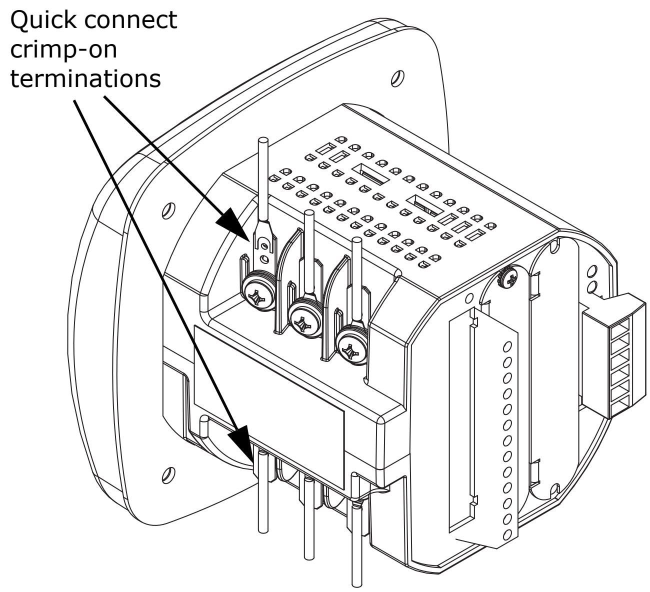


Figure 4-3: Quick Connect Electrical Connection

4.5 Voltage and Power Supply Connections

Voltage inputs are connected to the back of the unit via optional wire connectors. The connectors accommodate AWG# 12 -26/ (3.31 - 0.129) mm^2.

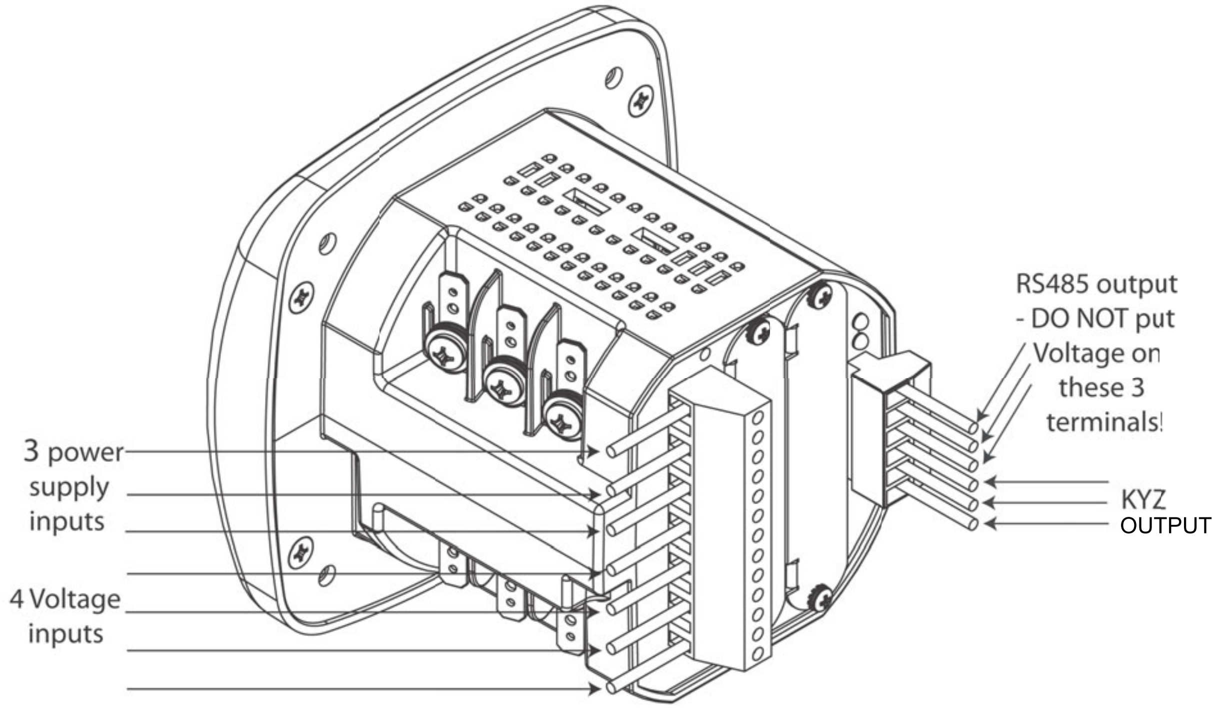


Figure 4-4: Meter Connections

4.6 Ground Connections

The meter's Ground terminals should be connected directly to the installation's protective earth ground. Use AWG# 12/.32 mm^2 wire for this connection.

4.7 Voltage Fuses

The EPM 7000P requires the use of fuses on each of the sense voltages and on the control power.

- Use a 0.1 A fuse on each voltage input.
- Use a 3 A Slow Blow fuse on the power supply.

4.8 Electrical Connection Diagrams

The following pages contain electrical connection diagrams for the EPM 7000P meter. Choose the diagram that best suits your application. Be sure to maintain the CT polarity when wiring.

The diagrams are presented in the following order:

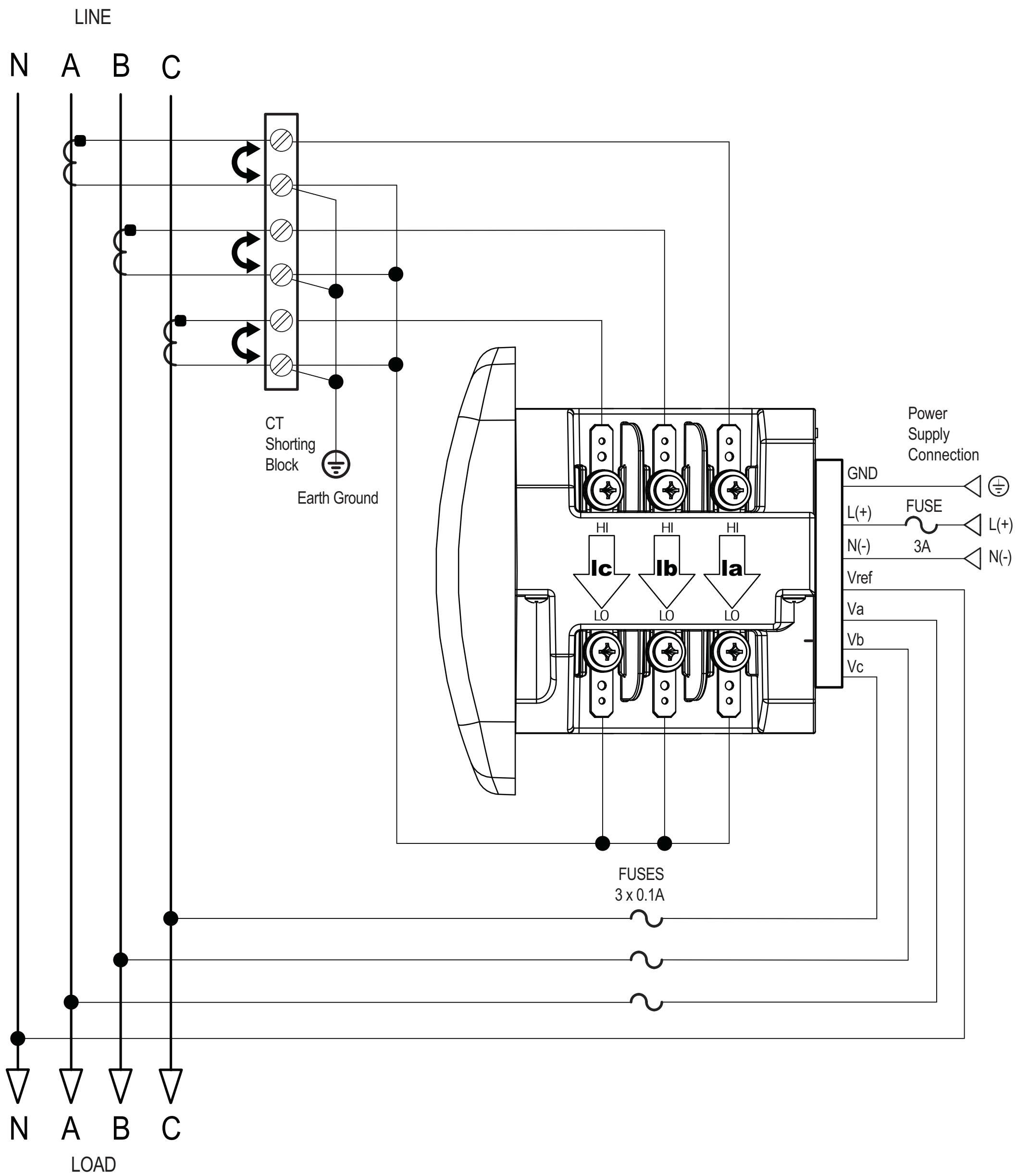
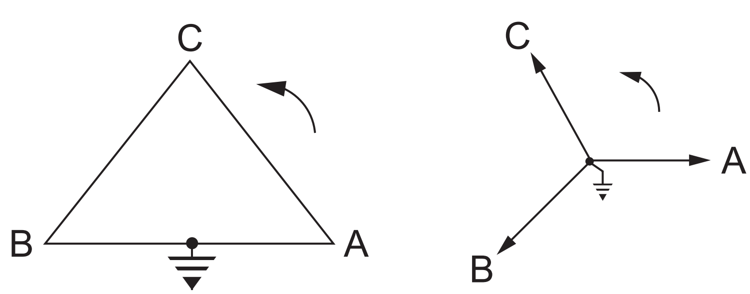


Figure 4-5: WYE/Delta, 4-Wire with No PTs, 3 CTs

Select: " 3 EL WYE " (3 Element Wye) from the EPM meter's front panel display (see 2.2 *Using the Front Panel* on page 2–3).



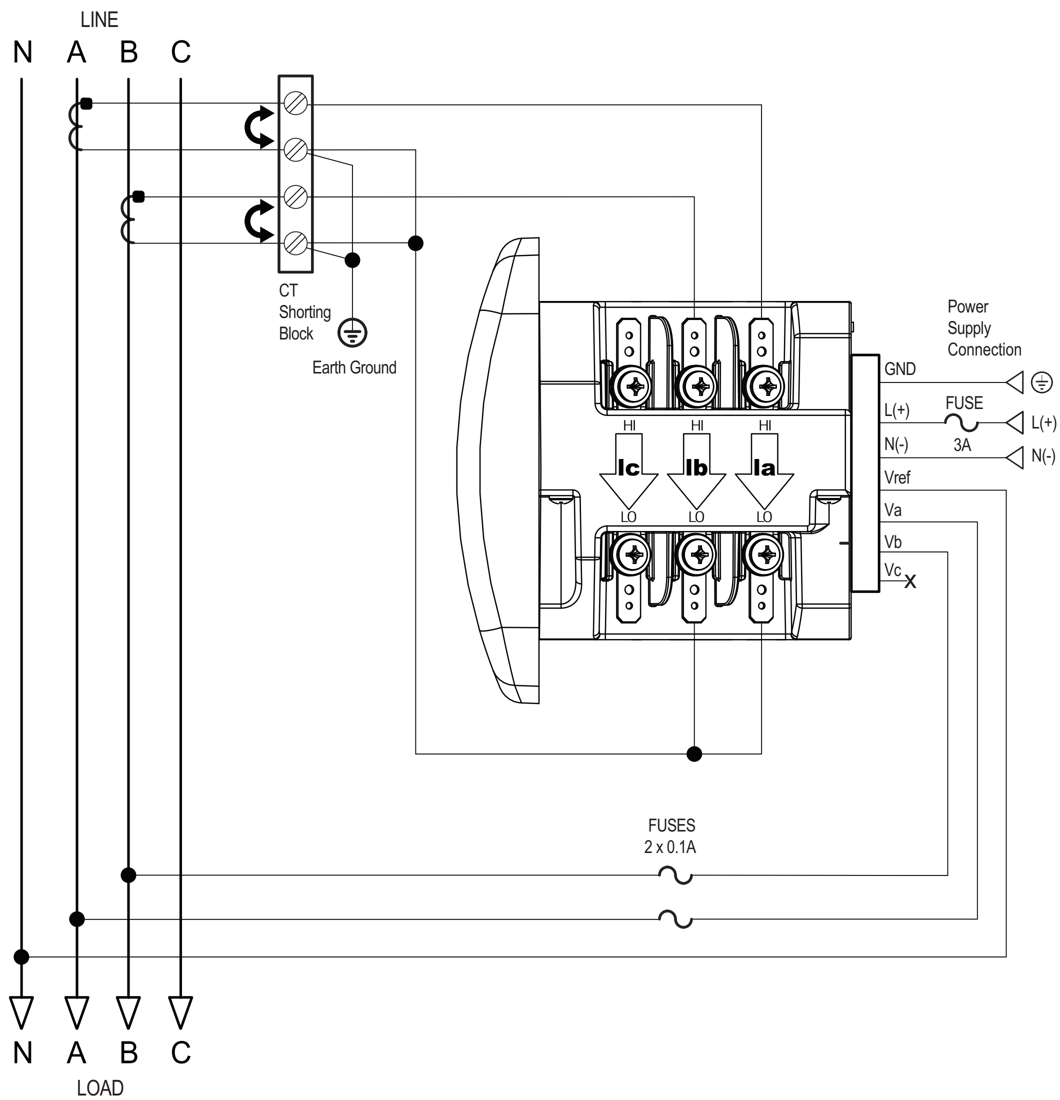


Figure 4-6: Example of Dual Phase Hookup

Select: " 3 EL WYE " (3 Element Wye) from the EPM meter's Front Panel Display (see 2.2 *Using the Front Panel* on page 2–3).

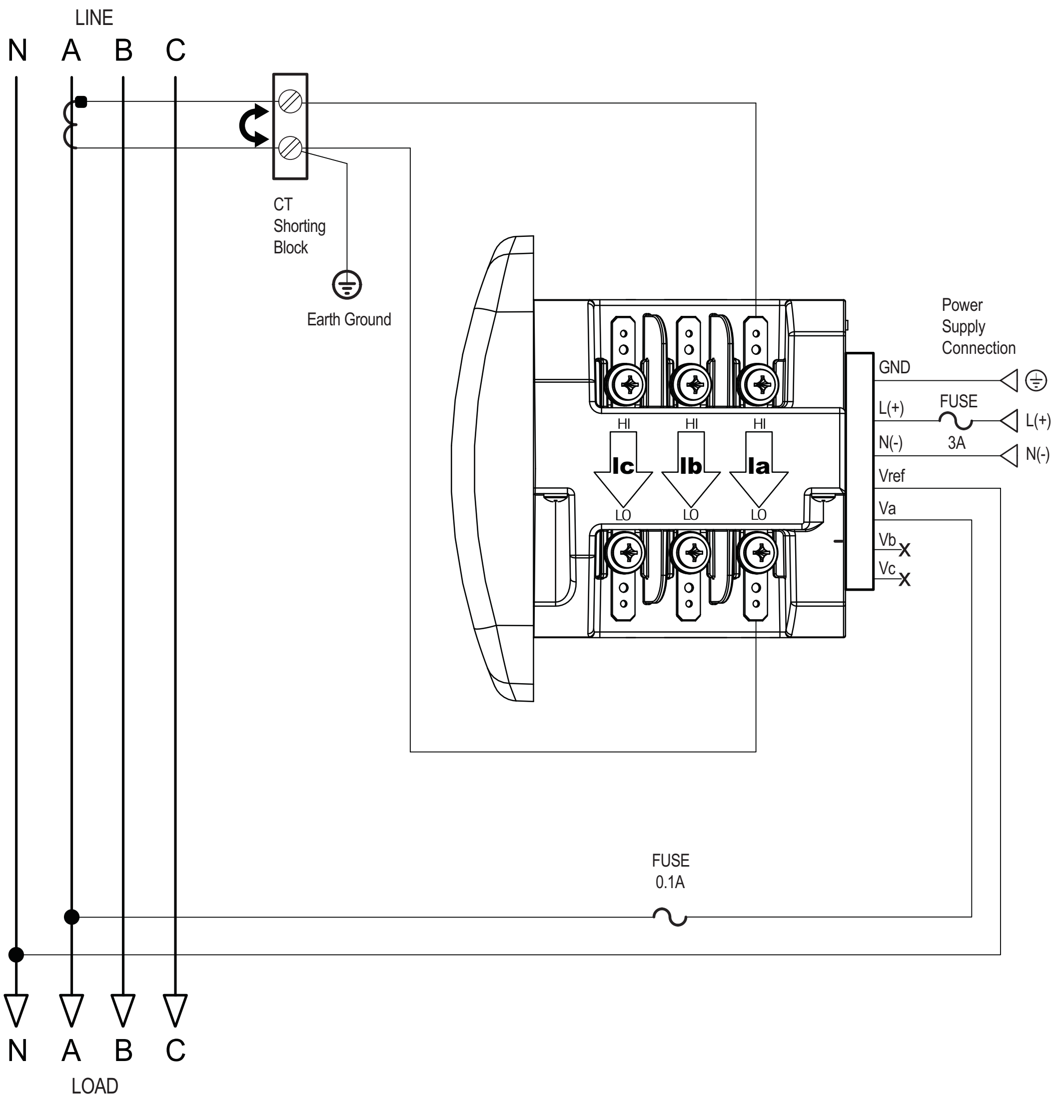


Figure 4-7: Example of Single Phase Hookup

Select: " 3 EL WYE " (3 Element Wye) from the EPM meter's Front Panel Display (see 2.2 *Using the Front Panel* on page 2–3).

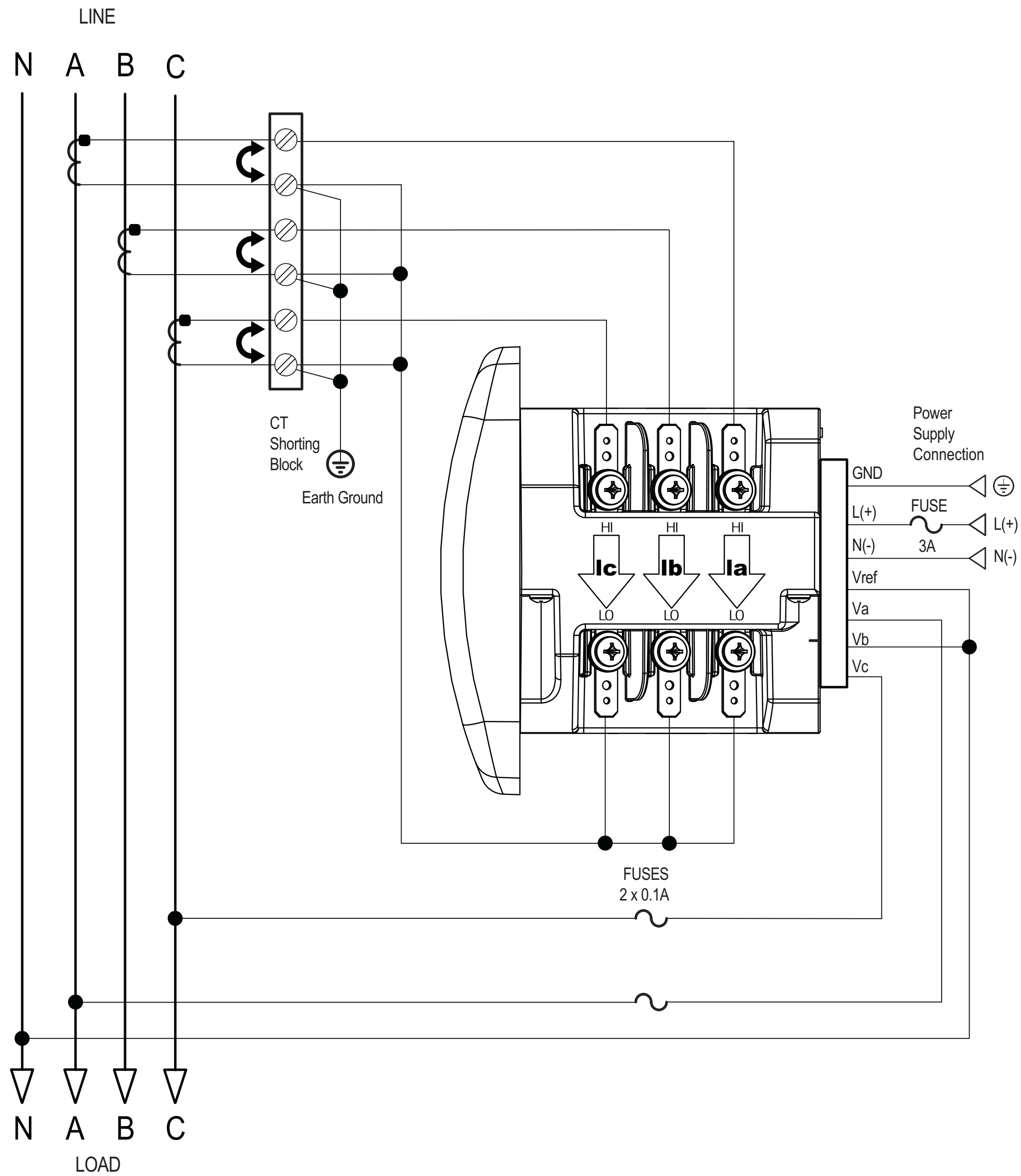
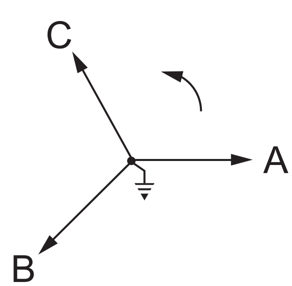


Figure 4-8: 2.5 Element WYE, 4-Wire with No PTs, 3 CTs

Select: “2.5 EL WYE” (2.5 Element Wye) from the EPM meter’s front panel display (see 2.2 *Using the Front Panel* on page 2–3).



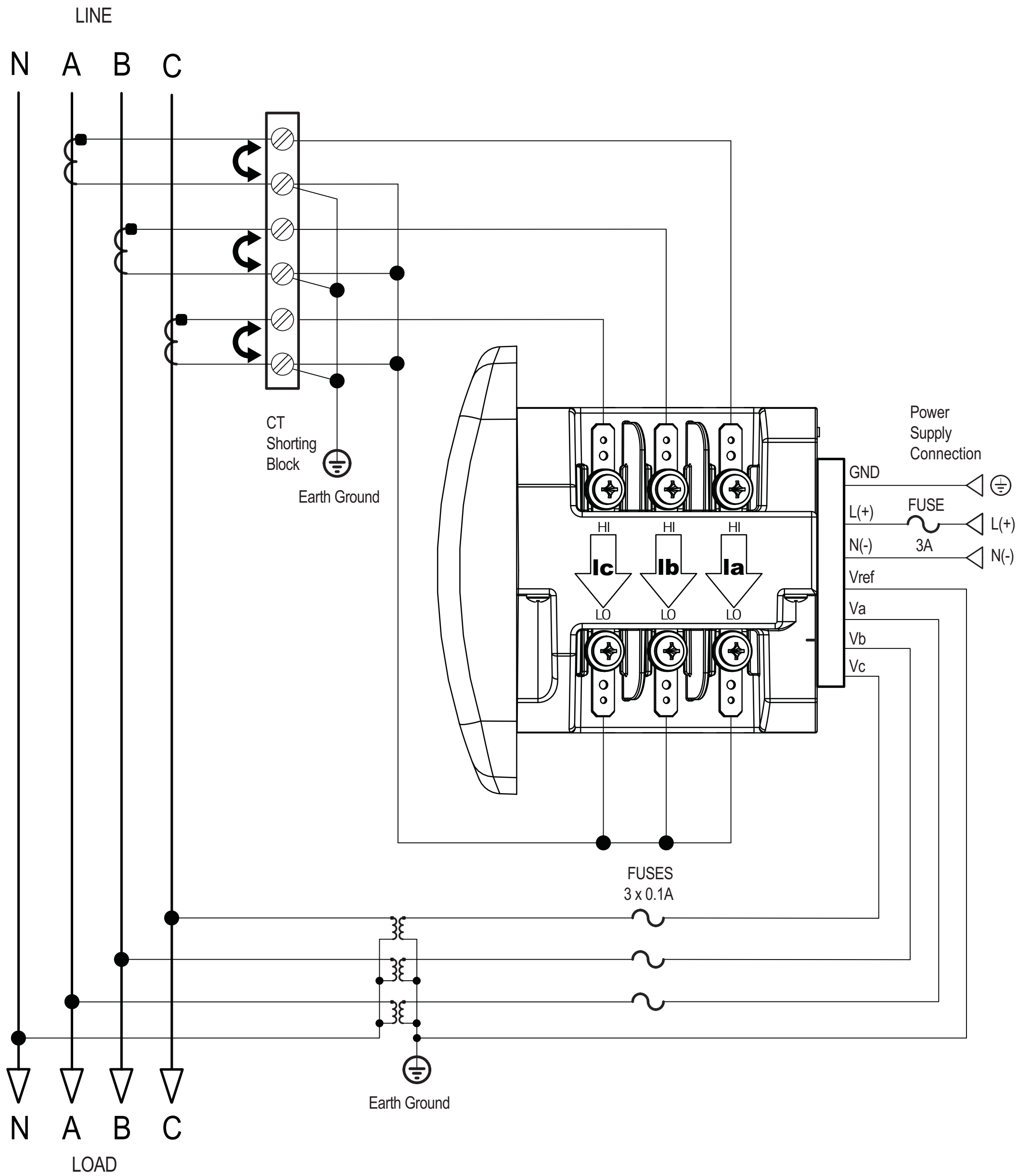
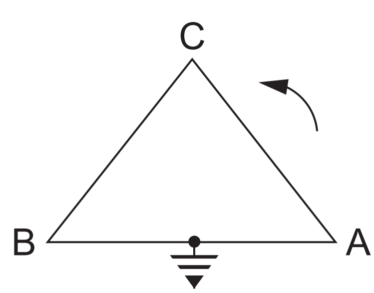


Figure 4-9: WYE/Delta, 4-Wire with 3 PTs, 3 CTs

Select: "3 EL WYE" (3 Element Wye) from the EPM meter's front panel display (see 2.2 *Using the Front Panel* on page 2–3).



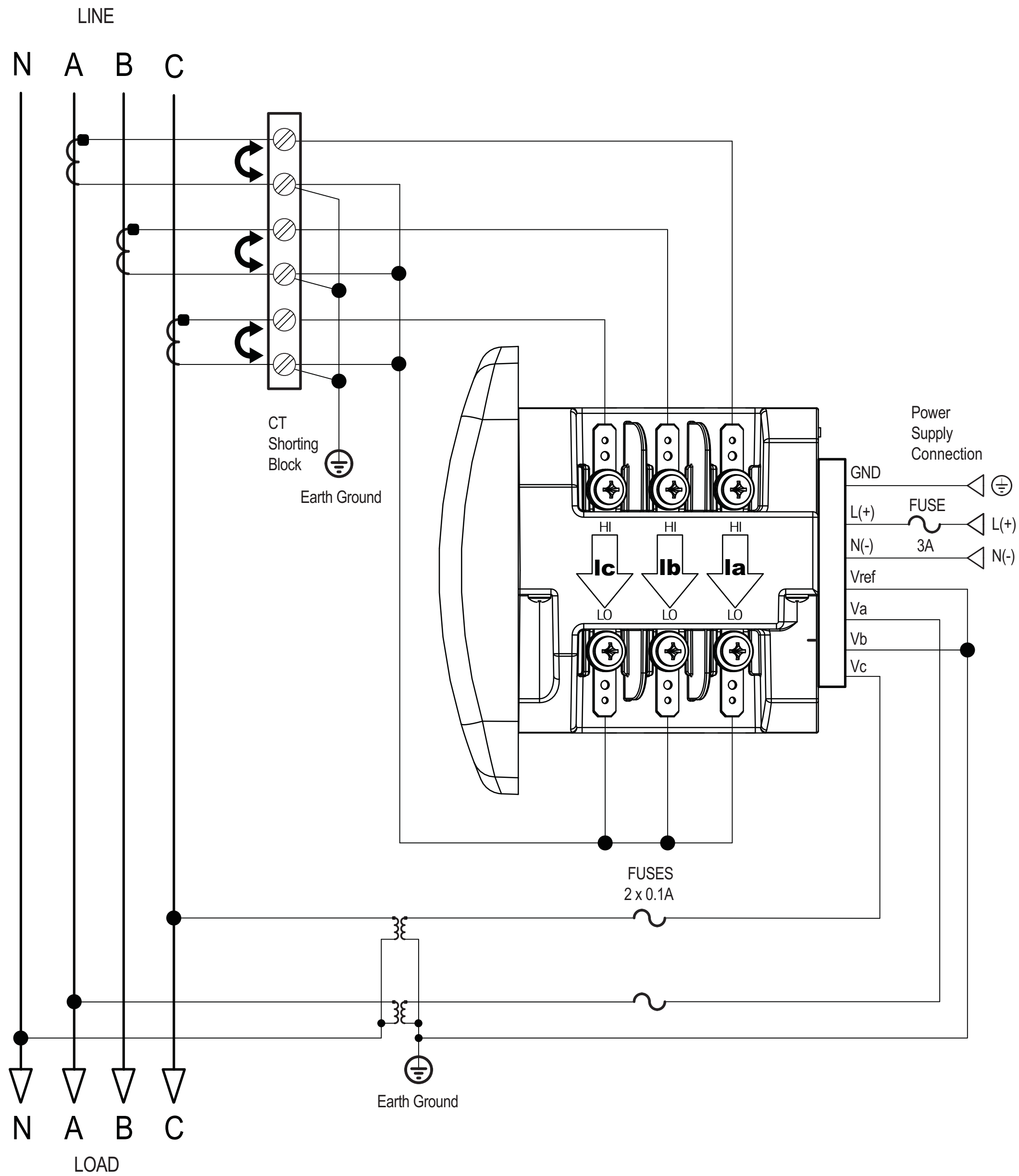
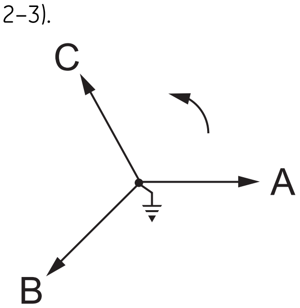


Figure 4-10: 2.5 Element WYE, 4-Wire with 2 PTs, 3 CTs

Select: "2.5 EL WYE" (2.5 Element Wye) from the EPM meter's front panel display (see 2.2 *Using the Front Panel* on page 2–3).



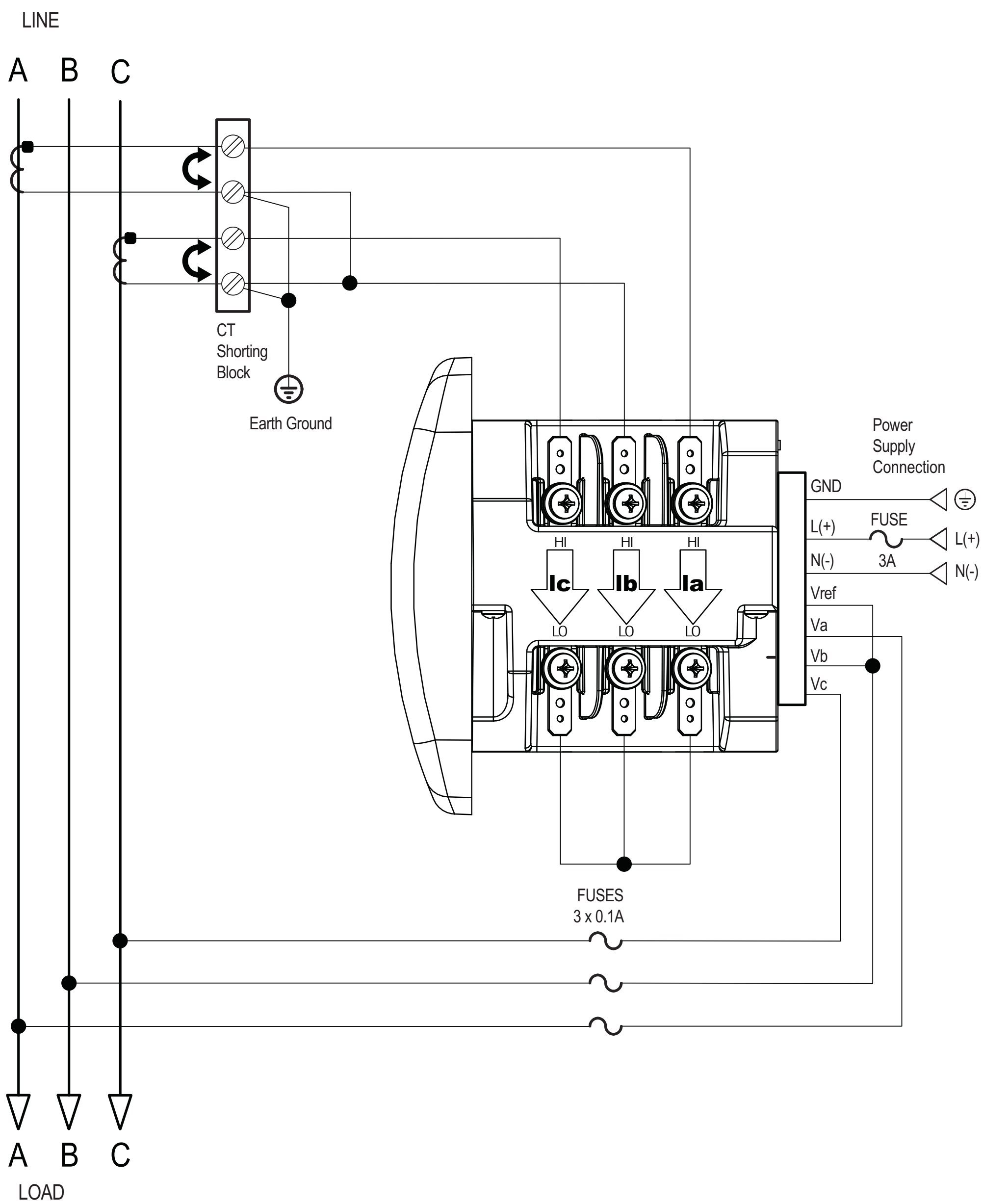
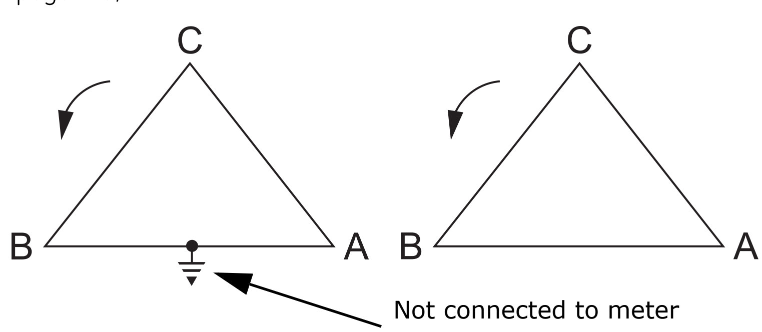


Figure 4-11: Delta, 3-Wire with No PTs, 2 CTs

Select: "2 CT DEL" (2 CT Delta) from the EPM meter's front panel display (see 2.2 *Using the Front Panel* on page 2–3).



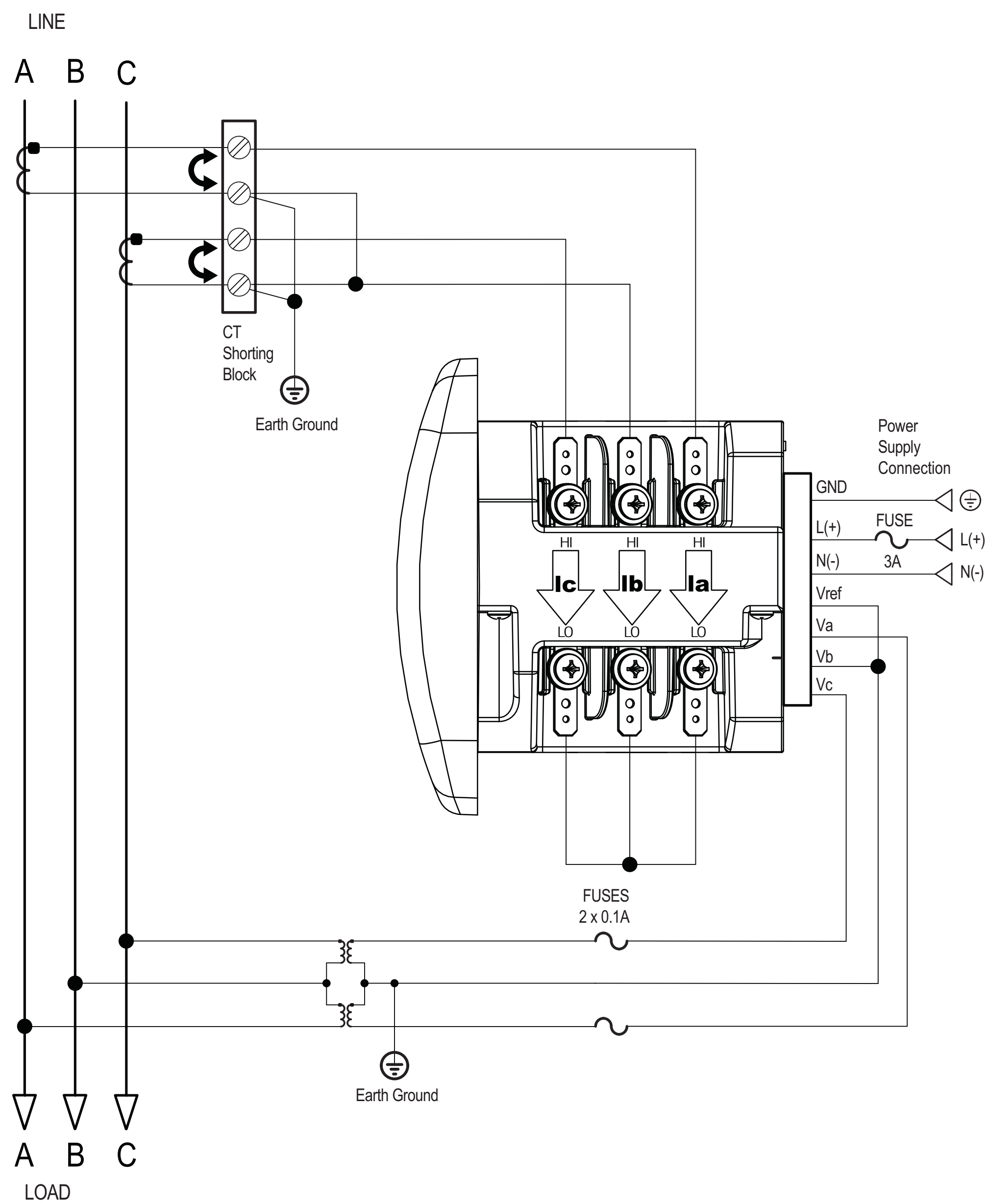
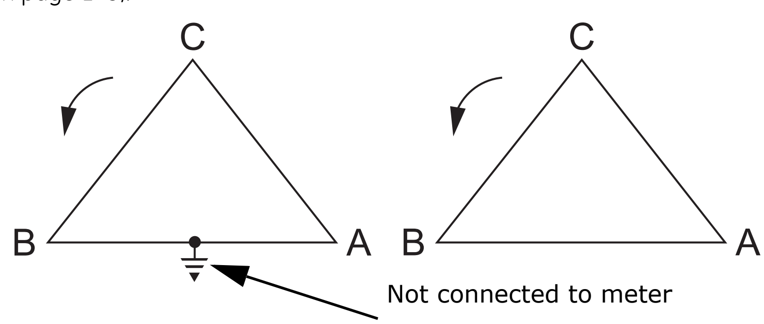


Figure 4-12: Delta, 3-Wire with 2 PTs, 2 CTs

Select: "2 CT DEL" (2 CT Delta) from the EPM meter's front panel display (see 2.2 *Using the Front Panel* on page 2–3).



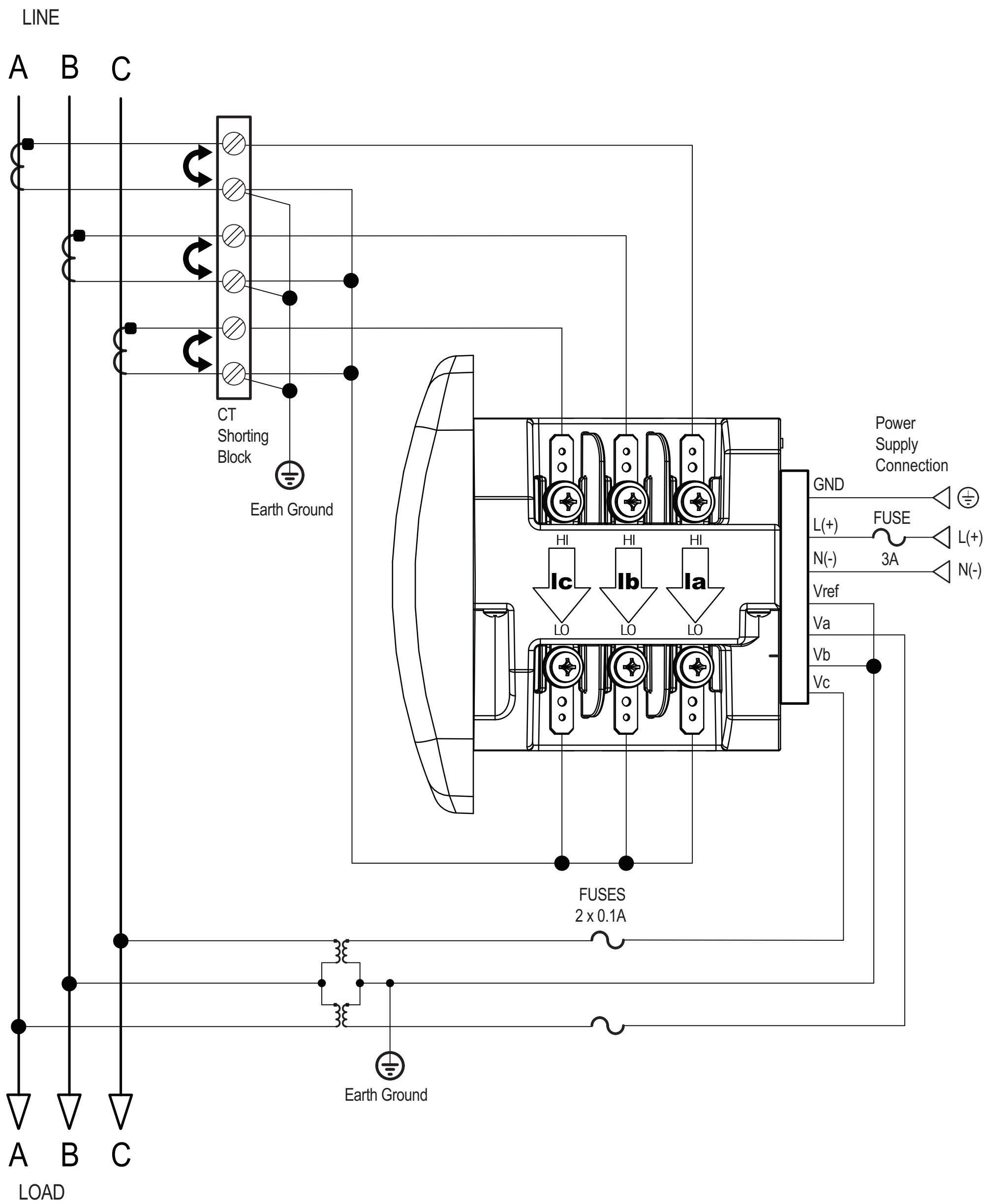
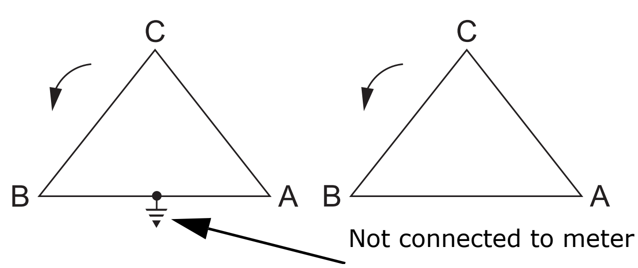


Figure 4-13: Delta, 3-Wire with 2 PTs, 3 CTs

Select: “2 CT DEL” (2 CT Delta) from the EPM meter’s front panel display (see 2.2 *Using the Front Panel* on page 2–3).

NOTICE

The third CT for hookup is optional, and is used only for Current measurement.



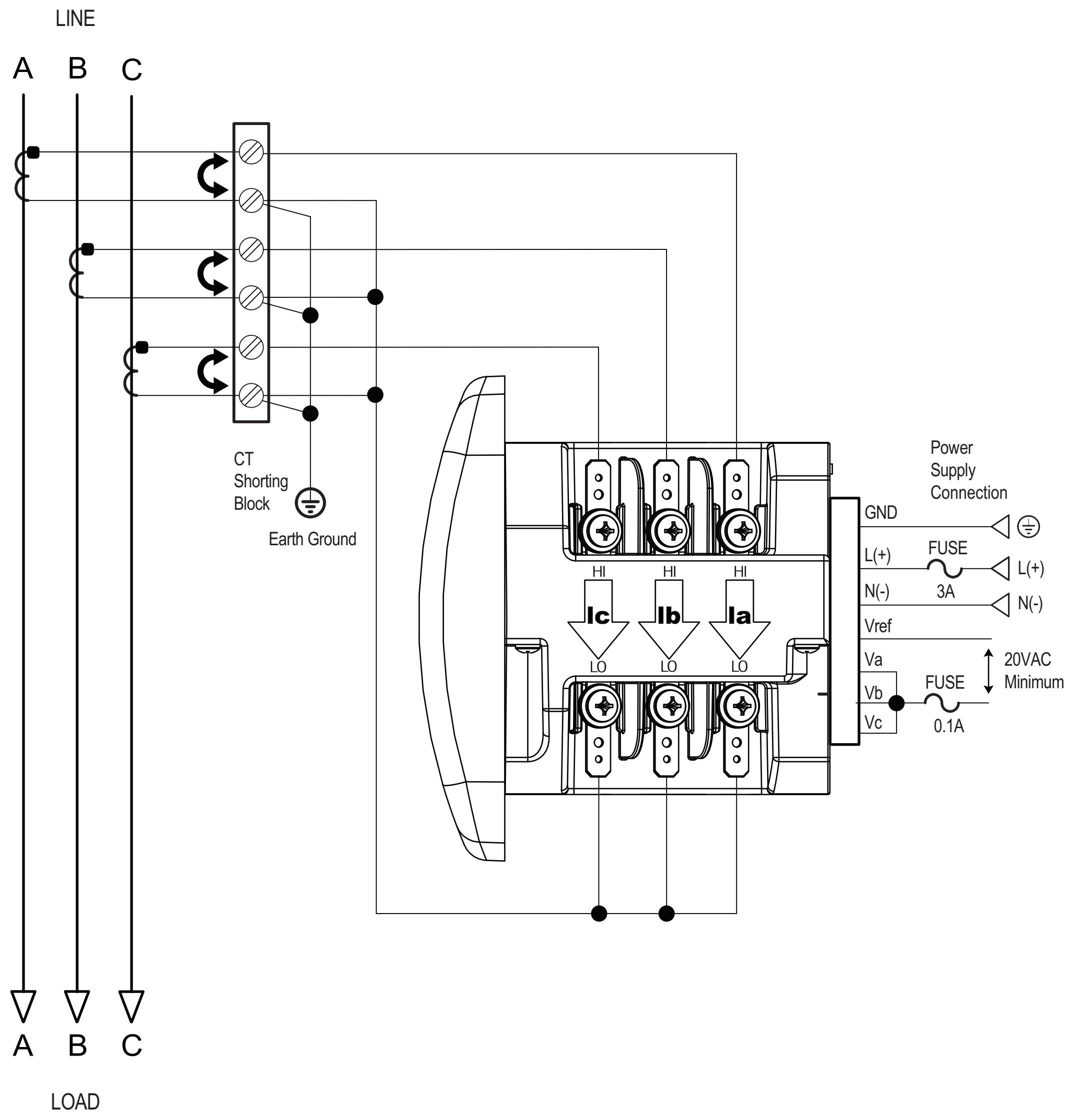


Figure 4-14: Current Only Measurement (Three Phase)

Select: “3 EL WYE” (3 Element Wye) from the EPM meter’s front panel display (see 2.2 *Using the Front Panel* on page 2–3.)

NOTICE

Even if the meter is used only for current measurement, an AN reference is recommended for improved accuracy.

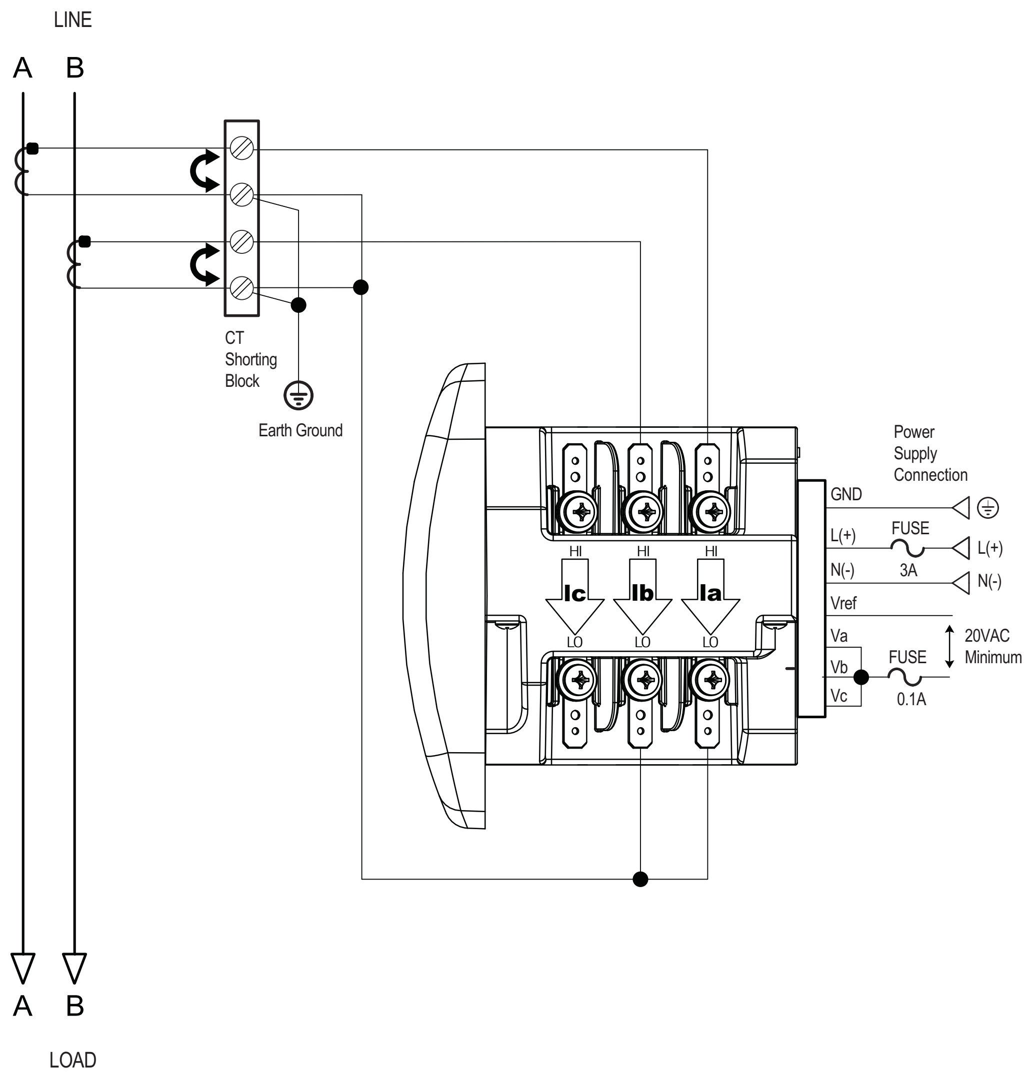


Figure 4-15: Current Only Measurement (Dual Phase)

Select: "3 EL WYE" (3 Element Wye) from the EPM meter's front panel display (see 2.2 *Using the Front Panel* on page 2–3).

NOTICE

Even if the meter is used only for current measurement, an AN reference is recommended for improved accuracy.

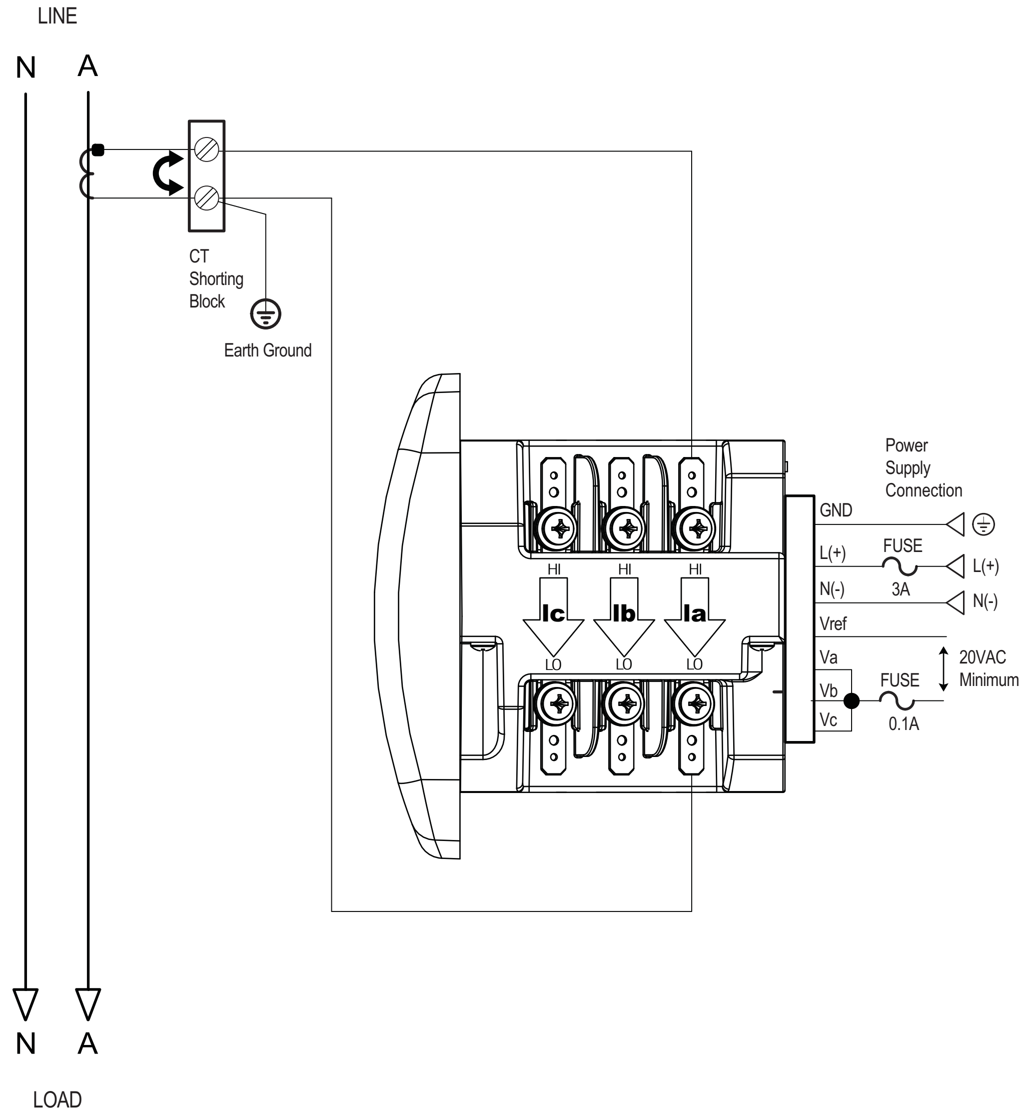


Figure 4-16: Current Only Measurement (Single Phase)

Select: “3 EL WYE” (3 Element Wye) he EPM meter’s front panel display (see 2.2 *Using the Front Panel* on page 2–3).

