Shark® 270

Economical and Highly Featured Revenue Energy Meter

www.electroind.com

Installation & Operation Manual
V.1.02
February 7, 2017

Electro Industries/GaugeTech
The Leader In Power Monitoring and Smart Grid Solutions

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Customer Service and Support

Customer support is available 9:00 am to 4:30 pm, Eastern Standard Time, Monday through Friday. Please have the model, serial number and a detailed problem description available. If the problem concerns a particular reading, please have all meter readings available. When returning any merchandise to EIG, a return materials authorization number is required. For customer or technical assistance, repair or calibration, phone 516-334-0870 or fax 516-338-4741.

Product Warranty

Electro Industries/GaugeTech warrants all products to be free from defects in material and workmanship for a period of four years from the date of shipment. During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

To exercise this warranty, fax or call our customer-support department. You will receive prompt assistance and return instructions. Send the instrument, transportation prepaid, to EIG at 1800 Shames Drive, Westbury, NY 11590. Repairs will be made and the instrument will be returned.

This warranty does not apply to defects resulting from unauthorized modification, misuse, or use for any reason other than electrical power monitoring. The Shark® 270 meter is not a user-serviceable product.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. ELECTRO INDUSTRIES/GAUGETECH SHALL NOT BE LIABLE FOR ANY INDIRECT, SPECIAL OR CONSEQUENTIAL DAMAGES ARISING FROM ANY AUTHORIZED OR UNAUTHORIZED USE OF ANY ELECTRO INDUSTRIES/GAUGETECH PRODUCT. LIABILITY SHALL BE LIMITED TO THE ORIGINAL COST OF THE PRODUCT SOLD.

Use of Product for Protection

Our products must not be used for primary over-current protection. Any protection feature in our products must be used only for alarm or secondary protection.

Statement of Calibration

Our instruments are inspected and tested in accordance with specifications published by Electro Industries/GaugeTech. The accuracy and calibration of our instruments is traceable to the National Institute of Standards and Technology through equipment that is calibrated at planned intervals by comparison to certified standards. For optimal performance, EIG recommends that any meter, including those manufactured by EIG, be verified for accuracy on a yearly interval using NIST traceable accuracy standards.

Disclaimer

The information presented in this publication has been carefully checked for reliability; however, no responsibility is assumed for inaccuracies. The information contained in this document is subject to change without notice.

Safety Symbols

In this manual, this symbol indicates that the operator must refer to an important WARNING or CAUTION in the operating instructions. Please see Chapter 9: Electrical Installation, on page 9-1,for important safety information regarding installation and hookup of the meter. Dans ce manuel, ce symbole indique que l'opérateur doit se référer à un important AVERTISSEMENT ou une MISE EN GARDE dans les instructions opérationnelles. Veuillez consulter le chapitre 9 pour des informations importantes relatives à l'installation et branchement du compteur.

The following safety symbols may be used on the meter itself:
Les symboles de sécurité suivante peuvent être utilisés sur le compteur même:

This symbol alerts you to the presence of high voltage, which can cause dangerous electrical shock.
Ce symbole vous indique la présence d'une haute tension qui peut provoquer une décharge électrique dangereuse.

This symbol indicates the field wiring terminal that must be connected to earth ground before operating the meter, which protects against electrical shock in case of a fault condition.

Ce symbole indique que la borne de pose des canalisations in-situ qui doit être branchée dans la mise à terre avant de faire fonctionner le compteur qui est protégé contre une décharge électrique ou un état défectueux.

About Electro Industries/GaugeTech (EIG)

Founded in 1975 by engineer and inventor Dr. Samuel Kagan, Electro Industries/GaugeTech changed the face of power monitoring forever with its first breakthrough innovation: an affordable, easy-to-use AC power meter.

More than forty years since its founding, Electro Industries/GaugeTech, the leader in power monitoring and control, continues to revolutionize the industry with the highest quality, cutting edge power monitoring and control technology on the market today. An ISO 9001:2008 certified company, EIG sets the industry standard for advanced power quality and reporting, revenue metering and substation data acquisition and control. EIG products can be found on site at mainly all of today's leading manufacturers, industrial giants and utilities.

EIG products are primarily designed, manufactured, tested and calibrated at our facility in Westbury, New York.

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1: Meter Overview

1.1: The Shark® 270 High Accuracy Revenue Meter

The Shark® 270 is a socket form revenue meter for both critical meter applications and basic commercial/ industrial metering applications. The Shark® 270 meter is a full four quadrant, bidirectional revenue meter that can also be used for inter-tie metering. Its 0.15% metrology accuracy meets and exceeds all the accuracy requirements of ANSI C12.20 Class 0.2% 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.

1.1.1: Hookup Connections and Measurements

Meter Base (Socket Form) options:

- 9S
- 36S
- 45S

Measurement supported Power systems:

- Delta - 3 wire
- Delta - 4 wire
- Wye - 4 Wire

Measurements:

- Voltage:
  - True RMS
  - Ranges - Minimum is the startup voltage
    - Power and Energy computation: (20 to 576)V AC
    - RMS - startup is programmable: (0 to 576)V AC
    - For Waveform: (-815 to +815)V

NOTE: Higher Voltages require the use of potential transformers (PTs).

- Current:
  - True RMS
  - Ranges - Minimum value is startup current for RMS and Power/Energy computations
    - Class 20: (0.005 to 21)A AC; Maximum noise spike: 400 mA
    - Class 2: (0.001 to 2.1)A AC; Maximum noise spike: 40 mA
    - For waveform capture CL20: (-100 to +100)A
    - For waveform capture CL2: (-10 to +10)A

NOTE: The secondary current must be specified when ordering the meter.

WARNING! The current inputs are only to be connected to external current transformers.

- Power (W, VA, VAR): 2, 2.5, 3 element method.
  - Range: see voltage and current minimum and maximum values.

1.1.2: Ordering Codes

Model	Form	Frequency	Current Class	V-Switch™ Pack	Power Supply	Option Card 1 Type*	Option Card 2 Type*
Option Numbers:							
E.g: Shark270	**- 9S**	**- 60**	**- 2**	**- V2**	**- S**	**- INP100S**	**- X**
Shark® 270 Revenue Meter	9S	50 50 Hz System	2 2 A Secondary	V1 Multifunction Meter	S Blade Powered	X None	X None
	45S	60 60 Hz System	20 20 A Secondary	V2 V1 + 2 MB Memory	SE Externally Powered	PO1S 4 Pulses/4 Status Inputs	PO1S 4 Pulses/4 Status Inputs
	36S			V3 V2 + 4 MB Memory and Power Quality Harmonics		RO1S 2 Relay Out- puts/2 Digital Inputs	RO1S 2 Relay Out- puts/2 Digital Inputs
	9A			V4 V3 + 10 MB Memory and 128 Samples/Cycle Waveform Recording		1mAOS 4 Channel Analog Output 0-1mA bi-directional	1mAOS 4 Channel Analog Output 0-1mA bi-directional
				V5 V4 + 128 MB Memory and 512 Samples/Cycle Waveform Recording		20mAOS 4 Channel Analog Output 4-20mA	20mAOS 4 Channel Analog Output 4-20mA
						INP100S 100BaseT Ethernet	INP100S 100BaseT Ethernet
						INP300S IEC 61850 Protocol Ethernet	INP300S IEC 61850 Protocol Ethernet

*Any combination of Option cards is available, except that only one Ethernet card, INP100S or INP300S, is allowed per unit.

1.1.3: V-Switch™ Key Technology

The Shark® 270 meter is equipped with V-Switch™ key technology, a virtual firmware-based switch that lets you enable meter features through software communication. V-Switch™ key technology allows meter upgrades after installation without removal from service.

Features	V1	V2	V3	V4	V5
Multifunction Measurement	*	*	*	*	*
Programmable Display	*	*	*	*	*
Time of Use	*	*	*	*	*
System Events		*	*	*	*
Input Status Change		*	*	*	*
Limits		*	*	*	*
Harmonics			*	*	*
2 MB Memory**		*			
4 MB Memory**			*		
10 MB Memory**				*	
128 MB Memory**					*
Waveform 128 samples				*	
Waveform 512 samples					*
CT/PT Comp	*	*	*	*	*
TLC Compensation	*	*	*	*	*
IEC 61850 Protocol			*	*	*
DNP 3.0			*	*	*
Modbus Protocol***	*	*	*	*	*

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

*** See the *Shark® 270 Meter Modbus Protocol Application Guide* for instructions on using Modbus with the meter.

Obtaining a V-Switch™ Key:

Contact EIG's inside sales staff at sales@electroind.com or by calling (516) 334-0870 (USA) 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 Communicator EXT™ Device Status screen (from the Communicator EXT™ Main screen, click **Tools>Device Status**).

2. Desired V-Switch™ key.

3. Credit card or Purchase Order number. EIG will issue you the V-Switch™ key.

Enabling the V-Switch™ Key:

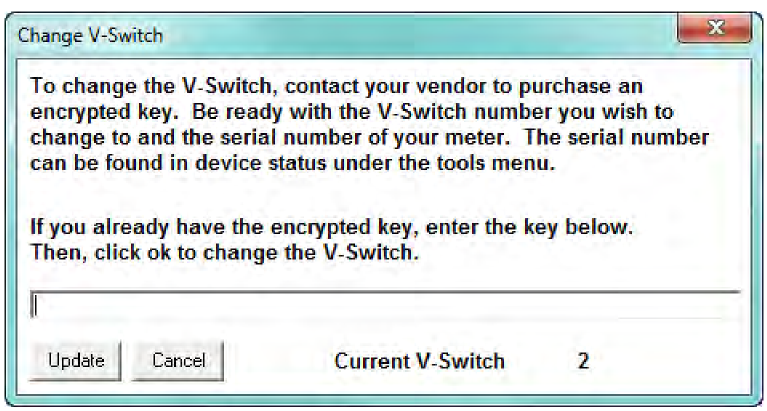
1. Open Communicator EXT™ software.

2. Power up your meter.

3. Connect to the Shark® 270 meter through Communicator EXT™ software.

4. Download all meter logs and then reset them - see chapters 16 and 20 in the *Communicator EXT™ 4.0 and MeterManager EXT Software User 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's Main screen.

5. Click Tools>Change V-Switch from the Menu Bar. A screen opens, requesting the encrypted key.



6. Enter the V-Switch™ key provided by EIG.

7. Click the Update button. The V-Switch™ key is enabled and the meter resets.

8. Configure the log sizes - see Chapter 26 in the *Communicator EXT™ 4.0 and Meter-Manager EXT Software User Manual* for instructions.

1.1.4: Measured Values

The following table shows the primary measurements of the Shark® 270 meter.

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

1.1.5: Utility Demand

The Shark® 270 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 Watt, VAR, VA and PF readings. See 11.2: Demand Integrators, on page 11-5, for more details on the meter's Utility Demand feature.

1.2: Advanced Measurement Functionality

The following sections describe the Shark® 270 meter's measurement features in detail.

1.2.1: Advanced Revenue Billing Capability

The Shark® 270 device is a full four-quadrant power and energy meter with 0.2 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 Shark® 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.
- 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.
- Present month and present season readings for each schedule.
- Present month and present season for each accumulation rate, for each defined data set.
- Season may be customized for daily or weekly use.
- 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.

NOTE: 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 *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for instructions.)

Multiple Demand Windows

The Shark® 270 meter simultaneously calculates four quadrant demand with the following features:

- Block Window Demand or Rolling Window Demand averaging, divided into of up to 15 subintervals.
- 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 4PO1 card).
- End of Interval Pulse Input (with optional 4PO1 or 4RO1 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 Chapter 26 in the *Communicator EXT™ 4.0 and MeterManager EXT Software User 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

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

1.2.2: Communications and I/O Capabilities

The Shark® 270 meter features advanced communication which utilizes multiple Com ports using open protocols. The meter's multi-port design allows multiple communication connections simultaneously. The Shark® 270 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 270 are made available through industry-standard Modbus or DNP 3.0 protocols. No proprietary or closed protocols are used.

Standard Communications

- ANSI Type 2 Optical port.
- RS485 serial port.
- Modbus RTU/ASCII protocol.
- DNP 3.0 Level 2 protocol (V3 or higher): the Shark® 270 meter's version of DNP is a reduced set of the Distributed Network Protocol Version 3.0 subset 2, with enough functionality to get critical measurements from the meter.
- Speeds up to 57600 bps.

Optional Communications

The Shark® 270 meter allows you to select one of two optional cards for the following uses (note that only one optional Communication card is allowed per meter):

- INP100S optional Ethernet Option card communicating Modbus TCP and DNP 3.0 over Ethernet.
- INP300S optional Ethernet card with Modbus TCP and embedded IEC 61850 Protocol server.

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

- 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: Display Screen

The Shark® 270 meter features a built-in graphical back-lit HR-TFT LCD display with extended temperature compensation. The display is high contrast monochrome that is optimized for outdoor use. The display allows you to view energy data and to gather circuit diagnostic data such as voltage, current, harmonics and phasor information. The display screens are easily customized to display any information contained within the meter. See Chapter 2: Operating Instructions, on page 2-1, for more information on the programmable display.

1.2.4: Switches and Buttons

The Shark® 270 meter has additional switches & signals that help in using the unit (see 2.2.1: Switches and Indicators, on page 2-4, for more information):

- The Mode Switch (magnetic reed switch) to switch operating modes.
- The Test button is used to access Test Mode.

- The Reset button is used to reset Demand.

1.3: Shark® 270 Meter Forms

- The Shark® 270 Socket meter offers three supported S-Based meter forms

Form	Service
9S	Wye or Delta
36S	Wye
45S	Delta - 3 or 4 wire

NOTE: See 1.1.1: Hookup Connections and Measurements, on page 1-1, for Rated Voltages.

- Form 9S can be ordered in an S to A-Base adapter (Order Form 9A).
- Form 45S replaces Form 5S and may also be used in 4-wire Delta circuits.
- See 9.5: Wiring Diagrams, on page 9-5, for corresponding Wiring diagrams.

1.4: Shark® 270 Meter Accuracy

For 23 ^{o}C +/- 5 ^{o}C, 3 Phase balanced Wye or Delta load, at 50 or 60 Hz (as per order), Class 20 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 (Form 36S), degrade accuracy by an additional 0.5% of reading.

2

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

3

With regard to current readings, reference Voltage applied (VA, VB, or VC). Otherwise, degrade accuracy to 0.2%. See hookup diagrams in 9.5: Wiring Diagrams, on page 9-5.

4

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

1.5: Shark® 270 Meter Specifications Overview

Sense Inputs Electrical Ratings

Current

- 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 depending on the ANSI Socket form.
- Class 20 - 5A nominal, burden 0.0112 VA at 20 A Input/phase.
- Class 2 - 1A nominal, burden 0.0112 VA at 2 A Input/phase.
- Pickup Current: Shall begin reading at 0.005 A (5 mA) for Class 20 and 0.001 A (1 mA) for Class 2.
- Continuous maximum ratings: Class 20: 30 A AC; Class 2: 5 A AC.
- Overcurrent ratings as the factor of Current Class (CL): 5x - for 10 seconds, 15x - for 3 seconds, 25x - for 1 second.
- Maximum voltage from current inputs to Earth Ground is 40 V AC.

Voltage

- Absolute Maximum rating, between any voltage sense inputs:
    - Unit with external power connection (power supply “-SE” option): 720 VAC.
    - Unit powered from voltage blades, (power supply “-S” option): 576 VAC.
- Supported common Power Mains with direct voltage connections:
    - Forms 9S, 36S, 45S with blade ("-S") or external ("-SE") power option; 57.7/100 V, 69/120 V, 120/208 V, 230/400 V, 277/480 V.
    - Form 45S with external ("-SE") power option only: 347/600 V.
    - For lower or higher voltage Power Mains use voltage transformers
- Input Impedance: 4 MΩ per phase.
- Surge withstand. See compliance section for details.
- Burden:
    - With external power connection: 0.09 VA/input at 600 VAC (4 MΩ/input).
    - Unit powered from voltage blades: see power supply ratings.

Power Supply

- Input Voltage range:
    - Absolute maximum continuous:
        - 576 VAC (between any voltage inputs for blade powered units: power supply “- S” option).
        - 300 VAC or 400 VDC (for externally powered units: power supply “-SE” option).

- Absolute minimum startup/dropout voltage for blade-powered, fully loaded unit ("-S" option), at 60 Hz. All applicable blades are symmetrically energized:

- 4W Wye service, Form 9S, 3 x L-N:	45/35 V AC
- 4W Wye service, Form 36S, 2 x L-N:	50/45 V AC
- 4W Delta service, Form 9S, 3 x L-N:	70(40)/52(30) V AC - high(low) phase
- 3W Delta service, Form 45S, 3 x L-L:	65/55 V AC

- Absolute minimum startup/dropout voltage for externally powered, fully loaded unit ("-SE" option): 75/70 V AC or DC.
- Surge withstand: see compliance section for details.
- Frequency range: (45 to 65)Hz or DC.
- Ride through characteristics at 120 V at maximum power consumption: ~33 ms.
- Power consumption (burden), maximum: 8 VA/4.5 W per Phase – with 3 phase supply:
    - Typical burden with 1 Ethernet Card installed: 3.3 VA/1.7 W per phase – at 3 phase 120 VAC.
- Power Supply Connection options
    - Direct internal connection through voltage blades: "- S" option (range is limited by power supply voltage rating).
    - External connection through external plug: "-SE" option (maximum sense input voltage range, see sense voltage input rating).

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 V-Switch™ key configuration.

Standard Communications

- ANSI Type 2 Optical port.
- RS485 serial port.
- Supports Modbus® RTU, Modbus ASCII and DNP 3.0 protocols.
- Data Speeds of up to 57600 bps.

Optional Communications

- INP100S: 10/100BaseT Ethernet with Total Web Solutions and Alarm/Notification Email; Modbus TCP, DNP LAN/WAN protocols.
- INP300S: Modbus TCP and IEC 61850 Protocol server.

NOTE: Only one optional Communication card is allowed per meter.

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 - "P" light port, Kh value is user definable.
  - Pulse Width: 100 ms, fixed.
  - Full Scale Frequency: ~5 Hz.

- Contact type: SPDT (NO – C – NC).
- Relay type: Solid state.
- Peak switching voltage: AC/DC 30 V.
- Continuous load current: 120 mA.
- Peak load current: 350 mA for 10 ms.
- On resistance, max.: 35 Ω.
- Leakage current: 1 μA maximum.
- Isolation: 3750 V AC.
- Reset state: (NC - C) Closed; (NO - C) Open.

Clock Timing and Synchronization: see 1.7: Time Synchronization Alternatives, on page 1-22.

Environmental (Temperature Specifications to Indirect Sunlight)

- Operating Temperature: (-40 to +70)°C.
- Display Operating Temperature: (-30 to +60)°C.
- Humidity: 95% RH maximum, non-condensing.
- Storage Temperature: (-40 to +85)°C.
- Raintight Lexan Cover, UV protected.

Display

- High resolution, monochrome graphical back-illuminated TFT LCD programmable display.
- Pre-configured screens and Screen Designer for fully customized display screens.
- Size: 2.7”.
- Resolution: 400 X 240.

Security

The Shark® 270 meter has multiple security features that prevent unauthorized access to the meter’s data:

- Sealable Reset switch (seal switch).
- 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. Communicator EXT™ 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 logon attempts. If an incorrect user-name and/or password is entered, a timer runs for 30 seconds before the user can attampt to logon again. For a second and subsequent log on failures, the lockout timer runs for five minutes.

Internal Battery

- Replaceable 3V Lithium battery BATT21214 maintains time during outages (see 5.3: Internal Battery Installation and Maintenance, on page 5-8). Replacement battery can be purchased through Electro Industries.

Shipping Dimensions

- Size: 10” W x 10” D x 12” H.
- Weight: 5.6 lbs.

Compliance

- ANSI C12.1 Code for Electricity Metering (METLAB Tested)
- ANSI C12.18 (Type 2 Optical Port)
- ANSI C12.20 Class 0.2 (0.2% Accuracy) (METLAB Tested)
- CE (IEC 61000-6-2 & IEC 61000-6-4)
- FCC Class B (Radiated and Conducted Emissions)
- IEC 61000-4-2 (Electrostatic Discharge)
- IEC 61000-4-3 (Radiated EM Immunity)
- IEC 61000-4-4 (EFT)
- IEC 61000-6-4 (EMC)
- IEC 62052-11 (General Requirements; Mechanical Properties; Climactic Influences)
- IEC 62053-22 CL 0.2S (0.2% Accuracy)
- IEC/CISPR 11 (Radiated Emissions)
- IEEE C37.90.1 (Surge Withstand)
- IEEE C62.41 (Surge Immunity)
- REACH Compliant
- RoHS Compliant

1.6: DNP V 3.0 Protocol Implementation

The Shark® 270 meter's version of DNP is the Distributed Network Protocol Version 3.0 subset 2, with basic functionality to get critical measurements from the meter. For complete details, see Appendix C: Shark® 270 Meter DNP Mapping, on page D-1.

1.7: Time Synchronization Alternatives

(See the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for details.)

Internal Clock

- All Shark® meters are equipped with internal clock crystals which are 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 Shark® 270 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

- All Shark® meters are 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 INP100S Ethernet card, or the INP300S IEC 61850 Protocol Server card), you can use the card to access a Network Time Protocol (NTP) Server for clock synchronization. See Chapter 26 in the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual*, for instructions.

2: Operating Instructions

2.1: Nameplate Information

The Shark® 270 Socket meter has its operating information on the nameplate, which is located on the face of the meter (see following figures).

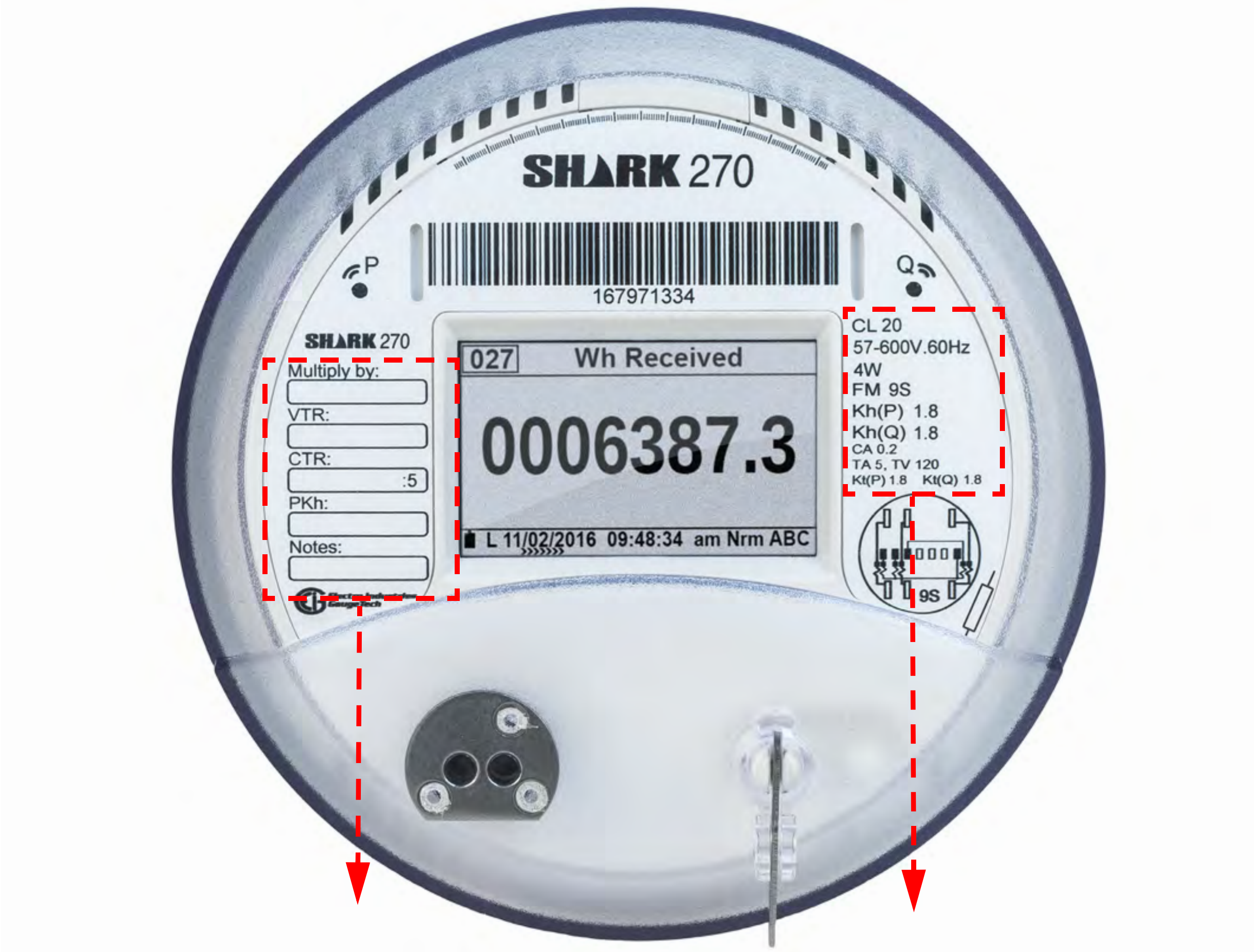


Figure 2.1: Faceplate Label Nomenclature Example

Left Side of the Meter Face

Multiply by: Multiplication factor for energy readings.

VTR: Voltage instrument transformer turns ratio.

Right Side of the Meter Face

CL20: Current class - 20 A full scale for the meter shown.

50-600V. 60Hz: Absolute sense voltage input range and nominal frequency.

CTR: Current instrument transformer turns ratio - preset to 5 A for the meter shown.

Pkh: Primary energy pulse constant.

Notes: Custom notes for the meter.

4W: Metering voltage sense connections wire count - 4 for the meter shown.

Form 9S: ANSI Form Factor 9S for the meter shown.

Kh(P)1.8: Secondary Wh energy constant for light pulse on light port “P,” (also on KYZ output) in normal mode - 1.8 for the meter shown.

Kh(Q) 1.8: Secondary VARh energy constant for light pulse on light port “Q” in normal mode - 1.8 for the meter shown.

CA 0.2: Accuracy class for energy measurement - 0.2% for the meter shown.

TA 5, TV 120: Test current and voltage conditions at reference point - 5A, 120V for the meter shown.

Kt(P)1.8: Secondary Wh energy constant for light pulse on light port “P,” (also on KYZ output in Test Mode) - 1.8 for the meter shown.

Kt(Q) 1.8: Secondary VARh energy constant for light pulse on light port “Q” in Test Mode - 1.8 for the meter shown.

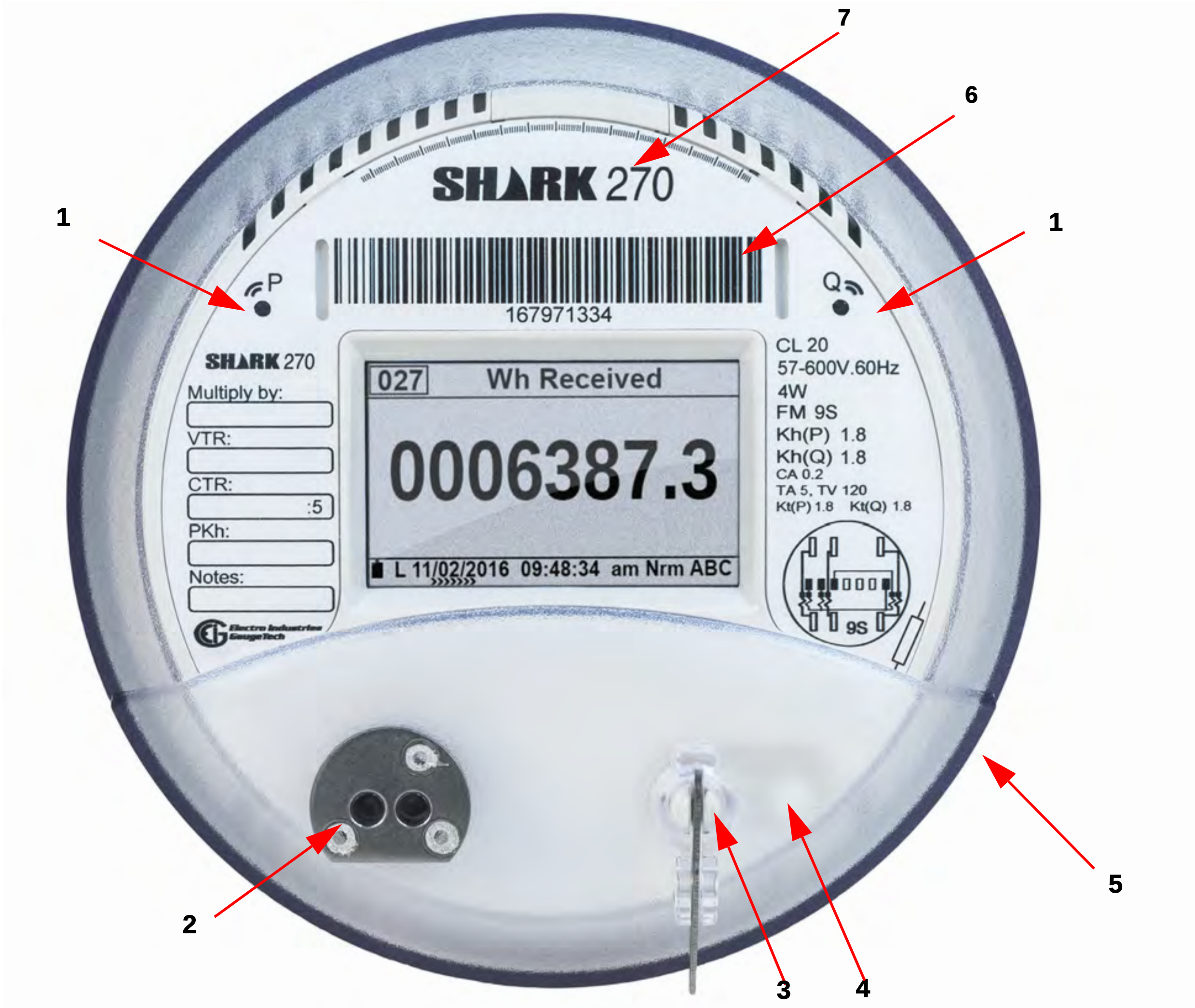


Figure 2.2: Electrical Features on Front of the Meter

1: Infrared light ports for pulse-based accuracy testing.

- "P" - Wh pulses output.
- "Q" - VARh pulses output.

  Associated constant values are Kh and Kt.

2: ANSI Type 2 optical communication port.

- Requires optical signal converter for connecting to the meter. See 4.2: Communicating to the Meter through the ANSI Type II Optical Port, on page 4-2.

3: Reset button.

- Resets essential parameters in the meter.

- Accessible externally with sealable plunger.

4: Test button (located under the clear cover).

- Puts the meter into Test Mode.
- Is only accessible after the clear cover is removed.

5: Mode magnetic switch.

- Magnetic field actuated switch.
- Enters the unit into various display modes.
- Located at this area, but not visible from the outside of the meter. The Mode magnetic switch is just above and to the right of the Test button (number 4), and just below the top of the frosted area of the clear cover.

6: AEP barcode. (The AEP (American Electric Power) barcode system is a standard for the electric utility industry. It contains a unique identifier for the equipment owner, and other, pertinent information, about the meter. If you require the AEP barcode to be printed on the front of the meter, you must specify it when ordering.

7: Customizable Meter Logo.

2.2.1: Switches and Indicators

- Two switches are accessible from outside the meter's clear cover:

  1. The Mode switch (number 5), is activated by moving a magnet (or an ANSI Type II magnetic optical communications coupler) along the circumference of the meter where the Mode switch is located. When the Mode switch is activated, the display will change to the next View mode - 2 or 3 (the Circuit Diagnostic and Time of Use mode are the default View modes 2 and 3, but the names and screen assigned to the View modes can be changed using the Screen Designer).

- If you hold the magnet steady over the Mode switch for two seconds, rather than swiping it, the current display will be frozen by a user-selectable number of seconds (this value is set using the Screen Designer). When the screen is in hold mode, a small circle with an X inside it appears in the upper, right corner of the display. To un-hold the screen, hold the magnet steady over the Mod switch for two seconds.

2. The Reset switch (number 3) is used to reset Demand. This switch is also equipped with provisions for a locking device.

- A third switch, the Test button (number 4), is accessible only when the clear cover has been removed. The Test button switches the meter from one of the operational modes to Test Mode and back to Normal Mode.

2.2.2: Optical Port

The Optical port is located on the lower left side of the meter face. With the Optical port you can program the meter with Communicator EXT™ software using an optical signal converter, like EIG's A7Z or A9U Communication Interface (or other ANSI Type II magnetic optical communications coupler) and an RS232 cable (A7Z) or a USB cable (A9U) to a PC. See 4.2: Communicating to the Meter through the ANSI Type II Optical Port, on page 4-2, for instructions and product information.

2.2.3: Infrared Light Ports

Infrared light ports for testing accuracy are located on the upper left and right sides of the meter face. In normal mode, the Kt values can be configured using Communicator EXT™ software. See the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual*, for instructions. See 3.1.1: Test Pulse LED, on page 3-2, for more information on using the pulses in Test mode.

2.2.4: Phase Indicator

A Phase indicator is located on the lower right side of the face. "ABC" stays displayed if all three phases of Voltage and current are present. "CBA" indicates reversed phase sequence. The indicator blinks A, B or C if that phase is not present. If no phases are present, the meter turns off (unless the meter is connected to an external power source). If the meter has an external power source and there is no current or voltage, the Phase indicator will be blank, appearing as "___".

2.3: LCD Display Information

The Shark® 270 meter has a graphical back-illuminated TFT LCD programmable display with extended temperature compensation. The display lets you view Energy data and gather circuit diagnostic data such as voltage, current, harmonics, and phasor information. The meter features a Screen Designer that lets you program the display to meet your application needs. See 20.1.23 in the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for detailed instructions on using the Screen Designer.

The meter ships with pre-configured, initial display screens that scroll on the display as soon as you power up the meter. The initial display screens are a sampling of the pre-defined screens.

There are 8 startup screens, which appear in the following order:

- Boot Screen: Displayed by the boot firmware, as the meter starts up.
- Unit Init Screen: First screen displayed when the unit first switches to Run mode firmware. This screen identifies the unit and displays the EIG Logo. A series of messages flash across the bottom of this screen, indicating the stage of the Unit initialization process. This screen is displayed only for a second or two.
- Warm-up Screen: Displayed while the full system comes online, and the unit can begin measuring. It displays the Unit Name (Shark270), Firmware version, and the text "Booting," followed by "Warming up." This screen is displayed for less than five seconds. Note that this is when the unit starts measuring at ~6 seconds after startup.
- Unit Information Screen: Displayed when the unit has begun to measure voltage and current). It displays the Unit Name (Shark270), the Run firmware version, the Boot firmware version, the Serial number, the V-Switch key, and the Security status (Security Enabled/Disabled). This screen is displayed for three seconds.
- Comm 1: This screen displays ANSI IR port settings: Baud, Bits, Parity, Stop bits, Protocol (MODBUS RTU, MODBUS ASCII), Receiver (Inverted/Not Inverted), and Packets (Good:0, Bad:0). This screen is displayed for three seconds.

- Comm 2: This screen displays RS485/KYZ port settings: Baud, Bits, Parity, Stop bits, Protocol (MODBUS RTU, MODBUS ASCII, DNP3), Packets (Good:0, Bad:0). This screen is displayed for three seconds.

- Option Card #1 information: Data displayed on this screen will vary with the installed card:

  - Network cards will display IP and MAC addresses.

  - Other cards will display the Type and Name of the card; e.g., for an Analog Output Card - 1mAOS, 4 Channel - 0-1 (bidirectional).

  This screen is displayed for three seconds.

- Option Card #2 information: same as Option Card #1 information.

The total time of the 8 initial display screens is approximately 20 seconds. At this point the meter switches to View mode 1 and the pre-defined screens and/or user-defined begin displaying.

The display has three View modes. A mode is a list of screens that will display in order while in that mode. The default View modes are Normal (Nrm), Circuit Diagnostics (CD), and Time of Use (TOU), but you can change those titles and abbreviations using the Screen Designer. With the Screen Designer, you can also select screens for each mode. This lets you determine what data is displayed and in what order. View mode 1 is the primary mode; the other modes automatically return to View mode 1 after a user-set amount of inactivity.

Following is a list of the pre-defined screen in their modes:

Normal Mode (Nrm):

kWh Delivered
kWh Received
Positive kVARh
Negative kVARh
Demand at Last Reset Positive kW
Com 1 Optical
Com 2 RS485

Pixel Test

Circuit Diagnostic Mode (Circuit Diag):

Line to Neutral

Line to Line Voltage

Phase Current

Phasor Diagram

VA Harmonics

VB Harmonics

VC Harmonics

IA Harmonics

IB Harmonics

IC HarmonicsQ1 Totals Hours

Frequency

Waveforms

Power

Power Factor

Expansion Slot #1

Expansion Slot #2

Time of Use Mode (TOU):

Prior Month Final Season Rate 0 Accumulator

Prior Month Final Season Rate 0 Demand

Prior Month Final Season Rate 0 Time

Prior Month Final Season Rate 1 Accumulator

Prior Month Final Season Rate 1 Demand

Prior Month Final Season Rate 1 Time

Prior Month Final Season Rate 2 Accumulator

Prior Month Final Season Rate 2 Demand

Prior Month Final Season Rate 2 Time

Prior Month Final Season Rate 3 Accumulator

Prior Month Final Season Rate 3 Demand

Prior Month Final Season Rate 3 Time

Prior Month Final Season Rate 4 Accumulator

Prior Month Final Season Rate 4 Demand

Prior Month Final Season Rate 4 Time

Prior Month Initial Season Rate 0 Accumulator
Prior Month Initial Season Rate 0 Demand
Prior Month Initial Season Rate 0 Time
Prior Month Initial Season Rate 1 Accumulator
Prior Month Initial Season Rate 1 Demand
Prior Month Initial Season Rate 1 Time
Prior Month Initial Season Rate 2 Accumulator
Prior Month Initial Season Rate 2 Demand
Prior Month Initial Season Rate 2 Time
Prior Month Initial Season Rate 3 Accumulator
Prior Month Initial Season Rate 3 Demand
Prior Month Initial Season Rate 3 Time
Prior Month Initial Season Rate 4 Accumulator
Prior Month Initial Season Rate 4 Demand
Prior Month Initial Season Rate 4 Time
Prior Month Whole Month Rate 0 Accumulator
Prior Month Whole Month Rate 0 Demand
Prior Month Whole Month Rate 0 Time
Prior Month Whole Month Rate 1 Accumulator
Prior Month Whole Month Rate 1 Demand
Prior Month Whole Month Rate 1 Time
Prior Month Whole Month Rate 2 Accumulator
Prior Month Whole Month Rate 2 Demand
Prior Month Whole Month Rate 2 Time
Prior Month Whole Month Rate 3 Accumulator
Prior Month Whole Month Rate 3 Demand
Prior Month Whole Month Rate 3 Time
Prior Month Whole Month Rate 4 Accumulator
Prior Month Whole Month Rate 4 Demand
Prior Month Whole Month Rate 4 Time

Current Month Final Season Rate 0 Accumulator
Current Month Final Season Rate 0 Demand
Current Month Final Season Rate 0 Time
Current Month Final Season Rate 1 Accumulator
Current Month Final Season Rate 1 Demand

Current Month Final Season Rate 1 Time
Current Month Final Season Rate 2 Accumulator
Current Month Final Season Rate 2 Demand
Current Month Final Season Rate 2 Time
Current Month Final Season Rate 3 Accumulator
Current Month Final Season Rate 3 Demand
Current Month Final Season Rate 3 Time
Current Month Final Season Rate 4 Accumulator
Current Month Final Season Rate 4 Demand
Current Month Final Season Rate 4 Time
Current Month Initial Season Rate 0 Accumulator
Current Month Initial Season Rate 0 Demand
Current Month Initial Season Rate 0 Time
Current Month Initial Season Rate 1 Accumulator
Current Month Initial Season Rate 1 Demand
Current Month Initial Season Rate 1 Time
Current Month Initial Season Rate 2 Accumulator
Current Month Initial Season Rate 2 Demand
Current Month Initial Season Rate 2 Time
Current Month Initial Season Rate 3 Accumulator
Current Month Initial Season Rate 3 Demand
Current Month Initial Season Rate 3 Time
Current Month Initial Season Rate 4 Accumulator
Current Month Initial Season Rate 4 Demand
Current Month Initial Season Rate 4 Time
Current Month Whole Month Rate 0 Accumulator
Current Month Whole Month Rate 0 Demand
Current Month Whole Month Rate 0 Time
Current Month Whole Month Rate 1 Accumulator
Current Month Whole Month Rate 1 Demand
Current Month Whole Month Rate 1 Time
Current Month Whole Month Rate 2 Accumulator
Current Month Whole Month Rate 2 Demand
Current Month Whole Month Rate 2 Time
Current Month Whole Month Rate 3 Accumulator
Current Month Whole Month Rate 3 Demand

Current Month Whole Month Rate 3 Time
Current Month Whole Month Rate 4 Accumulator
Current Month Whole Month Rate 4 Demand
Current Month Whole Month Rate 4 Time

Current Season Rate 0 Accumulator
Current Season Rate 0 Demand
Current Season Rate 0 Time

Prior Season Rate 0 Accumulator
Prior Season Rate 0 Demand
Prior Season Rate 0 Time

2.3.1: Mode Details

- Access View mode 2 and View mode 3 by swiping the Mode Switch with a magnet (see 2.2.1: Switches and Indicators, on page 2-4, and Figure 2.2).
- Access Test mode by removing the clear cover, pressing and holding the Test Button for three seconds, and then releasing it. Test Mode will begin upon release of the Test button. This action can be performed at any time.
- Test mode automatically returns to View mode 1 after an amount of time since the last user action with no energy accumulation (or) an amount of time since the last user action plus the Demand interval with energy accumulation. The values for the amount of time since the last user action are set in the Test Mode setup (see the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual*, for instructions).
- See 2.4: Shark® 270 Meter Programmable Display Navigation Map, on page 2-14, for display mode details.

2.3.2: Low Battery

There is an icon for the real time clock's internal battery, located on the upper right side of the display screen. When the battery needs to be replaced (or if it is not installed properly), the low battery version of the icon flashes on and off every second. It should be replaced once this happens.

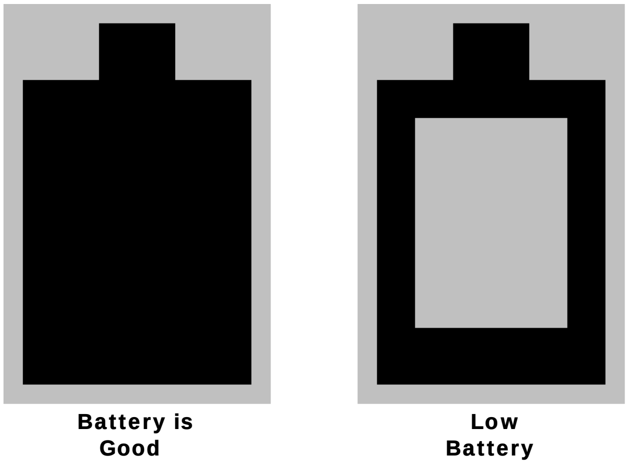


Figure 2.3: Display Battery Icons

See 5.3: Internal Battery Installation and Maintenance, on page 5-8, for instructions on replacing the battery.

Note that the battery life is ten years from the date of manufacture.

2.3.3: Test Mode

The Test Mode display screens and the values they show are shown in the table, below. See Chapter 3 for detailed instructions for using Test Mode.

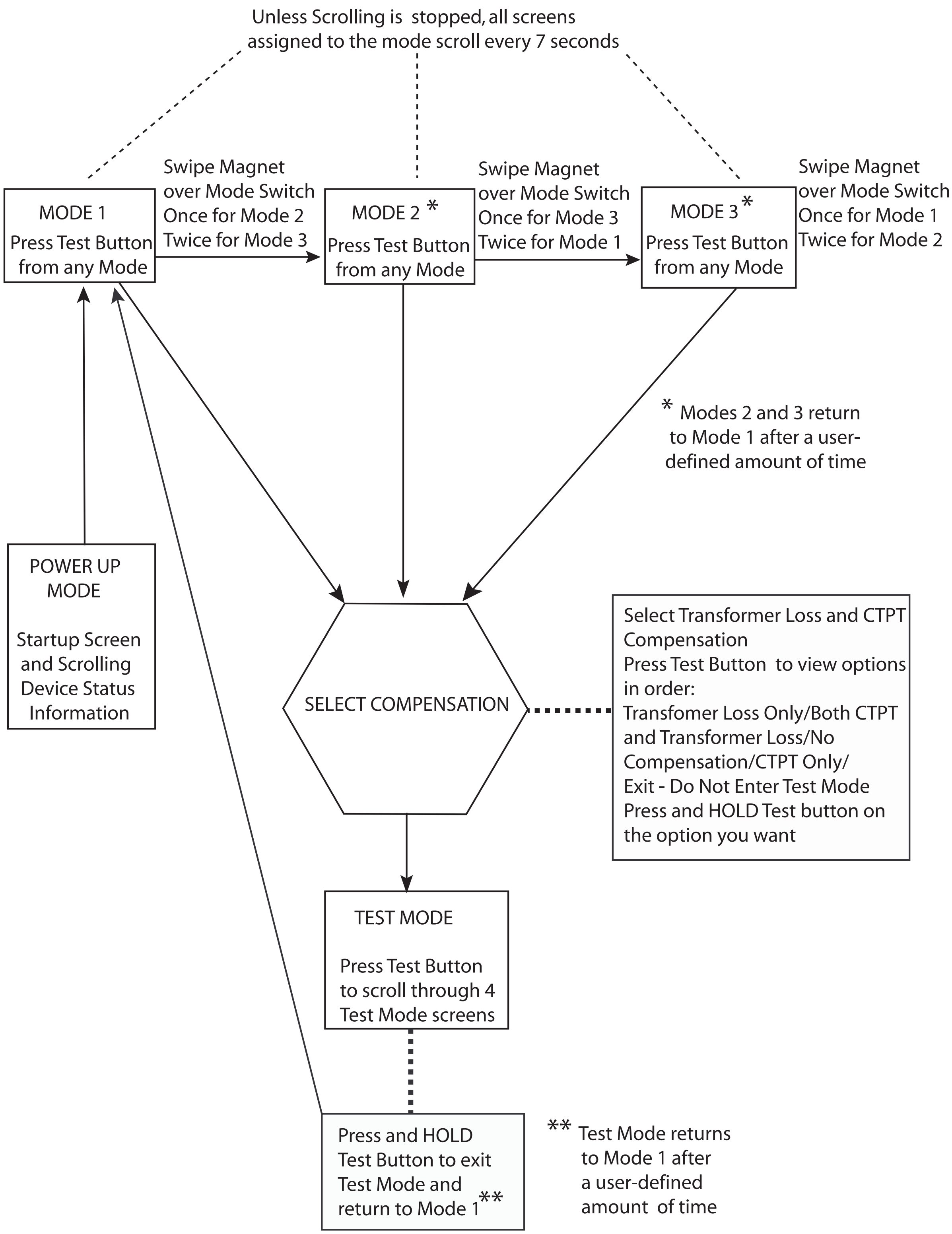
Screen	Parameters
1	Wh (Q1+Q4) VARh (Q1+Q2) VARh (Q3+Q4) VAh
2	Wh Delivered (Q2+Q3) VARh (Q1+Q2) VARh (Q3+Q4) VAh
3	W (Q1+Q4) Demand VAR (Q1+Q2) Demand VAR (Q3+Q4) Demand VA Demand
4	W (Q2+Q3) Demand VAR (Q1+Q2) Demand VAR (Q3+Q4) Demand VA Demand

In Test Mode, the meter will zero out the readings while under test and put the meter into a test sequence. After the testing is completed, the meter will return the previous readings back into the registers. At that time, the meter can be put back into service.