NOTICE

- Even if the meter is used only for current measurement, an AN reference is recommended for improved accuracy.
- The diagram shows a connection to Phase A, but you can also connect to Phase B or Phase C.

Multilin™ EPM 7000P

Chapter 5: Communication Installation

5.1 EPM 7000P Meter Communication

The EPM 7000P meter provides two independent Communication ports. The first port, Com 1, is a USB port. The second port, Com 2, provides RS485 communication speaking Modbus ASCII, Modbus RTU, and DNP 3.0 protocols. Additionally, the EPM 7000P meter has optional communication cards: the Fiber Optic communication card. the 10/100BaseT Ethernet communication card, and the IEC 61850 Protocol Ethernet card. See Chapter 6 *Using the I/O Option Cards*, Chapter 7 *Using the Ethernet Card (E1)*, and Chapter 9 *Using the E2 IEC 61850 Protocol Card*, for information on these options. Note that the EPM 7000PT transducer model does not have the USB port.

NOTICE

Refer to the *GE Communicator Instruction Manual* for instructions on configuring the EPM 7000P meter's Device Profile settings, including Transformer and Line Loss Compensation, CT and PT Compensation, Option card configuration, Secondary Voltage display, Symmetrical Components, Voltage and Current Unbalance, and scaling Primary readings for use with DNP.

5.1.1 USB Port (Com 1)

The GE Communicator meter’s Com 1 USB port is on the left side of the meter face. The USB port allows the unit to be read and programmed through a USB connection to a PC. Note that for the EPM 7000PT, you will use the RS485 port. See 2.4 *EPM 7000PT Transducer Communication and Programming Overview* on page 2–13 for instructions.

NOTICE

- The cable connector to the meter must be a USB mini-B. The cable connector to the PC should be whatever type you need to connect to your PC or tablet.
- Settings for Com 1 are configured using GE Communicator software.
- This port only communicates via Modbus ASCII Protocol, at a Baud Rate of 57600 bps, 1 stop bit, 8 data bits, and parity set to None.

To connect to the meter using the USB port follow these steps:

1. Connect the meter to the PC, using the USB cable (the meter’s connection uses a USB mini-B plug).

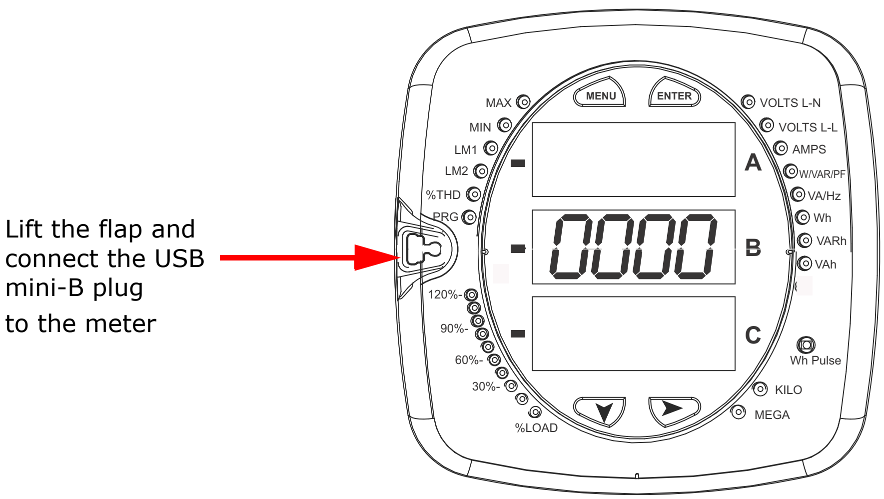
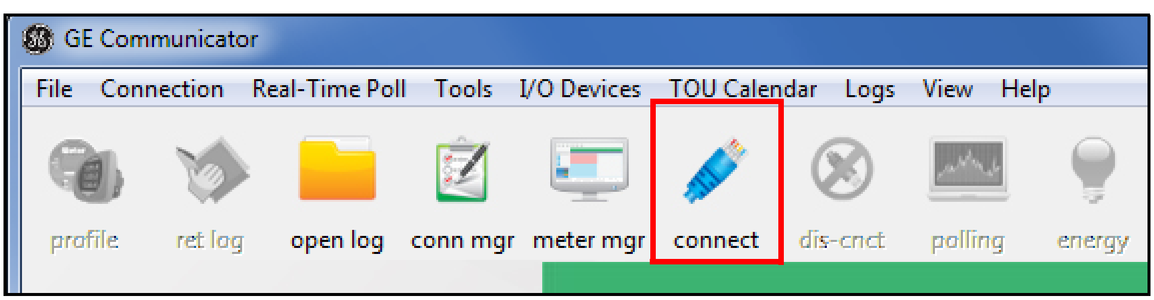
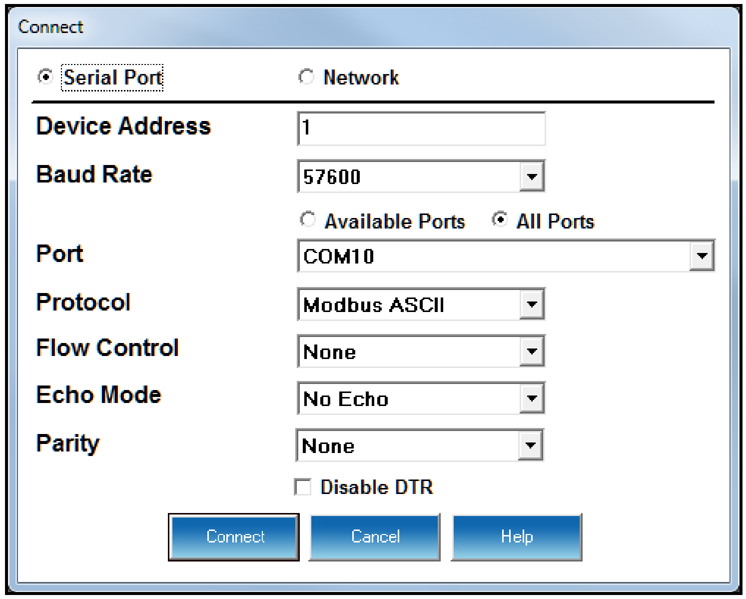


Figure 5-1: Connecting the USB Cable to the Meter

2. Open GE Communicator software (download from product CD or the GE Grid Solutions website).
3. Click Connect in the Icon Bar.



4. You will see the Connect screen. The default settings are shown in the following example screen.



- Click the Serial Port button.
- Enter the Device Address (can be from 1-247).
- Select a Baud Rate of 57600.
- Click the Available Ports button and select the USB Com port.
- Select Modbus ASCII protocol.
- Keep Flow Control, Echo Mode, and Parity as is shown here (Parity must be set to None).
- Click **Connect**.

5. The Device Status screen opens, displaying information about the meter.

5.1.2 RS485 / KYZ Output (Com 2)

Com 2 provides a combination RS485 and an Energy Pulse Output (KYZ pulse).

See 1.4 *EPM 7000P Meter Specifications Overview* on page 1–11, for the KYZ Output specifications; see Chapter 12 *Performing Meter Testing*, for pulse constants.

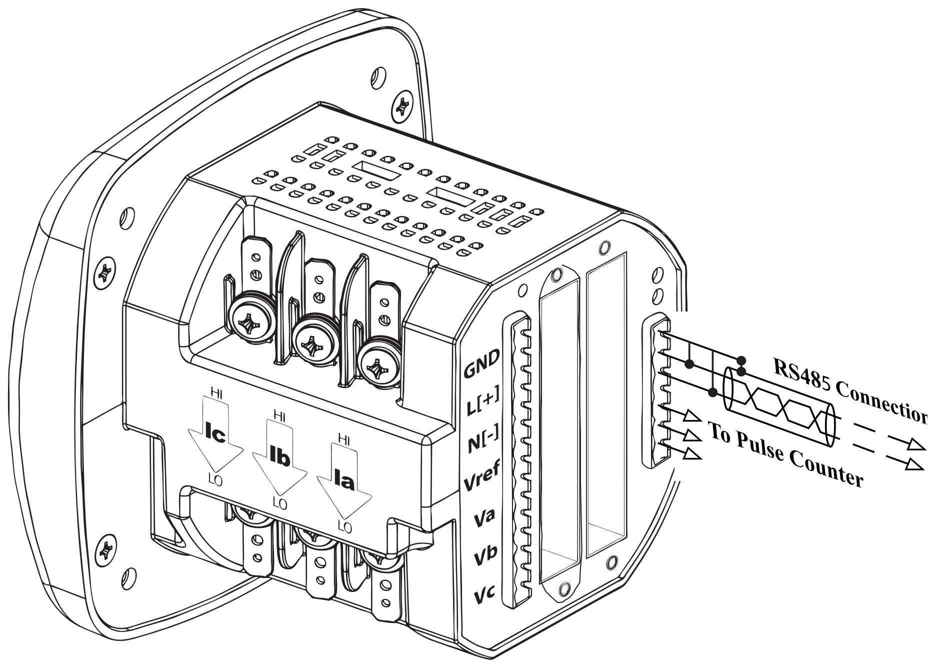


Figure 5-2: EPM 7000P Meter Back with RS485 Communication Installation

RS485 allows you to connect one or multiple EPM 7000P meters to a PC or other device, at either a local or remote site. All RS485 connections are viable for up to 4000 feet (1219.20 meters).

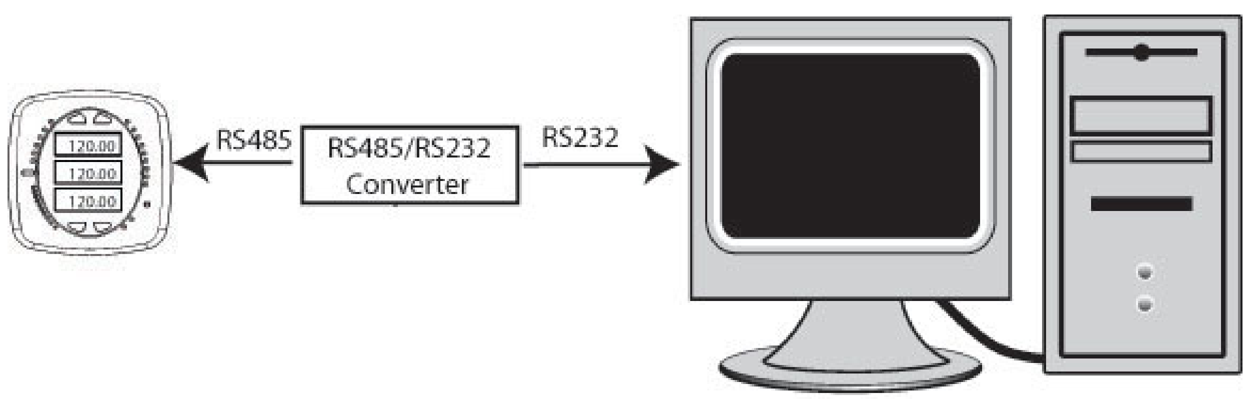


Figure 5-3: EPM 7000P Meter Connected to a PC via RS485 bus

As shown in Figure 5.3, to connect an EPM 7000P meter to a PC, you need to use an RS485 to RS232 converter.

Figure 5.4 shows the detail of a 2-wire RS485 connection

Figure 5-4: 2-wire RS485 Connection

NOTICE

For All RS485 Connections:

- Use a shielded twisted pair cable and ground the shield, preferably at one location only.
- Establish point-to-point configurations for each device on a RS485 bus: connect (+) terminals to (+) terminals; connect (-) terminals to (-) terminals.
- You may connect up to 31 meters on a single bus using RS485. Before assembling the bus, each meter must have a unique address: refer to the *GE Communicator Instruction Manual* for instructions.
- Protect cables from sources of electrical noise.
- Avoid both "Star" and "Tee" connections (see Figure 5.6).
- 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 you are not using an RS485 repeater, the maximum length for cable connecting all devices is 4000 feet (1219.20 meters).
- Connect shield to RS485 Master and individual devices as shown in Figure 5.5. You may also connect the shield to earth-ground at one point.
- Termination Resistors (RT) may be needed on both ends for longer length transmission lines. However, since the meter has some level of termination internally, Termination Resistors may not be needed. When they are used, the value of the Termination Resistors is determined by the electrical parameters of the cable.

Figure 5.5 shows a representation of an RS485 Daisy Chain connection..

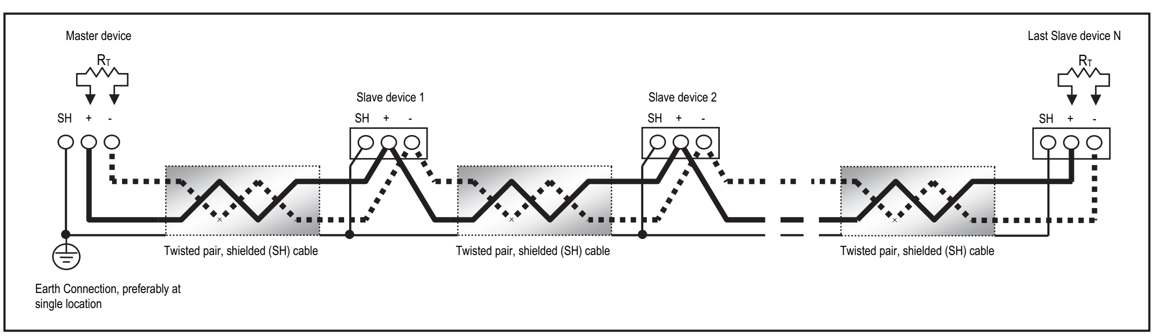


Figure 5-5: RS485 Daisy Chain Connection

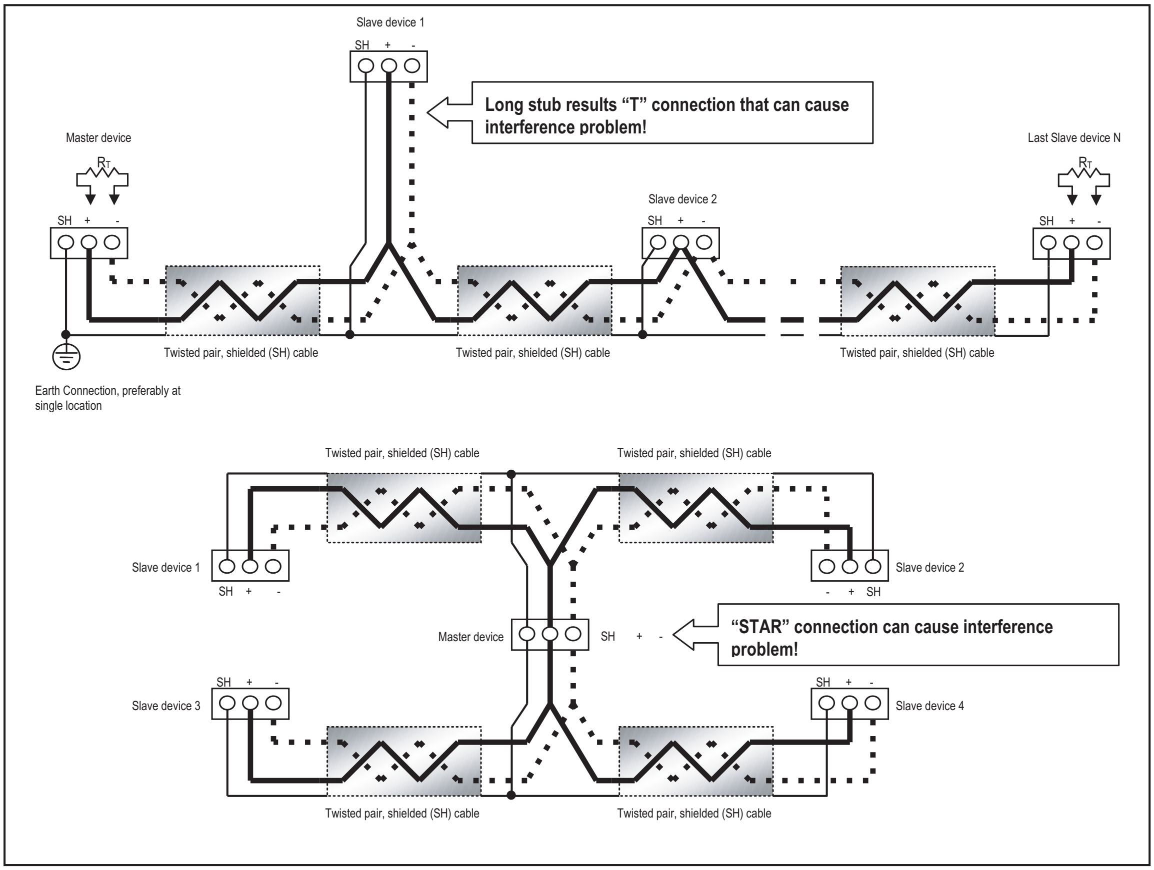


Figure 5-6: Incorrect "T" and "Star" Topologies

Multilin™ EPM 7000P

Chapter 6: Using the I/O Option Cards

6.1 Overview

The EPM 7000P meter offers extensive I/O expandability. Using the two universal Option Card slots, the unit can be easily configured to accept new I/O Option cards even after installation, without your needing to remove the meter. The EPM 7000P meter auto-detects any installed Option cards. Up to 2 cards of any type outlined in this chapter can be used per meter.

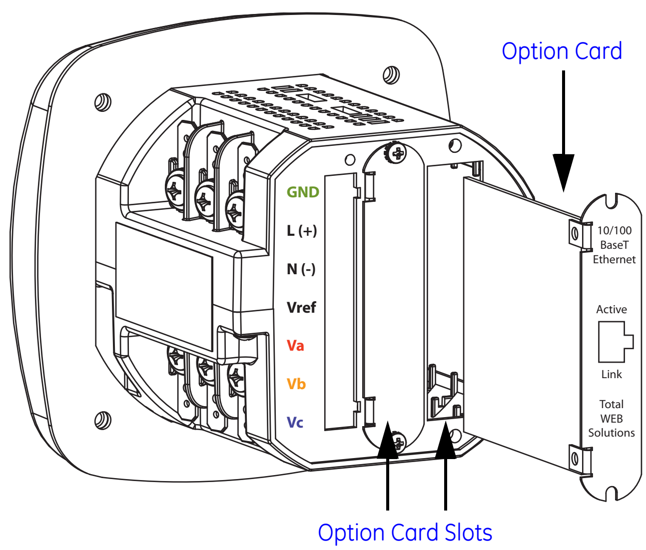


Figure 6-1: EPM 7000P Meter Back, Showing Option Card Slots and I/O Card

6.2 Installing Option Cards

The Option cards are inserted in one of the two Option Card slots in the back of the EPM 7000P meter.

NOTICE

Remove Voltage inputs and power supply terminal to the meter before performing card installation.

1. Remove the screws at the top and the bottom of the Option Card slot covers.
2. There is a plastic "track" on the top and the bottom of the slot. The Option card fits into this track.

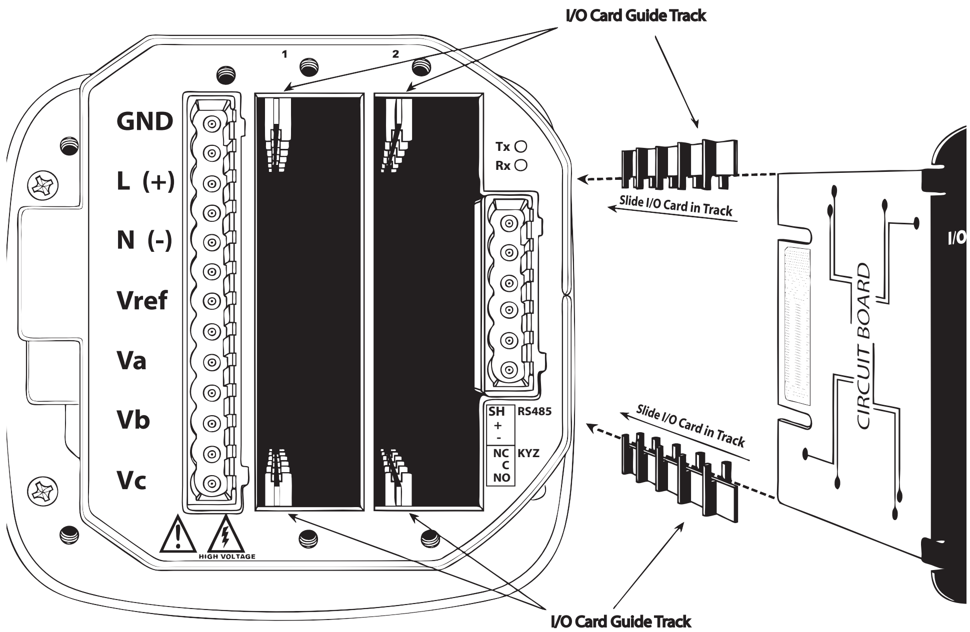


Figure 6-2: Detail of Guide Track

WARNING

For safety, remove ALL these connections before installing Option cards: GND, L+, N-, Vref, Va, Vb, Vc.

3. Slide the card inside the plastic track and insert it into the slot. You will hear a click when the card is fully inserted. Be careful, it is easy to miss the guide track.
4. Securely re-fasten the screws at the top and bottom of the card.

CAUTION

- **Make sure the I/O card is inserted properly into the track to avoid damaging the card's components.**
- **For proper card fit, and to avoid damaging the unit, insert components in the following order:**
    1. **Option card 1**
    2. **Option card 2**
    3. **Detachable terminal block 1**
    4. **Detachable terminal block 2**
    5. **Communication connection for Port 2**

6.3 Configuring Option Cards

⚠CAUTION

FOR PROPER OPERATION, RESET ALL PARAMETERS IN THE UNIT AFTER HARDWARE MODIFICATION.

The EPM 7000P meter auto-detects any Option cards installed in it. You configure the Option cards through GE Communicator software. Refer to the *GE Communicator Instruction Manual* for detailed instructions.

The following sections describe the available Option cards.

6.4 1 mA Output Card (C1)

The 1 mA card transmits a standardized bi-directional 0-1 mA signal. This signal is linearly proportional to real-time quantities measured by the EPM 7000P meter. The outputs are electrically isolated from the main unit.

6.4.1 Specifications

TECHNICAL SPECIFICATIONS AT 25 °C AT 5K LOAD

Number of outputs:...................... 4 single ended
Power consumption: .... 1.2 W internal
Signal output range:.................... (-1.2 to +1.2) mA
Max. load impedance: .... 10 k
Hardware resolution:................. 12 bits
Effective resolution: .... 14 bits with 2.5 kHz PWM
Update rate per channel:.......... 100 ms
Output accuracy:.......................... ± 0.1 % of output range (2.4 mA)
Load regulation .... ± 0.06 % of output range (2.4 mA) load step of 5 k @ ± 1 mA
Temperature coefficient............ ± 30 nA/ °C
Isolation:... AC 2500 V system to outputs
Reset/Default output value:...... 0 mA

GENERAL SPECIFICATIONS

Operating temperature:............. (-20 to +70) °C
Storage temperature:................. (-40 to +80) °C
Relative air humidity: .... Maximum 95%, non-condensing
EMC - Immunity Interference:. EN 61000-4-2
Weight:... 1.6 oz
Dimensions (inch) W x H x L: ... 0.72 x 2.68 x 3.26
External connection:.................... AWG 12-26/(3.31 - 0.129) mm^2
5 pin, 0.200" pluggable terminal block

6.4.2 Default Configuration

The EPM 7000P meter automatically recognizes the installed Option card during power up. If you have not programmed a configuration for the card, the unit defaults to the following outputs:

Channel 1 ....+Watts, +1800 Watts => +1 mA
-Watts, - 1800 Watts => -1 mA
Channel 2 ....+VARs, +1800 VARs => +1 mA
- VARs, -1800 VARs => -1 mA
Channel 3 ....Phase A Voltage WYE, 300 Volts => +1 mA
Phase A Voltage Delta, 600 Volts => +1 mA
Channel 4 ....Phase A Current, 10 Amps => +1 mA

6.4.3 Wiring Diagram

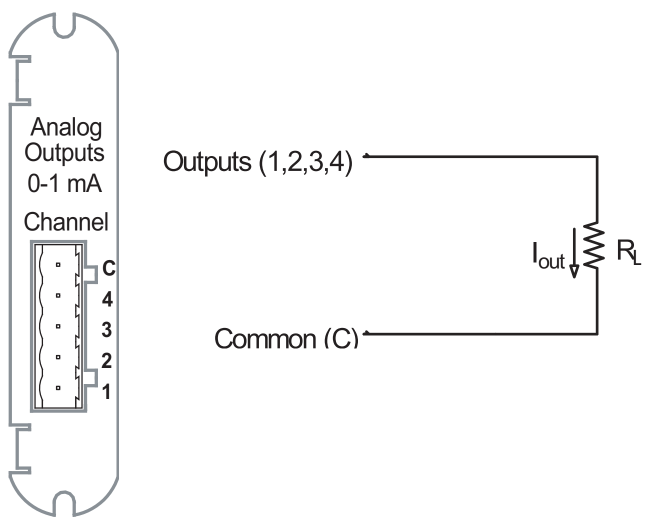


Figure 6-3: 4-Channel 0 - 1 mA Output Card

6.5 20 mA Output Card (C2)

The 20 mA card transmits a standardized 0-20 mA signal. This signal is linearly proportional to real-time quantities measured by the EPM 7000P meter. The current sources need to be loop powered. The outputs are electrically isolated from the main unit.

6.5.1 Specifications

TECHNICAL SPECIFICATIONS AT 25 °C AT 500 LOAD

Number of outputs:...................... 4 single ended
Power consumption: .... 1 W internal
Signal output range:.................... (0 to 24) mA
Max. load impedance: .... 850 @ 24 VDC
Hardware resolution: .... 12 bits
Effective resolution: .... 14 bits with 2.5 kHz PWM
Update rate per channel:.......... 100 ms
Output accuracy:......................... ± 0.1% of output range (24 mA)
Load regulation: .... ± 0.03% of output range (24 mA) load step of 200 @ 20 mA
Temperature coefficient........... ± 300 n A/ °C
Isolation:... AC 2500 V system to outputs
Maximum loop voltage: .... 28 V DC max.
Internal voltage drop: .... 3.4 V DC @ 24 mA
Reset/Default output value:..... 12 mA

GENERAL SPECIFICATIONS

Operating temperature:............ (-20 to +70) °C
Storage temperature: .... (-40 to +80) °C
Relative air humidity: .... Maximum 95%, non-condensing
EMC - Immunity interference:. EN 61000-4-2
Weight:.. 1.6 oz
Dimensions (inch) W x H x L: ... 0.72 x 2.68 x 3.26
External connection:................... AWG 12-26/(3.31 - 0.129) $mm^{2|}$
5 pin, 0.200” pluggable terminal block

6.5.2 Default Configuration

The EPM 7000P meter automatically recognizes the installed Option card during power up. If you have not programmed a configuration for the card, the unit defaults to the following outputs:

Channel 1 .... +Watts, +1800 Watts => 20 mA
-Watts, -1800 Watts => 4 mA
0 Watts => 12 mA
Channel 2 .... +VARs, +1800 VARs => 20 mA
- VARs, -1800 VARs => 4 mA
0 VARs => 12 mA
Channel 3 .... Phase A Voltage WYE, 300 Volts => 20 mA
0 Volts => 4 mA
Phase A Voltage Delta, 600 Volts => 20 mA
Channel 4 .... Phase A Current, 10 Amps => 20 mA
0 Phase A Current, 0 Amps => 4 mA

6.5.3 Wiring Diagram

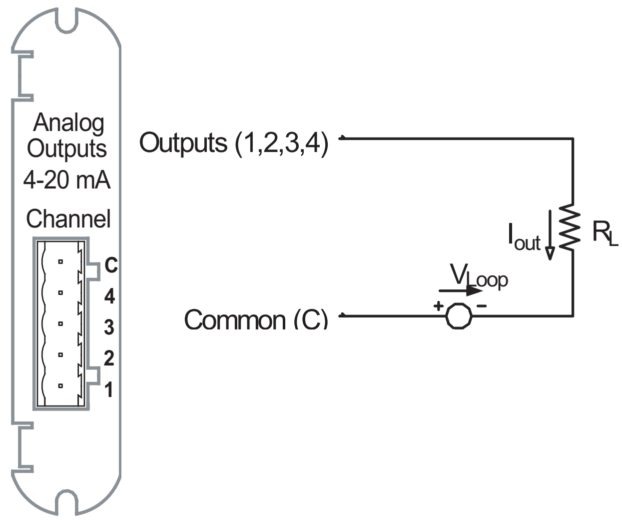


Figure 6-4: 4-Channel 4 - 20mA Output Card

6.6 Digital Output (Relay Contact) / Digital Input Card (RS)

The Digital Output/Input card is a combination of relay contact outputs for load switching and dry/wet contact sensing digital inputs. The outputs are electrically isolated from the inputs and from the main unit.

6.6.1 Specifications

TECHNICAL SPECIFICATIONS AT 25 °C

Power consumption: ....0.320 W internal
Relay outputs:
Number of outputs: 2
Contact type:.................................Changeover (SPDT)
Relay type:......................................Mechanically latching
Switching voltage:.........................AC 250 V / DC 30 V
Switching power: ....1250 VA / 150 W
Switching current: ....5 A
Switching rate max.:.....................10/s
Mechanical life:..............................5 x 10^7 switching operations
Electrical life:..................................10^5 switching operations at rated current
Breakdown voltage: ....AC 1000 V between open contacts
Isolation: ....AC 3000 V / 5000 V surge system to contacts
Reset/Power down state:...........No change - last state is retained

INPUTS

Number of Inputs:........................ 2
Sensing type: .... Wet or dry contact status detection
Wetting voltage: .... DC (12-24) V, internally generated
Input current: .... 2.5 mA – constant current regulated
Minimum input voltage:............ 0 V (input shorted to common)
Maximum input voltage:........... DC 150 V (diode protected against polarity reversal)
Filtering:.. De-bouncing with 50 ms delay time
Detection scan rate: .... 100 ms
Isolation:... AC 2500 V system to inputs

GENERAL SPECIFICATIONSOPERATING TEMPERATURE:(-20 TO +70) °C

Storage temperature: .... (-40 to +80) °C
Relative air humidity: .... Maximum 95%, non-condensing
EMC - Immunity Interference:. EN 61000-4-2
Weight:.. 1.5 oz
Dimensions (inch) W x H x L: ... 0.72 x 2.68 x 3.26
External Connection: .... AWG 12-26/(3.31 - 0.129) mm^2
9 pin, 0.200" pluggable terminal block

6.6.2 Wiring Diagram

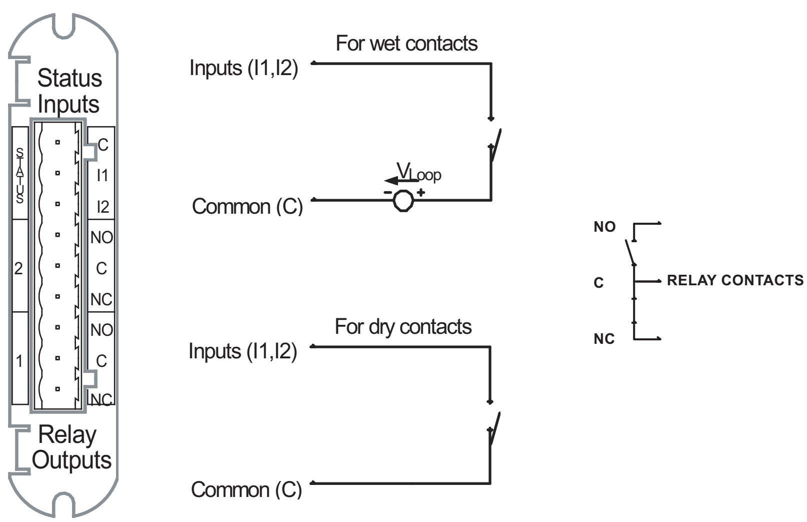


Figure 6-5: Relay Contact (2) / Status Input (2) Card

6.7 Pulse Output (Solid State Relay Contacts) / Digital Input Card (PS)

The Pulse Output/Digital Input card is a combination of pulse outputs via solid state contacts and dry/wet contact sensing digital inputs. The outputs are electrically isolated from the inputs and from the main unit.

6.7.1 Specifications

TECHNICAL SPECIFICATIONS AT 25 °C

Power consumption: ....0.420 W internal

RELAY OUTPUTS:

Number of outputs: 4
Contact type:..................................Closing (SPST - NO)
Relay type:.......................................Solid state
Peak switching voltage:..............DC ±350 V
Continuous load current: ....120 mA
Peak load current:.........................350 mA for 10ms
On resistance, max.:.....................35
Leakage current:............................1 μA@350 V
Switching Rate max.: 10/s
Isolation: ....AC 3750 V system to contacts
Reset/Power down state:...........Open contacts

INPUTS:

Number of inputs: 4
Sensing type:..................................Wet or dry contact status detection
Wetting voltage:.............................DC (12-24) V, internally generated
Input current:..................................2.5 mA – constant current regulated
Minimum input voltage:..............0 V (input shorted to common)
Maximum input voltage: ....DC 150 V (diode protected against polarity reversal)
Filtering: ....De-bouncing with 50 ms delay time
Detection scan rate:.....................100 ms
Isolation: ....AC 2500 V system to inputs

GENERAL SPECIFICATIONS

Operating Temperature: ....(-20 to +70) °C
Storage Temperature:.................(-40 to +80) °C
Relative air humidity: ....Maximum 95%, non-condensing
EMC - Immunity Interference: .EN 61000-4-2
Weight: ....1.3 oz
Dimensions (inch) W x H x L: ....0.72 x 2.68 x 3.26
External Connection:....................AWG 12-26/(3.31 - 0.129) mm^2
13 pin, 3.5 mm pluggable terminal block

6.7.2 Default Configuration

The EPM 7000P meter automatically recognizes the installed Option card during power up. If you have not programmed a configuration for the card, the unit defaults to the following outputs:

Status Inputs	Defaulted to Status Detect
Pulse Outputs	Defaulted to Energy Pulses
Pulse Channel 1	1.8 +Wh per pulse
Pulse Channel 2	1.8 -Wh per pulse
Pulse Channel 3	1.8 +VARh per pulse
Pulse Channel 4	1.8 -VARh per pulse

6.7.3 Wiring Diagram

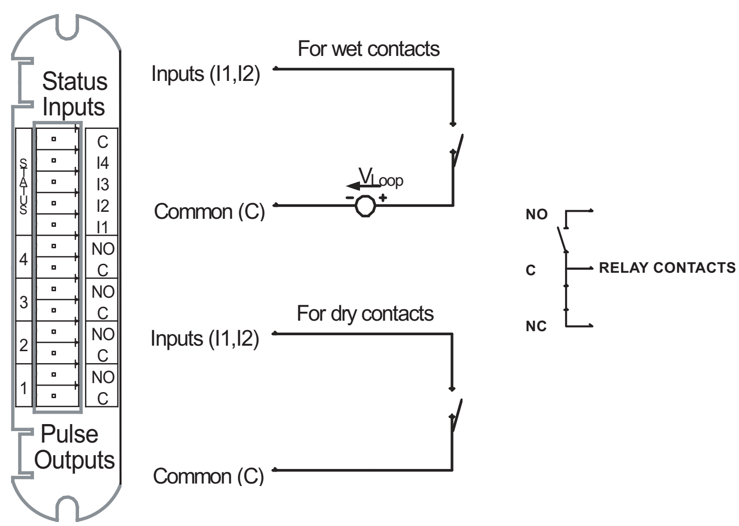


Figure 6-6: Pulse Output (4) / Status Input (4) Card

6.8 Fiber Optic Communication Card (F1; F2)

The Fiber Optic Communication card provides a standard serial communication port via a fiber optic connection. An echo switch is available to enable messages bypassing the unit. This feature can be used in a daisy chained network topology.

6.8.1 Specifications

TECHNICAL SPECIFICATIONS AT 25 °C

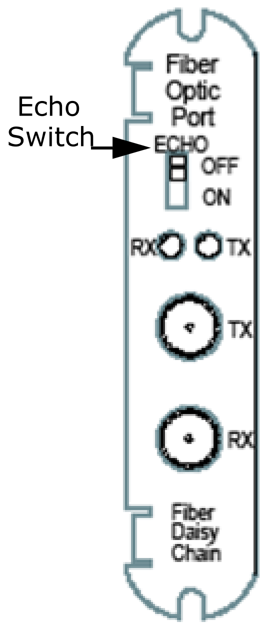
Number of Ports:..........................1
Power consumption: ....0.160 W internal
Fiber connection:..........................ST® (F1) or Versatile Link (F2) – as per order
Optical fiber details:......................Multimode
ST® (F1)..50/125 µm, 62.5/125 µm, 100/140 µm,
200 µm Hard Clad Silica (HCS®)
Versatile Link (F2):.........................200 µm Hard Clad Silica (HCS®)
1 mm Plastic Optical Fiber (POF)
Baud rate:...Up to 57.6 kB/s – pre-programmed in the main unit
Diagnostic feature: ....LED lamps for TX and RX activity

GENERAL SPECIFICATIONS

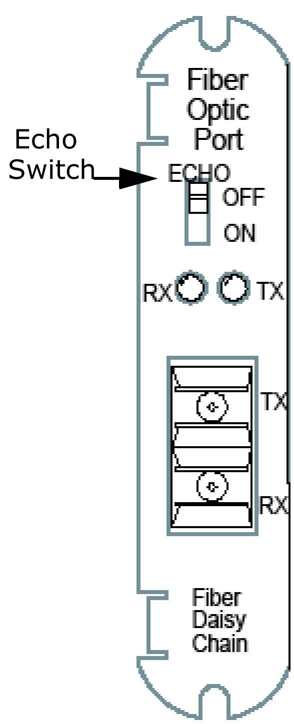
Operating Temperature: ....(-20 to +70) °C
Storage Temperature:................(-40 to +80) °C
Relative air humidity: ....Maximum 95%, non-condensing
EMC - Immunity Interference: .EN 61000-4-2
Weight: ....1.2 oz
Dimensions (inch) W x H x L: ....0.72 x 2.68 x 3.26
Fiber Connection:..........................ST® (F1) or Versatile Link (F2) – as per order
HCS® is a registered trademark of SpecTran Corporation.
ST® is a registered trademark of AT&T.

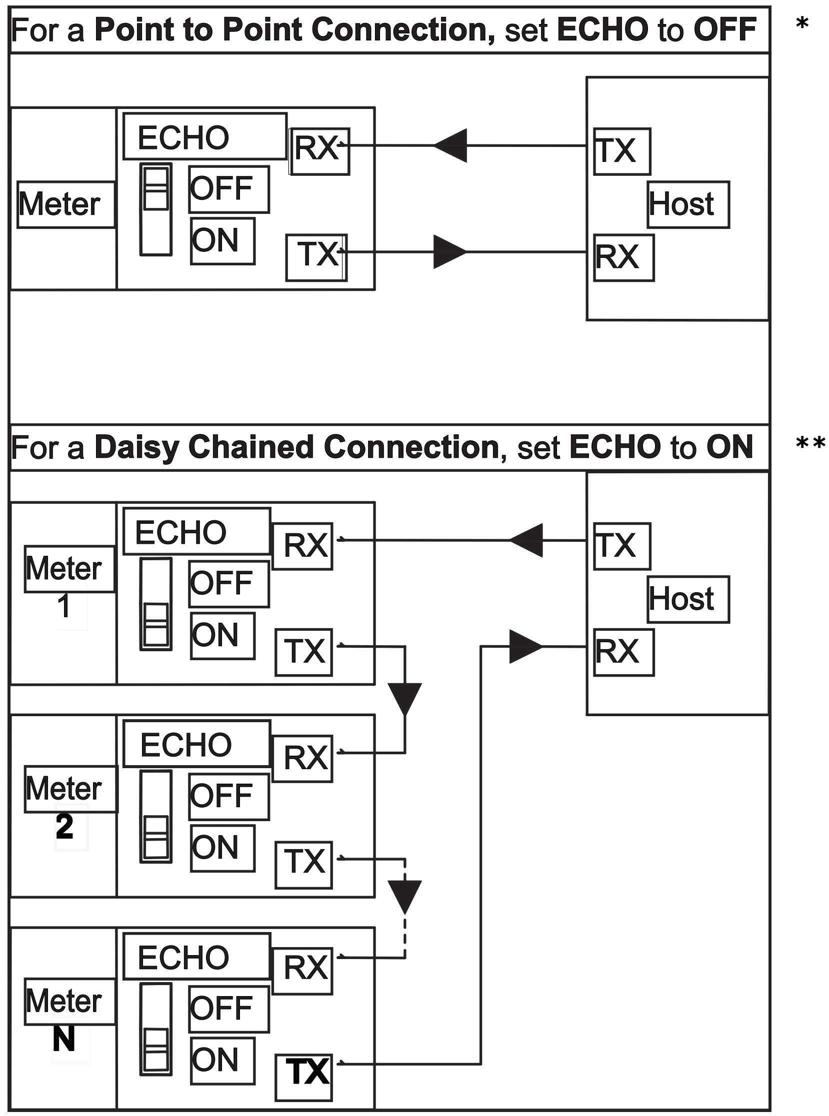
6.8.2 Wiring Diagram

ST® type connector F1



Versatile Link type connector F2





* When a Fiber Optic Com Card is used in point to point connection, set the Echo Switch to OFF.

**When a Fiber Optic Com Card is installed in a meter that is part of a Daisy Chained connection, set the Echo Switch to ON. This allows messages not for this meter to continue to the next meter in sequence.

Figure 6-7: Fiber Optic Communication Card

6.9 10/100BaseT Ethernet Communication Card (E1)

The 10/100BaseT Ethernet Communication card provides the EPM 7000P meter with Ethernet capability. See Chapter 7 *Using the Ethernet Card (E1)*, for details and instructions.

NOTICE

Refer to the *GE Communicator Instruction Manual* for instructions on performing Network configuration.

6.9.1 Specifications

TECHNICAL SPECIFICATIONS AT 25 °C

Number of Ports:1

Power consumption: ....2.1 W internal
Baud rate:..10/100 Mbit
Diagnostic feature: ....Status LEDs for LINK and ACTIVE
Number of simultaneous Modbus
connections:.....................................12

GENERAL SPECIFICATIONS

Operating Temperature: ....(-20 to +70) °C
Storage Temperature:..................(-40 to +80) °C
Relative air humidity: ....Maximum 95%, non-condensing
EMC - Immunity Interference: .EN 61000-4-2
Weight: ....1.7 oz
Dimensions (inch) W x H x L: ....0.72 x 2.68 x 3.26
Connection Type:...........................RJ45 modular (auto-detecting transmit and receive)

6.9.2 Default Configuration

The EPM 7000P meter automatically recognizes the installed Option card during power up. If you have not programmed a configuration for the card, the unit defaults to the following:

IP Address: 10.0.0.2

Subnet Mask: 255.255.255.0

Default Gateway: 0.0.0.0

6.9.3 Wiring Diagram

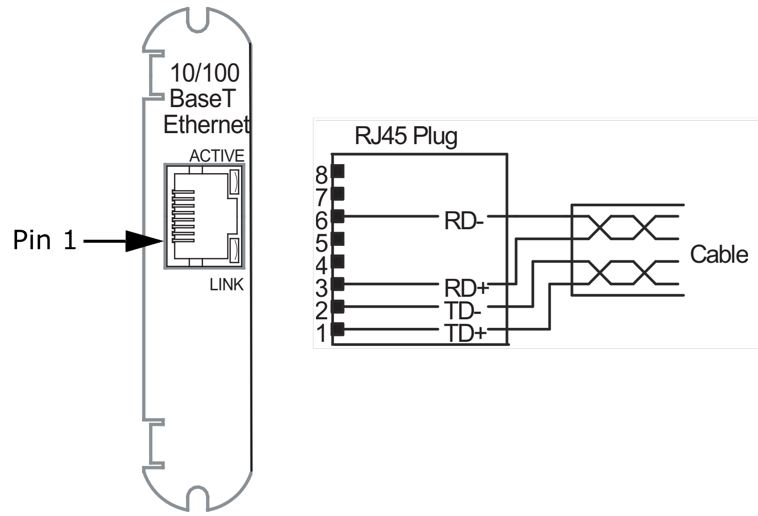


Figure 6-8: 10/100BaseT Ethernet Card

NOTICE

IMPORTANT! The E1 uses an auto-detecting circuit that automatically switches the transmit and receive in order to properly align communication. Because of this, when you are communicating directly to a meter with a PC or a switch, a straight cable can be used.

6.10 IEC 61850 Protocol Ethernet Network Card (E2)

The IEC 61850 Protocol Ethernet Network card provides the EPM 7000P meter with IEC 61850 as well as Modbus protocol, to allow it to operate in any IEC 61850 application. See Chapter 9 *Using the E2 IEC 61850 Protocol Card*, for details and instructions.

6.10.1 Specifications

TECHNICAL SPECIFICATIONS AT 25 °C

Number of Ports:........................... 1
Power consumption: .... 2.1 W internal
Baud rate:.. 10/100 Mbit
Diagnostic feature:....................... Status LEDs for LINK and ACTIVE
Number of simultaneous Modbus
connections:.................................. 12
Number of simultaneous MMS clients: 5

GENERAL SPECIFICATIONS

Operating Temperature:............ (-20 to +70) °C
Storage Temperature: .... (-40 to +80) °C
Relative air humidity: .... Maximum 95%, non-condensing
EMC - Immunity Interference:. EN 61000-4-2
Weight:... 1.7 oz
Dimensions (inch) W x H x L: ... 0.72 x 2.68 x 3.26
Connection Type:......................... RJ45 modular (auto-detecting transmit and receive)

6.10.2 Default Configuration

The EPM 7000P meter automatically recognizes the installed Option card during power up. If you have not programmed a configuration for the card, the unit defaults to the following:

IP Address: 10.0.0.2

Subnet Mask: 255.255.255.0

Default Gateway: 0.0.0.0

6.10.3 Wiring Diagram

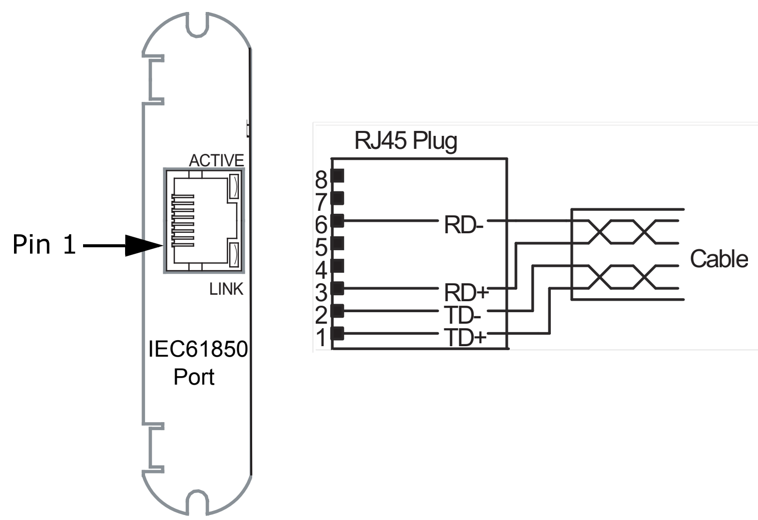


Figure 6-9: IEC61850 Protocol Ethernet Network Card

NOTICE

IMPORTANT! The E2 uses an auto-detecting circuit that automatically switches the transmit and receive in order to properly align communication. Because of this, when you are communicating directly to a meter with a PC or a switch, a straight cable can be used.

6.11 RS232/RS485 Card (S1)

The S1 Option card gives you an additional serial port configurable to either RS485 or RS232 with the "Sel" pin. The "Sel" pin jumpered to the "SH" pin sets the mode to RS232 and, if not jumpered, to RS485.

6.11.1 Specifications

TECHNICAL SPECIFICATIONS AT 25 °C

Number of Ports:.......................... 1
Power consumption: .... 0.55 W internal
RS485 mode details:.................... Type - Two-wire, half duplex
Typical input impedance125 kΩ
Max. output current.................... ±60 mA
RX (-) is the negative differential signal input/output
TX (+) is the positive differential signal input/output
RS232 mode details:.................... RX (-) is the receive signal input
TX (+) is the transmit signal output
Typical input impedance - 5 kΩ
Baud rate:.. Up to 57.6 kb/s – pre-programmed in the main unit
Protocol: .... Modbus RTU/ASCII, DNP3 Level 2*
Diagnostic feature:....................... LED lamps for TX and RX activity
* The meter supports only one serial port communicating via DNP3.

GENERAL SPECIFICATIONS

Operating Temperature:........... (-20 to +70) °C
Storage Temperature: .... (-40 to +80) °C
Relative air humidity: .... Maximum 95%, non-condensing
EMC - Immunity Interference:. EN 61000-4-2
Weight:.. 0.8 oz
Dimensions (inch) W x H x L: .... 0.72 x 2.68 x 3.26
External connection:.................... AWG 12-26/(0.29 - 3.31) mm2
4 pin, 0.200” pluggable terminal block

6.11.2 Default Configuration

The EPM 7000P meter automatically recognizes the installed Option card during power up. If you have not programmed a configuration for the card, the unit defaults to the following:

Address: 1

Protocol: Modbus RTU

Baud Rate: 57600

Parity: None

Response Delay: 1 ms

6.11.3 Wiring Diagram

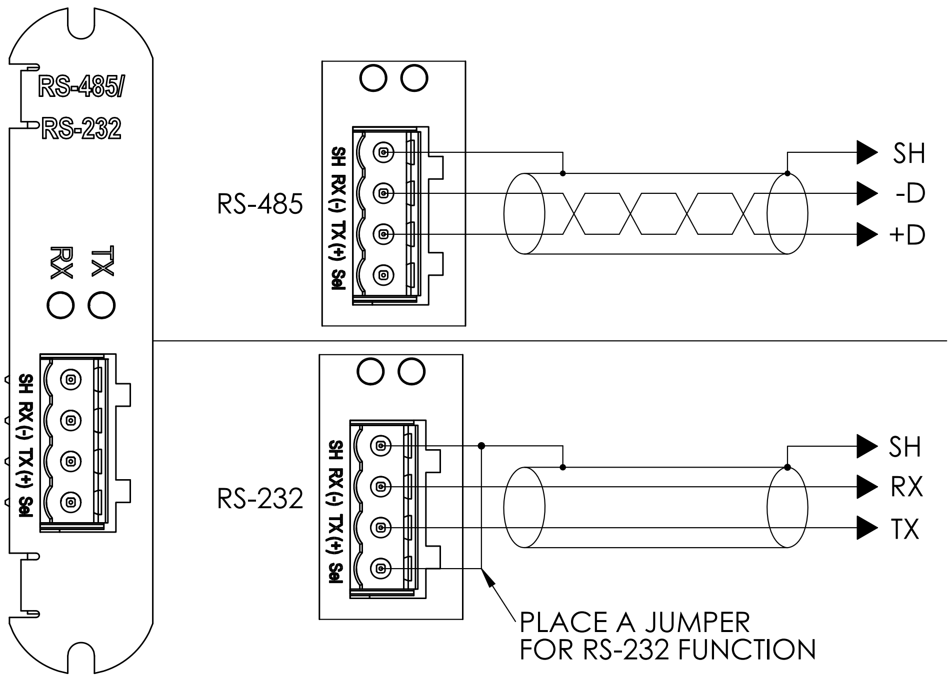


Figure 6-10: RS232/RS485 S1 Serial Communication Card

Multilin™ EPM 7000P

Chapter 7: Using the Ethernet Card (E1)

7.1 Overview

The EPM 7000P meter can have up to two optional Ethernet cards (E1). When you install the E1 in your EPM 7000P meter, you gain the capability of communicating over the Ethernet using GE's Rapid Response technology.

7.2 Hardware Connection

The E1 card fits into either of the two Option Card slots in the back of the EPM 7000P meter. Refer to Chapter 7 for card installation instructions.

Use a standard RJ45 10/100BaseT cable to connect to the Ethernet card. The E1 card auto-detects cable type and will work with either straight or crossover cable.

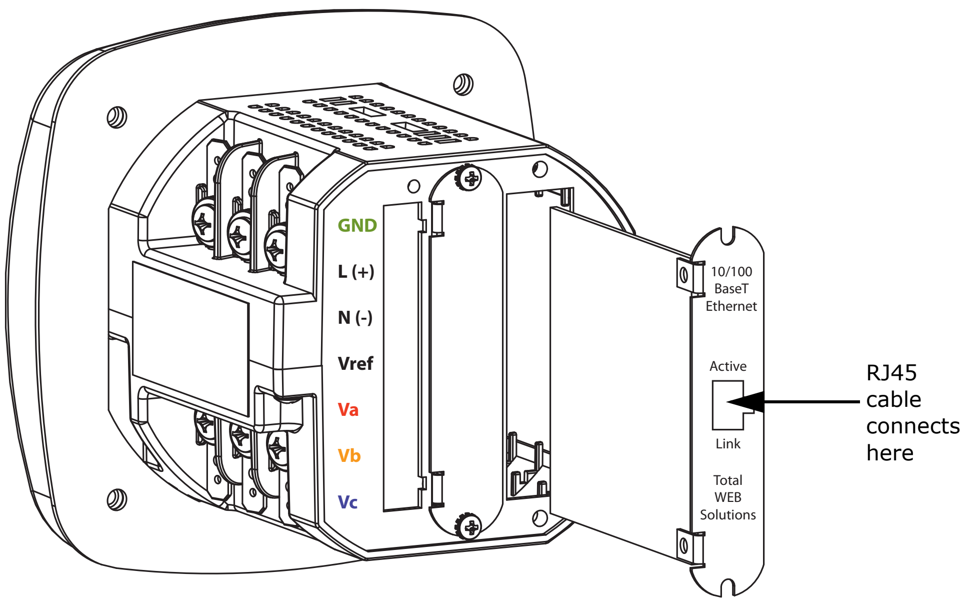


Figure 7-1: Meter with E1 Card

7.3 Performing Network Configuration

As with the other Option cards, the EPM 7000P meter auto-detects the presence of an installed Ethernet card. Configure the Ethernet card through GE Communicator software. Refer to the *GE Communicator Instruction Manual* for instructions. You can open the manual online by clicking **Help>Contents** from the GE Communicator Main screen.

7.4 E1 Ethernet Card Features

In addition to Ethernet communication, the E1 Ethernet card gives your meter the following capabilities:

- Embedded Web server - 7.4.2 *Embedded Web Server* on page 7–3.
- NTP Time Server synchronization - 7.4.3 *NTP Time Server Synchronization* on page 7–22.
- Alarm and notification emails, with meter readings - *Email Notification* on page 7–14.
- Data Push of meter readings to a cloud server using the JSON structure - *Data Push* on page 7–18.
- Enhanced security with the Exclusive Client feature, which lets you Whitelist an IP address or MAC address. When that address is used to connect to the meter, all other network communication with the meter, through the same Network card, is suspended. This ensures that anything being done, e.g., updating programmable settings, while the Whitelist address is being used to communicate with the meter, is secure. Refer to the *GE Communicator Instruction Manual* for instructions on setting the Exclusive Client feature.
- The network card supports NTP version 4.0 client/server mode up to Network card firmware version 3.44. Starting in version 3.45, the network card works with NTP version 3.0 or 4.0 (autodetect) in client/server mode. Broadcast is not supported in any version.

7.4.1 Ethernet Communication

The E1 enables high-speed Ethernet communication with up to 12 simultaneous connections for Modbus TCP. The card supports a static IP address and is treated like a node on the network.

7.4.2 Embedded Web Server

The E1 gives the meter a Web server that is viewable over the Ethernet by almost all browsers. The EPM webpages allow you to see the following information for the EPM 7000P meter:

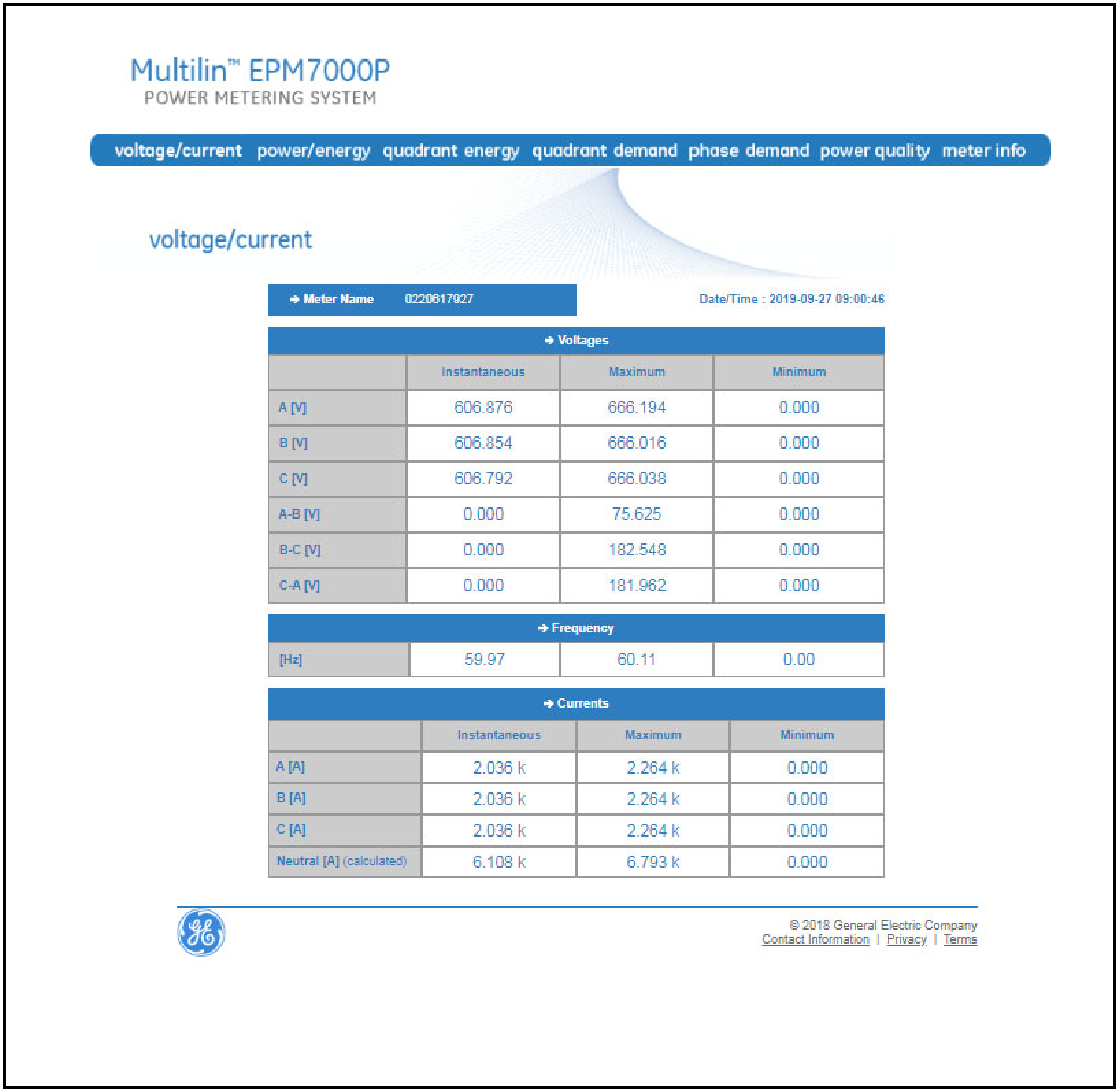
- Voltage and current readings
- Power and Energy readings
- Power quality information
- General meter information
    - You can also upgrade the Ethernet (Network) card's firmware, Reset the Ethernet card, configure email notification, and set up Data Push from the meter's Information webpage.
    - The E1 card also supports the "keep alive" feature - 7.4.5 *Keep-Alive Feature* on page 7–22.

Follow these steps to access the EPM 7000P meter's webpages:

1. Open a standard Web browser from your PC, smart phone, or tablet.

2. Type the Ethernet Card's IP address in the address bar, preceded by "http://". For example: http://172.20.167.99

3. You will see the EPM Voltage/Current webpage shown below.



Multilin™ EPM7000P
POWER METERING SYSTEM

voltage/current power/energy quadrant energy quadrant demand phase demand power quality meter info

voltage/current

➔ Meter Name 0220617927

Date/Time : 2019-09-27 09:00:46

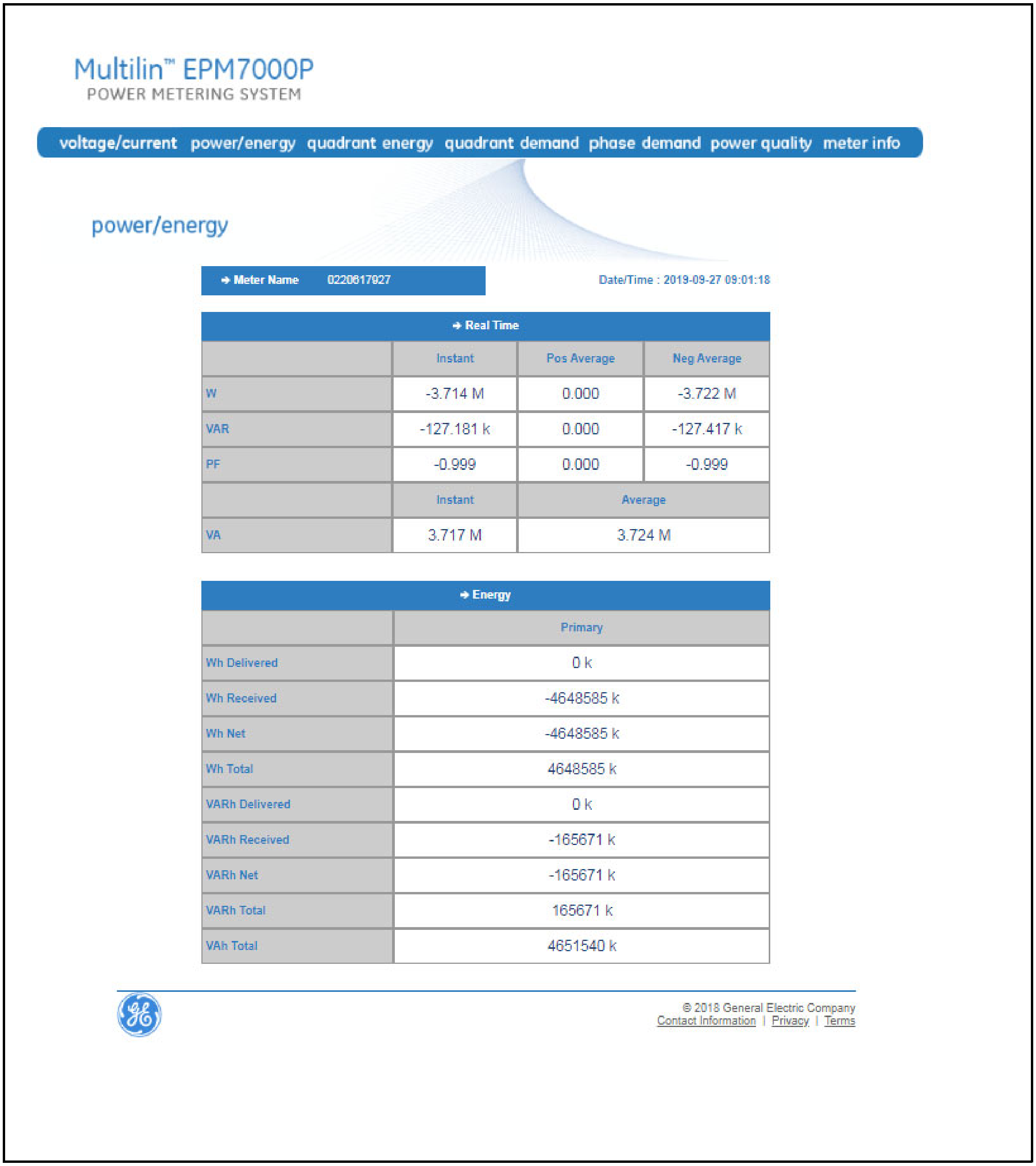
➔ Voltages			
	Instantaneous	Maximum	Minimum
A [V]	606.876	666.194	0.000
B [V]	606.854	666.016	0.000
C [V]	606.792	666.038	0.000
A-B [V]	0.000	75.625	0.000
B-C [V]	0.000	182.548	0.000
C-A [V]	0.000	181.962	0.000

➔ Frequency			
[Hz]	59.97	60.11	0.00

➔ Currents			
	Instantaneous	Maximum	Minimum
A [A]	2.036 k	2.264 k	0.000
B [A]	2.036 k	2.264 k	0.000
C [A]	2.036 k	2.264 k	0.000
Neutral [A] (calculated)	6.108 k	6.793 k	0.000

© 2018 General Electric Company
Contact Information | Privacy | Terms

4. To view power and Energy readings, click **Power/Energy** on the left side of the webpage. You will see the webpage shown below.



Multilin™ EPM7000P
POWER METERING SYSTEM

voltage/current power/energy quadrant energy quadrant demand phase demand power quality meter info

power/energy

➔ Meter Name 0220617927

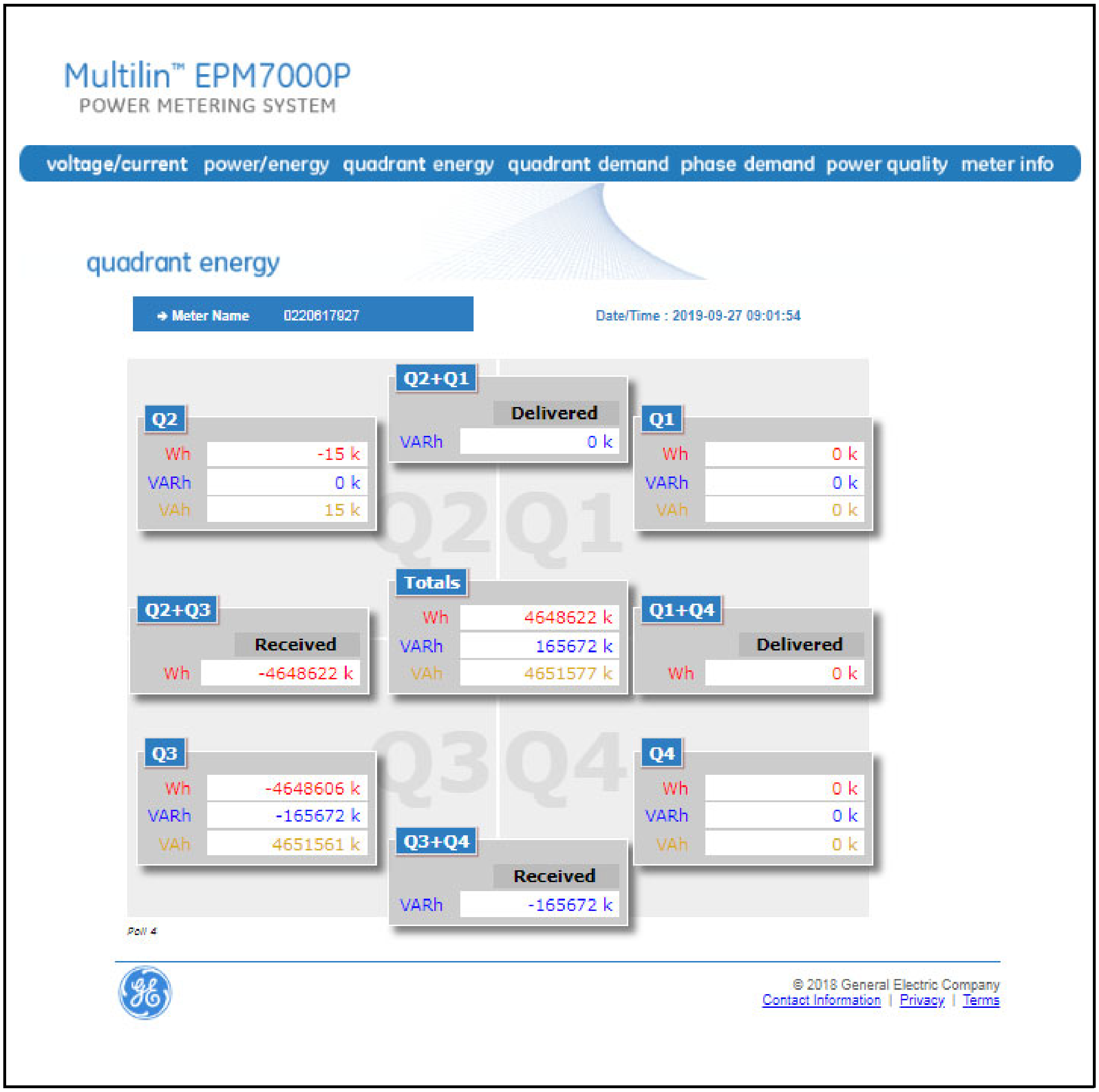
Date/Time : 2019-09-27 09:01:18

➔ Real Time			
	Instant	Pos Average	Neg Average
W	-3.714 M	0.000	-3.722 M
VAR	-127.181 k	0.000	-127.417 k
PF	-0.999	0.000	-0.999
	Instant	Average	
VA	3.717 M	3.724 M	

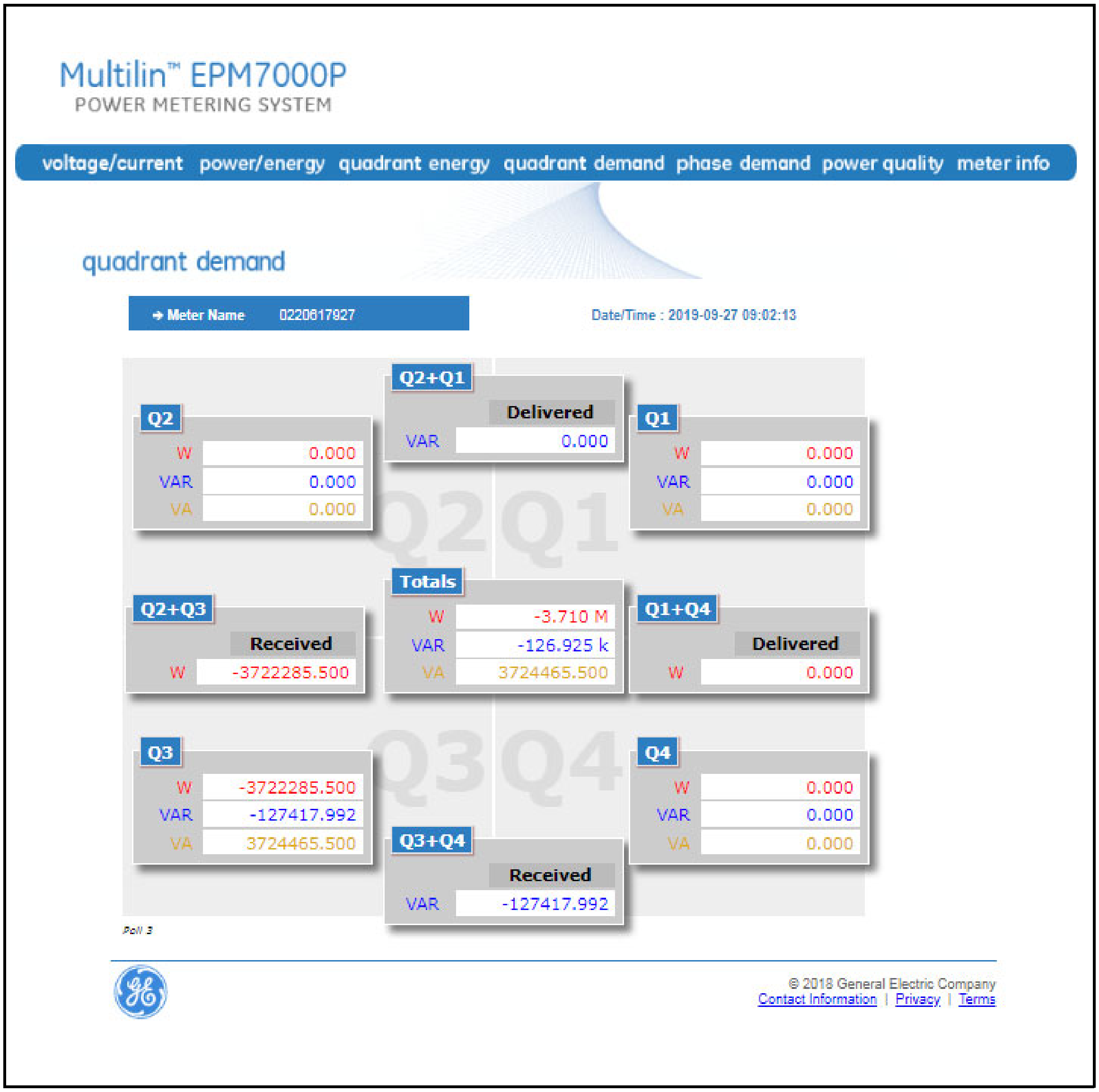
➔ Energy	
	Primary
Wh Delivered	0 k
Wh Received	-4648585 k
Wh Net	-4648585 k
Wh Total	4648585 k
VARh Delivered	0 k
VARh Received	-165671 k
VARh Net	-165671 k
VARh Total	165671 k
VAh Total	4651540 k

© 2018 General Electric Company
Contact Information | Privacy | Terms

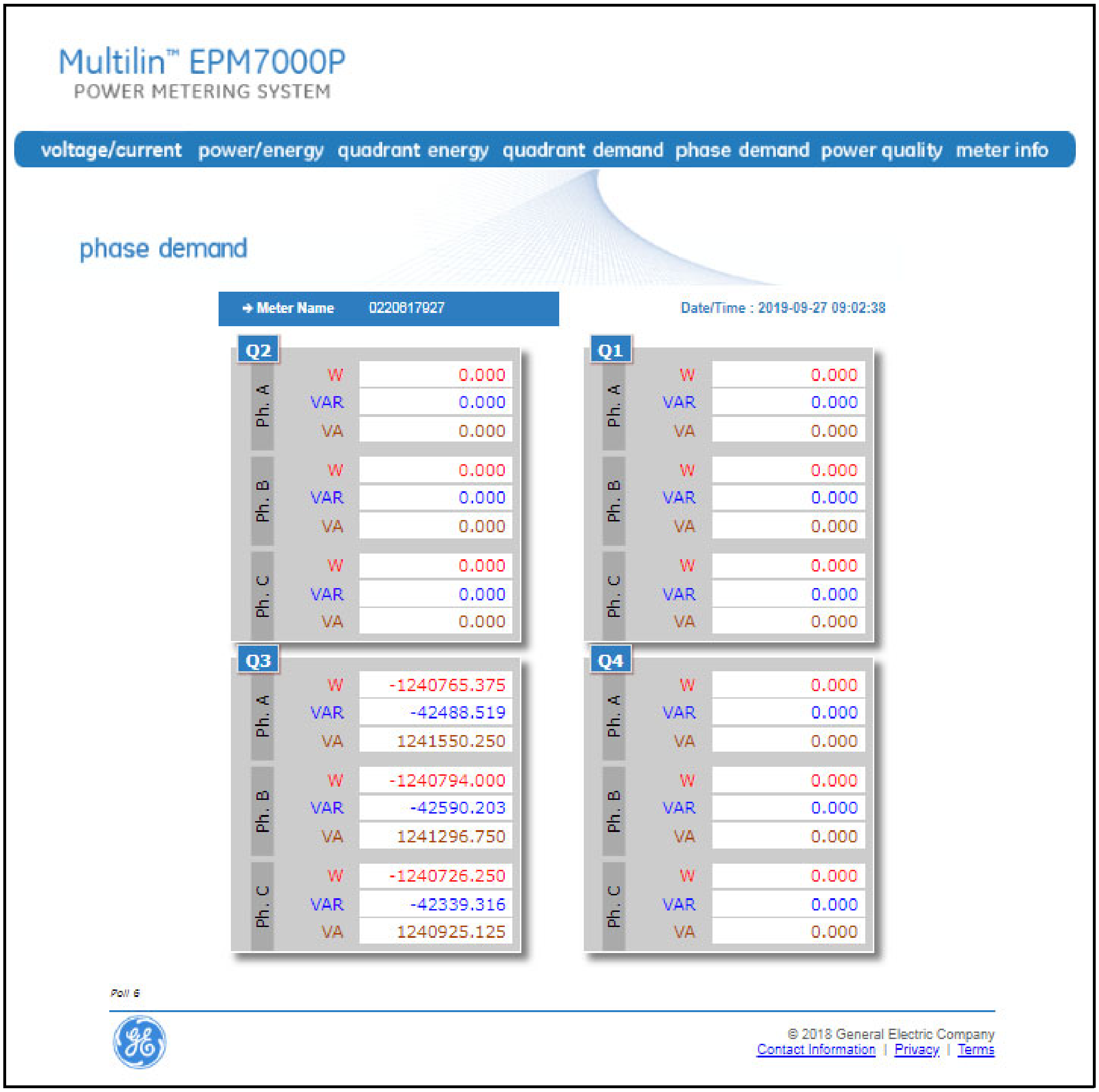
5. To view energy readings for each quadrant, click **Quadrant Energy** on the left side of the webpage. You will see the webpage shown below.



6. To view demand for each quadrant, click **Quadrant Demand** on the left side of the webpage. You will see the webpage shown below.



7. To view demand for each phase, click **Phase Demand** on the left side of the webpage. You will see the webpage shown below.



8. To view power quality information, click **Power Quality** on the left side of the webpage. You will see the webpage shown below.

Multilin™ EPM7000P
POWER METERING SYSTEM

voltage/current power/energy quadrant energy quadrant demand phase demand power quality meter info

power quality

Meter Name 0220617927 Date/Time : 2019-09-27 09:03:10

Voltages & Currents Harmonics

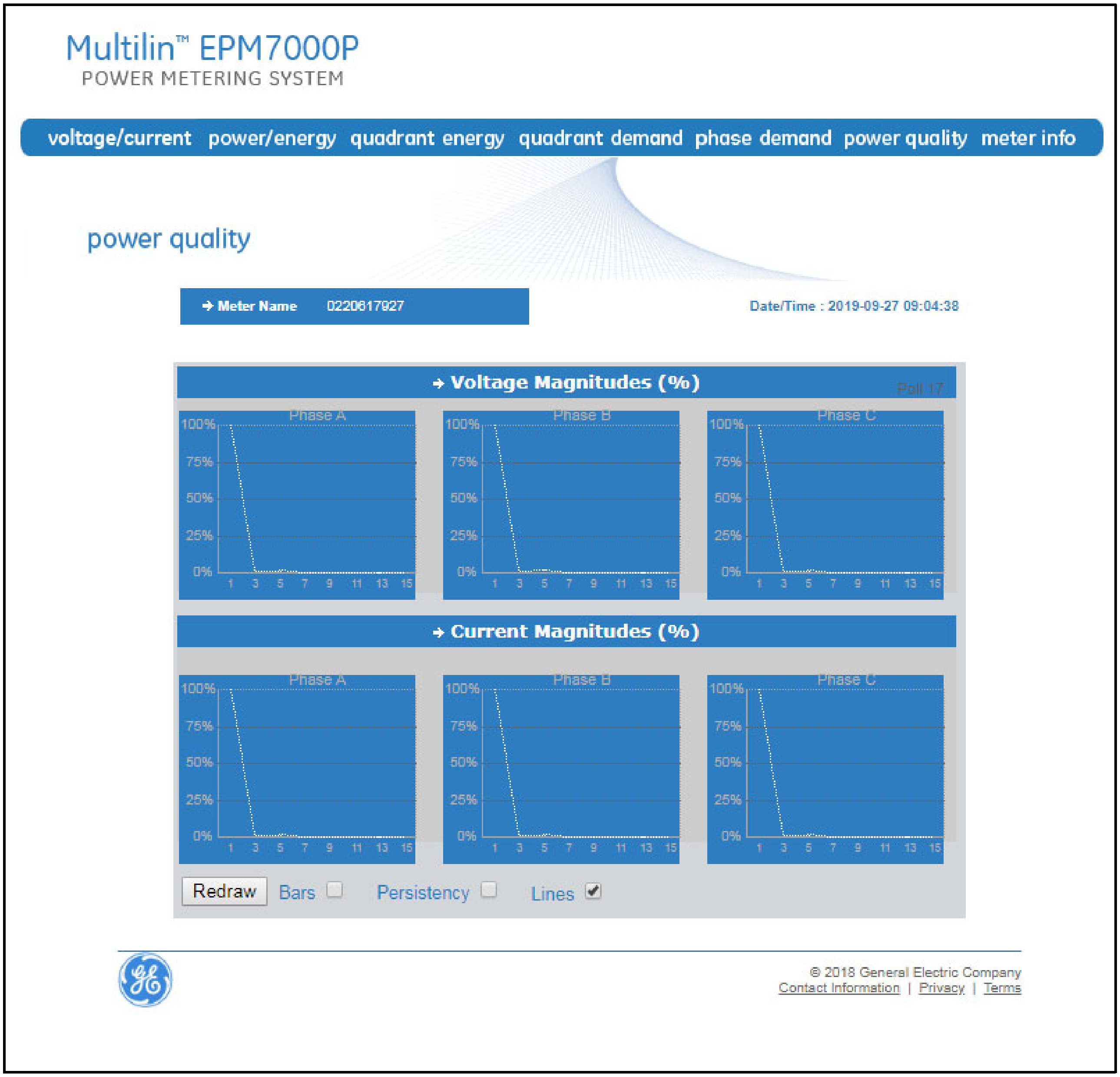
	3	5	7	9	11	13	15	%THD
	Mag.	Mag.	Mag.	Mag.	Mag.	Mag.	Mag.	
VA	1.25	2.20	0.00	0.00	0.00	0.00	0.00	2.54
VB	1.25	2.22	0.00	0.00	0.00	0.00	0.00	2.55
VC	1.23	2.22	0.00	0.00	0.00	0.00	0.00	2.55
IA	1.20	2.18	0.00	0.00	0.00	0.00	0.00	2.50
IB	1.27	2.16	0.00	0.00	0.00	0.00	0.00	2.52
IC	1.18	2.20	0.00	0.00	0.00	0.00	0.00	2.50

Phase Angles

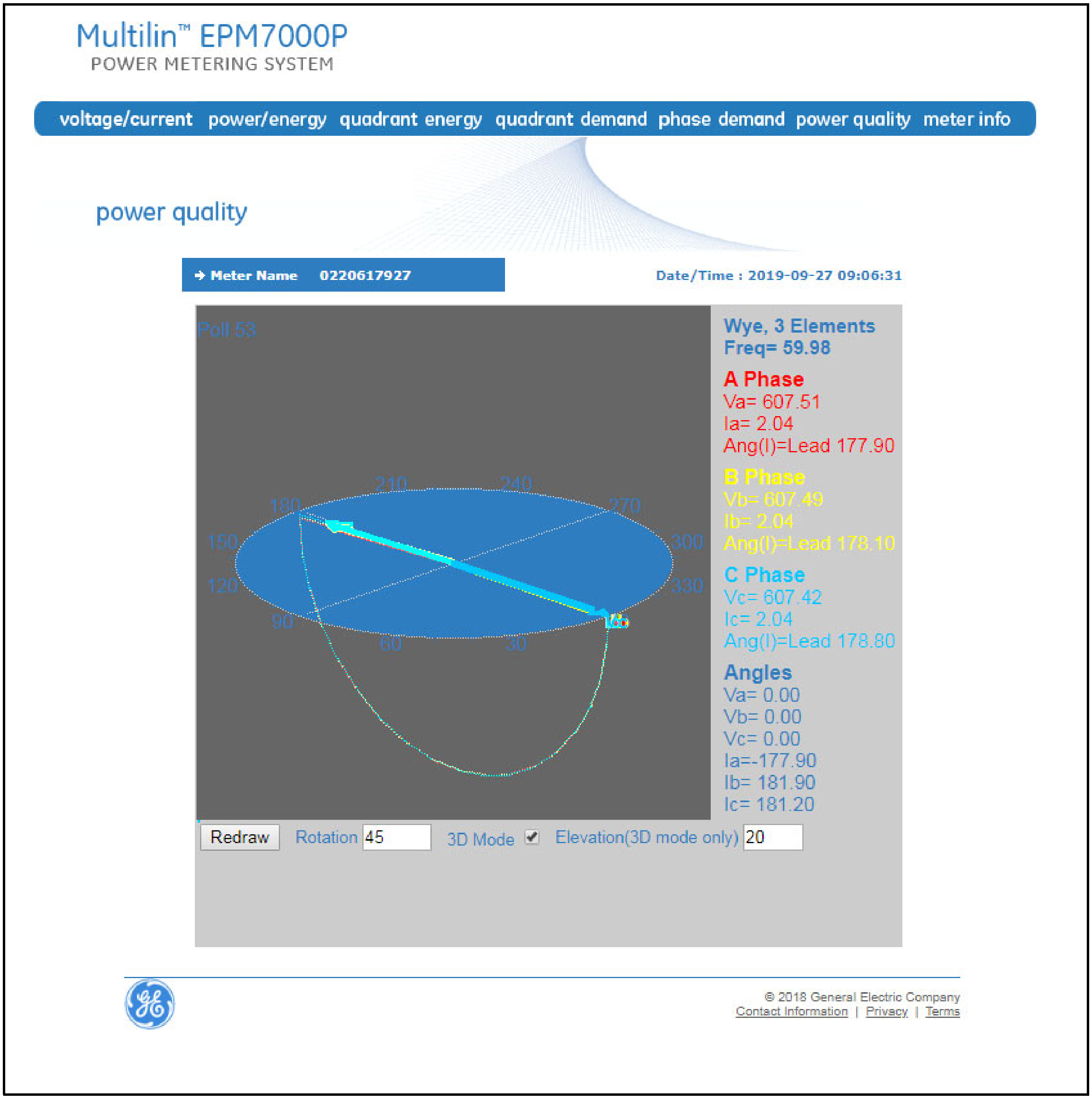
	Voltage		Current
A-B	0.0	A	177.9
B-C	0.0	B	178.3
C-A	0.0	C	178.8

© 2018 General Electric Company
Contact Information | Privacy | Terms

- To view a graphical representation of the Voltage and current magnitudes, click the **Graph** icon in the corner of the Voltage/Current box. You will see the webpage shown below.

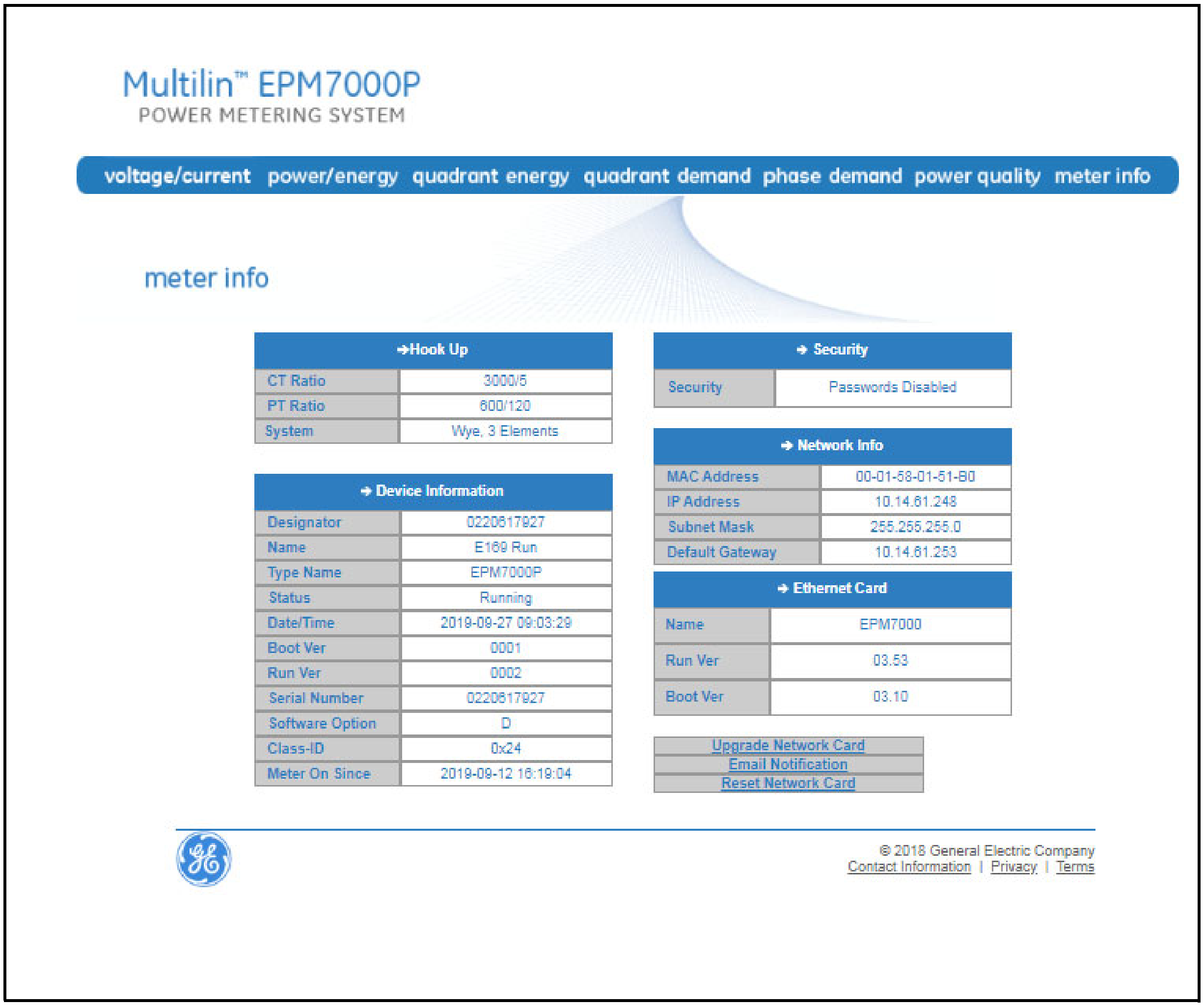


- To view a graphical representation of the phase angles, click the **Phase Angles** icon in the corner of the Phase Angles box. You will see the webpage shown below.



9. Click **Power Quality** on the left side of the webpage to return to the previous webpage.

10. To view meter information, or to upgrade the Network card's firmware, click **Information** on the left side of the webpage. You will see the webpage shown below.



NOTICE

- Any special characters (i.e., any of the following characters * :" | \ < > ? /) used in the meter name or any other designator string in the meter, are displayed as '_' (underscore) in the webpage.
- In addition to information about the meter and its firmware, this webpage gives you access to the following functions:
  - *Upgrading the Ethernet Card's Firmware* on page 7–13.
  - *Resetting the Ethernet Card* on page 7–13.
  - Configuring Alarm/Email Notification (*Email Notification* on page 7–14).
  - Data push of meter readings to a cloud server using the JSON structure (*Data Push* on page 7–18.)

NOTICE

The EPM 7000P meter's Device Profile must be set up before configuring keep-alive or email settings in the Network card. See the *GE Communicator Instruction Manual* for instructions.

Upgrading the Ethernet Card's Firmware

From one of the EPM 7000P meter's webpages:

1. Click **Information** on the left side of the webpage.
2. Click **Upgrade Network Card** (bottom box on the right). You will see the webpage shown on the next page.

NOTICE

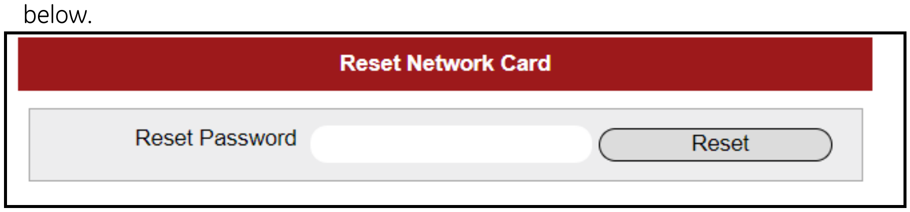
In order to upgrade the Network (Ethernet) Card, you must be using the PC on which the upgrade file is stored.

3. Click the **Browse** button to locate the Upgrade file. Make sure that you select the E1 option card upgrade file. If you upgrade with an E2 upgrade file, the card will not work.
4. Enter the safety code (supplied with the Upgrade file) and the password (the default is **n3tUp!0Ad**).
5. Click **Submit**. The upgrade starts immediately (it may take several minutes to complete). Once the upgrade is complete, you will see a confirmation message. **CAUTION!** Note the Warning message on the screen. If there is a power interruption during upgrade, please call GE's Technical Support department for assistance.

Resetting the Ethernet Card

From one of the EPM 7000P meter's webpages:

1. Click **Information** on the left side of the webpage.
2. Click **Reset Network Card** (bottom box on the right). You will see the webpage shown below.



3. Enter the Reset password (the default is **adminR35et**).
4. Click **Reset**.

NOTICE

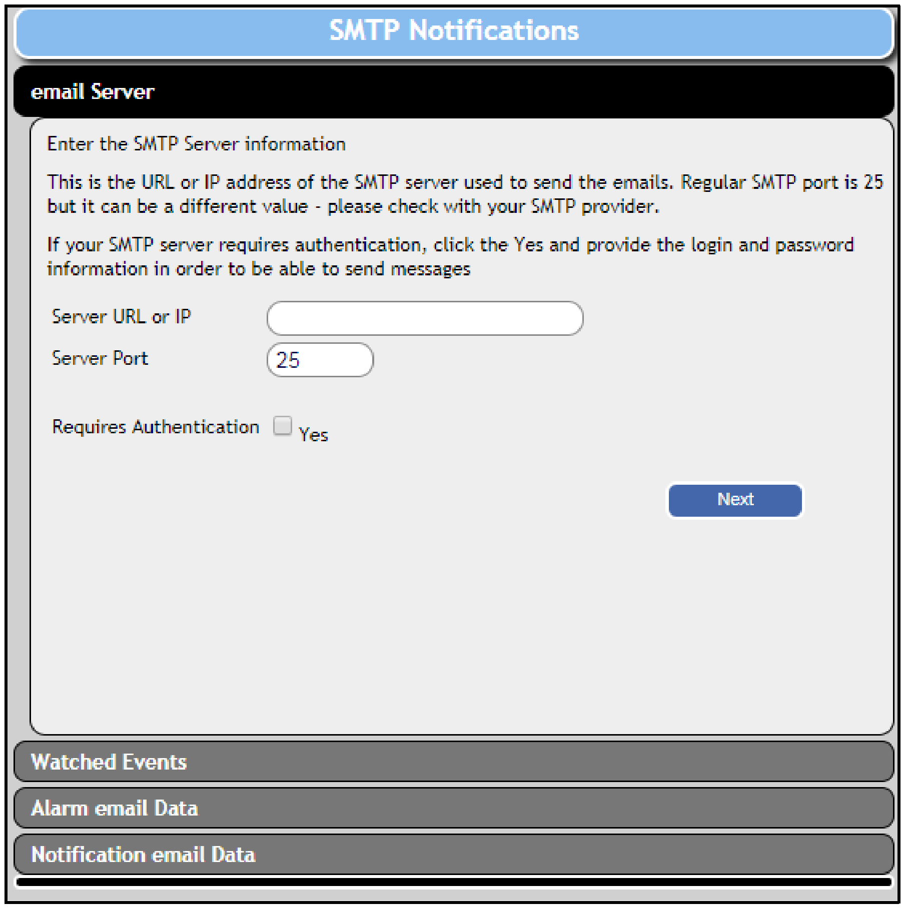
As a result of the reset, the communication link with the card will be lost and must be re-established.

Email Notification

The E1 card can be configured to send either alarm or periodic notification emails and to send meter data along with either type of email. The Firmware version of the Ethernet card must be 337 or higher for this feature to be available. See page 7-9 for information on finding the firmware version.

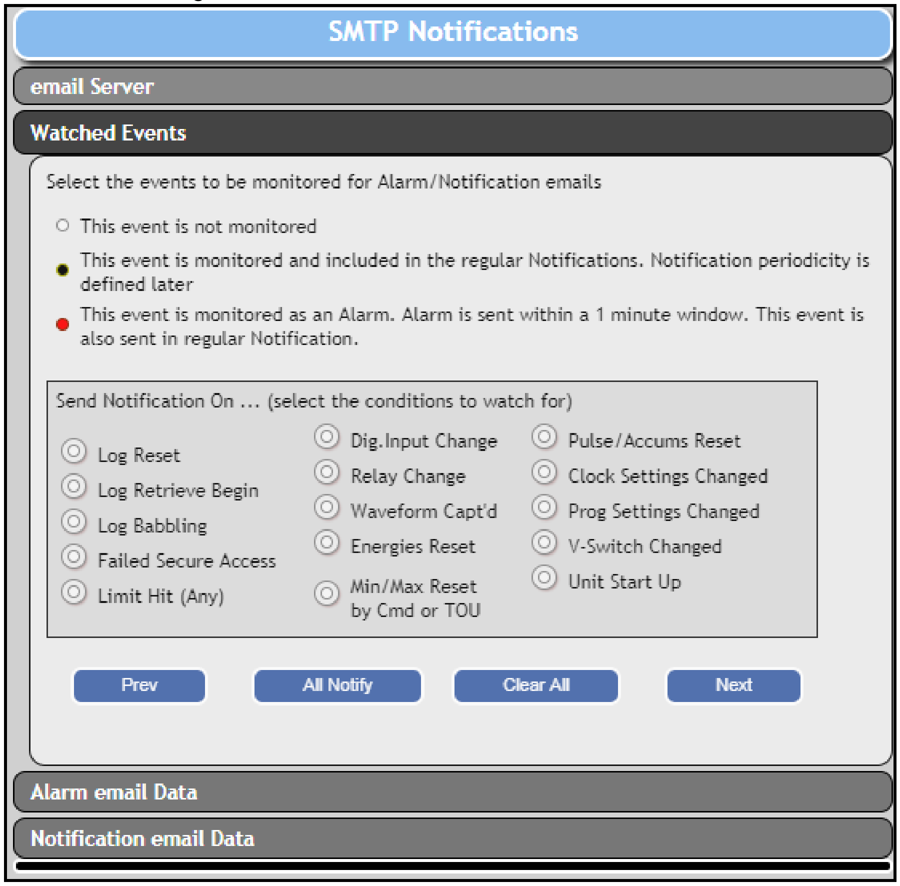
From one of the EPM 7000P meter's webpages:

1. Click **Information** on the left side of the webpage.
2. Click **Email Notification** on the bottom right of the webpage. The first screen you will see is Email Server, shown below.



3. This screen lets you set up the SMTP email server that the Network card will use to send the emails.
   - Enter the url or IP address of the email server you will be using.
   - Enter the Server port. Usually this is 25, but check with your system administrator in case you are using a different port.
   - If your email server requires authorization, click the checkbox next to Yes and enter the Username and Password.
   - Click the **Next** button.

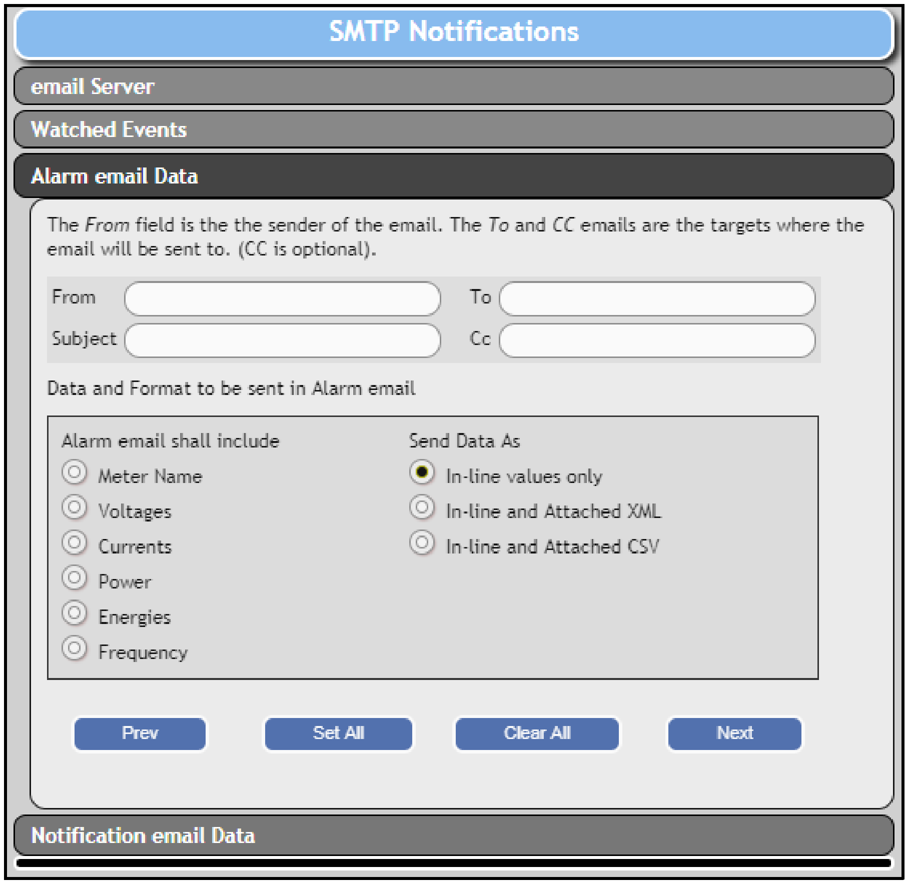
4. The next screen you will see is Watched Events.



This screen lets you select the conditions that will cause an alarm or notification email to be sent, e.g, Relay Change or Unit Startup.

- You select an event by clicking on the button next to it:
  - To select a condition that will cause a Notification email to be sent, click once on the button next to the condition. The button will turn black.
  - To select a condition that will cause an Alarm email to be sent, click twice on the button next to the condition. The button will turn red.
    - Note that when you designate a condition as an alarm, an alarm email will be sent out within a minute after the condition occurs and a notification email will **also** be sent out at the next notification period. If you have not set up any notification emails, then only the alarm email will be sent.
    - There are some conditions which cannot be set as alarms, but only as notifications. These conditions are Programmable Settings Change, Software Option Changed, and Unit Start Up.
  - To de-select a condition, click on the button until it is empty, again - not black or red.
- You can select multiple conditions for alarms and notifications. When you are done, click the **Next** button.

5. The next screen you will see is Alarm Email Data.



This screen lets you designate to whom the alarm email will be sent, any data you want sent with the email, and the format the data should be in. If you are not setting up an alarm email, just click the Next button and go to step 6.

- Enter the email address of the person sending the email in the From field.
- Enter the email subject line in the Subject field- the default is Alarm Email.
- Enter the email address of the person receiving the email in the To field.
- Enter the email address of anyone you want to receive a copy of the email in the CC field.
- Select any data you want included in the email from the list, by clicking on the button next to it. Note that these values are taken about one second after the alarm condition occurred. You can click Set All to select all of the values at one time, or Clear All to clear all of your selections.
- Select the format for the data from the Send Data As field: In line Values only - just in the body of the email; In line and Attached XML - in the body of the email and in an XML file that will be attached to the email; or In Line and Attached CSV - in the body of the email and in a .csv file that will be attached to the email.
- Click the **Next** button.

6. The next screen you will see is Notification Email Data.

This screen lets you designate to whom the periodic notification email will be sent, any data you want sent with the email, and the format the data should be in. You will also set up the notification period, which is the amount of time between periodic notification emails. If you are not setting up a notification email, go to step h.

- Enter the email address of the person sending the email in the From field.
- Enter the email subject line in the Subject field- the default is Notification Email.
- Enter the email address of the person receiving the email in the To field.
- Enter the email address of anyone you want to receive a copy of the email in the CC field.
- Select any data you want included in the email from the list, by clicking on the button next to it. Note that these values are taken about one second after the notification condition occurred. You can click Set All to select all of the values at one time, or Clear All to clear all of your selections.
- Select the format for the data from the Send Data As field: In line Values only - just in the body of the email; In line and Attached XML - in the body of the email and in an XML file that will be attached to the email; or In Line and Attached CSV - in the body of the email and in a .csv file that will be attached to the email.
- Enter the interval you want between notification emails, in minutes, in the Notification Period field. For example, to set up notification emails every 15 minutes, enter 15 in this field. Any notification conditions that occur in the interval will be saved and sent

in the next notification email. Valid entries is in this field are between 15 minutes and 10080 minutes (168 hours, or seven days).

- If you want a notification email sent on the scheduled interval even if there are no values for the selected data, click the Enforced radio button to select this option. If you want the email to be sent only if there are values for the selected data, leave the Enforced button unselected (the default setting is unselected).
- Enter the Password in the Change Password field. The default password is "n07!fY" (without the quotation marks). You need to enter this password in order to implement your selections.
- Click **Submit** to save your settings. The Network card will reset. Note that any pending emails will be canceled.

Data Push

The EPM 7000P meter's E1 card with Firmware 3.43 or higher is capable of pushing up to 15 meter readings to a cloud service that uses the JSON structure, such as Lucid BuildingOS®, which collects and manages building commodity usage information for building companies/facility managers that are registered with the service. A cloud service gives the customer the ability to access all of their buildings' usage data, including meter readings, in one place.

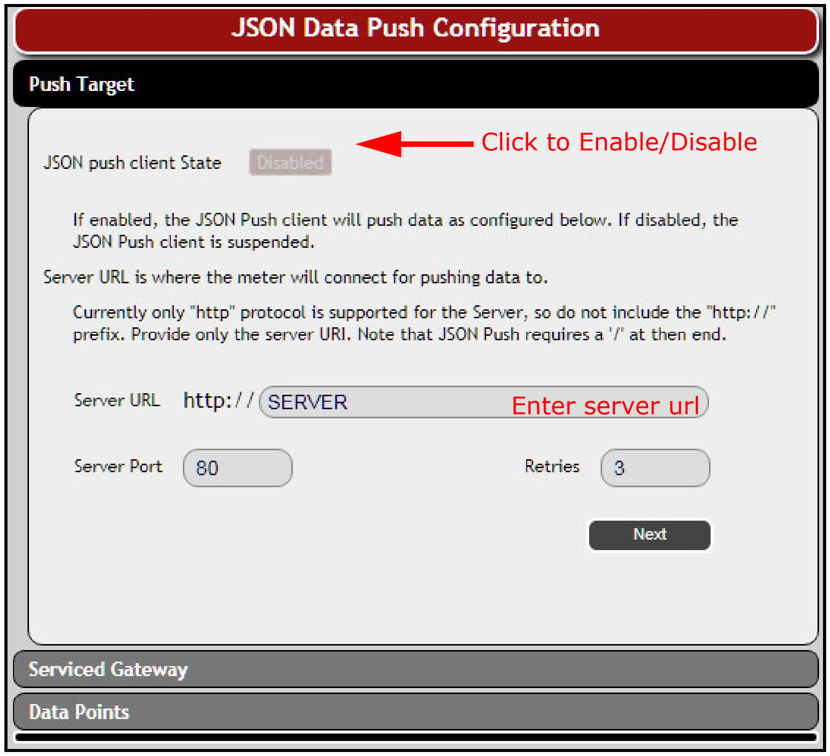
JSON is a free, open-standard format that is widely used in asynchronous browser/server communication. It uses text to transmit data objects made up of attribute-value pairs and array data types.

The specific meter readings and the frequency of the data push are configured through the card's web server.

1. From one of the EPM 7000P meter's webpages, click **Meter Information** on the top of the webpage.
2. Click **JSON Push Client** (second box on the bottom right of the webpage). You will see the webpage shown on the next page.

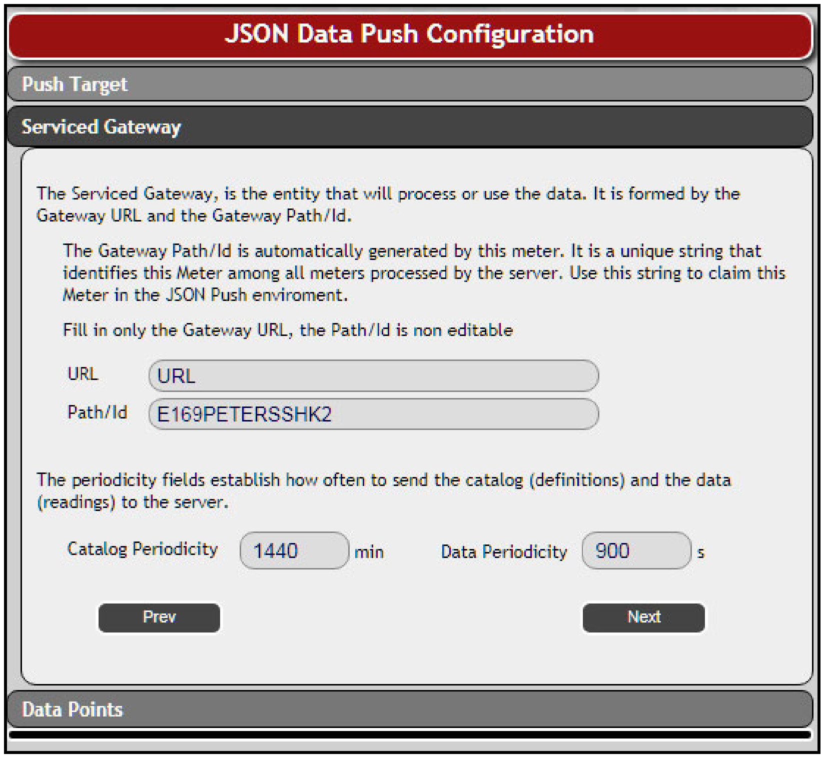
NOTICE

IMPORTANT! The specific information you enter in the Data Push screens will be supplied by the cloud service., e.g., the url and server path to use.



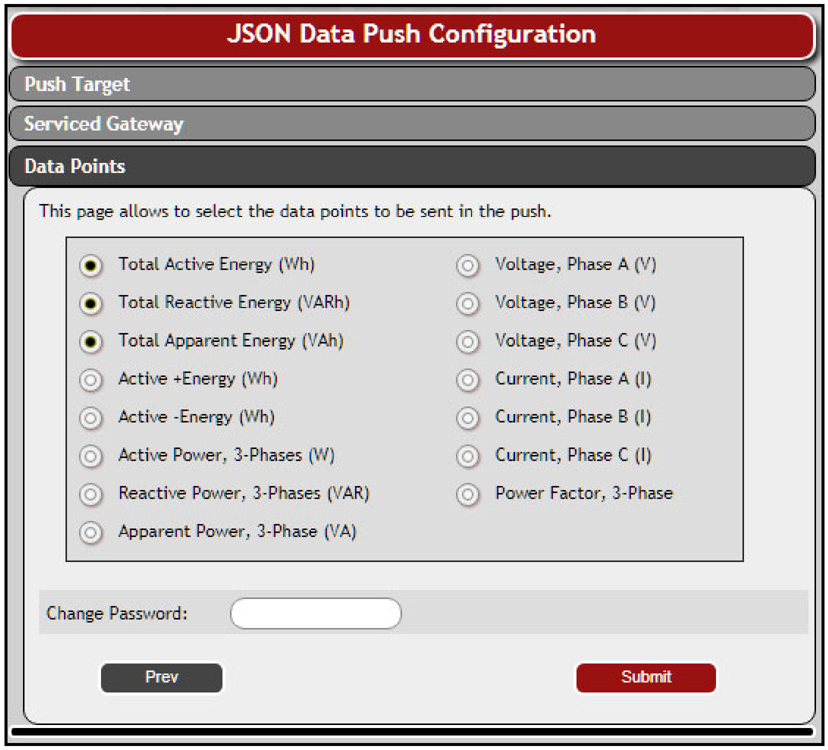
3. When active, the JSON Push Client State button says Enabled. If the button says Disabled, click on it to change it to Enabled. Note that when the client is disabled, it is in a suspended mode (no data is being pushed), but settings can still be changed.
4. Enter:
   - The url of the server: this is the address the client will connect to. It can be either a url or an IP address. This information will be supplied to the customer by the cloud service. Note that Lucid Push in the E1 implements "http" protocol, not "https": if the supplied address uses “https,” contact Lucid for instructions on accessing the http only server.
   - The server port: this is the TCP/IP port the Lucid client connects to - this is usually 80.
   - The number of retries you want to implement in the case of a failed first attempt, which may happen if network traffic is heavy.