2.3.4: Backlight

The meter's backlight cannot be set to stay on indefinitely. It turns off after an interval programmed in the Screen Designer: 300 seconds (five minutes) is the maximum time allowed; 30 seconds is the factory-set default. If the backlight times out and is off, swipe the magnetic reed Mode Switch (see 2.2.1: Switches and Indicators, on page 2-4 and number 5 on Figure 2.2) once to turn the backlight on and redirect the screen. The backlight is only needed for nighttime readings. The display normally has a very high contrast and doesn't need a backlight.

2.4: Shark® 270 Meter Programmable Display Navigation Map



2.5: Preset Accumulators

The Shark® 270 meter lets you pre-set a value for all billing energy registers. This allows you to replace a meter already in service with this meter, using the pre-existing register reads. If you are replacing an existing Shark® 270 meter, you can just download the register reads and upload them back to the new meter.

See 20.1.22 in the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for instructions.

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3: Performing Meter Testing

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.

Les informations contenues dans ce chapitre sont destinées à assister au personnel de relevé qualifié. Il n'est pas destiné à remplacer la formation approfondie nécessaire pour installer ou retirer les compteurs de leur fonction. Toute intervention sur ou à proximité de compteurs sous tension, socles de compteur ou autres équipements de mesure présente un risque de choc électrique, de blessures ou la mort. Toute intervention avec ces produits doit être effectuée **UNIQUEMENT** par des électriciens industriels qualifiés et des spécialistes de relevé. Toute intervention doit être faite en conformité avec les pratiques de sécurité des services publics locaux.

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 Shark® 270 meter is a traceable revenue meter, it contains utility grade test pulses that can be used to gate an accuracy standard. This is an essential feature required of all billing grade meters.

EIG recommends that meter accuracy testing be done every 5 years.

3.1: Testing Tools

The Shark® 270 meter is equipped with light-emitting diodes (LEDs) for calibration and a liquid crystal display with Test Mode screens. These two standard features provide user interface and equipment interface points for meter testing.

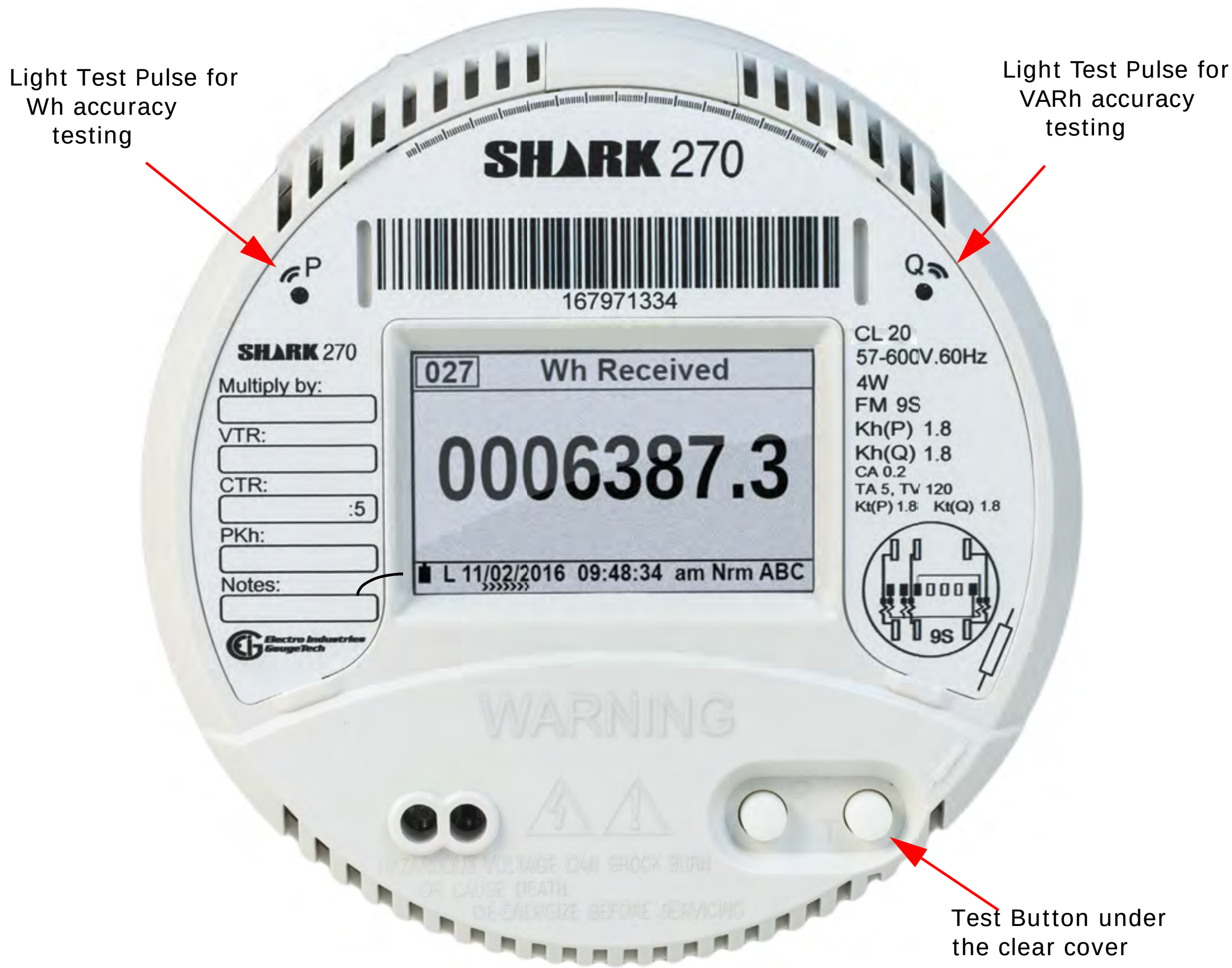


Figure 3.1: Meter Test Pulse and Test Button Location

3.1.1: Test Pulse LED

The Shark 270 meter has two IR test pulses. Test Pulse LEDs are located in the upper left and right-hand portion of the meter face as shown in Figure 3.1.

The Test Pulse LEDs continuously emit calibration pulses (infrared light). The pulses are indicative of the energy flow magnitude regardless of the operating quadrant.

Test Pulse 1 (“P” port) is used for watt-hour, and Test Pulse 2 (“Q” port) is used for VAR-hour. Each calibration pulse is equal to the value assigned to Kh (watt-hours per pulse and VAR-hours per pulse) in the meter’s Device Profile. See Chapter 26 in the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for instructions on programming the Pulse Factors for Energy accumulations.

For Test Mode, the pulses are fixed at the values shown in the chart below. (With the "P" light port only, a standard KYZ output runs simultaneously. See Standard KYZ/ RS485 Card Specifications, on page 1-18, 1.5: Shark® 270 Meter Specifications Overview, on page 1-15, for more details).

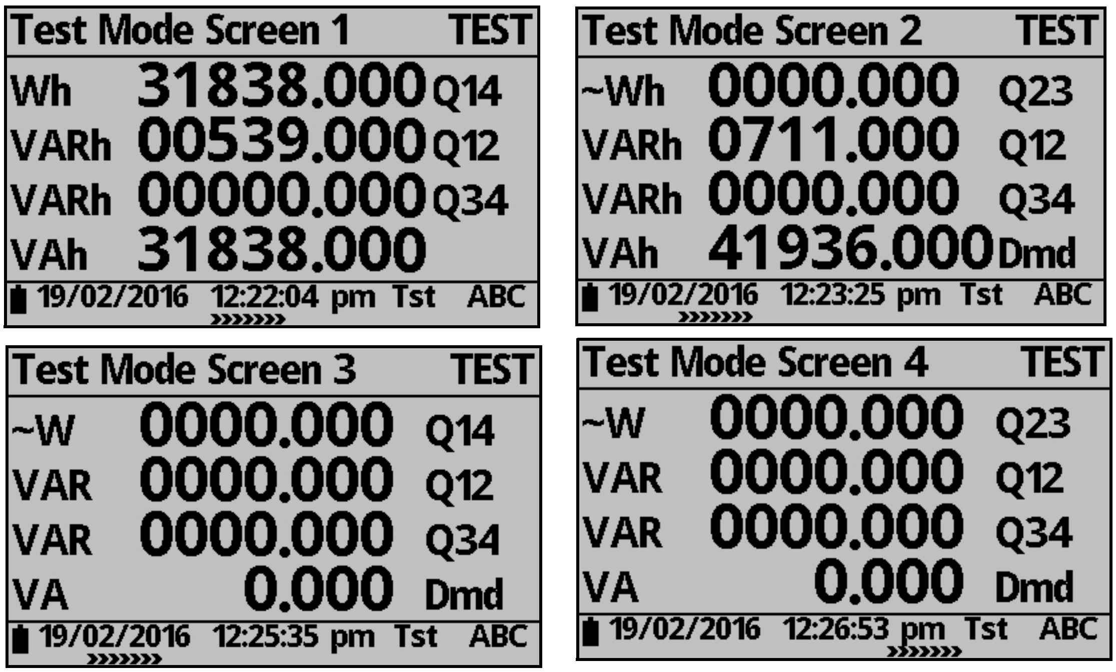
Test Pulse	Wye		Delta	
	Class 2	Class 20	Class 2	Class 20
1 - Wh pulse (P light port)	0.18	1.8	0.12	1.2
2 - VARh pulse (Q light port)	0.18	1.8	0.12	1.2

The pulse parameters are as follows:

- Pulse Width: 100 ms, fixed.
- Full Scale Frequency: ~5Hz.
- Light peak color wavelength: 940 nm.

3.1.2: LCD Display

In Test Mode, the LCD display provides user access to accumulated real, reactive and apparent energy as well as Block Demand for real power. There are four screens in Test Mode, shown below. See 3.2.2: Using Test Mode, on page 3-6, for more detail.



The LCD display also includes three phase Voltage indicators. These indicators are labeled A, B and C to represent the presence of Voltage on the labeled phase.

If Voltage is not present on one phase, its indicator is not displayed. These indicators also show whether current is flowing on the phase. If no current is flowing on a phase, the indicator blinks; when current is flowing, the indicator shows a continuously illuminated digit. The indicator also shows phase sequence.

3.2: Test Mode

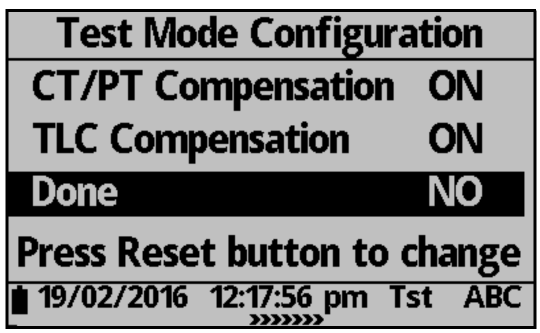
Test Mode allows the meter to be tested without disturbing billing data or setting a new maximum Demand. Test Mode performs the same function as setting the pointers back on an electromechanical meter after testing.

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.

3.2.1: Entering Test Mode

To enter Test Mode, you must bypass the meter’s security system. Break the meter seal and remove the clear cover. Then press and hold the Test button for three seconds, then release it.

The first LCD screen you see lets you set up compensation for Test Mode.



This screen lets you enable (ON) or disable (OFF) CT/PT and TLC compensation during testing.

- Click the Reset button to change ON to OFF, or vice versa.
- Click the Test button to move to the next setting.

When you have finished making your settings, click the Reset button to change NO to YES next to DONE.

Press the Test button again to begin testing.

3.2.2: Using Test Mode

The same selected measurement profile quantities (data accumulations) that are calculated during normal operation are calculated in Test Mode. Display quantities (Watt-hour, VAR-hour, and Block Demand quantities) are displayed in secondary units rather than kilo-units; i.e. the data is displayed as Wh, VARh, VAh and Watts rather than kWh, kVARh, kVAh and kW. The same Demand values calculated during normal operation are also calculated in Test Mode. The display formats in Test Mode are changed to provide greater resolution during test operations.

The display does not scroll while in Test Mode. Each item remains displayed until the Test Button is pressed, which causes the next Test Mode screen to display.

The following table shows the display screens available in Test Mode, the data displayed on each screen and the pulse source for each screen.

Screen	Parameters	Pulse 1 Source	Pulse 2 Source
1	Wh (Q1+Q4) VARh (Q1+Q2) VARh (Q3+Q4) VAh	Wh (Q1+Q4)	VARh (Q1+Q2) or (Q3+Q4)
2	Wh (Q2+Q3) VARh (Q1+Q2) VARh (Q3+Q4) VAh	Wh (Q2+Q3)	VARh (Q1+Q2) or (Q3+Q4)
3	W (Q1+Q4)Demand VAR (Q1+Q2) Demand VAR (Q3+Q4) Demand VA Demand	Wh (Q1+Q4)	VARh (Q1+Q2) or (Q3+Q4)
4	W (Q2+Q3) Demand VAR (Q1+Q2) Demand VAR (Q3+Q4) Demand VA Demand	Wh (Q2+Q3)	VARh (Q1+Q2) or (Q3+Q4)

To perform a Test Mode reset, press and hold the Reset button for two seconds, while in Test Mode. A Test Mode reset causes all Test Mode energy and demand to be reset to zero and a new block interval to be started. The item displayed when the reset occurred remains in the display but the value is initialized.

While in Test Mode, the Test Pulse LED pulses. The value of the pulse (the pulse factor) is shown in the table in 3.1.1: Test Pulse LED, on page 3-2. The meter quantity assigned to the Test Pulse LED changes as the user moves from one test screen to another. The assigned values are defined in the Pulse Source column of the table above.

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

In the event of a power outage, data for Test Mode Energy, Demand and Power Factor is not saved. Upon power up, the meter returns to Normal Mode. The test data is lost and all registers are restored to their pretest values.

While in Test Mode, the IR Port and Communications Port 1 are available for communication with the meter.

See Figure 3.2 for an example of how the testing process works.

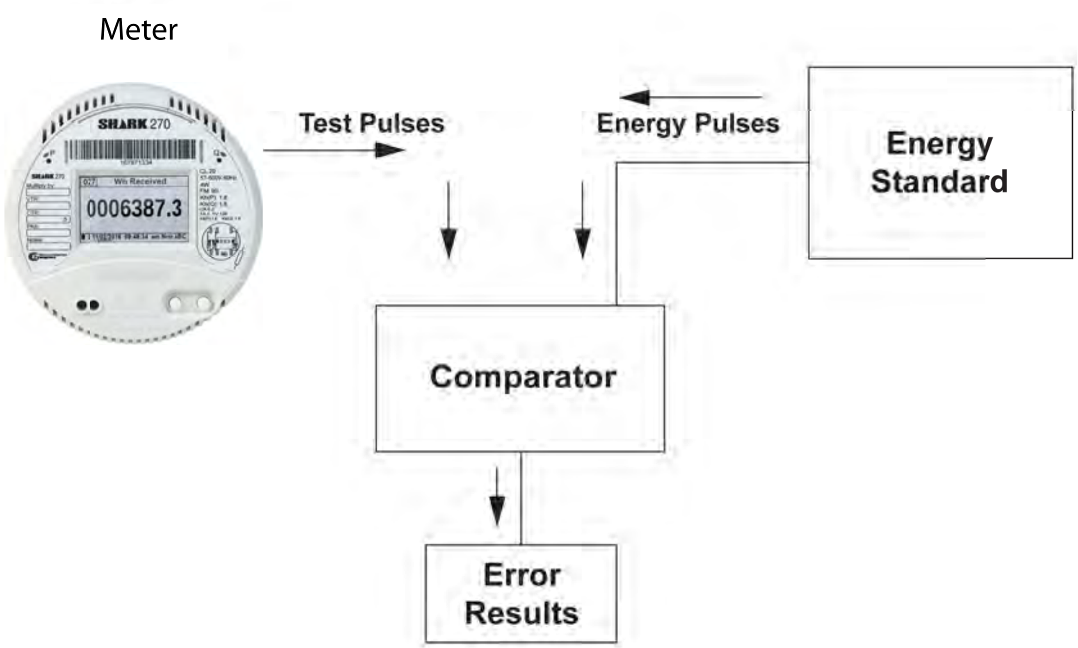


Figure 3.2: Using the Test Pulse

3.2.3: Exiting Test Mode

Exit Test Mode in one of the following three ways:

- Press and hold the Test Button for more than three seconds, but less than ten seconds, and then release it.
- Use the Test Mode Time-out Timer, if no load is present.
- Use the Extended Test Mode Time-out Timer, if load is present.

These options are explained further in the following sections.

Exiting Test Mode Details:

Test Mode Button

Pressing the Test Mode Button for more than three seconds, but less than ten seconds, and then releasing it, ends Test Mode and returns the meter to Normal Mode.

Test Mode Time-out Timer

The Test Mode Time-out Timer has two modes of operation, depending on whether the meter sees measurable load.

If the meter does not recognize measurable load:

The meter watches for user interaction by monitoring activity on the Test Button and the Reset Button. If neither button is pushed within the programmed Exit Delay time, the meter exits Test Mode and returns to Normal Mode. Each time the Test or Reset Button is pressed, the meter starts the Exit Delay Timer again. The Exit Delay time is programmed in the meter's Device Profile in the System Settings screen (see 26.1.3 in the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual*, for instructions).

If the Meter recognizes measurable load:

The meter watches the Test and Reset Buttons for activity, using an extended time limit consisting of the Exit Delay time plus the programmed Demand Interval Time. This insures that the meter completes a full block Demand test without interruption.

After exiting Test Mode:

All Test Mode data is lost when you exit Test Mode. Upon exiting Test Mode, a new (possibly partial) Demand interval and subinterval begin. The past subinterval as well as the current subinterval are zeroed. Upon returning to Normal operating mode, a TOU meter or Demand meter with load profiling completes the time remaining in the current partial subinterval so that subsequent subintervals are synchronized with the hourly boundary.

Maximum Demand values for each Demand integration type are not modified while in Test Mode. The previously recorded maximums are restored when you exit Test Mode. If you choose to reset Demand data during testing operations, you can complete this action when you exit Test Mode by pressing the Reset Button after the meter returns to Normal Mode.

NOTE: Normal billing and historical log data accumulation is suspended during Test Mode operation. Upon exiting Test Mode, accumulation of billing and historical log quantities resumes from the values in place when Test Mode was entered.

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4: Serial Communication Wiring

4.1: Communication Overview

The Shark® 270 meter offers multiple communication ports, both standard and optional. The figure below shows the serial communication options.

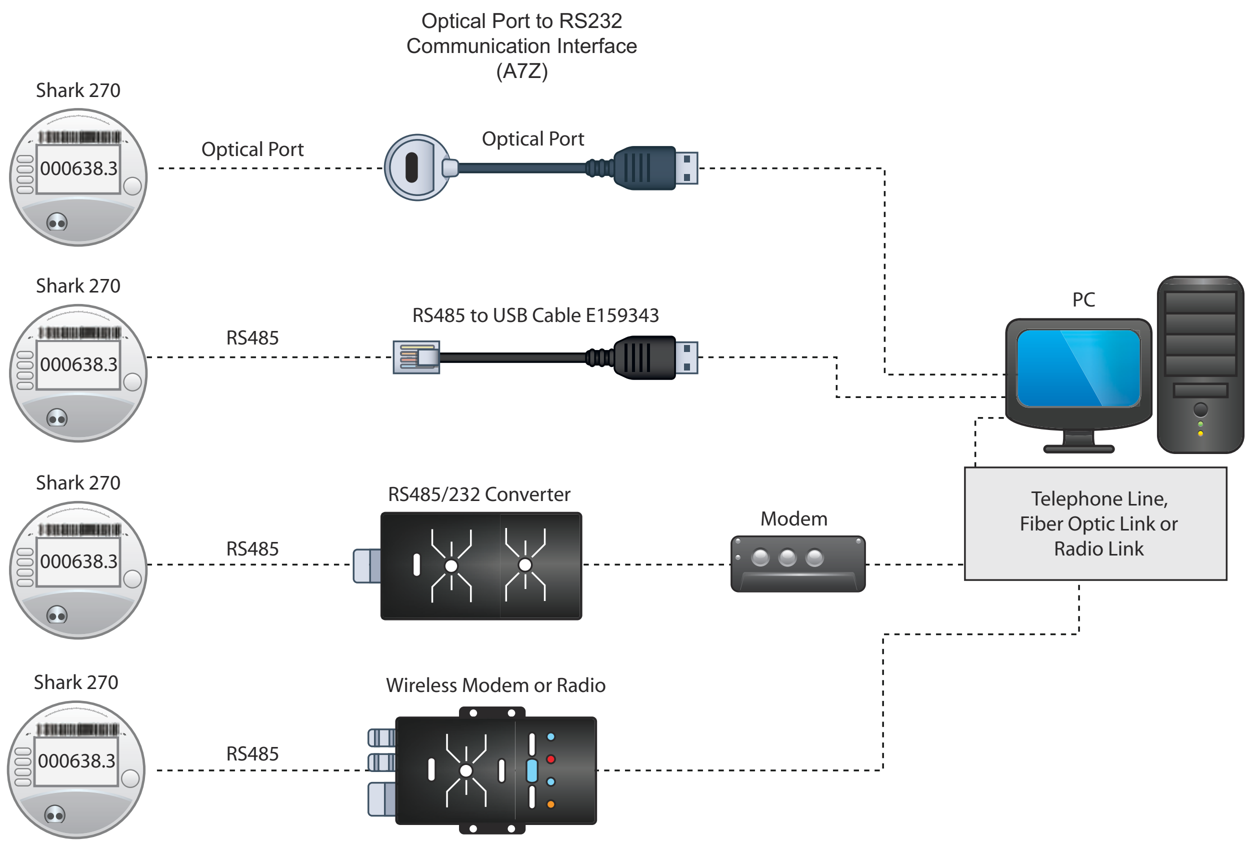

Figure 4.1: Serial Communication

- Communication is available through the meter's Optical port with a communication interface; see figures 4.2 and 4.3.
- The Shark® 270 meter's standard port is a two-wire RS485 connection. RS485 communication allows multiple meters to communicate with another device at a local or remote site. All RS485 links are viable for up to 4000 feet (1220 m).
- Optional communication connections for INP100S (10/100BaseT connection) or INP300S (IEC 61850 Protocol Server) are cables with appropriate connectors. See 8.3.1: INP100S Ethernet Card, on page 8-5 and 8.3.2: INP300S IEC 61850 Protocol Card, on page 8-7, for wiring information.

Figure 4.2: Optical Port Location

4.2: Communicating to the Meter through the ANSI Type II Optical Port

The Optical port allows the Shark® 270 meter to communicate with one other device, e.g., a PC. Located on the left side of the meter's face, it provides communication with the meter through an ANSI C12.13 Type II Magnetic Optical Communications Coupler, such as either:

- An A7Z Communication Interface connected to the RS232 port of the PC
- An A9U Communication Interface connected to the USB port of the PC.

You can order the A7Z or A9U from EIG's webstore: https://electroind.com/shop/. Select the Communications Products category from the left side of the webpage.

See Figure 4.3.

A7Z - Serial Converter

A9U - USB Converter

Figure 4.3: A7Z and A9U Communication Interfaces

A7Z Instructions:

One end of the magnetic interface simply snaps onto the optical port; the magnet keeps it in place. The other end is an RS232 connection. Insert that end into a 9-pin serial port on a computer or other device. The A7Z requires no power supply. All power is received from the host computer serial port using transmitter and receiver circuits within the probe. The RS232 standard limits the cable length to 50 feet (15.2m).

A9U Instructions:

You may need to download and install the driver for the A9U from EIG's website: www.electroind.com/http://Tech-Support/AbacusProbeDrivers110.exe. Once the driver is installed, attach the A9U's magnetic interface onto the meter's Optical port and attach the A9U's USB connection into your PC.

4.3: RS485 Serial Communication

The meter's standard RS485/KYZ serial port uses an RJ45 jack connection, which is labeled Conn.3. See Figure 4.4.

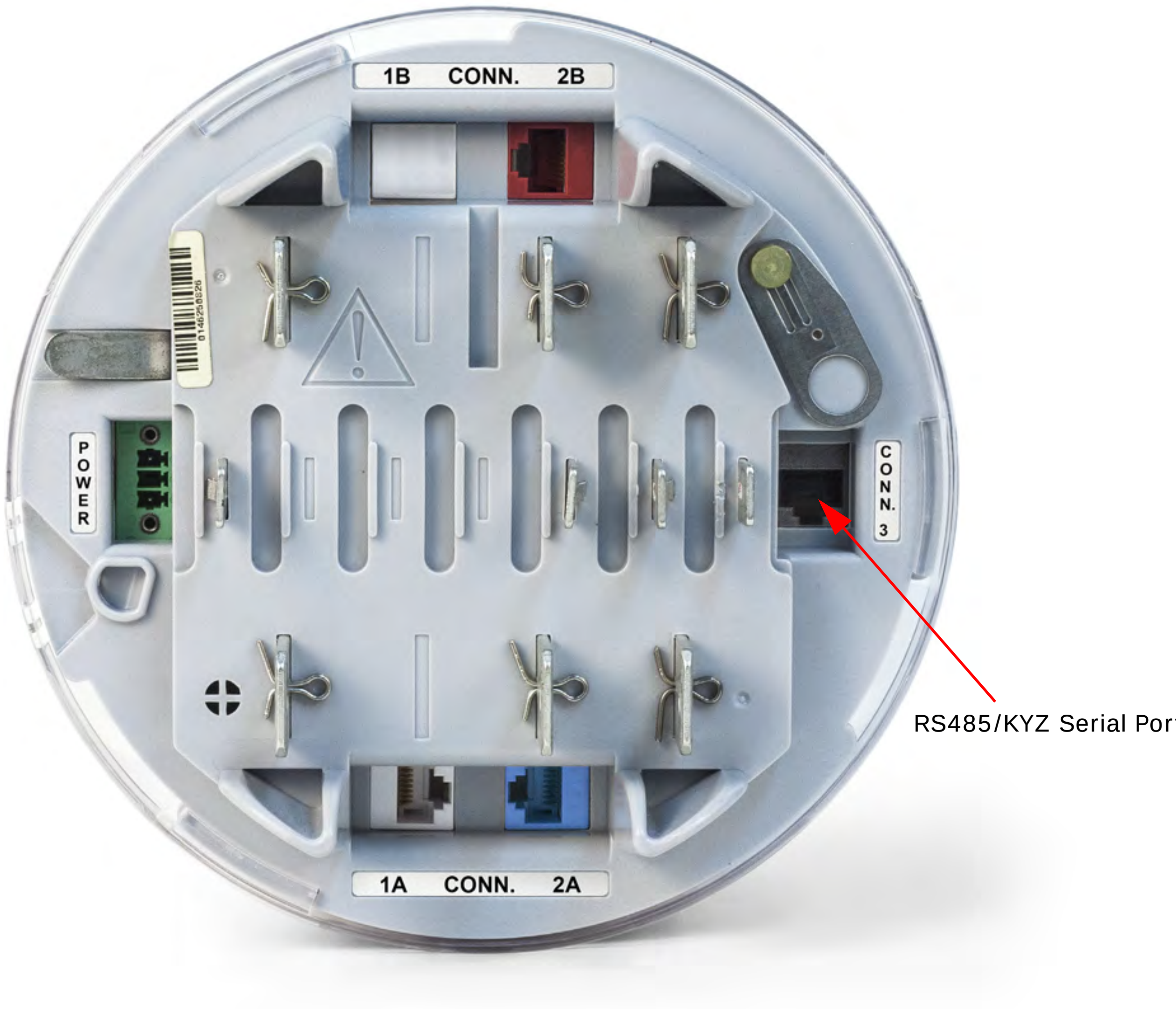

Figure 4.4: RS485/KYZ Serial Port Jack

The following chart describes the pinouts for the RS485/KYZ port.

Jack (Conn.) #3, RS485/KYZ, Color is Gray			
Pin#	**Ethernet Wire Color**		**Signal Name**
1	RS485	Orange/White	Data -
2	RS485	Orange	Data+
3	RS485	Green/White	SH
4	KYZ	Green	NC
5	KYZ	Brown/White	Common
6	KYZ	Brown	NO

You can use a communication converter to connect the meter's RS485 port to a PC's USB port (or 232 port, if applicable). The following sections describe two such products.

4.3.1: Using the Unicom 2500

The Unicom 2500 provides RS485/RS232/Fiber Optic conversion. In doing so it allows the Shark® 270 meter to communicate with a PC or other device. See the *Unicom 2500 Installation and Operation Manual* for additional information. You can order the Unicom 2500 from EIG's webstore: https://electroind.com/shop/. Select the Communications Products category from the left side of the webpage.

Figure 4.5 illustrates the Unicom 2500 connections for RS485.

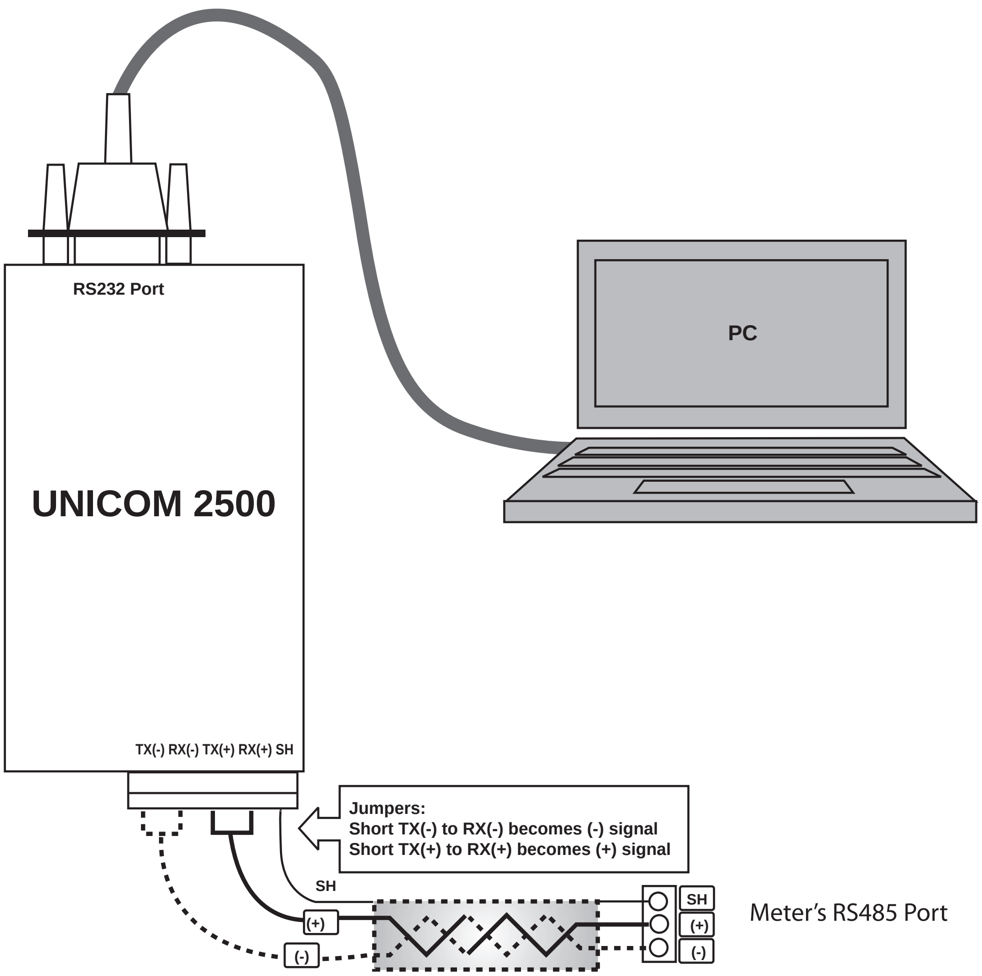

Figure 4.5: Meter Connected to a PC Using Unicom 2500

The Unicom 2500 can be configured for either 4-wire or 2-wire RS485 connections. Since the Shark® meter uses a 2-wire connection, you need to add jumper wires to convert the Unicom 2500 to the 2-wire configuration.

As shown in Figure 4.5, you connect the "RX-" and "TX-" terminals with a jumper wire to make the "-" terminal, and connect the "RX+" and "TX+" terminals with a jumper wire to make the "+" terminal. See Figure 4.5 for the Unicom 2500's settings.

The Unicom's Baud rate must match the Baud rate of the meter's RS485 port: you set the Baud rate by turning the screw to point at the rate you want.

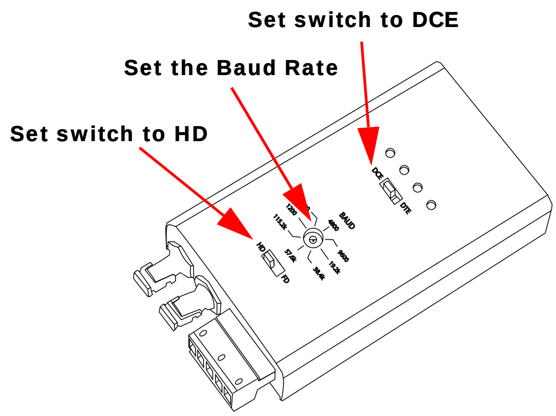

Figure 4.6: Setting the Unicom

4.3.1: Using the RS485 to USB Communication Converter - E159343

EIG offers an RS485 to USB converter, model number E159343, to facilitate communication between meters with an RS485 port and a device with a USB port, e.g., a PC. Utilizing a driver downloaded from the EIG website, the USB operates as a virtual Com port, allowing a user to communicate with the meter as with a standard PC serial emulation port.

The E159343, can be ordered from EIG's webstore: https://electroind.com/shop/.

Figure 4.7: RS485 to USB Communication Converter (Model Number E159343)

To use the E159343:

1. If necessary, download the E159343 driver from the EIG website: https://electroind.com/downloads/communication-products/.

2. Connect the RS485 side of the cable to the meter's RS485 port, using the RJ45 connector.

3. Connect the USB connector to your device's USB port.

5: Hardware Installation

5.1: Meter Dimensions

The Shark® 270 Socket meter is designed to mount into a standard meter socket. See the following dimension diagrams, and 5.2: Meter Installation, on page 5-5.

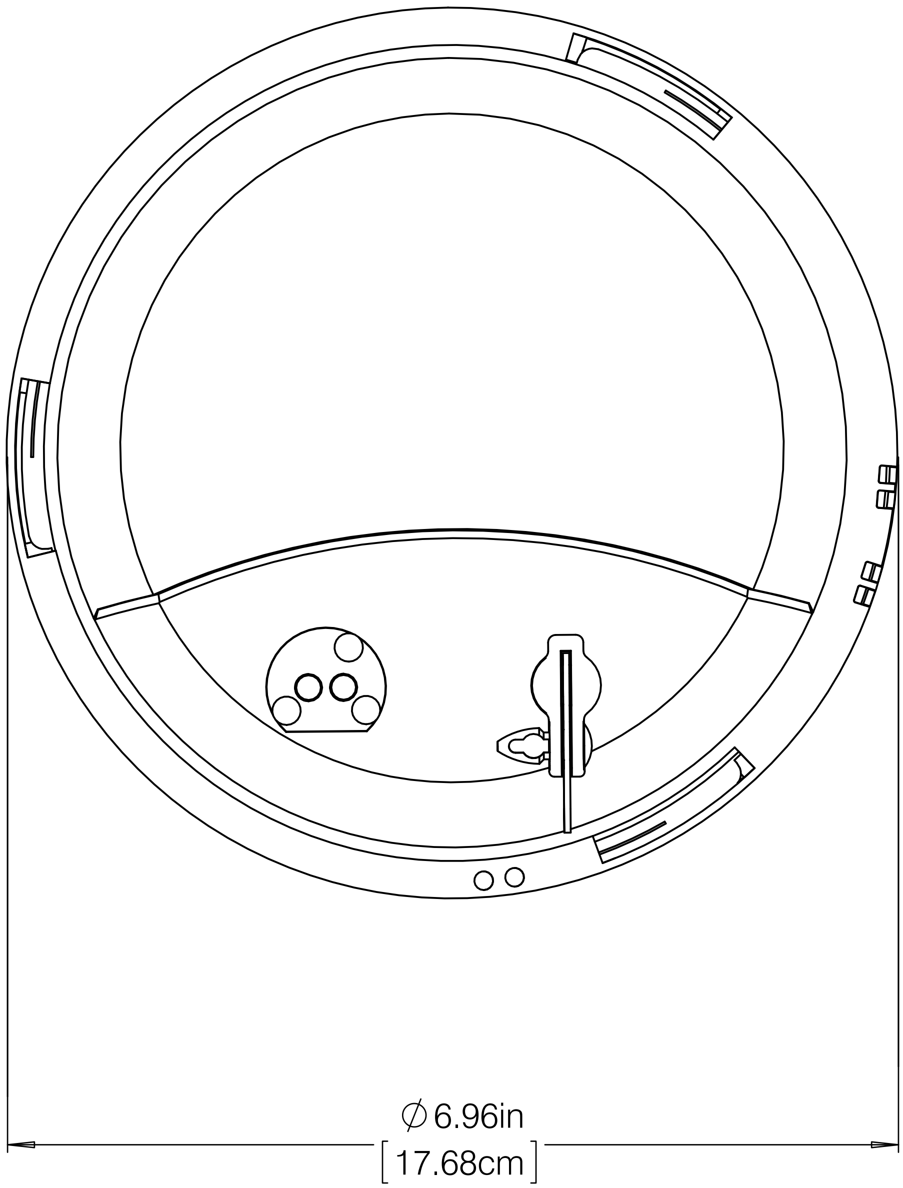

Figure 5.1: Socket Meter Front Dimensions

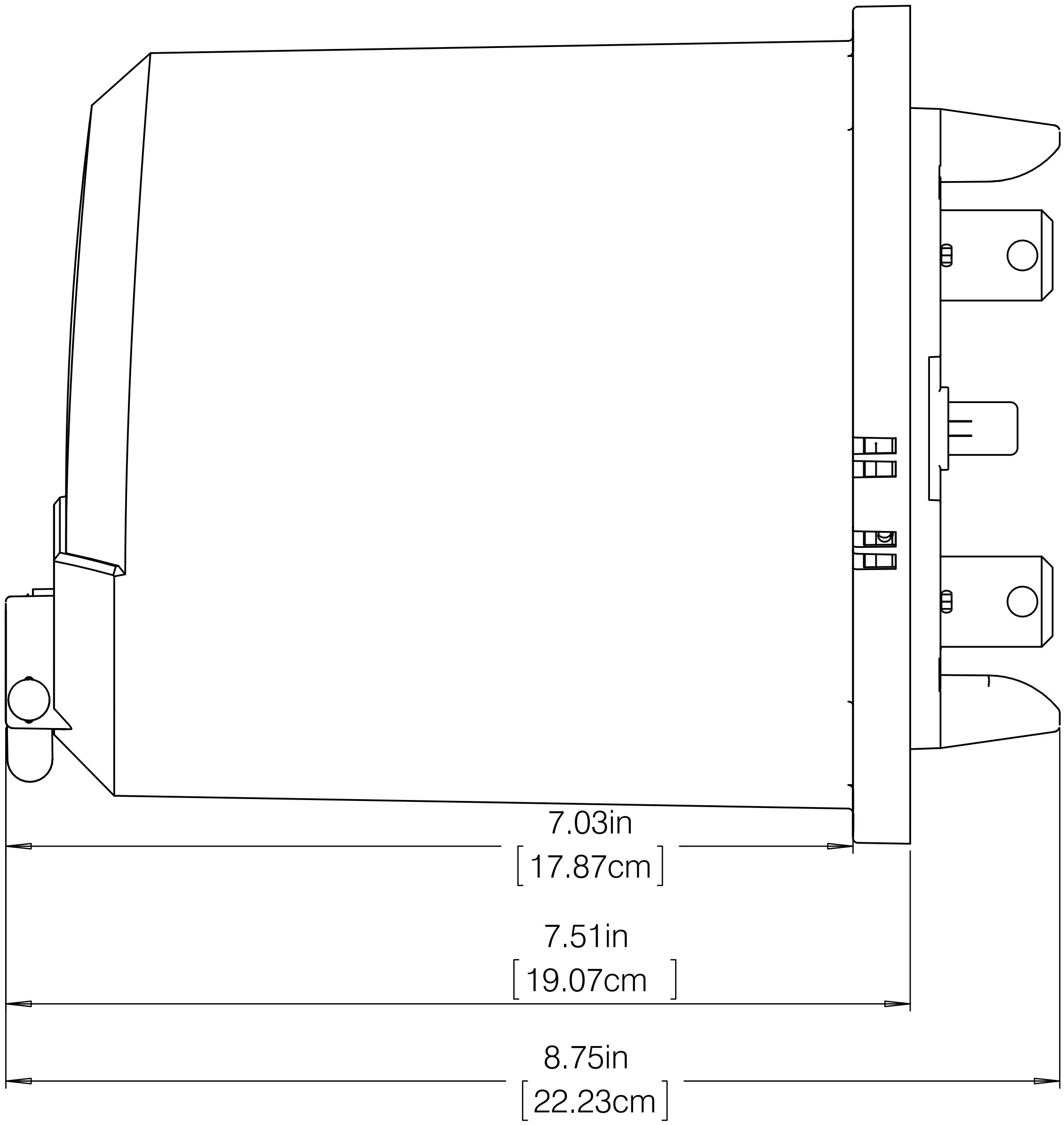

Figure 5.2: Socket Meter Side Dimensions

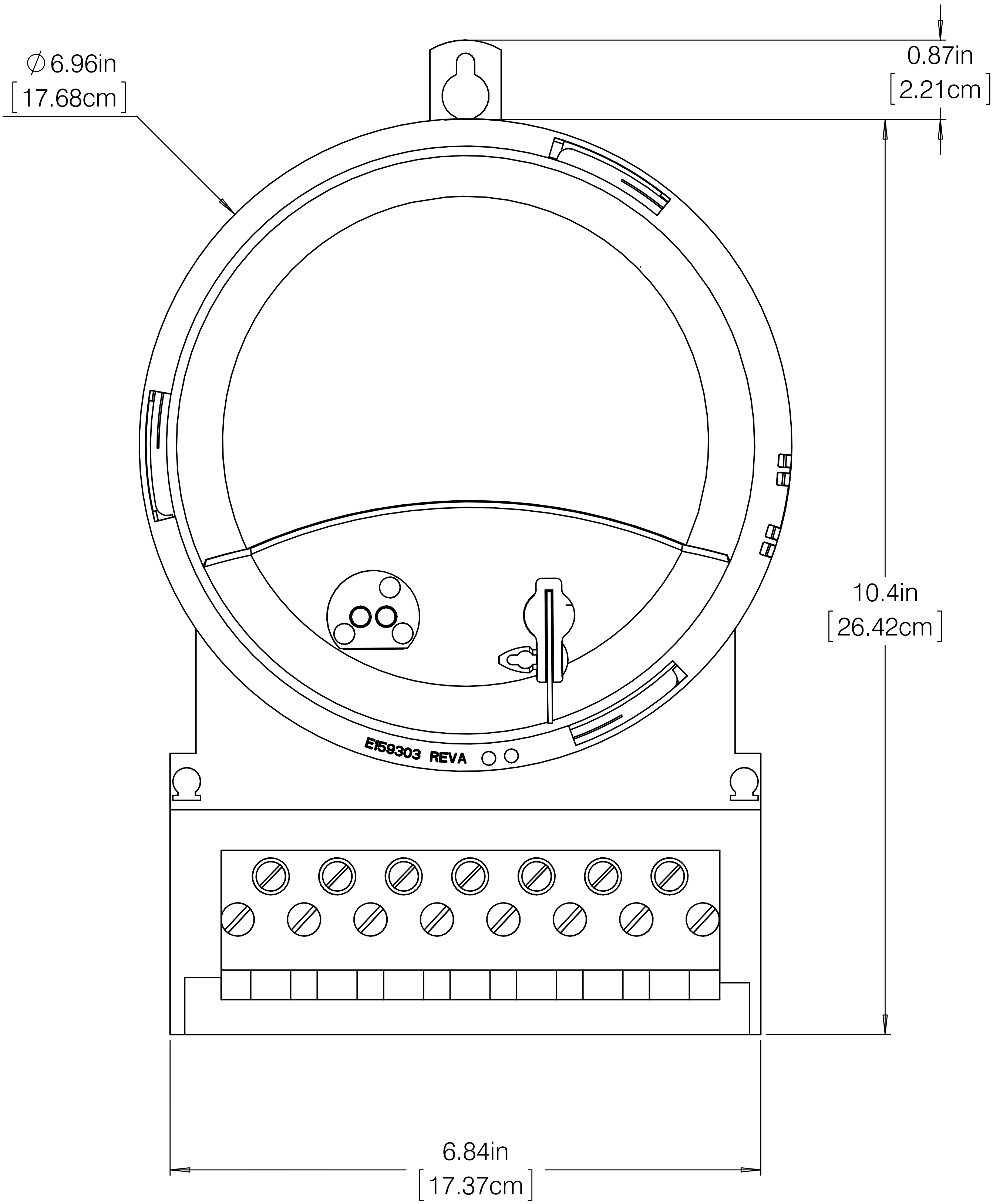

Figure 5.3: Socket Meter Mounted in S to A-Base Adapter Front Dimensions

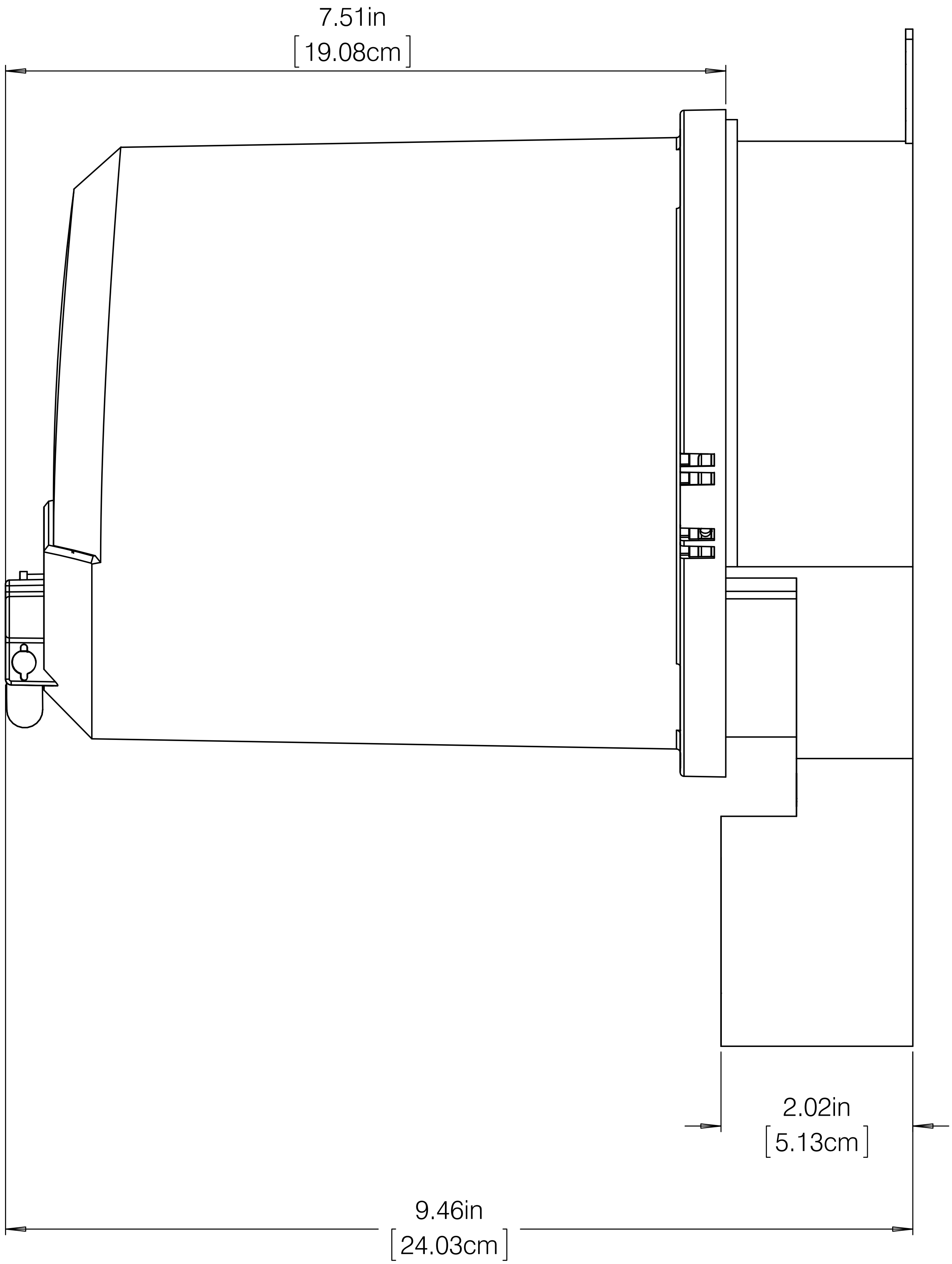

Figure 5.4: Socket Meter Mounted in S to A-Base Adapter Side Dimensions

5.2: Meter Installation

- Examine the labels to verify that the meter you are installing is, in fact, the correct form factor and service type. Make sure that the socket and meter current class ratings are compatible.