5. Click **Next**. You will see the webpage shown below.



6. In the Serviced Gateway webpage, enter:
   - Enter the Gateway URL of the data service to connect with - this will be supplied by the cloud service.
   - The Gateway ID/Path is the unique identifier for this meter. It is supplied by the meter and cannot be changed - the field is display only.
   - Enter the minute interval for sending the catalog (which tells the server which readings will be sent) to the server. Note that since the catalog is sent automatically when the meter starts up, which includes after any changes to the configuration, so you don't need to make this a small interval. GE recommends that you set this value at 1440 minutes, which is once a day.
7. Enter the seconds interval for pushing (sending) the data (meter readings) to the server; e.g., if you enter 300, the meter readings will be sent every 300 seconds. Avoid using very small values for the interval in order to reduce the network traffic. For Billing applications, set this values between 300 and 900 seconds (5 to 15 minutes).

8. Click **Next**. You will see the webpage shown below.



9. In the Data Points webpage, you select the meter readings you want to be pushed (sent) to the cloud server. You can select up to 15 values. The selected data points have a dark circle inside the larger circle. Click on the circle to the left of a meter reading to select it - click again to de-select it.

10. Enter the password: **1Uc!dPu5H**

11. Click **Submit** to save the changes. The Reset Network Card webpage will be shown (the network card must be restarted for the settings to take effect); *Resetting the Ethernet Card* on page 7–13.

7.4.3 NTP Time Server Synchronization

The E1 can be configured to perform time synchronization through a Network Time Protocol (NTP) server. This feature lets you synchronize the EPM 7000P meter's real-time clock with this outside source. See the *GE Communicator Instruction Manual* for configuration instructions (configuring the Network Card section). You can view the manual online by clicking **Help>Contents** from the GE Communicator Main screen.

NOTICE

- The network card works with NTP version 3.0 or 4.0 (autodetect) in client/server mode. Broadcast is not supported in any version.
- After the meter boots up, it may take up to 20 seconds for the first time synchronization request to be made.

7.4.4 Modbus and DNP over Ethernet

The E1 card enables up to 12 simultaneous sockets of Modbus TCP/IP and up to 5 simultaneous sockets of DNP 3.0 over Ethernet. This means that multiple users can poll the meter using Modbus and/or DNP at the same time. For configuration instructions, refer to the Network card settings section of Chapter 26 in the *GE Communicator Instruction Manual*.

Using DNP over Ethernet you can control Relay outputs and Status inputs, if you also have a Relay Output/Status Input Option card installed in your meter.

7.4.5 Keep-Alive Feature

The E1 and E2 Network option cards support user configurable Keep-Alive timing settings. The Keep-Alive feature is used by the TCP/IP layer for detecting broken connections. Once detected, the connection is closed in the Network card, and the server port is freed. This prevents the card from running out of server connections due to invalid links.

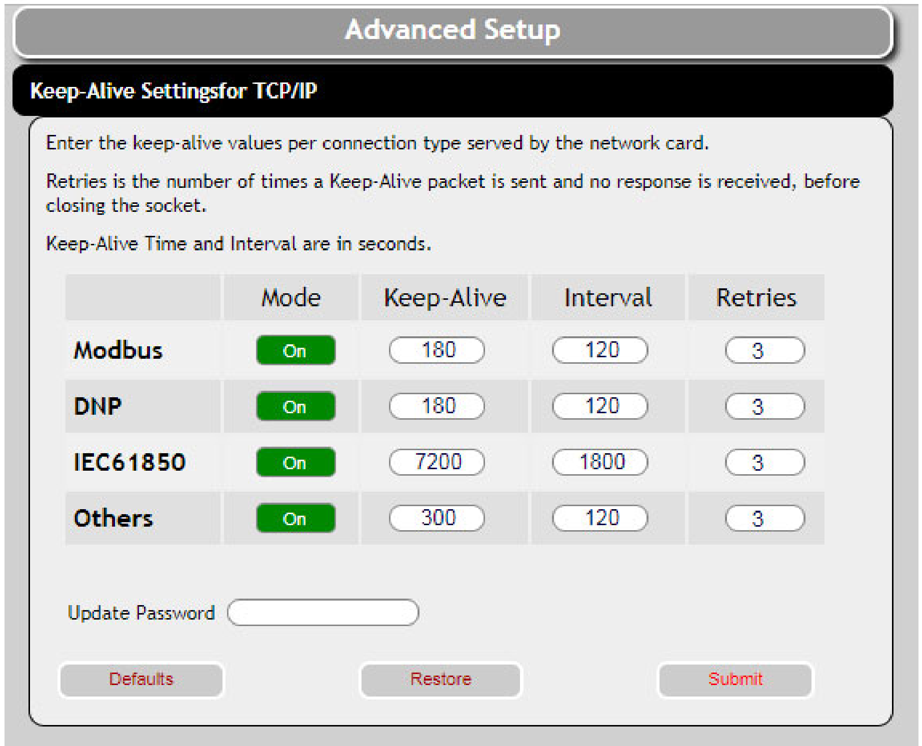
The Keep-Alive settings can be configured differently for each protocol group: Modbus TCP/IP, DNP over Ethernet, IEC61850, and others.

NOTICE

WARNING! Only modify these settings if you are knowledgeable about them, since setting them incorrectly can lead to unstable connections.

To access the Keep-Alive setting screen, key the following into your web browser's address bar:
http://xx.xx.xx.xx/sys/setup_keepalive_ssi.htm

where xx.xx.xx.xx is your E1 card's IP address. You will see the screen shown below.



- You can click on the **On** button to turn off the keep-alive feature for a protocol The button will turn red and say Off.
- For each protocol, you can enter a keep-alive time and interval in seconds.
- For each protocol, you can enter the number of retries, in the event of communication failure, before the communication socket is closed.
- Enter the password (the default is chgK339@).
- Click **Submit** to implement your entries; click Restore to change back to previous settings; click Default to revert to the default system settings.

NOTICE

IMPORTANT! You should not make changes to the settings unless you are sure of what you are doing, since even small changes to the values on this screen can render the network connection unstable. GE is not responsible for instability of the network link when values other than the default are set.

Multilin™ EPM 7000P

Chapter 8: Data Logging

8.1 Overview

Software options B to D give the EPM 7000P meter additional memory for extensive data logging. The EPM 7000P meter can log historical trends, limit alarms, I/O changes, sequence of events, and waveforms (C and D, only). In addition, the meter has a real-time clock that allows all events to be time stamped when they occur.

8.2 Available Logs

The following logs are available for a EPM 7000P meter equipped with Software options B to D. Software option B meters have 2 MB of flash memory for data logging, option C have 10 MB and option D have 128 MB.)

- Historical logs: The EPM 7000P meter has up to six Historical logs. Each log can be independently programmed with individual trending profiles, that is, each can be used to measure different values. You can program up to 64 parameters per log. You also have the ability to allocate available system resources between the logs, to increase or decrease the size of the individual historical logs. See the *GE Communicator Instruction Manual* for additional information and instructions.
- Limit/Alarm log: This log provides the magnitude and duration of events that fall outside of configured acceptable limits. Time stamps and alarm value are provided in the log. Up to 2,048 events can be logged. See the *GE Communicator Instruction Manual* for additional information and instructions.
- I/O Change log: This log is unique to the EPM 7000P meter. The I/O Change Log provides a time-stamped record of any Relay Output/Digital Input or Pulse Output/ Digital Input card output or input status changes. Up to 2,048 events can be logged. Refer to the *GE Communicator Instruction Manual* for additional information and instructions.

- System Events log: In order to protect critical billing information, the EPM 7000P meter records and logs the following information with a timestamp:
  - Demand resets
  - Password requests
  - System startup
  - Energy resets
  - Log resets
  - Log reads
  - Programmable settings changes
  - Critical data repairs

A EPM 7000P meter equipped with Software option C or D has additional memory for data logging: Software option C gives the meter 10 Megabytes of Flash memory, and Software option D gives the meter 128 Megabytes of Flash memory. These meters also have waveform recording capabilities, and the following additional log:

- Waveform log: This event-triggered log records a waveform when a user-programmed value goes out of limit and when the value returns to normal.

All of the EPM 7000P meter logs can be viewed through the GE Log Viewer. Refer to the *GE Communicator Instruction Manual* for additional information and instructions regarding logs and the Log Viewer.

Multilin™ EPM 7000P

Chapter 9: Using the E2 IEC 61850 Protocol Card

9.1 Overview

The EPM 7000P meter can have two optional Ethernet cards (either the E2 or the E1 - see Chapter 7: *Using the Ethernet Card (E1)* on page 7–1, for the E1 card). With the E2 in your EPM 7000P meter, you gain the capability of communicating IEC 61850 Protocol as well as Modbus TCP/IP, over the Ethernet.

9.2 Overview of IEC 61850

When the IEC 61850 Protocol Ethernet Network card (E2) is added to the EPM 7000P meter, the unit becomes an advanced intelligent device that can be networked on a IEC 61850 standard network within an electrical distribution system.

IEC 61850 is a standard for the design of electrical substation automation, including the networking of substation devices. The IEC 61850 standard is part of the International Electrotechnical Commission's (IEC) Technical Committee 57 (TC57). It consists of a suite of protocols (MMS, SMV, etc.) and abstract definitions that provide a standardized method of communication and integration to support intelligent electronic devices from any vendor, networked together to perform protection, monitoring, automation, metering and control in a substation environment. For more information on IEC 61850 go to: http://iec61850.ucaiug.org/.

IEC 61850 was developed to:

- Specify a design methodology for automation system construction.
- Reduce the effort for users to construct automation systems using devices from multiple vendors.
- Assure interoperability between components within the automation system.
- “Future-proof” the system by providing simple upgrade paths as the underlying technologies change.

- Communicate information rather than data that requires further processing. The functionality of the components is moved away from the clients (requesters) toward the servers (responders).

IEC 61850 differs from previous standards in that:

- It specifies all aspects of the automation system from system specifications, through device specifications, and then through the testing regime.
- The IEC 61850 standard specifies a layered approach to the specification of devices. The layered approach allows "future-proofing" of basic functionality by allowing individual "stack" components to be upgraded as technology progresses.
- The individual objects within devices are addressed through a hierarchy of names rather than numbers.
- Each object has precise, standard terminology across the entire vendor community.
- Devices can provide an online description of their data model.
- A complete (offline) description language defines the way all of the parts of the system are handled, giving a consistent view of all components within the system.

The IEC 61850 standard was developed for electrical substation automation, but has been applied to Distributed Energy resources, distribution line equipment, hydro-electric power plants, and wind power plants.

9.2.1 Relationship of Clients and Servers in IEC 61850

The understanding of the roles of clients and servers and publishers and subscribers is key to the use of IEC 61850 devices.

A client is the requester (sink) of information while the server is the responder (source) of information. Information generally flows on a request-response basis with the client issuing the request and the server issuing the response. However, the concept of servers is extended to provide autonomous transmissions when "interesting" events occur within the server. This information flow is always to the client requesting this "interesting information." Clients are the devices or services which "talk" to IEC 61850 servers. The function of the client is to configure the server "connection," set up any dynamic information in the server, enable the reporting mechanisms, and possibly interrogate specific information from the server. Most clients are relatively passive devices which await information from the server but perform little direct ongoing interactions with them except for control operations.

Some clients are used for diagnostic purposes. These devices generally perform ongoing direct interrogation of the servers. A specific example is the "desktop client," where the engineer remotely diagnoses system problems or retrieves data which is not normally sent from the server (for example, power quality information).

IEC 61850 clients are highly inter-operable with IEC 61850 servers. Clients are able to retrieve the server object directory (when needed) and then perform any allowable operation with that server.

Example GE clients include: D400, G500, C264 and aView (DS Agile HMI)

An example of the object model display on a diagnostic client is shown in Figure 9.1

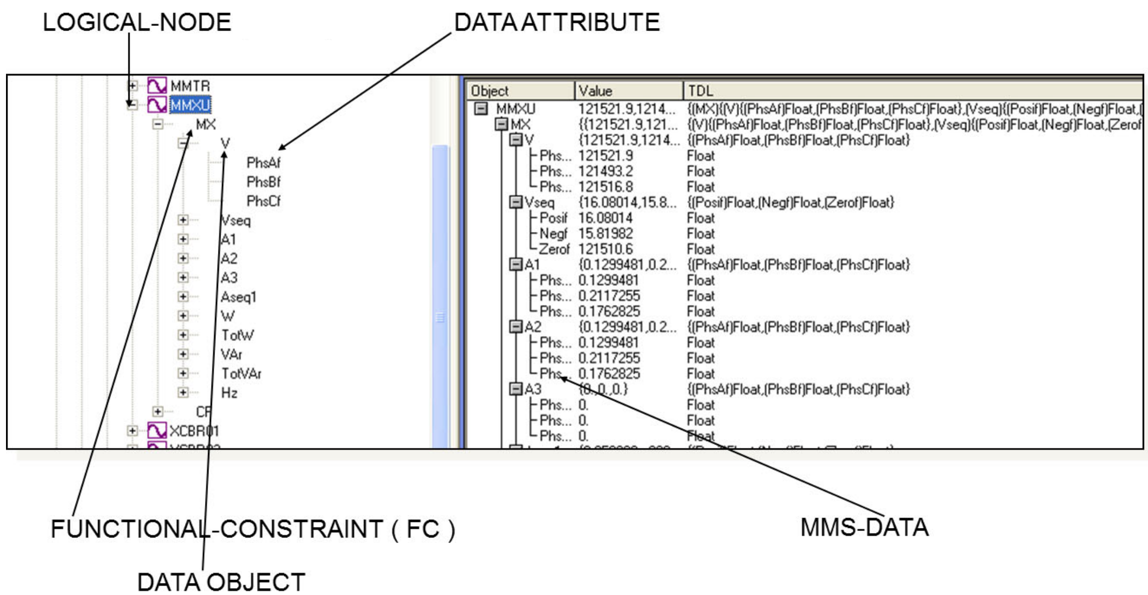


Figure 9-1: Object Model Display on a Diagnostic Browser

NOTICE

There is an additional relationship in IEC 61850, known as publisher and subscriber. The publisher/subscriber relationship differs from the client/server in that there is no explicit one-to-one relationship between the information producer and consumer. Publishers issue data without knowledge of which devices will consume the data, and whether the data has been received. Subscribers use internal means to access the published data. From the viewpoint of IEC 61850, the publisher/subscriber mechanism uses the Ethernet multicast mechanism (i.e. multicast MAC addresses at layer 2). The communication layer of the system is responsible for transmitting this information to all interested subscribers and the subscribers are responsible for accepting these multicast packets from the Ethernet layer. The publish/subscribe mechanism is used for GOOSE and Sampled Value services. Note that GOOSE and Sampled Value services are not available with the EPM 7000P meter's IEC 61850 Protocol Ethernet Network card.

9.2.2 Structure of IEC 61850 Network

As mentioned before, IEC 61850 lets you set up an automated communication structure for devices from any vendor. In order to set up this network, IEC 61850 renames devices (e.g., meters), measured parameters (e.g., Phase to Phase Voltage), and functions (e.g., reporting) into a specific language and file structure. This way all of the elements of the network can function together quickly and effectively. The language that the IEC 61850 network uses is structured, that is it is very specific in how the system information is entered, and hierarchical, which means that it has different levels for specific information; for example, meter information is entered on one level, and the information about the actual physical connection between meters and other hardware is entered on another level.

The structure of the IEC 61850 network is composed of different kinds of files, each containing information that the system needs in order to function. IEC 61850 configuration uses text-based (XML) files known as the System Configuration Language (SCL). SCL files use the concept of an XML schema, which defines the structure and content of an XML file. The schema used by SCL files describes most (though not all) of the restrictions required to ensure a consistent description file. An SCL file superficially looks like an HTML file. It consists of 6 parts:

- Prologue: XML declaration, (XML) namespace declarations, etc.
- Header element: Names the system and contains the file version history
- Substation element: defines the physical structure of the system
- Communication element: defines all device-to-device communication aspects
- IED element: defines the data model presented by each communicating device
- DataTypeTemplates element: contains the detailed definition of data models

After it is written, the XML file can be checked by "validators" against the schema using freely available tools.

The IEC 61850 network uses four types of SCL files, each with identical structure:

- SSD - System Specification Description: used during the specification stage of a system to define physical equipment, connections between physical equipment, and Logical Nodes which will be used by each piece of equipment.
- ICD - IED Capability Description: this is provided by the communication equipment vendor to specify the features of the equipment and the data model published by the equipment. Each of the devices in the network has an ICD file which describes all of the information about the device, for example, IP address on the network and Com ports. The (vendor supplied) ICD variation of the SCL file contains a Communication section specifying the lower-layer selectors and default addressing and also an IED section containing the data model of the device. See *Configuring the Meter on the IEC 61850 Network* on page 9–14, for information on the EPM 7000P meter's .icd file.
- SCD - System Configuration Description: a complete description of the configured automation system including all devices (for example, meters, breakers, and relays) and all needed inter-device communications (for example, the measured parameters and the actions to be performed, such as turning on a relay when a certain reading is obtained). It can also include elements of the SSD file. The SCD file is created by a System Configurator, which is a software application that takes the information from the various devices along with other configuration parameters and generates the SCD file.

- CID - Configured IED Description: the file used to configure an individual device. It is a pure subset of the SCD file. The device may also have a CID file, which is a smaller subset of the devices ICD file. The CID file describes the exact settings for the device in this particular IEC 61850 network. The EPM 7000P meter's IEC 61850 Protocol Ethernet Network card uses a CID file. See *Configuring the Meter on the IEC 61850 Network* on page 9–14, for information on uploading the EPM 7000P meter's .cid file.

Each type of SCL file has different required elements with only the prologue and Header element required in every file type.

Elements of an IEC 61850 Network

- A physical device has a name (IEDname) and consists of one or more AccessPoints.
- An AccessPoint has an IP address and consists of one or more Logical Devices
- A Logical Device contains LLN0 and LPHD1 and optional other Logical Nodes.
- LLN0 (Logical Node Zero) is a special object which "controls" the Logical Device. It contains all of the datasets used for unsolicited transmission from the device. It also contains the report, SV, and GOOSE control blocks (which reference the datasets).
- LPHD1 (Physical Device) represents the hardware "box" and contains nameplate information.
- Logical Nodes (LNs) are standardized groups of "Data Objects" (DOs). The grouping is used to assemble complex functions from small groups of objects (think of them as building blocks). The standard defines specific mandatory and optional DOs for each LN. The device may instantiate multiple LNs of the same type differentiated by either a (named) prefix or (numerical) suffix.
- Data Objects represent "real-world" information, possibly grouped by electrical object. The IEC 61850 standard has specific semantics for each of the DOs. For example, the DO named "PhV" represents the voltage of a point on a three-phase power system. The DOs are composed of standardized Common Data Classes (CDCs) which are groups of low-level attributes of the objects. For example, the DO named "Hz" represents system frequency and is of CDC named "MV" (Measurement Value).
- Common Data Classes (CDCs) consists of standardized groups of "attributes" (simple data types). For example, the attribute "instMag" represents the instantaneous magnitude of the underlying quantity. The standard specifies mandatory and optional attributes for each CDC. For example, the DO named "Hz" in Logical Node class MMXU contains a mandatory attribute named "mag" which represents the deadbanded value of the frequency. The physical device contains a database of data values which map to the various structures described above. The database values are manipulated by the device to perform actions such as deadbanding (holding a constant value until the underlying value changes by more than a specified amount) or triggering of reports.

Steps in Configuring an IEC 61850 Network

1. The first thing needed is the SSD for physical connections, then the vendor-provided ICD files which are combined into a SCD file by a vendor-independent System Configurator. The System Configurator assigns addresses to the equipment and sets up datasets, reports, etc. for inter-device communication. The system configurator will create an "instance" of the configured device by applying the following information:
    - The name of the device

- The IP address, subnet mask, and IP gateway of the device
- Datasets: the user must decide which information within the IED will be included in reports, etc. and place this information into datasets. The System Configurator should allow the selection of information using a "pick list" from information within the ICD file.

2. The resulting SCD file is then imported by vendor-specific tools into the various devices.

   Some vendors add the additional step of filtering the SCD file into a smaller file containing only information needed by the specific device, resulting in a CID file which is used to configure the device. The actual configuration of the device is left unspecified by IEC 61850 except to require that the SCD file remains the source of the configuration information. In this way, consistency of the information across the whole system is maintained.

   See Figure 9.2 for a graphical illustration of the process.

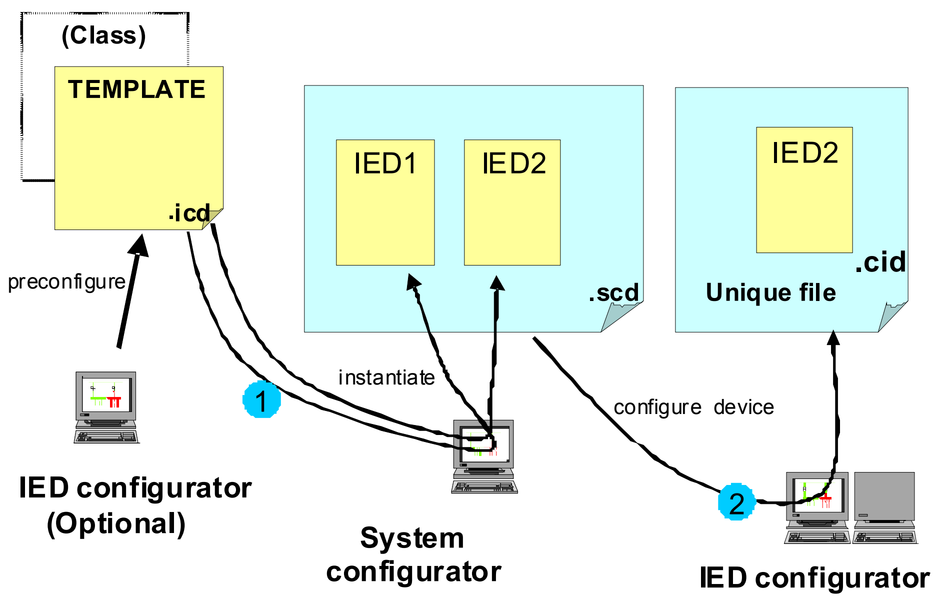


Figure 9-2: Configuration Process

Referring to Figure 9.2:

In step 1, the IED template is provided by the vendor (or sometimes created by a vendor tool). This file is imported into the vendor-independent tool, the System Configurator, along with other device templates. The System Configurator uses these templates to set up the correct number of IEDs in the system and then provides configuration information. The configuration information consists of providing addresses for all IEDs in the system, creation of datasets, configuring control blocks, and setting individual device parameters such as analog deadbands. The System Configurator then creates a SCD file with a consistent view of the entire system.

In step 2, the SCD file is used to configure each device using vendor-supplied tools. Vendors are free to choose the configuration mechanism, but the configuration information MUST be derived from the SCD file.

NOTICE

In the EPM 7000P meter's IEC 61850 Protocol Ethernet network card implementation, every service and object within the server is defined in the standard (there is nothing non-standard in the device).

Also in step 2, the user sets up report control blocks, buffered and unbuffered, for each of the clients. Setup information includes the dataset name, a report identifier, the optional fields to be used in the report, the trigger options, buffer time (delay from first event to report issuance), and integrity time (server periodic reports of all data in dataset). The decision whether to use buffered or unbuffered must be decided by the user.

Finally, in step 2 the System Configurator performs a consistency check and then outputs the SCD file. The SCD file is imported by the "ScdToCid" (this is an example, only) tool where the user specifies the device name.

The resulting CID file is then imported into the target device.

9.2.3 GE's Implementation of the IEC 61850 Protocol Server

Following are features of GE's IEC 61850 implementation:

- The lower-level addressing uses PSEL=00000001, SSEL=0001, and TSEL=0001.
- At the server level, each implements a single Logical Device name formed by concatenating the IED name (chosen by the System Configurator) and "Meas" (ex, "MyDeviceMeas").
- The Logical Nodes implemented within the Logical Device include the standard LLN0 and LPHD1 with optional standard logical nodes in the "M" class (ex, "MMXU") and "T" class (ex, "TVTR"). Each Logical Node contains only standardized objects of standardized types (Common Data Class, CDC). The device is based upon the first edition of the IEC 61850 standards.
  Examples of Logical Nodes within the EPM 7000P family include eneMMTR1 (energy metering) and nsMMXU1 (normal speed Measurement Unit).
- The EPM 7000P device will get its IED name from the first <IED> section in the configuration file (.cid). This name will be used for accessing its access point (IP address) and its single Logical Device named "Meas". The IED name can be composed of any string of up to 32 (alphanumeric only) characters.
- The logical nodes implemented in the EPM 7000P meter are listed below:
  - The node "LLN0" keeps common information for the entire logical device. In this node Datasets and Reports can be defined, based on the limitations provided in the ICD file: the EPM 7000P meter supports up to 8 datasets with up to 256 attributes, and up to 16 report control blocks. The report control blocks and datasets must be configured in the CID file, although the options, triggers and integrity period can be dynamically configured by IEC client. (The EPM 7000P meter does not support Goose or Journals.)
  - The node LPHD1 defines physical parameters such as vendor, serial number, device name plate and the software revision number.
  - The node "nsMMXU1" contains the "normal-speed" basic electrical measurements such as Volts / Amps / Watts / VARs / Frequency / Power Factor / etc. The electrical measurements are data objects in hierarchical structure as per the IEC 61850 specifications.
    For example, Phase A voltage:

- which is in the object "PhV"
- which is of type "WYE_ABC_mag_noDC"
- which in turn has the object "phsA"
- which again has an attribute named "instVal" to represent instantaneous values, and also the "mag" attribute, which represents the magnitude as an analog magnitude, with the attribute "f" to get the value in 32-bit floating point.

Thus the voltage of phase A, would be referred in this nested structure as "Meas/nsMMXU1.PhV.phsA.instVal.mag.f".

- The node "nsMHAI1" groups together the THD per phase measurements taken at normal speed.
  Following the previous example, the THD for phase A would be referred as "Meas/nsMHAI1.ThdPhV.phsA.instCVal.mag.f".
- The node "eneMMTR1" groups together all measurements related to energy counters, like +/- Watt;hours, +/- VAr-hours and Total VA-hours.
- The nodes "setTCTR1", "setTCTR2", "setTCTR3" and "setTCTR4" contain the ratio of the current used by the measuring device, for phases A,B,C and Neutral, respectively. In this way, the user can take the IEC measurements (primary) and convert them to Secondary using the ratios contained in these nodes.
- The nodes "setTVTR1", "setTVTR2" and "setTVTR3" contain the ratio of the voltage used by the measuring device.

- Any of the defined objects/ attributes can be placed within a dataset.
- The normal-speed in the EPM 7000P meter is measurements taken every second. The energy counters are also updated every second.

The configuration of the devices takes place by converting the SCD file exported by the System Configuration tool into a CID file. This CID file contains all of the information from the SCD file which is needed for configuration by the GE device. The tool is named "SCDtoCIDConverter" and is a simple, publicly available program. The resulting CID file is then sent to the GE device using HTTP file transfer.

EPM 7000P Server Configuration

The configuration file (CID) should be stored in the EPM 7000P meter in order to configure the server. At power up the server reads the file, parses it and configures all the internal settings for proper functionality.

Storing the CID file in the EPM 7000P meter is accomplished through its webpage. The webpage allows the user to locate the CID file, and submit it to the EPM 7000P meter for storage.

The EPM 7000P meter does not need to be reset in order to accept the new configuration, unless the IP address has been changed.

After storing the CID file, access the EPM 7000P meter’s webpage again, to make sure that the file has been stored, and to see if there is any problem with it, by checking its status.

- A common problem you may see is IP mismatch (the IP address in the CID file does not match the IP configured in the EPM 7000P meter’s device profile). In this case the EPM 7000P meter will use the IP address from its device profile, and the IEC Server will work only with that address.

- If there is a critical error in the stored CID file, which prevents the IEC Server from running, the CID file will not be used, and instead the Default CID file (embedded in the server) will be used. The webpage will alert you to this situation.
- If further details are needed, for example, information on the reason the CID storage failed, the web server provides a link to the system log. In the system log screen you can view messages from the IEC 61850 parser, and you can take actions to correct the error.

See 9.3.3 *Configuring the IEC 61850 Protocol Ethernet Network Card* on page 9–11, for instructions on configuring the EPM 7000P meter's IEC 61850 Protocol Ethernet Network card.

9.2.4 Reference Materials

Following is a list of background information on IEC 61850 that is available on the Internet:

- http://www.sisconet.com/downloads/IEC61850_Overview_and_Benefits_Paper_General.pdf
- http://www.sisconet.com/downloads/CIGRE%202004%20Presentations.zip (IEC618650 Presentation IEC 61850 Data Model and Services.pdf)
- http://www.ucaiug.org/Meetings/Austin2011/Shared%20Documents/IEC_61850-Tutorial.pdf (pages 24-32 and 40-161)
- http://brodersensystems.com/wordpress/wp-content/uploads/DTU-Master-Thesis-RTU32.pdf (pages 9-36)

Additionally, there is a good article on the predecessor to IEC 61850 (UCA 2.0) at http://www.elp.com/index/display/article-display/66170/articles/utility-automation-engineering-td/volume-5/issue-2/features/uca-20-for-dummies.html.

Another good article on multi-vendor IED integration can be found at http://www.gedigitalenergy.com/smartgrid/Aug07/EIC61850.pdf.

9.2.5 Free Tools for IEC 61850 Start-up

The Internet also provides some free IEC 61850 configuration tools:

- Schema validation tools: http://notepad-plus-plus.org/
  go to plug-in manager and install XML tools (however, there is no (legal) public copies of the schema available). However, a web search file the filename SCL_Basetypes.xsd turns up many copies and the entire set of XSD file is often nearby.
- http://opensclconfig.git.sourceforge.net/
  Apparent open-source project, not tested
- An application for SCDtoCIDConverter application can be found at http://www.sisconet.com
- An application for SCDtoCIDConverter application can be found at http://www.sisconet.com

9.2.6 Commercial Tools for IEC 61850 Implementation

The following lists GE clients for IEC 61850 configuration which you can purchase:

- D400
- G500
- C264
- aView (DS Agile HMI)

9.3 Using the IEC 61850 Protocol Ethernet Network Card

This section contains instructions for understanding and configuring the EPM 7000P meter's IEC 61850 Protocol Ethernet Network Option card.

9.3.1 Overview

The IEC 61850 Protocol Ethernet Network card is a EPM 7000P standard Option card. The IEC 61850 Protocol Ethernet Network card has the following features:

- Standard Ethernet 10/100 Mbps connector is used to link the unit into an Ethernet network.
- Standard operation port 102, which can be reconfigured to any valid TCP/IP port.
- Up to 5 simultaneous connections can be established with the unit.
- Configurable via the .CID file (XML formatted)
- Embedded Capabilities File (.ICD downloadable from the unit)
- Supports MMS protocol.
- Supports the following Logical Nodes:
  - LLN0 (with predefined Sets and Reports)
  - LPHD (Identifiers)
  - MMXU with
    - Phase-to-N Voltages
    - Phase-to-Phase Voltages
    - Phase Currents
    - Per Phase VA
    - Total VA
    - Per Phase Var
    - Total Var
    - Per Phase W
    - Total W
    - Per Phase PF
    - Total PF
    - Frequency
  - MHAI with Per Phase THD
  - MMTR with
    - Demand Wh

    - Supplied Wh
    - Demand Varh
    - SuppliedVArh
    - Total VAh
- Supports polled (Queried Requests) operation mode.
- Supports Buffered Reports
- Supports Unbuffered Reports

9.3.2 Installing the IEC 61850 Protocol Ethernet Network Card

The IEC 61850 Protocol Ethernet Network card can be installed in either Option card slot #1 or slot#2. Make sure the EPM 7000P unit is powered down when installing the IEC 61850 Protocol Ethernet Network card. Follow the procedure in Chapter 10.

Connect the network card to a Hub/Switch with a Cat5 Ethernet cable. Both ends must be firmly placed in the RJ45 receptacles.

Turn on the EPM 7000P unit. After about 10 seconds, the Link LED near the RJ45 Ethernet connector on the IEC 61850 Protocol Ethernet Network card will light, which means a link has been established to your network, and the EPM 7000P meter has correctly identified the IEC 61850 Protocol Ethernet Network card. (The first time you connect, it may take up to one minute for the link to be established.)

9.3.3 Configuring the IEC 61850 Protocol Ethernet Network Card

You need to configure the IEC 61850 Protocol Ethernet Network card for communication, both from the standpoint of the device (the Device Profile) and of the network (the SCL configuration file, which is a .cid file uploaded to the meter.)

Configuring the Device Profile IEC 61850 Protocol Ethernet Network Card Settings

You use the GE Communicator application to set the card's network parameters. Basic instructions are given here, but you can refer the *GE Communicator Instruction Manual* for additional information. You can view the manual online by clicking **Help > Contents** from the GE Communicator software main screen.

- You will need the following information:
- The IP address to be assigned to the card
- The Network Mask used on your network
- The IP address of the Gateway on your network (you can use 0.0.0.0 if you don't have a gateway IP address)
- The IP address of the DNS (Domain Name Server) on your network (only needed if you plan to use URLs instead of IP addresses for the NTP (Network Time Protocol); if not needed you can leave this field blank)
- The IP address of the NTP server on your network, or the URL if you configured the DNS in the previous entry field.

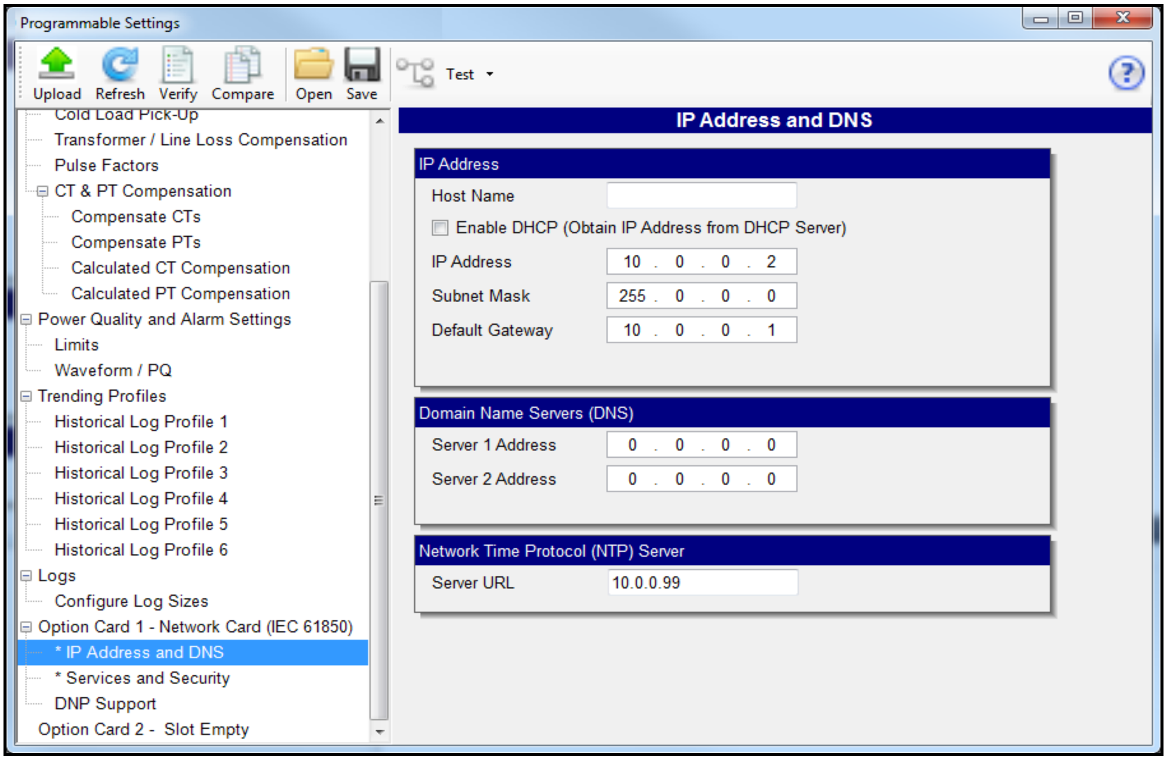
NOTICE

The network card supports NTP version 3.0 or 4.0 (autodetect) in client/server mode. Broadcast is not supported in any version.

1. Using GE Communicator software, connect to the meter through its RS485 serial port, or through an E1 Network Card if one is installed in the other Option card slot (see the *GE Communicator Instruction Manual* for instructions).

2. Click the Profile icon to open the meter's Device Profile screen The profile is retrieved from the EPM 7000P meter.

3. From the Tree menu on the left side of the screen, click on the + sign next to the IEC 61850 Protocol Ethernet Network Option card (Option Card 1 or Option Card 2), then click **Comm > Network > IP Addresses and DNS**.

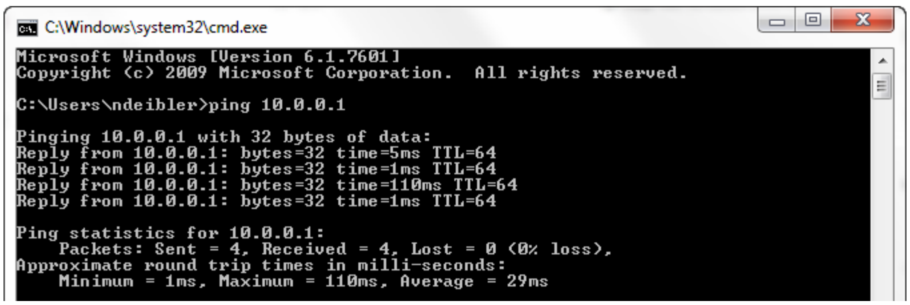


4. Fill in the information on this screen.
   - Host Name: the name of the device on the network (accessed through the Network card)
   - IP Address: the IP v4 address for the unit on the network.
   - Subnet Mask: the IP v4 mask, which identifies the sub-network to which the unit belongs.
   - Default Gateway: the IP v4 address of the gateway device on the network.
   - Domain Name Server 1 and 2: if DNS is used, the IP addresses of the DNS server(s) on the network.
   - Network Time Protocol (NTP) Server: if you are using NTP time synchronization, enter the IP address or url of the NPT server.

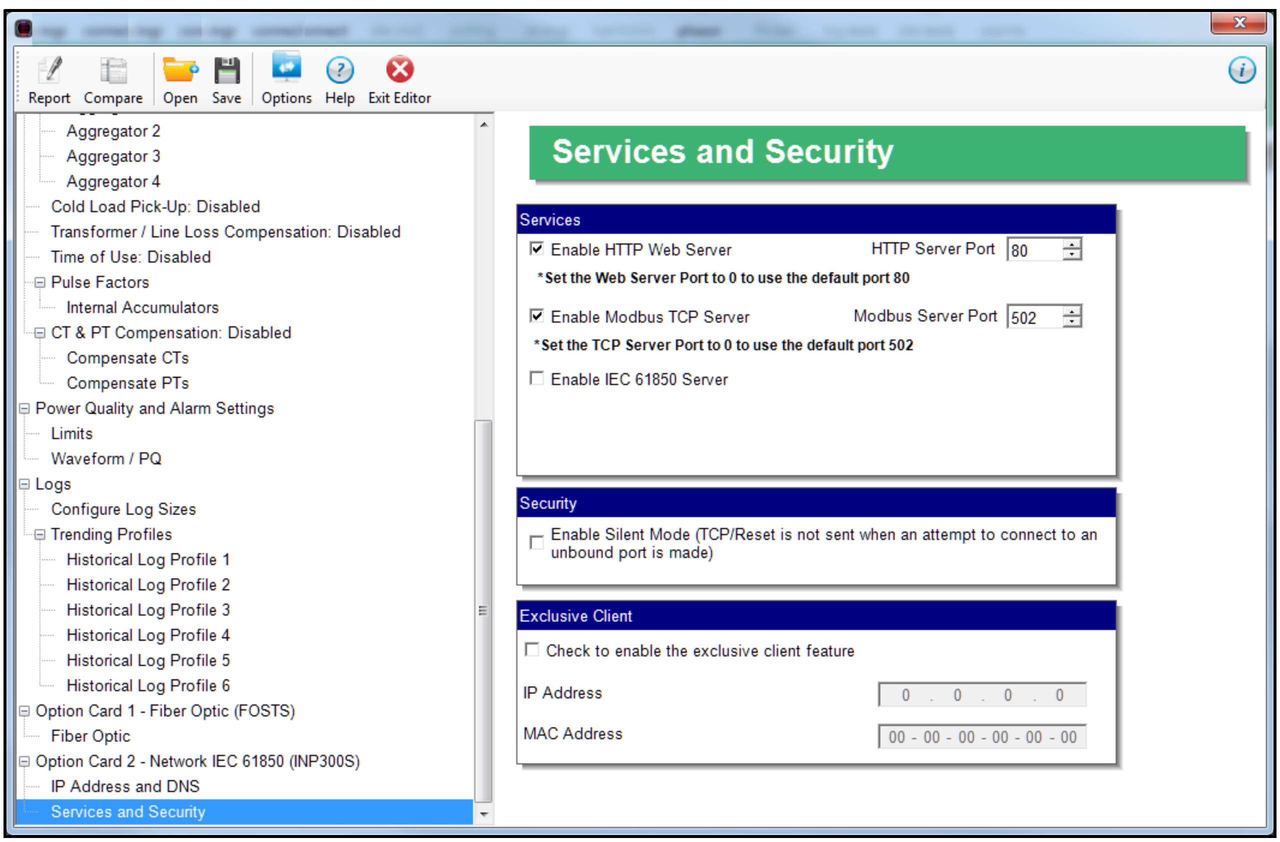
NOTICE

- The IEC 61850 Protocol Ethernet Network card needs time information to work properly. The time can be provided either by a Network Time Protocol (NTP) server or by the EPM 7000P meter itself (via Line Sync, which is selected and enabled through the Time Settings screen). If you enter an NTP server on this screen, you still need to enable it in the Time Settings screen (see the *GE Communicator Instruction Manual* for instructions).

- All of these parameters must be properly set up in order to allow the EPM 7000P meter to communicate on the network. After configuration, a simple "ping" test can be performed to see if the EPM 7000P meter is correctly connected to the network:
  - From the Start menu, type **run** and press Enter.
  - In the Run window, type **cmd** and click OK.
  - In the command window type **ping *Network Card's IP address***. See the example screen below.



5. From the Tree menu, click Services and Security.



6. Check the Enable HTTP Web server box, and set the Web server port to 80 (this is the default).

7. Click the Enable IEC 61850 Server box.
8. Click Update Device to send the settings to the EPM 7000P meter. The meter will reboot. The IEC 61850 Protocol Ethernet Network card is now configured properly to work on an IEC 61850 network.

Configuring the Meter on the IEC 61850 Network

The System Integrator must configure the EPM 7000P meter within the substation IEC 61850 network. To do this, the System Integrator needs the EPM 7000P capabilities file (.icd) (as well as information about the rest of the devices in the network).

This .icd file, as mentioned earlier, is the SCL file that contains the IEC 61850 nodes, objects, and parameters implemented in the EPM 7000P meter, including the Network IP address.

This .icd file will be processed with the rest of the system (clients, other meters, switches, breakers, etc., in the network) and the resulting file, which will be uploaded to the meter to configure it, is the Configured IED Description file (.cid file).

The IP address for the EPM 7000P meter is contained in the Communication section of this .cid file. See the example Communication section, below.

NOTICE

If the CID file to be uploaded has more than one IED definition block, the EPM 7000P meter will take the first one in the file.

<Communication>

<SubNetwork name="Subnet_MMS" type="8-MMS">

<BitRate unit="b/s" multiplier="M">10</BitRate>

<ConnectedAP iedName="EPM7000PIEC" apName="S1">

<Address>

<P type="OSI-PSEL" xsi:type="tP_OSI-PSEL">00000001</P>

<P type="OSI-SSEL" xsi:type="tP_OSI-SSEL">0001</P>

<P type="OSI-TSEL" xsi:type="tP_OSI-TSEL">0001</P>

<P type="IP" xsi:type="tP_IP">172.20.167.199</P>

</Address>

</ConnectedAP>

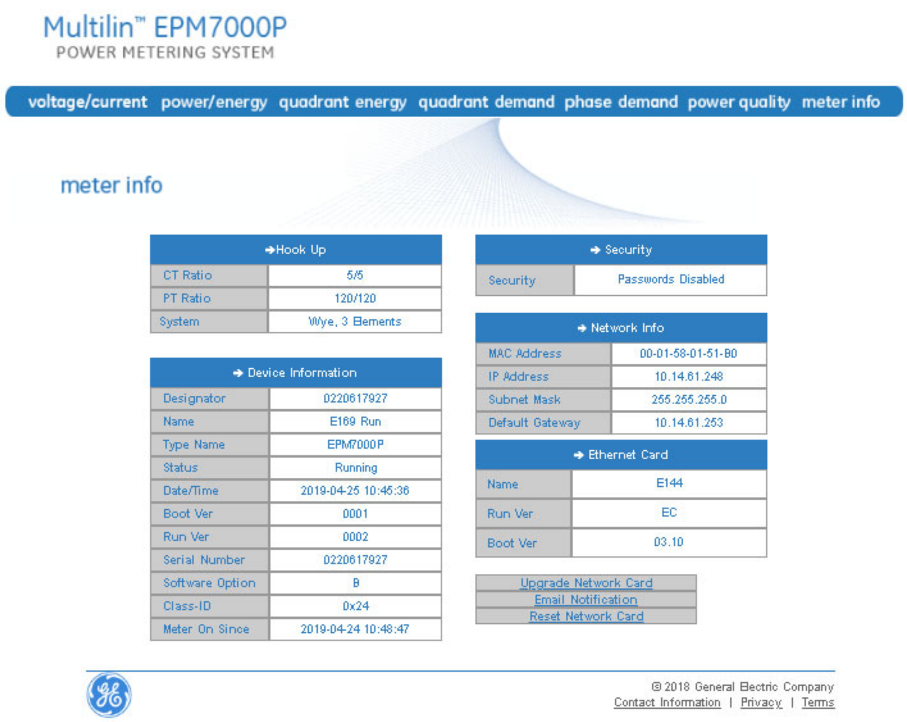
</SubNetwork>

</Communication>

The node <P type="IP" xsi:type="tP_IP"> (bolded in the example above) defines the meter's IP address. This IP address **must** be the same as the IP address configured in the meter's Device Profile (see *Configuring the Device Profile IEC 61850 Protocol Ethernet Network Card Settings* on page 9–11) for each IEC 61850 Protocol Ethernet Network card in the meter.

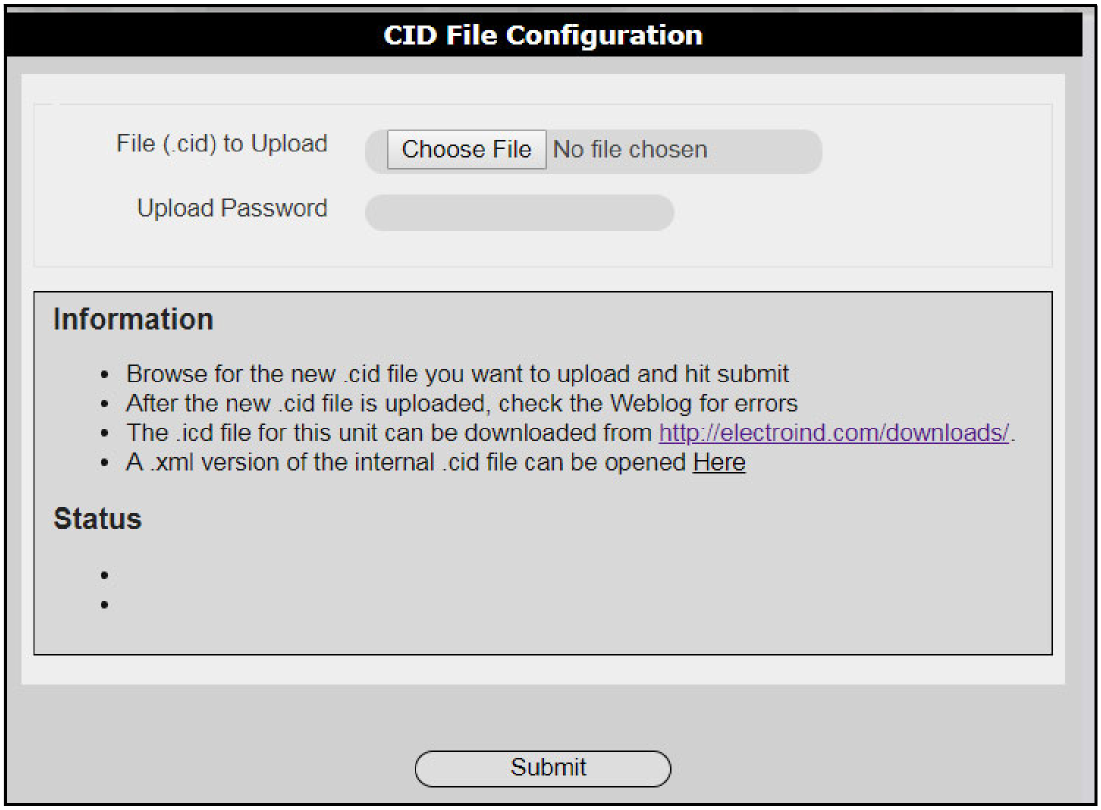
Also, make sure that the iedName field in the ConnectedAp section (underlined in the example) is the same as the name field defined in the IED section. This is how the unit is assigned its name and IP address.

1. The EPM 7000P meter's .icd file can be downloaded directly from the EPM 7000P unit. To do this, use a web browser and enter: http://aa.bb.cc.dd/, where aa.bb.cc.dd is the IP address assigned to the IEC 61850 Protocol Ethernet Network card (see 9.5 *Upgrading the E2 Card's Firmware* on page 9–19).



The Information webpage is displayed.

2. From the left side of the screen, click CID File.



3. The Information area contains instructions for downloading an xml version of the ".icd" file. Right-click the "Here (right click to "Save As")" link, and save a copy of the .icd file on your computer. An example of a downloaded .icd file is shown below.


```
<?xml version="1.0" encoding="UTF-8"?>

<SCL xmlns="http://www.iec.ch/61850/2003/SCL" xmlns:xsi="http://www.w3.org/
2001/XMLSchema-instance" xsi:schemaLocation="http://www.iec.ch/61850/2003/
SCL SCL.xsd" xmlns:ext="http://nari-relays.com">

<Header id="EPM 7000P ICD" nameStructure="IEDName" version="1.0" revision="">

 <History>

  <Hitem version="0.1" revision="13" when="9-May-2012" who="BAM" what="initial
draft" why="initial ICD">

  </Hitem>

 </History>

</Header>

<Communication>

 <SubNetwork name="Subnet_MMS" type="8-MMS">

  <BitRate unit="b/s" multiplier="M">10</BitRate>

  <ConnectedAP iedName="EPM7000PIEC" apName="S1">

   <Address>
```

```
        <P type="OSI-PSEL" xsi:type="tP_OSI-PSEL">00000001</P>
        <P type="OSI-SSEL" xsi:type="tP_OSI-SSEL">0001</P>
        <P type="OSI-TSEL" xsi:type="tP_OSI-TSEL">0001</P>
        <P type="IP" xsi:type="tP_IP">10.0.0.24</P>
       </Address>
     </ConnectedAP>
   </SubNetwork>
 </Communication>
 <IED name="EPM7000PIEC" desc="GE EPM 7000P" type="EPM7000P"
 manufacturer="GE" configVersion="1.00">
  <Services>
   <DynAssociation/>
```

4. Once the System Integrator has processed the EPM 7000P meter's .icd file and the information of the other devices on the network (using either automated tools or manually), the final result is a configuration file with the extension ".cid". This file must now be uploaded to the EPM 7000P meter's IEC 61850 Protocol Ethernet network card.
5. To upload the .cid file, go to the IEC 61850 File Configuration screen shown in step 2.
6. Click the **Browse** button to locate the .cid file you want to upload.
7. Fill in the upload password (the default is **n3tUp!0Ad**).
8. Click **Submit**. The upload process begins. When the upload is finished a report is shown on the screen.

NOTICE

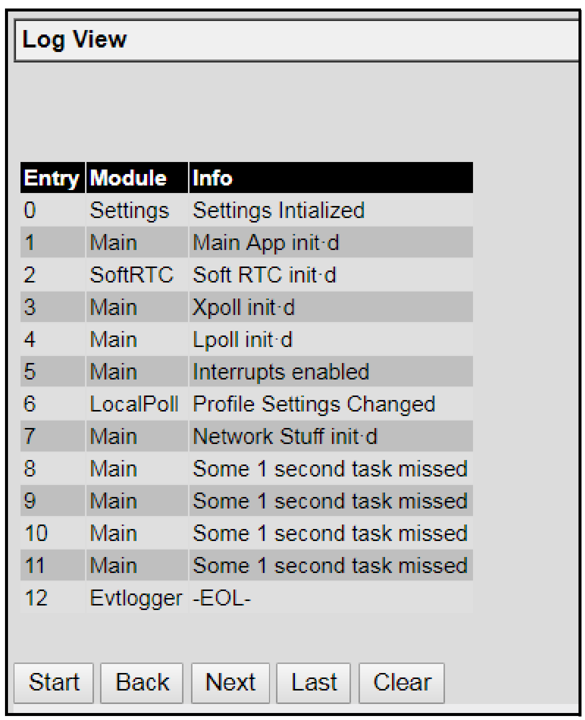
- The IP address configured into the IEC 61850 Protocol Ethernet Network card with the GE Communicator software **must be the same** as the IP address configured in the .cid file. This is necessary to insure proper communication. If there is a communication problem it will be reported on the IEC 61850 Protocol Ethernet Network card's Meter Information screen, shown in step 1 on page 9-22.
- The maximum size of the .cid file is 250KB. Avoid putting too many comments or unnecessary historical information into the file. If the file is bigger than 250KB it will be rejected by the IEC 61850 Protocol Ethernet Network card.
- The sAddr fields in each object of the .icd file must be preserved when generating the .cid file. **Do not change these,** because they are used internally by the IEC 61850 server.
- If the .cid file has more than one IED definition block, the first one in the file will be used by the network.
- Do not use non-ASCII characters in your .cid file (such as punctuation marks). Non-ASCII characters can cause the parsing of the .cid file to fail.
- You do not need to reboot the Network Card or the EPM 7000P meter when the .cid file is uploaded, unless the IP address has changed.
- If the uploaded .cid file has non-critical errors, the IEC 61850 Protocol Ethernet Network card will use the file anyway and will start up. Any errors can be seen in the Start Up log (see following instructions).

- If the uploaded .cid file has critical errors, the IEC 61850 will use the default .cid file (not the uploaded file) and it will start up. The errors can be seen in the Start Up log (instructions follow). If the card does not start up see 9.9 *Additional Important Information* on page 9–22.
- The default .cid in the E2 card is for demonstration only. It must be modified to suit the actual application needs.
- The default .cid in the E2 has the arbitrary IED name of EPM7000PIEC, which must be replaced by the user's own name.