- Make sure that all communication and auxiliary power wiring is accessible in case disconnection is required for any reason.

- Make sure that any communications wiring from the back of the meter is fed through the appropriate openings in your socket to allow for clean connections with external devices.

- **WARNING!** All communication cabling to the meter must be routed around the socket connections so that they are as far away as possible from all high voltage connections and wires. Where sufficient spacing between the communication cables and high voltage is not practical, additional local insulation must be provided.
  ATTENTION! Toutes les communications de câblage au compteur doit être acheminé autour des connexions socket de sorte qu'ils soient aussi loin que possible de toutes les connexions et les fils à haute tension. Si un espacement suffisant entre les câbles de communication et de haute tension est pas pratique, l'isolation locale supplémentaire doit être fourni.

- Insert the meter into the socket, making sure that the unit's blades are firmly within the jaws of the socket.

- Connect external devices to the appropriate communications wiring. See Chapter 8: Optional Communication and I/O, on page 8-1.

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

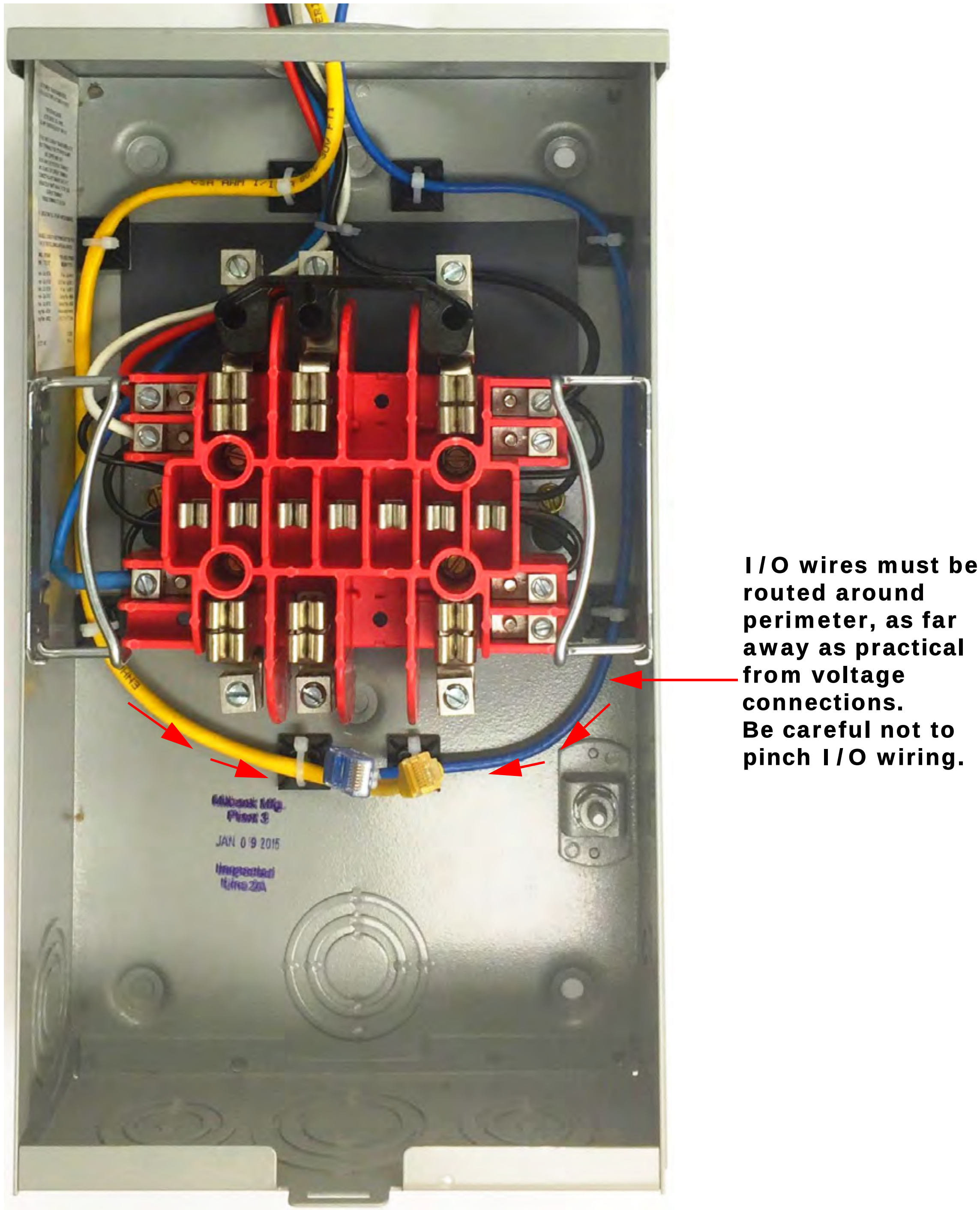

Figure 5.5: Routing Data Lines Around Perimeter of the S-Base Type Meter Socket
(Typical S Base shown; others may vary)

5.2.1: Socket Form Installation

The meter is designed to be installed into an S Form base. This allows the meter to retrofit into any base already existing that can accept that meter form.

See Figure 5.6 for an illustration of the meter's backplate connections.

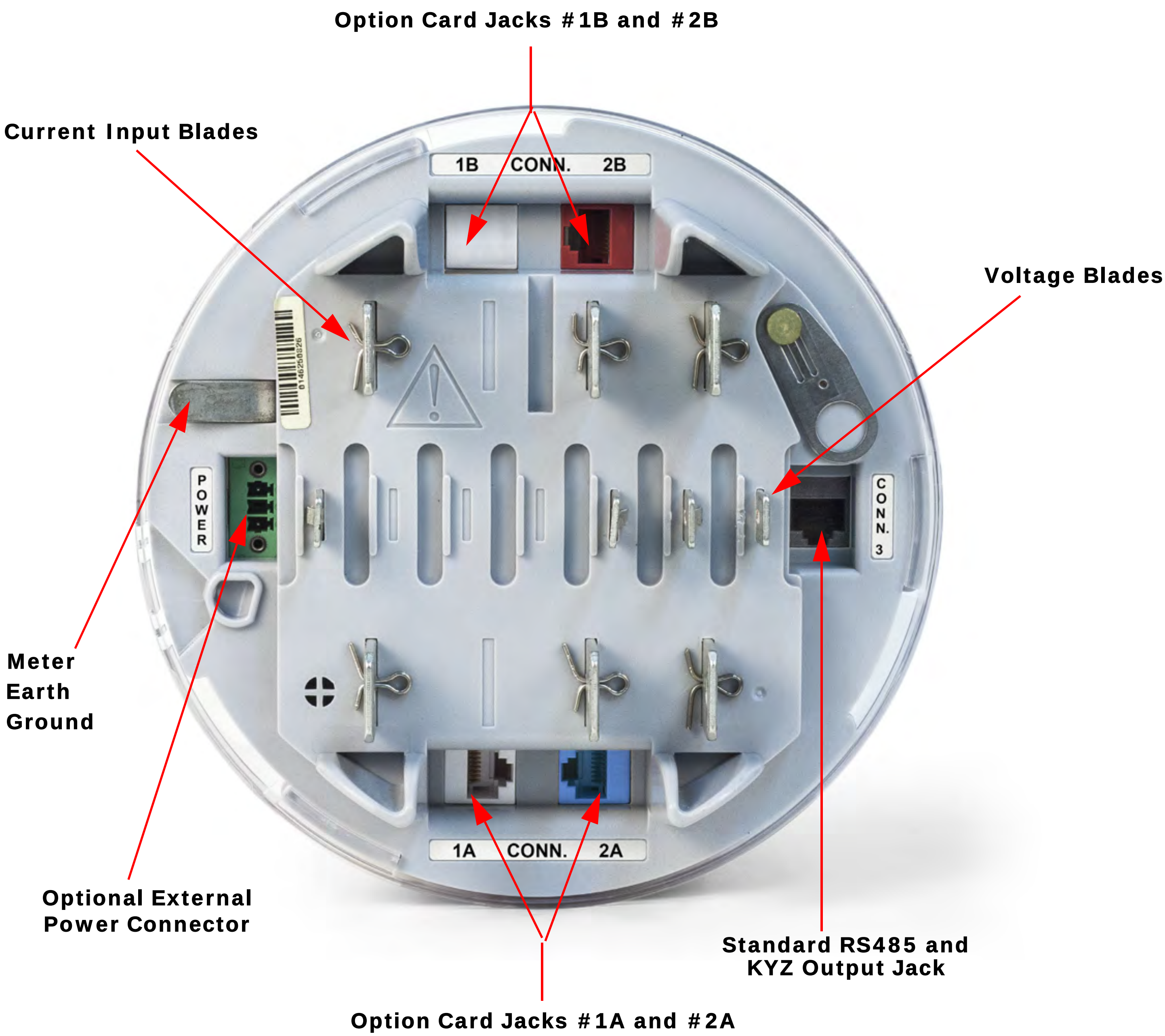

Figure 5.6: Meter's Backplate Connections

5.3: Internal Battery Installation and Maintenance

The Shark® 270 meter is equipped with a 3V Lithium cell size 1632 battery (EIG part number BATT21214). The internal battery maintains time during outages.

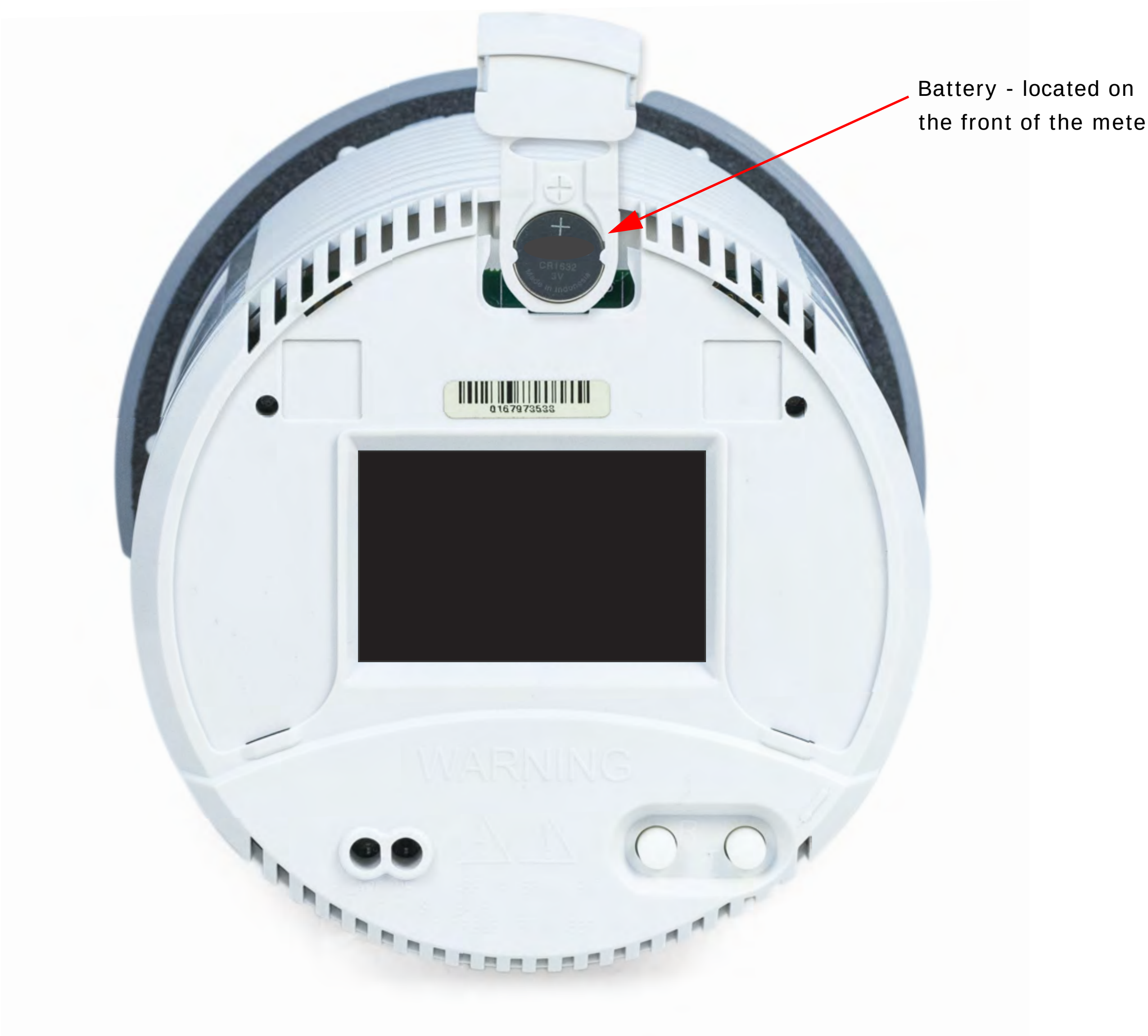

Figure 5.7: Location of Meter's Battery

Since the battery is used only to back up the meter's real time clock in the event of a power outage, under normal conditions, the battery should provide ten years of service from the time of manufacture, during storage conditions (disconnected from terminals) or when properly installed in an energized meter. The battery should provide more than one year of service during outage conditions (time on battery backup). A LOW BATTERY indicator on the display screen tells you when replacement is needed.

Follow these steps to install the battery:

1. If a meter seal is present, remove it.

2. If a meter socket ring and seal are present, remove them.

3. Remove the outer, clear cover by rotating it counter-clockwise.

4. Remove the bezel label.

5. Remove the battery cover.

6. Pull out the battery door and remove the battery.

7. Insert the new battery.

IMPORTANT!

You must insert the replacement battery into the holder correctly. Otherwise proper contact will not be achieved and the meter may lose time functions.

DO NOT SHORT THE TWO SIDES OF THE BATTERY TOGETHER. Even a momentary short can drastically reduce the battery's life. Never use metal tweezers to hold the battery - this will immediately cause the battery to drain.

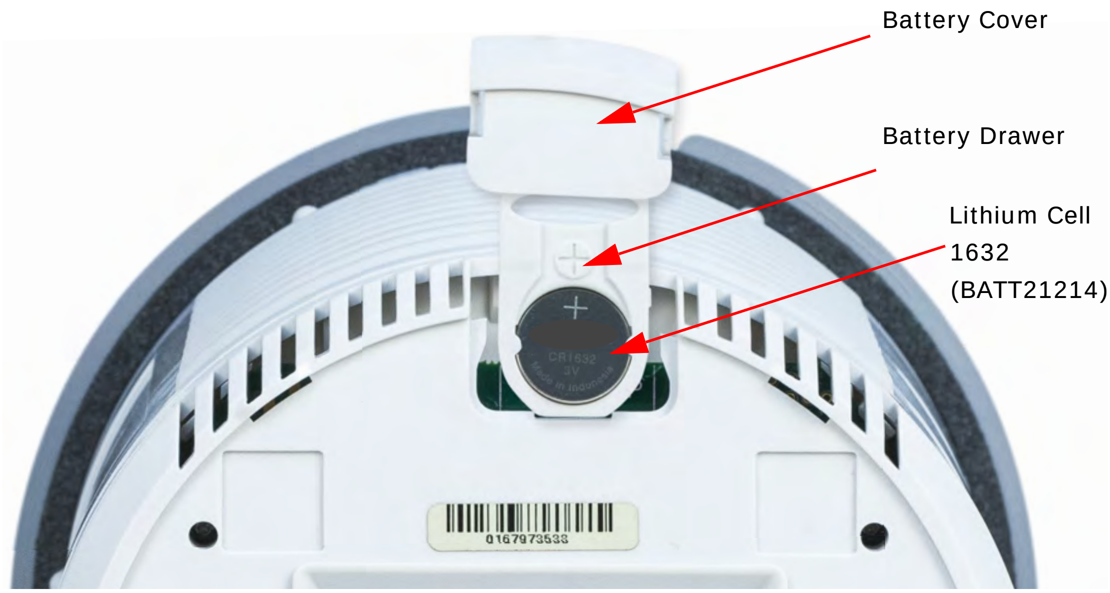

Figure 5.8: Battery Replacement

a. Make sure the + on the battery is facing UP and toward you.

b. Insert the RIGHT SIDE of the battery UNDER the clip on the right side of the holder while gently pushing the battery against the INSIDE RIGHT WALL of the battery holder. USE NON-CONDUCIVE TOOLS.

c. Gently push the LEFT SIDE of the battery in until it snaps into place.

8. Slide the battery drawer into place and replace the battery cover.
   NOTE: It is important that you DO NOT close the battery drawer unless there is a battery in the holder. If the battery drawer is closed without a battery in the holder, the battery drawer may become stuck.

9. Replace the bezel label.

10. Install the clear cover and turn it clockwise until it locks into place.

11. If required, affix a meter seal.

12. If required, affix a meter socket ring and seal.

EIG recommends replacing the battery with EIG part number BATT21214, which can be purchased directly from EIG.

5.3.1: Battery Safety and Disposal

Dispose of lithium batteries in accordance with local, state and federal hazardous waste regulations. For disposal outside the United States, follow your country's disposal guidelines.

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6: Time of Use Function

6.1: 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 Shark® 270 meter's TOU functionality, available with the Communicator EXT™ 4.0 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 Shark® 270 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 *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for details on programming the Shark® 270 meter’s TOU calendar and retrieving TOU data.

Time of Use Metering

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:

Energy Used: **12am-7:59 am** **8am-5:59pm** **6pm-7:59pm** **8pm-11:59pm**

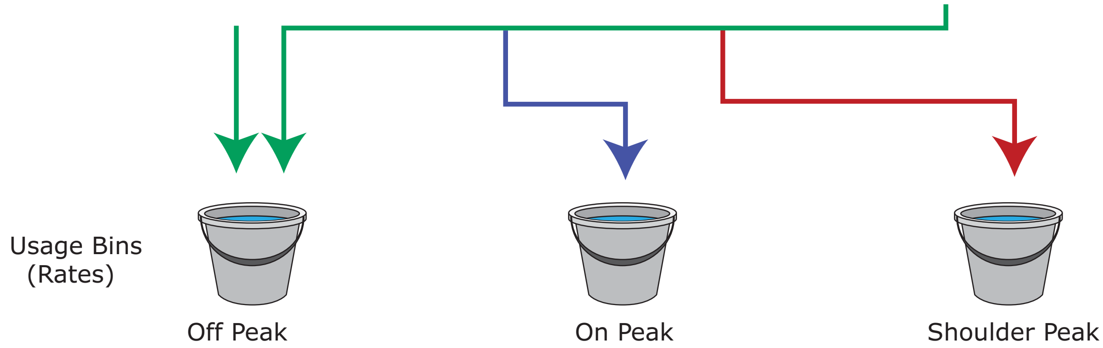


Figure 6.1: Time of Use

6.2: The Shark® 270 Meter's TOU Profile

A Shark® 270 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 Shark® 270 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.

6.3: TOU Prior Season and Month

The Shark® 270 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 registers are then cleared and accumulations resume, using the next set of TOU schedules and register assignments from the TOU profile. Prior and current accumulations to date are always available.

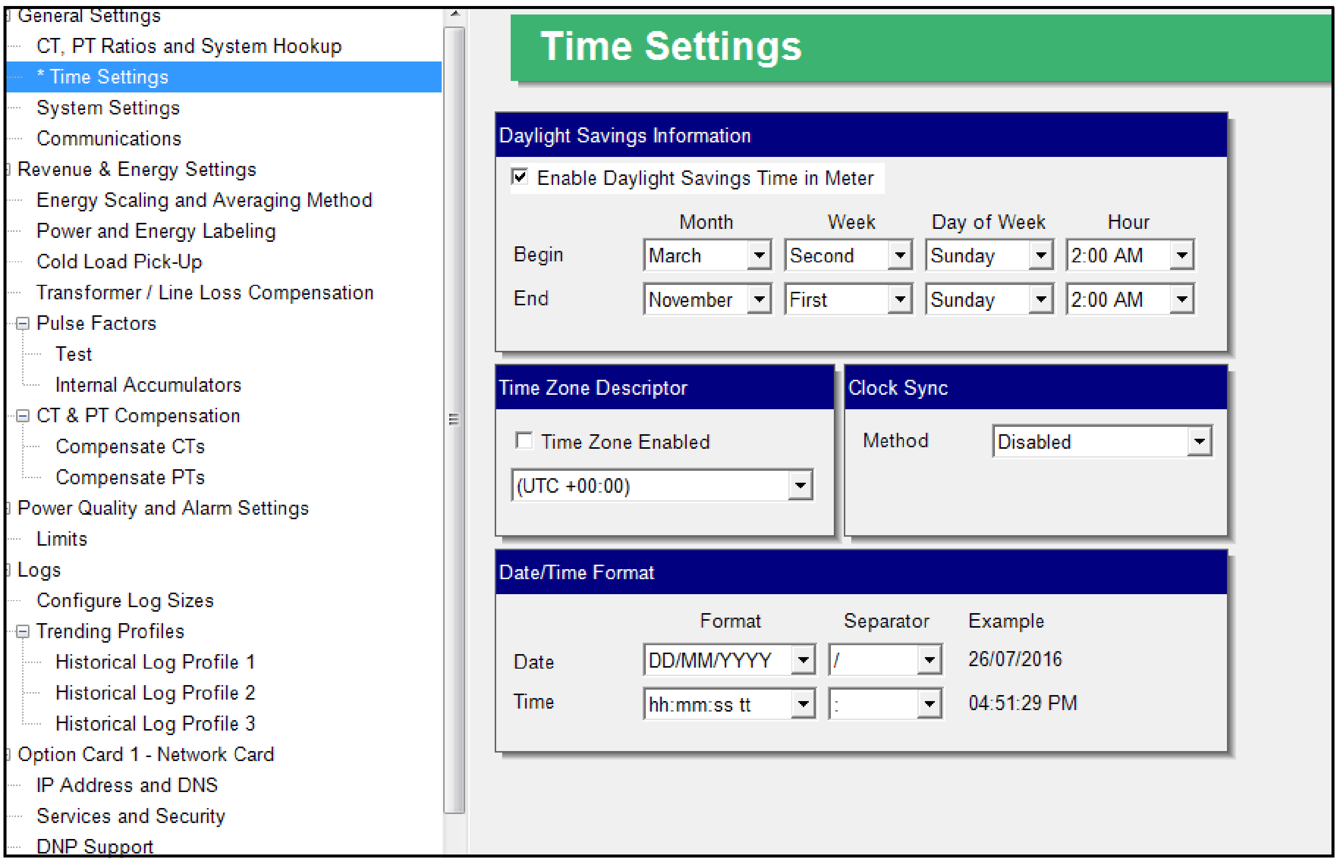
6.4: Updating, Retrieving and Replacing the TOU Profile

Communicator EXT™ software retrieves the TOU Profile from the Shark® 270 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 *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for instructions on updating the TOU profile.

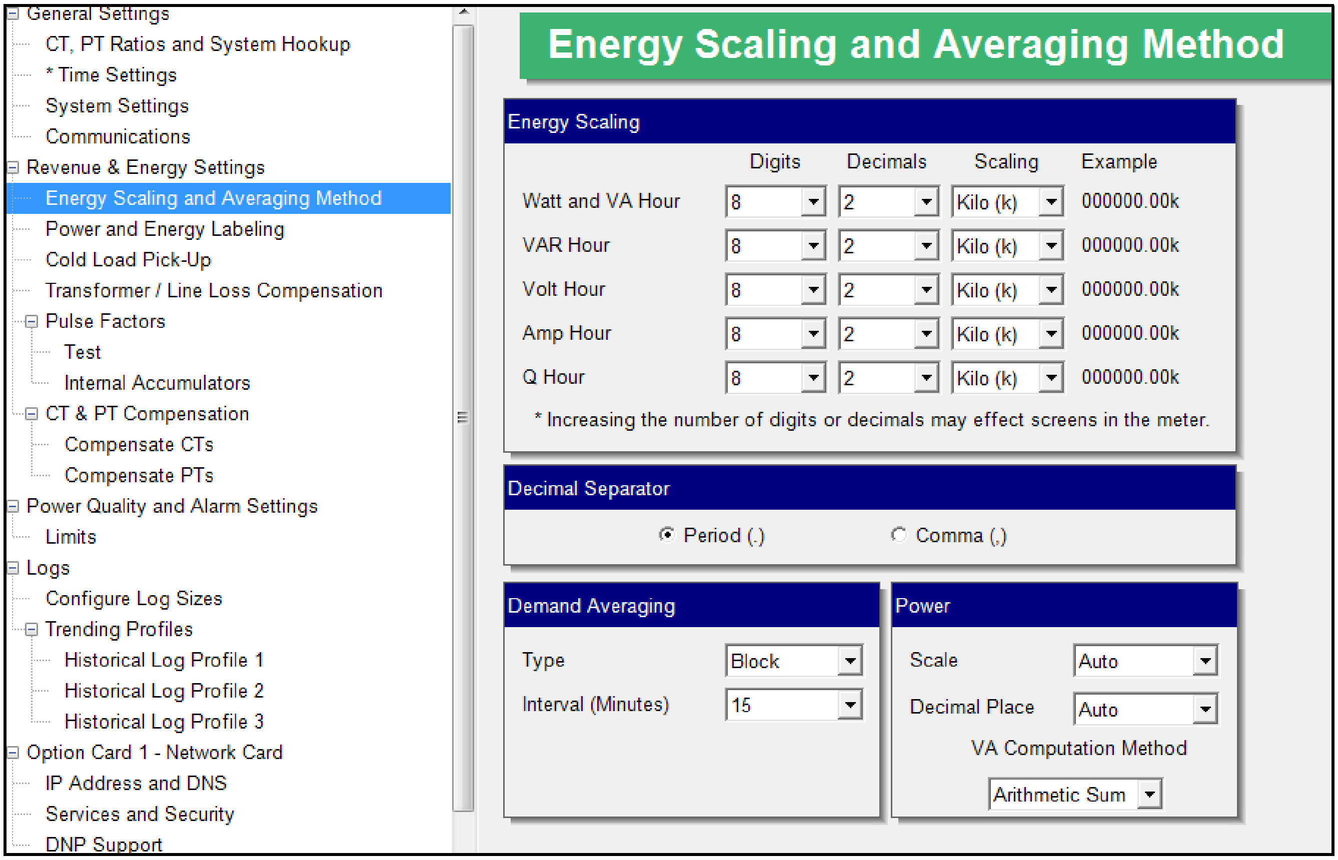
6.5: Daylight Savings and Demand

To use Daylight Savings Time and to set Demand intervals, you must configure the settings in the Shark® 270 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 Chapter 26 in the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for programming details for these and other Device Profile settings.

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7: Transformer Loss Compensation

7.1: 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 7.1.

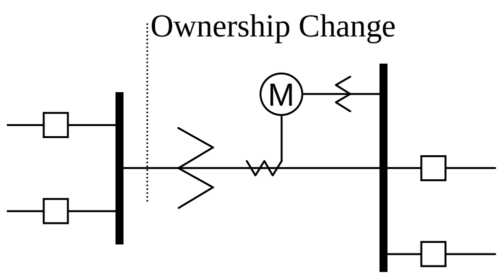

Figure 7.1: Low Voltage Metering Installation Requiring Loss Compensation

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 7.2.

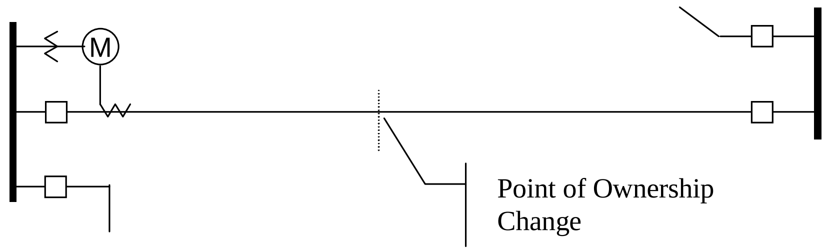

Figure 7.2: Joint Ownership Line Meeting Requiring Loss Compensation

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 Shark® 270 meter. Refer to Appendix A in this manual and Appendix B of the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for detailed explanation and instructions for using the Transformer Line Loss Compensation feature of the Shark® 270 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 Shark® 270 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).

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

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

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.

7.2: Shark® 270 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 Shark® 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 EIG Loss Compensation Calculator in Microsoft Excel
- By figuring the values from the worksheet shown in 7.2.1.1: Three-Element Loss Compensation Worksheet, on page 7-6, and in Appendix B of the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual*

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

The Communicator EXT™ 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 *Communicator EXT™ 4.0 and MeterManager EXT Software User 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.

7.2.1: 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 Shark® 270 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

7.2.1.1: Three-Element Loss Compensation Worksheet

If you are not using the TLC Calculator in the Communicator EXT™ 4.0 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.

   a. Calculate Phase-to-Neutral Test Voltage by dividing Phase-to-Phase Test Voltage by the square root of 3.

   b. 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:

a. For Transformer Voltage, enter the Phase-to-Neutral of Test Voltage (Volts) previously calculated (step 6).

b. For Transformer Current, enter the Full Load Current (Amps) previously calculated (step 6).

c. For Multiplier, enter the PT and CT Multipliers previously calculated (step 7).

d. 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.

e. 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 Nom-inal	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:

   a. Enter Value at Trf Nominal for each quantity from previous calculations (step 10).

   b. Enter Meter/Trf Value from Conversion Factors for Nominal Values (step 9).

   c. Calculate M/T Factor w/Exp by raising the Meter/Trf Value to the power indicated in Exp.

   d. 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:

a. Enter Value at Meter Nominal from Normalize Losses (step 11).

b. Enter Meter Nominal kVA from previous calculation (step 12).

c. Calculate % Loss at Meter Nominal by dividing Value at Meter Nominal by Meter Nominal kVA and multiplying by 100.

d. Enter calculated % Loss at Meter Nominal Watt values into the Shark® 270 meter using Communicator EXT™ software. Refer to Appendix B of the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for additional instructions.

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8: Optional Communication and I/O

8.1: Option Cards

The Shark® 270 meter has an ANSI Type 2 Optical port and an RS485/KYZ port, standard. In addition, it has connection ports for optional communication or I/O cards. Up to two of the following cards can be installed in the meter, with the exception that, because of a power consumption issue, only <u>one</u> Ethernet card - either INP100S or INP300S, can be installed in a meter:

- INP100S Ethernet card
- INP300S IEC 61850 Protocol card
- 1mAOS - 0-1 mA analog output card
- 20mAOS - 4-20 mA analog output card
- PO1S - pulse output/digital input card
- RO1S - relay output/digital input card

8.2: Option Card Connections

For ease of wiring, the meter uses standard RJ45 modular jacks (labeled Conn.) on the blade side of the base. All I/O connections are made through these jacks. You can use the standard UTP Ethernet cable for wiring. Different outputs are mapped to the connectors, depending on the output type. See Figure 8.1 for jack locations.

CAUTION! Refer to Figure 5.5: Routing Data Lines Around Perimeter of the S-Base Type Meter Socket (Typical S Base shown; others may vary), on page 5-6, for proper safe routing of communication wiring.

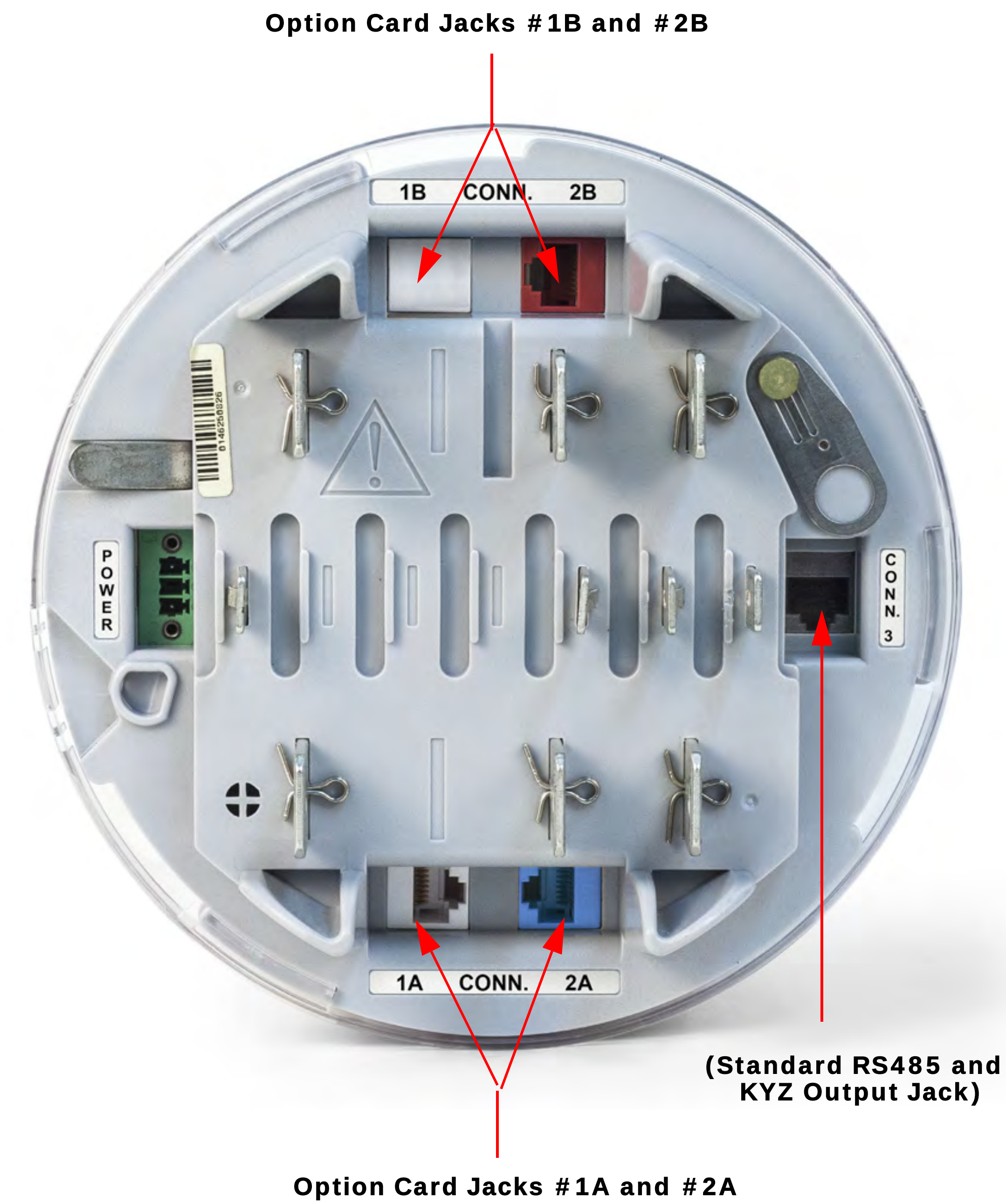


Figure 8.1: Option Card Jack Locations (Example Configuration)

The meter has two interchangeable slots for installing two option cards. To upgrade the unit with option cards, or to change existing option cards, see the installation instructions in 8.4.2: Add a New Card, on page 8-32.

Make sure to follow the correct pinout diagrams when connecting wires, as detailed in the wiring drawings and tables in 8.3: Option Card Details, on page 8-4.

For ease of installation, a terminal breakout box - CONN20163, which is available for purchase from EIG, can be used. The terminal designations are labeled on the CONN20163 unit. You can purchase CONN20163 from EIG's web store: https://electroind.com/shop/.

Figure 8.2: Terminal Breakout Box CONN20163

8.3: Option Card Details

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

The Shark® 270 meter auto-detects any Option cards installed in it. You configure the Option cards through Communicator EXT^{TM} software. Refer to the *Communicator EXT^{TM} 4.0 and MeterManager EXT Software User Manual* for detailed instructions.

The following sections describe the available Option cards. See 8:4: Installing the Option Cards, on page 8-26, for installation instructions.

8.3.1: INP100S Ethernet Card

The 10/100BaseT Ethernet Communication card provides the Shark® 270 meter with Ethernet capability. See Chapter 10: Using the INP100S Ethernet Card, on page 10-1, for details and instructions.

NOTE: Refer to Chapter 26 of the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for instructions on performing Network configuration.

8.3.1.1: Specifications

The technical specifications at 25° C are as follows:

Number of Ports:	1
Power consumption:	2.1 W internal
Baud rate:	10/100 Mbit
Number of simultaneous Modbus connections:	12

8.3.1.2: Default Configuration

The Shark® 270 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

8.3.1.3: Wiring Diagram and Connections Table

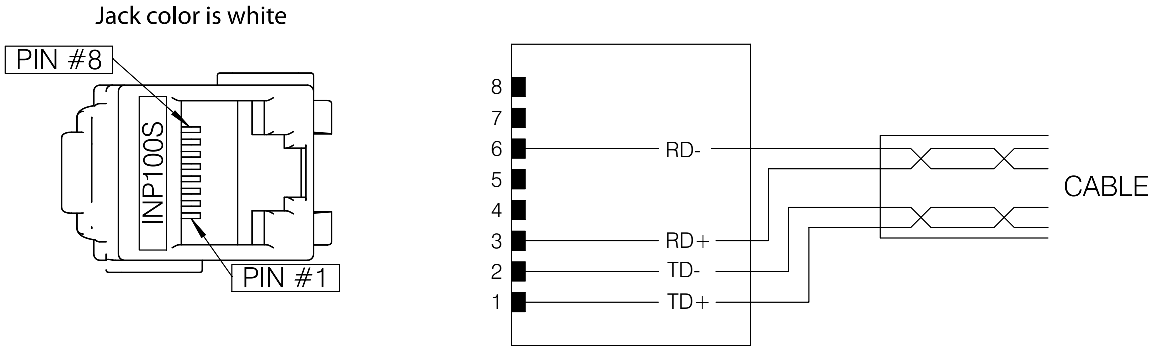


Figure 8.3: 10/100BaseT Ethernet Card Connections

The INP100S Ethernet card plugs into either Card slot #1, with its keystone jack inserted into the opening for Jack 1A; or Card slot#2 with its keystone jack inserted into the opening for Jack 2A. The meter can accommodate only one Ethernet card.

INP100S White Keystone Jack to Jack 1A or Jack 2A		
Pin#	**Ethernet Wire Color (following EIA/TIA568B standard)**	**Signal Name**
1	Orange/White	Transmit Data+
2	Orange	Transmit Data-
3	Green/White	Receive Data+
4	Blue	Not Connected
5	Blue/White	Not Connected
6	Green	Receive Data-
7	Brown/White	Not Connected
8	Brown	Not Connected

IMPORTANT! The INP100S 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.

8.3.2: INP300S IEC 61850 Protocol Card

The IEC 61850 Protocol Ethernet Network card provides the Shark® 270 meter with IEC 61850 as well as Modbus protocol, to allow it to operate in any IEC 61850 application. See Chapter 12: Using the INP300S IEC 61850 Protocol Card, on page 12-1, for details and instructions.

8.3.2.1: Specifications

The technical specifications at 25° C are as follows:

Number of Ports:	1
Power consumption:	2.1 W internal
Baud rate:	10/100 Mbit
Number of simultaneous Modbus connections:	12
Number of simultaneous MMS clients:	5

8.3.2.2: Default Configuration

The Shark® 270 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

8.3.2.3: Wiring Diagram and Connections Table

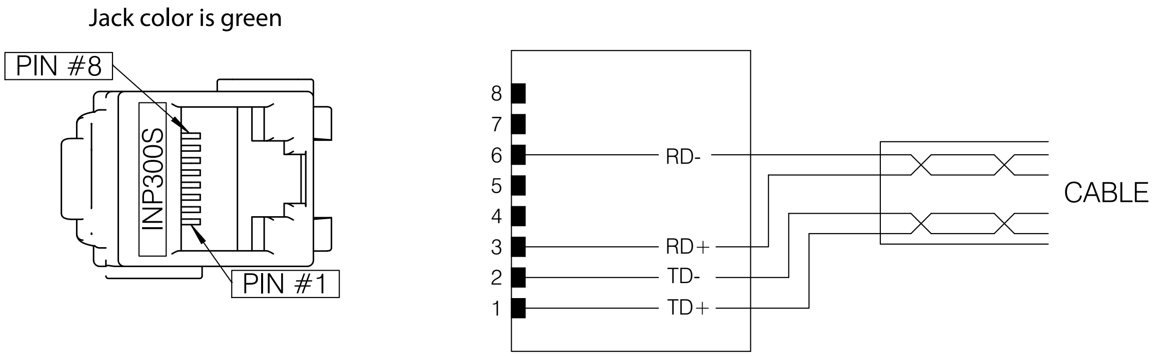


Figure 8.4: IEC61850 Protocol Ethernet Network Card

The INP300S Ethernet card plugs into either Card slot #1, with its keystone jack inserted into the opening for Jack 1A or Card slot#2 with its keystone jack inserted into the opening for Jack 2A. The meter can accommodate only one Ethernet card. See the table on the next page.

INP300S Green Keystone Jack to Jack 1A or Jack 2A		
Pin#	**Ethernet Wire Color (following EIA/TIA568B standard)**	**Signal Name**
1	Orange/White	Transmit Data+
2	Orange	Transmit Data-
3	Green/White	Receive Data+
4	Blue	Not Connected
5	Blue/White	Not Connected
6	Green	Receive Data-
7	Brown/White	Not Connected
8	Brown	Not Connected

IMPORTANT! The INP300S 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.

8.3.3: 1MAOS Analog Output Card

The 1mA card transmits a standardized bi-directional 0-1 mA signal. This signal is linearly proportional to real-time quantities measured by the Shark® 270 meter. The outputs are electrically isolated from the main unit.

8.3.3.1: Specifications

The technical specifications at 25° C at 5 kΩ load are as follows:

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 kΩ
Hardware resolution:	12 bits
Effective resolution:	14 bits with 2.5k Hz 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 5k @ ± 1 mA
Temperature coefficient:	± 30 nA/ °C
Isolation:	AC 2500 V system to outputs
Reset/Default output value:	0 mA
Weight:	1.6 oz
Dimensions (inch) W x H x L:	0.72 x 2.68 x 3.26

8.3.3.2: Default Configuration

The Shark® 270 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 V =>	+1 mA
	Phase A voltage Delta, 600 V =>	+1 mA
Channel 4:	Phase A current, 10 A =>	+1 mA

8.3.3.3: Wiring Diagram and Connections Table

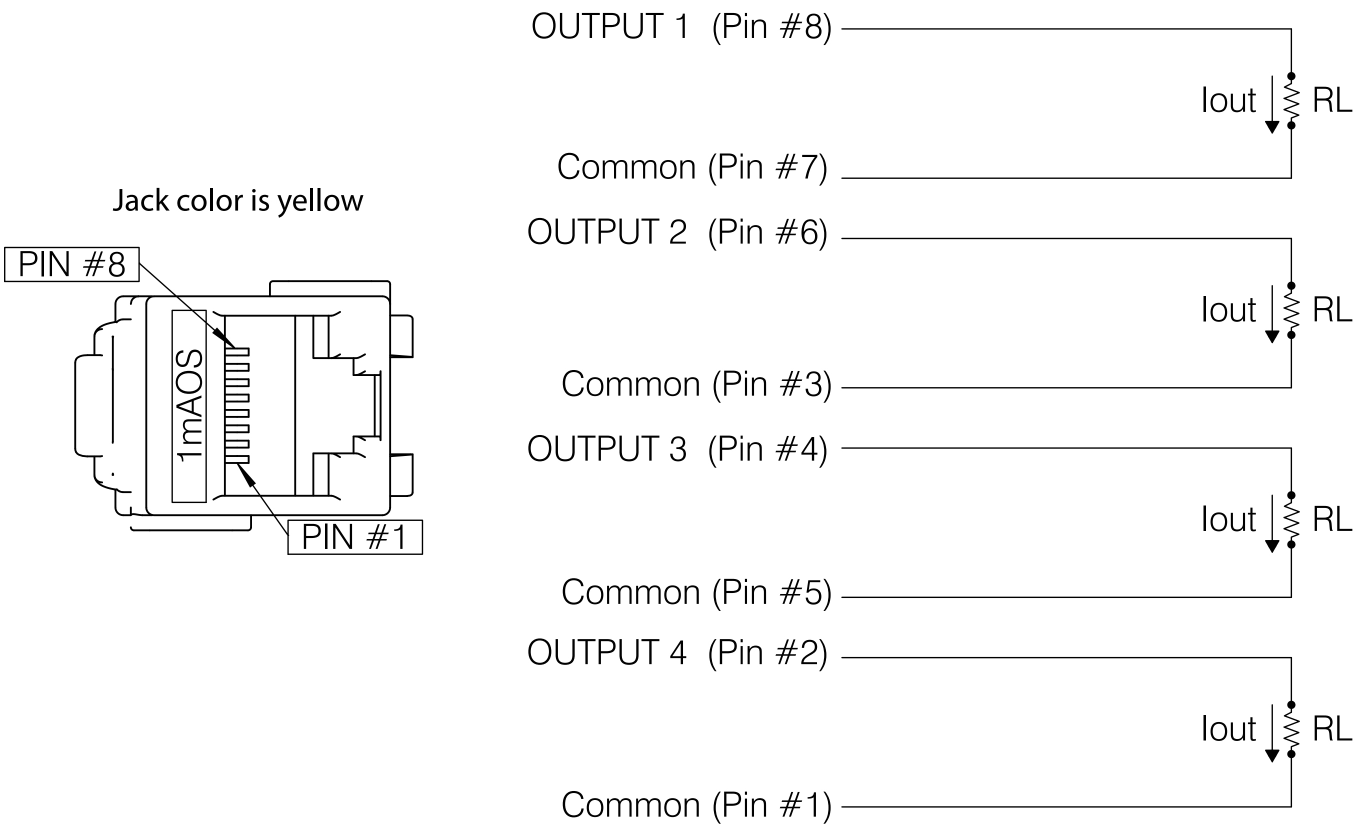


Figure 8.5: 4-Channel 0 - 1mA Output Card

The 1mAOS card plugs into either Card slot #1 with its keystone jack inserted into the opening for Jack 1A, or Card slot #2 with its keystone jack inserted into the opening for Jack 2A. See the table on the next page.

1mAOS Yellow Keystone Jack to Jack 1A or 2A		
Pin#	**Ethernet Wire Color**	**Signal Name**
1	Orange/White	Common
2	Orange	Output4
3	Green/White	Common
4	Blue	Output3
5	Blue/White	Common
6	Green	Output2
7	Brown/White	Common
8	Brown	Output1

8.3.4: 20mAOS Analog Output Card

The 20mA card transmits a standardized 0-20 mA signal. This signal is linearly proportional to real-time quantities measured by the Shark® 270 meter. The current sources need to be loop powered. The outputs are electrically isolated from the main unit.

8.3.4.1: Specifications

The technical specifications at 25° C at 500 Ω load are as follows:

Number of outputs:	4 single ended
Power consumption:	1 W internal
Signal output range:	(0 to 24)mA
Max. load impedance:	850 Ω @ 24 VDC
Hardware resolution:	12 bits
Effective resolution:	14 bits with 2.5k Hz 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:	± 300n A/°C
Isolation:	AC 2500 V system to outputs
Maximum loop voltage:	28 VDC max.
Internal voltage drop:	3.4 VDC @ 24 mA
Reset/Default output value:	12 mA

8.3.4.2: Default Configuration

The Shark® 270 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 V => 20 mA
	0 V => 4 mA
	Phase A voltage Delta, 600 V => 20 mA
Channel 4:	Phase A current, 10 A => 20 mA
	0 Phase A current, 0 A => 4 mA

8.3.4.3: Wiring Diagram

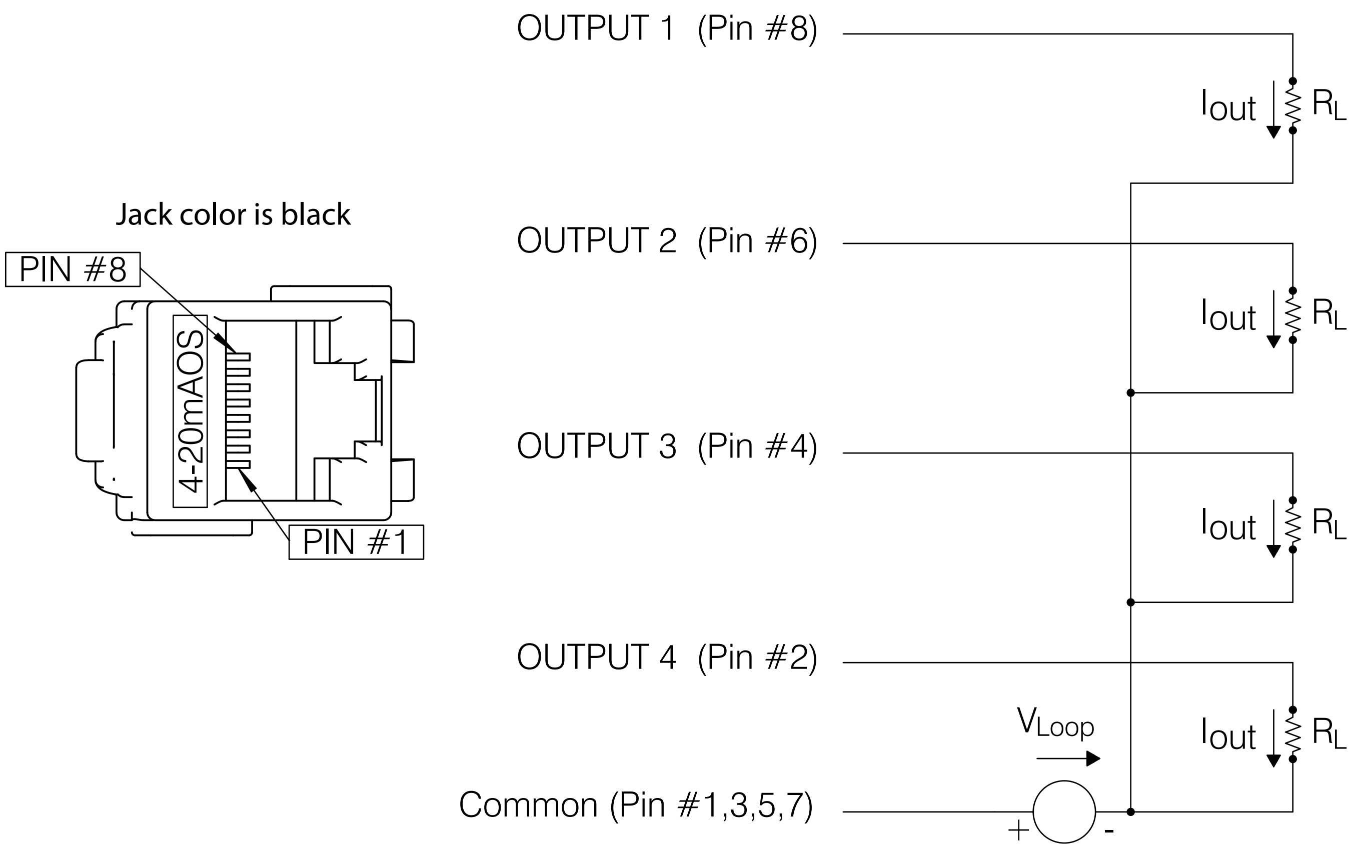


Figure 8.6: 4-Channel 0 - 20mA Output Card

The 20mAOS plugs into either Card slot #1 with its keystone jack inserted into the opening for Jack 1A, or Card slot #2 with its keystone jack inserted into the opening for Jack 2A. See the table on the next page.

20mAOS Black Keystone Jack to Jack 1A or 2A		
Pin#	**Ethernet Wire Color**	**Signal Name**
1	Orange/White	Common
2	Orange	Output4
3	Green/White	Common
4	Blue	Output3
5	Blue/White	Common
6	Green	Output2
7	Brown/White	Common
8	Brown	Output1

8.3.5: PO1S Pulse Output/Digital Input Card

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

8.3.5.1: Specifications

The technical specifications at 25° C are as follows:

Power consumption:	0.420 W internal
Relay outputs:	
Number of outputs:	4
Contact type:	Closing (SPST - NO)
Relay type:	Solid state
Continuous load current:	120 mA
Peak load current:	350 mA for 10 ms
On resistance, max.:	35 Ω
Leakage current, max.:	1µA
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:	Dry contact status detection, only
Input open circuit voltage:	24 VDC, internally generated
Input short circuit current:	2.5 mA – constant current regulated
Filtering:	De-bouncing with 50ms delay time

Detection scan rate:	100 ms
Isolation:	AC 2500 V system to inputs

8.3.5.2: Default Configuration

The Shark® 270 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 +watt-hours per pulse
Pulse Channel 2:	1.8 -watt-hours per pulse
Pulse Channel 3:	1.8 +VAR-hours per pulse
Pulse Channel 4:	1.8 -VAR-hours per pulse

8.3.5.3: Wiring Diagram

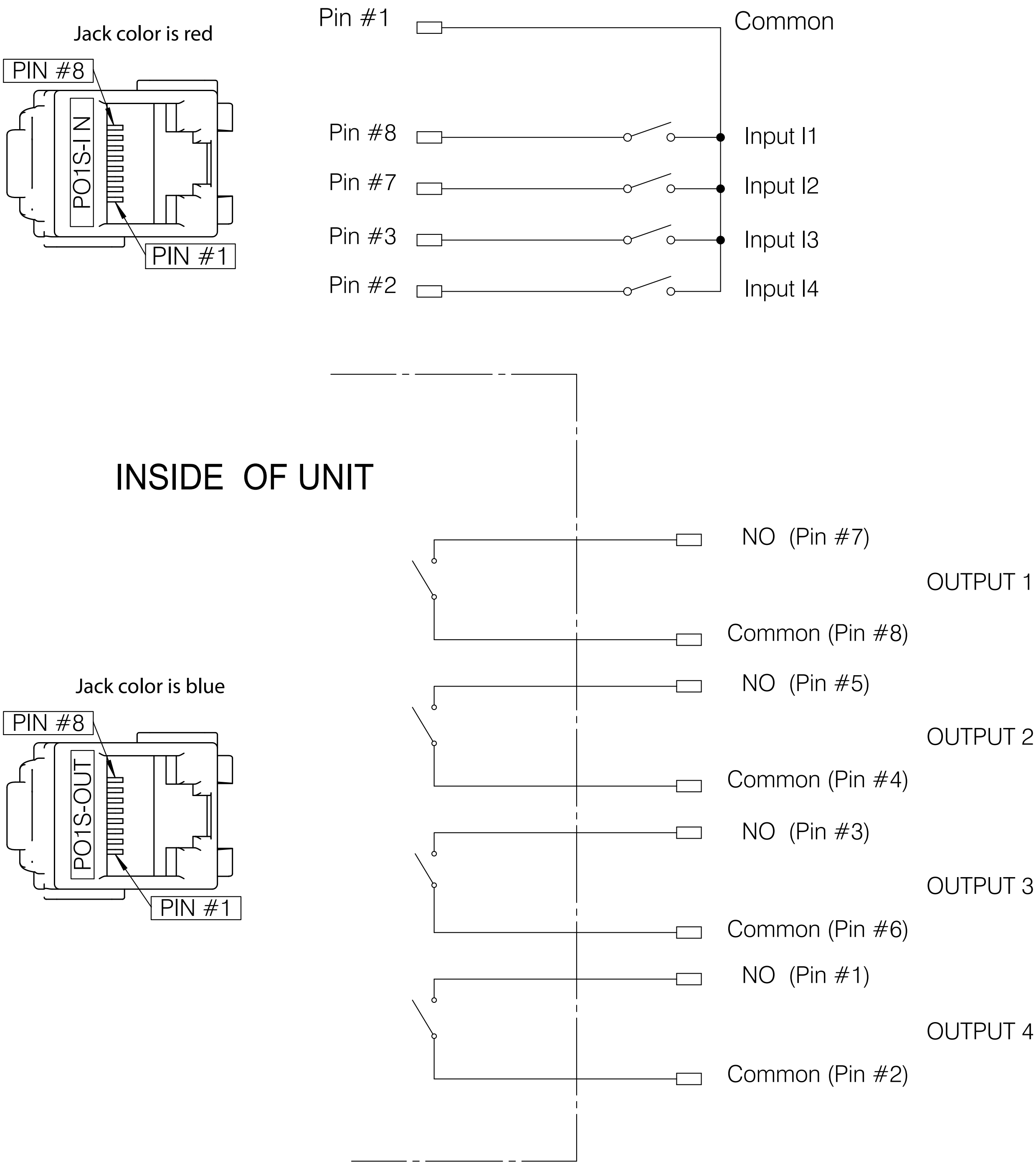


Figure 8.7: Pulse Output (4) / Status Input (4) Card

See CAUTION on next page.

CAUTION! Make sure to connect the Input connector to the Input section of the card and the Output connector to the Output section of the card.

The Pulse Output card (PO1S) plugs into either Card slot #1 with its Input keystone jack inserted into the opening for Jack 1B and its Output keystone jack inserted into the opening for Jack 1A; or Card slot #2 with its Input keystone jack inserted into the opening for Jack 2B and its Output keystone jack inserted into the opening for Jack 2A.

PO1S-IN Red Keystone Jack to Jack 1B or 2B		
Pin#	**Ethernet Wire Color**	**Signal Name**
1	Orange/White	Common
2	Orange	Input4
3	Green/White	Input3
7	Brown/White	Input2
8	Brown	Input1

PO1S-OUT Blue Keystone Jack to Jack 1A or 2A		
Pin#	**Ethernet Wire Color**	**Signal Name**
1	Orange/White	NO4
2	Orange	Common4
3	Green/White	NO3
4	Blue	Common3
5	Blue/White	NO2
6	Green	Common2
7	Brown/White	NO1
8	Brown	Common1

8.3.6: Digital Output (Relay Contact) / Digital Input Card (RO1S)

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

8.3.6.1: Specifications

The technical specifications at 25° C are as follows:

Power consumption:	0.320 W internal
Relay outputs:	
Number of outputs:	2
Contact type:	Changeover (SPDT)
Relay type:	Mechanically latching
Max. allowed switching voltage:	AC 30 V / DC 30 V
Switching power:	7.5 VA / 7.5 W
Switching current:	0.250 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 30 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:	Dry contact status detection, only
Internal wetting voltage:	24 VDC, internally generated

Input current:	2.5 mA – constant current regulated
Filtering:	De-bouncing with 50 ms delay time
Detection scan rate:	100 ms
Isolation:	AC 2500 V system to inputs

8.3.6.2: Wiring Diagram

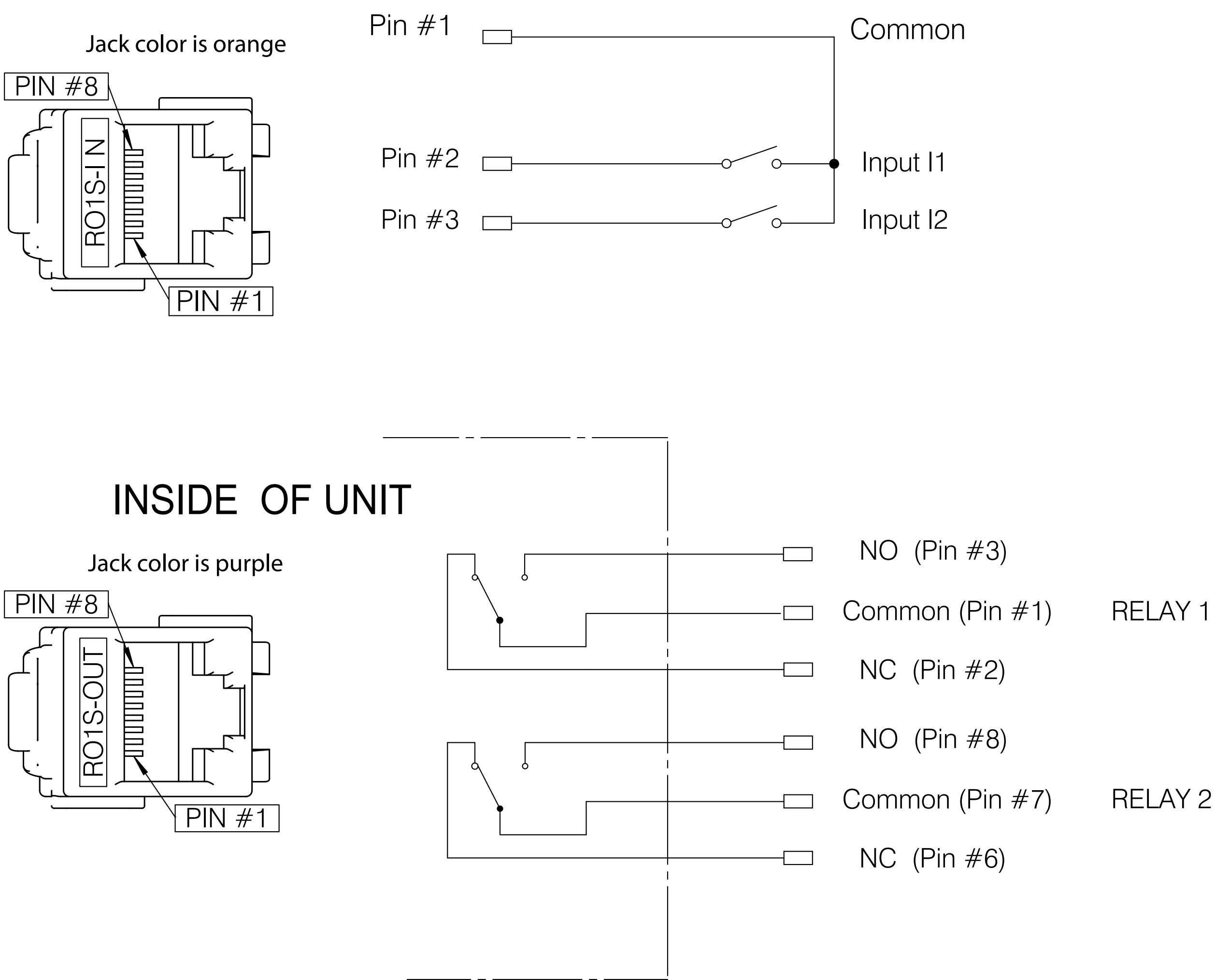


Figure 8.8: Relay Contact (2) / Status Input (2) Card

The Relay Output card (RO1S) plugs into either Card slot #1 with its Input keystone jack inserted into the opening for Jack 1B and its Output keystone jack inserted into the opening for Jack 1A; or Card slot #2 with its Input keystone jack inserted into the opening for Jack 2B and its Output keystone jack inserted into the opening for Jack 2A.

RO1S-IN Orange Keystone Jack to Jack 1B or Jack 2B		
Pin#	**Ethernet Wire Color**	**Signal Name**
1	Orange/White	Common
2	Orange	Input1
3	Green/White	Input2

RO1S-OUT Purple Keystone Jack to Jack 1A or Jack 2A		
Pin#	**Ethernet Wire Color**	**Signal Name**
1	Orange/White	Common
2	Orange	Relay 1 NC
3	Green/White	Relay 1 NO
4		
5		
6	Green	Relay2 NC
7	Brown/White	Common
8	Brown	Relay2 NO

8:4: Installing the Option Cards

The only tools you need to install an Option card are as follows:

- #1 Phillips screwdriver for steps 5 of 8.4.1: Accessing Option Cards, on page 8-26; step 2 in 8.4.2: Add a New Card, on page 8-32; and step 5 in 8.4.5: Closing the Meter, on page 8-38.
- 8 mm Flat blade torque screwdriver set to 30 in-lbs for steps 6 and 7 in 8.4.1: Accessing Option Cards, on page 8-26; and step 4 in 8.4.5: Closing the Meter, on page 8-38.

Following is a typical example of installing or removing an option card in the Shark® 270 meter.

8.4.1: Accessing Option Cards

1. Power down the meter:
   - If meter is remote powered, disconnect the meter from remote power.
   - Short all current transformers' secondary windings to protective earth.
   - If meter is blade powered, if possible remove power to the meter. If power cannot be removed from the meter, disconnect the load side of the meter.
2. Remove the meter from the socket.
3. Place the meter, blade side down, on a clean, smooth surface.

4. Remove the clear cover by holding the base with one hand, rotating the cover counterclockwise with your other hand, and then lifting off the cover.

Figure 8.9: Meter with Clear Cover

5. Unscrew the 4 screws securing the half covers and remove the two halves.

Figure 8.10: Separating Cover Halves

6. Turn the meter on its base as shown in the picture, below. Loosen, by only a couple of turns, the two captive screws (pivot point) - one facing you and one on the far side, located closest to the meter power plug (left side, as shown in the picture).

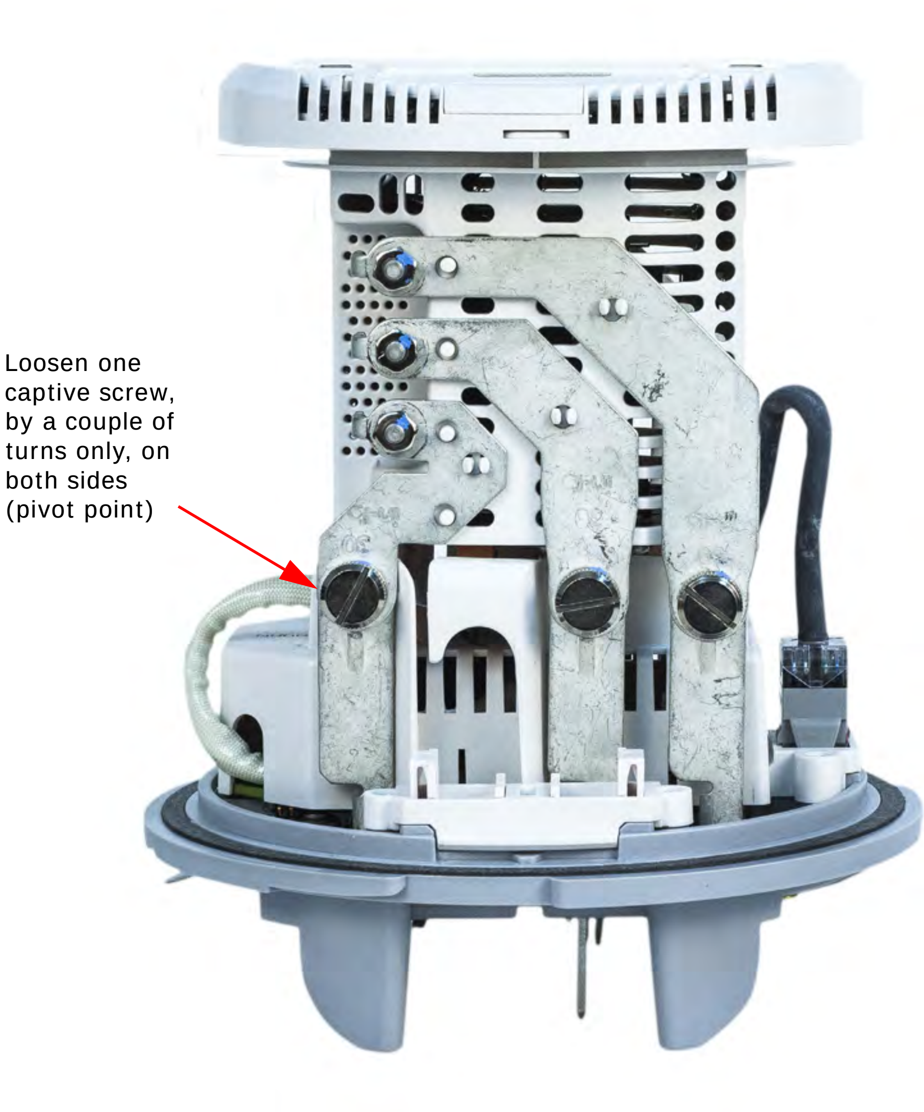


Figure 8.11: Loosen Two Captive Screws (Pivot Point)

7. Completely unscrew the remaining 4 captive screws (2 captive screws if the meter has the 45S base).

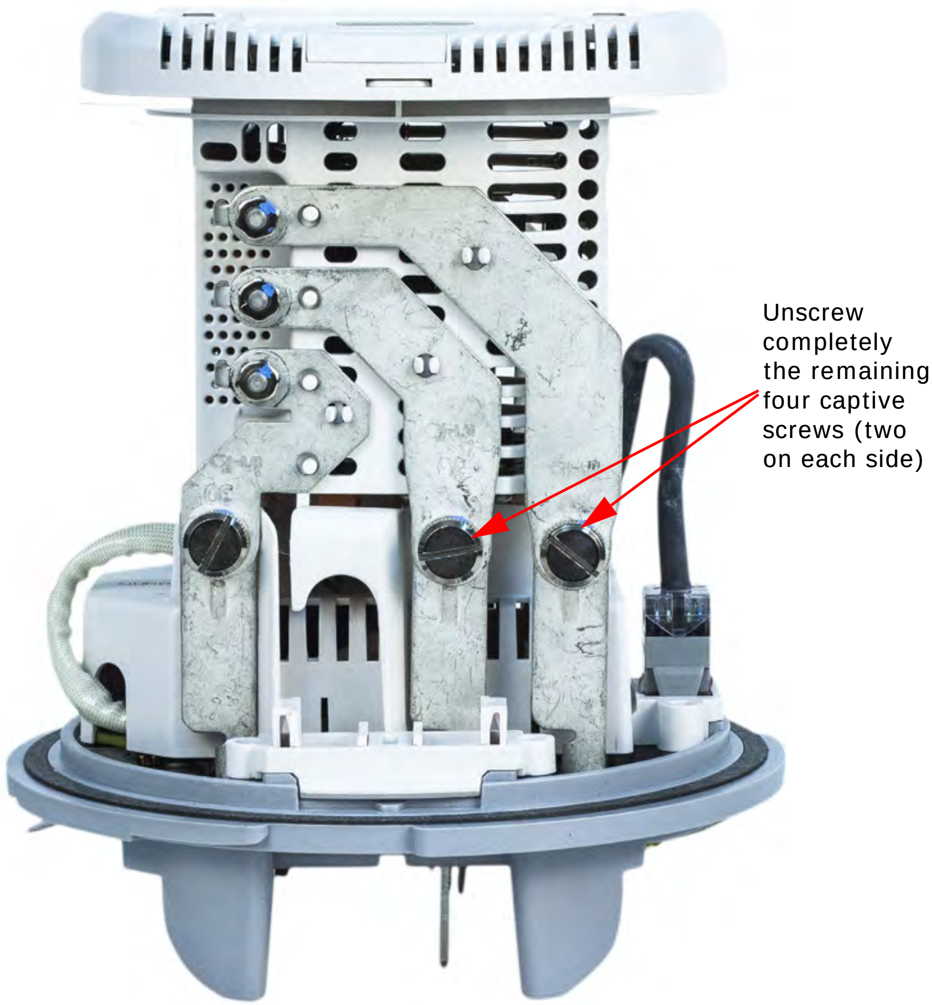
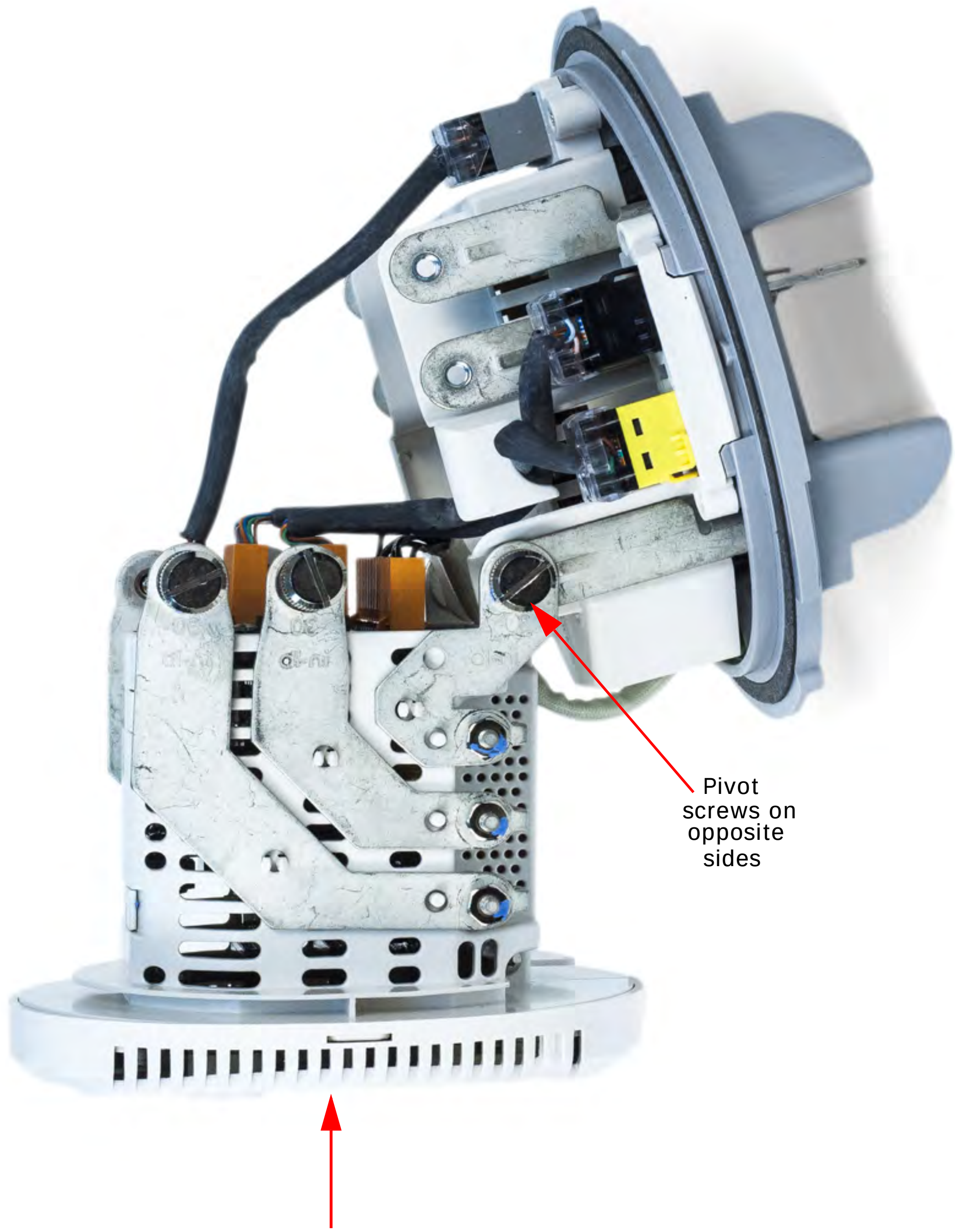


Figure 8.12: Unscrewing Captive Screws

8. Hold the meter face securely with one hand; with your other hand, move the base of the meter to the right, so that the rear of the meter is accessible.



CAUTION! Hold the meter face in your hand, to avoid damaging the glass!

Figure 8.13: Accessing Meter Rear

8.4.2: Add a New Card

For safety, the meter must be removed from socket and from power, before attempting to perform any operation on the meter.

1. Place the meter on a clean flat surface as shown in Fig. 8.14. Remove the 6 pin RS485/KYZ port connector on the right side of the meter's rear panel.

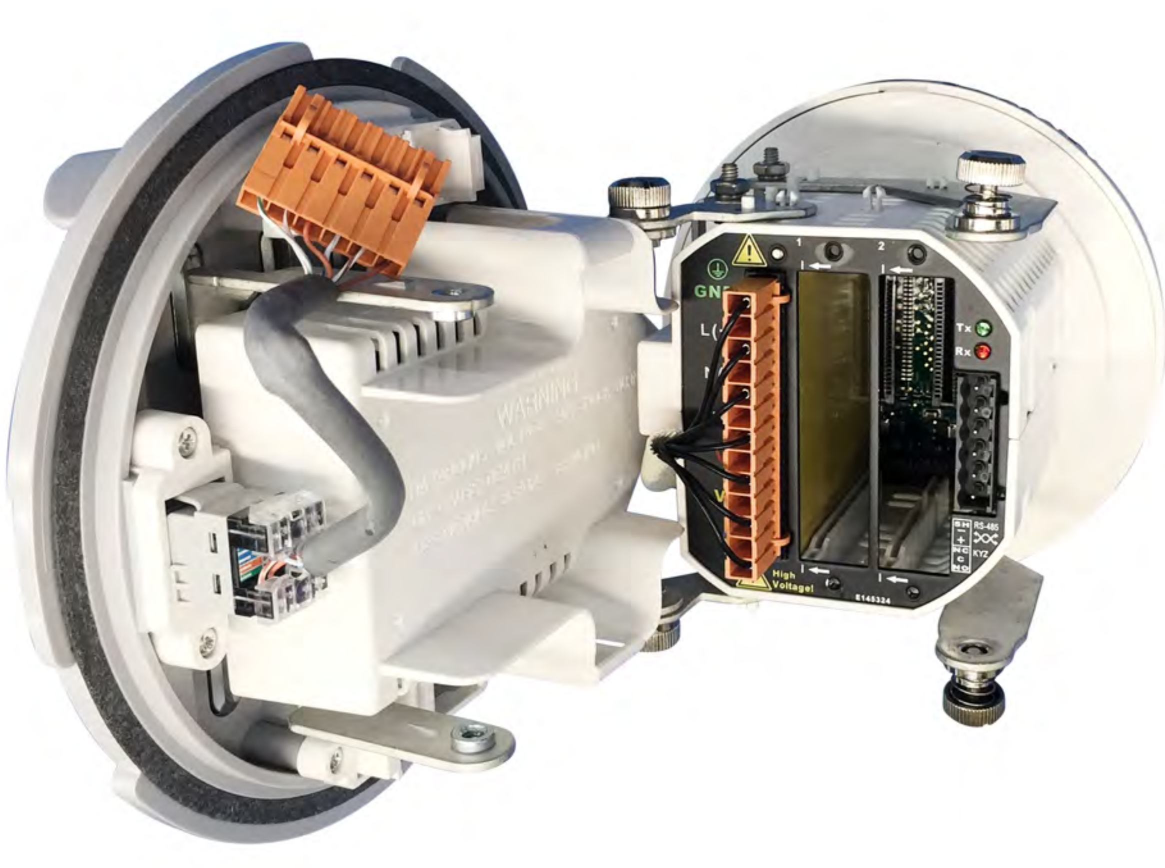


Figure 8.14: Meter Back Showing Card Location

2. Remove the #1 slot cover and save the two screws. Insert the new card in the #1 slot.
   NOTE: There is a plastic “track” on the top and the bottom of the slot. The Option card fits into this track.

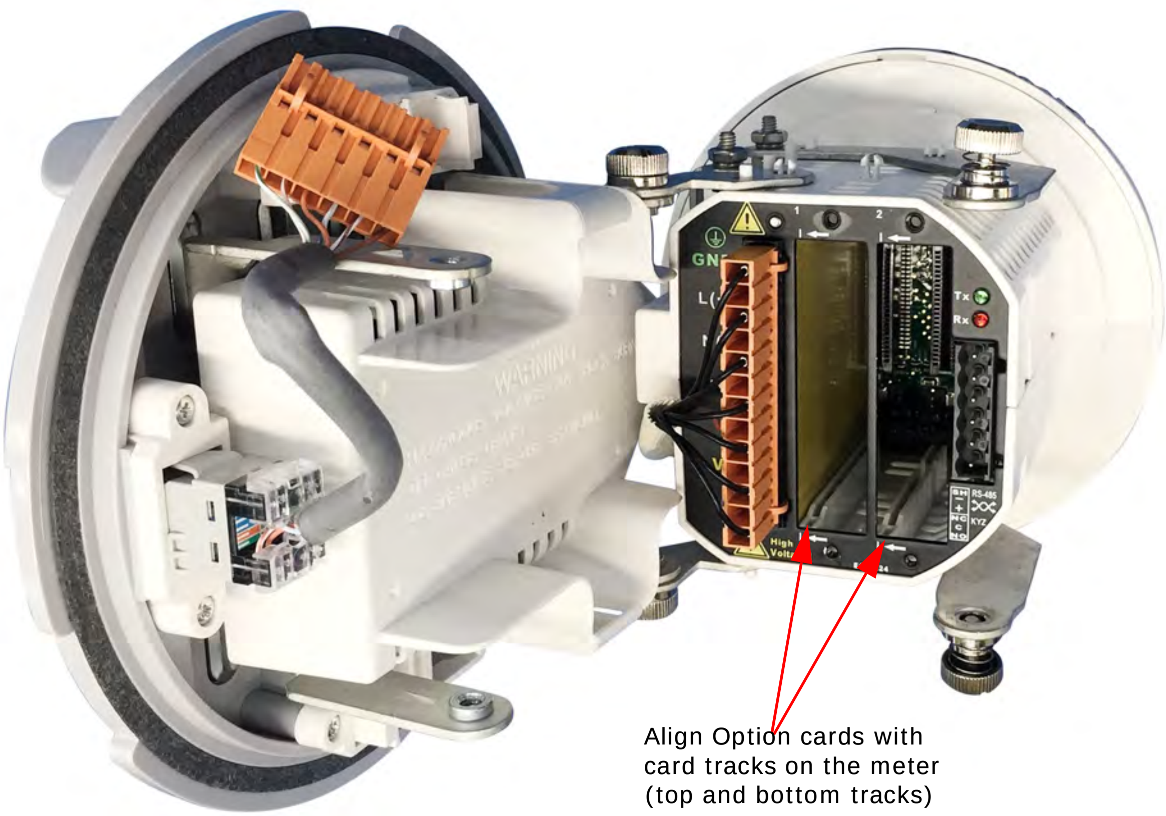


Figure 8.15: Fitting Card into Track

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.

CAUTIONS!

- Make sure the Option 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:

  a. Option card 1

b. Option card 2

c. Connector to Card #1

d. Connector to Card #2

e. Communication connection for Port 2 (RS485/KYZ port)

5. Rotate the entire meter so that it rests on the base.

6. On the base locate the port opening where the keystone jack will be placed. The location of all jacks is shown in Figure 8.1: Option Card Jack Locations (Example Configuration), on page 8-2. All locations specific to each Option card are listed in 8.3: Option Card Details, on page 8-4.

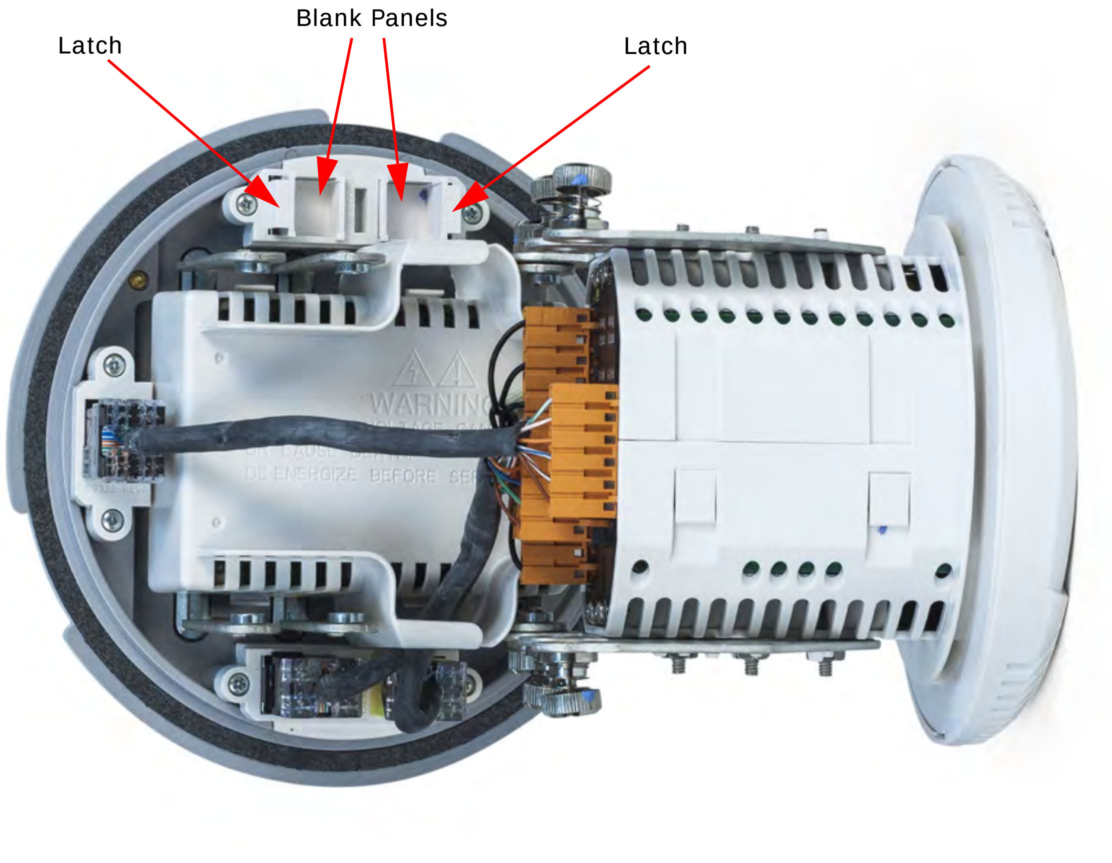


Figure 8.16.: Blank Panels and Latch

7. Remove blank panel by pressing the latch from the meter side of the base.

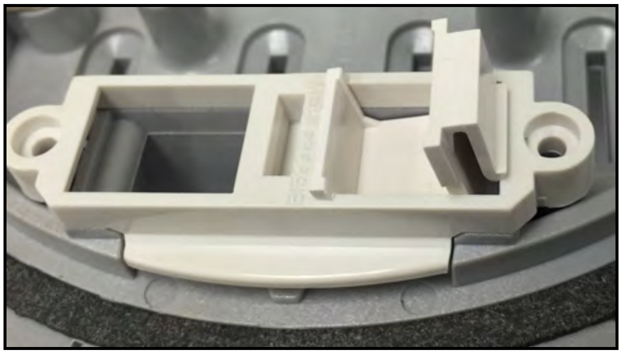


Figure 8.17: Removing Blank Panel

The blank panel in the Figure 8.17 is shown partially removed in the figure (accomplished by pressing the tab on the right side).

8. Insert the keystone jack(s) where the blank(s) was removed, with its latch facing the same direction (see Figure 8.17), making sure it locks in place. A properly latched jack should stand straight up, perpendicular to the base, and there shouldn't be a large gap visible between the jack and the port opening (see Figure 8.18).

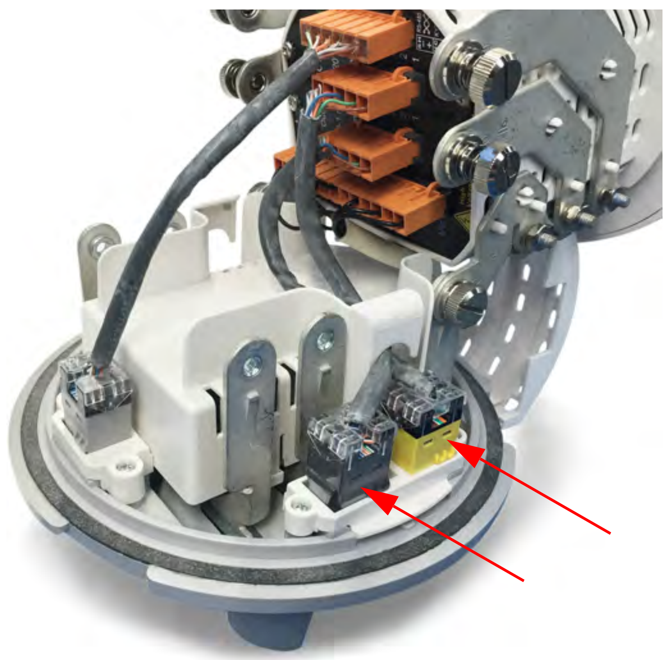
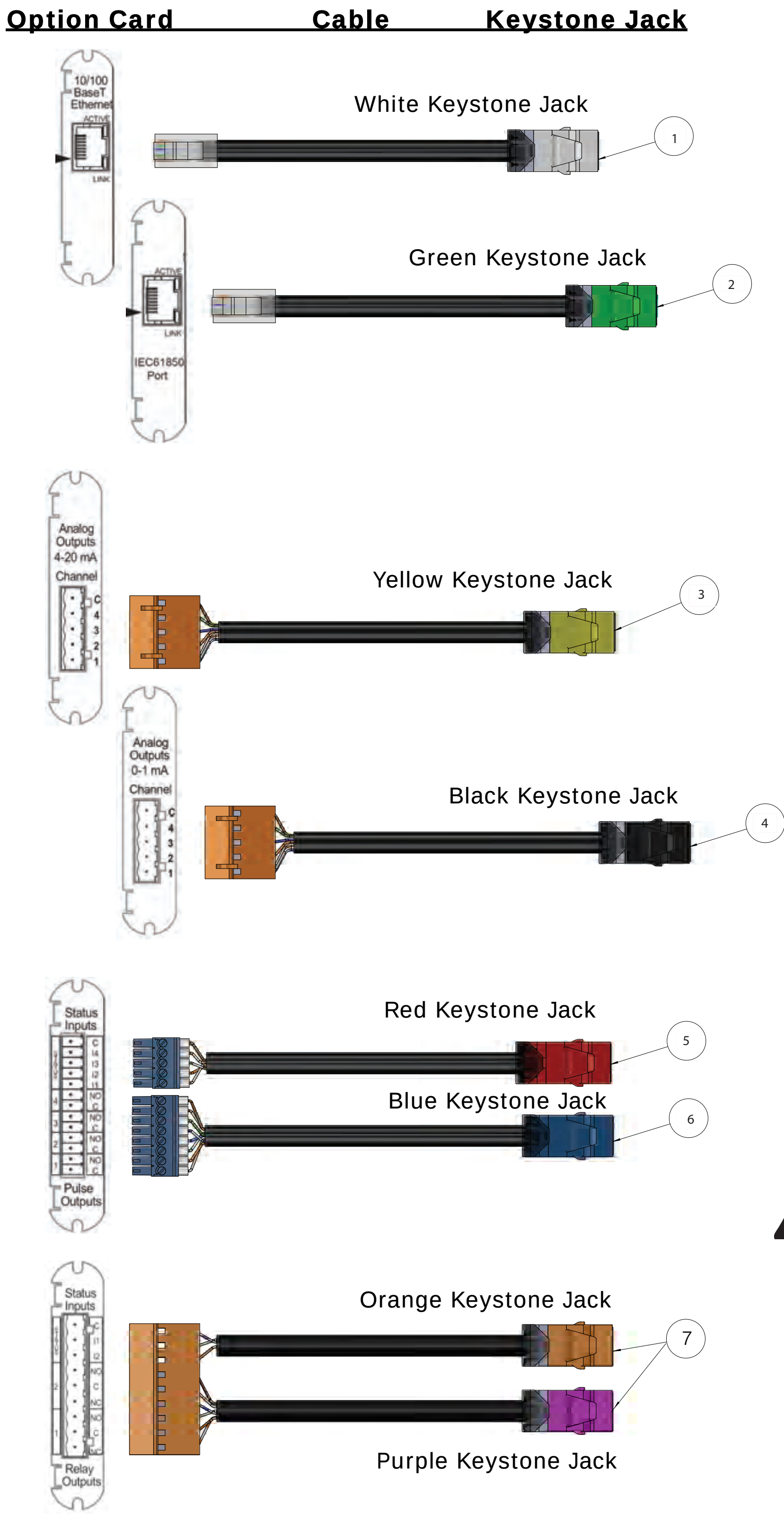


Figure 18.18: Keystone Jack Placement

See Figure 8.19 for detailed images of the cable connections for the different cards.