9.4 Viewing the E2 Card's System Log

The IEC 61850 Protocol Ethernet Network card's main webpage (Information webpage) has general information on the status of the card (e.g., version, healthy, serial number) and the status of the IEC 61850 server (e.g., ok, errors in the uploaded .cid file).

In addition to this information there is a System log, which contains events (e.g., errors and warnings) from the IEC 61850 protocol layer, including problems found when parsing the .cid file. To view the System log's webpage, click Log View from the left side of the Information webpage.

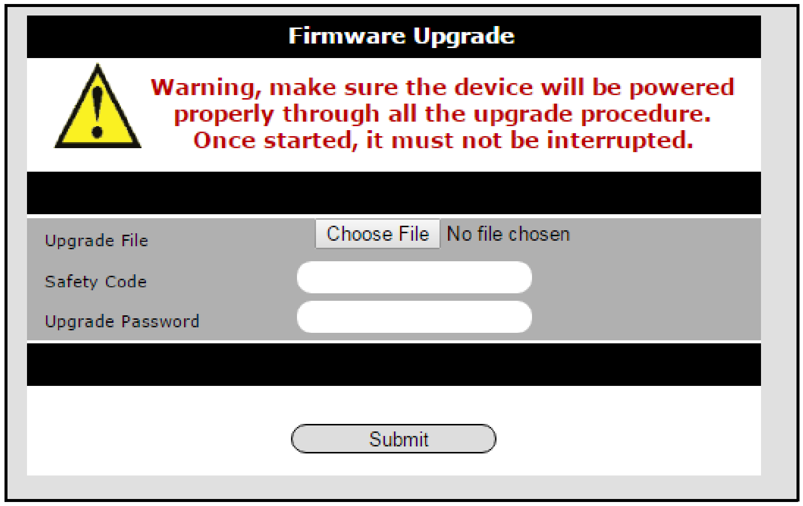


Entry	Module	Info
0	Settings	Settings Intialized
1	Main	Main App init·d
2	SoftRTC	Soft RTC init·d
3	Main	Xpoll init·d
4	Main	Lpoll init·d
5	Main	Interrupts enabled
6	LocalPoll	Profile Settings Changed
7	Main	Network Stuff init·d
8	Main	Some 1 second task missed
9	Main	Some 1 second task missed
10	Main	Some 1 second task missed
11	Main	Some 1 second task missed
12	Evtlogger	-EOL-

You will see a screen similar to the one shown above. Oldest messages appear first on the screen. The buttons at the bottom of the screen let you navigate through the message pages (Start, Back, Next, Last) or remove all of the messages (Clear).

9.5 Upgrading the E2 Card's Firmware

To upgrade the IEC 61850 Protocol Ethernet Network card's firmware, click Upgrade Firmware from the bottom of the Information webpage.



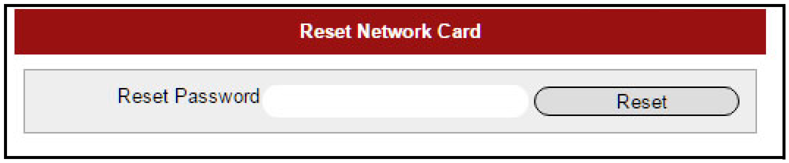
You will see a screen similar to the one shown above.

1. Click the Browse button to locate the Upgrade file. Make sure that you select the E2 option card upgrade file. If you upgrade with the E1 upgrade file, the card will work, but most IEC 61850 features will be disabled. In that case, perform the upgrade again, using the correct E2 upgrade file.
2. Enter the Safety Code.
3. Enter the Upgrade Password (the default is **n3tUp!0Ad**).
4. Click Submit. Be sure to keep the meter powered during the firmware upgrade. After the upgrade process is complete, the Network card will reset.
   NOTE: As a result of the reset, the communication link with the card will be lost and must be re-established.

9.6 Resetting the E2 Network Card

If you need to reset the IEC 61850 Protocol Ethernet Network card, you can either do a hardware reset (see *Resetting the Ethernet Card* on page 7–13) or use the Reset Network Card webpage.

1. Click Reset Network Card from the bottom of the Information webpage.



2. You will see a screen similar to the one shown above. Enter the Reset Password (the default is **adminR35et**).
3. Click the Reset button. The Network card will reset.

NOTICE

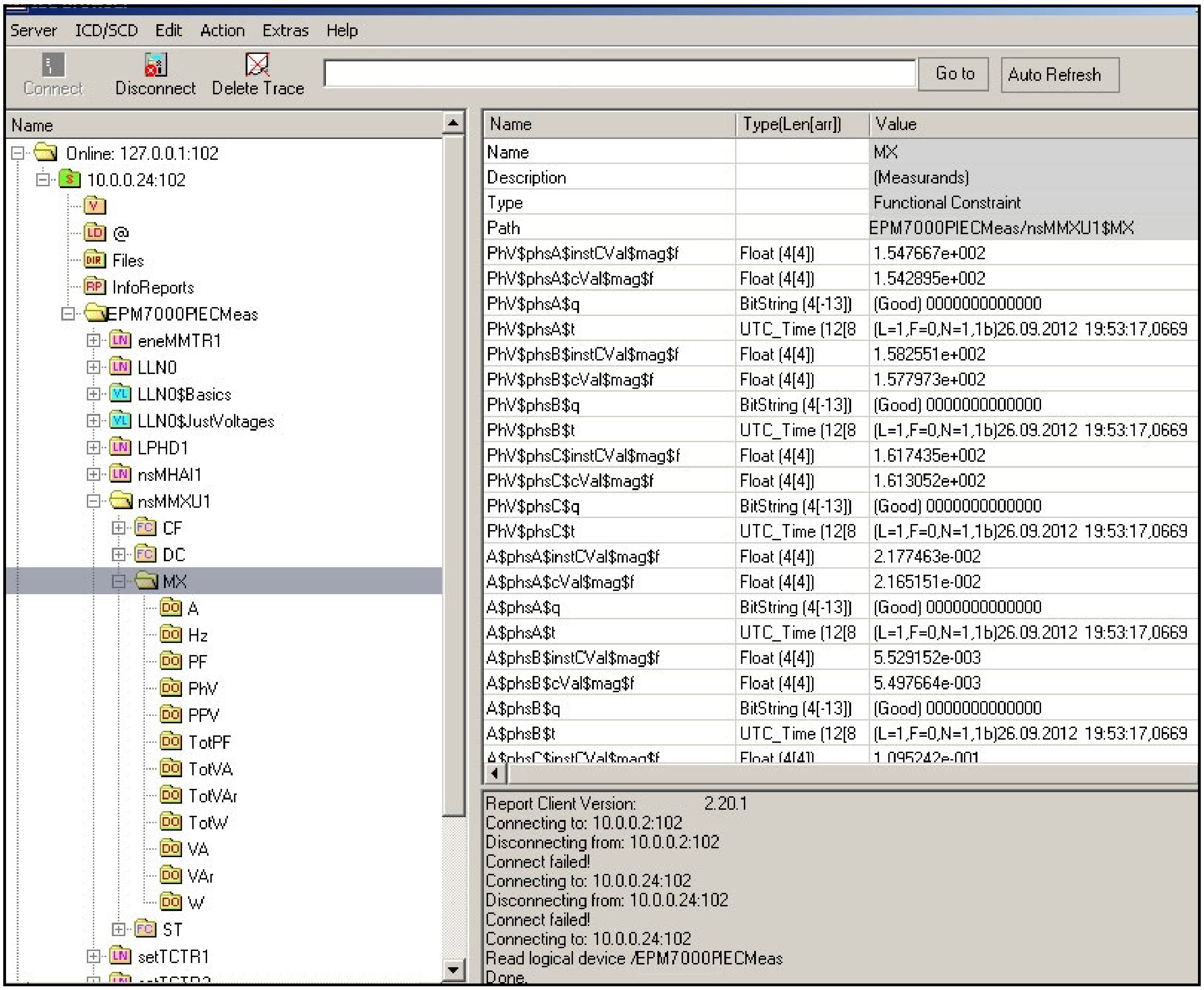
As a result of the reset, the communication link with the card will be lost and must be re-established.

9.7 Keep-Alive Feature

The E2 card supports user configurable Keep-Alive timing settings. The Keep-Alive feature is used by the TCP/IP layer for detecting broken connections. Once detected, the connection is closed in the Network card, and the server port is freed. This prevents the card from running out of server connections due to invalid links. See 7.4.5 *Keep-Alive Feature* on page 7–22, for instructions on configuring this feature.

9.8 Testing

You can use any IEC 61850 certified tool to connect to the EPM 7000P meter and test out the IEC 61850 protocol (see example screen below). There are numerous commercial tools available for purchase.



9.9 Additional Important Information

The E2 card has the ability to process and analyze the uploaded .cid file, which gives added functionality to the its IEC 61850 implementation, but is not intended as a validation tool. Even though some errors in the .cid file can be detected, EIG recommends that you use an external validation tool before uploading a new .cid file.

This is especially important when changes have been made to the object type definitions.

Some errors in type definitions might put the E2 card's parser into a critical state, block the IEC 61850 server start up, and possibly even block the Web server. If this situation occurs and the IEC 61850 server and Web server become unresponsive, follow these recovery steps:

1. Disable the IEC 61850 server in the meter profile.
2. Make sure the Web server is enabled in the meter profile.
3. Restart the meter.
4. Upload a corrected .cid file using the Web server.
5. Re-enable the IEC61850 server in the meter profile.

9.10 Error Codes

The following table lists possible Error codes you will see if there is a problem uploading a .CID file, along with the meaning of the code and the action required to correct the error.

Code	Name	Description	Required Action
20561	BADPASS	The Upload password is incorrect.	Use the correct password: check product documentation for the correct password.
21325	TOOSMALL	The uploaded file is too small: it does not contain the minimum necessary description.	Check to ensure the file is not trimmed. Sometimes an illegal character (non-ASCII) makes the file look smaller. Verify that the entire file can be read.
16969	TOOBIG	The uploaded file is too big: it does not fit in the reserved area for the CID file.	Check to ensure the file is correct. Try to delete large comment sections or historical sections. Sometimes secondary IED descriptions are in the same file - delete those from the file, and leave just the ones necessary to configure the E2 Card.
18766	INVALID	The .CID file is not a valid xml file, or it is not UTF-8 encoded.	The .CID file is a text file that needs to begin with "<?xml". Check to ensure that the codification of the text file is UTF-8; Multi-byte codification will also cause this error.
17985	FAILED	The upload failed. This can be because of network linkage problems or failed integrity in storage.	Try to upload the file again: DO NOT click the back button on the browser if the update is not completed. Assure that the network link is stable. If the problem persists, contact GE technical support.

Multilin™ EPM 7000P

Chapter 10: Time of Use Function

10.1 Introduction

In response to both higher energy costs and concern for energy conservation (oftentimes spurred on by governmental regulations), many utilities have adopted strategies for load management. Time of Use (TOU) metering is one of these strategies. TOU is a means of accumulating usage during specified time periods with the purpose of billing with different rates for the different periods; for example, off-peak versus on-peak usage, and weekday versus weekend usage. So, a TOU usage structure takes into account both the quantity of energy used and the time at which it was consumed. TOU metering by utilities lets them charge a higher rate for electricity used when it is more expensive to produce and distribute, i.e., a Peak Demand period. In this way the utility tries to reward usage during lower demand periods and curtail usage during higher demand periods, by charging more or less for equivalent energy use.

The EPM 7000P meter's TOU functionality, available with the GE Communicator software application, lets you set up a TOU profile to meet your application needs. It has been developed to offer a variety of programmable rate structures, for maximum flexibility. Once programmed, the EPM 7000P meter's TOU function accumulates data based on the time-scheme you programmed into the meter. See the figure on the next page for a graphical representation of TOU.

See the *GE Communicator Instruction Manual* for details on programming the EPM 7000P meter’s TOU calendar and retrieving TOU data.

Time of Use

Energy use is binned according to the time it is used, so that it can be billed for appropriately

To set up the bins (that is, the rates), you can use:

Seasons 1-4

Months 1-12

Type of Days (Weekend/Weekday/Holiday)

Time of Day Bins (Rates)

For Example: Off-Peak=Lowest Energy Usage Cost
On-Peak=Highest Energy Usage Cost
Shoulder Peak=Middle Energy Usage Cost

TOU example: Season One, Month 1

Weekdays
Off Peak 12 am-7:59am
On Peak 8 am - 5:59pm
Shoulder Peak 6 pm - 7:59 pm
Off Peak 8 pm-11:59pm

Weekends
Off Peak 12 am-11:59pm

Holidays
Off Peak 12 am-11:59pm

Monday: the day's usage is binned as shown below:

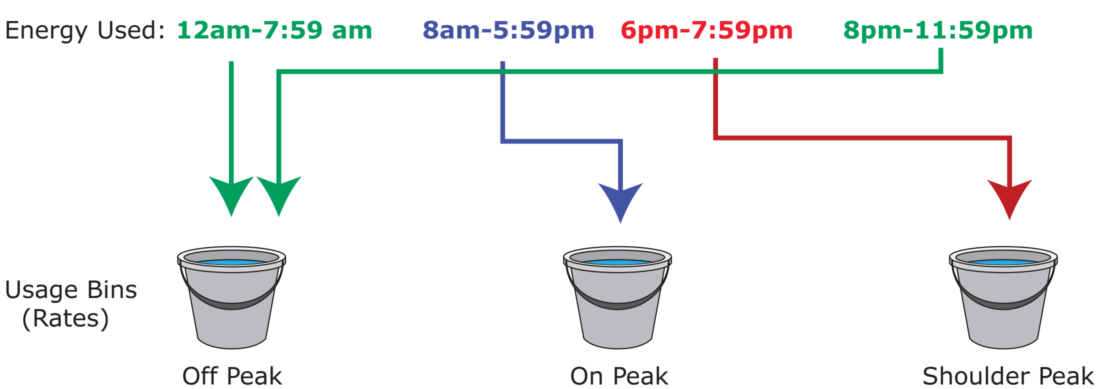


Figure 10-1: Time of Use

10.2 The EPM 7000P Meter's TOU Profile

A EPM 7000P meter's TOU profile sets the parameters for TOU data accumulation into rate bins. Features of the meter's TOU implementation include:

- The meter uses a perpetual TOU scheme, so you only need to set up the TOU profile once and then you can apply it to all subsequent years.
- You can save the TOU profile as a file and easily import it into any other EPM 7000P meters that you have.
- You can set up to 16 daily schedules, e.g., Weekday, Weekend, or Holiday, or any type of daily schedule you need.
- You can set up to four Season types, which can also be customized as daily or weekly schedules.
- You can set up to 12 Month types.
- Season and month end time can be customized as needed.
- The meter has 38 available accumulators for TOU; 16 accumulators can be tracked in a TOU profile. The user can choose any of the TOU accumulators to put into the TOU bin.

10.3 TOU Prior Season and Month

The EPM 7000P meter stores accumulations for the prior season and the prior month. When the end of a billing period is reached, the current season or month is stored as the prior data. The Demand registers are cleared and accumulators are resumed, using the next set of TOU schedules and register assignments from the TOU profile. Prior and current accumulations to date are always available.

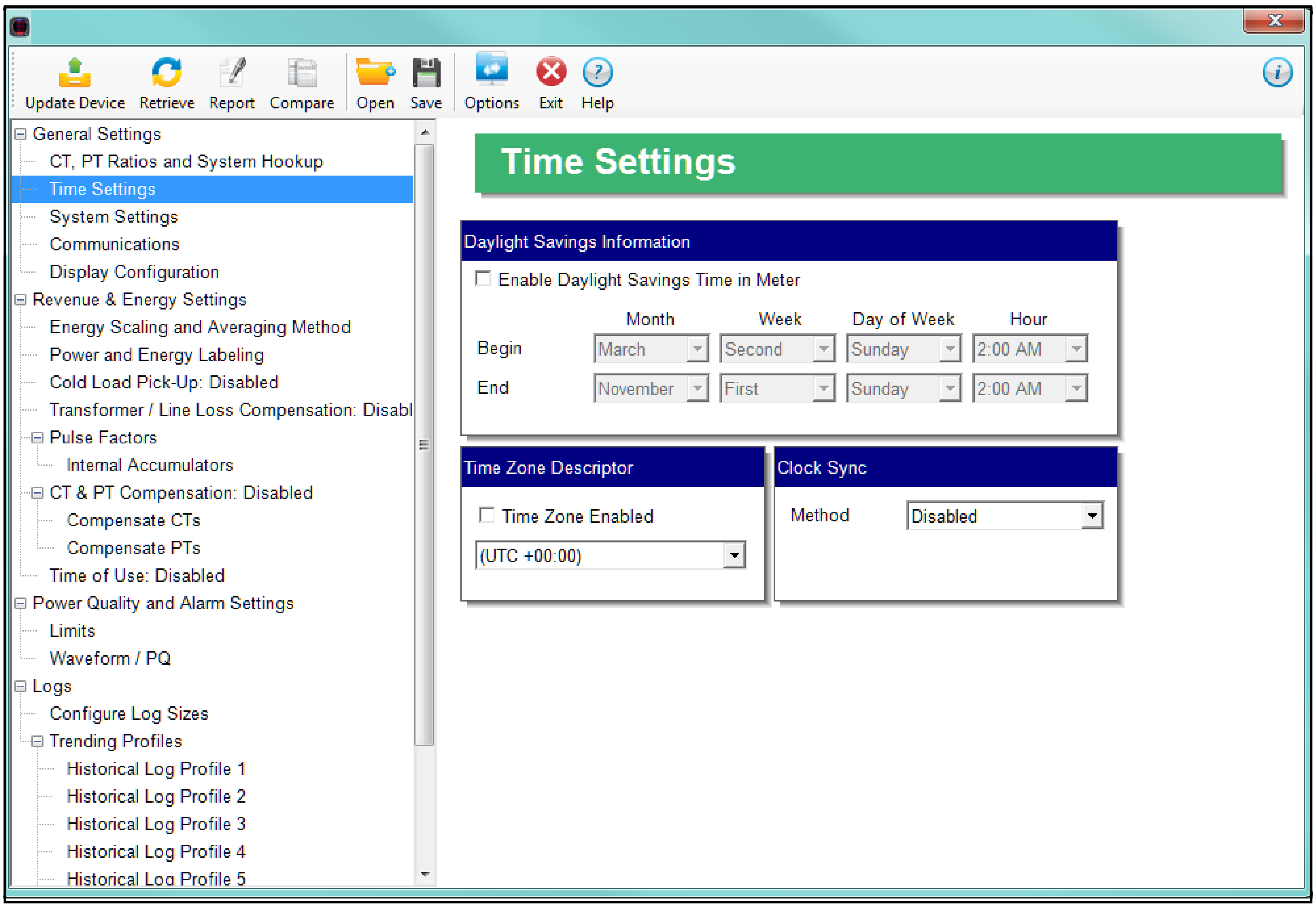
10.4 Updating, Retrieving and Replacing the TOU Profile

GE Communicator software retrieves the TOU Profile from the EPM 7000P meter or from the computer's hard drive for review and edit. Accumulations do not stop during TOU profile updates, but once you have made your changes and updated the meter, the meter performs a self-read and the current month and season data blocks are moved to the prior data blocks, and the current data blocks and all accumulator "buckets" are cleared. See the *GE Communicator Instruction Manual* for instructions on updating the TOU profile.

10.5 Daylight Savings and Demand

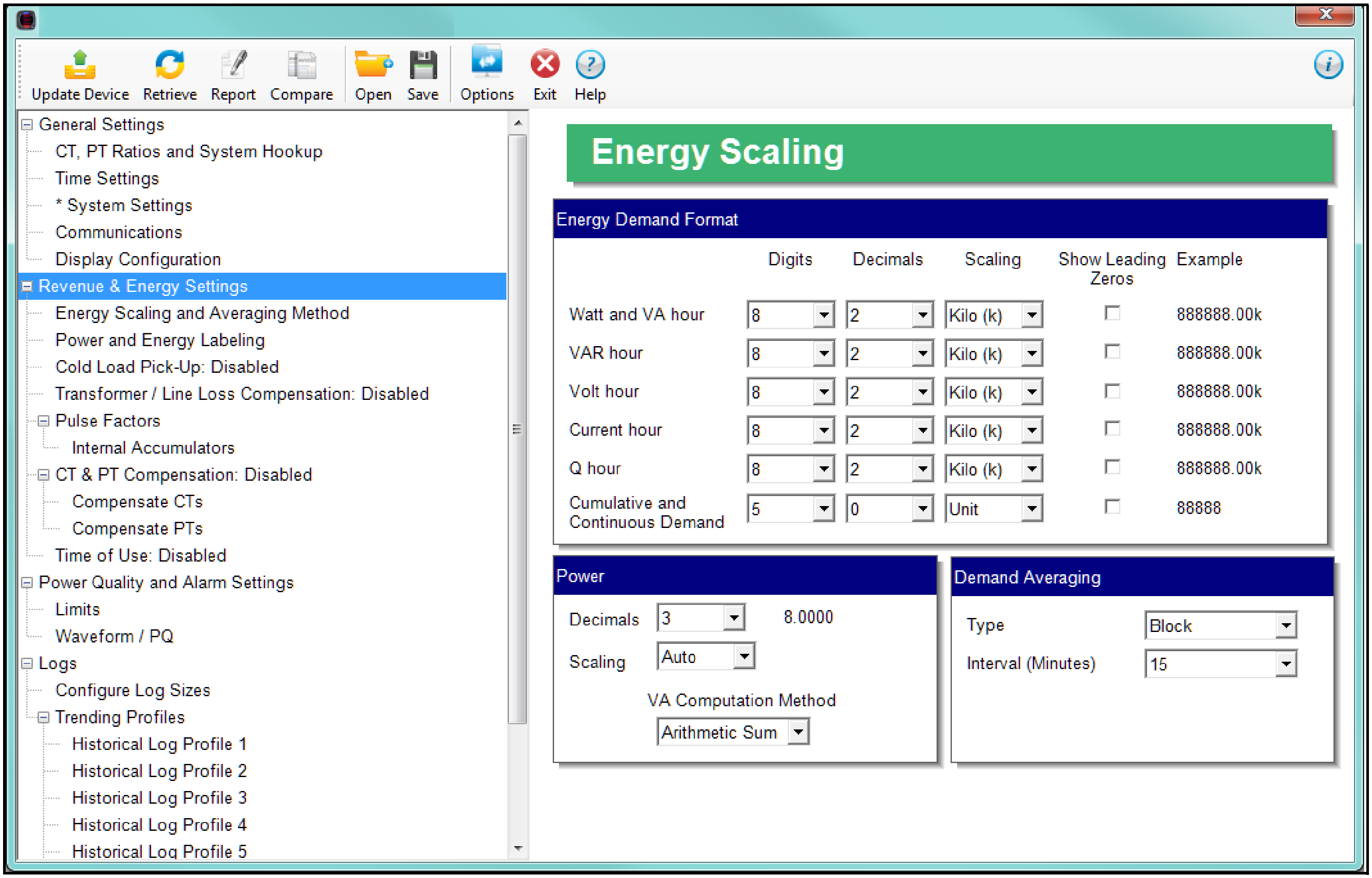
To use Daylight Savings Time and to set Demand intervals, you must configure the settings in the EPM 7000P meter's Device Profile.

- To set up Daylight Savings Time, from the Device Profile select **General Settings > Time Settings**. Click the box next to **enable Daylight Savings Time i Meter** to select it, which sets Daylight Savings Time automatically (for the United States ONLY). You can also select alternate beginning and ending dates for Daylight Savings Time. See the example screen, below.



- To set Demand Intervals, from the Device Profile select **Revenue & Energy Settings > Energy Scaling and Averaging Method** and set the desired interval in the Demand

Averaging setting section. See the example screen below.



See the *GE Communicator Instruction Manual* for programming details for these and other Device Profile settings.

Multilin™ EPM 7000P

Chapter 11: Meter Calculations

11.1 Measurements and Calculations

The EPM 7000P Meter measures many different power parameters. Following is a list of the formulas used to perform calculations with samples for Wye and Delta services.

Number of samples: N

Sample number: n

1. Voltage RMS:

Line to Neutral; Form 9S: $V_{a\text{-}n}$, $V_{b\text{-}n}$, $V_{c\text{-}n}$; Form 36S: $V_{a\text{-}n}$, $V_{c\text{-}n}$; Form 45S: $V_{a\text{-}b}$, $V_{c\text{-}b}$

$$V_{RMS} = \sqrt{\frac{1}{N} \times \sum_{n=1}^{N} v_{(n)}^2}$$

Line to Line; Form 9S, Form 36S: $V_{a\text{-}b}$, $V_{b\text{-}c}$, $V_{c\text{-}a}$ Form 45S: $V_{c\text{-}a}$

$$V_{RMS_{xy}} = \sqrt{V^2{}_{RMS_x} - 2 \times V_{RMS_x} \times V_{RMS_y} \times \cos\varphi_{(x-y)} + V^2{}_{RMS_y}}$$

Phases: x, y. Phase angle x to y: φ(x-y)

2. Current RMS:

Form 9S, Form 9S, Form 36S: I_a, I_b, I_c; Form 45S: I_a, I_c

$$I_{RMS} = \sqrt{\frac{1}{N} \times \sum_{n=1}^{N} i_{(n)}^2}$$

3. Active Energy Accumulation:

Form 9S (Wye): Wh_a, Wh_b, Wh_c, Wh_{total}

$$Wh[Wh] = \sum_n v_{(n)} \times i_{(n)} \times (T_n - T_{(n-1)})$$

$$Wh_{total}[Wh] = Wh_a + Wh_b + Wh_c$$

Form 36S (Wye - 2.5 EL): Wh_{total}

$$Wh_{total}[Wh] = \sum_n v_{a(n)} \times (i_{a(n)} - i_{b(n)}) \times (T_n - T_{(n-1)}) + \sum_n v_{c(n)} \times (i_{c(n)} - i_{b(n)}) \times (T_n - T_{(n-1)})$$

Form 45S (Delta): Wh_{total}

$$Wh_{total}[Wh] = \sum_n v_{ab(n)} \times i_{a(n)} \times (T_n - T_{(n-1)}) + \sum_n v_{cb(n)} \times i_{c(n)} \times (T_n - T_{(n-1)})$$

4. Apparent Energy:

Form 9S(Wye): VAh_a, VAh_b, VAh_c, VAh_{total}

$$VAh[VAh] = \sum_n V_{RMS_{(n)}} \times I_{RMS_{(n)}} \times (T_n - T_{(n-1)})$$

$$VAh_{total(arithmetic)}[VAh] = VAh_a + VAh_b + VAh_c * \; ; \quad VAh_{total(vector)}[VAh] = \sqrt{Wh_{total}^2 + VARh_{total}^2}$$

* not available when loss compensation is enabled.

Form 36S(Wye - 2.5 EL): $VAh_{total(arithmetic)}$

$$VAh_{total(arithmetic)}[VAh] = \sum_n V_{RMS_{a(n)}} \times I_{RMS_{(a-b)}} \times (T_n - T_{(n-1)}) + \sum_{n=1}^{N} V_{RMS_{c(n)}} \times I_{RMS_{(c-b)}} \times (T_n - T_{(n-1)})$$

Form 45S (Delta): $VAh_{total(arithmetic)}$, $VAh_{total(vector)}$

$$VAh_{total(arithmetic)}[VAh] = \cos 30° \times \left(\sum_n V_{RMS_{ab(n)}} \times I_{RMS_{a(n)}} \times (T_n - T_{(n-1)}) + \sum_n V_{RMS_{cb(n)}} \times I_{RMS_{c(n)}} \times (T_n - T_{(n-1)}) \right)$$

$$VAh_{total(vector)}[VAh] = \sqrt{Wh_{total}^2 + VARh_{total}^2}$$

5. Reactive Energy:

Form 9S (Wye): $VARh_a$, $VARh_b$, $VARh_c$, $VARh_{total}$

$$VARh[VARh] = \sqrt{VAh^2 - Wh^2}$$

$$VARh_{total}[VARh] = VARh_a + VARh_b + VARh_c$$

Form 36S(Wye - 2.5 EL): $VARh_{total}$

$$VARh_{total}[VARh] = \sqrt{VAh_{total}^2 - Wh_{total}^2}$$

Form 45S (Delta): $VARh_{total}$

$$VARh_{total}[VARh] = \sqrt{VAh_{ab}^2 - Wh_{ab}^2} + \sqrt{VAh_{cb}^2 - Wh_{cb}^2}$$

6. Q-hour Energy:

Form 9S (Wye): Qh_a, Qh_b, Qh_c, Qh_{total}

$$Qh\,[Qh] = \frac{\sqrt{3} \times VARh + Wh}{2}$$

$$Qh_{total}[Qh] = Qh_a + Qh_b + Qh_c$$

Form 36S (Wye - 2.5 EL), Form 45S (Delta): Qh_{total}
//Only total is computed; the per element values are set to 0.

$$Qh_{total}[Qh] = \frac{\sqrt{3} \times VARh_{total} + Wh_{total}}{2}$$

7. Power:

Active Power:

$$P[W] = \frac{Wh}{T[hrs]}$$

Apparent Power:

$$S\,[VA] = \frac{VAh}{T[hrs]}$$

Reactive Power:

$$Q\,[VAR] = \sqrt{S^2 - P^2};$$

Power Factor:

$$PF = \frac{P}{S}$$

Total average Power Factor:

$$PF_{tot.avg\_Q1+4} = \frac{Wh_{tot,Q1+4}}{VAh_{tot,Q1+4}} \; ; \; PF_{tot.avg\_Q2+3} = \frac{Wh_{tot,Q2+3}}{VAh_{tot,Q2+3}}$$

//bi-Quadrant measurement; "Q1+4," Q2+3"

Phase Angle:

$$\varphi = \cos^{-1}(PF)$$

8. Total Harmonic Distortion:

$$\mathrm{THD}_{V_{RMS}}[\%] = 100 \times \frac{\sqrt{\sum_{h=2}^{39}({V_{RMS}}_h)^2}}{{V_{RMS}}_1} \quad \text{// Voltage}$$

$$\mathrm{THD}_{I_{RMS}}[\%] = 100 \times \frac{\sqrt{\sum_{h=2}^{39}({I_{RMS}}_h)^2}}{{I_{RMS}}_1} \quad \text{// Currents}$$

9. K-Factor for Current:

$$\mathrm{KFactor}_I[\%] = 100 \times \frac{\sum_{h=1}^{39}(h \times {I_{RMS}}_h)^2}{\sum_{h=1}^{39}({I_{RMS}}_h)^2}$$

10. Total Demand Distortion; ($I_{L\text{-}RMS}$: average max. load current, set by user):

$$\mathrm{TDD}_{I_{RMS}}[\%] = 100 \times \frac{\sqrt{\sum_{h=2}^{39}({I_{RMS}}_h)^2}}{I_{L-RMS}}$$

11. Voltage Unbalance:

Unbalance 0 sequence = 0 sequence magnitude / + sequence magnitude
Unbalance - sequence = -sequence magnitude / + sequence magnitude

12. Current Unbalance:

$$IMB_{I_{RMS}} = \frac{MAX.\left\{\left|\boldsymbol{I_{RMS_{avg.}}} - I_{RMS_a}\right|, \left|\boldsymbol{I_{RMS_{avg.}}} - I_{RMS_b}\right|, \left|\boldsymbol{I_{RMS_{avg.}}} - I_{RMS_c}\right|\right\}}{I_{RMS_{avg.}}}$$

$$\text{// where: } \boldsymbol{I_{RMS_{avg.}}} = \frac{I_{RMS_a} + I_{RMS_b} + I_{RMS_c}}{3}$$

13. Transformer Loss:

$$W_{Total\ Transformer\ Loss} = VA_{Transformer\ Full\ Scale} \times \left[\%\mathrm{LWFE} \times \left(\frac{\mathrm{Vmeasured}}{Vnominal}\right)^2 + \%\mathrm{LWCU} \times \left(\frac{\mathrm{Imeasured}}{Inominal}\right)^2\right]$$

$$VAR_{Total\ Transformer\ Loss} = VA_{Transformer\ Full\ Scale} \times \left[\%\mathrm{LVFE} \times \left(\frac{\mathrm{Vmeasured}}{Vnominal}\right)^4 + \%\mathrm{LVCU} \times \left(\frac{\mathrm{Imeasured}}{Inominal}\right)^2\right]$$

11.2 Demand Integrators

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 7000P meter supports Block Window Demand and Rolling Window Demand, though not simultaneously - only one can be used, at a time. You can choose the demand method and program its settings with the GE Communicator software (see the *GE Communicator Instruction Manual*).

Block (Fixed) Window Demand:

This convention records the average (arithmetic mean) demand for consecutive time intervals (usually 15 minutes).

Example: A typical setting of 15 minutes produces an average value every 15 minutes (at 12:00, 12:15. 12:30. etc.) for power reading over the previous fifteen minute interval (11:45-12:00, 12:00-12:15, 12:15-12:30, etc.).

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. At 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.

Example: With settings of 3 five-minute subintervals, subinterval averages are computed every 5 minutes (12:00, 12:05, 12:15, etc.) for power readings over the previous five-minute interval (11:55-12:00, 12:00-12:05, 12:05-12:10, 12:10-12:15, etc.). Further, every 5 minutes, the subinterval averages are averaged in groups of 3 (12:00. 12:05, 12:10, 12:15. etc.) to produce a fifteen (5x3) minute average every 5 minutes (rolling (sliding) every 5 minutes) (11:55-12:10, 12:00-12:15, etc.).

Multilin™ EPM 7000P

Chapter 12: Performing Meter Testing

12.1 Overview

⚠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**. All work must be done in accordance with local utility safety practices.

To be certified for revenue metering, power providers and utility companies must verify that the billing energy meter performs to the stated accuracy. To confirm the meter's performance and calibration, power providers use field test standards to ensure that the unit's energy measurements are correct. Since the EPM 7000P meter is a traceable revenue meter, it contains a utility grade test pulse that can be used to gate an accuracy standard. This is an essential feature required of all billing grade meters.

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.

- GE recommends that meter accuracy testing be done every 5 years.
- Figure 12.1 shows the location of the pulse.
- Refer to Figure 12.2 for an example of how this process works.
- Refer to Table 12.1 for the Wh/Pulse constants for accuracy testing.

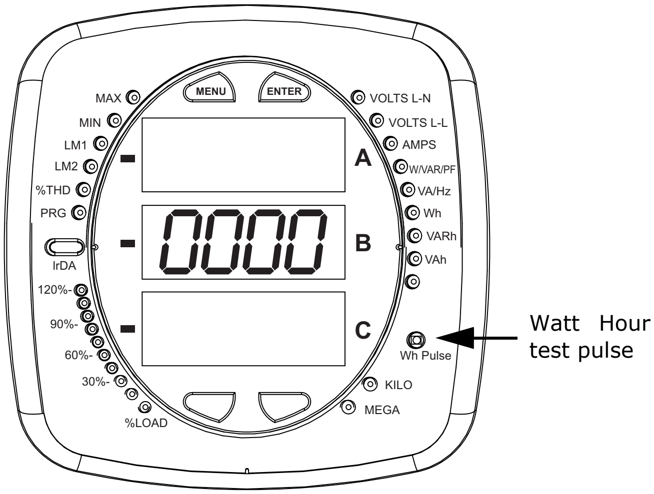


Figure 12-1: Watt Hour Test Pulse

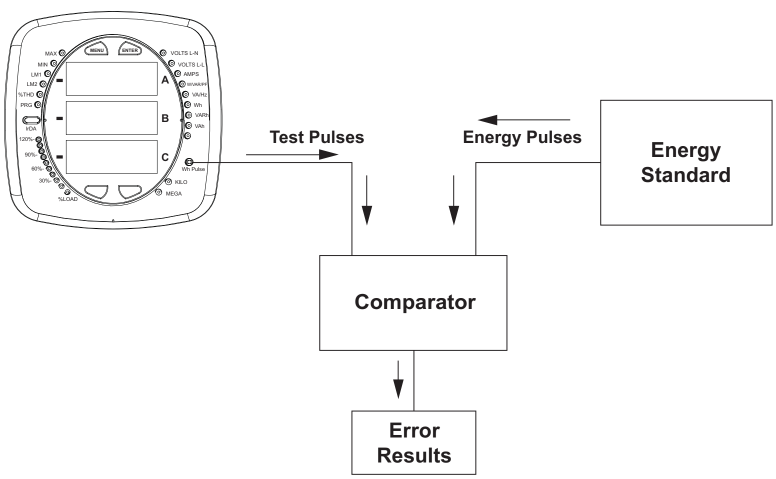


Figure 12-2: Using the Watt Hour Test Pulse

Table 12–1: Infrared & KYZ Pulse Constants for Accuracy Testing - Kh Watt hour per pulse

Input Voltage Level	Class 10 Models	Class 2 Models
Below 150 V	0.500039881	0.1000079762
Above 150 V	2.000159523	0.4000319046

NOTICE

- Minimum pulse width is 90 milliseconds.
- Refer to Chapter 2, Section 2.2, for Wh Pulse specifications.

- Typical standards are: Radian Research RD20 & RD21 or a Watt hour Engineering Company Three Phase Automated Test System.

NOTICE

- Watt hour Standards offer pulse inputs that take in the CPU's test pulses. The accuracy is computed by ratio-metrically comparing the period of the meter's pulse to the period of the Standard's internal pulse. You must program the test pulse value (Kh) into the Standard for the results to be accurate.
- The pulse rate will be based on uncompensated energy in case TLC is enabled.

The example test procedure that follows covers the testing of the EPM 7000P meter. The test procedure used for the Standard shall be determined by the manufacturer of the Standard used.

12.2 Test Procedure

1. All circuits and equipment must be de-energized.
2. Connect the three phase potential input lines to "Va", "Vb", and "Vc" and the neutral to "V-Ref" & "GND."
3. Connect power leads to the "L" and "N" connections.
4. Monitor the #1 test pulse by placing the photo detector over the #1 LED.
5. Connect the three phase current inputs to the current terminals associated with the test pulse LED being monitored. There must be no other current inputs connected.
6. Energize the Standard and the EPM 7000P meter. To assure accuracy, both must be on for a minimum of 30 minutes.
7. Energize the sources and wait for the outputs to stabilize before starting the test.
8. Start the test as per the appropriate procedure for the Standard and/or comparator used.
9. When the test is completed, de-energize the sources.
10. Place the photo detector over the next test pulse to be monitored.
11. Repeat steps 5 through 10 until all test pulses are checked.
12. De-energize all circuits and remove power from the Standard, sources, and the EPM 7000P meter.
13. Disconnect all connections from the EPM 7000P meter.

Multilin™ EPM 7000P

Chapter 13: Transformer Loss Compensation

13.1 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 I2R 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 side of the transformer. This condition is illustrated in Figure 13.1.

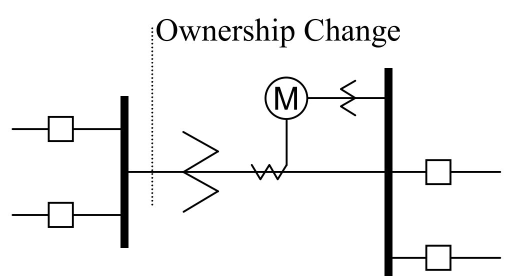


Figure 13-1: Figure 13.1: Low Voltage Metering Installation Requiring Loss Compensation

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 in Figure 13.2.

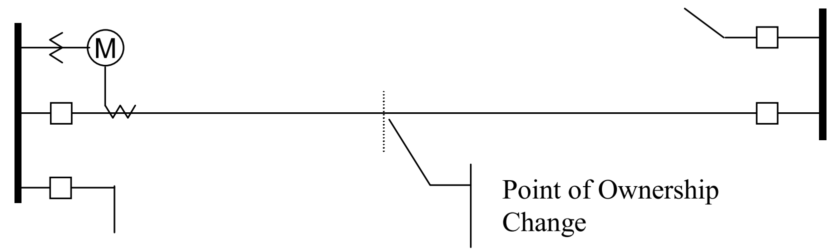


Figure 13-2: Joint Ownership Line Meeting Requiring Loss Compensation

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 energy flow measured at the meter location. This is the method used for loss compensation in the EPM 7000P meter. Refer to Appendix D in this manual and the *GE Communicator Instruction Manual* for detailed explanation and instructions for using the Transformer Line Loss Compensation feature of the EPM 7000P meter.

The computational corrections used for transformer and transmission line loss compensation are similar. In both cases, 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 this chapter.

In the EPM 7000P meter, Loss Compensation is a technique that computationally accounts for active and reactive power losses. The meter calculations are based on the following formulae. 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).

$$W_{TotalTransformerLoss} = VA_{TransformerFullScale} \times \left[\%LFWE \times \left(\frac{Vmeasured}{Vnominal}\right)^2 + \%LWCU \times \left(\frac{Imeasured}{Inominal}\right)^2 \right]$$

$$VAR_{TotalTransfomerLoss} = VA_{TransformerFullScale} \times \left[\%LVFE \times \left(\frac{Vmeasured}{Vnominal}\right)^4 + \%LVCU \times \left(\frac{Imeasured}{Inominal}\right)^2 \right]$$

The Values for %LWFE, %LWCU, %LVFE, and %LVCU are derived from the transformer and meter information, as demonstrated in the 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's profile when programming the meter (see the following section for instructions). 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.

13.2 EPM 7000P Meter's Transformer Loss Compensation

- Performs calculations on each phase of the meter for every measurement taken; unbalanced loads are handled accurately.
- Calculates numerically, eliminating the environmental effects that cause inaccuracies in electromechanical compensators.
- Performs bidirectional loss compensation.
- Requires no additional wiring; the compensation occurs internally.
- Imposes no additional electrical burden when performing loss compensation.

Loss Compensation is applied to watt/VAR readings and, because of that, affects all subsequent watt/VAR readings. This method results in loss compensation being applied to the following quantities:

- Total power
- Demands, per phase and total (Block (Fixed) window and Rolling (Sliding) window)
- Maximum and minimum Demand
- Energy accumulations
- KYZ output of energy accumulations

The EPM meter provides compensation for active and reactive power quantities by performing numerical calculations. The factors used in these calculations are derived either:

- By clicking the TLC Calculator button on the Transformer Loss screen of the Device Profile, to open the Loss Compensation Calculator in Microsoft Excel
- By figuring the values from the worksheet shown in *Three-Element Loss Compensation Worksheet* on page 13–5, and in the *GE Communicator Instruction Manual*.

Either way, you enter the derived values into the GE Communicator software through the Device Profile Transformer and Line Loss Compensation screen.

The GE Communicator software allows you to 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. Refer to Appendix B in the *GE Communicator Instruction Manual* for instructions.

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 nominal 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 line-to-line voltage and the line current. This process is described in the following sections.

13.2.1 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)
- % Exciting current @ 100% voltage
- % 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. In order to calculate the loss compensation settings you will need the following information regarding the meter and the installation:

- Number of meter elements
- Potential transformer ratio (PTR)
- Current transformer ratio (CTR)

- Meter nominal voltage
- Meter nominal current

This section is limited to application of EPM 7000P meters to three-element metering installations. As a result, we know that:

- Number of metering elements = 3
- Meter nominal voltage = 120 Volts
- Meter nominal current = 5 Amps

Three-Element Loss Compensation Worksheet

If you are not using the TLC Calculator in the GE Communicator software, use the worksheet in this section to calculate the values to use for the meter's Transformer and Line Loss compensation. Note that the instructions for one of the worksheet tables directly follows the table.

Company		Station Name	
Date		Trf. Bank No.	
Trf Mfg		Trf Serial No.	
Calculation by			

1. Enter the general information.

Winding	Voltage	MVA	Connection
HV - High			Δ-Y
XV - Low			Δ-Y
YV - Tertiary			Δ-Y

2. Enter Transformer data (from Transformer Manufacturer's Test Sheet).

Value	Watts Loss		
	3-Phase	1-Phase	1-Phase kW
No-Load Loss			
Full Load Loss			

3. Enter 3-Phase or 1-Phase values.
   - If 3-Phase values are entered, calculate 1-Phase values by dividing the 3-Phase values by three.

- Convert 1-Phase Watts Loss to 1-Phase kW by dividing the 1-Phase Watts Loss by 1000.

Value	3-Phase MVA	1-Phase MVA	1-Phase kVA
Self-Cooled Rating			

4. Enter 3-Phase MVA or 1-Phase MVA values.
   - If 3-Phase MVA values are entered, calculate 1-Phase MVA values by dividing 3-Phase MVA values by three.
   - Convert 1-Phase MVA to 1-Phase kVA by multiplying by 1000.

% Exciting Current	
% Impedance	

5. Enter the % Exciting Current and % Impedance values.

Value	Phase-to-Phase	Phase-to-Neutral
Test Voltage (Volts)		
Full Load Current (Amps)		

6. Enter the Phase-to-Phase values for Test Voltage (Volts) and Full Load Currents (Amps). Note that Test Voltage is generally Phase-to-Phase for 3-Phase transformers.
   - Calculate Phase-to-Neutral Test Voltage by dividing Phase-to-Phase Test Voltage by the square root of 3.
   - Calculate Full Load Current (Amps) by dividing the 1-Phase kW self-cooled rating by the Phase-to-Neutral Voltage and multiplying by 1000.

Instrument Transformers	Numerator	Denominator	Multiplier
Potential Transformers			
Current Transformers			
Power Multiplier [(PT Multiplier) x (CT Multiplier)]			

7. Meter/Installation Data: enter the Numerator and Denominator for each instrument transformer. For example, a PT with a ratio of 7200/120 has a numerator or 7200, a denominator or 120 and a multiplier of 60 (7200/120 = 60/1).

Meter Secondary Nominal Voltage (Volts)	120 V
Meter Secondary Nominal Current (Amps)	5 A

8. Meter/Installation Data: enter the Meter Secondary Nominal Voltage (Volts) and Meter Secondary Nominal Current (Amps).

Quantity	Transformer	Multiplier	Trf IT Sec (Instrument Transformer Secondary Value)	Meter Nominal	Meter/Trf (Meter-Transfomer Ratio)
Voltage				120	
Current				5	

9. Conversion Factors for Nominal Value:
    - For Transformer Voltage, enter the Phase-to-Neutral of Test Voltage (Volts) previously calculated (step 6).
    - For Transformer Current, enter the Full Load Current (Amps) previously calculated (step 6).
    - For Multiplier, enter the PT and CT Multipliers previously calculated (step 7).
    - Trf IT Sec is the nominal value of voltage and current at the instrument transformer secondary. These numbers are obtained by dividing the Transformer Voltage and Transformer Current by their respective Multiplier.
    - The Meter/Trf values for Voltage and Current are obtained by dividing the Meter Nominal by the Trf IT Sec.
10. Normalized Losses: fill out the following section of the worksheet:

No-Load Loss Watts (kW) = 1-Phase kW No-Load Loss = _______________

No-Load Loss VA (kVA) = (%Exciting Current) * (1-Phase kVA Self-Cooled Rating) / 100 = (_______________) * (_________________) / 100

= ________________ kVA

No-Load Loss VAR (kVAR) = SQRT((No-Load Loss kVA)2 - (No-Load Loss kW)2) = SQRT((_________________)2 - (_________________)2)

= SQRT((___________________) - (__________________))

= SQRT (__________________) = _____________________

Full-Load Loss Watts (kW) = 1-Phase Kw Load Loss = _______________

Full-Load Loss VA (kVA) = (%Impedance) * (1-Phase kVA Self-Cooled Rating) / 100 = (_______________) * (_________________) / 100

= ________________ kVA

Full-Load Loss VAR (kVAR) = SQRT((Full-Load Loss kVA)2 - (Full-Load Loss kW)^2) = SQRT((_________________)^2 - (_________________)^2)

= SQRT((___________________) - (__________________))

= SQRT (__________________) = __________________

Quantity	Value at Trf Nominal	M/T Factor	Meter/Trf Value (Meter Transformer Ratio)	Exp	M/T Factor w/ Exp	Value at Meter Nominal
No-Load Loss Watts (kW)		Voltage		?2		
No-Load Loss VAR (kVAR)		Voltage		?4		
Full Load Loss Watts (kW)		Current		?2		
Full Load Loss VAR (kVAR)		Current		?2		

11. Normalize Losses to Meter Nominal Power:
    - Enter Value at Trf Nominal for each quantity from previous calculations (step 10).
    - Enter Meter/Trf Value from Conversion Factors for Nominal Values (step 9).
    - Calculate M/T Factor w/Exp by raising the Meter/Trf Value to the power indicated in Exp.
    - Calculate the Value at Meter Nominal by multiplying the M/T Factor w/Exp by the Value at Trf Nominal.
12. Loss Watts Percentage Values: fill out the following section of the worksheet:

Meter Nominal kVA = 600 * (PT Multiplier) * (CT Multiplier) / 1000

= 600 * (____________) * (___________) / 1000

= ________________

Quantity	Value at Meter Nominal	Meter Nominal kVA	% Loss at Meter Nominal	Quantity
No-Load Loss W (kW)				% Loss Watts FE
No-Load Loss VAR (kVAR)				% Loss VARs FE
Full Load Loss W (kW)				% Loss Watts CU
Full Load Loss VAR (kVAR)				% Loss VARs CU

13. Calculate Load Loss Values:
    - Enter Value at Meter Nominal from Normalize Losses (step 11).
    - Enter Meter Nominal kVA from previous calculation (step 12).
    - Calculate % Loss at Meter Nominal by dividing Value at Meter Nominal by Meter Nominal kVA and multiplying by 100.
    - Enter calculated % Loss at Meter Nominal Watt values into the EPM 7000P meter using GE Communicator software. Refer to Appendix B of the *GE Communicator Instruction Manual* for additional instructions.

Multilin™ EPM 7000P

Appendix A: EPM 7000P Meter Navigation Maps

A.1 Introduction

You can configure the EPM 7000P meter and perform related tasks using the buttons on the meter face. Chapter 2 contains a description of the buttons on the meter face and instructions for programming the meter using them. The meter can also be programmed using software (see Chapter 5 *Communication Installation* and the *GE Communicator Instruction Manual*).

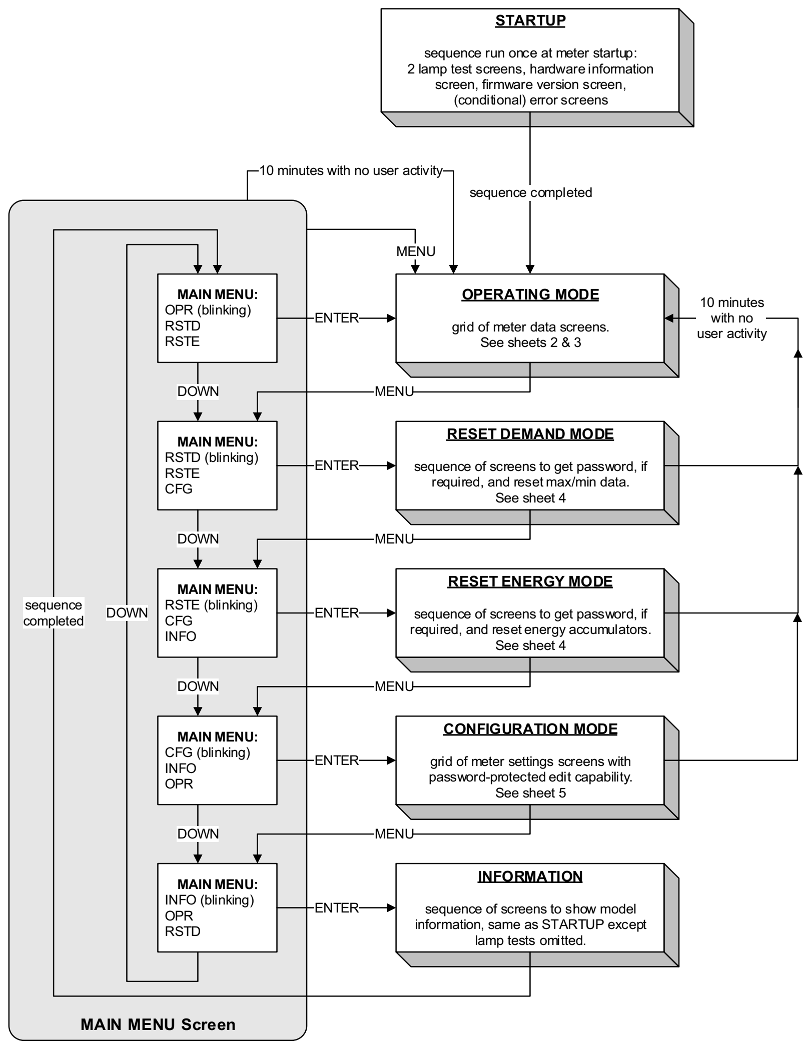
A.2 Navigation Maps (Sheets 1 to 4)

The EPM 7000P meter's Navigation maps begin on the next page. The maps show in detail how to move from one screen to another and from one Display mode to another using the buttons on the face of the meter. All Display modes automatically return to Operating mode after 10 minutes with no user activity.

EPM 7000P Meter Navigation Map Titles:

- Navigation Overview
- Operating Mode screens
- Reset Mode screens
- Configuration Mode screens

Navigation Overview

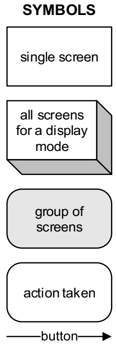


Note that access to Reset Demand Mode, Reset Energy Mode, and Configuration Mode can be password protected or disabled in the meter's security configuration. If access is password protected, the user must enter the correct password in order to perform the function. If access is disabled, a message is shown, stating that the function is denied.

Configuration Mode is not available during a Programmable Settings update via a COM port.

MAIN MENU screen scrolls through 5 choices, showing 3 at a time. The top choice is always the "active" one, which is indicated by blinking the legend.