1: INP100S Option card connections

2: INP300S Option card connections

3: 20mAOS Option card connections

4: 1mAOS Option card connections

5: PO1S Option card Input connections

6: PO1S Option card Output connections

CAUTION! Be sure to connect the Input connector to the Input section of the card and the Output connector to the Output section of the card!

7: RO1S Option card Input and Output connections

Figure 8.19: Cable connections

9. From the meter side of the base, route the wires as shown in the figure below, and insert the connector into the card.

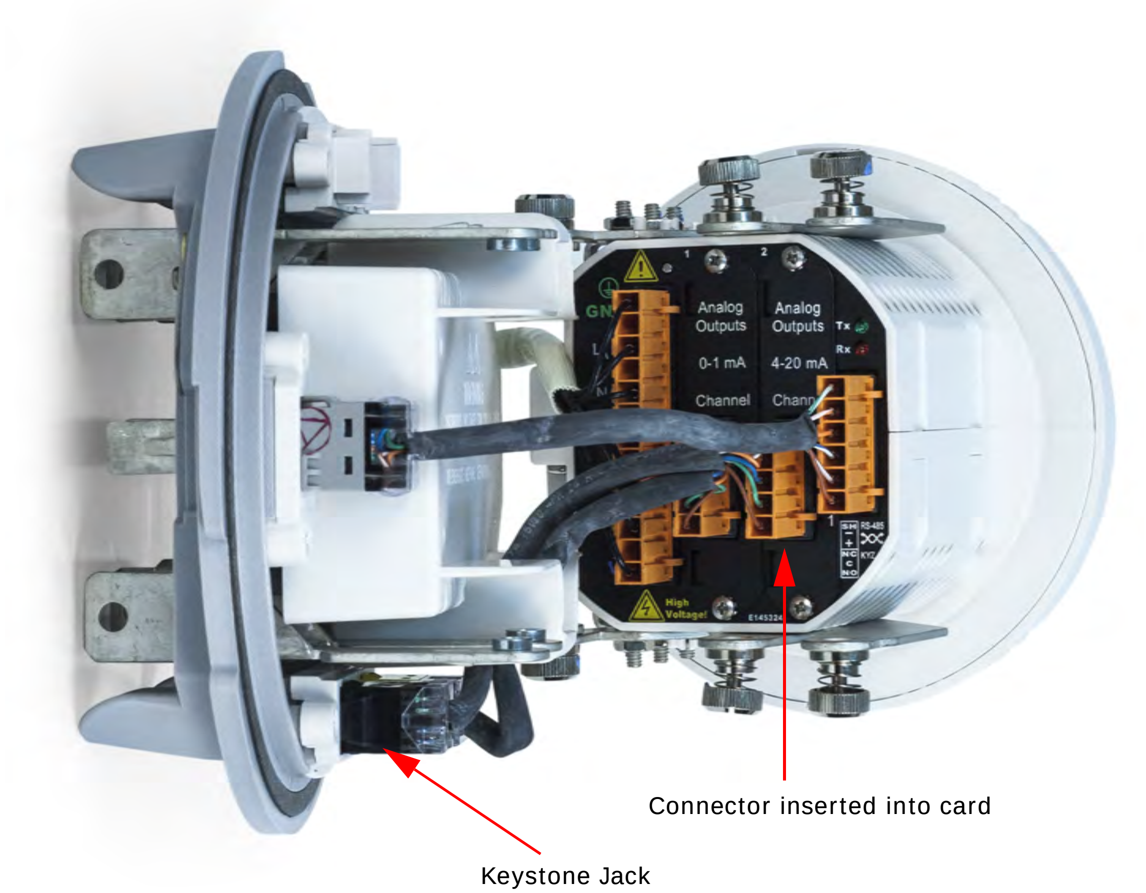


Figure 8.20: Routing Wires and Plugging Connector in the Card

CAUTION! Refer to Figure 5.5: Routing Data Lines Around Perimeter of the S-Base Type Meter Socket (Typical S Base shown; others may vary), on page 5-6, for proper safe routing of communication wiring.

10. Go to 8.4.5: Closing the Meter, on page 8-38.

8.4.4: To Replace/Remove a Card

1. Remove the RS485/KYZ connector from the meter.

2. Remove the connector(s) going to the card being replaced.

3. Remove the screws securing the card and save them.

4. Remove the card in question. If the card is being replaced (identical replacement) go to step 8.

5. If available, install a blank slot cover. It is acceptable to operate the meter without slots being covered.

    - If no blank Port cover is available, leave the keystone jack in place.

    - If a blank Port cover is available, remove the keystone jack and the attached wiring and then install the blank Port cover

6. Insert the RS485/KYZ keystone jack into the socket on the rear panel of the meter.

7. Go to 8.4.5: Closing the Meter, on page 8-38.

8. Insert the new card and secure its back plate to the meter using the screws previously removed.

9. Insert the connector(s), previously removed, into the socket(s) on the card.

10. Insert the RS485/KYZ keystone jack into the socket on the rear panel of the meter.

8.4.5: Closing the Meter

1. Before closing up the meter, verify the following:

    a. All connectors on the back of the meter are fully seated.

    b. All keystone jacks on the base of the meter are properly attached.

    c. All the contact surfaces that will be engaged by the captive screws are clean.

d. All wires are routed as shown in Figure 8.20: Routing Wires and Plugging Connector in the Card, on page 8-37.

2. Rotate the meter so the captive screws align with the blade tabs.

3. Verify that no wires are restricted or crimped.

4. If a port is not connected to a card, make sure the connector going to the unused port is located under the meter by the cards, and does not interfere with any wiring.

5. Finger tighten all captive screws and then torque all captive screws to 30 In-Lb.

6. Attach both half covers and secure with the 4 screws previously removed.

7. Place the clear cover over the meter with the optical port positioned approximately 1" counterclockwise from the LED's on the meter face: then the cover will slide over the lip on the base.

8. Rotate the clear cover clockwise to secure; the optical port must align with the LED's on the meter face.

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9: Electrical Installation

The Shark® 270 Socket meter supported forms and their wiring configurations are shown in this chapter. The forms are based on the rated Voltage and hookup required for your application. (Custom forms and configurations are also available from EIG.)

9.1: Considerations When Installing Meters

Installation of the Shark® 270 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 Shark 270® meter, dangerous voltages flow through many parts of the unit, including: Terminals and any connected CTs (Current Transformers) and PTs (Potential Transformers), all I/O Modules 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 of the meter's I/O devices 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 must be inaccessible after installation.

Do not apply more than the maximum voltage or current that the meter or any attached device is rated for. Refer to meter and/or device labels and to the Specifications for all devices before applying voltages or currents. Do not HIPOT/Dielectric test any Outputs, Inputs or Communications terminals.

EIG requires the use of Fuses for voltage leads and power supply, and shorting blocks to prevent hazardous voltage conditions or damage to CTs, if the meter needs to be removed from service. One side of the CT must be grounded.

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

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

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

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

L'installation des compteurs de Shark® 270 doit être effectuée seulement par un personnel qualifié qui suit les normes relatives aux précautions de sécurité pendant toute la procédure. Le personnel doit avoir la formation appropriée et l'expérience avec les appareils de haute tension. Des gants de sécurité, des verres et des vêtements de protection appropriés sont recommandés.

AVERTISSEMENT! Pendant le fonctionnement normal du compteur Shark® 270 des tensions dangereuses suivant de nombreuses pièces, notamment, les bornes et tous les transformateurs de courant branchés, les transformateurs de tension, toutes les sorties, les entrées et leurs circuits. **Tous les circuits secondaires et primaires peuvent parfois produire des tensions de létal et des courants. Évitez le contact avec les surfaces sous tensions. Avant de faire un travail dans le compteur, assurez-vous d'éteindre l'alimentation et de mettre tous les circuits branchés hors tension.**

Ne pas utiliser le compteur, ou sorties d'appareil ou entrées, pour une protection primaire ou la capacité de limite d'énergie. Le compteur peut seulement être utilisé comme une protection secondaire.

Ne pas utiliser le compteur pour application dans laquelle une panne de compteur peut causer la mort ou des blessures graves.

Ne pas utiliser le compteur ou pour toute application dans laquelle un risque d'incendie est susceptible.

Toutes les bornes de compteur doivent être inaccessibles après l'installation.

Ne pas appliquer plus que la tension maximale que le compteur ou appareil relatif peut résister. Référez-vous au compteur ou aux étiquettes de l'appareil et les spécifications de tous les appareils avant d'appliquer les tensions. Ne pas faire de test HIPOT/diélectrique, une sortie, une entrée ou un terminal de réseau.

EIG nécessite l'utilisation de les fusibles pour les fils de tension et alimentations électriques, ainsi que des coupe-circuits pour prévenir les tensions dangereuses ou endommagements de transformateur de courant si l'unité Shark® 270 doit être enlevée du service. Un côté du transformateur de courant doit être mis à terre.

NOTE: Les entrées actuelles doivent seulement être branchées dans le transformateur externe actuel par l'installateur. Le transformateur de courant doit être approuvé ou certifié et déterminé pour le compteur actuel utilisé.

IMPORTANT! SI L'ÉQUIPEMENT EST UTILISÉ D'UNE FAÇON NON SPÉCIFIÉE PAR LE FABRICANT, LA PROTECTION FOURNIE PAR L'ÉQUIPEMENT PEUT ÊTRE ENDOMMAGÉE.

NOTE: Il N'Y A AUCUNE MAINTENANCE REQUISE POUR LA PRÉVENTION OU INSPECTION NÉCESSAIRE POUR LA SÉCURITÉ. CEPENDANT, TOUTE RÉPARATION OU MAINTENANCE DEVRAIT ÊTRE RÉALISÉE PAR LE FABRICANT.

DÉBRANCHEMENT DE L'APPAREIL: la partie suivante est considérée l'appareil de débranchement de l'équipement. UN INTERRUPTEUR OU UN DISJONCTEUR DEVRAIT ÊTRE INCLUS DANS L'UTILISATION FINALE DE L'ÉQUIPEMENT OU L'INSTALLATION. L'INTERRUPTEUR DOIT ÊTRE DANS UNE PROXIMITÉ PROCHE DE L'ÉQUIPEMENT ET A LA PORTÉE DE L'OPÉRATEUR. L'INTERRUPTEUR DOIT AVOIR LA MENTION DÉBRANCHEMENT DE L'APPAREIL POUR L'ÉQUIPEMENT.

9.2: Blade Configuration for Forms 9S, 36S, and 45S

NOTE: The forms referred to in this chapter comply with ANSI forms 9S, 36S and 45S.

9.3: Ground Connection

For safety, proper functionality and to meet EMI emission/susceptibility standards, the meter must be connected to earth via a low impedance grounding mechanism. The meter’s Ground connection consists of a spring-loaded metal tab that must touch the socket’s ground.

9.4: Voltage Fuses

EIG requires the use of fuses on each of the sense voltages and on the control power.
NOTE: The fuse voltage rating is at least the maximum value the meter is exposed to relative to earth ground and should comply with the applicable safety regulation standards.

- For a meter with the external power supply connection (-SE option):
  - Use a 0.1 Amp fuse on each voltage input.
  - Use a 3 Amp Slow Blow fuse on the power supply.
- For a meter with the internal (blade) power supply connection (-S option):
  - Use a 3 Amp fuse on each voltage input.

EIG offers the EI-CP Panel meter protective fuse kit, which can be ordered from EIG’s webstore: www.electroind.com/shop. Select Fuse Kits from the list on the left side of the webpage.

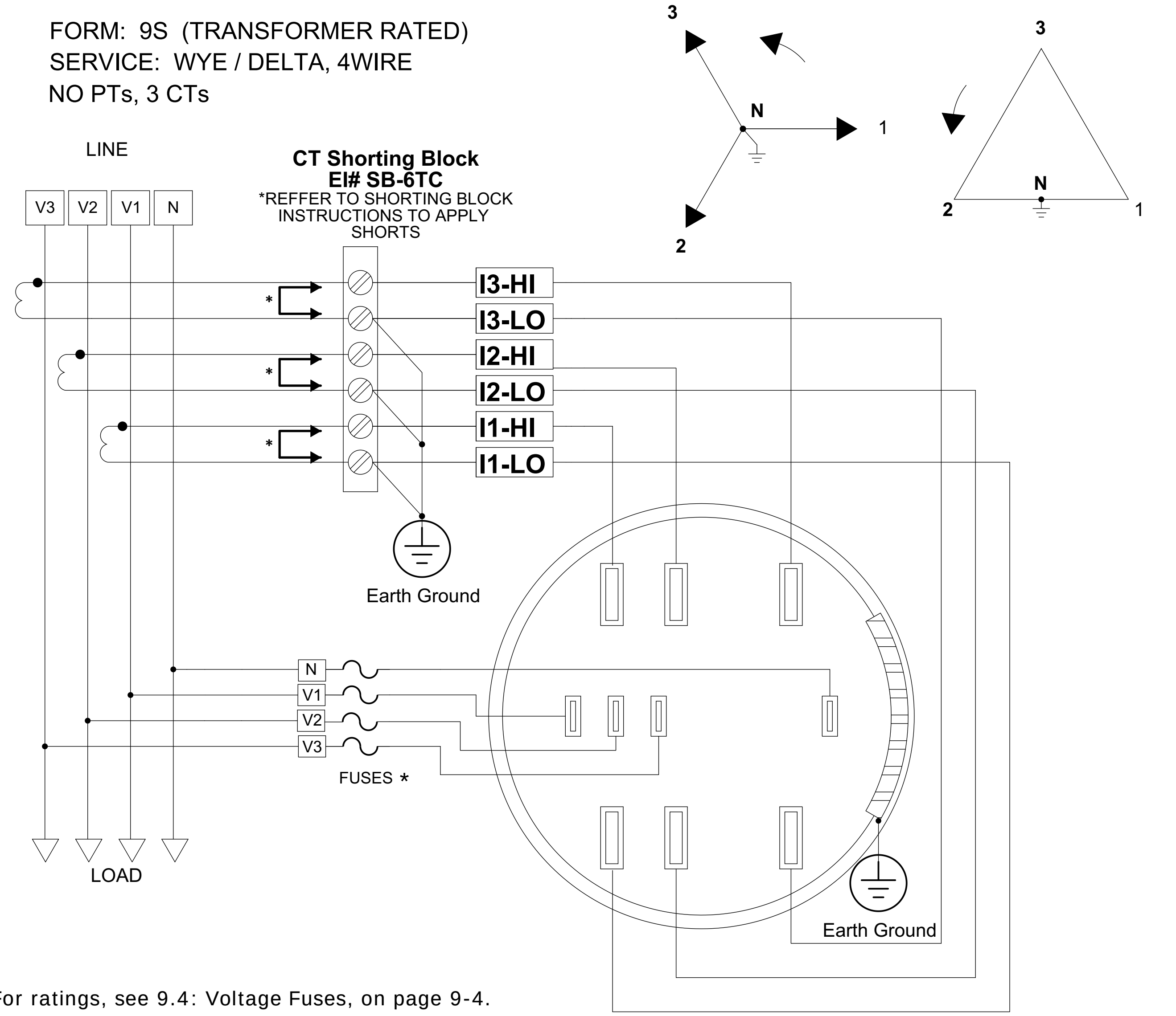
9.5: Wiring Diagrams

Choose from the supported meter forms based on the rated Voltage and hookup required for your application. Corresponding wiring diagrams appear on the following pages. If the connection diagram you need is not listed, contact EIG for a custom connection diagram. Form 9S mounted in an A/S Adapter is shown in Figure 9.19.

NOTE: Form 45S replaces Form 5S and may also be used in 4-wire circuits.

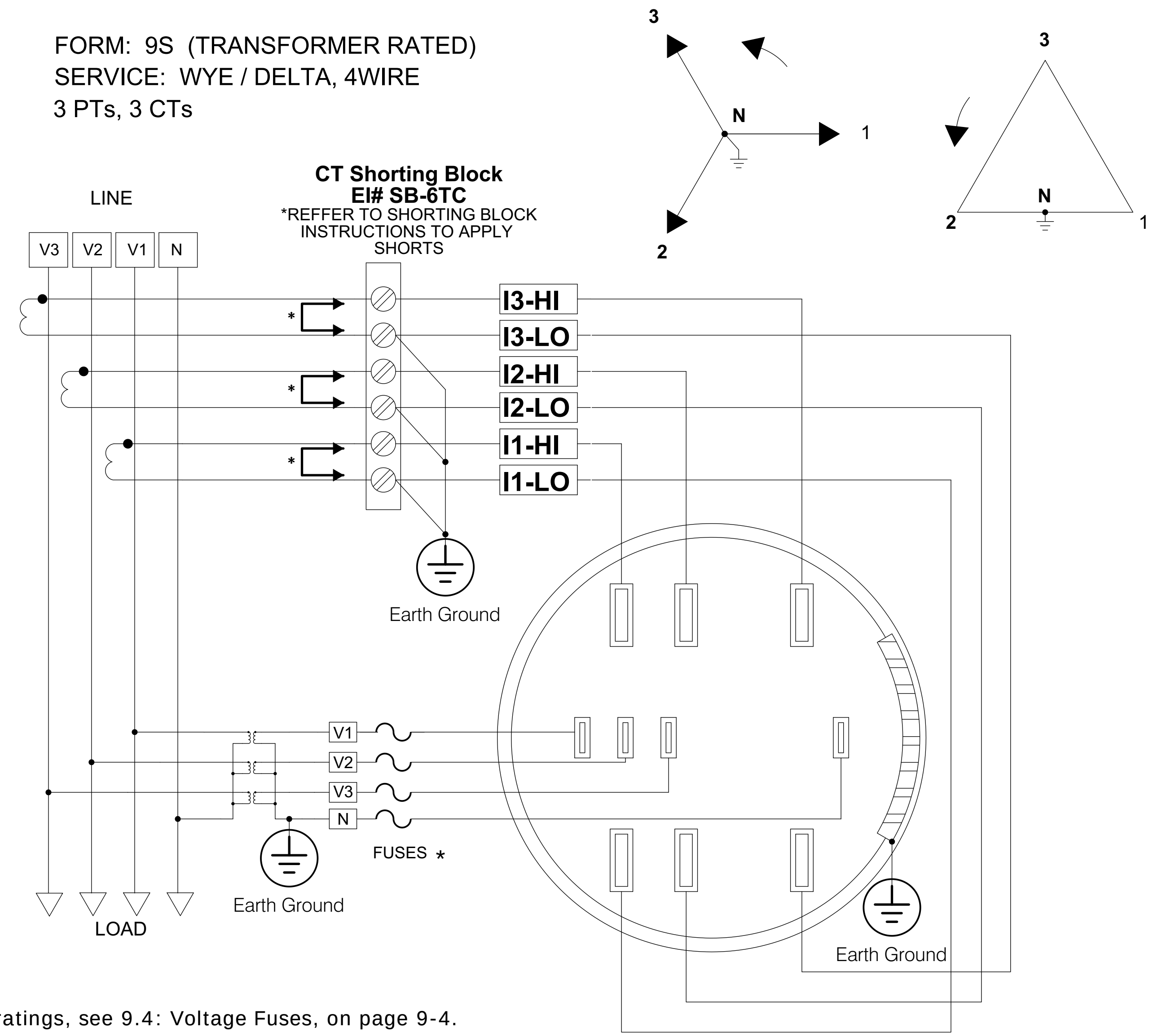
Form	Description	Figure#
9S	Wye/Delta, no PTs, 3 CTs	9.3
	Wye/Delta, 3 PTs, 3 CTs	9.4
	3 or 4-Wire Delta, no PTs, 2 CTs	9.5
	3 or 4-Wire Delta, 2 PTs, 2 CTs	9.6
36S	2.5 EL Wye, no PTs, 3 CTs	9.7
	2.5 EL Wye, 2 PTs, 3 CTs	9.8
45S	3 or 4-wire Delta, no PTs, 2 CTs	9.9
	3 or 4-wire Delta, 2 PTs, 2 CTs	9.10
9S in S/A	Form 9S Mounted in S/A Adapter (showing connectors)	9.11

Table 9.1: Shark® 270 Meter Forms



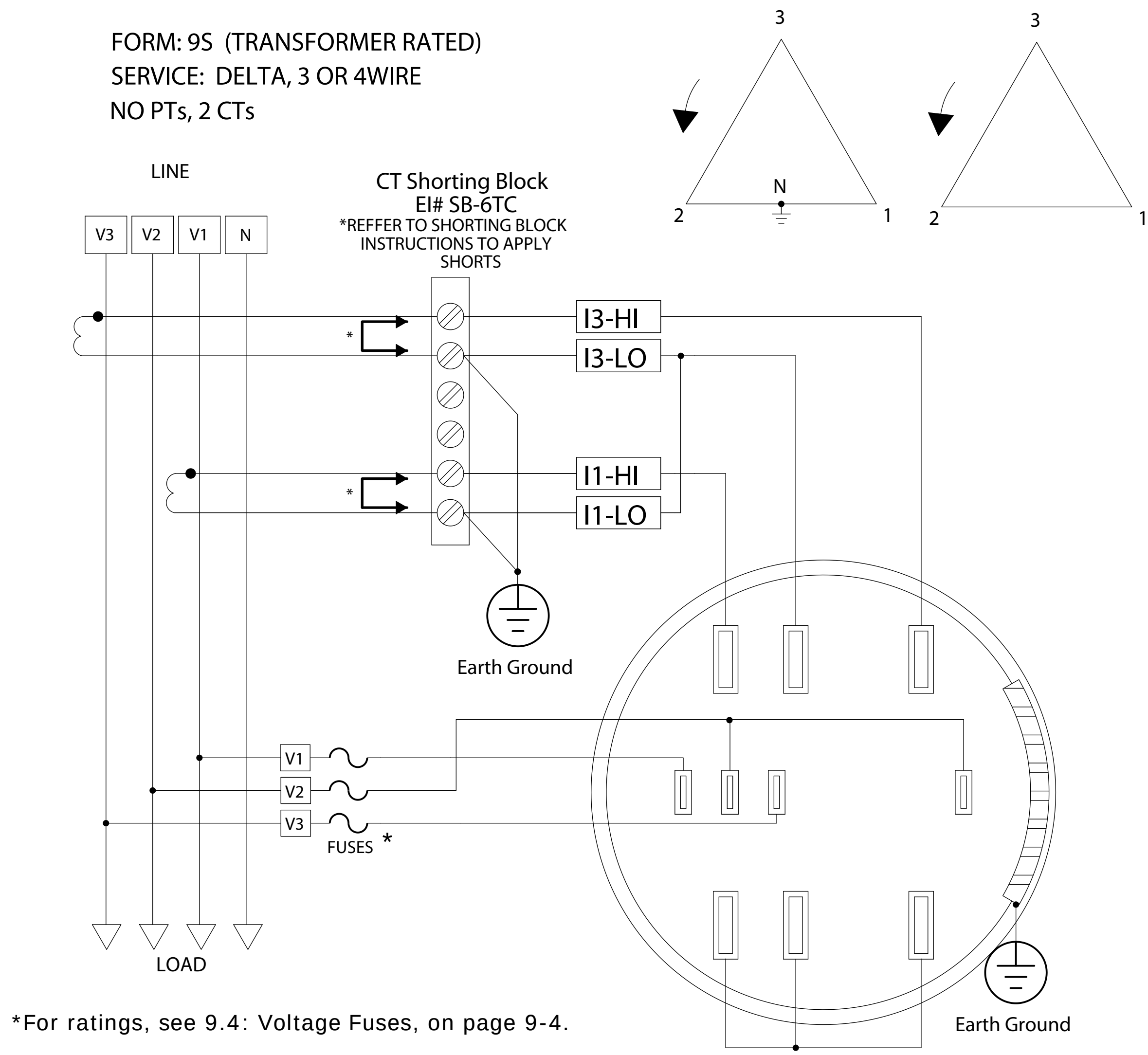
*For ratings, see 9.4: Voltage Fuses, on page 9-4.

Figure 9.3: Form 9S Wye/Delta, No PTs, 3 CTs



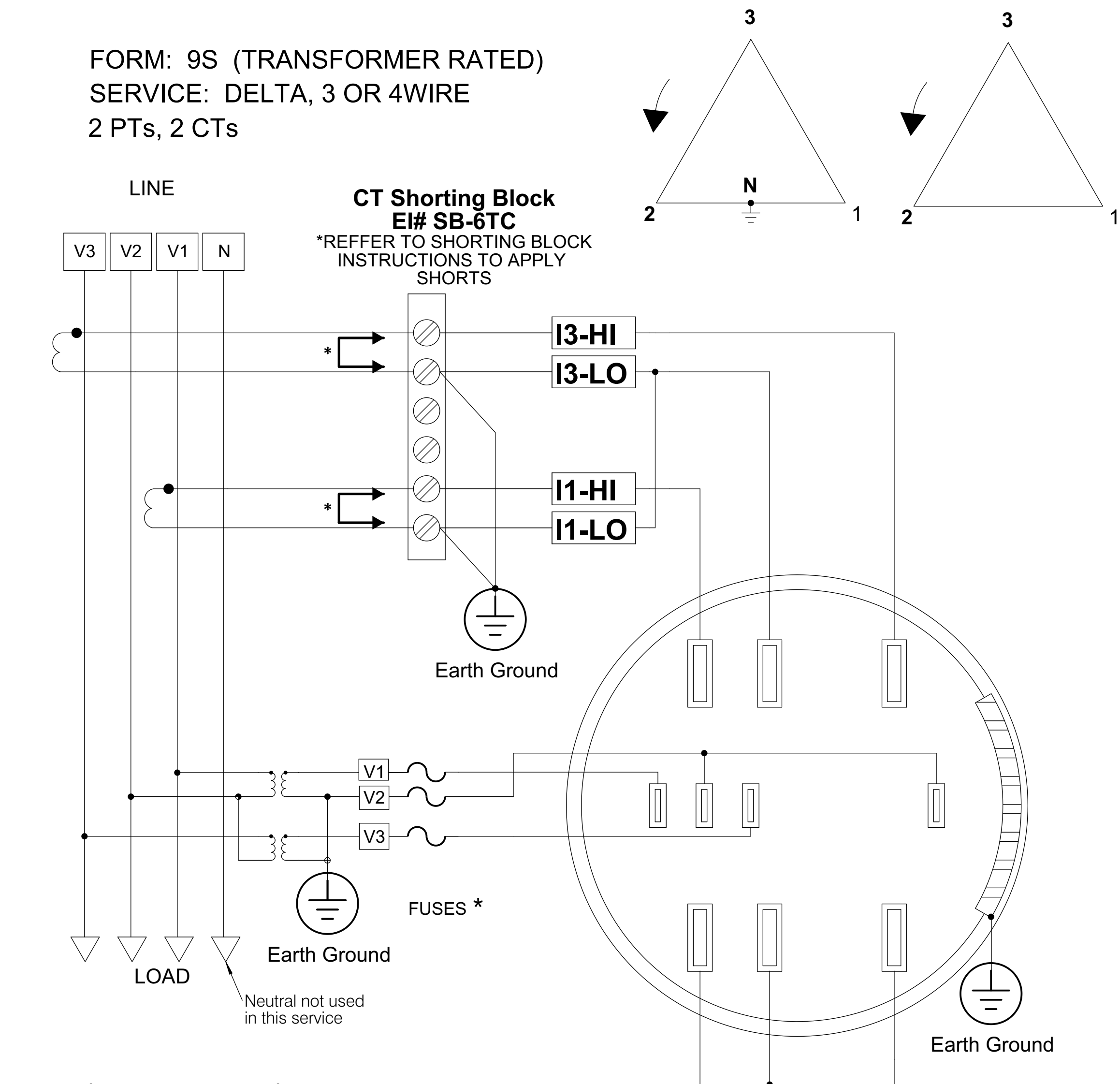
*For ratings, see 9.4: Voltage Fuses, on page 9-4.

Figure 9.4: Form 9S Wye/Delta, 3 PTs, 3 CTs



*For ratings, see 9.4: Voltage Fuses, on page 9-4.

Figure 9.5: Form 9S 3 or 4-Wire Delta No PTs, 2 CTs



*For ratings, see 9.4: Voltage Fuses, on page 9-4.

Figure 9.6: Form 9S 3 or 4-Wire Delta, 2 PTs, 2 CTs

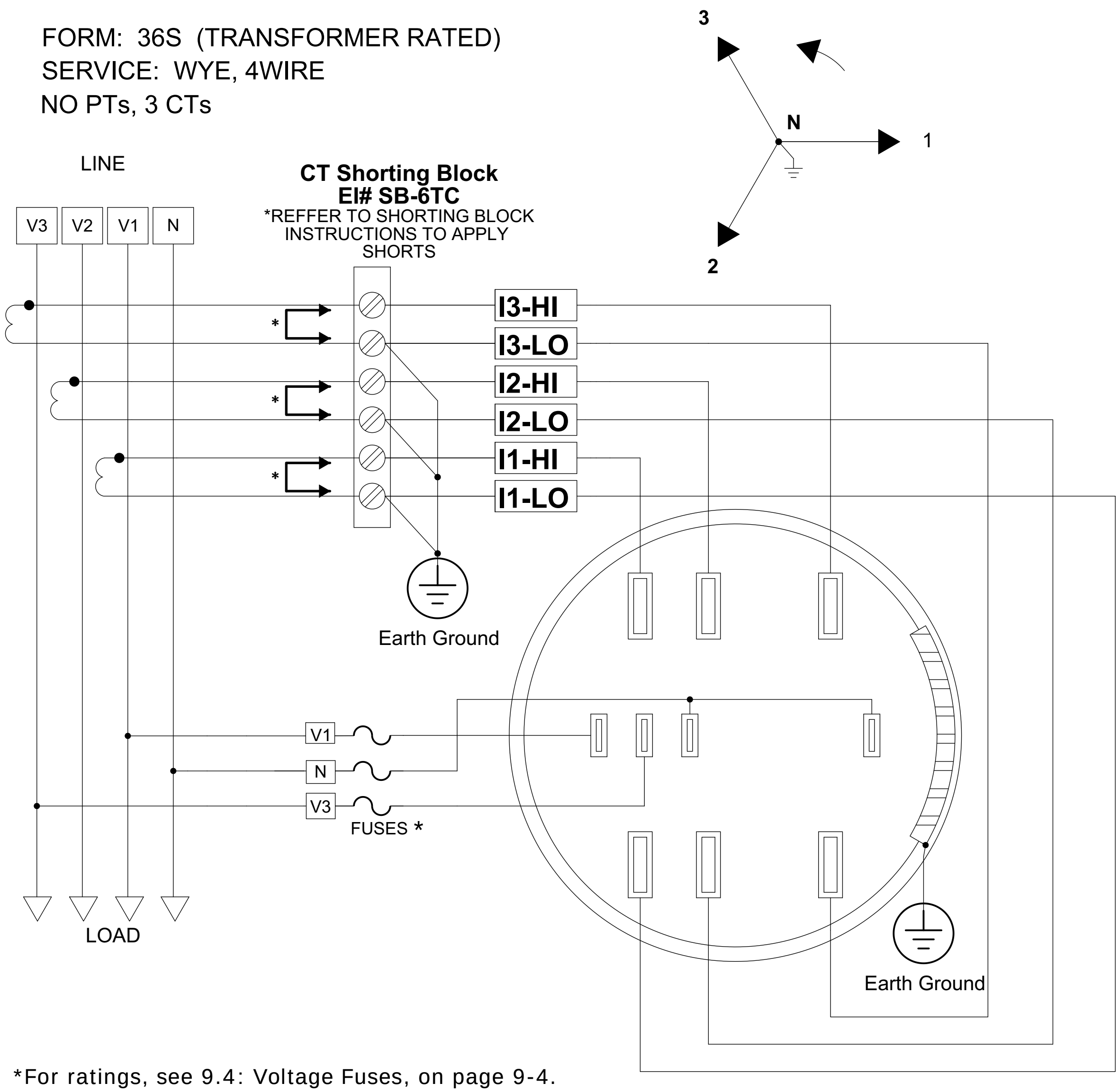
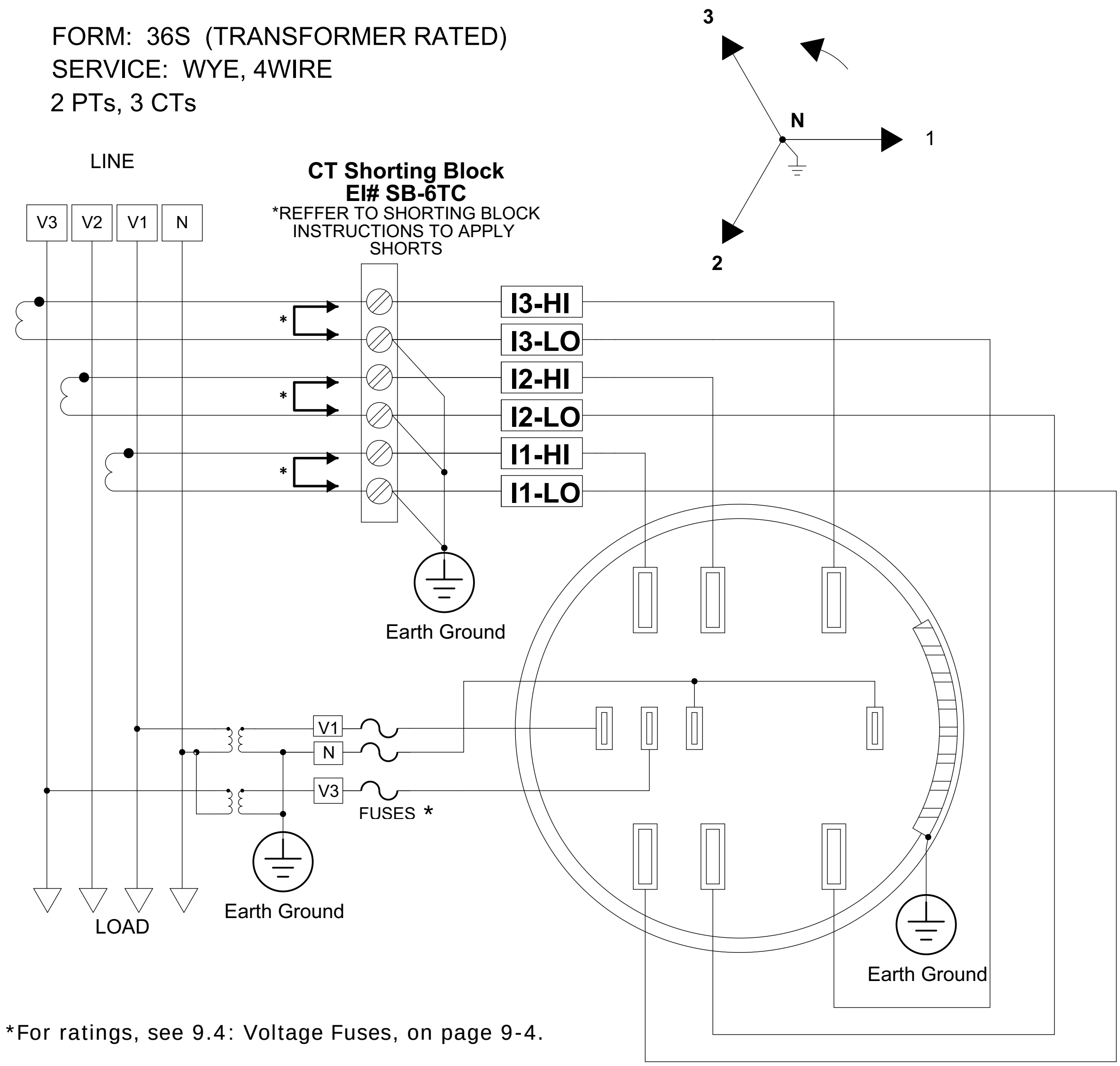
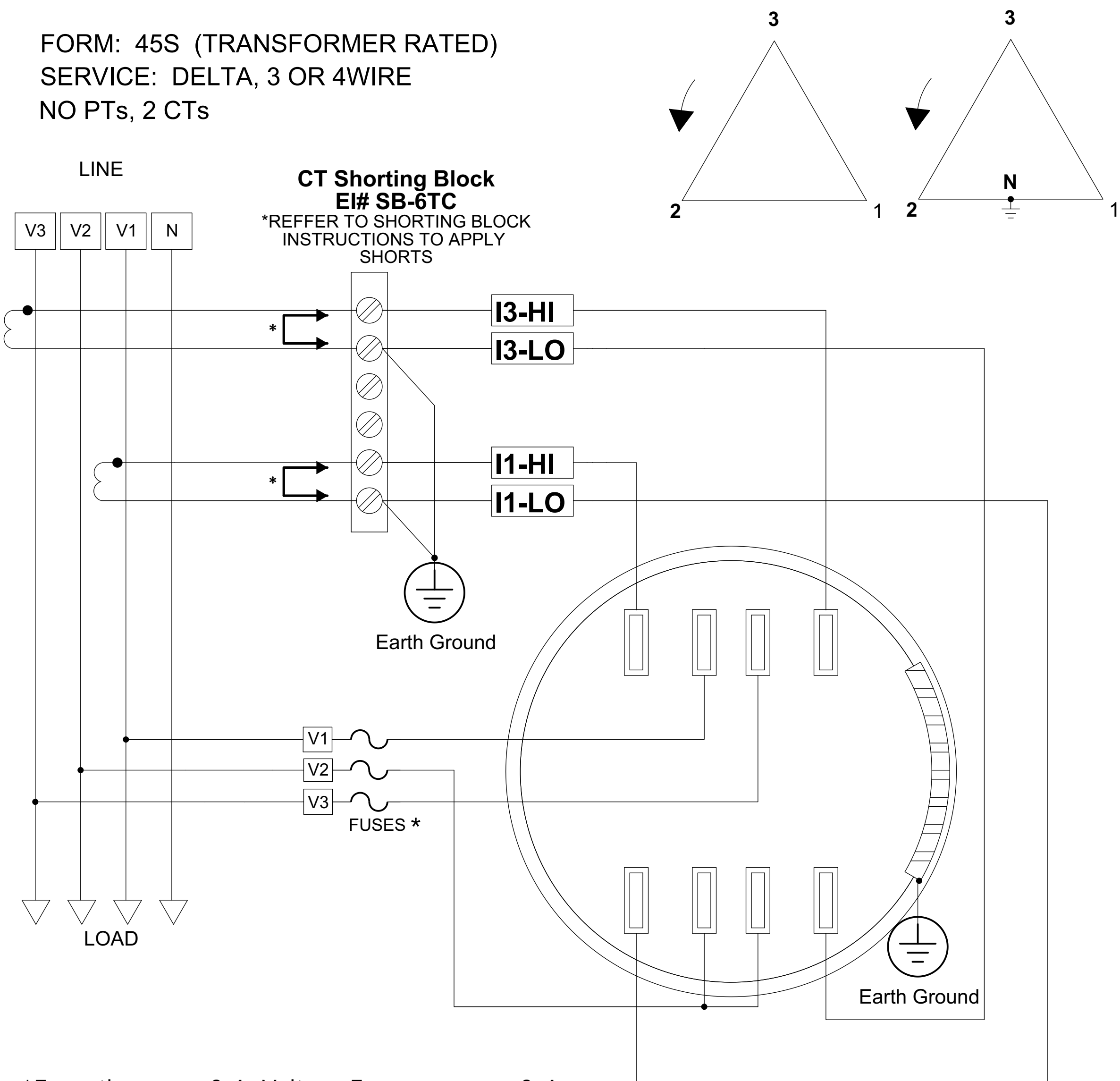


Figure 9.7: Form 36S 2.5 Element Wye, no PTs, 3 CTs



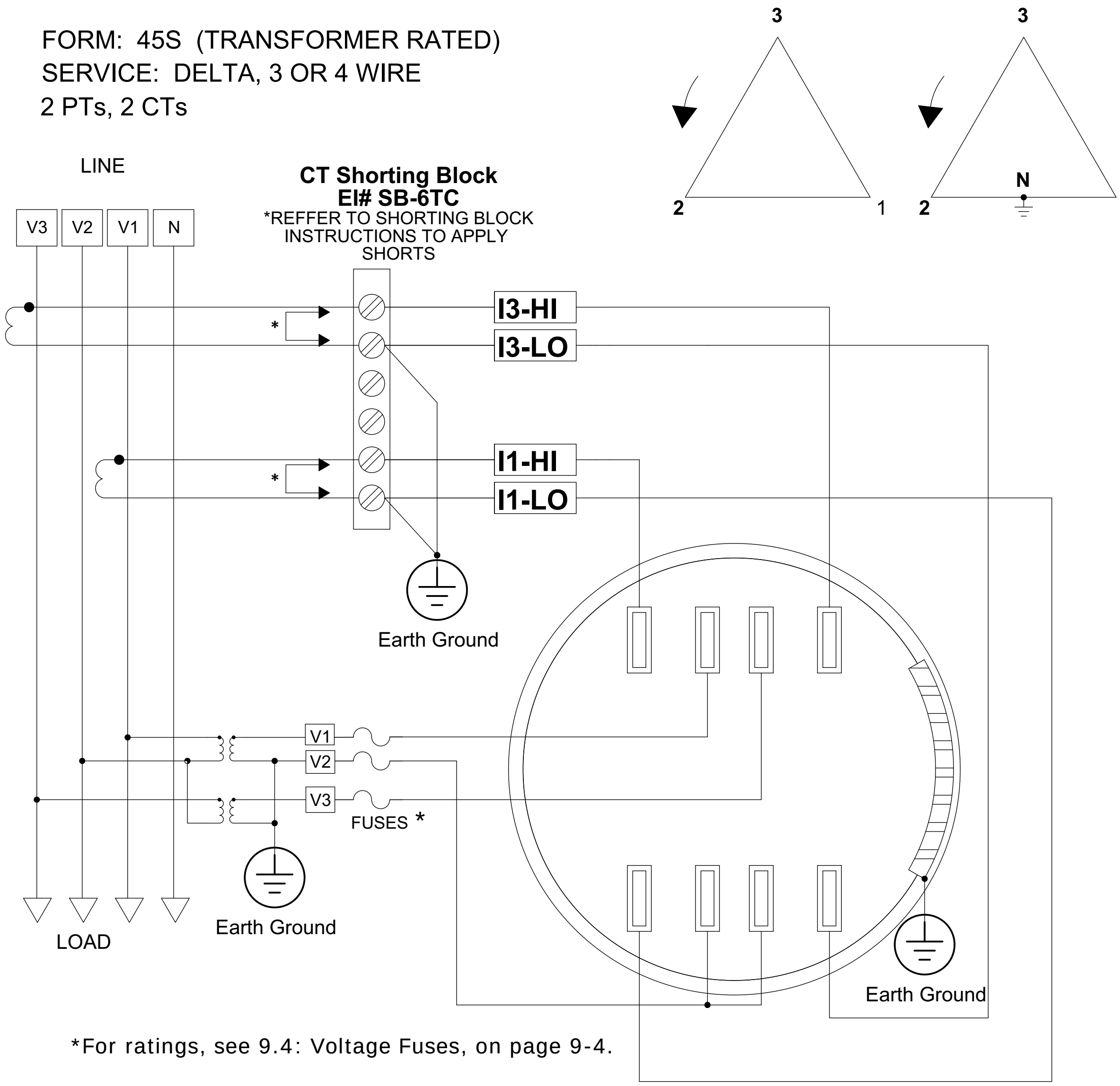
*For ratings, see 9.4: Voltage Fuses, on page 9-4.

Figure 9.8: Form 36S 2.5 Element Wye, 2 PTs, 3 CTs



*For ratings, see 9.4: Voltage Fuses, on page 9-4.

Figure 9.9: Form 45S 3-Wire Delta, no PTs, 2 CTs



*For ratings, see 9.4: Voltage Fuses, on page 9-4.

Figure 9.10: Form 45S 3-Wire Delta, 2 PTs, 2 CTs

9.6: 9S Meter Mounted in S/A Adapter

For a 9A solution, the 9S Form meter can be mounted in an S/A Adapter, such as the one shown below. The socket meter is “pushed” into the S/A Adapter until the meter “snaps” into place and the blades on the back of the socket meter make proper connection. See Figures 9.3 to 9.6 for the 9S wiring diagrams.

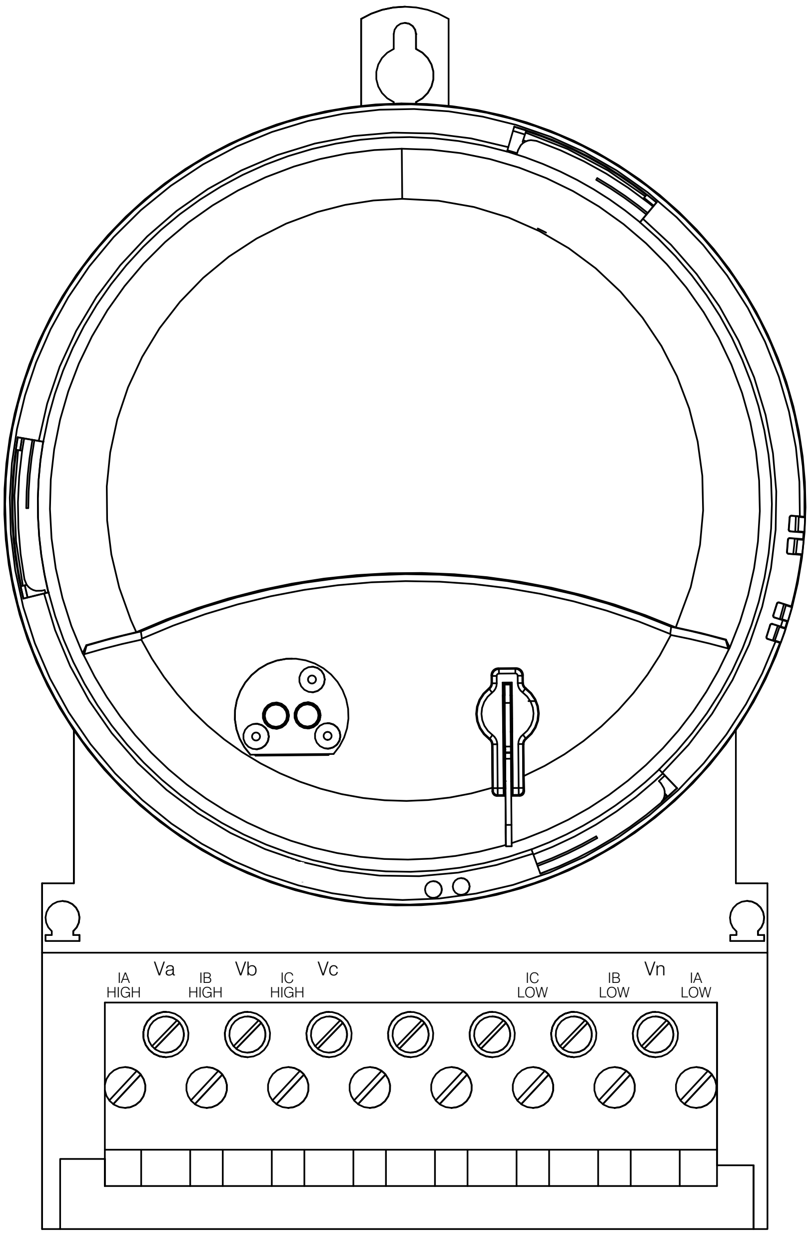


Figure 9.11: Form 9S mounted in an S/A Adapter

10: Using the INP100S Ethernet Card

10.1: Overview

The Shark® 270 meter can have one optional Ethernet card - either the INP100S or the INP300S - see Chapter 12: Using the INP300S IEC 61850 Protocol Card, on page 12-1, for the INP300S card. This chapter describes and gives instructions for the INP100S.

10.2: Hardware Connection

Refer to 8:4: Installing the Option Cards, on page 8-26.

Use a standard RJ45 10/100BaseT cable to connect to the Ethernet port. The INP100S card auto-detects cable type and will work with either straight or crossover cable. See 5.1: Meter Dimensions, on page 5-1; and both Figure 8.20: Routing Wires and Plugging Connector in the Card, on page 8-37, and Figure 5.5: Routing Data Lines Around Perimeter of the S-Base Type Meter Socket (Typical S Base shown; others may vary), on page 5-6, for examples of correct cable routing in a socket meter.

10.3: Performing Network Configuration

As with the other Option cards, the Shark® 270 meter auto-detects the presence of an installed Ethernet card. Configure the Ethernet card through Communicator EXT™ software. Refer to Chapter 26 of the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for instructions. You can open the manual online by clicking **Help>Contents** from the Communicator EXT™ Main screen.

10.4: INP100S Ethernet Card Features

The INP100S Ethernet card gives your meter the following capabilities:

- Ethernet communication
- Embedded Web server
- NTP Time Server synchronization
- Alarm/notification email feature

10.4.1: Ethernet Communication

The INP100S 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.

10.4.2: Embedded Web Server

The INP100S gives the meter a Web server that is viewable over the Ethernet by almost all browsers. The Shark® Series webpages allow you to see the following information for the Shark® 270 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 and/or Reset the Network card from the Meter Information web page.

The INP100S card also supports:

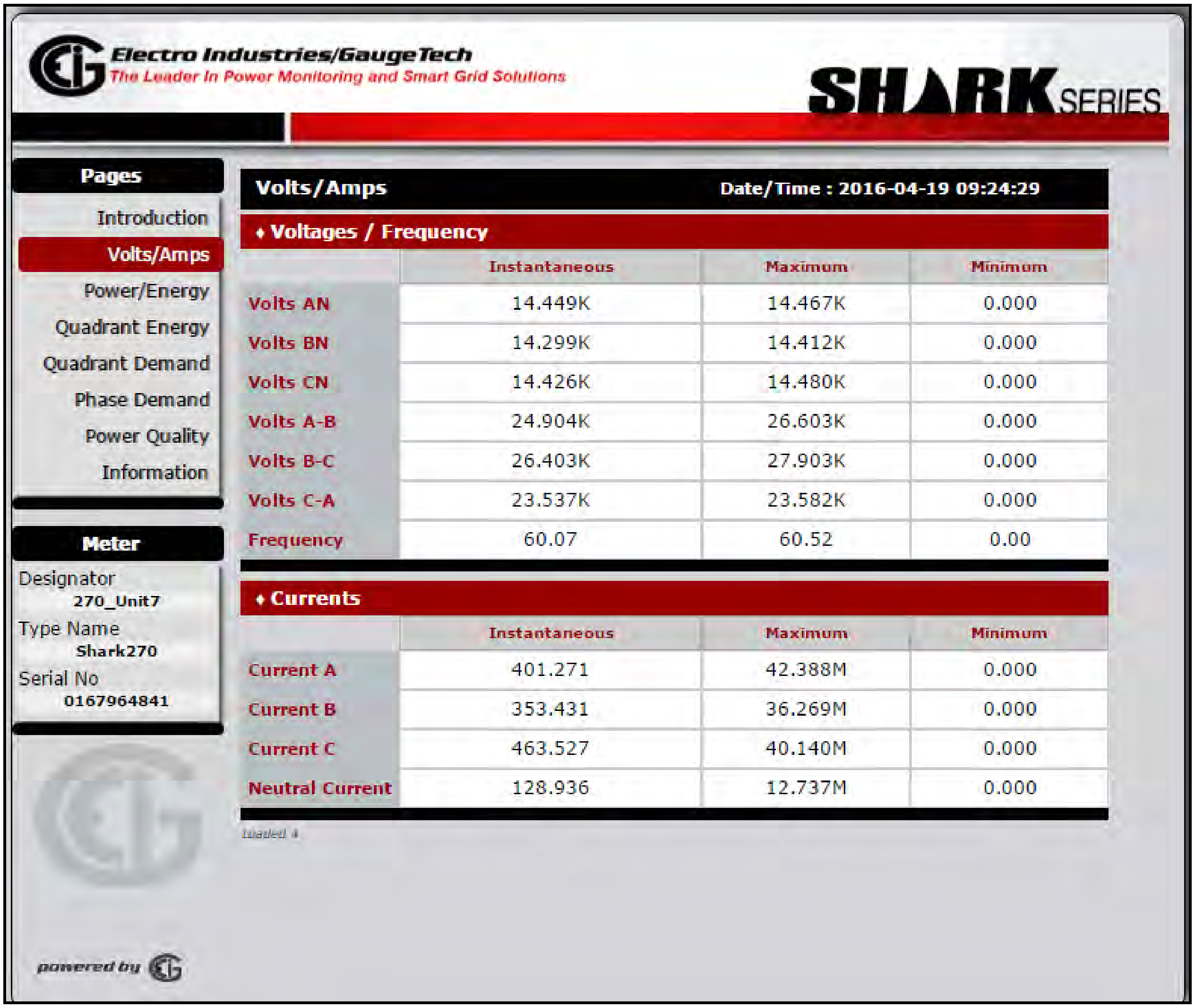
- The "keep alive" feature - see 10.4.5: Keep-Alive Feature, on page 10-16.
- Email on Alarm and Periodic notification email setup - see 10.4.6: Email Alarm/ Notification, on page 10-18.
- Advanced settings - see 10.4.7: Advanced Setup, on page 10-25.

NOTE: The Shark® 270 meter's Device Profile must be set up before configuring keep-alive or email settings in the Network card. See Chapter 26 in the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for instructions.

Follow these steps to access the Shark® 270 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 Shark® Series Introduction web page shown below.

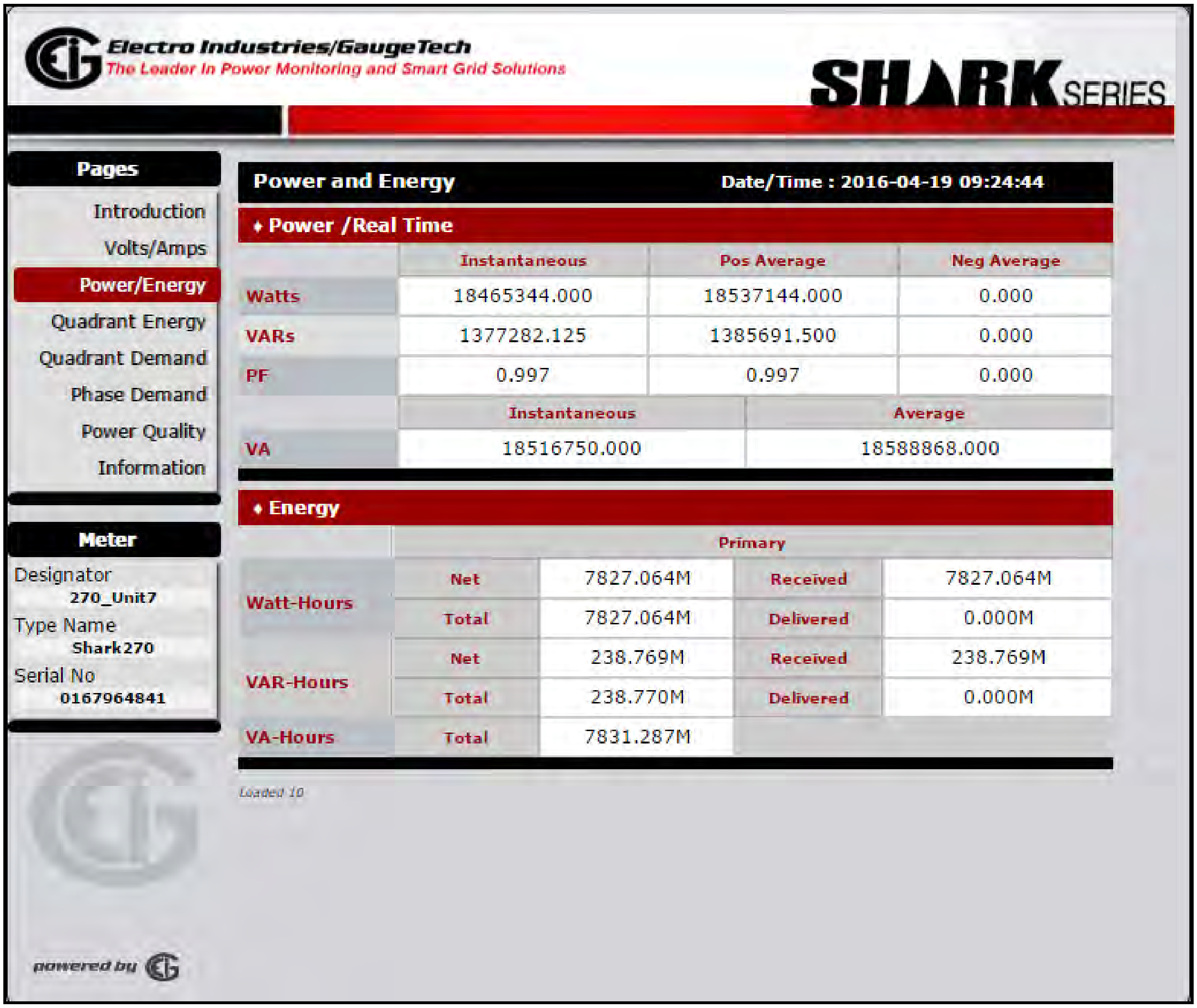
4. To view voltage and current readings, click **Volts/Amps** on the left side of the web page. You will see the webpage shown below.



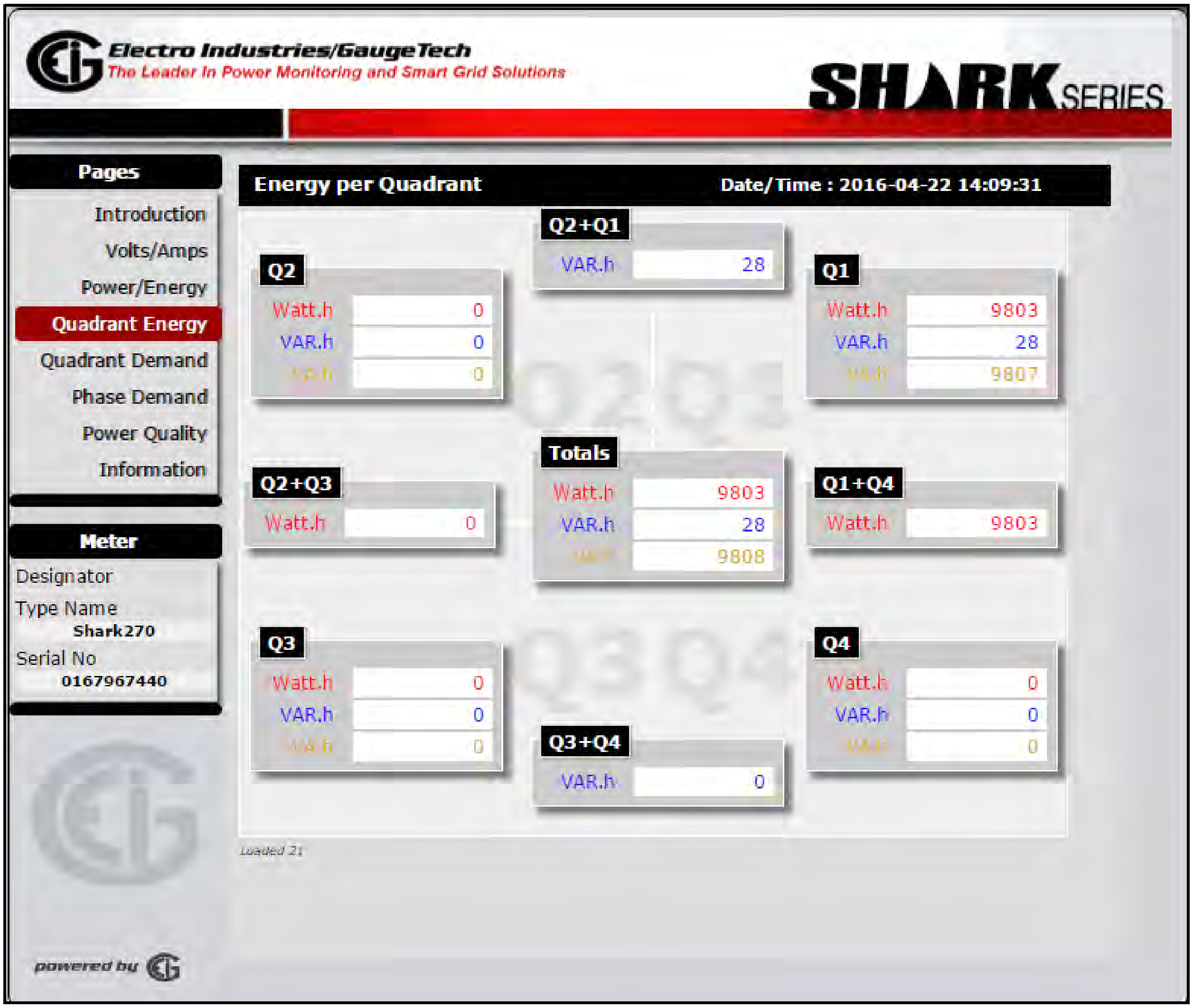
	Instantaneous	Maximum	Minimum
Volts AN	14.449K	14.467K	0.000
Volts BN	14.299K	14.412K	0.000
Volts CN	14.426K	14.480K	0.000
Volts A-B	24.904K	26.603K	0.000
Volts B-C	26.403K	27.903K	0.000
Volts C-A	23.537K	23.582K	0.000
Frequency	60.07	60.52	0.00

	Instantaneous	Maximum	Minimum
Current A	401.271	42.388M	0.000
Current B	353.431	36.269M	0.000
Current C	463.527	40.140M	0.000
Neutral Current	128.936	12.737M	0.000

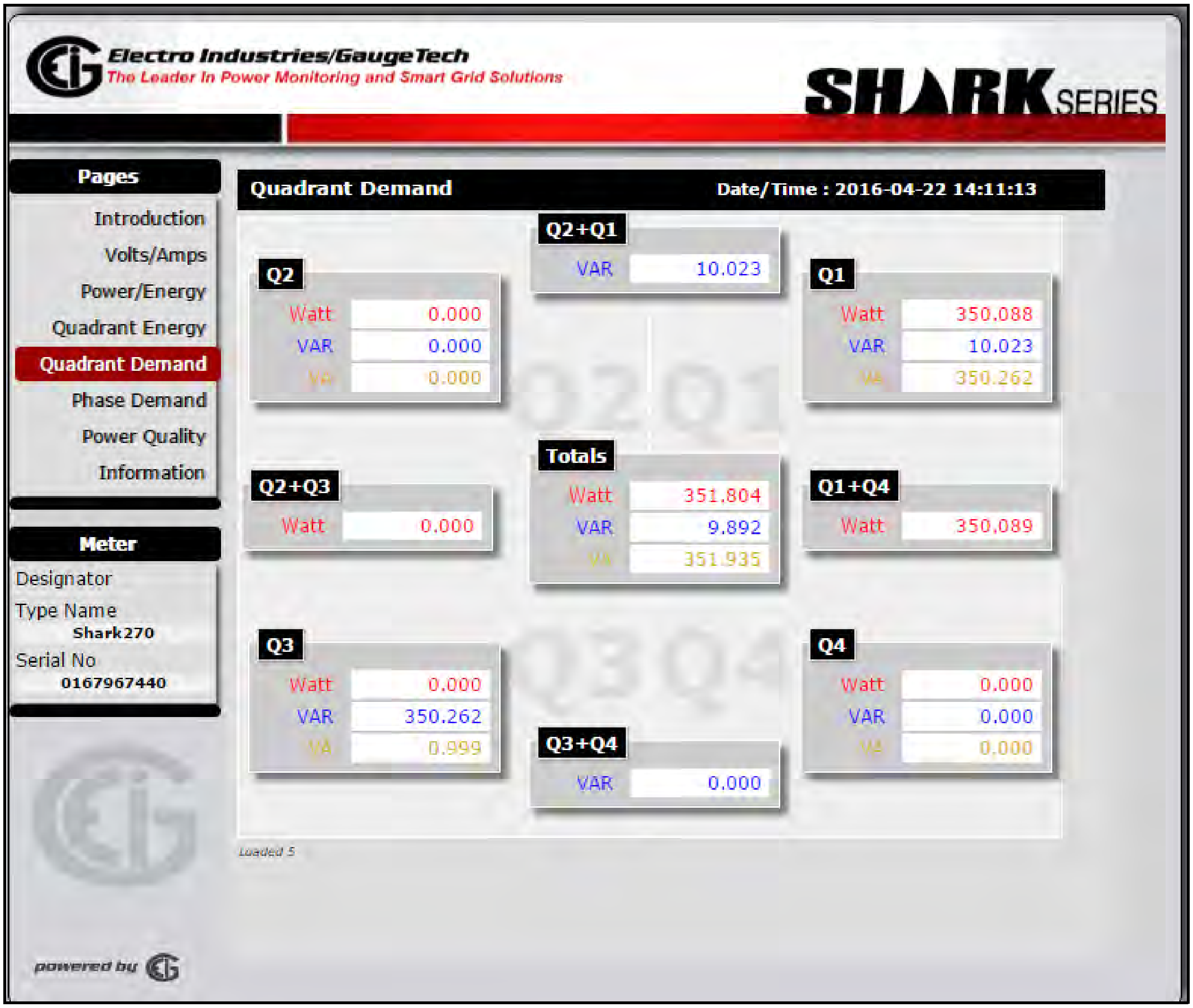
5. To view power and energy readings, click **Power/Energy** on the left side of the webpage. You will see the webpage shown below.



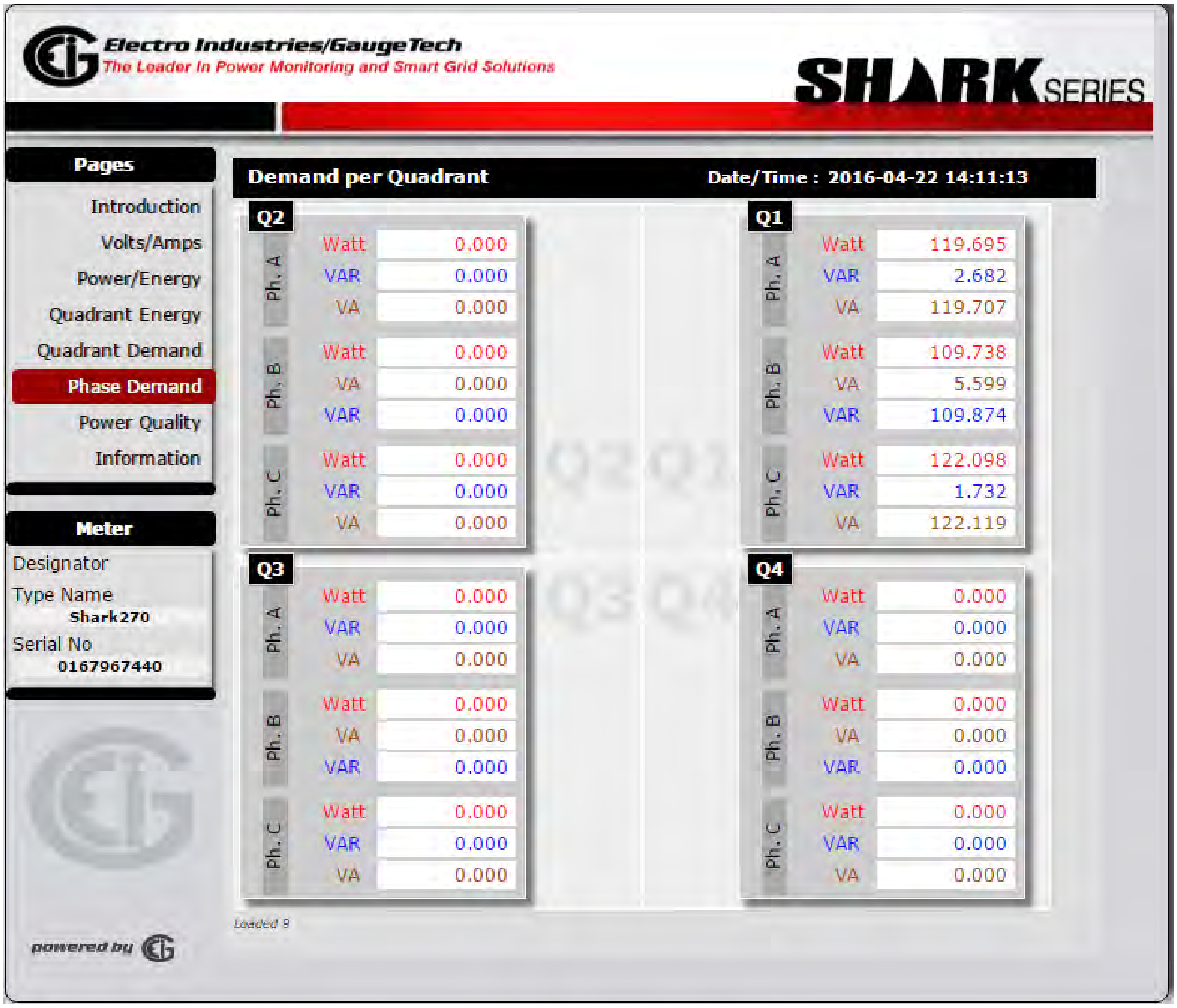
6. To view energy readings for each quadrant, click **Quadrant Energy** on the left side of the webpage. You will see the webpage shown below.



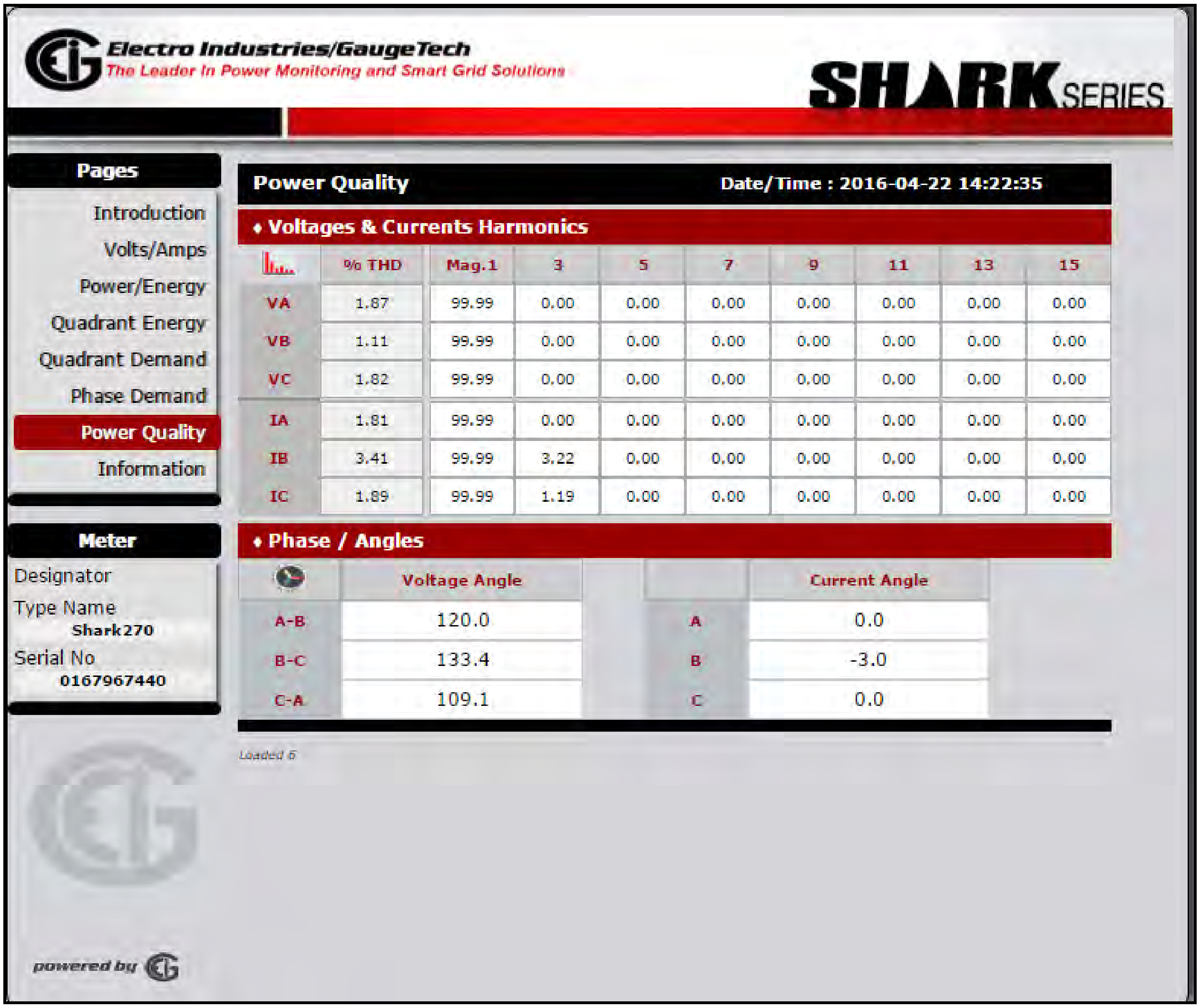
7. To view demand for each quadrant, click **Quadrant Demand** on the left side of the webpage. You will see the webpage shown below.



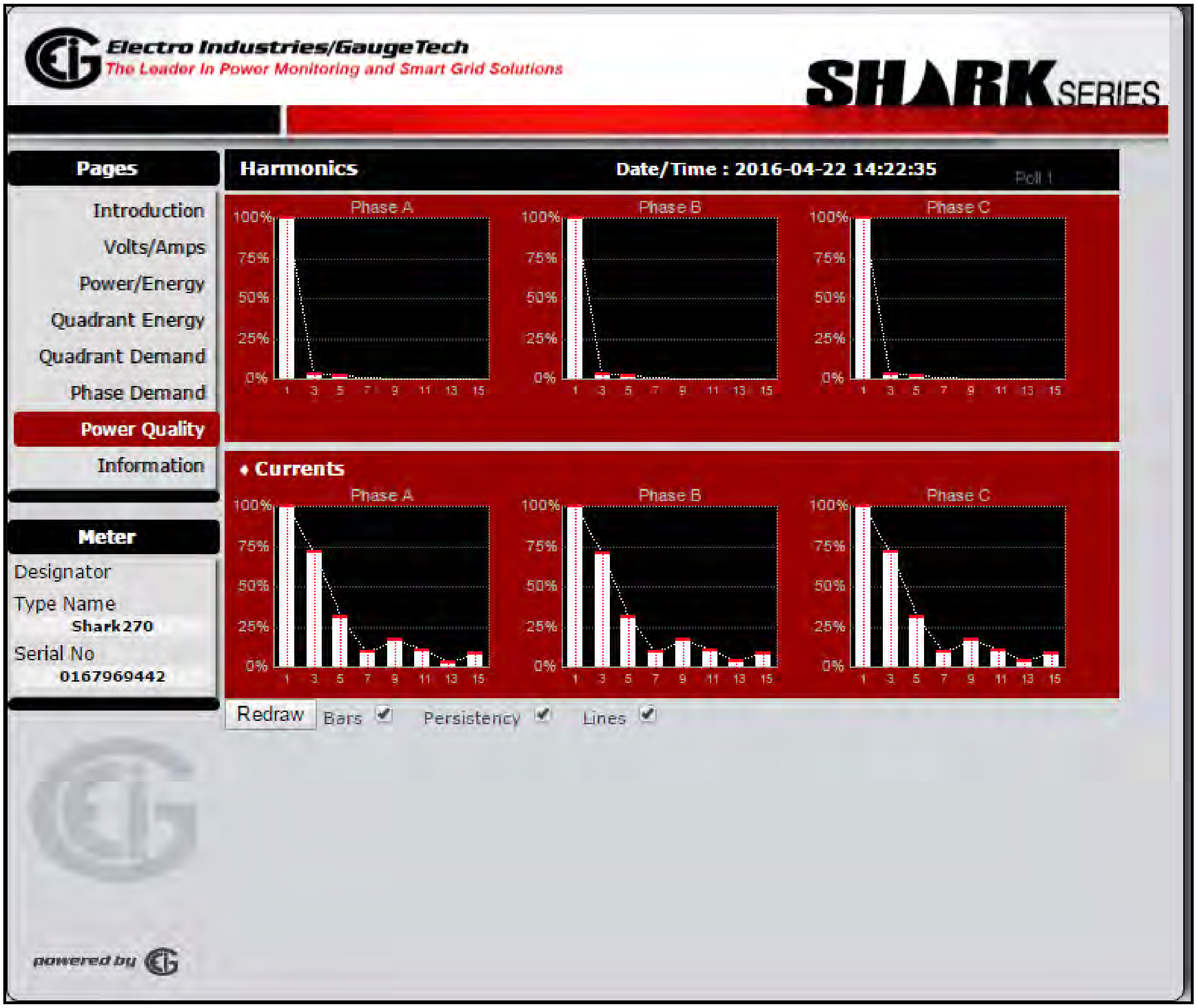
8. To view demand for each phase, click **Phase Demand** on the left side of the webpage. You will see the webpage shown below.



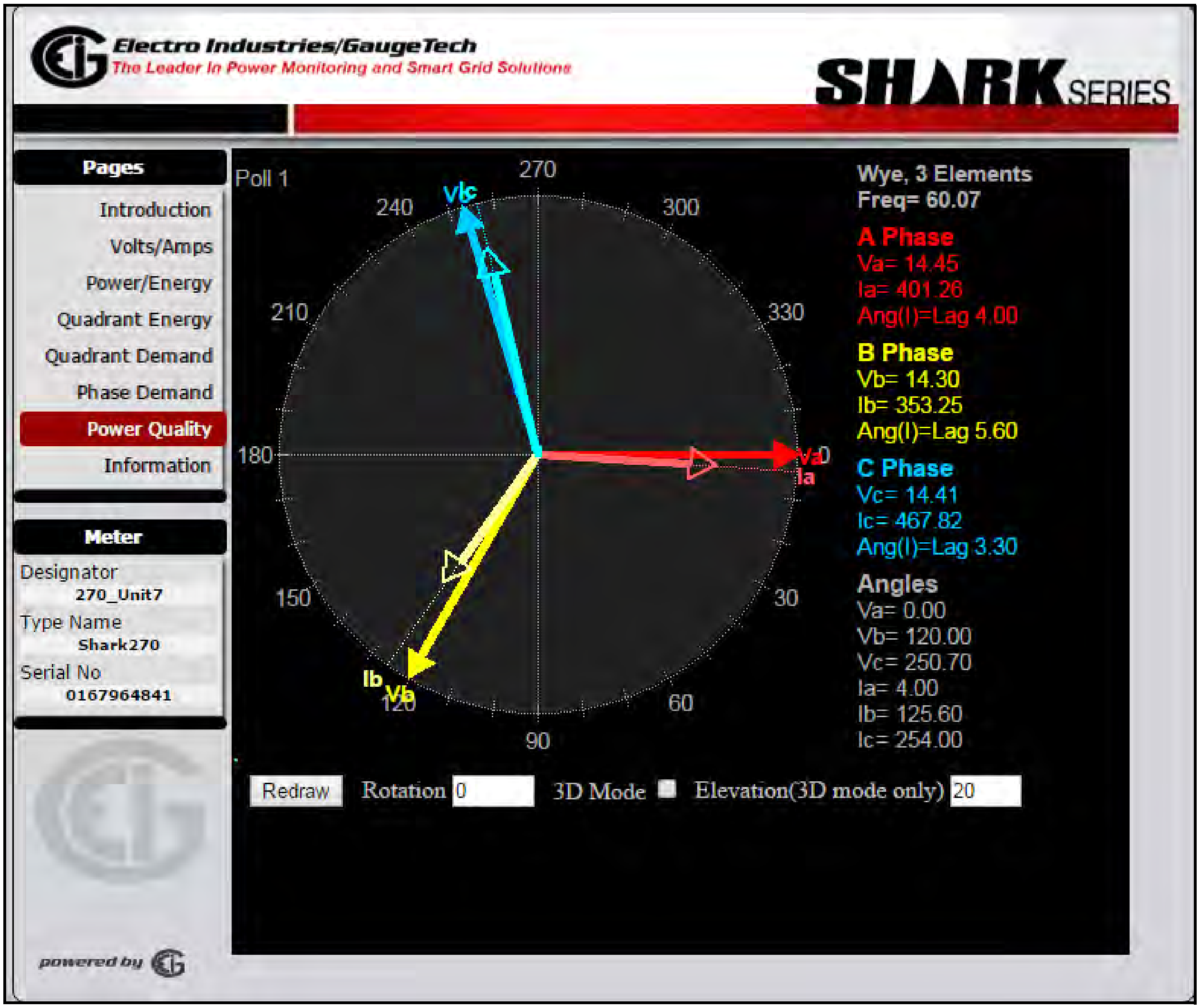
9.To view power quality information, click **Power Quality** on the left side of the webpage. You will see the webpage shown below



a. 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 Harmonics Spectrum webpage shown below.

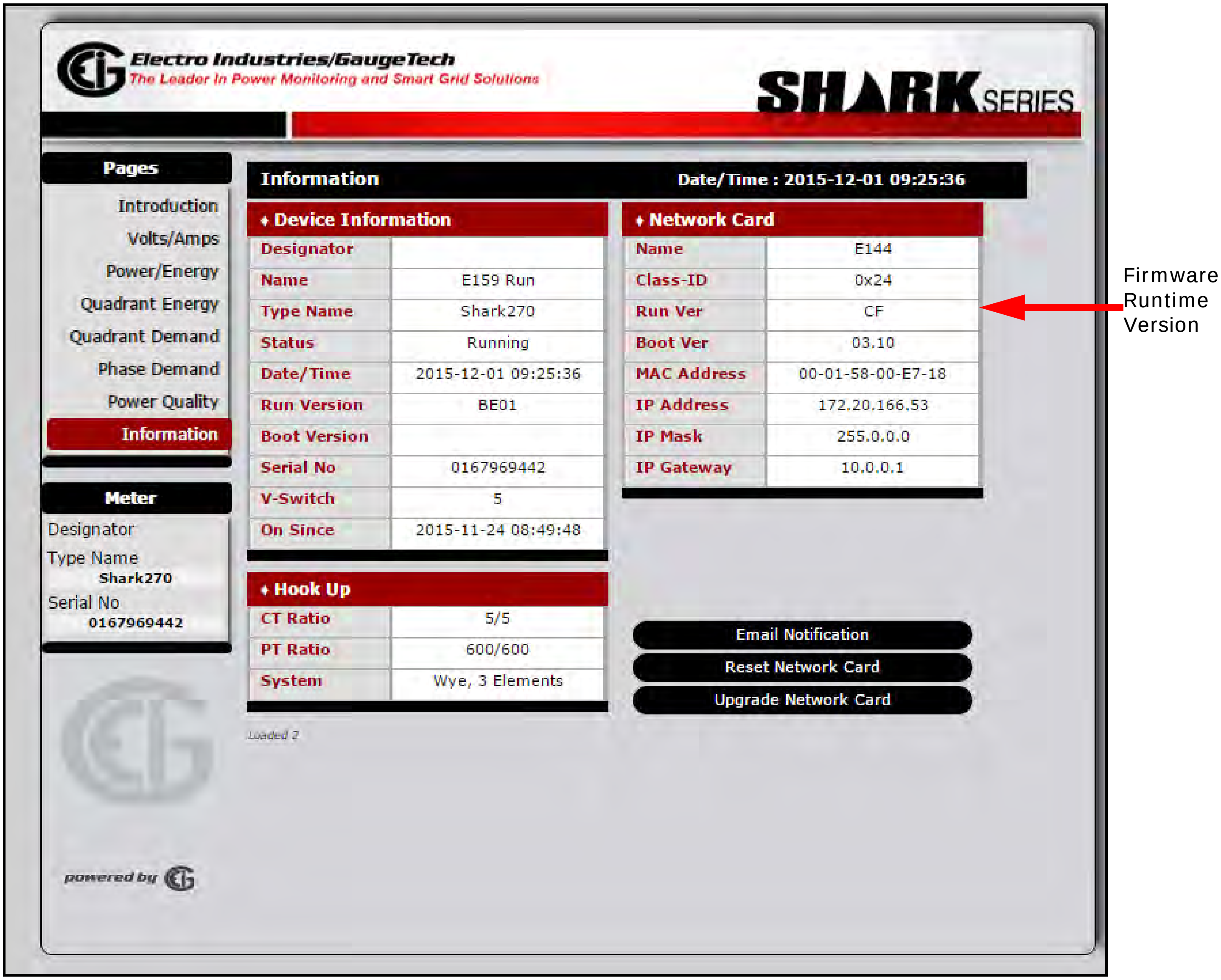


b. To view a graphical representation of the phase angles, click the **Phase Angles** icon in the corner of the Phase Angles box. You will see the webpage shown below.



c. 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 **Meter Information** on the left side of the webpage. You will see the webpage shown below.



NOTES:

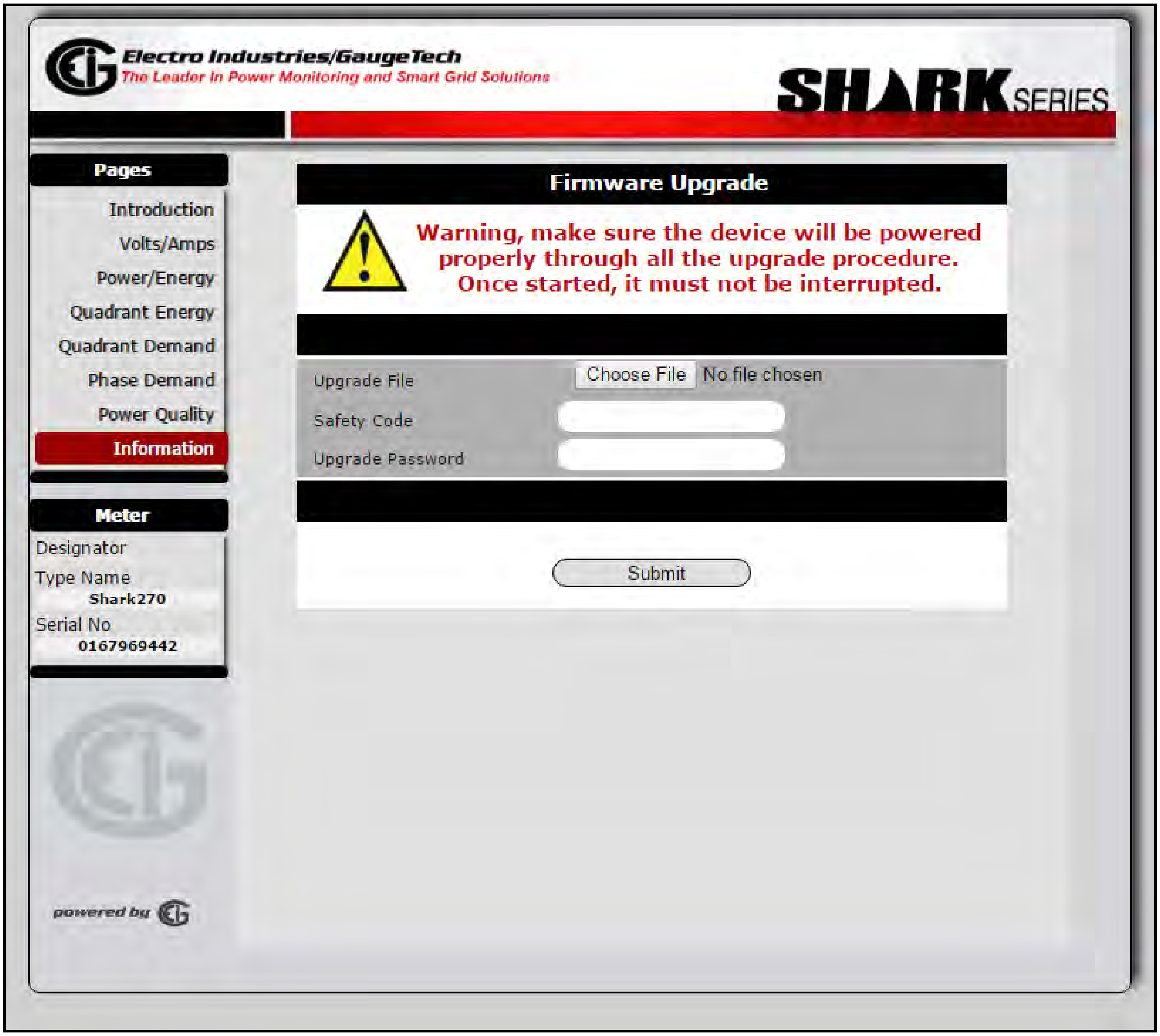
- The firmware runtime version is displayed in the Run Ver field of this webpage.
- Any special characters (i.e., any of the following characters * :" | \ < > ? /) used in the meter name or any other designator string in the meter, are displayed as '_' (underscore) in the webpage.

10.4.2.1: Upgrading the Ethernet Card's Firmware

From one of the Shark® 270 meter's webpages:

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

NOTE: 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 INP100S option card upgrade file. If you upgrade with an INP300S 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.