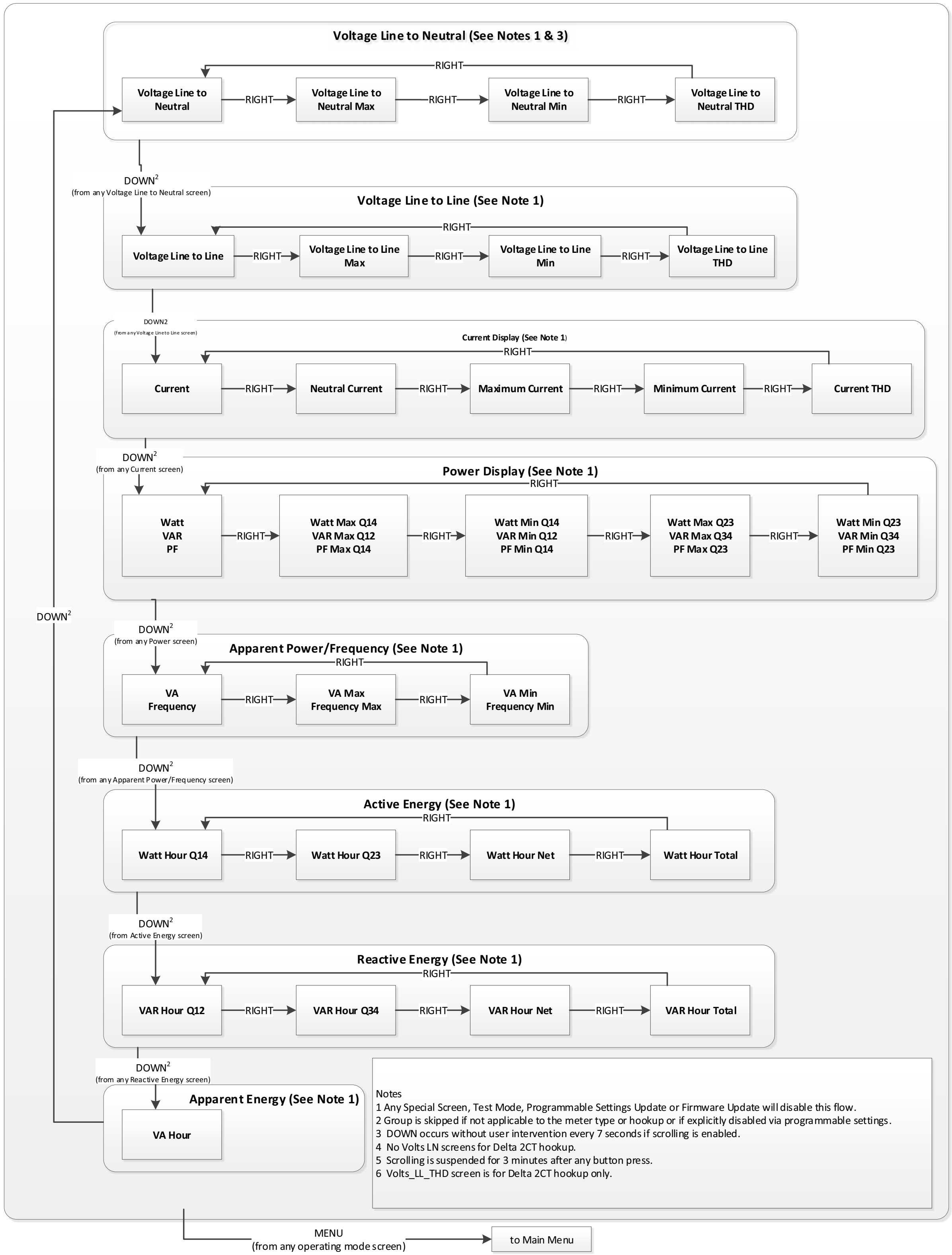
SYMBOLS

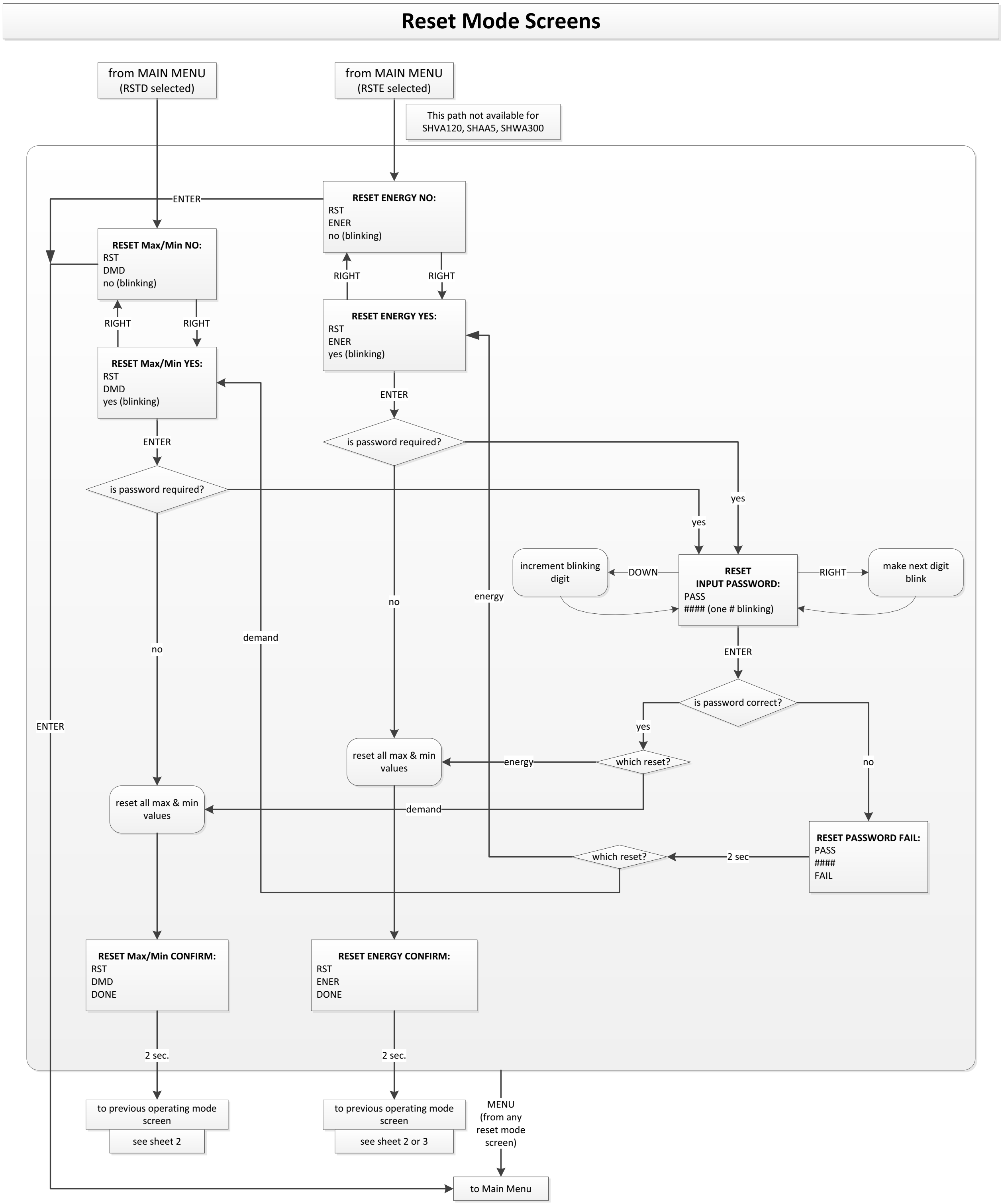


BUTTONS

MENU		Returns to previous menu from any screen in any mode
ENTER		Indicates acceptance of the current screen and advances to the next one
DOWN, RIGHT		Navigation and edit buttons
	Navigation:	No digits or legends are blinking. On a menu, down advances to the next menu selection, right does nothing. In a grid of screens, down advances to the next row, right advances to the next column. Rows, columns, and menus all navigate circularly.
	Editing:	A digit or legend is blinking to indicate that it is eligible for change. When a digit is blinking, down increases the digit value, right moves to the next digit. When a legend is blinking, either button advances to the next choice legend.

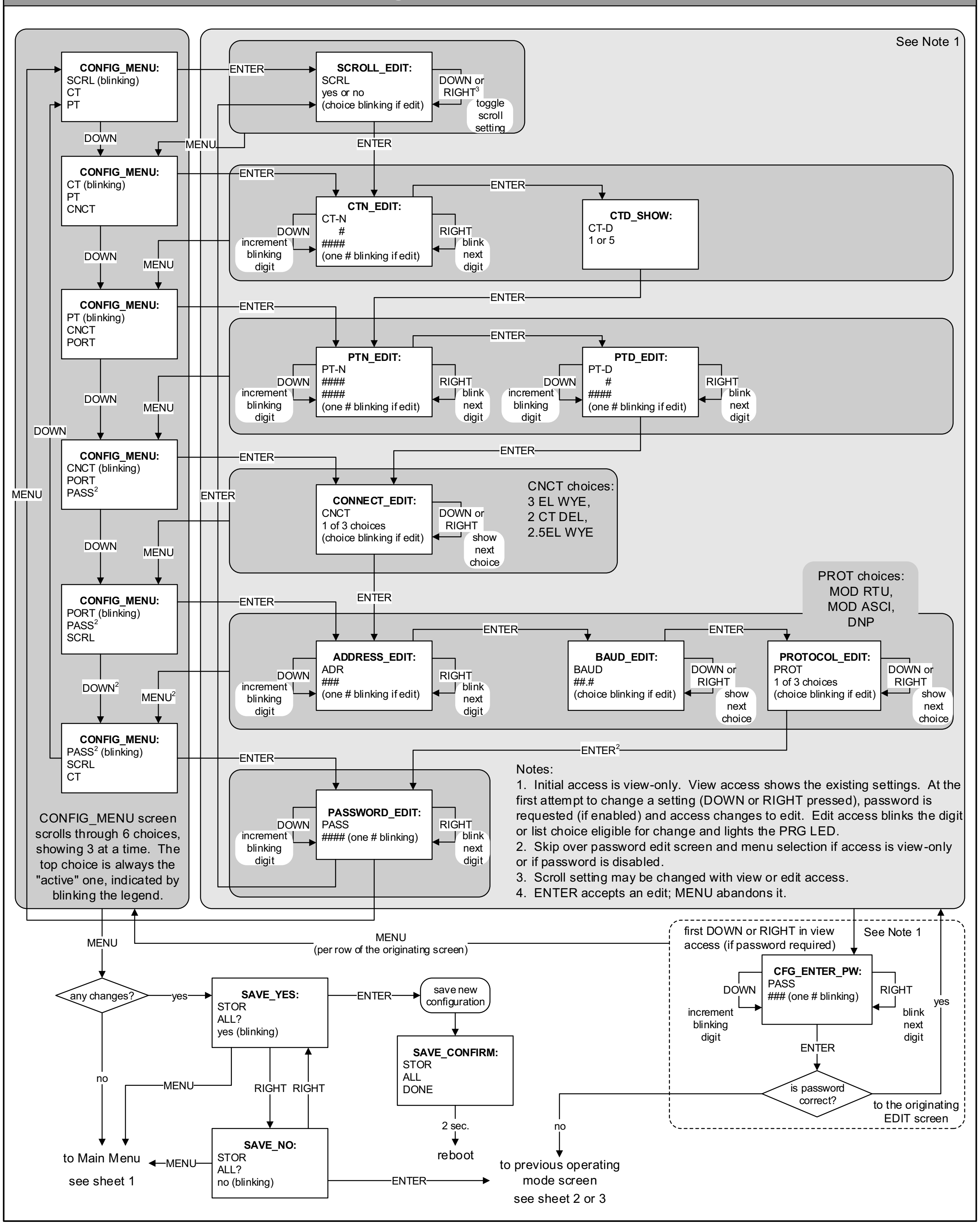
Operating Mode Screens





Reset Mode Screens
from MAIN MENU (RSTD selected)
from MAIN MENU (RSTE selected)
This path not available for SHVA120, SHAA5, SHWA300
ENTER
RESET ENERGY NO:
RST
ENER
no (blinking)
RESET Max/Min NO:
RST
DMD
no (blinking)
RIGHT
RIGHT
RESET ENERGY YES:
RST
ENER
yes (blinking)
RESET Max/Min YES:
RST
DMD
yes (blinking)
ENTER
is password required?
yes
no
RESET INPUT PASSWORD:
PASS
(one # blinking)
increment blinking digit
DOWN
make next digit blink
energy
demand
is password correct?
which reset?
reset all max & min values
RESET PASSWORD FAIL:
PASS
####
FAIL
2 sec
RESET Max/Min CONFIRM:
RST
DMD
DONE
RESET ENERGY CONFIRM:
RST
ENER
DONE
2 sec.
to previous operating mode screen
see sheet 2
see sheet 2 or 3
MENU (from any reset mode screen)
to Main Menu

Configuration Mode Screens



Multilin™ EPM 7000P

Appendix B: Three-Phase Power Measurement

This introduction to three-phase power and power measurement is intended to provide only a brief overview of the subject. The professional meter engineer or meter technician should refer to more advanced documents such as the EEI Handbook for Electricity Metering and the application standards for more in-depth and technical coverage of the subject.

B.1 Three-Phase System Configurations

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 that is 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.

B.2 Wye Connection

The wye connection is so called because when you look at the phase relationships and the winding relationships between the phases it looks like a Y. Figure B.1 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).

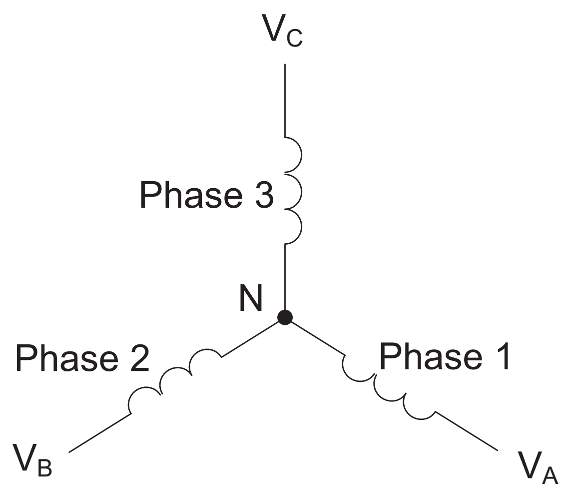


Figure B-1: Three-phase Wye Winding

The three voltages are separated by 120° electrically. Under balanced load conditions 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 in Figure B.2.

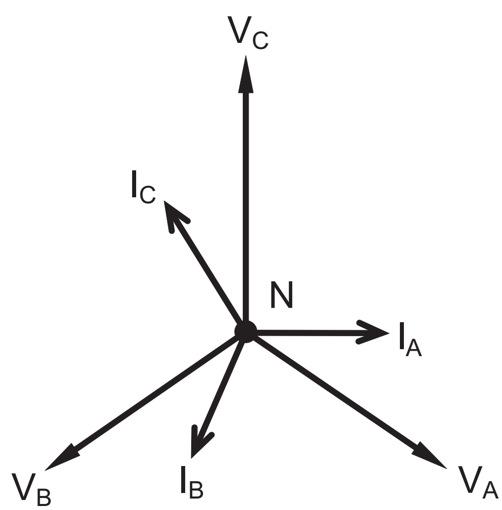


Figure B-2: Phasor Diagram Showing Three-phase Voltages and Currents

The phasor diagram shows the 120^{o} 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. Table B.1 shows the common voltages used in the United States for wye-connected systems.

Table B.1: Common Phase Voltages on Wye Services

Phase to Ground Voltage	Phase to Phase Voltage
120 volts	208 volts
277 volts	480 volts
2,400 volts	4,160 volts
7,200 volts	12,470 volts
7,620 volts	13,200 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 (as shown in Figure B.1). The neutral wire is typically tied to the ground or center point of the wye.

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 you trace the circuit 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 Table 1, 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.

B.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. Figure B.3 shows the physical load connections for a delta service.

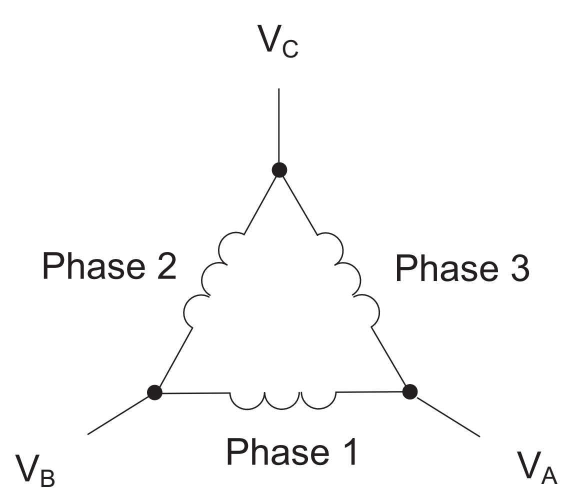


Figure B-3: Three-phase Delta Winding Relationship

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.

Figure B.4 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.

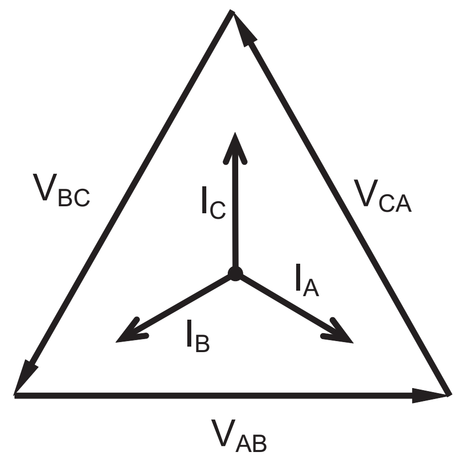


Figure B-4: Phasor Diagram, Three-Phase Voltages and Currents, Delta-Connected

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. Figure B.5 shows the phasor diagram for the voltages in a three-phase, four-wire delta system.

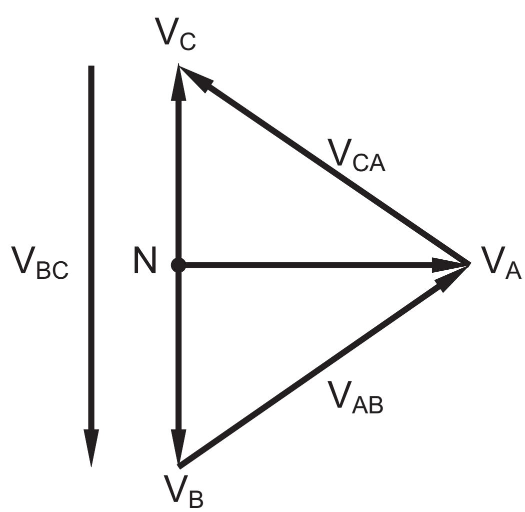


Figure B-5: Phasor Diagram Showing Three-phase Four-Wire Delta-Connected System

B.4 Blondel's Theorem and Three-Phase Measurement

In 1893 an engineer and mathematician named Andre E. Blondel set forth the first scientific basis for polyphase 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 accomplished 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 Blondel'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, Blondel'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 measure 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 adds 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.

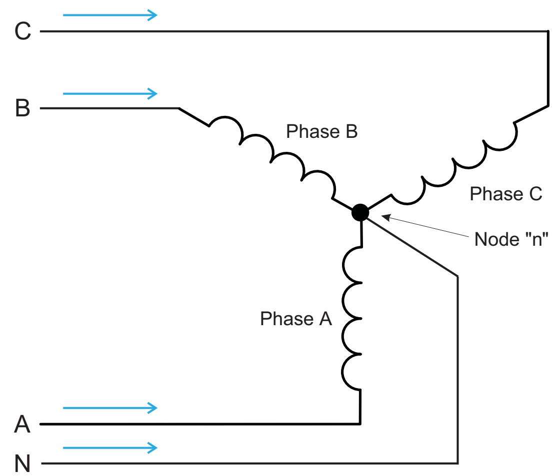


Figure B-6: Three-Phase Wye Load Illustrating Kirchoff's Law and Blondel's Theorem

Blondel's Theorem is a derivation that results from Kirchoff's Law. Kirchoff'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. Figure B.6 shows a typical connection of a three-phase load applied to a three-phase, four-wire service. Kirchoff's Law holds 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.

If we measure the currents in wires A, B and C, we then know the current in wire N by Kirchoff's Law and it is not necessary to measure it. This fact leads us to the conclusion of Blondel'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 B.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.

B.5 Power, Energy and Demand

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.

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 because it takes some amount of time to calculate the RMS values of voltage and current. But this time interval is kept small to preserve the instantaneous nature of power.

Energy is always based on 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 used.

Typically, electrical energy is measured in units of kilowatt-hours (kWh). A kilowatt-hour represents a constant load of one thousand watts (one kilowatt) for one hour. Stated another way, if the power delivered (instantaneous watts) is measured as 1,000 watts and the load was served for a one hour time interval then the load would have absorbed one kilowatt-hour of energy. A different load may have a constant power requirement of 4,000 watts. If the load were served for one hour it would absorb four kWh. If the load were served for 15 minutes it would absorb ¼ of that total or one kWh.

Figure B.7 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 will represent the power load for the one-minute increment of time. In real life the power value moves almost constantly.

The data from Figure B.7 is reproduced in Table B.2 to illustrate the calculation of energy. Since the time increment of the measurement is one minute and since we specified that the load is constant over that minute, we can convert the power reading to an equivalent consumed energy reading by multiplying the power reading times 1/60 (converting the time base from minutes to hours).

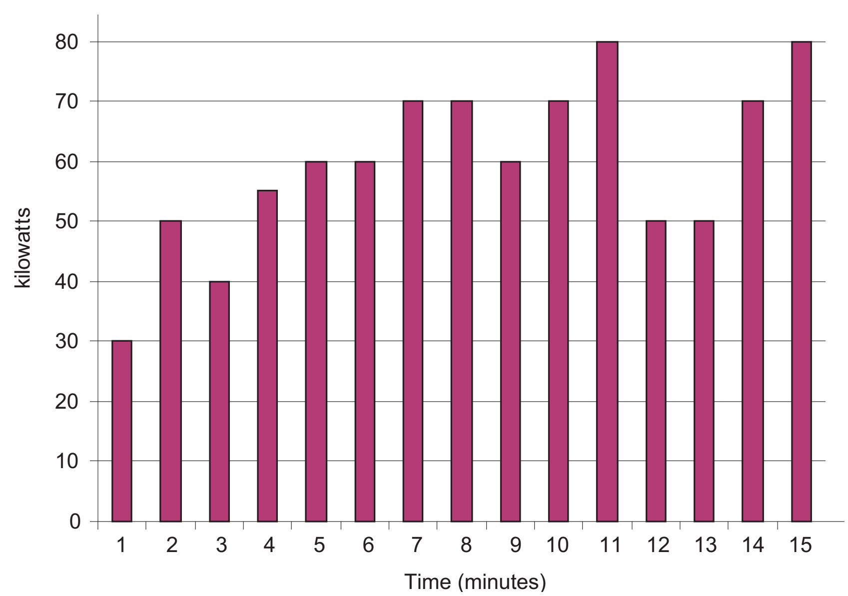


Figure B-7: Power Use over Time

Table B.2: Power and Energy Relationship over Time

Time Interval (minute)	Power (kW)	Energy (kWh)	Accumulated Energy (kWh)
1	30	0.50	0.50
2	50	0.83	1.33
3	40	0.67	2.00
4	55	0.92	2.92
5	60	1.00	3.92
6	60	1.00	4.92

Table B.2: Power and Energy Relationship over Time

Time Interval (minute)	Power (kW)	Energy (kWh)	Accumulated Energy (kWh)
7	70	1.17	6.09
8	70	1.17	7.26
9	60	1.00	8.26
10	70	1.17	9.43
11	80	1.33	10.76
12	50	0.83	12.42
13	50	0.83	12.42
14	70	1.17	13.59
15	80	1.33	14.92

As in Table B.2, the accumulated energy for the power load profile of Figure B.7 is 14.92 kWh.

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 Figure B.7) and adjust the energy reading to an hourly value that constitutes the demand.

In the 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/hr or 59.68 kWd. Note that the peak instantaneous value of power is 80 kW, significantly more than the demand value.

Figure B.8 shows 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 number 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.

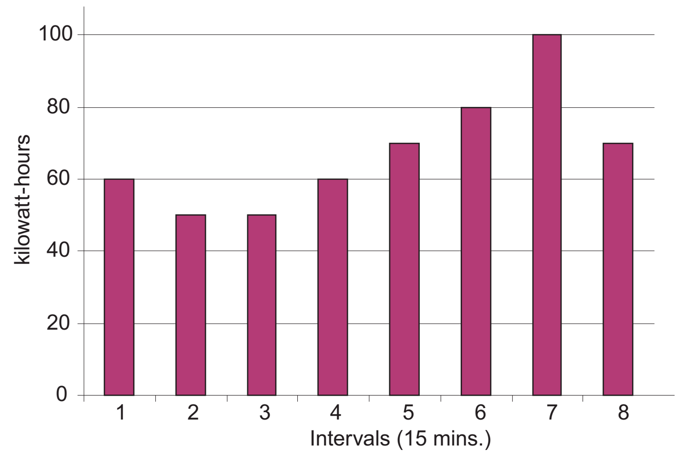


Figure B-8: Energy Use and Demand

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

B.6 Reactive Energy and Power Factor

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 inphase component and the component that is at quadrature (angularly rotated 90o or perpendicular) to the voltage. Figure B.9 shows a single-phase voltage and current and breaks the current into its in-phase and quadrature components.

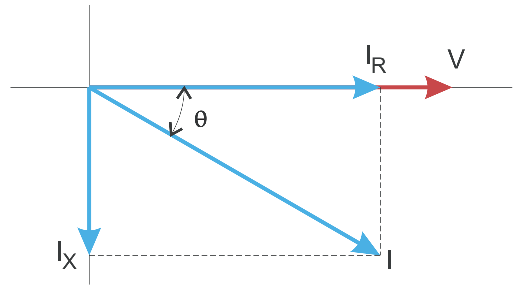


Figure B-9: Voltage and Complex Current

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 (IR) are combined to produce the real power or watts. The voltage and the quadrature current (IX) are combined to calculate the reactive power.

The quadrature current may be lagging the voltage (as shown in Figure B.9) 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 in order 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. In order to encourage customers to keep VAR requirements low, some utilities impose a penalty if the VAR content of the load rises above a specified value.

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:

Total PF = real power / apparent power = watts/VA

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:

$$\text{Displacement PF} = \cos\theta$$

where q is the angle between the voltage and the current (see Fig. B.9).

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.

B.7 Harmonic Distortion

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. Figure B.10 shows a normal, sinusoidal current waveform. This example has no distortion.

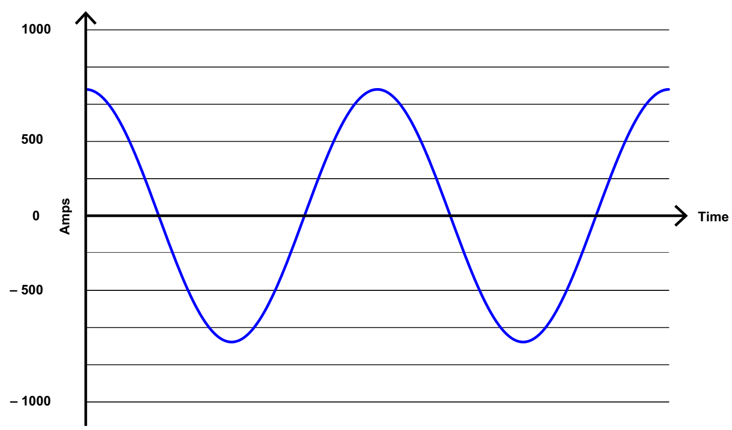


Figure B-10: Nondistorted Current Waveform

Figure B.11 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. However, the waveform is not a smooth sinusoidal form as seen in Figure B.10.

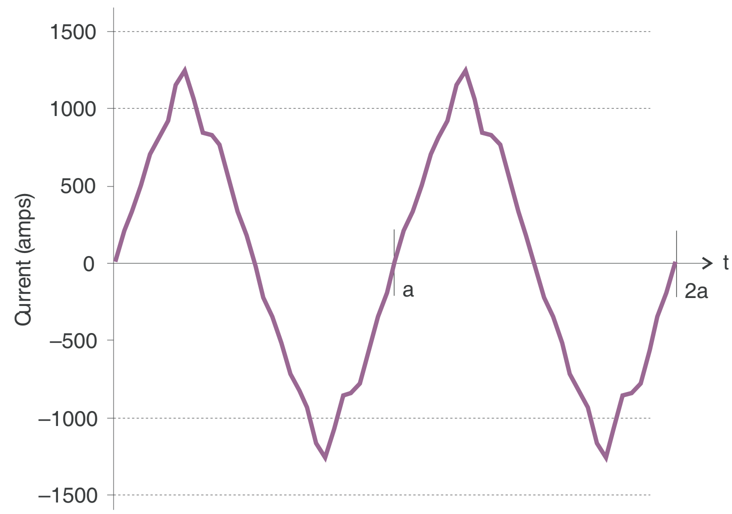


Figure B-11: Distorted Current Waveform

The distortion observed in Figure B.11 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 disassembling the distorted waveform into a collection of higher frequency waveforms.

These higher frequency waveforms are referred to as harmonics. Figure B.12 shows the content of the harmonic frequencies that make up the distortion portion of the waveform in Figure B.11.

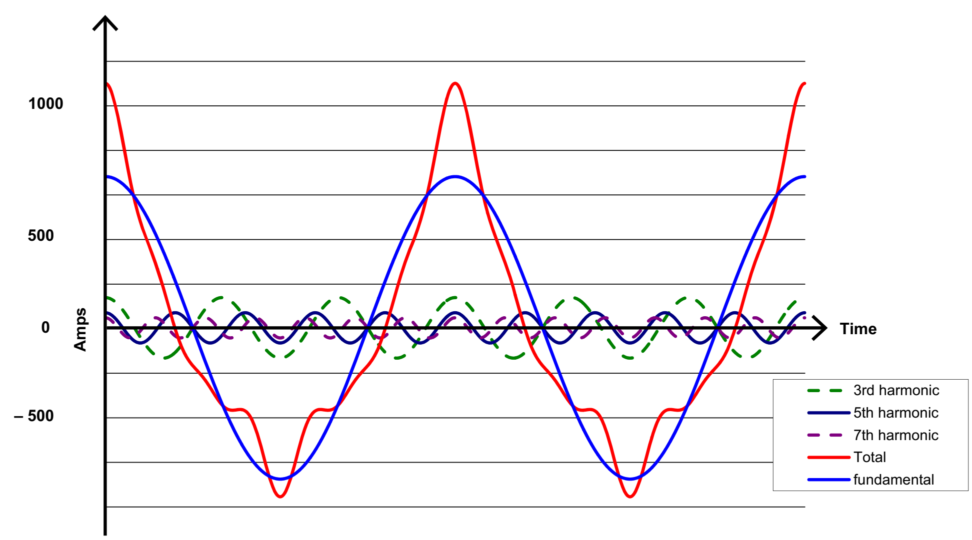


Figure B-12: Waveforms of the Harmonics

The waveforms shown in Figure B.12 are not smoothed but do provide an indication of the impact of combining multiple harmonic frequencies together.

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

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.

XL = jwL and

XC = 1/jwC

At 60 Hz, w = 377; but at 300 Hz (5th harmonic) w = 1,885. As frequency changes impedance changes and system impedance characteristics that are normal at 60 Hz may behave entirely differently in the presence of higher order harmonic waveforms.

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.

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 volt 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.

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.

B.8 Power Quality

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 mis-operation 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 Table B.3.

Table B.3: Typical Power Quality Problems and Sources

Cause	Disturbance Type	Source
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 seconds or longer duration	System protection Circuit breakers Fuses Maintenance
Under voltage/over voltage	RMS voltage, steady state, multiple seconds 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 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.

Multilin™ EPM 7000P

Appendix C: EPM 7000P Meter DNP Mapping

C.1 Overview

This Appendix describes the functionality of the EPM 7000P meter's version of the DNP protocol. A DNP programmer needs this information in order to retrieve data from the EPM 7000P meter using this protocol.

DNP3 is a set of communications protocols used between various types of data acquisition and control equipment within a network. The network can use different types of network media, e.g., RS485 serial network, TCP/IP Ethernet network, UDP/IP network, or P2P links. Each device on the network can be a master (inquirer), a slave (outstation) or a mix of both (peer).

The EPM 7000P meter acts as an outstation in its DNP3 implementation. Several of its DNP3 features are user configurable and several of its DNP3 features are dependent on the meter's installed hardware (i.e., Option cards).

C.2 Configuration

The meter's DNP3 features are configured via GE Communicator software, using Modbus protocol. The set of parameters and values that comprise the meter's DNP3 features is referred to as the DNP Configurable Profile. The DNP Configurable Profile is stored in non-volatile memory, meaning it will be loaded when the meter powers up.

Once DNP3 is configured for the meter, the GE Communicator software can generate a DNP XML Profile for the meter, if one is needed to set up the Master and/or other devices on the network. Also, some DNP3 configuration settings, e.g., enabling a class unsolicited message, are configured through the DNP protocol itself. A sample DNP XML Profile can be downloaded from the meter's product page. For more information, refer to Chapter 8 of the DNP3 Specification Volume 8 (Interoperability) standard.

C.3 Communication

The DNP3 protocol is able to communicate through two channels: the RS485 port (standard) or through the TCP/IP Network option card (E1) if it is installed in the meter.

- Up to two simultaneous DNP3 sessions can be handled by the meter: one for each channel (RS485 link and TCP/IP network card).
- The logical address of the unit on the DNP3 network can be configured between 1 and 65519 (see the *GE Communicator Instruction Manual* for instructions).
  - Through the RS485 port, the user can configure some physical transfer parameters such as bits per second, parity, and response delay. Note that this interface does not detect collision, so the RS485 port channel is recommended only when there is a single Master on the DNP3 network.
  - Through the network card, DNP3 is available by default at TCP/IP port 20000. This port setting can be changed by the user. Also, the user can allow only predetermined devices to connect through the meter's DNP by configuring an IP address/Port mask to filter remote devices. This feature is useful for security purposes. Note that the EPM 7000P meter can have two Network cards installed. Only one Network card can be used to communicate DNP3.
  - When communicating through TCP/IP, up to 5 sockets are available to DNP3 communication, but all of them share the same session, which means the meter does not differentiate packets coming from different TCP/IP ports. It does, however, differentiate packets coming from different devices, as long as the devices' DNP addresses are different.
  - A user may allow only 1 socket to be available for DNP3 over TCP/IP by configuring this mode using GE Communicator software. This is mandatory when unsolicited messages must be sent through the Network interface (see C.5 *Events* on page C–3).
- There are minor differences in some features when DNP3 is communicating through RS485 or TCP/IP. This will be mentioned in applicable areas.

C.4 Classes

The EPM 7000P meter's DNP3 version supports Classes 0, 1, 2 and 3, depending on the object and qualifier. This is explained in the following sections, for each object implemented. Static objects can be assigned only to Class 0. Event objects or change objects can be assigned to Classes 1, 2 or 3.

C.5 Events

Events are supported by the meter's DNP3, and are configured through GE Communicator software. Events can be gathered by polling when the respective Internal Indication shows their availability, or they can automatically sent via unsolicited messages. Unsolicited messages can be enabled for Classes 1, 2 or 3 via configuration and via DNP3 protocol. The DNP Master must allow the meter to send the unsolicited message.

- There is a minor difference in handling unsolicited messages between RS485 and TCP/IP network links. Since RS485 and TCP/IP networks have their own session environment, changes in binary counters or analog inputs are detected within each session. Even if the detection occurs in both sessions, the event generation can be different. This is especially true, because:
    - In RS485, the target address of the unsolicited message should be unique, because it is used to help the receiver identify which data is being requested.
    - In TCP/IP, the routing and final destination of a packet depends on the socket (the combined IP address and TCP port). In addition, as there can be more than one client connected through TCP/IP - and more than one socket communicating - knowing which socket the unsolicited message should be sent to is a challenge, especially because all network DNP3 communication is regarded by the meter as a single session. So in order to enable unsolicited messages through TCP/IP network communication, the single socket mode must be enabled in the Network card (the *GE Communicator Instruction Manual* for instructions). If the single socket is not enabled, unsolicited messages will not be available for network communication, even if they are assigned and enabled in the DNP3 configuration.

C.6 Time Synchronization

The EPM 7000P meter's DNP3 version supports Time Synchronization. Time Synchronization allows an external device to write an updated time/date to the meter. This is achieved through Object 50 (see C.10.13 *Object 50 - Time* on page C–14).

The user can configure three modes of operation:

Mode	Description
Time Synchronization Disabled	Meter will not accept writes to Object 50.
Enabled from Serial only	Meter will accept writes to Object 50 only from the RS485 link.
Enabled from Serial or Network	Meter will accept writes to Object 50 from either RS485 link or from TCP/IP network.

- When the time is written to the meter (assuming Time Synchronization is enabled), the new time is considered valid for a certain period. After this period, we recommend you rewrite the time, in order to reduce jitter and inaccuracy in time between devices on the DNP3 network. The period is known as "Time Sync Renewal Interval." When the Time Sync Renewal Interval has elapsed, the meter sets a flag (called "Need Time") in the DNP3 Internal Indications to signal other devices that its time needs to be updated. The Need Time Indication is sent as part of the Internal Indication replies sent from the meter to external queries. The Need Time Indication is also set after meter the starts up. When time is written to the meter, the Indication is cleared until the Time Sync Renewal Interval lapses again.

- Note that this process is referred to as Passive Mode, because devices on the DNP3 network become aware of the "Need Time" Indication only if someone queries the meter. If no one queries the meter, the Indication will not be seen.
- GE recommends you use only one method of updating the meter's clock. If DNP time sync is being used, make sure to disable NTP time synchronization from the Network cards (see 7.4.3 *NTP Time Server Synchronization* on page 7–22).

- If Time synchronization is disabled, this "Need Time" Indication is never set.
- The meter also provides an Active Mode, in which as soon as the "Need Time" Indication is set, a null unsolicited message is sent out to the DNP3 link. Active Mode is enabled by allowing the "send unsolicited null message when valid period expires" setting in the DNP Configurable Profile, using GE Communicator software. Note that the Active Mode is an additional feature which is not required by the DNP standard.
  - If the link is through RS485, there is no provision to detect whether or not the channel is busy, so collision may occur.
  - If the link is through the TCP/IP Network, the unsolicited message is sent only if the DNP3 in the Network card is configured as a Single Socket.

C.7 Link Layer Functions

The EPM 7000P meter's DNP3 version follows the standard FT3 frame, supporting Reset Link, Test Link, Link Status, Confirmed Data and Unconfirmed Data.

C.8 Application Layer Functions

The EPM 7000P meter's DNP3 version supports the Read function, Write function, Select function, Operate function, Direct Operate function and Direct Operate Unconfirmed function. The functions are available depending on the object and qualifier. See for details.

C.9 Errors

In the case of an unsupported function, unsupported object or any other recognizable error, an error reply is generated from the EPM 7000P meter to the Primary station (the requester). The Internal Indication field will report the type of error: unsupported function or bad parameter or even unknown object.The broadcast acknowledge and restart bit are also signaled in the Internal Indication field, but they do not indicate an error condition.

C.10 Object Specifics

The following sections contain details on the different objects. The objects can be accessed for reading or writing.

- When reading or writing objects, the data of the object is presented in a specific format, e.g., time, float, short integer or long integer. This format is referred to as a "variation." The variation is coded as decimal numbers for each object type.
  - In general, Variation 0 indicates the default format. In other words, Variation 0 means that the data is requested to be sent in its default format. This is noted in the following Object tables.
  - If an object is being accessed specifying a variation other than 0, make sure the variation is supported by the object. The following tables show the supported variations for each object.

C.10.1 Object 0 - Device Attributes

Only mandatory point 0 is implemented. The meter will respond to a read of point 0 with the following variations.

Variation	Description
216	Max Number of Binary Output requests Supported
217	Local Timing Accuracy
221	Max Analog output index
222	Max Analog Outputs
223	Max Binary output index
224	Max Binary outputs
238	Max Binary Input Index
239	Max Binary Input points
254	Non-specific all attributes request
255	List of attribute variations
242	Device manufacturer's software
243	Device manufacturer's hardware
246	User assigned ID code/number
248	Device serial number
250	Device manufacturer's product name
252	Device manufacturer's name
254	Non-Specific variation

- When requesting using variation 254, all the available variations are returned. This object cannot be assigned to any class.

C.10.2 Object 1 - Binary Inputs Status

This object is available when a digital input option card (Relay card RS or KYZ Pulse card PS) is installed in the meter. If a card is not installed, the corresponding points become unavailable.

- The user can individually configure which points are available and which are unavailable to DNP3 protocol by selecting the Allowed state in each point using GE Communicator software.
- Object 1: This object holds 8 points that are mapped as shown in the following table.

Point	Description	Availability
0	Binary Input #1 of Option Card #1	When Relay card or Pulse card is installed in Slot 1 and the point is allowed in the DNP Configurable Profile.
1	Binary Input #2 of Option Card #1	
2	Binary Input #3 of Option Card #1	When Pulse card is installed in Slot 1 and the point is allowed in the DNP Configurable Profile.
3	Binary Input #4 of Option Card #1	
4	Binary Input #1 of Option Card #2	When Relay card or Pulse card is installed in Slot 2 and the point is allowed in the DNP Configurable Profile.
5	Binary Input #2 of Option Card #2	
6	Binary Input #3 of Option Card #2	When Pulse card is installed in Slot 2 and the point is allowed in the DNP Configurable Profile.
7	Binary Input #4 of Option Card #2	

- This object can reply to a Read function (Function 1) using the following variations:

Variation	Description
0 (Default)	Reply with variation 1.
1	Binary Input without Status.
2	Binary Input with Status.

- Any point of this object can be assigned to Class 0 in the DNP Configurable Profile, using GE Communicator software.

NOTICE

When inputs are read:

- The OFF_LINE indicator is returned if the input is not physically present in the meter, i.e., the pulse output or relay option card is not installed for the corresponding point.
    - If any point is read offline, the returned variation is changed to 2, automatically.
- The LOCAL_FORCED indicator is returned if the DNP3 configuration does not allow the input to be accessed by the DNP3 system.
- If the read is successful, ON_LINE and BINARY_ON/OFF is returned.

C.10.3 Object 2 - Binary Input Change

This object represents the binary input change. The mapping is the same as the points for Object 1.

- The inputs are scanned for change every second. If a change is found, the internal queue is filled with the event and the event becomes available to be read by other devices. Optionally, the event can generate an unsolicited message containing information about it.
- This object will reply to a Read function (Function 1) with the following variations:

Variation	Description
0 (Default)	Reply with variation 1
1	Binary Input without Time
2	Binary Input with Time

- Any point in this object can be assigned to Class 1, 2 or 3 in the DNP Configurable Profile, using GE Communicator software.

C.10.4 Object 10 - Binary Output States

These points are mapped to the digital relays on any Digital Relay Option card (such as RS or PS) installed in the meter. Some points are mapped as triggers for specific actions in the meter. Any point can also be made available to DNP3 or made not available to DNP3 by the DNP Configurable Profile on Object 12. This is useful as a security feature.

- The mapping is as follows:

Point	Description	Availability
0	Relay Out#1 in Option Card #1	When a Relay Option card is installed in slot #1; and the relay is not used as an alarm output or ElectroLogic™ assignment; and the point is allowed in the DNP Configurable Profile.
1	Relay Out# 2 in Option Card #1	
2	Relay Out#1 in Option Card #2	When a Relay Option card is installed in slot #2; and the relay is not used as an alarm output or ElectroLogic™ assignment; and the point is allowed in the DNP Configurable Profile.
3	Relay Out#2 in Option Card #2	
4-7	Always read as tripped.	When the point is allowed in the DNP Configurable Profile.

- The object will reply to a Read function (Function 1) with the following variations:

Variation	Description
0 (Default)	Reply with variation 2
1	Binary Output without Status
2	Binary Output with Status

- Note that when any point from 0 to 3 is not available because no Relay or Pulse output card is installed, it will be read as offline (when reading with variation 1).
- If the output is not allowed to be handled through DNP, i.e., not configured in the DNP configuration profile, it will be returned as LOCAL_FORCED.
- If the relay has been never active since the meter was powered up, its state is unknown. This will be reported with the flag "Communication Lost" when reading the output state with variation 1.

C.10.5 Object 12 - Relay Output Block

These points are mapped to the digital relays on any Digital Relay Option card installed in the meter as Object 10. Object 12 contains the control point for the card, i.e., the meter sends an action for this point. The points are implemented as latching relays.

- The mapping is as follows:.

<table>
<tr><th>Point</th><th>Description</th><th>Availability</th></tr>
<tr><td>0</td><td>Relay Out#1 in Option Card #1</td><td rowspan="2">When a Relay Option card is installed in slot #1; and the relay is not used as an alarm output or ElectroLogic™ assignment; and the point is allowed in the DNP Configurable Profile.</td></tr>
<tr><td>1</td><td>Relay Out# 2 in Option Card #1</td></tr>
<tr><td>2</td><td>Relay Out#1 in Option Card #2</td><td rowspan="2">When a Relay Option card is installed in slot #2; and the relay is not used as an alarm output or ElectroLogic™assignment; and the point is allowed in the DNP Configurable Profile.</td></tr>
<tr><td>3</td><td>Relay Out#2 in Option Card #2</td></tr>
<tr><td>4</td><td>Reset Energy Counters</td><td rowspan="4">When the point is allowed in the DNP Configurable Profile.</td></tr>
<tr><td>5</td><td>Change Serial Com Protocol to Modbus RTU</td></tr>
<tr><td>6</td><td>Reset Demand Min/Max</td></tr>
<tr><td>7</td><td>Manual Trigger Waveform Capture</td></tr>
</table>

- Since the points are implemented as latching relays, they can be set to either On or Off.
- Points 0 to 3 are controlled using 1. the Select function and 2. the Operate function. This is because they first need to be Selected (Function 3) before they can latch On or Off; then Operated (Function 4) to the corresponding Latch On or Latch Off.
  - There is a timeout period between the Select function and the Operate function. The Operate function must be completed before this time elapses. If it is not, the Operate function is ignored. The timeout period is configurable through the DNP Configurable Profile.
- Points 4 to 7 are controlled using the Direct Operate function (Function 5). The operation of Latch On will trigger the action they represent, but there will not be any physical actuation. The read back of points 4-7 will always be tripped.

- When selecting, operating or direct operating points in this object, only the following variation is allowed.

Variation	Description
1	Control Relay Output Block

- Object 12 cannot be assigned to any class, because it is a control block object.
- Note that Variation 0 cannot be used for this object, because the format of the data being sent must be specified.
- Note that if you try to select any point from 0 to 3, but it is unavailable because no Relay card is installed in the meter, it will be flagged as offline.
- If the output is not allowed to be handled through DNP, i.e, not configured in the DNP configuration profile, or if it has already been assigned to a limit, the flag LOCAL will be returned. No Operate function should be attempted.
- When selecting a group of outputs (e.g., 0 to 3), the NOT SUPPORTED flag or FORCED flag will be returned if one of the outputs is either not present or not allowed in DNP. No Operate function should be performed, since the outputs will be unselected, internally.
- Outputs 4-7 shall be handled with the Direct Operate function.

C.10.6 Object 20 - Binary Counters

The Binary Counters are values that represent energy, counting or some type of accumulation. The meter supports configurable mapping for the Binary Counter objects. This means that a point can be assigned to be any of several available counter-reading in the meter, e.g., Wh, VARh, Vah, positive energies, pulse accumulators, etc.

- The mapping is set in the DNP Configurable Profile via the GE Communicator application, and up to 32 points can be assigned. See the *GE Communicator Instruction Manual* for the assignable readings. All mapped points can be scaled by a factor entered in the DNP Configurable Profile.
- Depending on the mapped reading, a point can be read using the following variations:

Variation	Description
0 (Default)	Reply with variation 1 if mapped reading is a 32 bit integer.
	Reply with variation 2 if mapped reading is a 16 bit register.
1	Integer 32 bit with Flags
2	Integer 16 bit with Flags
5	Integer 32bit without Flags
6	Integer 16bit without Flags

- Any point of Object 20 can be assigned to Class 0 in the DNP Configurable Profile, using GE Communicator software.
- Note that DNP3 always reports the Binary Counters as positive numbers.

C.10.7 Object 21 - Frozen Counters

The points in this object have the same readings as those in Object 20, but these points are a frozen version of the counters. This means that when a Freeze action is received by the Meter instructing it to freeze a point (or points), the value of the Object 20 point is copied into the corresponding point in Object 21.

- Note that the action to copy a point from Object 20 to Object 21 is performed with the Freeze-NoAck function (Function 8). When freezing, the only qualifiers that can be used are either "All points" or "Range of Points."
- When reading a point from Object 21, the following variations are supported:

Variation	Description
0 (Default)	Reply with variation 5 if mapped reading is a 32 bit integer
	Reply with variation 6 if mapped reading is a 16 bit integer.
1	Integer 32 bit
2	Integer 16 bit
5	Integer 32 bit with time of Freeze
6	Integer 16 bit with time of Freeze
9	Integer 32 bit without flag
10	Integer 16 bit without flag

- Any point of Object 21 can be assigned to Class 0 in the DNP Configurable Profile, using GE Communicator software.
- The Frozen values are preserved in non-volatile memory, so after being frozen at least once they become available, even if the meter loses power.

C.10.8 Object 22 - Binary Counter Event

This object is the same as Object 20, but it is related to a change in the value of the binary counter, by a predefined amount.

- The amount of change is referred to as the Delta value. It is configurable by the user and is always a positive number. The binary counters (Object 20) are scanned for a change of Delta value every 30 seconds. If an absolute change amount is found that is equal or more than the Delta value, the value of the point in Object 20 is copied to the corresponding point in Object 22. This is called an Object 22 event.
- Note that the Delta value is an unscaled value - the binary counter point is checked for change before its value is scaled, if scaling for the point is not 1.0 (i.e., not scaled).
- Additional changes are scanned later using the value in Object 22 as reference.
- The event is saved into a queue according to the assigned class, so that it can be read later on, from the meter.
- If unsolicited message is enabled in the meter, a message is sent as soon as the event is detected.

- The variations supported to read the Object 22 are shown in following table.

Variation	Description
0 (Default)	Reply with variation 1 if mapped reading is a 32 bit integer
	Reply with variation 2 if mapped reading is a 16 bit register.
1	Integer 32 bit without Time
2	Integer 16 bit without Time
5	Integer 32 bit with Time
6	Integer 16 bit with Time

- Any point for Object 21 can be assigned to Class 1, 2 or 3 in the DNP Configurable Profile, using GE Communicator software.

C.10.9 Object 30 - Analog Inputs

The points in Object 30 are mapped by the user in the DNP Configurable Profile. The user can map up to 64 points of any analog readings into this object at any point position. The status of the meter (Meter Health), which is a value based in binary fields but read as a whole number, can also be mapped into this object.

- Every point, except Meter Health, can be scaled up or down, by using a scale factor configured by the user using the GE Communicator application. The scale factor can only be a positive number of either a fraction or an integer. When the scaling factor is 1, no scaling is applied to the reading. For more information about which readings can be mapped, see the *GE Communicator Instruction Manual*.

  Example: The Instantaneous Voltage reading is mapped to point #0 in Object 30, the scaling factor is 0.1, and the meter is fed with 200 volts. Reading the point#0 of Object 30 will give you the value 20.

- Since the analog readings in the meter consist of different types (float values, 16 bit integer values, and 32 bit integer values), the possibles variation when reading this object are listed below.

Variation	Description
0 (Default)	Reply with variation 1 if mapped reading is a 32 bit integer.
	Reply with variation 2 if mapped reading is a 16 bit register.
	Reply with variation 5 if mapped reading is a float value register.
1	Integer 32 bit with Flags
2	Integer 16 bit with Flags
3	Integer 32 bit without Flags
4	Integer 16 bit without Flags
5	Short Float

- Any point of Object 30 can be assigned to Class 0 data in the DNP Configurable Profile, using GE Communicator software.

C.10.10 Object 31 - Frozen Analog Inputs

The points in Object 31 have the same mapping as those in Object 30, but these points are the frozen version of the corresponding Analog Readings.

- This object is mainly used by the Auto Freeze feature. When enabled, the Auto Freeze feature will periodically copy the value of each Object 30 point into the corresponding point in Object 31. The time stamp of when the freeze was performed is also saved.
- When reading Object 31, the following variations are supported by the meter:

Variation	Description
0 (Default)	The meter replies with variation 7 if mapped reading is a float; replies with variation 1 if mapped reading is a 32 bit integer; or replies with variation 2 if mapped reading is a 16 bit integer.
1	Integer 32 bit and Flag
2	Integer 16 bit and Flag
3	Integer 32 bit with Time of Freeze
4	Integer 16 bit with Time of Freeze
5	Integer 32 bit without Flags
6	Integer 16 bit without Flags
7	Short Float value

- Any point of Object 31 can be configured to be part of the Class 0 static group, using GE Communicator software (meter's Device Profile).
- The Frozen values are preserved in non-volatile memory, so after being frozen at least once they become available, even if the meter loses power

C.10.11 Object 32 - Analog Inputs Change

The points in this object represent the same reading as the points mapped in Object 30, but the value of the points in this object are captured when the reading changes by an amount configured as the Dead-Band value. This means that if the value of a point in Object 30 changes by the Dead-Band value or more (with either a positive or a negative change) the new value is captured in the corresponding point of Object 32.

- When the change is detected, the event is also saved in a buffer that is used to notify external devices that there is a new value available for this point/object; so that the new value can be read later or, if enabled, an unsolicited message can be sent as soon as the change is detected.
- The Dead-Band value is configured in the DNP Configurable Profile via GE Communicator software. It can also be changed through Object 34 (see C.10.12 *Object 34 - Analog Input Dead-Band* on page C–13).
- The scan period for detecting analog input changes is approximately 1 second - it is not configurable.

- Note that scaling defined for points in Object 30 are applied also to points in Object 32, so the value read from a point of Object 32 is already scaled. However, the Dead-Band applied to Object 32 is not scaled.

  Example: Instantaneous Voltage reading is mapped to point #0 in Object 30, scaling value is 0.1, and the meter is fed with 200 volts. Reading the point#0 of Object 30 will give you the value 20. If the Dead-Band value of point#0 is set with the number 7.5:
  - If the voltage changes to 205 V, the absolute change (205-200 =5) is less than the Dead-Band value, so there won't be a new value for Object 32.

  - If the voltage changes to 198 V, again the absolute change (198 - 200 = -2) is less than Dead-Band value, so there won't be a new value for Object 32.

  - If the voltage changes to 190 V, then the absolute change (190-200 = -10) is larger than the Dead-Band value of 7.5, so a new capture will occur for the Object 32 in the corresponding point. The reading of point#0 of Object 32 will have the value 19.0 (because the new value is 190 and the scaling is 0.1).
- The possible variations when reading Object 32 are:

Variation	Description
0 (Default)	Reply with variation 1 if mapped reading is a 32 bit integer.
	Reply with variation 2 if mapped reading is a 16 bit.
	Reply with variation 5 if mapped reading is a float.
1	Integer 32 bit without Time
2	Integer 16 bit without Time
5	Short Float without Time

- Any point in Object 32 can be assigned to Class 1, 2 or 3 in the DNP Configurable Profile, using GE Communicator software.

C.10.12 Object 34 - Analog Input Dead-Band

This object defines the Dead-Band values for each point in Object 30. The Dead-Band value is always a positive number. A value of 0 for the Dead-Band disables detection for the corresponding point.

- The type of the Dead-Band value can be floating or a 32 bit integer, depending on the analog reading mapped to the corresponding point in Object 30. For float analog readings, the Dead-Band must be a floating type. For 32 bit or 16 bit integer analog readings, the Dead-Band must be a 32 bit integer type.
- If, for example, the reading is voltage, which is a floating value, then the Dead-Band must be a floating value too. This is handled automatically by the GE Communicator software when editing the DNP Configurable profile. However, since Dead-Band values are also accessible through DNP3 protocol (through this Object 34), care must be taken when writing a Dead-Band value to assure that it matches the type of the corresponding point in Object 30.

- The possible variations when reading points from Object 34 are:

Variation	Description
0 (Default)	Reply with variation 2 if mapped reading is 16 or 32 bit integer.
	Reply with variation 3 if mapped reading is a float.
2	Integer 32 bit
3	Short Float

- The possible variations when writing points into Object 34 are:

Variation	Description
2	Integer 32 bit
3	Short Float

No class can be assigned to any point in Object 34.

C.10.13 Object 50 - Time

Object 50 contains the meter's current time and date information. Object 50 can be read and written.

- The possible variations when reading Object 50 are:

Variation	Description
0 (Default)	Reply with variation 1.
1	Date and time.

- The possible variation when writing Object 50 is:

Variation	Description
1	Date and time.

- The duration that a new time is valid in the meter after it is written is called "Time Sync Renewal Interval," and it is configurable from 0 minutes (time never expires) to 4095 minutes (roughly more than two and one half days).
- Only Read function (Function 1) and Write function (Function 2) are allowed for this object.

C.10.14 Object 60 - Class Objects

This object allows reading points from objects that belong to a specific class. It is possible, for example, to read all objects belonging to Class 0; or to get Change event Values by reading Class 1, 2 or 3.

- For Read function the possible variations are:

Variation	Description
1 (Default)	Reply with objects in Class 0.
2	Reply with objects in Class 1.
3	Reply with objects in Class 2.
4	Reply with objects in Class 3.

- This object also supports the "Enable Unsolicited" function (Function 21), the "Disable Unsolicited" function (Function22), and the "Assign Class" function (Function 23).
- No classes can be assigned to this object.
- Note that for unsolicited messages in Class 1,2 and 3, there is a 5 second delay, to buffer any events before sending the message.