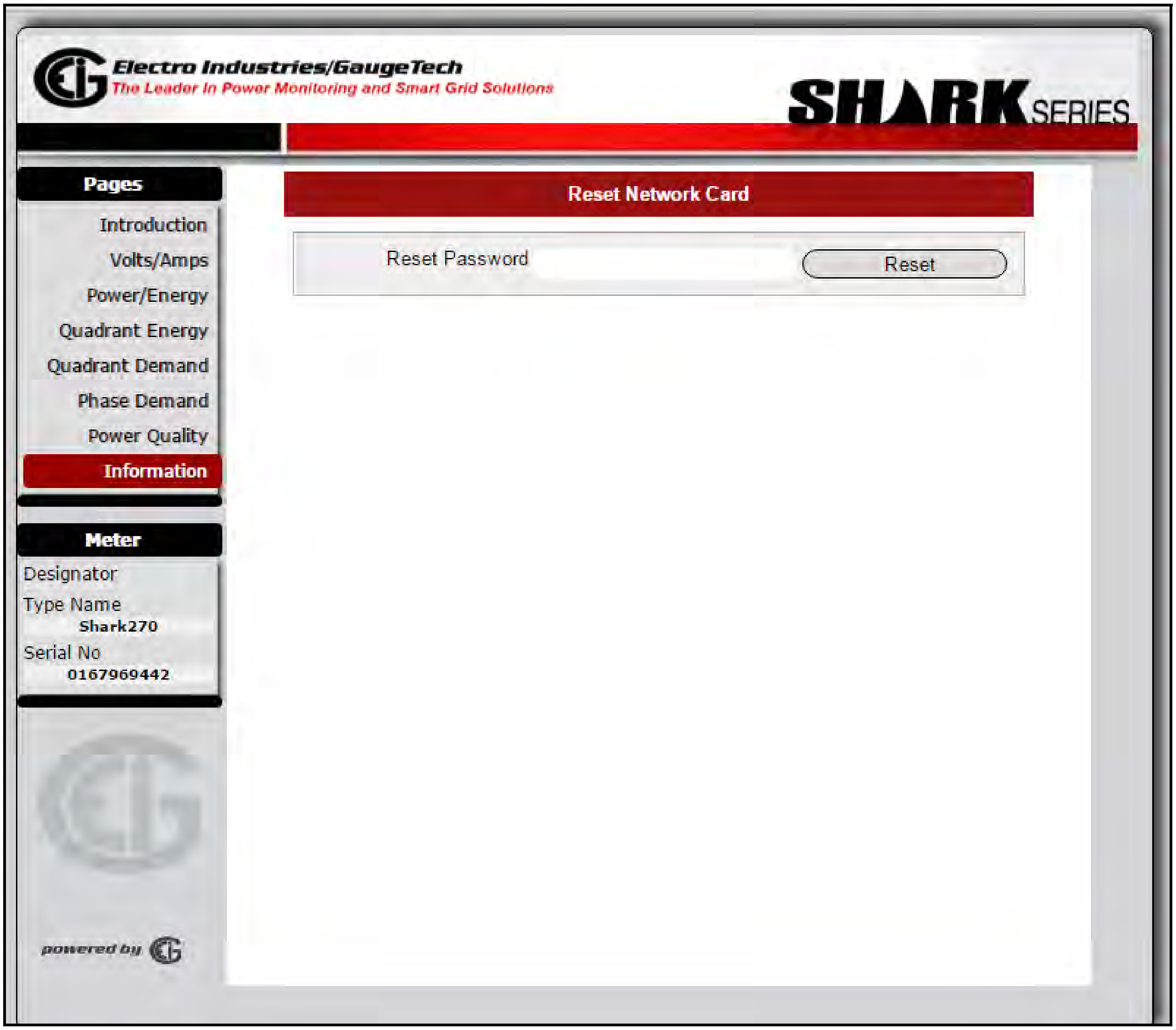
CAUTION! Note the Warning message on the screen. If there is a power interruption during upgrade, please call EIG's Technical Support department at 516-334-0870 for assistance.

10.4.2.2: Resetting the Ethernet Card

From one of the Shark® 270 meter's webpages:

1. Click **Meter 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**.

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

10.4.3: NTP Time Server Synchronization

The INP100S can be configured to perform time synchronization through a Network Time Protocol (NTP) server. This feature lets you synchronize the Shark® 270 meter's real-time clock with this outside source. See Chapter 26 in the *Communicator EXT*™ *4.0 and MeterManager EXT Software User Manual* for configuration instructions (configuring the Network Card section).

NOTES:

- The SNTP/NTP client protocol used in the network card is version 4, backward compatible to version 3.
- After the meter boots up, it may take up to 20 seconds for the first time synchronization request to be made.

10.4.4: Modbus and DNP over Ethernet

The INP100S 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 *Communicator EXT*™ *4.0 and MeterManager EXT Software User 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.

10.4.5: Keep-Alive Feature

The INP100S and INP300S 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.

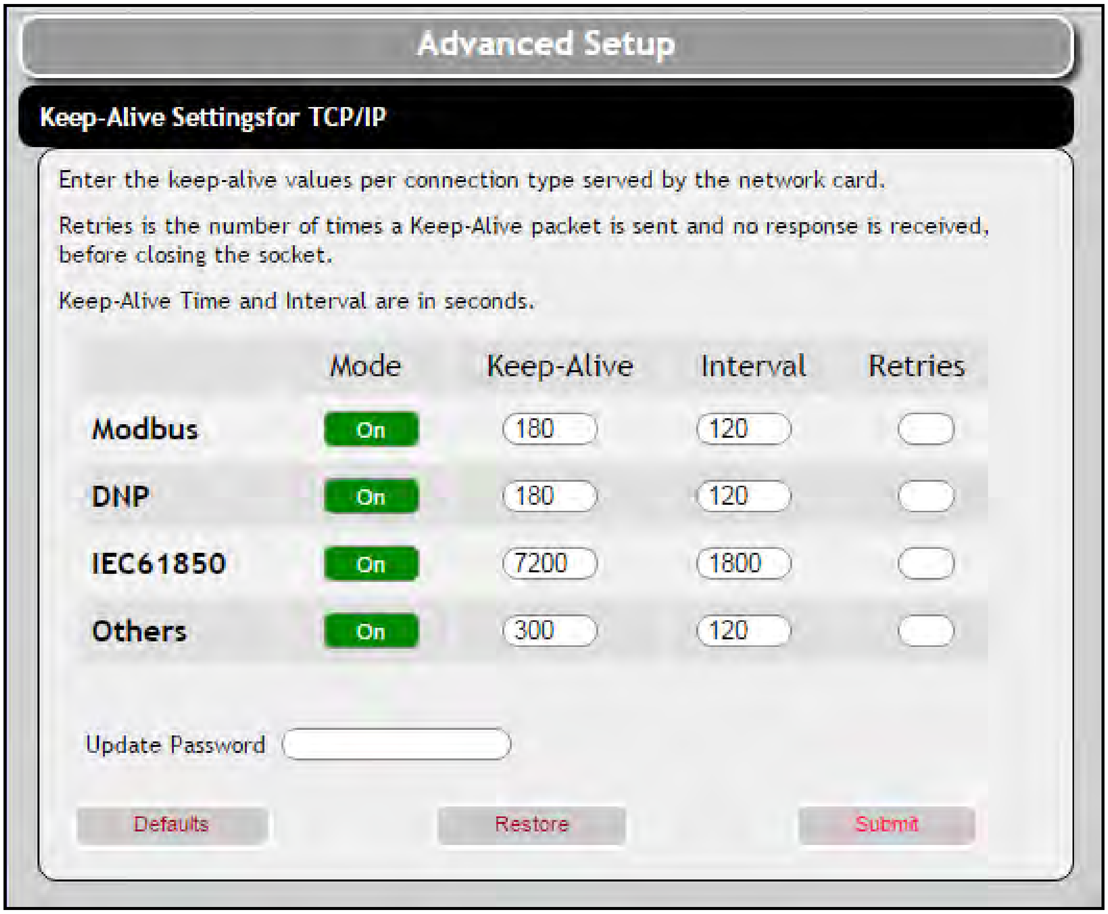
The Keep-Alive settings can be configured differently for each protocol group: Modbus TCP/IP, DNP over Ethernet, IEC61850, and others.

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 INP100S card's IP address. You will see the screen shown below.



- You can click 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.

IMPORTANT! You should not make changes to these 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 for different applications or clients. EIG is not responsible for instability of the network link when values other than the default are set.

- 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.

10.4.6: Email Alarm / Notification

Email Alarm/Notification is a feature that allows the unit Shark® 270 INP100S card to be configured to send emails when selected events occur. These events are: Log Reset, Log Retrieval Begins, Clock Settings Changed, Energy Reset, Reset Min/Max values, Reset Pulse Accumulators, Measuring turned Off, Programmable Settings Change, Failed attempt to securely access unit (password fail), V-Switch™ key Change, Log Babbling, Limit Hit and Meter Started Up.

The User can program the unit to any, or all, of those events, and also to program the urgency of the event; i.e., whether a notification should be sent (not urgent) or an alarm should be sent (urgent). The reporting of these events, both Alarm and Notification, is through email.

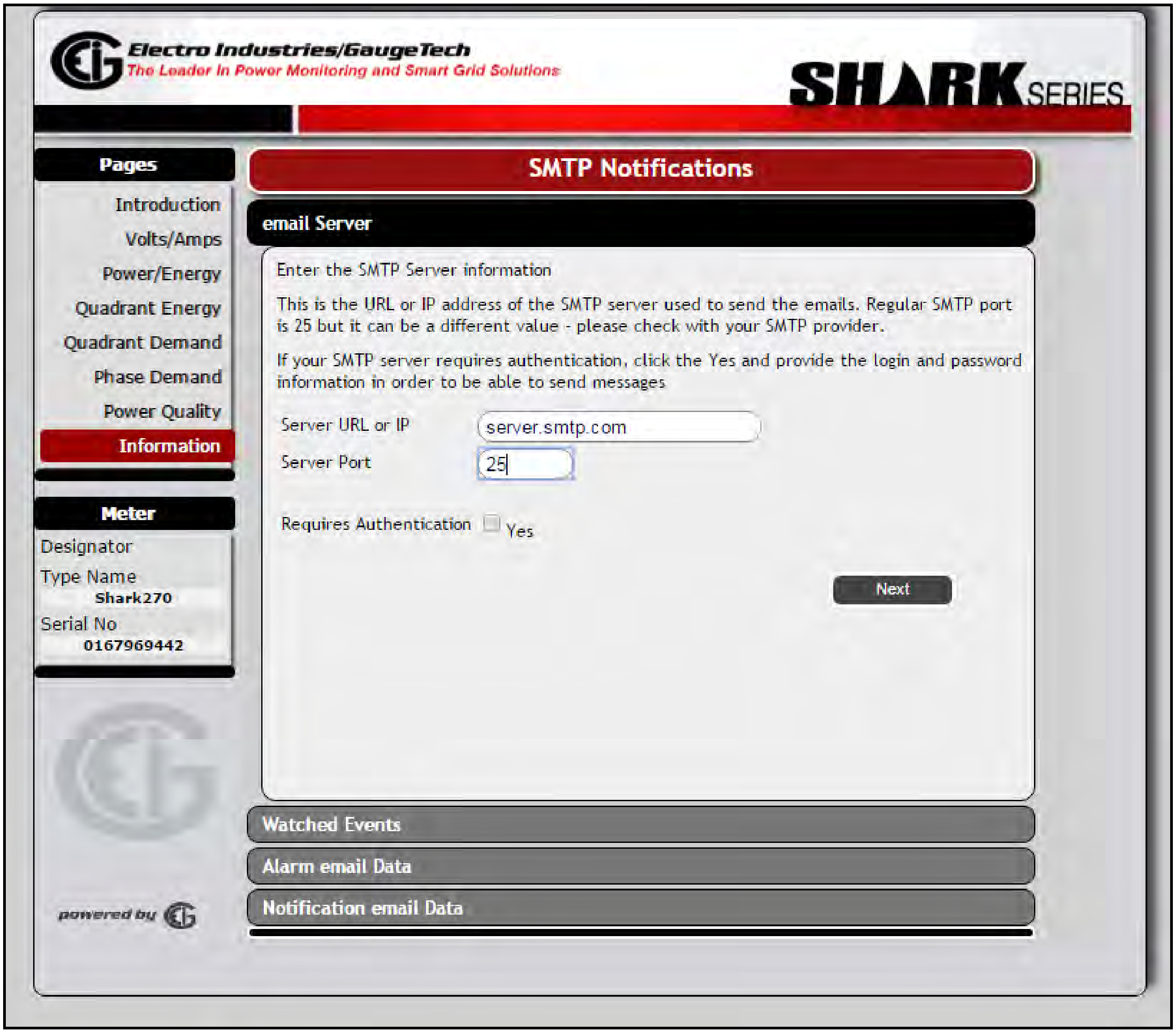
The Alarm and Notification conditions have separate configurations to define the email recipient addresses (To and CC) where the email Alarm/Notification must be sent to. In addition, the Notification can be configured to send the email at a specific time (between 5 minutes and 24 hours). The Alarm email will be sent as soon as possible within a 1-minute window.

The INP100S 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 10-12 for information on finding the firmware version.

From one of the Shark® 270 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.

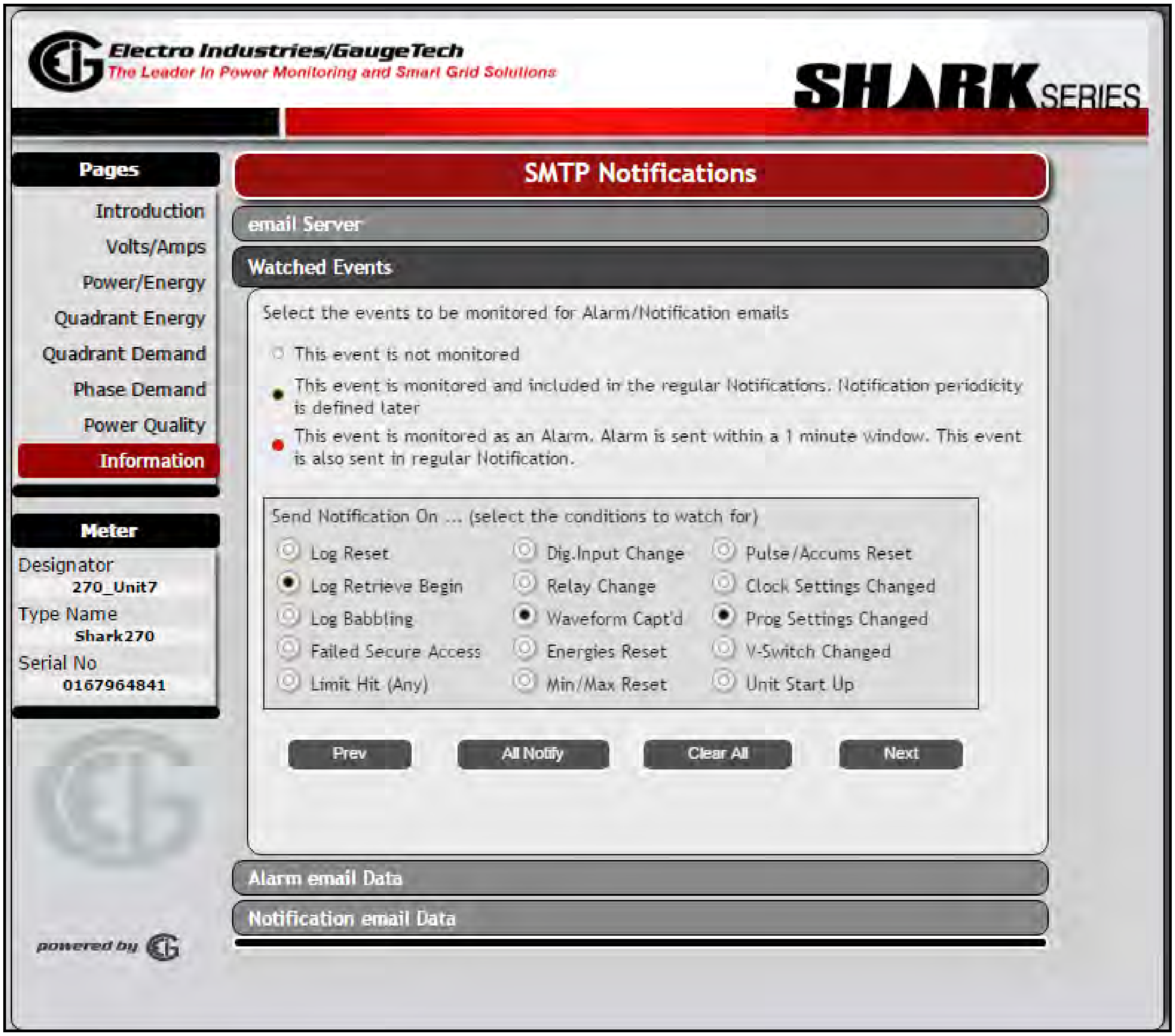
   a. Enter the url or IP address of the email server you will be using.

   b. Enter the Server port. Usually this is 25, but check with your system administrator in case you are using a different port.

c. If your email server requires authorization, click the checkbox next to Yes and enter the Username and Password.

d. 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.

NOTE: Prog(rammable) Settings Changed, V-Switch Changed, and Unit Start Up can only be assigned to notifications.

a. 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, V-Switch Changed, and Unit Start Up.

- To deselect a condition, click on the button until it is empty, again - not black or red.

b. 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.

a. Enter the email address of the person sending the email in the From field.

b. Enter the email subject line in the Subject field- the default is Alarm Email.

c. Enter the email address of the person receiving the email in the To field.

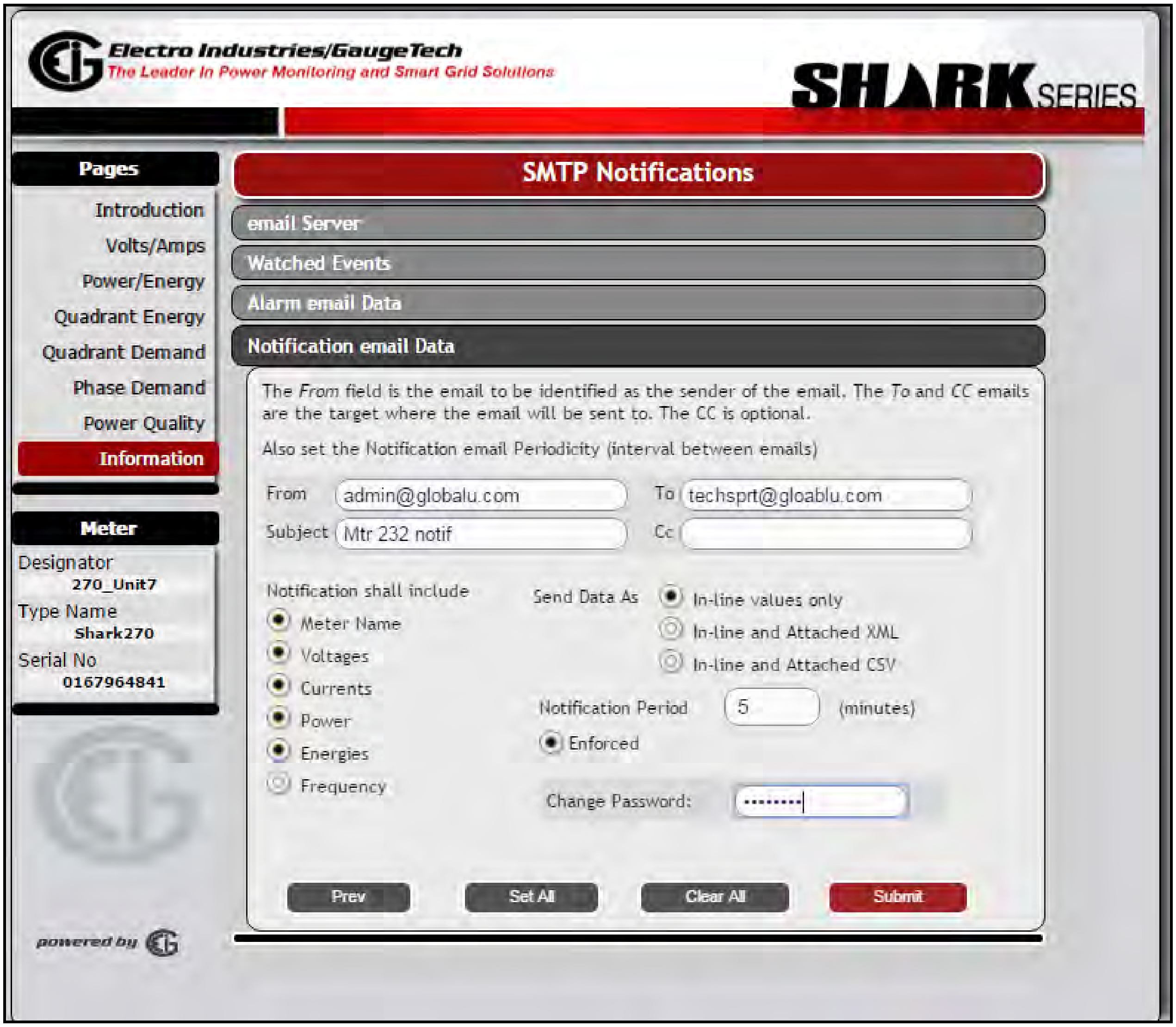
d. Enter the email address of anyone you want to receive a copy of the email in the CC field.

e. 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.

f. 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.

g. 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.

a. Enter the email address of the person sending the email in the From field.

b. Enter the email subject line in the Subject field- the default is Notification Email.

c. Enter the email address of the person receiving the email in the To field.

d. Enter the email address of anyone you want to receive a copy of the email in the CC field.

e. 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.

f. 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.

g. 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 10800 minutes (180 hours).

h. 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).

i. 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.

10. Click **Submit** to save your settings. The Network card will reset. Note that any pending emails will be canceled.

10.4.7: Advanced Setup

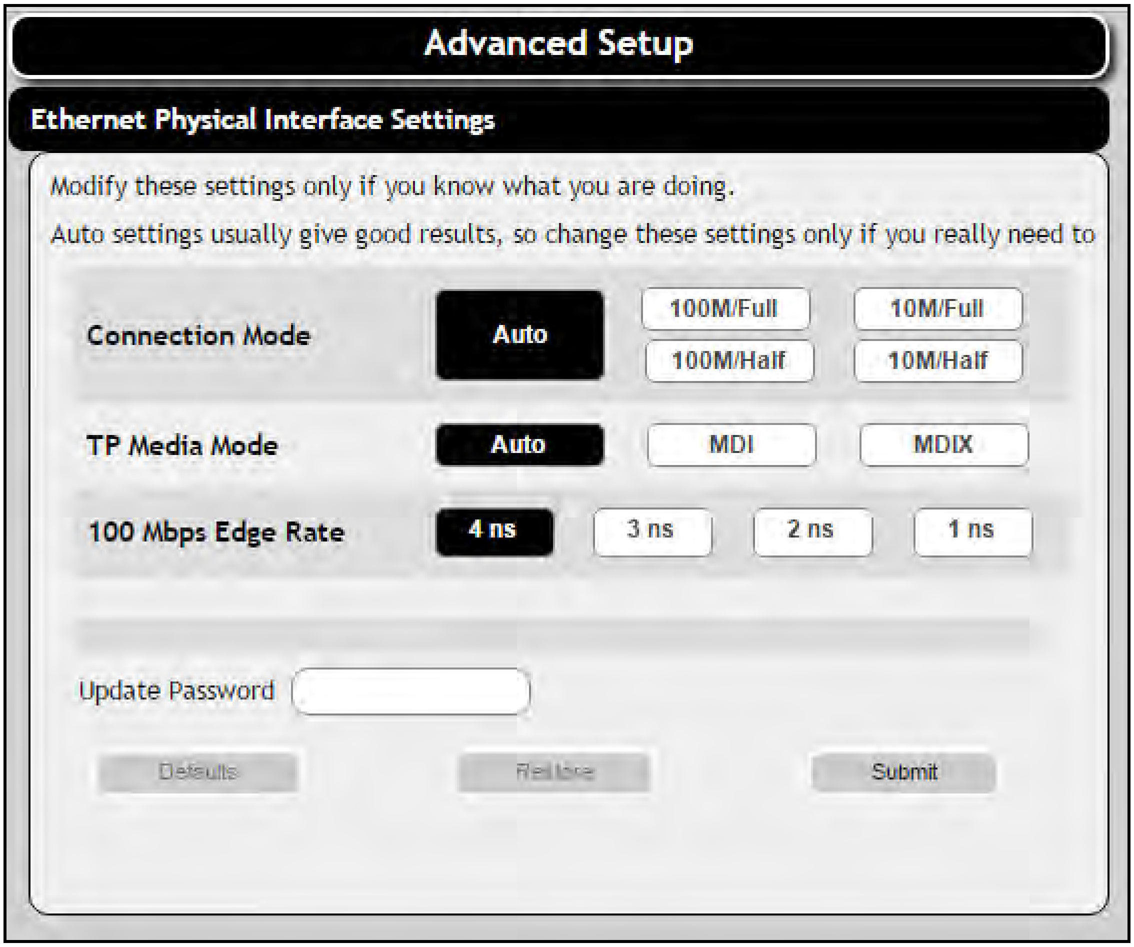
The INP100S and INP300S Network option cards support user Advanced settings for connection mode and other values. Note that the default settings are almost always the best, and will almost never need to be changed.

WARNING! Only modify these settings if you are knowledgeable about them, since setting them incorrectly can lead to unstable connections. Also, the default settings are almost always the best, and will almost never need to be changed.

To access the Advanced Settings screen, key the following into your web browser's address bar:

http://xx.xx.xx.xx/sys/setup_phy_ssi.htm

, where xx.xx.xx.xx is your INP100S card's IP address. You will see the screen shown below.



11: Meter Calculations

11.1: Measurements and Calculations

The Shark® 270 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}

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

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:

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

// 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 Shark® 270 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 Communicator EXT™ software (see the *Communicator EXT™ 4.0 and MeterManager EXT Software User 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.).

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12: Using the INP300S IEC 61850 Protocol Card

12.1: Overview

The Shark® 270 meter can have one optional Ethernet card (either the INP300S or the INP100S - see Chapter 10: Using the INP100S Ethernet Card, on page 10-1, for the INP100S card). With the INP300S in your Shark® 270 meter, you gain the capability of communicating IEC 61850 Protocol as well as Modbus TCP/IP, over the Ethernet.

12.2: Overview of IEC 61850

When the IEC 61850 Protocol Ethernet Network card (INP300S) is added to the Shark® 270 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.

12.2.1: 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 clients include: Omicron IED scout, SISCO AX-S4 61850, TMW Hammer, KalkiTech gateway, Siemens DIGSI

An example of the object model display on a diagnostic client is shown in Figure 12.1

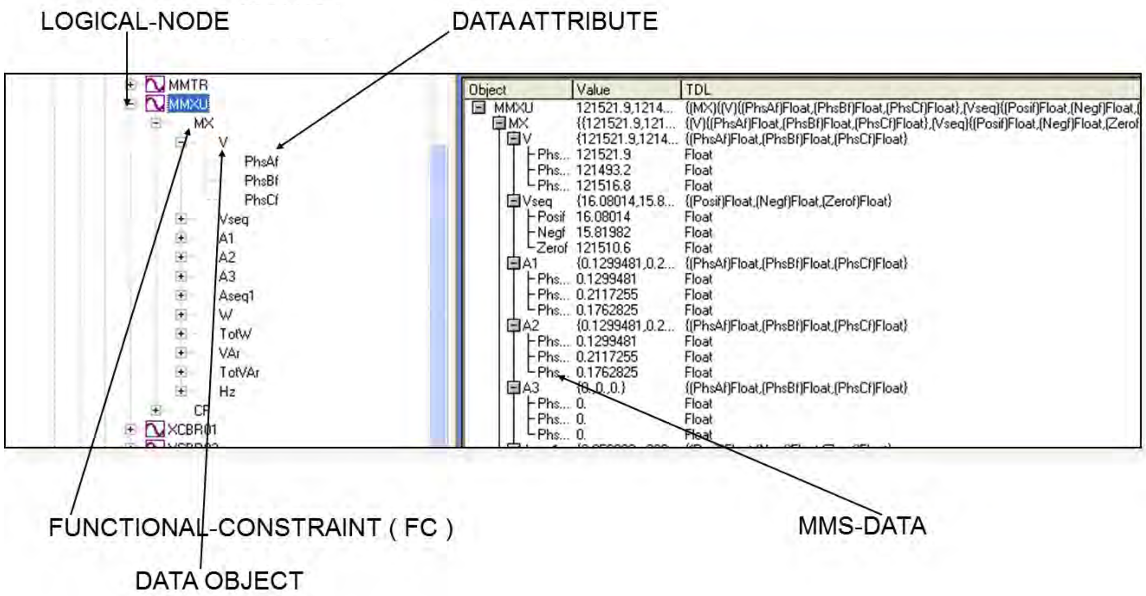


Figure 12.1 Object Model Display on a Diagnostic Browser

NOTE: 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 Shark® 270 meter's IEC 61850 Protocol Ethernet Network card.

12.2.2: 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 12.3.3.2: Configuring the Meter on the IEC 61850 Network, on page 12-21, for information on the Shark® 270 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 Shark® 270 meter's IEC 61850 Protocol Ethernet Network card uses a CID file. See 12.3.3.2: Configuring the Meter on the IEC 61850 Network, on page 12-21, for information on uploading the Shark® 270 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.

12.2.2.1: 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.

12.2.3: 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 12.2 for a graphical illustration of the process.

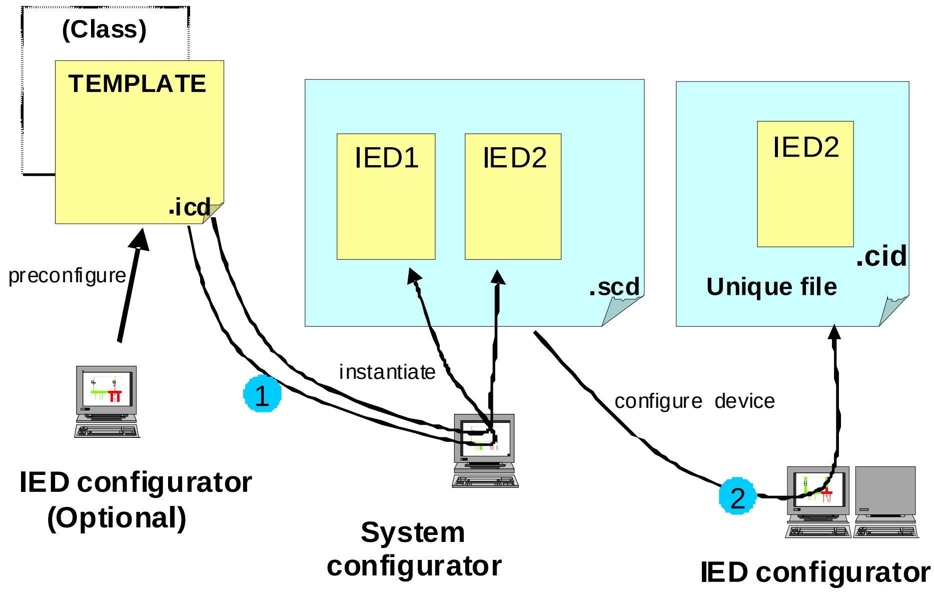


Figure 12.2: Configuration Process

Referring to Figure 12.2:

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.

NOTE: In the Shark® 270 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.

12.2.4: EIG's Implementation of the IEC 61850 Protocol Server

Following are features of EIG'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 Shark® 270 family include eneMMTR1 (energy metering) and nsMMXU1 (normal speed Measurement Unit).
- The Shark® 270 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 Shark® 270 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 Shark® 270 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 Shark® 270 meter does not support Goose nor 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 Shark® 270 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 EIG device. The tool is named "SCDtoCIDConverter" and is a simple, publicly available program. The resulting CID file is then sent to the EIG device using HTTP file transfer.

12.2.4.1: Shark® 270 Server Configuration

The configuration file (CID) should be stored in the Shark® 270 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 Shark® 270 meter is accomplished through its webpage. The webpage allows the user to locate the CID file, and submit it to the Shark® 270 meter for storage.

The Shark® 270 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 Shark® 270 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 Shark® 270 meter's device profile). In this case the Shark® 270 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 12.3.3: Configuring the IEC 61850 Protocol Ethernet Network Card, on page 12-17, for instructions on configuring the Shark® 270 meter's IEC 61850 Protocol Ethernet Network card.

12.2.5: 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.

12.2.6: 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

12.2.7: Commercial Tools for IEC 61850 Implementation

Following is a list of tools for IEC 61850 configuration which you can purchase:

- http://www.sisconet.com/ax-s4_61850.htm
  Client for IEC 61850

- http://products.trianglemicroworks.com/documents/TMW%2061850%20Test%20Suite%20Combined.pdf
  Clients and servers for IEC 61850

- http://www.omicron.at/en/products/pro/communication-protocols/iedscout/test client

- http://kalkitech.com/products/sync-6000-series-scl-manager--iec61850-substation-design-tool SCL editing tool

12.3: Using the Shark® 270 Meter's IEC 61850 Protocol Ethernet Network Card

This section contains instructions for understanding and configuring the Shark® 270 meter's IEC 61850 Protocol Ethernet Network Option card.

12.3.1: Overview

The IEC 61850 Protocol Ethernet Network card is a Shark® 270 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

12.3.2: 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 Shark® 270 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 Shark® 270 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 Shark® 270 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.)

12.3.3: 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.)

12.3.3.1: Configuring the Device Profile IEC 61850 Protocol Ethernet Network Card Settings

You use the Communicator EXT™ application to set the card's network parameters. Basic instructions are given here, but you can refer Chapter 26 in the *Communicator EXT™ and MeterManager EXT Software User Manual* for additional information. You can view the manual online by clicking Help>Contents from the Communicator EXT™ software main screen.

You will need the following information:

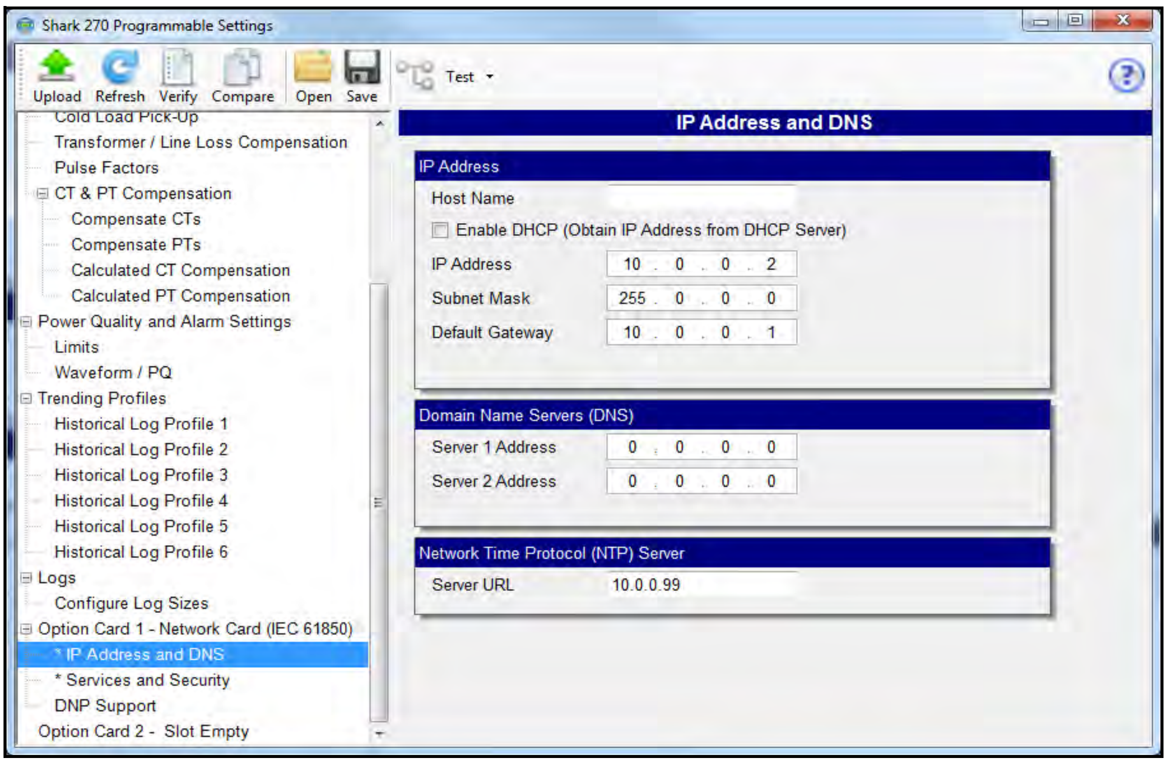
- The IP address to be assigned to the card
- The Network Mask used on your network
- The IP address of the Gateway on your network (you can use 0.0.0.0 if you don't have a gateway IP address)
- The IP address of the DNS (Domain Name Server) on your network (only needed if you plan to use URLs instead 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

1. Using Communicator EXT™ software, connect to the meter through its RS485 serial port, or through an INP100S Network Card if one is installed in the other Option card slot (see the *Communicator EXT 4.0 and MeterManager EXT Software User Manual*, for instructions).

2. Click the Profile icon to open the meter's Device Profile screen The profile is retrieved from the Shark® 270 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.

NOTES:

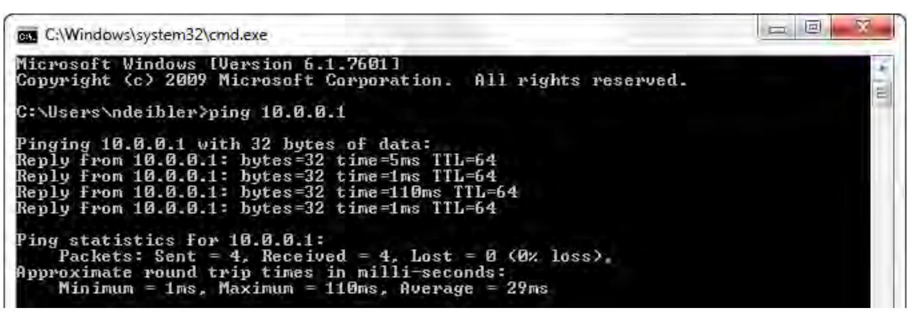
- The IEC 61850 Protocol Ethernet Network card needs time information to work properly. The time can be provided either by a Network Time Protocol (NTP) server or by the Shark 270® meter itself (via Line Sync, which is selected and enabled through the Time Settings screen). If you enter an NTP server on this screen, you still need to enable it in the Time Settings screen (see Chapter 26 in the *Communicator EXT 4.0 and Meter-Manager EXT Software User Manual*, for instructions).

- All of these parameters must be properly set up in order to allow the Shark® 270 meter to communicate on the network. After configuration, a simple “ping” test can be performed to see if the Shark® 270 meter is correctly connected to the network:

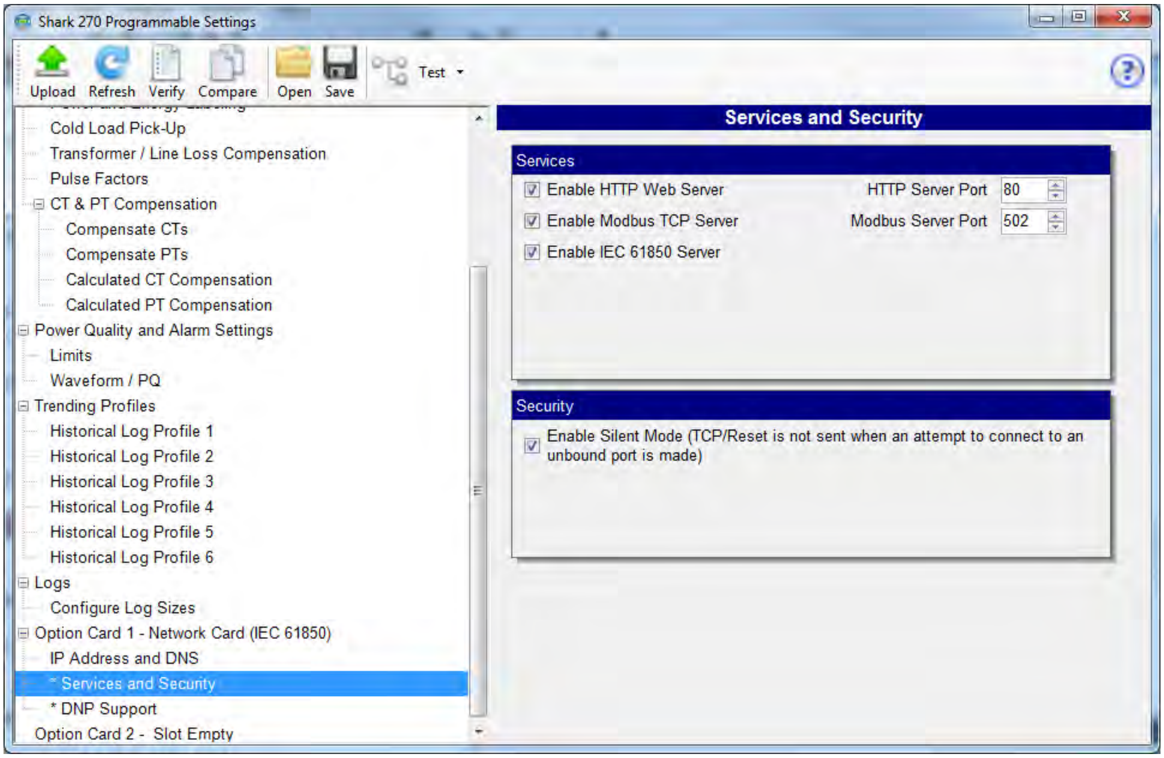
  a. From the Start menu, type **run** and press Enter.

  b. In the Run window, type **cmd** and click OK.

  c. In the command window type **ping *Network Card’s IP address***. See the example screen below.



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



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

6. Click the Enable IEC 61850 Server box.

7. Click Update Device to send the settings to the Shark® 270 meter. The meter will reboot. The IEC 61850 Protocol Ethernet Network card is now configured properly to work on an IEC 61850 network.

12.3.3.2: Configuring the Meter on the IEC 61850 Network

The System Integrator must configure the Shark® 270 meter within the substation IEC 61850 network. To do this, the System Integrator needs the Shark® 270 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 Shark® 270 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 Shark® 270 meter is contained in the Communication section of this .cid file. See the example Communication section, below.

NOTE: If the CID file to be uploaded has more than one IED definition block, the Shark® 270 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="SHARK270IEC" 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 12.3.3.1: Configuring the Device Profile IEC 61850 Protocol Ethernet Network Card Settings, on page 12-17) for each IEC 61850 Protocol Ethernet Network card in the meter.

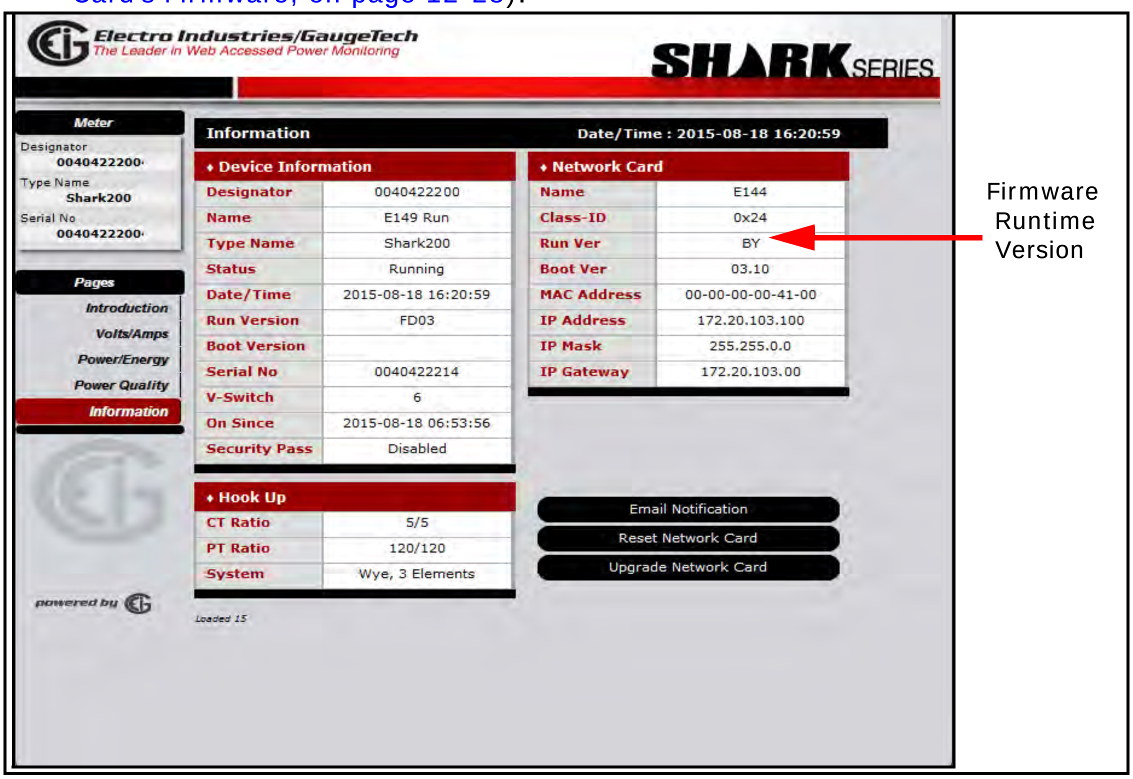
Also, make sure that the iedName field in the ConnectedAp section (underlined in the example) is the same as the name field defined in the IED section.

This is how the unit is assigned its name and IP address.

1. The Shark® 270 meter's .icd file can be downloaded directly from the Shark® 270 unit. To do this, use a web browser and key:

   http://aa.bb.cc.dd/

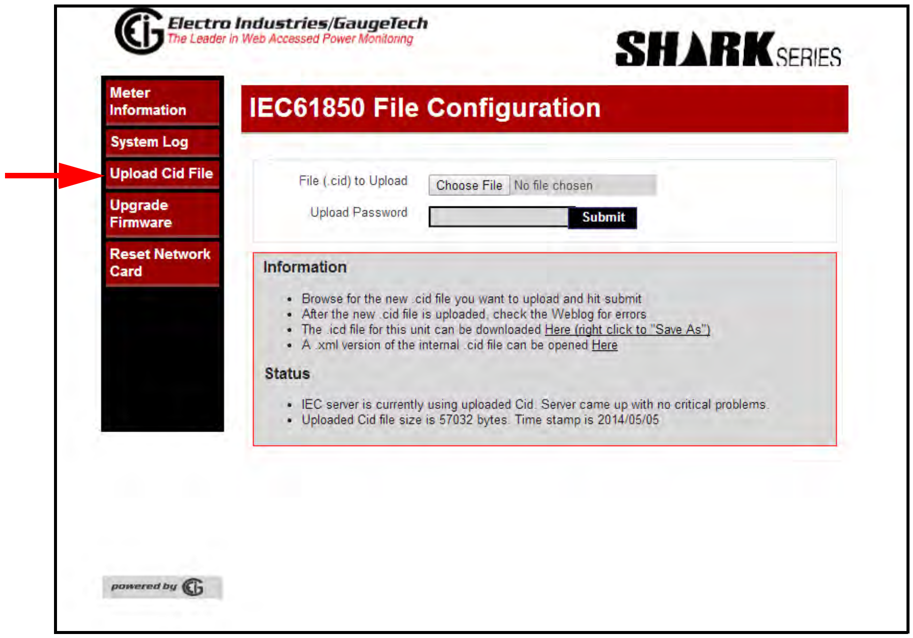
   , where aa.bb.cc.dd is the IP address assigned to the IEC 61850 Protocol Ethernet Network card (see 12.5: Upgrading the IEC 61850 Protocol Ethernet Network Card's Firmware, on page 12-28).



The Meter Information webpage is displayed.