C.10.15 Object 80 - Internal Indications

This object is used to access the Internal Indications. Reading and Writing (for clearing data) is supported.

- The supported Indication bits are:

Indication	Bit Location	Description
All Stations	1	Occurs when previous message was a broadcast message.
Class 1 data	2	Occurs when data configured as Class 1 is available (ready to be sent). Master station should request this class data from the meter when this bit is set in a response. Additionally, the data can be set by an unsolicited message when configured for that.
Class 2 data	3	Same as above, but for Class 2.
Class 3 data	4	Same as above, but for Class 3.
Need Time	5	Occurs when the "Time Sync Renewal Interval" has elapsed or at power up, informing the user that the meter needs time synchronization. The Master of the DNP network should synchronize the time by writing Object 50 into the meter. When time is written, the indication is cleared. This indication is also cleared when the Master explicitly writes a 0 into this bit of Object 80.
Local	6	Set when some, or all, of the digital output points in the meter are in the Local state, meaning the Master cannot control the outputs because the meter is already using them for limits, alarms, or ElectroLogic.
Device Trouble	7	Set when an abnormal condition exists in the Meter (configuration is bad or another error prevents proper functioning).
Device Restart	8	Set when the device starts up - is an indication that the device has restarted. Master station should send a clear to this Indication, so if in the future it appears again, it will be known that the meter restarted, again. It is also set after a Cold-Restart command.
Bad Function	9	Occurs if the function code in a User Data request is not supported.
Object Unknown2	10	Occurs if an unsupported object is specified for accessing.
Out of Range	11	Occurs for most other errors in a request, such as requesting points that don't exist or direct operate requests in unsupported formats.
Buffer Overflow	12	Occurs if any buffer of the DNP3 meter application has overflowed. For example, the event buffer (for classes), or the transmission buffer due to a lengthy reply.
Already Executing	13	Request understood and already in operation.

- No class can be assigned to this Object.

C.10.16 Object 110 - Strings

The Object 110 group strings are used for information purposes. The points are read only (Function 1) and they always have to be read with Variation 0. This is because the variation returned indicates the length of the string.

- The defined points are described below.

Point	Description	Variation	Comment
0	Meter Model Number String	16	Fixed.
1	Meter Configured Designator (#)	16	This string can be configured in the meter Device Profile. Commonly used to name the meter.
2	Firmware Version String	4	Version number of the firmware.
3	Meter Serial Number String	10	Fixed per device.
4	User String	1-16	This string can be edited by the user in the DNP Configurable Profile via GE Communicator software.

- Any point in this object can be assigned to Class 0 in the DNP Configurable Profile, using GE Communicator software.

C.11 Default Values

By default, DNP is disabled. Once you enable it, either for Serial COM2 or for a Network card, the default DNP settings will be shown in the programming screens. The following tables show these default values programmed into the meter at the factory.

General Settings	
Unsolicited Class Mask	none
Unsolicited Target Device	0
DNP Slave Address	1
Reply Confirm Timeout (ms)	2000
Unsolicited Timeout (ms)	2000

Binary Inputs - Objects 1, 2				
DNP Point	Allow Access by DNP	Object 1 Class 0	Object 2 Classes 1, 2, 3	Description
0	No	none	none	Option Card 1 Input #1
1	No	none	none	Option Card 1 Input #2
2	No	none	none	Option Card 1 Input #3
3	No	none	none	Option Card 1 Input #4
4	No	none	none	Option Card 2 Input #1
5	No	none	none	Option Card 2 Input #2

Binary Inputs - Objects 1, 2				
DNP Point	Allow Access by DNP	Object 1 Class 0	Object 2 Classes 1, 2, 3	Description
6	No	none	none	Option Card 2 Input #3
7	No	none	none	Option Card 1 Input #4

Binary Outputs - Object 12		
DNP Point	Allow Access by DNP	Description
0	No	Option Card 1 Relay #1
1	No	Option Card 1 Relay #2
2	No	Option Card 2 Relay #1
3	No	Option Card 2 Relay#2
4	No	Reset Energy Counters
5	No	Change to Modbus Protocol
6	No	Reset Demand Counters
7	No	Manual Waveform Capture

Binary Counters - Objects 20, 22, 23									
DNP Point	Modbus Register	DNP Object	Value Scaling	Class 0	Change Event (Object 22)		Frozen Event (Object 23)	Description	Default Variation
					Delta	Class 3, 2, 1	Class 3, 2, 1		
0	0x05DB	20	1	X	0			Wh+	1
1	0x05DD	20	1	X	0			Wh-	1
2	0x05E3	20	1	X	0			VARh+	1
3	0x05E5	20	1	X	0			VARh-	1
4	0x05EB	20	1	X	0			VAh Total	1

- Digital input accumulators are not assigned by default, because Inputs are optional.
- For Default Variation, the following rules apply:
  - If the value type is int16 (signed or unsigned), the default variation shall be 4.
  - If the value type is any other type, the default variation shall be 3.
- For scaling, the following rules apply:
  - If the Reading is a float type, the scaling shall be float also.
  - If the reading is integer 16b (signed or unsigned) the scaling shall be integer 16, unless rule (d) is valid.
  - If the reading is integer 32b (signed or unsigned) the scaling shall be integer 32b, unless rule (d) is valid. If the value has a valid fraction (non zero numbers after a decimal point), or if the absolute of the value is bigger than 8000000 value, then the scaling type shall be a float. Otherwise it shall be an integer 32b.

- If the scaling field is blank, no value shall be shown to the user, and the scaling field shall be defined as 1, integer 32b.

Analog Inputs - Objects 30, 32, 34								Default Variation
DNP Point	Modbus Register	DNP Object	Value Scaling	Class 0	Object 34 Deadband %	Object 32 3, 2, 1	Class Description	
0	0x1194	30	1	X	0		Meter Status	2
1	0x03E7	30	1	X	0		VAN	5
2	0x03E7	30	1	X	0		VBN	5
3	0x03EB	30	1	X	0		VCN	5
4	0x03EB	30	1		0		VAB	5
5	0x03EF	30	1		0		VBC	5
6	0x03F1	30	1		0		VCA	5
7	0x03F3	30	1		0		IA	5
8	0x03F5	30	1		0		IB	5
9	0x03F7	30	1		0		IC	5
10	0x0403	30	1		0		IN	5
11	0x03F9	30	1	X	0		W Total	5
12	0x03FB	30	1	X	0		VAR Total	5
13	0x03FD	30	1	X	0		VA total	5
14	0x03FF	30	1		0		PF Total	5
15	0x0401	30	1		0		Freq	5
16	0x2339	30	1		0		Max Demand Avg. W+	5
17	0x233B	30	1		0		Max Demand Avg. W-	5
18	0x233D	30	1		0		Max Demand Avg. VAR+	5
19	0x233F	30	1		0		Max Demand Avg. VAR-	5
20	0x2341	30	1		0		Max Demand Avg. VA	5
21	0x1003	30	1		0		Angle Phase IA	2
22	0x1004	30	1		0		Angle Phase IB	2
23	0x1005	30	1		0		Angle Phase IC	2
24	0x1006	30	1		0		Angle Phase VAB	2
25	0x1007	30	1		0		Angle Phase VBC	2

Analog Inputs - Objects 30, 32, 34								Default Variation
DNP Point	Modbus Register	DNP Object	Value Scaling	Class 0	Object 34	Object 32	Class	
					Deadband %	3, 2, 1	Description	
26	0x1008	30	1		0		Angle Phase VCA	2
27	0x7530	30	1		0		CT Num	2
28	0x752F	30	1		0		CT Den	2
29	0x7532	30	1		0		PT Num	2
30	0x7531	30	1		0		PT Den	2
31	0x0417	30	1		0		PF A	5
32	0x0419	30	1		0		PF B	5
33	0x041B	30	1		0		PF C	5
34	0x0405	30	1		0		W Phase A	5
35	0x0407	30	1		0		W Phase B	5
36	0x0409	30	1		0		W Phase C	5

- For Default Variation, the following rules apply:
  - If the value type is int16 (signed or unsigned) the default variation shall be shown as 4.
  - If the value type is float, the default variation shall be shown as 5.
  - For any other type, the variation shall be 3.
- For scaling, the following rules apply:
  - If the reading is a float type, the scaling shall be float also.
  - If the reading is integer 16b (signed or unsigned) the scaling shall be integer 16, unless rule (d) is valid.
  - If the reading is integer 32b (signed or unsigned) the scaling shall be integer 32b, unless rule (d) is valid. If the value has a valid fraction (non zero numbers after a decimal point), or if the absolute of the value is bigger than 8000000 value, then the scaling type shall be a float. Otherwise it shall be an integer 32b.
  - If the scaling field is blank, no value shall be shown to the user, and the scaling field shall be defined as 1, integer 32b.

Strings - Object 110	
User Definable String	Empty

- All strings belong to Class 0.

Time Synchronization	
Allow Time Synchronization	Disabled

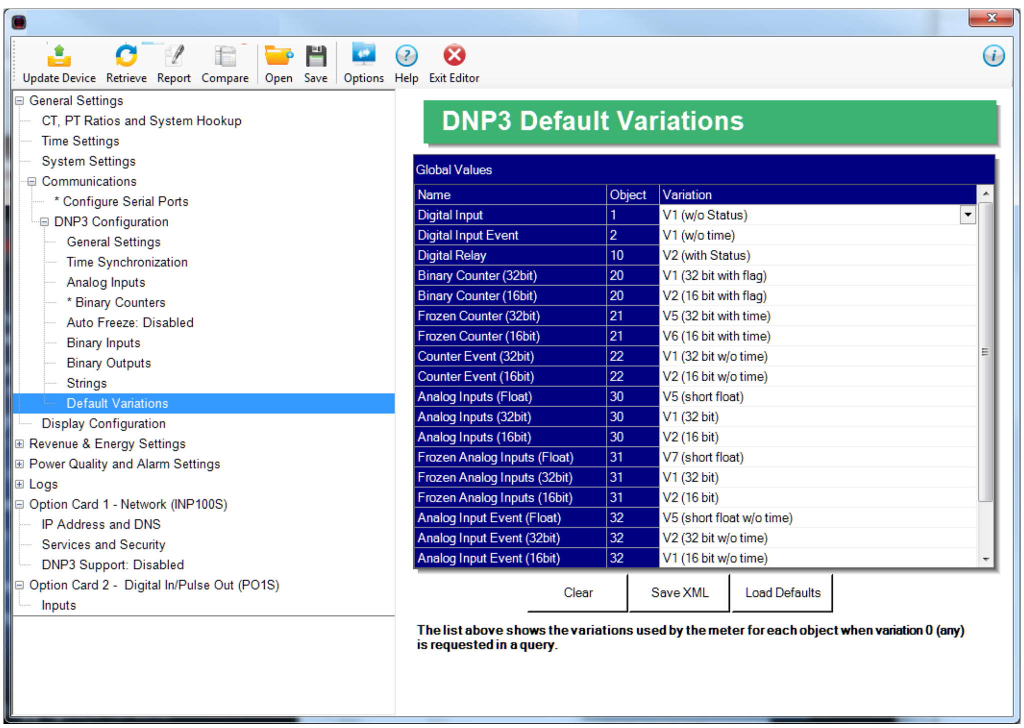
C.12 Cold and Warm Restart

The Cold Restart command (Function Code 13) and the Warm Restart command (Function Code 14) do not perform any action in the meter, except for setting the Restart bit when the Restart command is received.

Refer to the *GE Communicator Instruction Manual* for instructions on restarting the meter.

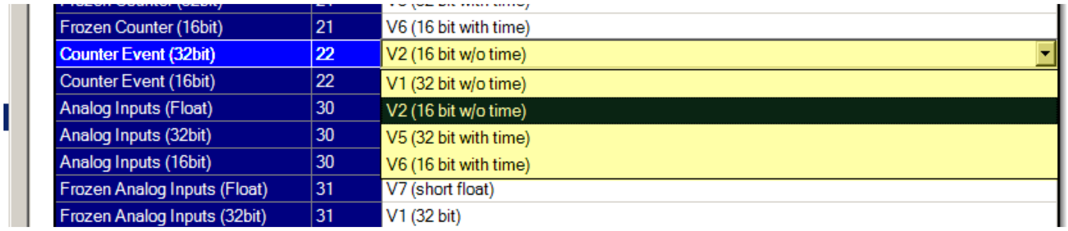
C.13 Default Variations

As explained in C.10 *Object Specifics* on page C–5, each object has a default variation that is used when Variation 0 is specified. The default variations are configured when the meter is manufactured, but you can reconfigure them in the meter's Device Profile, using GE Communicator software. The settings screen is shown below.



Any of the variations listed for each of the objects (see C.10.1 *Object 0 - Device Attributes* on page C–5 through C.10.16 *Object 110 - Strings* on page C–16) can be assigned as the default variation.

The settings are somewhat different in the case of Analog Inputs and Binary Counters. Since the DNP3 points are a mapped version of the Modbus registers in the meter, and since the Modbus register Type for some readings can be either float, 16 bit integer, or 32 bit integer, the EPM 7000P meter’s DNP3 implementation provides the flexibility to set up different default variations depending on the mapped Modbus register’s Type. See the following examples.



Use example 1:

The user wants to read Voltage Van (currently 112.55 V) and Phase Vab (currently 1800) as integers, so the user sets the default variation as integer. Both magnitudes are Analog Inputs for DNP3, but the Voltage Van Modbus register is a float value and the Phase Vab Modbus register is a 16-bit integer. In this case, the user could configure Voltage Van to be mapped into Analog Input Point #0 and Phase Vab into Analog Input Point #1, and then configure the Default Variation for Analog Input Float to use Variation #5 (short float), and the Default Variation for Analog Input 16-bit to use Variation #2 (16-bit integer). In this way, the actual register value is preserved and the meter can reply to a request with the default variation for these points: the Voltage Van will be replied as a float 112.55 (not losing precision) and the Phase Vab as the integer 1800 (also in its native format), supplying the optimized data read.

Use example 2:

The data and registers to be read are the same as in the first example, but the user wants to read any Analog Input as 16-bit integer, whatever the Type of the original Modbus register (float, 32-bit, 16-bit). Again, the user could configure Voltage Van to be mapped into Analog Input Point #0 and Phase Vab into Analog Input Point #1, but configure the Default Variation for both Analog Input Float and Analog Input 16-bit to use variation #2 (6-bit integer). The meter can then reply to a request with the default variation for these points: the Voltage Van will be replied as the 16-bit integer 112 (losing decimals due to conversion) and the Phase Vab as 1800 (in its native format). Although conversion can cause some loss of precision, the meter’s reply is much easier to process since the format of all the points is known.

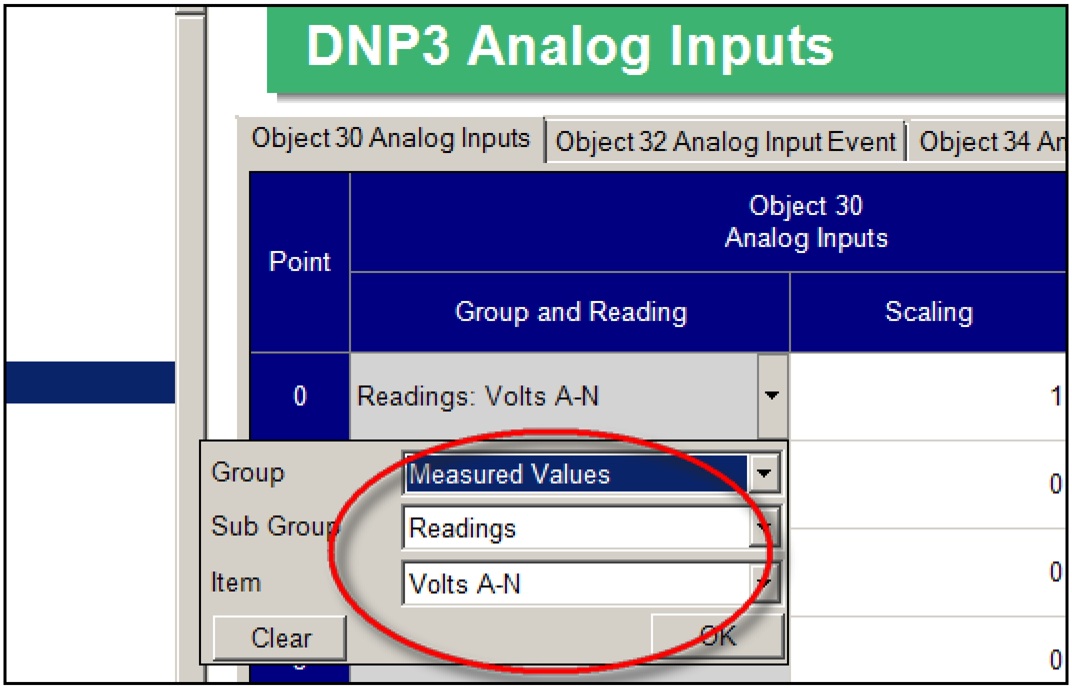
C.14 Use Cases

The following use cases show how to configure the meter’s DNP3 settings to see the data you need. The DNP3 polling screen examples were generated using ASE, Inc.’s application ASE2000 Version 2. The details of the DNP3 settings screens are given in the *GE Communicator Instruction Manual*. (Note that the data in the following use cases was generated by a source generator, so there is some variability in the example numbers. However, this does not affect the instructions themselves.)

C.14.1 Case 1 - Primary of 14.4 KV and Secondary of 120 V

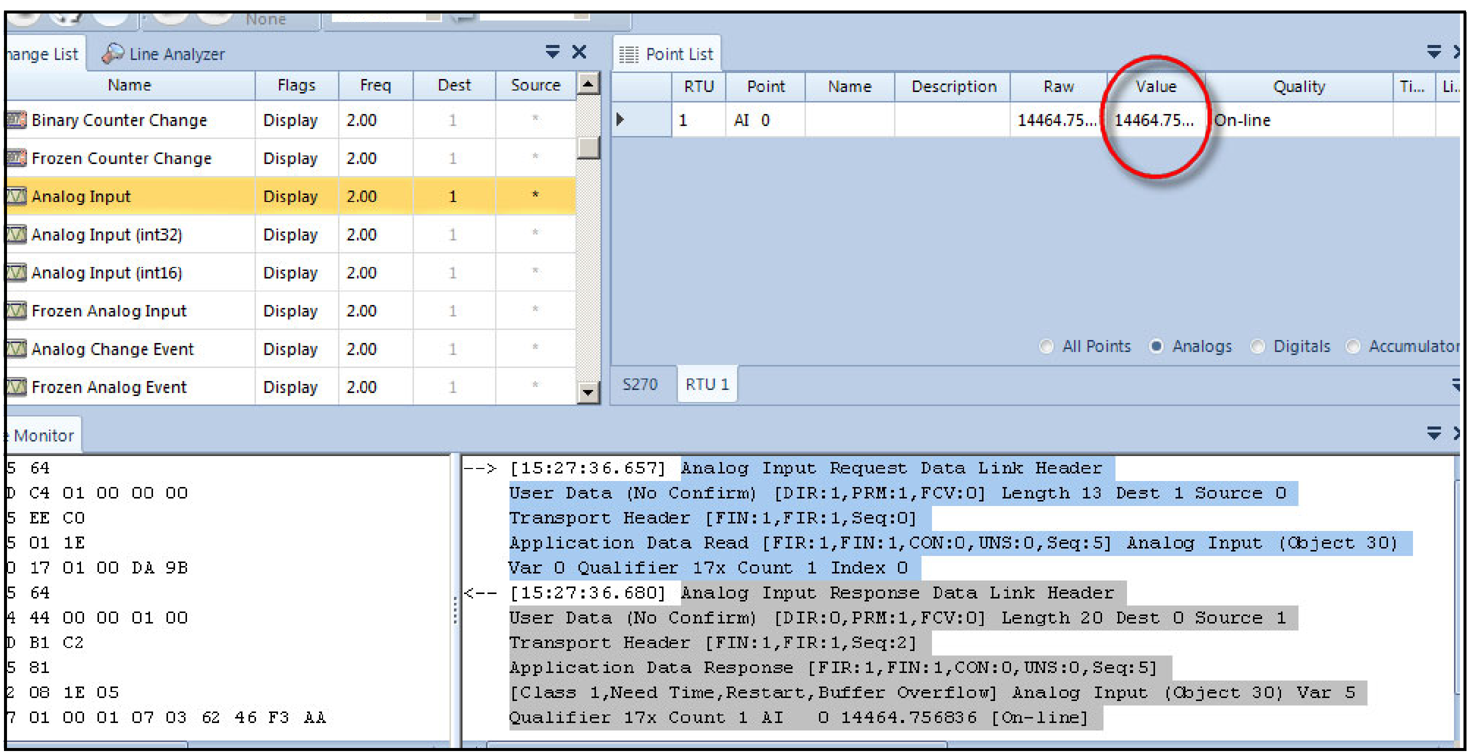
In the first case. the meter is set with a primary of 14.4 KV and a secondary of 120 V.

1. To read the primary voltage value volts A-N through DNP3, assign "Measured Values/ Readings/Volts A-N" to point #0 of Analog Inputs (Object 30).



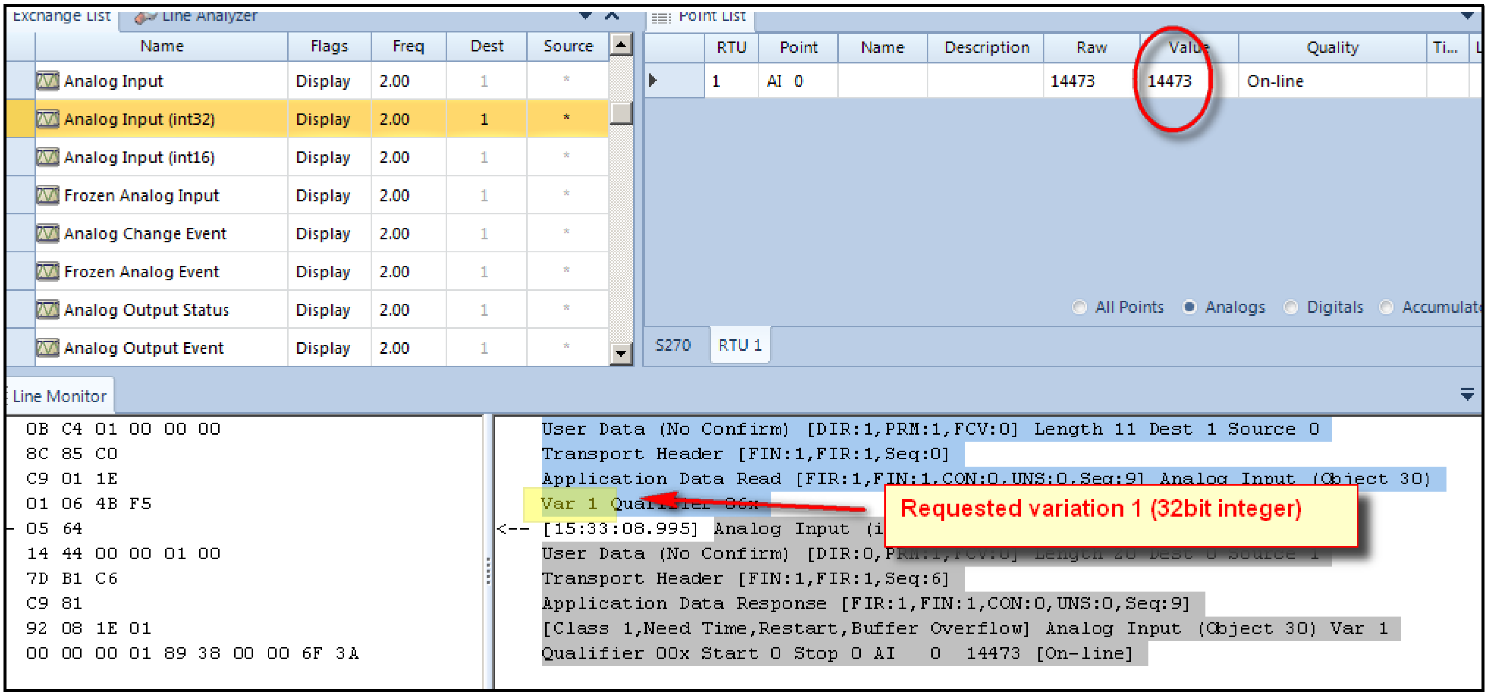
2. The EPM 7000P meter Readings group is in primary values, so the user does not need to modify the scaling in DNP Object 30 (the scaling defaults to 1.0).

3. To see the value, the user polls DNP Object 30, point#0.

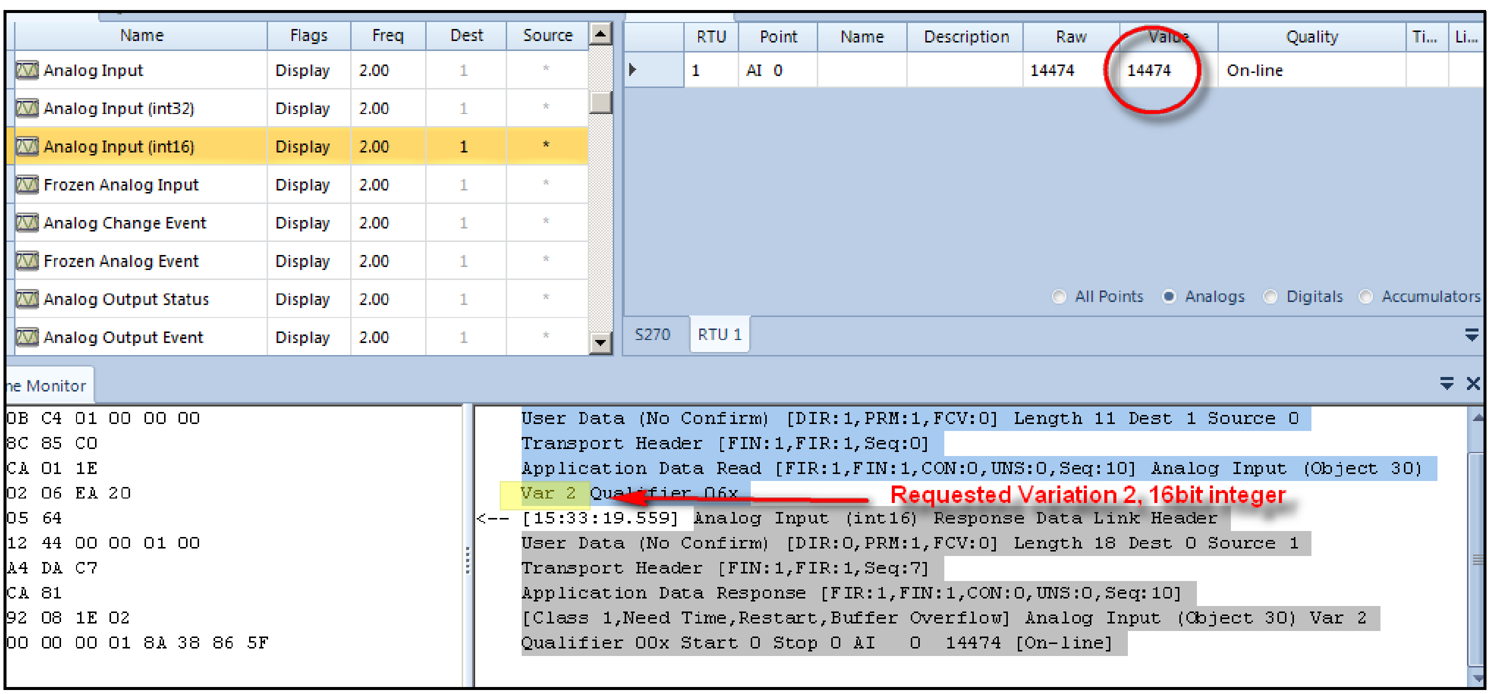


Note that the returned value is 14464.75, which is a floating point value. This is because the default variation returned by the meter for reading voltage is Variation 5.

Other variations can be requested. See the figure below for the result when Variation 1 (32 bit integer) is requested.

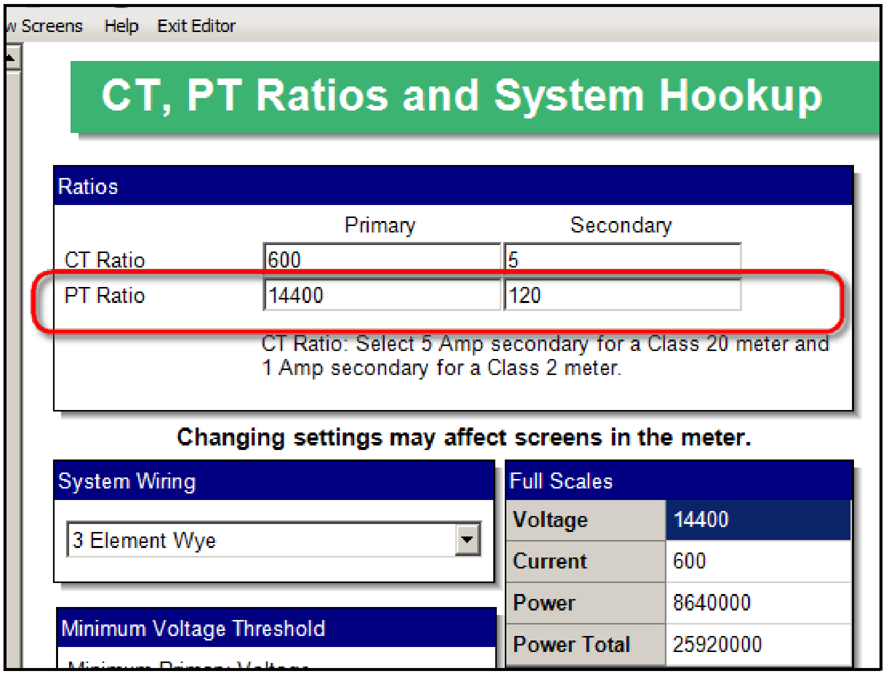


See the figure below when the same object/point is polled using Variation 2 (16 bit integer).



For information on the variations the EPM 7000P meter can provide for each reading, see the *GE Communicator Instruction Manual*.

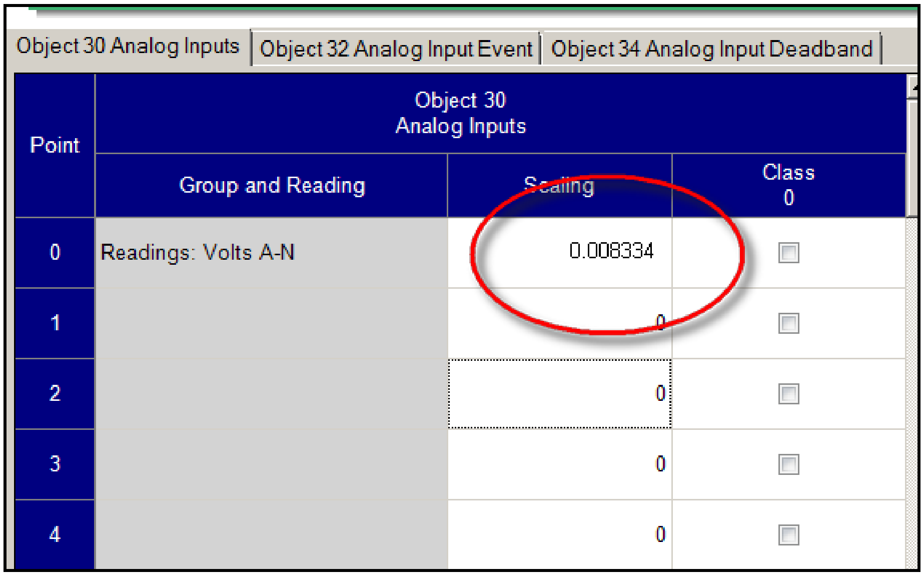
4. To read the secondary voltage of value volts A-N through DNP3, set the Scaling field in the DNP3 configuration of Object 30 to the value computed from the CT/PT Ratios and System Hookup setting screen, shown below.



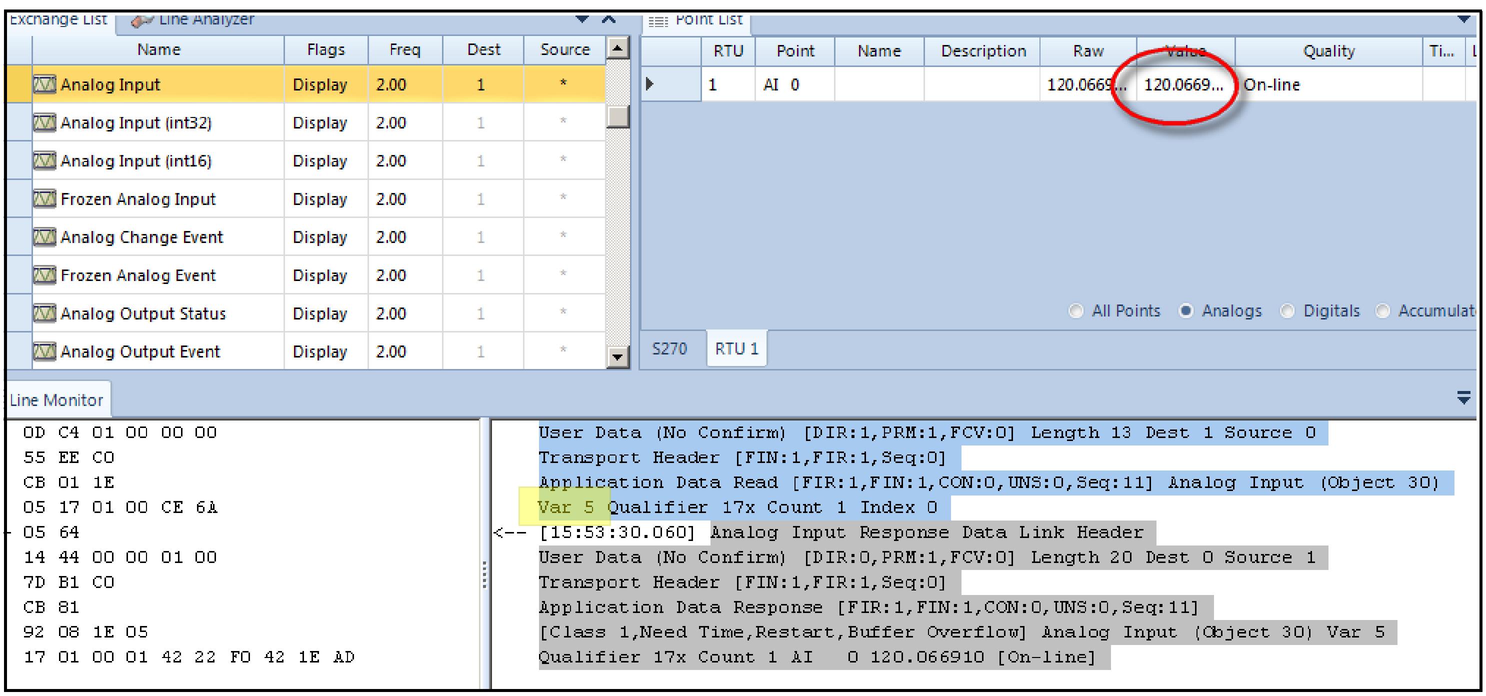
5. To see the secondary volts A-N using the settings shown above, compute the DNP3 Scaling value in this way:

$$Scaling_{DNP} = \frac{Secondary\_Volts}{Primary\_Volts} = \frac{120}{14400} = 0.008334$$

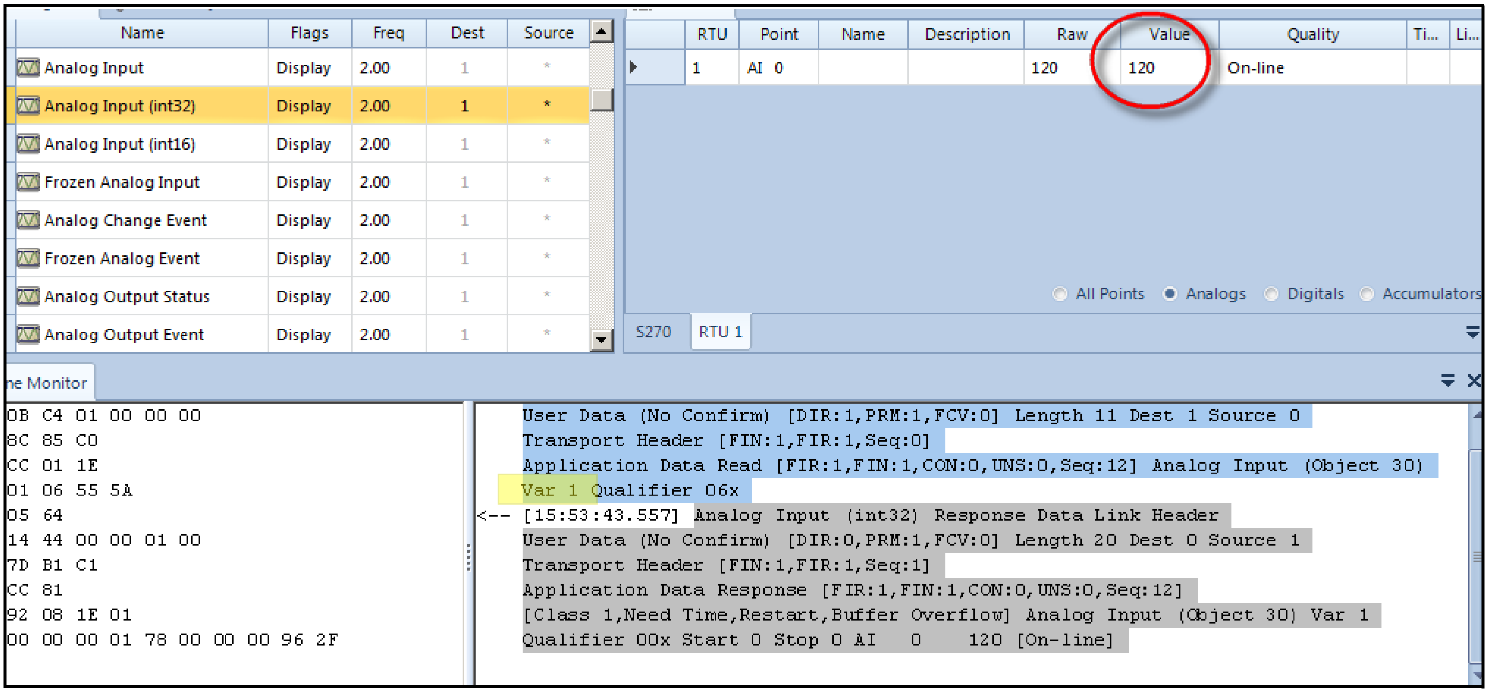
6. The scaling value of value 0.008334 is entered in the Scaling field for Point 0 Object 30 in the DNP Analog Inputs setting screen.



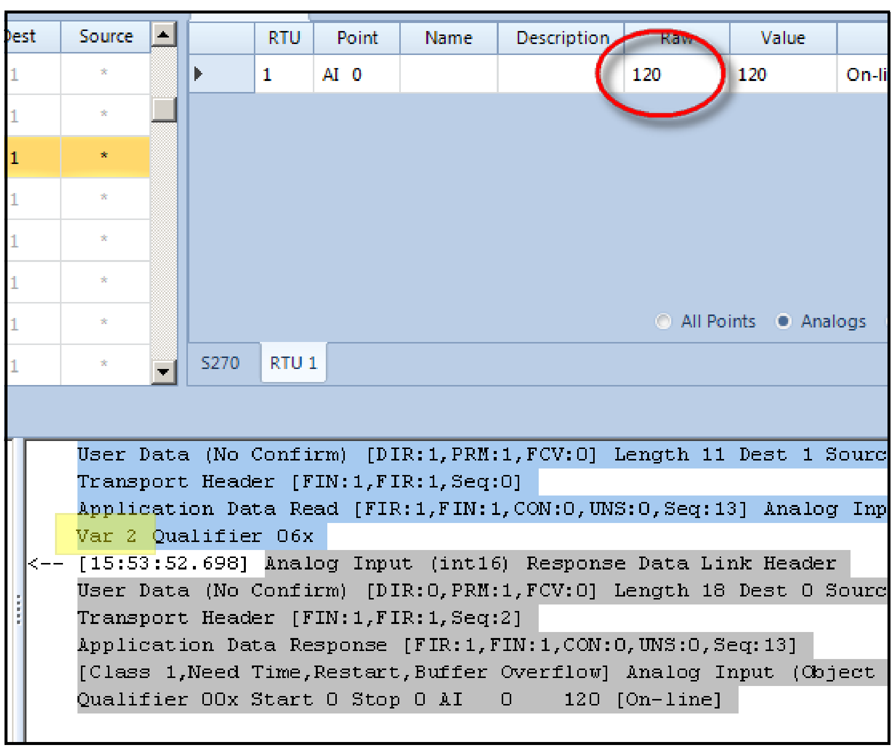
7. Now polling through DNP3, the user sees the expected secondary values. The figure below shows the secondary using Variation 5, which is a floating value.



The figure below shows the secondary using Variation 1 (32 bit integer), which displays a reading of 120.



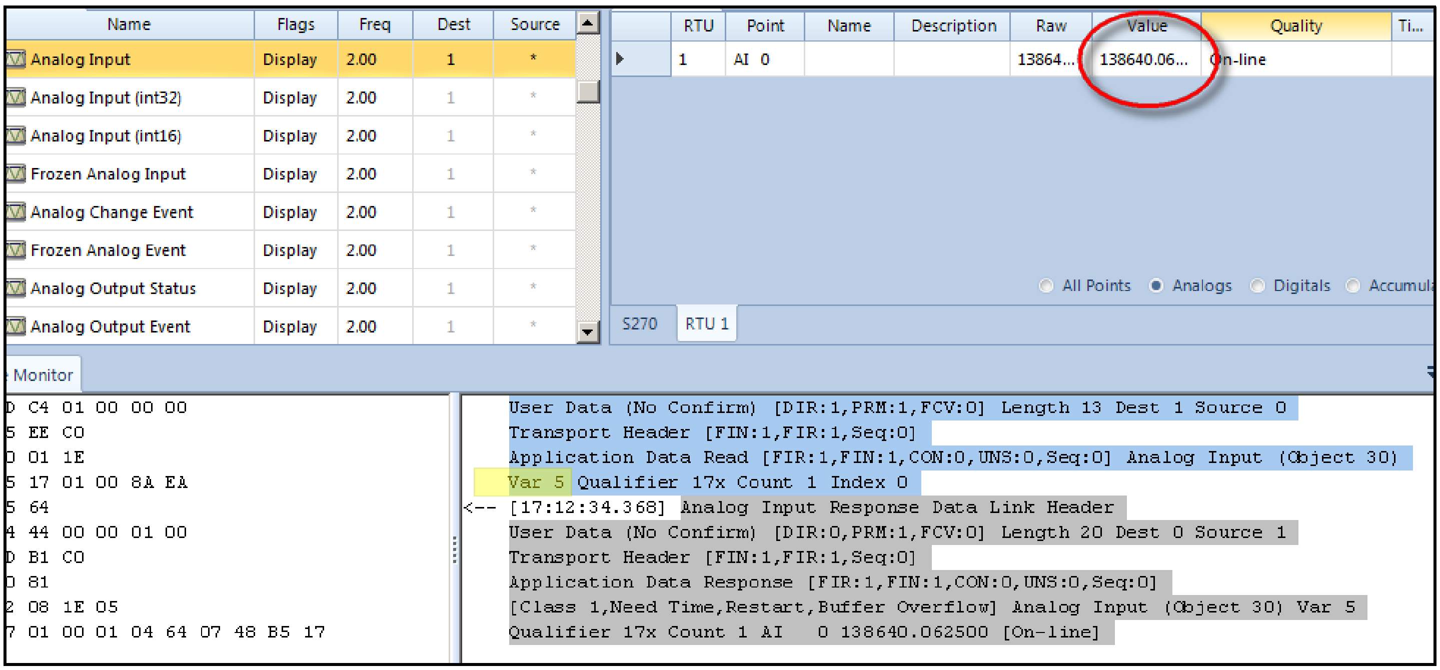
The figure below shows the secondary using Variation 2 (16 bit integer), which also displays a reading of 120.



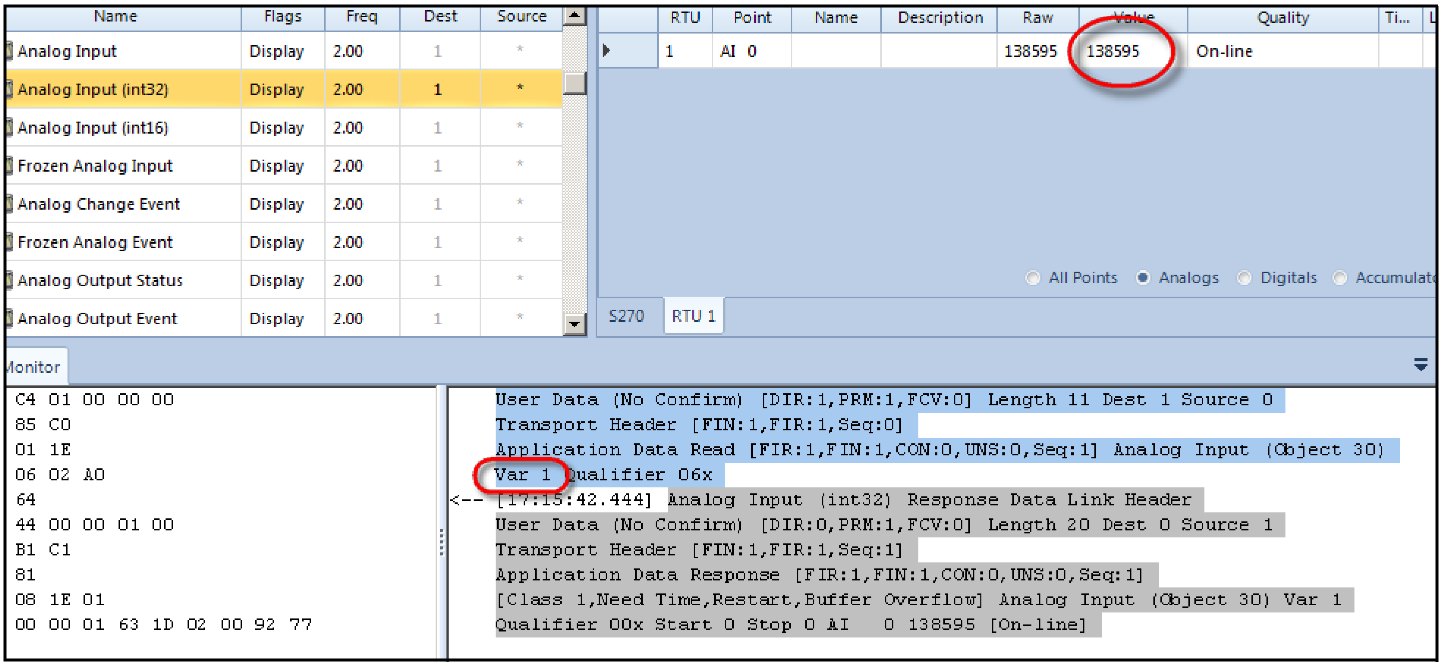
C.14.2 Case 2 - Primary of 138 KV and Secondary of 120 V

In the second case, the meter is set with a primary of 138 KV and a secondary of 120 V.

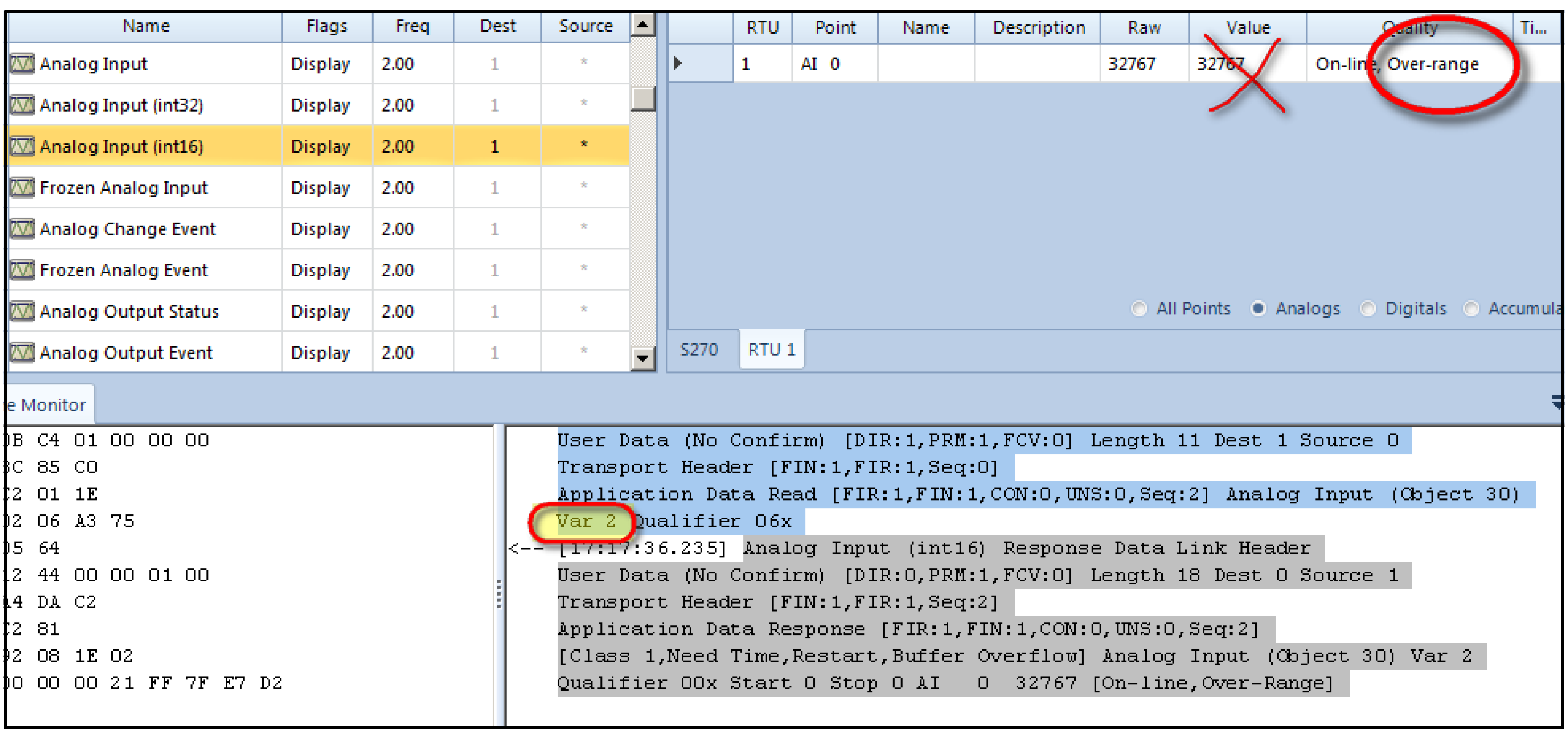
1. To read the primary voltage value VAN through DNP3, assign "Measured Values/ Readings/Volts A-N" to point #0 of Analog Inputs (Object 30) (as shown in C.14.1 *Case 1 - Primary of 14.4 KV and Secondary of 120 V* on page C–21). Since it is primary, the DNP scaling is kept to the default of 1.0.
2. When polling through DNP using the default variation (Variation 5), the result is 138640.06 volts.



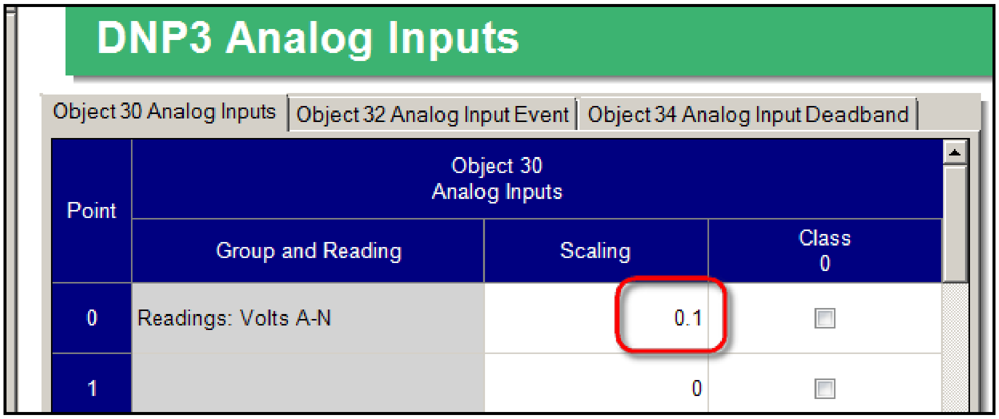
Polling the same point with Variation 1 (32 bit integer), gives a non-fractional value of 138595 V.



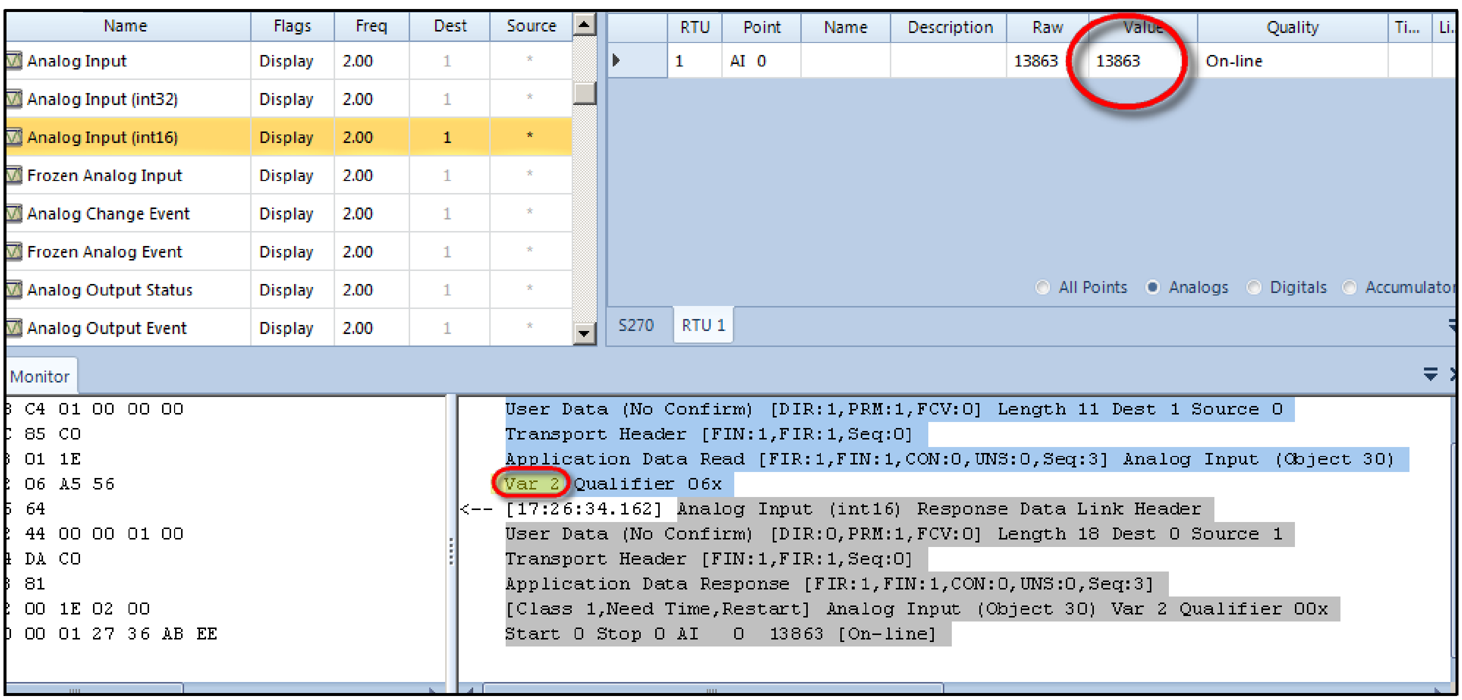
In this case, however, if the user polls the same point as Variation 2, the value won't fit in the 16 bit integer result. This is indicated by the qualifier "Over Range." In this situation, the returned value should be ignored.



If you need to read the value as a 16 bit integer, you can scale the value down using a pre-defined factor. For example, using a 1:10 scaling, the 138000 volts will fit in the 16 bit integer as the number 13800. To do this, the Scaling field for that point is set to 1:10, or 0.1 as shown in the following figure.



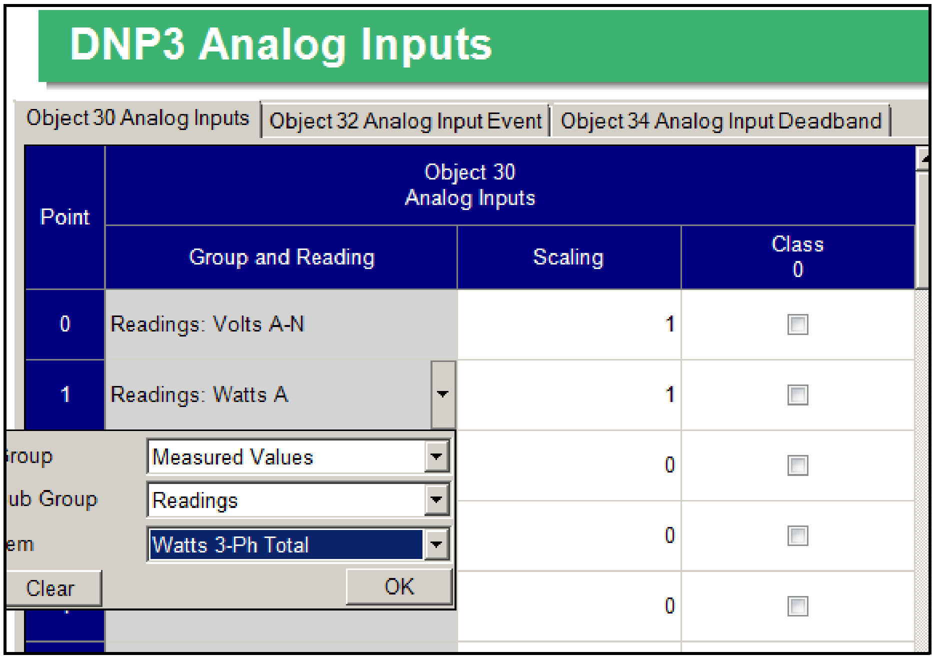
Polling that point gives a value of 13863 as expected, which
would be interpreted by the user as 138.63 KV since the 1:10 scaling was applied.



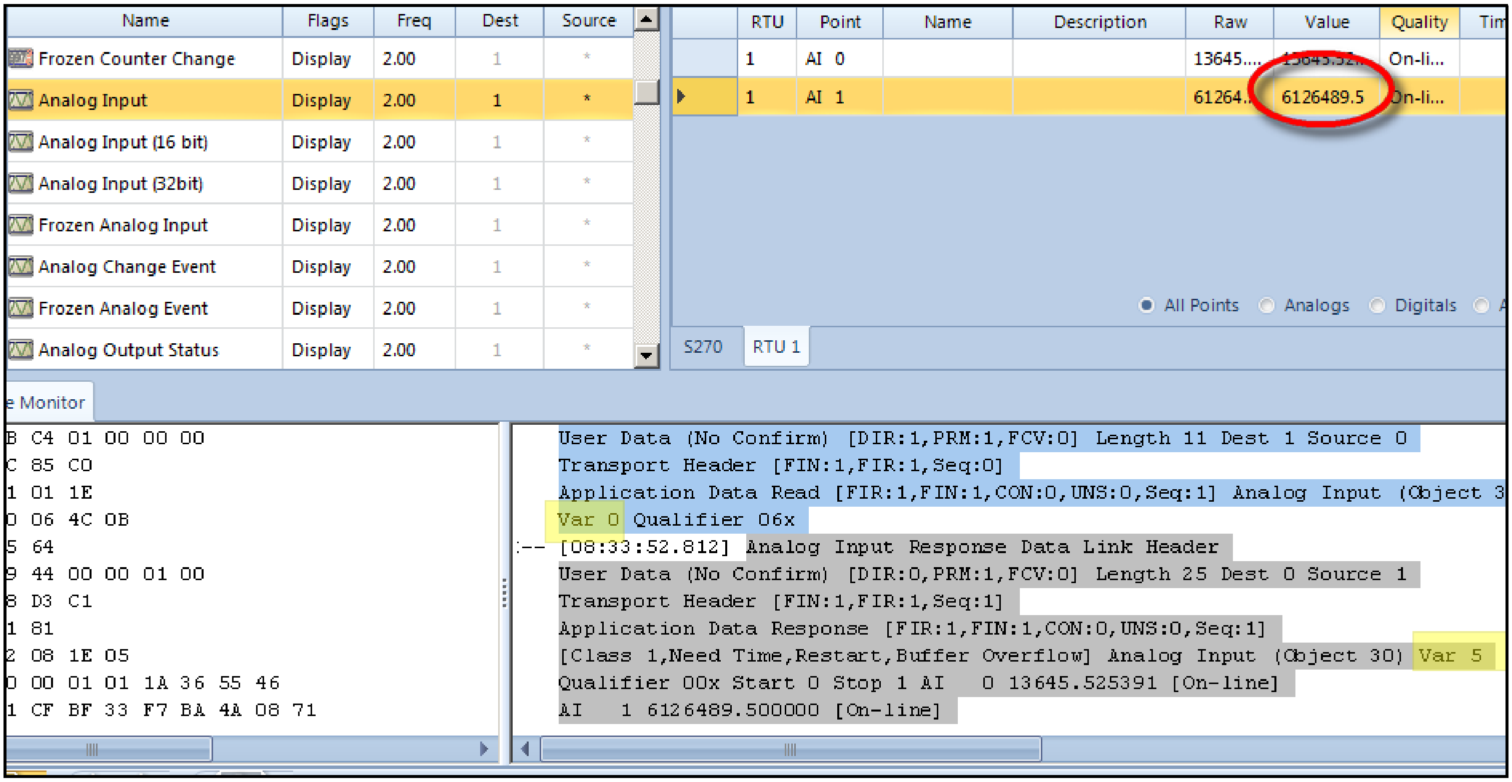
C.14.3 Case 3 - Read Power in the Range of 6000 Kilowatts

In this case, the user wants to read the total power, which is around 6000 kW.

1. The reading belongs to the Measured Values/Readings group: readings for that group are primary values. In this example, include the Total Power in point #1 of Object 30 as shown in the figure below. Keep the DNP Scaling field in its default of 1, to display the primary value.

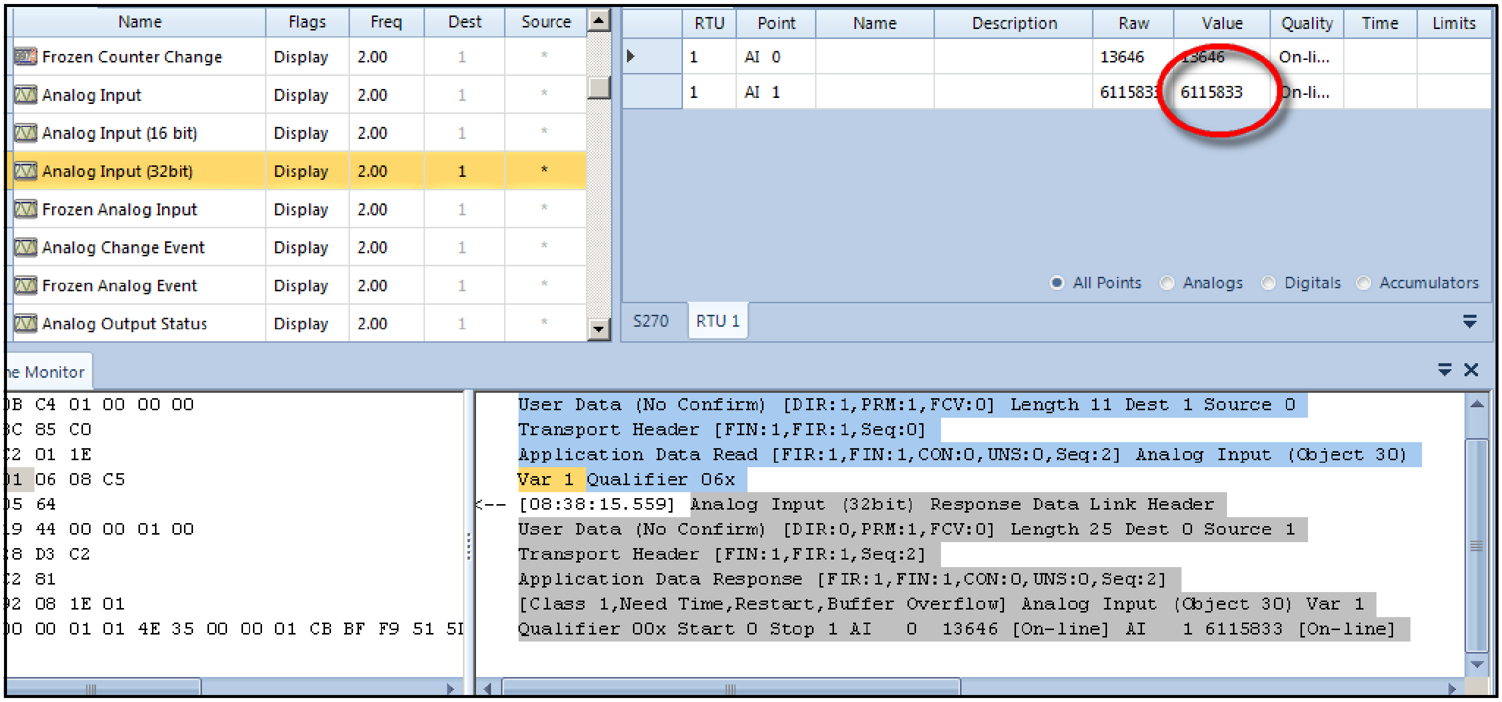


2. The user configured the application to read all the Analog Input points, so when the EPM 7000P meter is polled, there are 2 points: point 0 (from Case 2) and point 1, which is the Total Power.



Note that the received data is in Variation 5 (float). The number received for point 1 is 6126489.5, in other words 6126.48 kW. Reading this value is very simple if the default variation (Variation 5) is used.

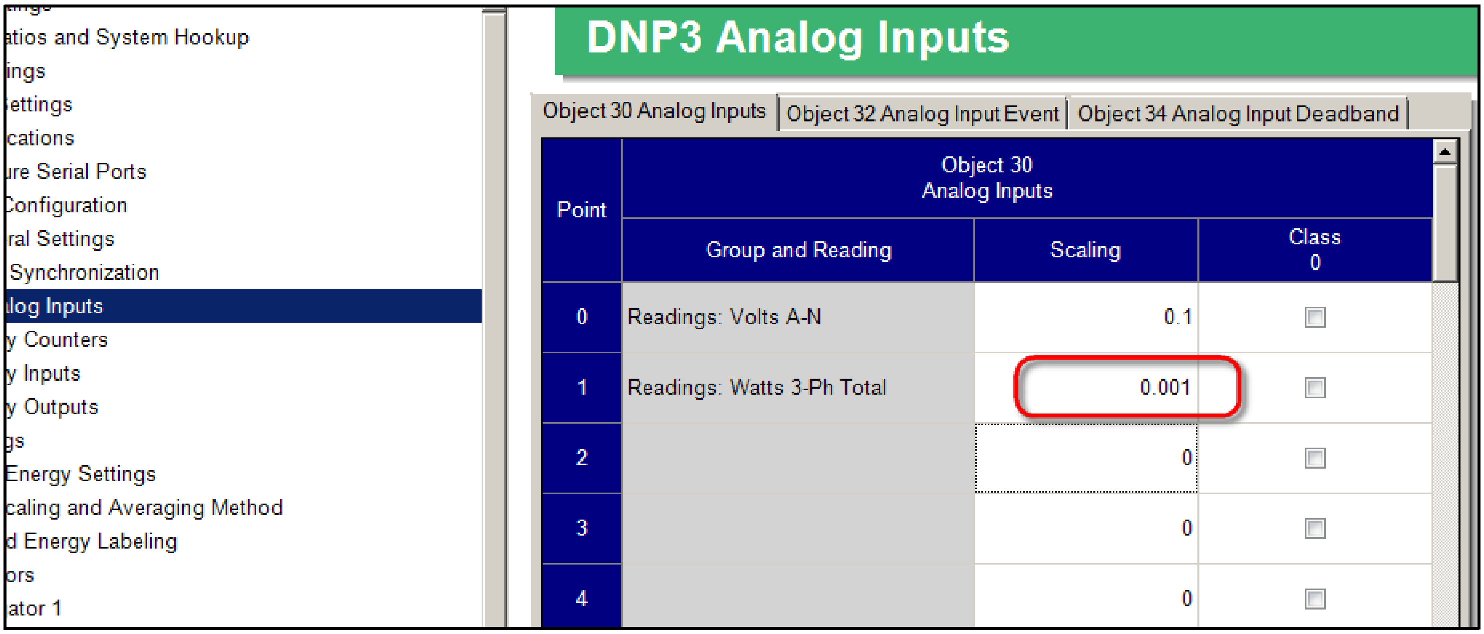
The value can also be requested using Variation 1 (32 bit integer).



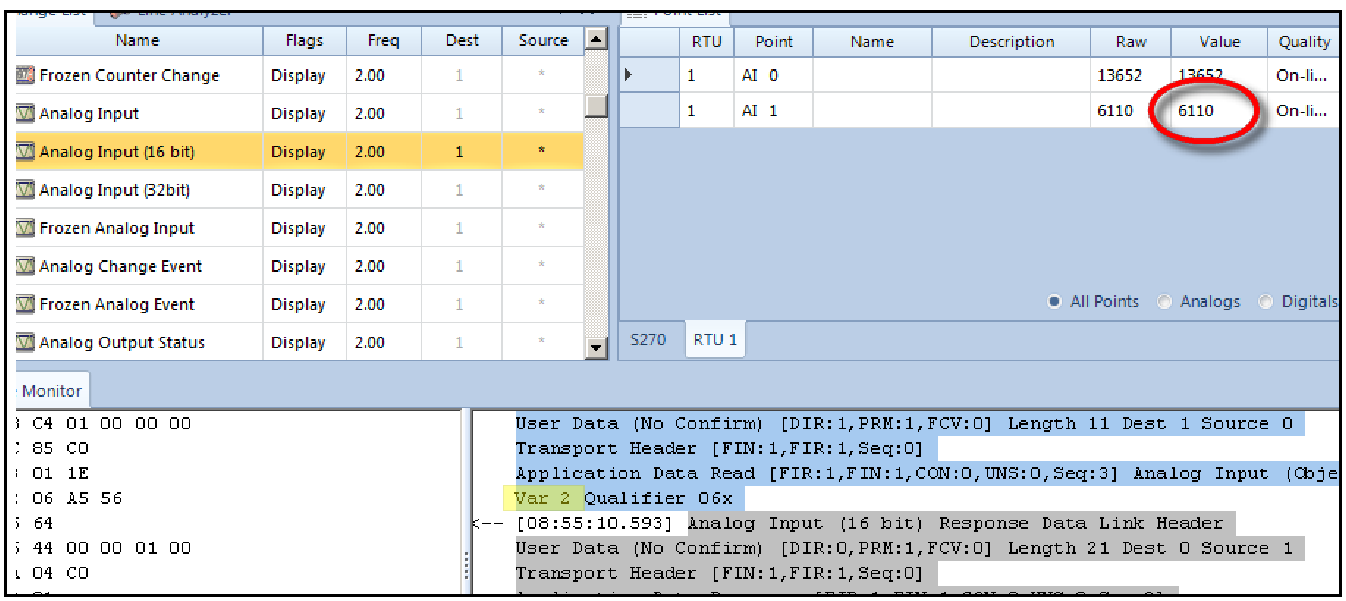
The received value is 6115833, which is 6115833 W or 6115.83 kW. Note that Variation 1 can be used as long as the value does not overflow the signed 32 bits. The limit for preventing overflow is approximately 2147 MW.

Using Variation 2 (16 bit integer) would result in an overflow, since the 6000 kW range does not fit into a 16 bit integer.

If you need to use Variation 1 or Variation 2 without encountering overflow (i.e., DNP3 "Over Range"), you can use the DNP Scaling field to scale down the reading by a predefined value. For example, the watt reading could be scaled down by 1000, so that it would be in kilowatt rather than watt.



The following figure shows the result of polling point 1 with the configured DNP scaling of 0.0001.



Note that the value is now 6110, which is interpreted as 6110 kW because of the 0.001 scaling.

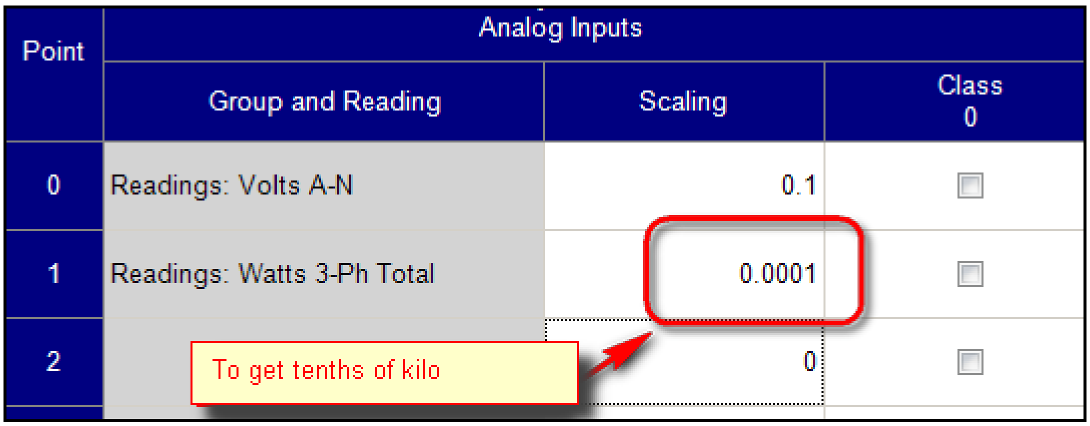
If the value is as big as 1000000000, and you needto use Variation 2, the value can be scaled to MW by using the DNP Scaling field value of 0.000001.

C.14.4 Case 4 - Read Power in the Range of 60000 Kilowatt

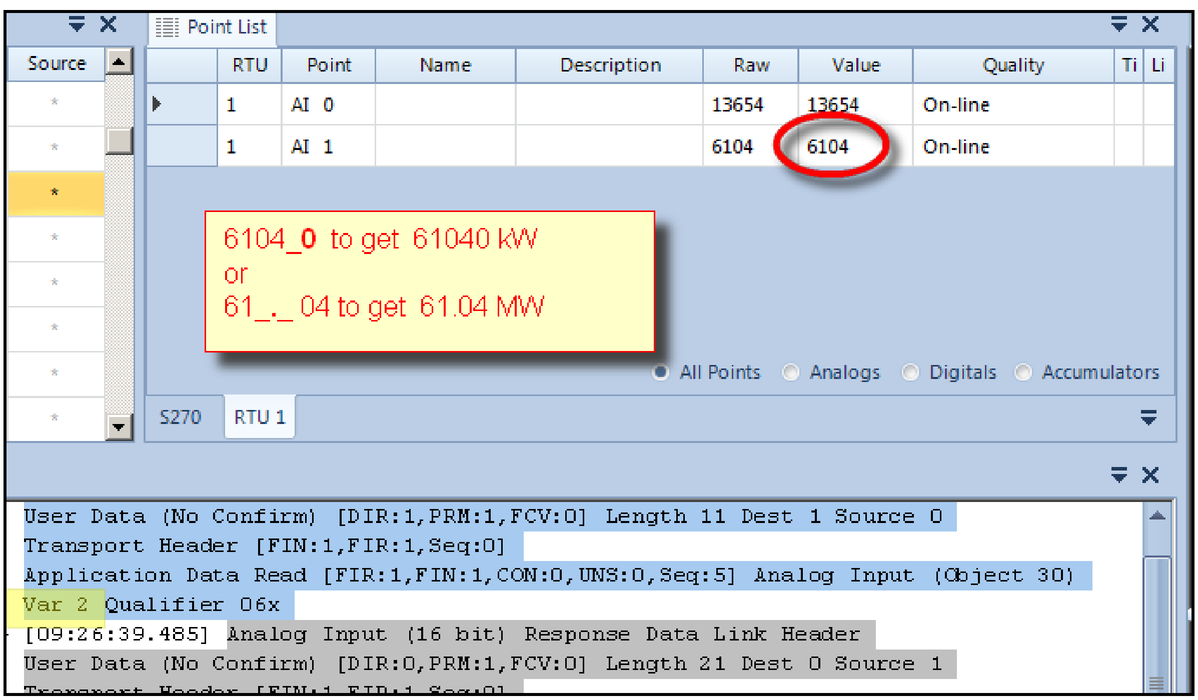
This case is similar to Case 3. If Variation 5 is used to read the value it is very simple, and the DNP Scaling field should be kept at its default of 1.0.

If Variation 1 is used to read the value, the 60000000 will fit in the 32 bit integer format, so there is no need to use any value other than 1.0 in the DNP scaling.

If Variation 2 is used, 60000000 will not fit in the 16 bit integer. A DNP Scaling value of 0.001 to read as kW would give 60000, which is still more than the max value for a 16 bit integer, which is 32767. To avoid data overflow and to get a consistent value, the original reading needs to be scaled down further. Using a DNP scaling of 0.0001 will result in a DNP value which is a tenth of kW.



To make the received value easy to understand, add a zero at the end of it to get kW, or put a decimal point at the left of the two rightmost digits to get MW.



C.14.5 Case 5 - Read Power in the Range of 120000 Kilowatts

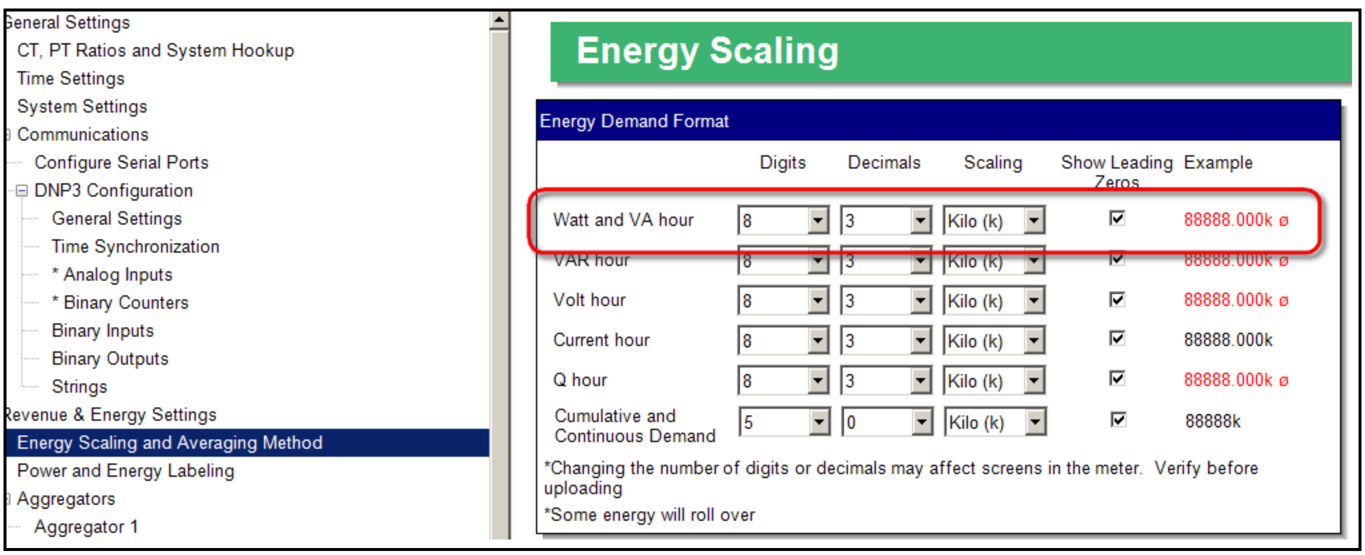
This case is very similar to Case 4. Reading the power using Variation 5 is straight forward, not requiring any DNP Scaling (DNP Scaling = 1.0).

Reading the value using Variation 1 (32 bit integer) also does not require any scaling unless the power is expected to go beyond the 2.14 GW.

Reading the value using Variation 2 (16 bit integer), can be accomplished using the DNP Scaling 0.0001 (tenths of kilo), exactly as in Case 4. If the DNP Scaling is set to 0.000001, the value read would be in MW units.

C.14.6 Case 6 - Reading Energy of Approximately 12345.678 kWh

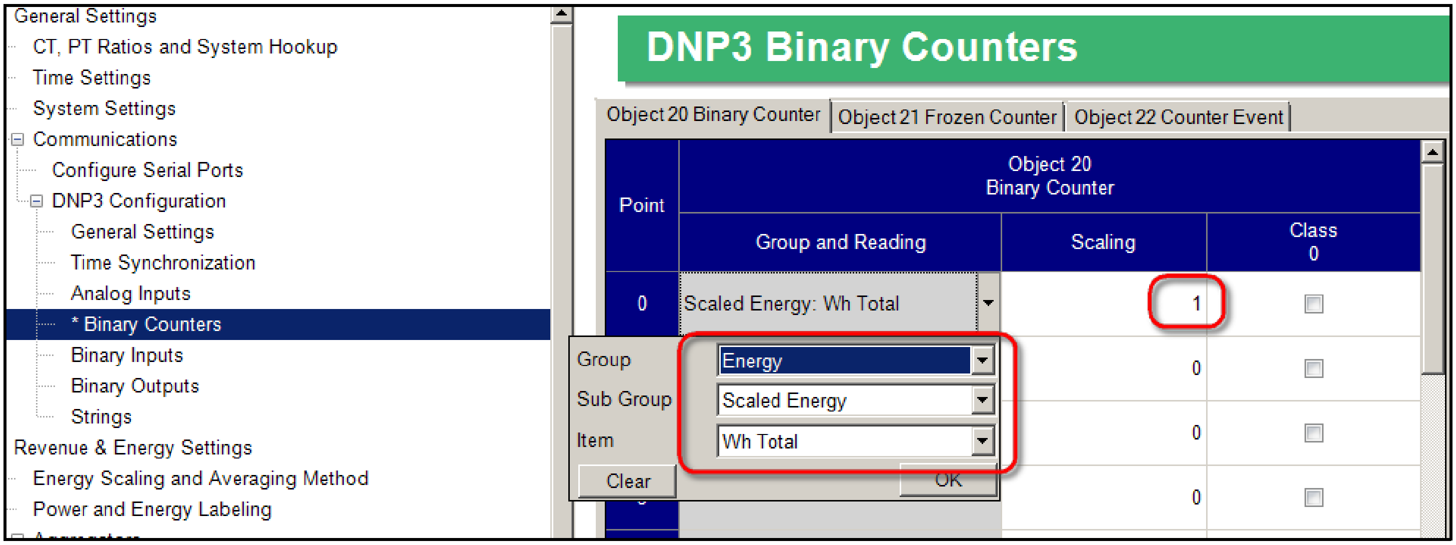
Primary energy in the EPM 7000P meter is scaled, which means that it has a scaling factor based on the selected unit (unit, kilo, mega, or giga) and the decimal point position. This is configured in the "Energy Scaling and Averaging Method" section of the meter's Device Profile (see the *GE Communicator Instruction Manual* for details). See the figure below.



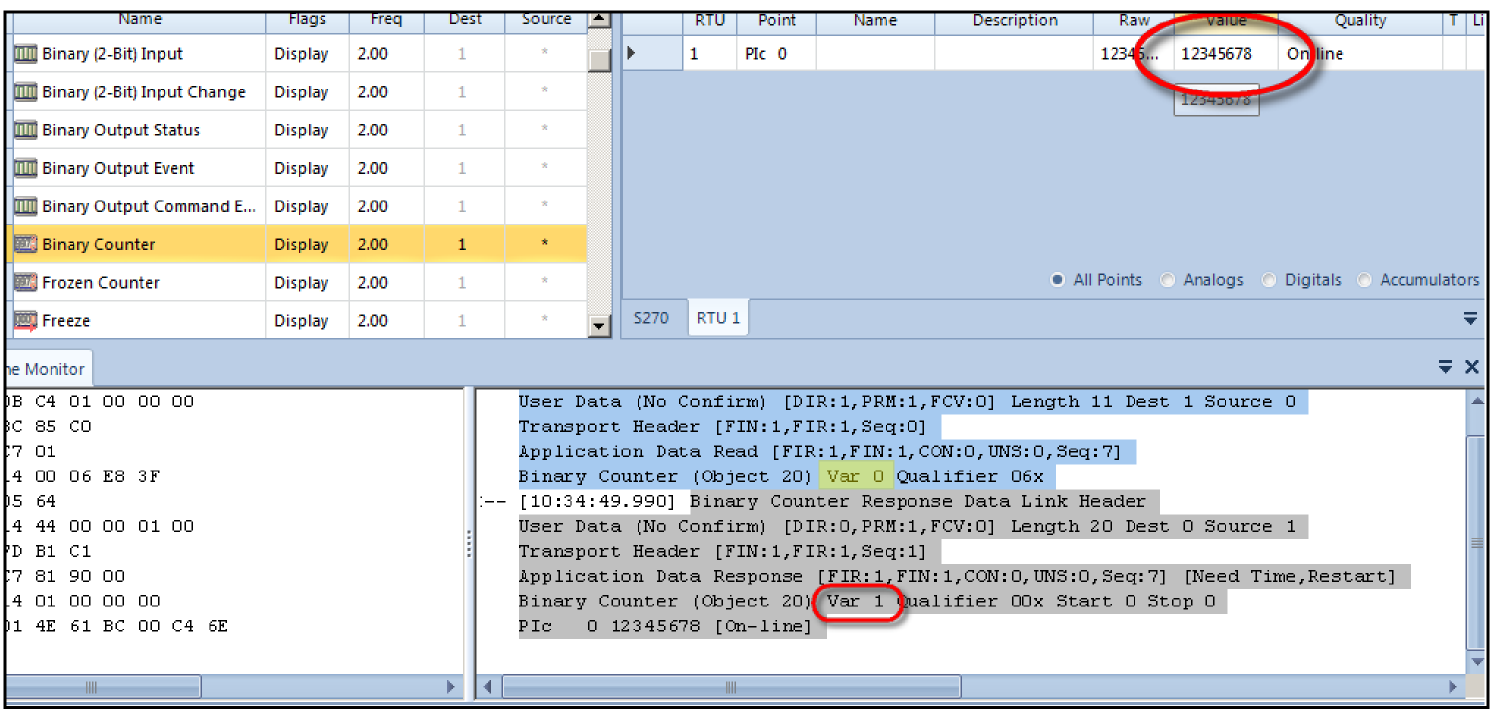
From the point of view of DNP, energy values are Binary Counters (Object 20). They can be read only as a 32 bit or a 16 bit integer, corresponding to Variation 1 and Variation 2; though Variation 5 or Variation 6 can be used when certain “flags” are also required.

In order to correctly interpret the value obtained from a binary counter point via DNP, the user needs to know the unit and decimal position of the energy reading.

In this example, the user reads the total Wh, which is scaled in kilo (kW) and has 3 decimal digits. The DNP Scaling is kept at its default of 1.0.



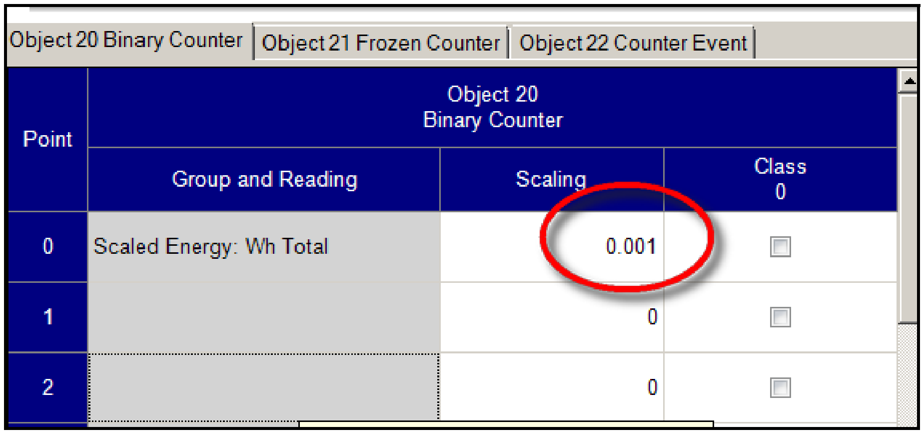
The total Wh is configured as point 0 of Object 20. Reading this value with the default Variation 1, results in the following display.



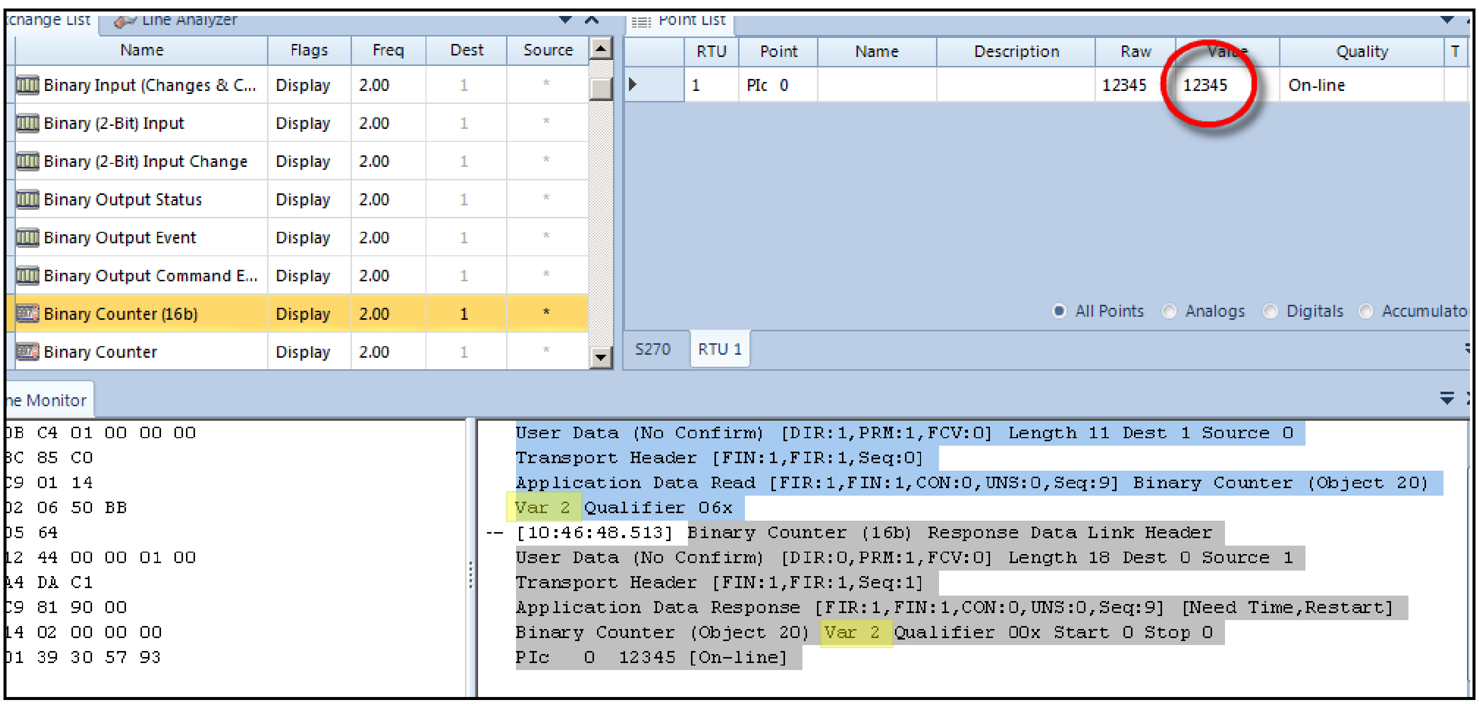
The value is 12345678 using Variation1. To correctly interpret this value, the user must apply the energy scaling that was set for the value (scaled in kilo (kW) with 3 decimal digits):

- To the value 12345678, the user adds the decimal point to have 3 decimal digits - 12345. 678 and adds the unit, which is kilo. The resulting value is 12345.678 kWh.

To use Variation 2, the user must make sure the value is going to fit in a 16 bit integer. Clearly 12345678 will not, so the DNP Scaling field can be used to remove the 3 decimal digits, simply by scaling the value with 0.001. See the figure below.



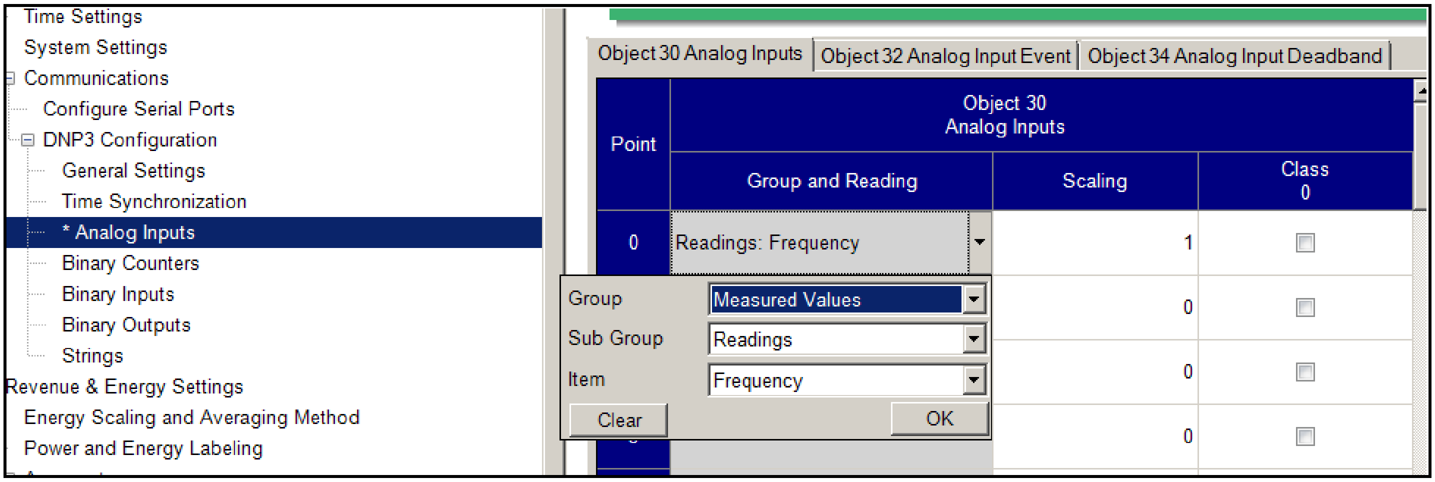
Reading the point, and asking for Variation 1 gives the value 12345.



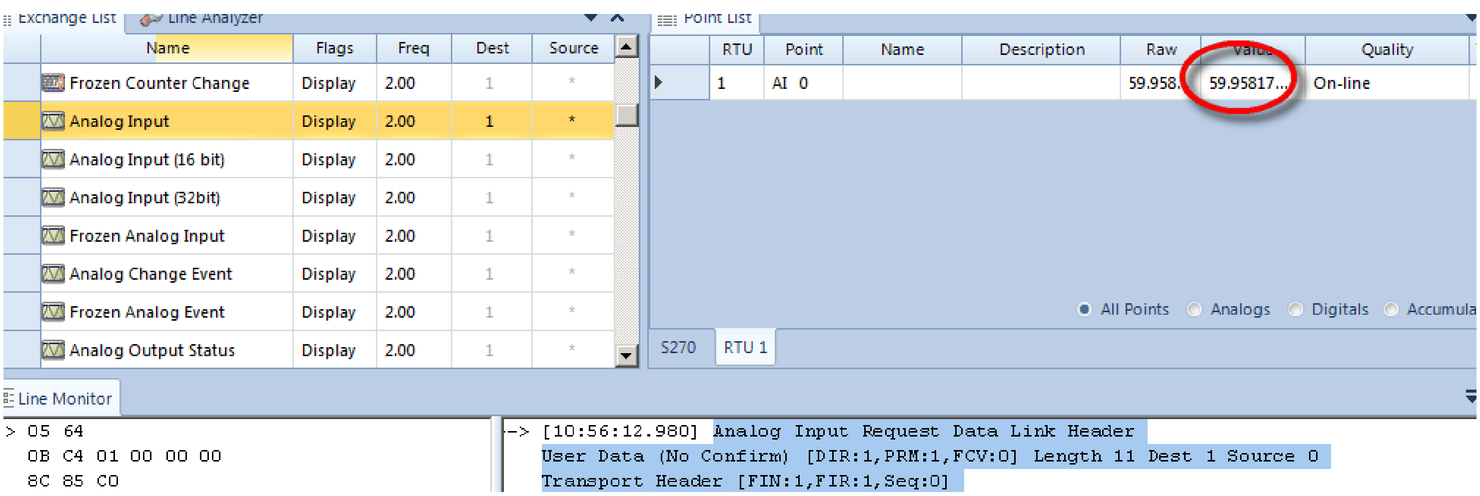
Since the energy scaling unit is kilo, the value is 12345 kWh.

C.14.7 Case 7 - Frequency of 59.95 Hz

The frequency can be included as a point in the Analog Inputs (Object 30). The frequency reading is originally a float value, so DNP Scaling can be left at its default of 1.0.

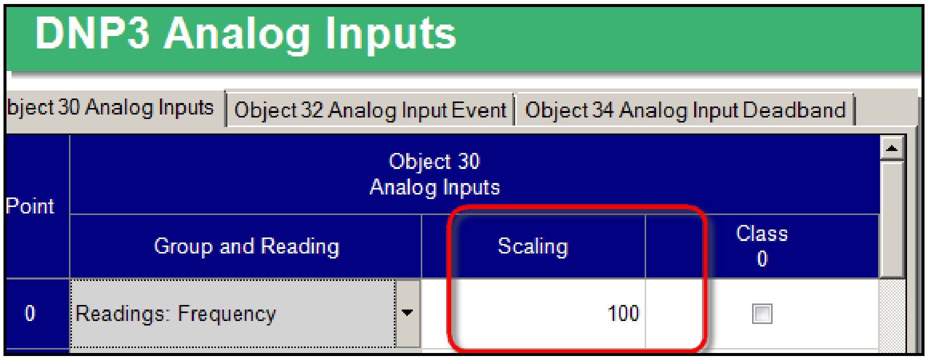


If Variation 5 is used to read this point, the value is straight forward, as shown below.

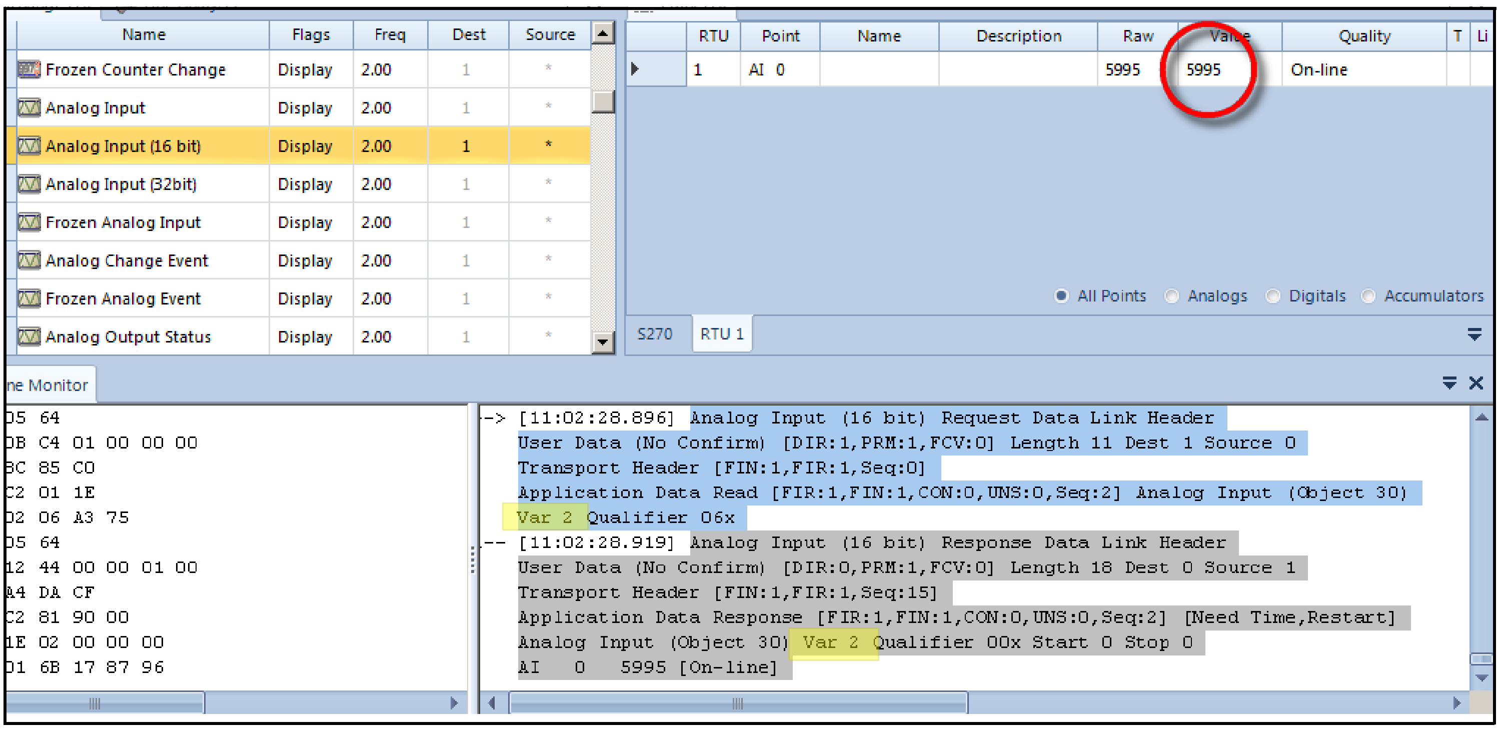


If Variation 2 (16 bit integer) is used, only the value 59 will be read - the fraction digits are discarded. If you need to use Variation 2 and still preserve some decimal digits, you ca do this using the DNP Scaling field.

For example, if the user wants to preserve 2 decimal digits in the frequency reading, the frequency must be scaled up 100 times, as shown in the figure below.



Using ASE2000 and requesting Variation 2 (16 bit integer) we get the value 5995.



Since the last two digits are the decimals we preserved through scaling, the value is interpreted as 59.95Hz.

GE
Grid Solutions

Multilin™ EPM 7000P

Appendix D: Transformer Loss Compensation Spreadsheet

D.1 Calculating Values

Transformer Loss Compensation is discussed in Chapter 13. Values for three element installations can be calculated in two ways:

Through an Excel Spreadsheet:

1. From the GE Communicator software, click the **TLC Calculator** button on the Transformer Loss screen of the meter's Device Profile. The TLC Calculator button activates an Excel Spreadsheet, but ONLY if you have MS Excel installed on your computer. A copy of the Excel Spreadsheet is shown on the following pages with example numbers.
2. Enter the required data into the Excel Spreadsheet. The Excel program will calculate the values needed for the Transformer Loss screen of the Device Profile.
3. Enter the values into the Device Profile.

Manually:

1. Use the worksheet found in *Three-Element Loss Compensation Worksheet* on page 13–5, to calculate the values by hand. Refer to the Notes under each section.
2. Enter values based on the transformer manufacturer's test report. The worksheet is progressive and notes under each section will guide you to the next section.
3. Enter the values into the Device Profile.

D.2 Excel Spreadsheet with Example Numbers

If you have MS Excel installed in your computer, use the **TLC Calculator** button on the Transformer Loss screen of the Device Profile. Refer to the spreadsheet copies with example numbers, found on the following pages.

NOTICE

IMPORTANT! Refer to the *GE Communicator Instruction Manual* for additional instructions and information on the Transformer Line Loss application.

System Losses Summary

Loss Compensation Calculator

Meter Correction Factors from this sheet are manually entered into GE Communicator Software

Note: Begin Data Entry by Going to Xfmr Loss Sheet

Company:	Example 2 - EEI Handbook Example	Project	
Name:		Location	
Date:			

Comments:	Example of Loss Calculation that includes Transformer Losses, but no Substation or Line
	Losses.

Meter Correction Factors		Loss Factors		
for Communicator Software		Calc	Used	
% No-Load Loss Watts	%LWFE	2.16780	2.168	Enter These
% Full-Load Loss Watts	%LWCU	0.02471	0.025	Values in GE
% No-Load Loss VARs	%LVFE	58.45983	58.460	Communicator
% Full-Load Loss VARs	%LVCU	0.35639	0.356	Software

Losses Shifted to IT Primary		per element	Total	Unit
LWFE	Core-Loss Watts	78.04	234.12	kW
LVFE	Core-Loss VArs	2,104.55	6,313.65	kVAr
LWCU	Watts Loss due to Cu	0.89	2.67	kW
LVCU	VA Rated Loss due to Cu	12.83	38.49	kVAr
VAnom	Nominal Meter VA Rating		10,800.00	kVA

Total System Losses

total losses *Note: If no data entered in Line or Substation Loss sheets contribution to total is zero*

Type	Source		kWatts Loss		kVAr Losses
No-Load Losses	Transformer Core	NLW	28.68	NLV	94.74
Load Losses	Transformer Windings	FLW	56.03	FLV	807.98
	Transmission Line	LLW	0.00	LLV	0.00
	Substation Conductors	CLW	0.00	CLV	0.00
	Total Load Losses	TLW	56.03	TLV	807.98

per element losses

Type	Source		kWatts Loss		kVAr Losses
No-Load Losses	Transformer Core	NLW	9.56	NLV	31.58
Load Losses	Transformer Windings	FLW	18.68	FLV	269.33
	Transmission Line	LLW	0.00	LLV	0.00
	Substation Conductors	CLW	0.00	CLV	0.00
	Total Load Losses	TLW	18.68	TLV	269.33

Comments:

Legend	
Information Only	
Required Data	
Calculated Value	
Data from other Sheet	
Enter this Data	
Comments	

Transformer Losses

Loss Compensation Calculator

Company:	Example 2 - EEI Handbook		Substation:	
Name:			Xmfr Bank No.:	
Date:			Xmfr S/N:	
Xmfr Manf:			Company Number	
Winding				
HV - High				
XV - Low				
YV - Tert.				
Comments:				

Legend

- Information Only
- Required Data
- Calculated Value
- Data from other Sheet
- Enter this Data
- Comments

Transformer Losses		Losses		
		per Element	Total	Unit
No Load VA	NLVA	32.9967	98.9901	kVA
No Load Watts	NLW	9.5600	28.6800	kW
No-Load Loss VARs	NLV	31.5815	94.7444	kVAr
Full Load VA	FLVA	269.9730	809.9190	kVA
Full-Load Loss Watts	FLW	18.6757	56.0270	kW
Full-Load Loss VARs	FLV	269.3263	807.9788	kVAr

Power Transformer Data		Watts Loss			
Value		Total	per element	Calculated	kVA
No Load Loss Watts	LWFe	28,680.00		9,560.00	9.56
Full Load Loss Watts	LWCu	56,027.00		18,675.67	18.68
% Exciting Current	%Ix	0.99			
% Impedance	%Z	8.1			
Transformer kVA Rating	kVA Rated	9,999.00		3,333.00	
Rated Primary L_L Volts	Vp	115,000			

Power Transformer - 3 Transformer bank		Line-to-Line		Line-to-Neut.
V Secondary Side of Xmfr	Vs	2520	Vr	1455
Rated Transformer Current	I Rated	2291		
Wye or Delta Connection		Wye		

Meter / Installation Data	*Three Element Meter with 3 PT's and 3 CT's*		
Instrument Transformers	Primary	Secondary	Multiplier
Voltage Xmfr	7200	120	60
Current Xmfr	500	5	100
Transformer Factor	TF	6000	
Meter Voltage Rating	VM	120	120 volts
Meter Test Amps	TA	2.5	2.5 amps
Meter Class	CL	20	CL20
Meter Form	Fm		
Nominal Current	Inom	2.5	Typically .5 Class(10) or TA(2.5)

Line Losses

Loss Compensation Calculator

Three Element Meter with 3 PT's and 3 CT's

Note: Leave Data Entry Cells Blank if not including Line Losses

Company:	Example 2 - EEI Handbook	Substation:	
Name:		Stn Trf Bank No.:	
Date:			

Metering Point Information	

Line Losses		Losses		
Value		per phase	Total	Unit
Total Line Length			0.0000	Mile
Line Current	Ip		50.1994	Amp
Line Loss Watts	LLW	0.0000	0.0000	kW
Line Loss VArs	LLV	0.0000	0.0000	kVA

Transmission Line Impedance Data				
Value		per Unit	Total	Unit
Resistance	R/unit	0.0000		Ohms
Inductive Reactance	XL/unit	0.0000		Ohms
Length of Line	LL - Units	0.0000		
Length Unit	U	Mile		
Resistive Losses			0.0000	kW
Inductive Losses			0.0000	kars

Note: Please make sure data entered uses a consistent unit of length

Adjustment for Line Charging Current				
Value		per Unit	Total	Unit
Capacitive Reactance	XC-unit	0.0000	#REF!	Ohms
Charging Current per line	Amps		0.0000	Amps
Capacitive Losses	kvar		0.0000	kvars

Line Losses refected to Secondary of PT		Losses		
Value		per phase	Total	Unit
Nominal Pri kVA Rating	VA mom-pri		5.4783	kVA
Nominal Sec kVA Rating	VA mom-sec		5.4783	kVA
Line Loss Watts	LLW	#REF!	#REF!	kW
Line Loss VArs	LLV	0.0000	0.0000	kVA

Transformer Data from Xmfr Loss Sheet				
Value		per phase	Total	Unit
Transformer kVA Rating	kvars	3333.0000	9,999.00	kvars
Rated Primary L_L Volts	Vp		115,000.00	Volts

Note: This Data must be entered on Transformer Loss Sheet before completing Line Loss Calculation

Notes:

Legend

- Information Only
- Required Data
- Calculated Value
- Data from other Sheet
- Enter this Data
- Comments

Substation Losses

Loss Compensation Calculator

Three Element Meter with 3 PT's and 3 CT's

Note: Leave Data Entry Cells Blank if not including Line Losses

Company:	Example 2 - EEI Handbook	Substation:	
Name:		Stn Trf Bank No.:	
Date:			

Substation Information	Example of Loss Calculation that includes Transformer, Substation, and Li
	Line Losses.

Line Losses		Losses		
		Total	per Element	Unit
Total Conductor Length		0.00		FT
Secondary Current @ Rating	Ir	2290.843		Amp
Conductor Loss Watts	CLW	0.000	0.000	kW
Conductor Loss VArs	CLV	0.000	0.000	kVA

Transmission Line Impedance Data		
Value		per Unit
Resistance		0.000000
Inductive Reactance	x	0.000000
Length of Conductor	CL	0.00
Length Unit	U	FT

Legend

- Information Only
- Required Data
- Calculated Value
- Data from other Sheet
- Enter this Data
- Comments

Note: This Data must be entered on Transformer Loss Sheet before completing Substation Loss Calculation

Transformer Data from Xmfr Loss Sheet			
Value			
Transformer kVA Rating	kVAr	9,999	3333.0000
Rated Secondary L_N Volts	Vr	1,455	