NOTE: The firmware runtime version which is displayed in the Run Ver field of this webpage determines the default password for Network card upgrading, uploading the .cid file, and resetting the Network card.

2. From the left side of the screen, click Upload 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="Shark 270 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>
```

```xml
</Header>
<Communication>
  <SubNetwork name="Subnet_MMS" type="8-MMS">
    <BitRate unit="b/s" multiplier="M">10</BitRate>
    <ConnectedAP iedName="SHARK270IEC" 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="SHARK270IEC" desc="Electro Industries Shark 270" type="S270"
manufacturer="ElectroIndustries" configVersion="1.00">
 <Services>
   <DynAssociation/>
```

4. Once the System Integrator has processed the Shark® 270 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 Shark® 270 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 for firmware runtime version 3.35 and later.

8. Click Submit. The upload process begins. When the upload is finished a report is shown on the screen.

IMPORTANT NOTES!

- The IP address configured into the IEC 61850 Protocol Ethernet Network card with the Communicator EXT™ 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 12-22.

- 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 Shark® 270 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).

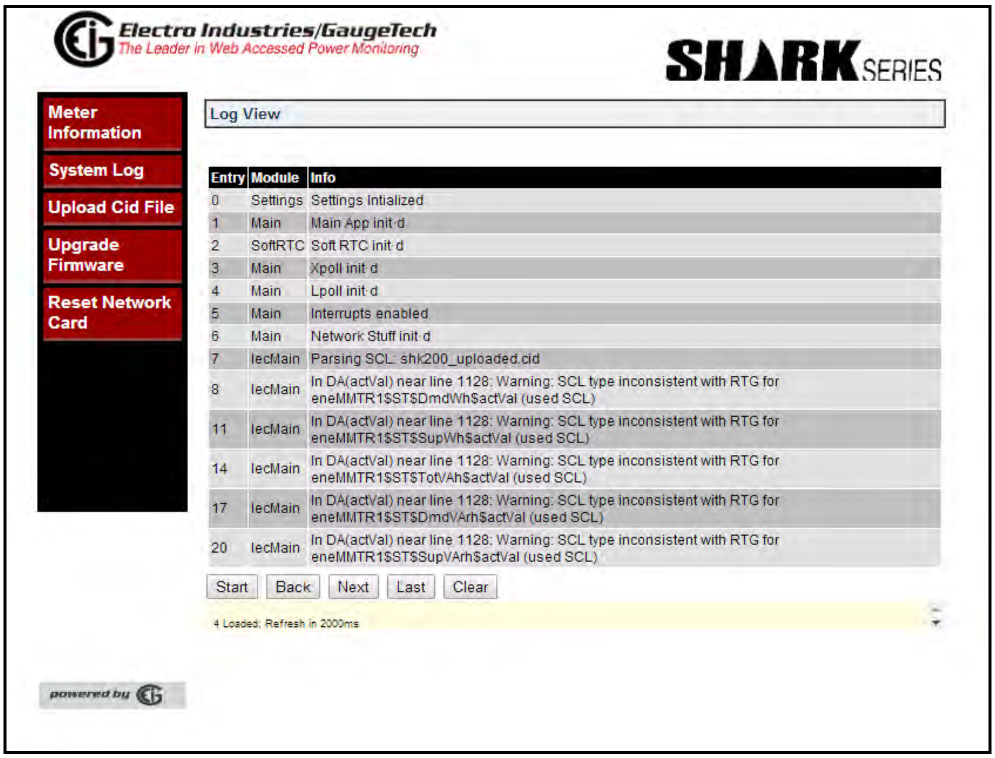
- If the uploaded .cid file has critical errors, the IEC 61850 will use the default .cid file (not the uploaded file) and it will start up. The errors can be seen in the Start Up log (instructions follow).

- The default .cid in the INP300S card is for demonstration only. It must be modified to suit the actual application needs.
- The default .cid in the INP300S has the arbitrary IED name of SHARK270IEC, which must be replaced by the user's own name.

12.4: Viewing the IEC 61850 Protocol Ethernet Network Card's System Log

The IEC 61850 Protocol Ethernet Network card's main webpage (Meter 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).

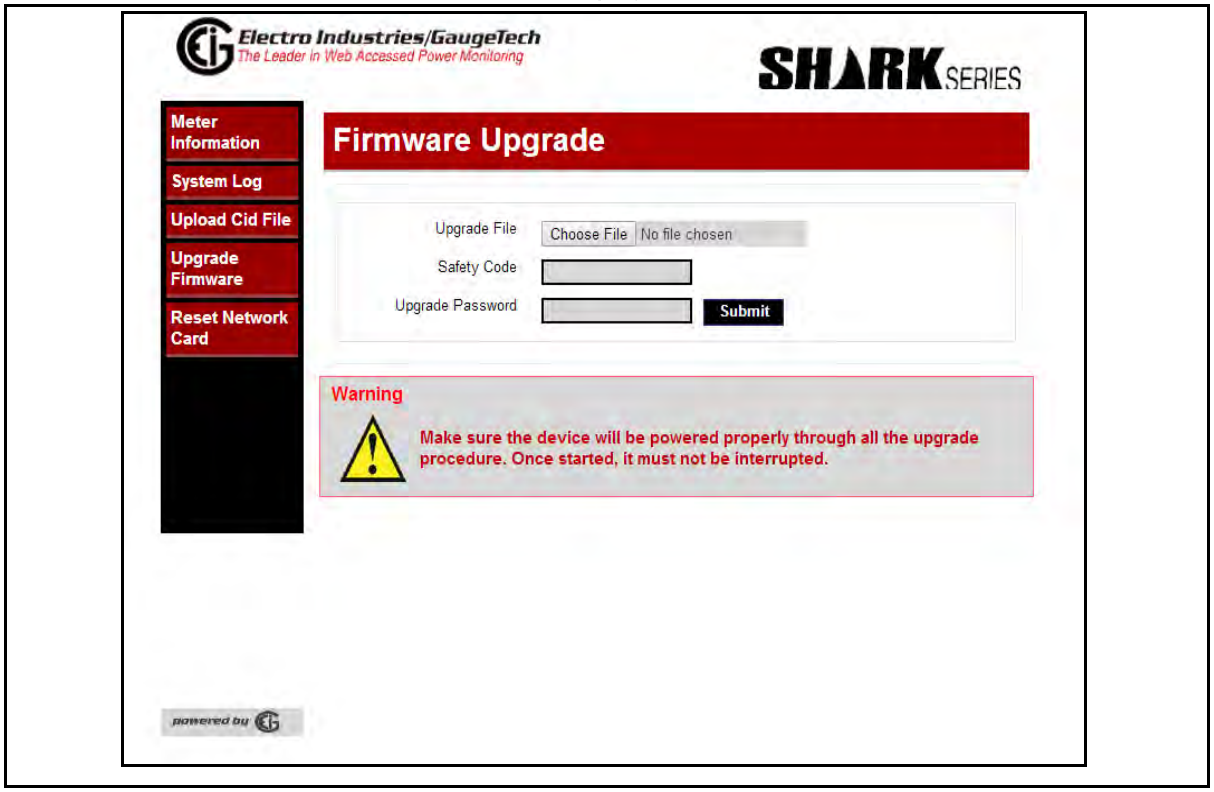
In addition to this information there is a System log, which contains events (e.g., errors and warnings) from the IEC 61850 protocol layer, including problems found when parsing the .cid file. To view the System log's webpage, click System Log from the left side of the Meter Information webpage.



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).

12.5: Upgrading the IEC 61850 Protocol Ethernet Network Card's Firmware

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



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

1. Click the Browse button to locate the Upgrade file. Make sure that you select the INP300S option card upgrade file. If you upgrade with the INP100S upgrade file, the card will work, but most IEC 61850 features will be disabled. In that case, perform the upgrade again, using the correct INP300S upgrade file.

2. Enter the Safety Code.

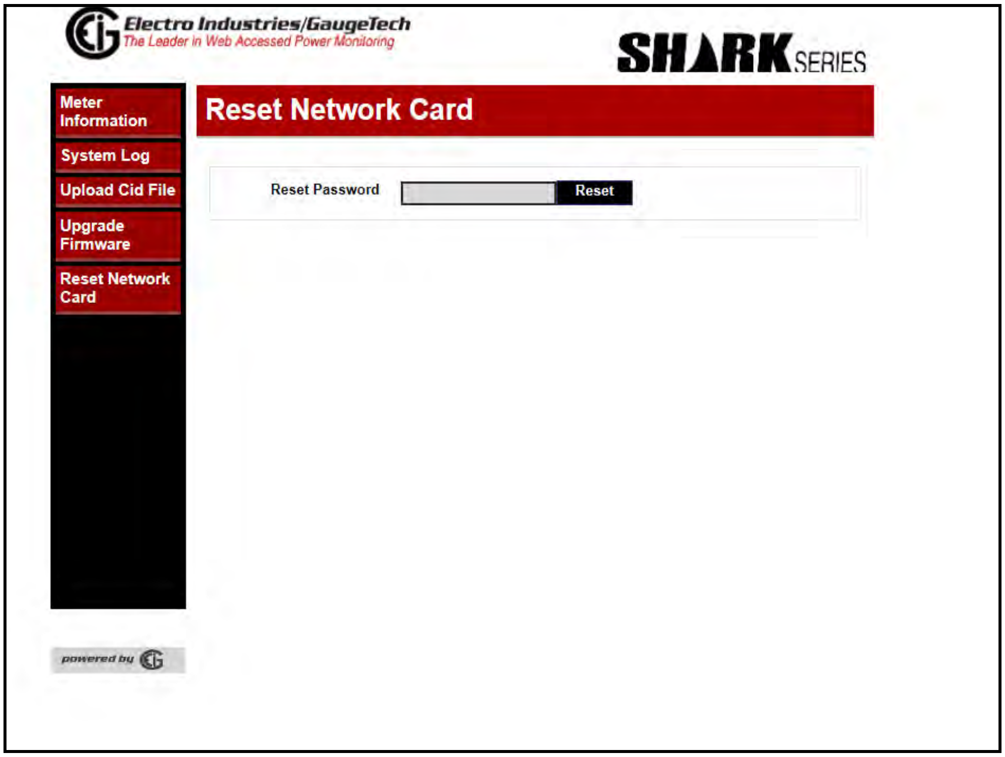
3. Enter the Upgrade Password: the default is n3tUp!0Ad for firmware runtime version 3.35 and later.

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.

12.6: Resetting the IEC 61850 Protocol Ethernet Network Card

If you need to reset the IEC 61850 Protocol Ethernet Network card, you can either do a hardware reset (see 10.4.2.2: Resetting the Ethernet Card, on page 10-15) or use the Reset Network Card webpage.

1. Click Reset Network Card from the left side of the webpage.



2. You will see a screen similar to the one shown above. Enter the Reset Password: the default is adminR35et for firmware runtime version 3.35 or later.

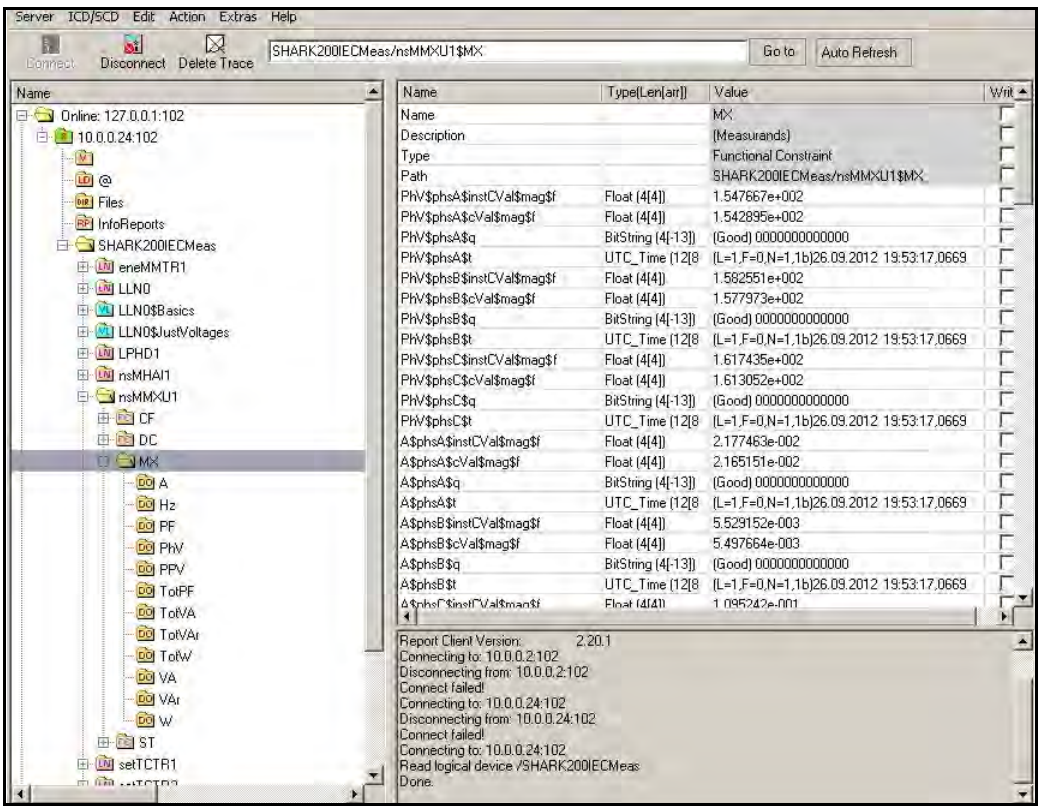
3. Click the Reset button. The Network card will reset.
   NOTE: As a result of the reset, the communication link with the card will be lost and must be re-established.

12.7: Keep-Alive Feature

The INP300S 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 10.4.5: Keep-Alive Feature, on page 10-16, for instructions on configuring this feature.

12.8: Testing

You can use any IEC 61850 certified tool to connect to the Shark® 270 meter and test out the IEC 61850 protocol (see example screen below). There are numerous commercial tools available for purchase.



12.9: 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 INP300.
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.

Code	Name	Description	Required Action
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 EIG's technical support.

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13: Shark® 270 Meter Logging

The Shark® 270 meter offers 12 logs. For details on programming the logs, see the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for complete instructions: Following are the available logs and a table that shows available logs by V-Switch™ key.

- 6 historical trending logs
    - Storage size: Maximum 6 MB per log; User programmable
    - Parameters logged: User programmable
    - Logging Interval: 1, 5, 10, 15, 30, or 60 minutes; User programmable
    - V-switch™ key: V2 and above
- Waveform log
    - Storage Size: Maximum 8MB; User programmable
    - Parameters Logged: Voltage and current waveform samples
    - Sampling rate: 32,64,128,256,512 samples per cycle; User programmable
    - V-switch™ key: V4 and above
- System Events Log
    - Storage Size: 256 KB
    - Parameters Logged: It logs all events that affect system function, e.g., time change, parameter reset, profile update, etc.
    - V-switch™ key: V2 and above
- Alarm Log
    - Storage Size: 256 KB
    - Parameters Logged: It logs all limit conditions when a parameter programmed for limit check goes out of limit
    - V-switch™ key: V2 and above
- I/O Change Log
    - Storage Size: 256 KB
    - Parameters Logged: Depending on the I/O it is configured for, it logs either:

- Changes in relay state in the event of an alarm condition
- Changes in the state of digital inputs

  - V-switch™ key: V2 and above

- Power Quality log
  - Storage Size: User programmable; Maximum 2 MB.
  - Parameter Logged: It logs all PQ events
  - V-switch™ key: V5 and above

V-Switch™ Key	Memory	Log size	Available Logs
1	NA	NA	NA
2	2 MB	2 MB	1. 3 Historical Logs 2. Alarm Log 3. Control output log 4. Input status change log
3	4 MB	2 MB	1. 3 Historical Logs 2. Alarm Log 3. Control output log 4. Input status change log
4	10 MB	2 MB	1. 6 Historical Logs 2. Alarm Log 3. Control output log 4. Input status change log 5. Waveform Log
5	128 MB	1. Max 6 MB per Historical log 2. Max 8 MB for Waveform Log 3. Max 2 MB for PQ log	1. 6 Historical Logs 2. Alarm Log 3. Control output log 4. Input status change log 5. Waveform Log 6. PQ log

A: Transformer Loss Compensation Spreadsheet and Examples

A.1: Calculating Values

Transformer Loss Compensation is discussed in Chapter 7. Values for three element installations can be calculated in two ways:

Through an Excel Spreadsheet:

1. 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 7.2.1.1: Three-Element Loss Compensation Worksheet, on page 7-6, 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.

A.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.

IMPORTANT! Refer to Appendix A of the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for additional instructions and information on the Transformer Line Loss application.

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1800 Shames Drive, Westbury, NY 11590

System Losses Summary

EIG Loss Compensation Calculator

Meter Correction Factors from this sheet are manually entered into EIG 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
% 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

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Transformer Losses

EIG 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 for Nexus**
Meter Test Amps	**TA**	**2.5**	**2.5 amps for Nexus**
Meter Class	**CL**	**20**	**Nexus CL20**
Meter Form	**Fm**		
Nominal Current	**Inom**	**2.5**	**Typically .5 Class(10) or TA(2.5)**

This spreadsheet is designed only to be used with EIG Nexus based metering equipment.

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Substation Losses

EIG 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	

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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.1.1: 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).

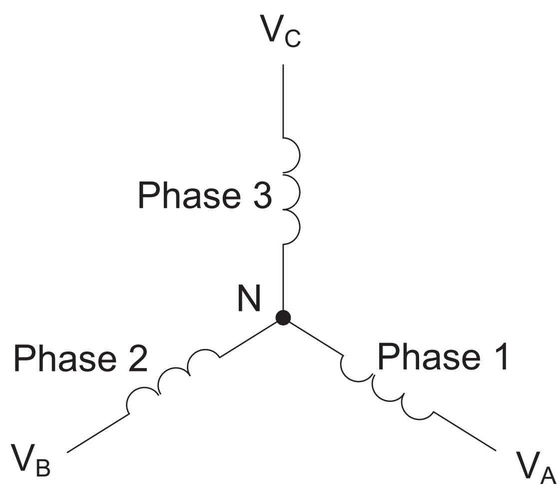

Figure B.1: Three-phase Wye Winding

The three voltages are separated by 120^o electrically. Under balanced load conditions the currents are also separated by 120^o. However, unbalanced loads and other conditions can cause the currents to depart from the ideal 120^o 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.

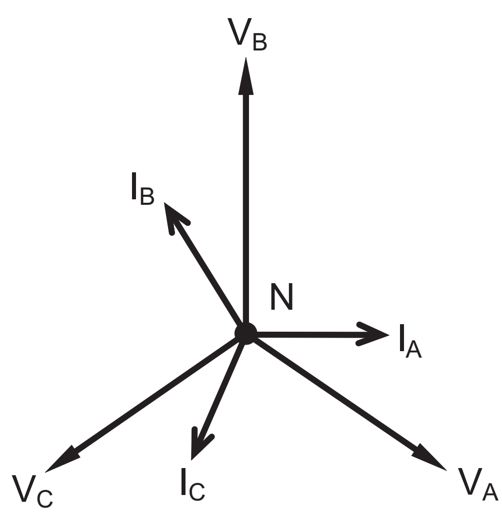

Figure B.2: Phasor Diagram Showing Three-phase Voltages and Currents

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 1 shows the common voltages used in the United States for wye-connected systems.

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

Table 1: Common Phase Voltages on Wye Services

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.1.2: 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.

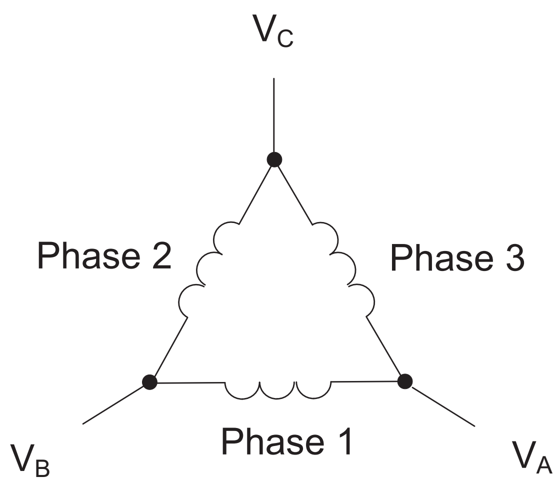

Figure B.3: Three-phase Delta Winding Relationship

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.

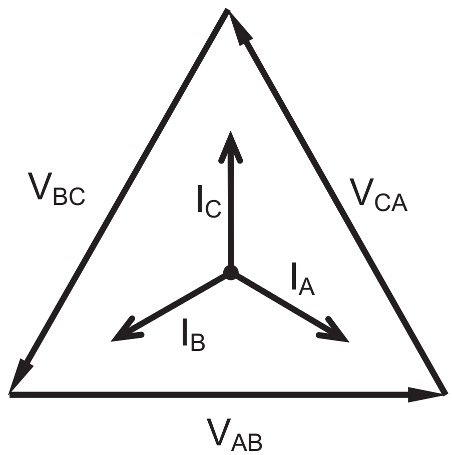

Figure B.4: Phasor Diagram, Three-Phase Voltages and Currents, Delta-Connected

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.

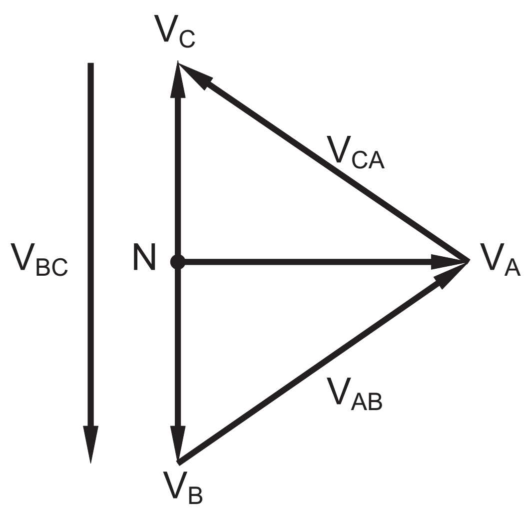

Figure B.5: Phasor Diagram Showing Three-phase Four-Wire Delta-Connected System

B.1.3: 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 calculate the individual phase power values one phase at a time. This means the meter samples the voltage and current on one phase and calculates a power value. Then it samples the second phase and calculates the power for the second phase. Finally, it samples the third phase and calculates that phase power. After sampling all three phases, the meter combines the three readings to create the equivalent three-phase power value. Using mathematical averaging techniques, this method can derive a quite accurate measurement of three-phase power.

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

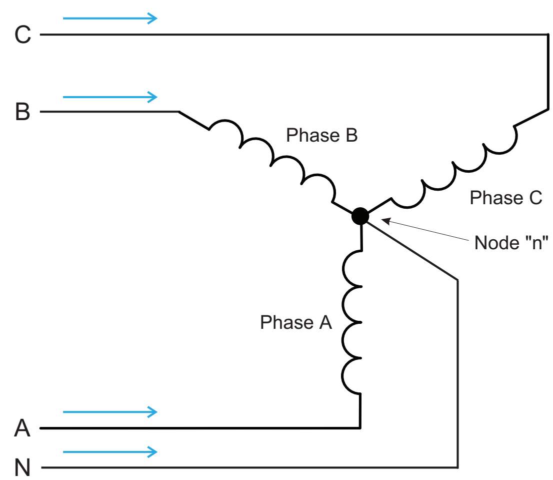

Figure B.6: Three-Phase Wye Load Illustrating Kirchhoff’s Law and Blondel’s Theorem

Blondel's Theorem is a derivation that results from Kirchhoff's Law. Kirchhoff's Law states that the sum of the currents into a node is zero. Another way of stating the same thing is that the current into a node (connection point) must equal the current out of the node. The law can be applied to measuring three-phase loads. Figure 1.6 shows a typical connection of a three-phase load applied to a three-phase, four-wire service. Kirchhoff'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 Kirchhoff'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.2: 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 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).

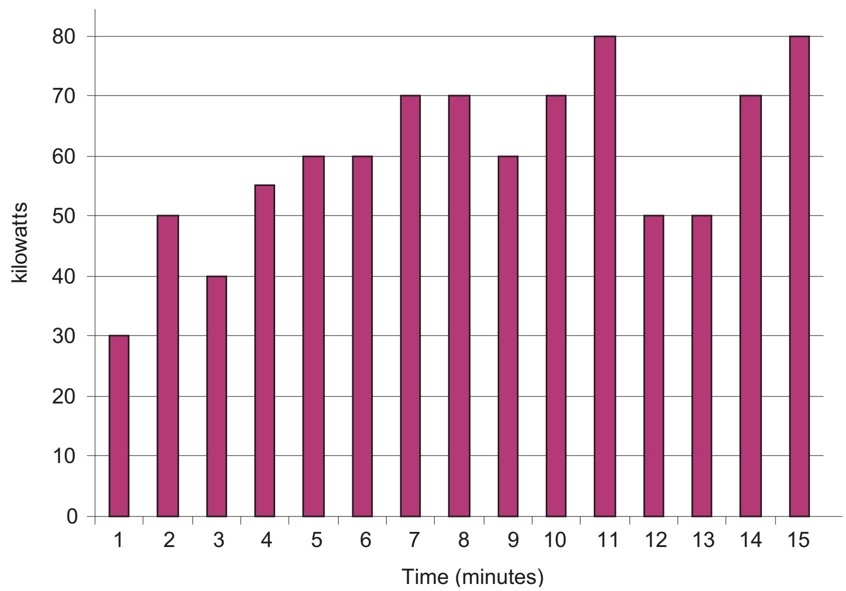

Figure B.7: Power Use over Time

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
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

Table 2: Power and Energy Relationship over Time

As in Table 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.

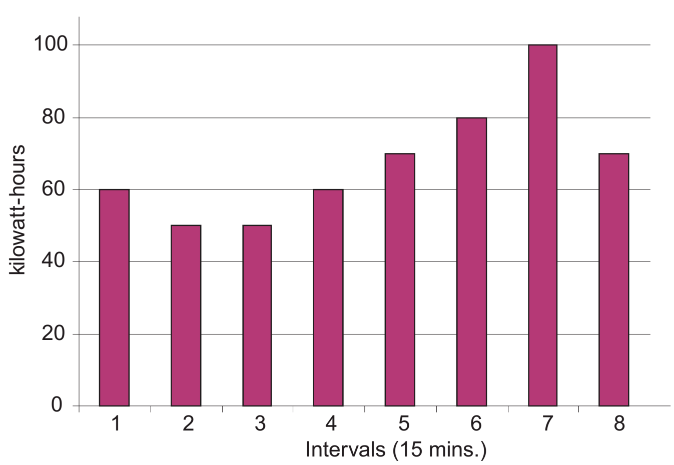

Figure B.8: Energy Use and Demand

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.3: 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 in-phase component and the component that is at quadrature (angularly rotated 90^o 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.

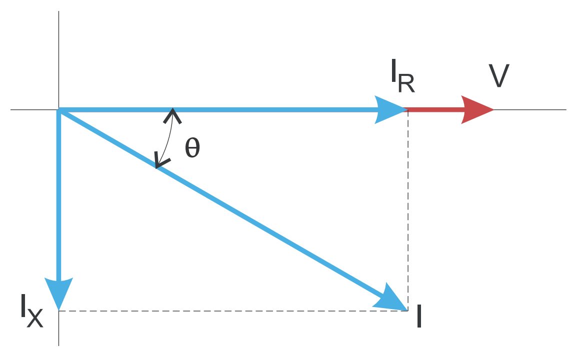

Figure B.9: Voltage and Complex Current

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

The quadrature current may be lagging the voltage (as shown 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 θ 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.4: 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.

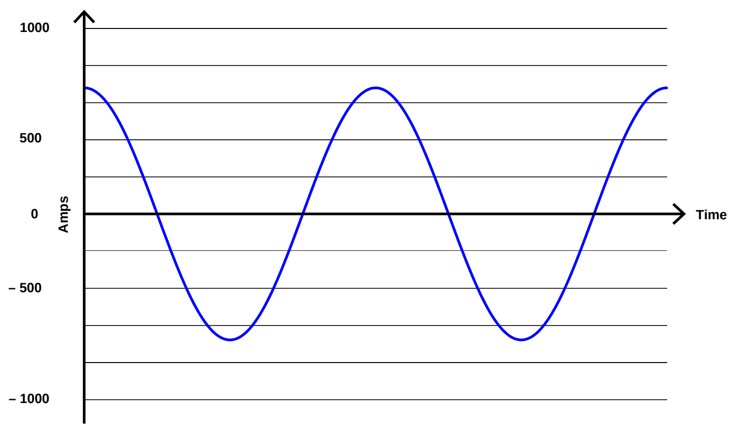

Figure B.10: Nondistorted Current Waveform

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.

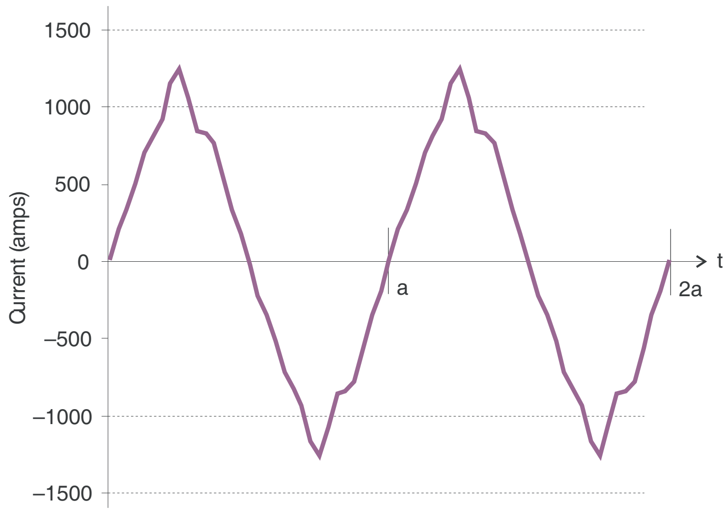

Figure B.11: Distorted Current Waveform

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.

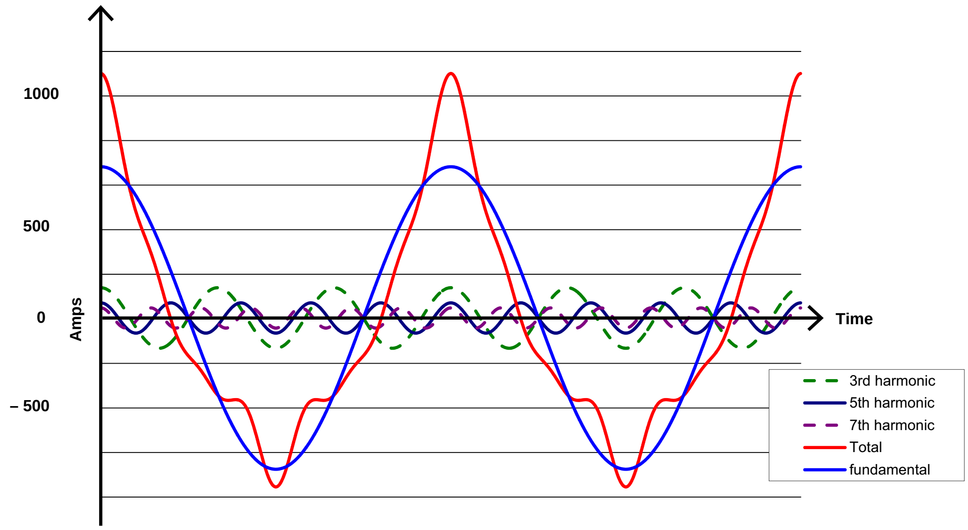

Figure B.12: Waveforms of the Harmonics

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.

X_L = jwL and

X_C = 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, new-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.5: 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 3.

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

Table 3: Typical Power Quality Problems and Sources

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.

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C: Shark® 270 Meter DNP Mapping

C.1: Overview

This Appendix describes the functionality of the Shark® 270 meter's version of the DNP protocol. A DNP programmer needs this information in order to retrieve data from the Shark® 270 meter using this protocol. The Shark® 270 meter's version of DNP is a reduced set of the Distributed Network Protocol Version 3.0 subset 2, with enough functionality to get critical measurements from the Shark® 270 meter.

The Shark® 270 meter's DNP version supports Class 0 object/qualifiers 0,1,2,6, only. No event generation is supported. The Shark® 270 meter always acts as a secondary device (slave) in DNP communication.

An important feature allows DNP readings in primary units with user-set scaling for current, Voltage, and power (see Chapter 26 in the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for instructions).

C.2: Physical Layer

DNP uses both Network (TCP/IP) and serial communication. DNP 3.0 serial communication can be assigned to Port 2 (RS485 compliant port) or any communication capable option board. Serial Speed and data format are transparent for DNP: they can be set to any supported value. The IrDA port cannot use DNP. DNP 3.0 over Ethernet is supported along with Modbus via a DNP 3.0-enabled Network card. DNP packets should be directed to the port assigned for DNP during the meter's Device Profile configuration (see Chapter 26 in the *Communicator EXT™ 4.0 and MeterManager EXT Software User Manual* for instructions). The DNP implementation is identical, regardless of the physical layer being used.

C.3: Data Link Layer

The Shark® 270 meter can be assigned a value from 1 to 65534 as the target device address for DNP. The data link layer follows the standard frame FT3 used by DNP Version 3.0 protocol, but only 4 functions are implemented: Reset Link, Reset User, Unconfirmed User Data, and Link Status, as depicted in the following table.

Function	Function Code
Reset Link	0
Reset User	1
Unconfirmed User Data	4
Link Status	9

Table C.1: Supported Link Functions

See C.7: DNP Object Point Map on page D-6, for more detail on supported frames for the data link layer.

In order to establish a clean communication with the Shark® 270 meter, we recommend that you perform the Reset Link and Reset User functions. The Link Status is not mandatory, but if queried, it will be attended to. The inter-character time-out for DNP is 1 second. If this amount of time, or more, elapses between two consecutive characters within a FT3 frame, the frame will be dropped.

C.4: Application Layer

The Shark® 270 meter's DNP version supports the Read, Write, Select, Operate, Direct Operate and Direct Operate Unconfirmed functions. All Application layer requests and responses follow the DNP standard. Some sample requests and responses are included in this Appendix (see C.8: DNP Message Layouts on page D-15).

- The Read function (code 01) provides a means of reading the critical measurement data and status from the meter. This function code, depending upon the qualifier, cab be used to read an individual object and point, a group of points within an object, or all points within an object. It is also used to read Object 60, variation 1, which will read all the available Class 0 objects from the DNP register map (see the Object map in C.6: Object Specifics on page D-4). In order to retrieve all objects with their respective variations, the qualifier must be set to ALL (0x06). See C.7:

DNP Object Point Map on page D-6, for an example showing a Read Class 0 request-data from the meter.

- The Write function (code 02) provides a means of clearing the Device restart bit in the Internal Indicator register, only. This is mapped to Object 80, point 0 with variation 1. When clearing the restart-device indicator, use qualifier 0. Section C.7 shows the supported frames for this function.

- The Select function (code 03) provides a means of selecting a Control Relay Output Block (CROB) (Object 12). This function can be used to select the Energy or Demand counters, or to select a Relay if there are any installed in the device.

- The Operate function (code 04) provides the means for repeating the operation of a previously selected CROB (Object 12) device. This function can be used to reset the Energy or Demand counters, or to operate a Relay if there are any installed in the device. The device must have been previously selected by the request immediately preceding the Operate command, and be received within the specified time limit (the default is 30 seconds). This function uses the same operation rules as a Direct Operate function.

- The Direct Operate function (code 05) provides the means for the direct operation of a CROB (Object 12) device. This function can be used for resetting the Energy and Demand counters (minimum and maximum energy registers) or controlling relays if there are any installed in the device. The relay must be operated (On) in 0 msec and released (Off) in 1 msec, only. Qualifiers 0x17 or x28 are supported for writing the energy reset. Sample frames are shown in Section C.7.

- The Direct Operate Unconfirmed (or Unacknowledged) function (code 06) is intended for asking the communication port to switch to Modbus RTU protocol from DNP. This switching is seen as a control relay mapped into Object 12, point 1 in the meter. The relay must be operated with qualifier 0x17, code 3 count 0, with 0 milliseconds on and 1 millisecond off, only. After sending this request the current communication port will accept Modbus RTU frames only. To make this port go back to DNP protocol, the unit must be powered down and up, again. Section C.7 shows the constructed frame to perform DNP to Modbus RTU protocol change.
  NOTE: This function has no effect when requested via a Network card.

C.5: Error Reply

In the case of an unsupported function, or any other recognizable error, an error reply is generated from the Shark® 270 meter to the Primary station (the requester). The Internal Indicator field will report the type of error: unsupported function or bad parameter.

The broadcast acknowledge and restart bit are also signaled in the Internal Indicator field, but they do not indicate an error condition.

C.6: Object Specifics

- Object 1 - Binary Input Status with Flags - These data points are mapped to the Digital Inputs on any Digital Relay Cards (RO1S) installed in the Shark® meter. They are only available if at least one Digital Relay Card is installed in the meter. The inputs on a card in Slot 1 are mapped to Points 0 and 1. The inputs on a card in Slot 2 are mapped to Points 2 and 3. If there is no card installed in a slot, those points will return a status with the “Offline” bit set.

- Object 10 - Binary Output States - These data points are mapped to the Digital Relays on any Digital Relay Cards (RO1S) installed in the Shark® meter. Data Points 3 through 6 are only available if there is at least one Digital Relay Card (RO1S) installed in the meter. The relays on a card in Slot 1 are mapped to Points 3 and 4. The relays on a card in Slot 2 are mapped to Points 5 and 6. If there is no card installed in a slot, those points will return a status with the "Offline" bit set.

- Object 12 - Control Relay Outputs - Points 0-2 reference internal controls. Points 3-6 are mapped to the Digital Relays on any Digital Relay Card (RO1S) installed in the Shark® meter. Control requests to relays not installed will return an unknown object response. See C.4: Application Layer on page D-2, for specific control mechanisms. Any relays that have been Assigned to a limit cannot be controlled via this command: the response status code will be 10 - Automation Inhibit, and no action will be taken.

- Object 20 - Binary Counters (Primary Readings) - Points 0-4 are mapped to Primary Energy readings, Points 5-8 are mapped to the Digital Inputs on any Digital Relay Card (RO1S) installed in the Shark® meter. If the digital inputs are set up as accumulators they can be read via this request; if they are not set up as accumulators the response will always be zero.

- Object 30 - Analog Inputs - These points may be either primary or secondary readings per a user setup option.
- Object 50 - Date and Time - This object supports the reading of the device's time, only.
- Object 60 - Class Objects - Class 0 requests, only, are supported.
  - Objects are returned, in the response, in the following order:
    - Object 20 all points (0-8) 32 bit values
    - Object 30 all points (count depends on settings) 16 bit values
    - Object 1 all points (0-3) 8 bit values
    - Object 10 all points (0-6) 8 bit values
- Object 80 - Internal Indicators - This request supports the clearing of the Restart bit. This is a write function, only, which should be done as soon as possible anytime the device has been restarted, as indicated by the restart bit being set in a response.

C.7: DNP Object Point Map

Object 1 - Binary Input Status with Flags

Read with Object 1, Var 2, and Qualifiers 0, 1, 2 or 6. (Included in Class 0 responses.)

Object	Point	Var	Description	Format	Range	Multiplier	Units	Comments
1	0	2	Read Digital Input 1 RO1S Status 1 (expansion port 1)	BYTE	Bit Flags	N/A	None	Returns the Status and State of the Input in the Flags.
1	1	2	Read Digital Input 2 RO1S Status 2 (expansion port 1)	BYTE	Bit Flags	N/A	None	Returns the Status and State of the Input in the Flags.
1	2	2	Read Digital Input 3 RO1S Status 1 (expansion port 2)	BYTE	Bit Flags	N/A	None	Returns the Status and State of the Input in the Flags.
1	3	2	Read Digital Input 4 RO1S Status 2 (expansion port 2)	BYTE	Bit Flags	N/A	None	Returns the Status and State of the Input in the Flags.

Supported Flags:

Bit 0: ONLINE (0=Offline, 1=Online) (If the Input is not present it will be shown as Offline.)

Bit 1: RESTART (1=The Object is in the Initial State and has not been updated since Restart.)

Bit 7: STATE (0=Off, 1=On)

Object 10 - Binary Output States

Read with Object 10, Var 2, and Qualifiers 0, 1, 2 or 6. (Included in Class 0 responses.)

Object	Point	Var	Description	Format	Range	Multiplier	Units	Comments
10	0	2	Reset Energy Counters	BYTE	Always 1	N/A	None	
10	1	2	Change to Modbus RTU Protocol	BYTE	Always 1	N/A	None	
10	2	2	Reset Demand Counters (Max / Min)	BYTE	Always 1	N/A	None	
10	3	2	Read Relay 1 State RO1S Relay 1 (expansion port 1)	BYTE	Bit Flags	N/A	None	Returns the Status and State of the Relay in the Flags.
10	4	2	Read Relay 2 State RO1S Relay 2 (expansion port 1)	BYTE	Bit Flags	N/A	None	Returns the Status and State of the Relay in the Flags.
10	5	2	Read Relay 3 State RO1S Relay 1 (expansion port 2)	BYTE	Bit Flags	N/A	None	Returns the Status and State of the Relay in the Flags.
10	6	2	Read Relay 4 State RO1S Relay 2 (expansion port 2)	BYTE	Bit Flags	N/A	None	Returns the Status and State of the Relay in the Flags.

Supported Flags:

Bit 0: ONLINE (0=Offline, 1=Online) (If the Input is not present it will be shown as Offline.)

Bit 1: RESTART (1=The Object is in the Initial State and has not been updated since Restart.)

Bit 7: STATE (0=Off, 1=On)

Object 12 - Control Relay Outputs

(Responds to Function 3 - Select, 4 - Operate, or 5 - Direct Operate; Count of 1 Only.)

(Control code 3 or 4, Qualifiers 17x or 28x, On - 0 msec; Off - 1 msec.)

(Only one control object at a time may be specified.)

Object	Point	Var	Description	Format	Range	Multiplier	Units	Comments
12	0	1	Reset Energy Counters	N/A	N/A	N/A	none	Control Code 3 only
12	1	1	Change to Modbus RTU Protocol	N/A	N/A	N/A	none	Responds to Function 6 (Direct Operate - No Ack), Qualifier Code 17x, Control Code 3, Count 0, On 0 msec, Off 1 msec ONLY.
12	2	1	Reset Demand Counters (Max / Min)	N/A	N/A	N/A	none	Control Code 3 only
12	3	1	Control Relay 1 RO1S Relay 1 (expansion port 1)	N/A	N/A	N/A	none	See Section C.4 for operation rules and parameters.
12	4	1	Control Relay 2 RO1S Relay 2 (expansion port 1)	N/A	N/A	N/A	none	See Section C.4 for operation rules and parameters.
12	5	1	Control Relay 3 RO1S Relay 1 (expansion port 2)	N/A	N/A	N/A	none	See Section C.4 for operation rules and parameters.
12	6	1	Control Relay 4 RO1S Relay 2 (expansion port 2)	N/A	N/A	N/A	none	See Section C.4 for operation rules and parameters.

Object 20 - Binary Counters (Primary Readings)

Read with Object 20, Var 5, and Qualifiers 0, 1, 2, or 6. (Included in Class 0 responses.)

Object	Point	Var	Description	Format	Range	Multiplier	Units	Comments
20	0	5	W-hours, Positive	UINT32	0 to 99999999	Multiplier = 10(n-d), where n and d are derived from the energyformat. n = 0, 3, or 6 per energy format scale and d = number of decimal places.	Whr	example: energy format = 7.2K and W-hours counter = 1234567 n=3 (K scale), d=2 (2 digits after deci-mal point), mul-tiplier = 10(3-2) = 101 = 10, so energy is 1234567 * 10 Whrs, or 12345.67 KWhrs
20	1	5	W-hours, Negative	UINT32	0 to 99999999		Whr	
20	2	5	VAR-hours, Positive	UINT32	0 to 99999999		VARhr	
20	3	5	VAR-hours, Negative	UINT32	0 to 99999999		VARhr	
20	4	5	VA-hours, Total	UINT32	0 to 99999999		VAhr	
20	5	5	Digital Input 1 RO1S Accu-mulator 1 (expansion port 1)	UINT32	0 to 9999			
20	6	5	Digital Input 2 RO1S Accu-mulator 2 (expansion port 1)	UINT32				
20	7	5	Digital Input 3 RO1S Accu-mulator 1 (expansion port 2)	UINT32				
20	8	5	Digital Input 4 RO1S Accu-mulator 2 (expansion port 2)	UINT32				

Object 30 - Analog Inputs (Secondary Readings)

Read with Object 30, Var 4, and Qualifiers 0, 1, 2, or 6. (Included in Class 0 responses.)

NOTE: Object 30 may be **either** primary or secondary readings per a user setup option. See page C-13 for the primary version of Object 30.

Object	Point	Var	Description	Format	Range	Multiplier	Units	Comments
30	0	4	Meter Health	SINT16	0 or 1	N/A	None	0 = OK
30	1	4	Volts A-N	SINT16	0 to 32767	(150 / 32768)	V	Values above 150V secondary read 32767.
30	2	4	Volts B-N	SINT16	0 to 32767	(150 / 32768)	V	
30	3	4	Volts C-N	SINT16	0 to 32767	(150 / 32768)	V	
30	4	4	Volts A-B	SINT16	0 to 32767	(300 / 32768)	V	Values above 300V secondary read 32767.
30	5	4	Volts B-C	SINT16	0 to 32767	(300 / 32768)	V	
30	6	4	Volts C-A	SINT16	0 to 32767	(300 / 32768)	V	
30	7	4	Amps A	SINT16	0 to 32767	(10 / 32768)	A	Values above 10A secondary read 32767.
30	8	4	Amps B	SINT16	0 to 32767	(10 / 32768)	A	
30	9	4	Amps C	SINT16	0 to 32767	(10 / 32768)	A	
30	10	4	Watts, 3-Ph total	SINT16	-32768 to +32767	(4500 / 32768)	W	
30	11	4	VARs, 3-Ph total	SINT16	-32768 to +32767	(4500 / 32768)	VAR	
30	12	4	VAs, 3-Ph total	SINT16	0 to +32767	(4500 / 32768)	VA	
30	13	4	Power Factor, 3-Ph total	SINT16	-1000 to +1000	0.001	None	
30	14	4	Frequency	SINT16	0 to 9999	0.01	Hz	

Object	Point	Var	Description	Format	Range	Multiplier	Units	Comments
30	15	4	Positive Watts, 3-Ph, Maximum Avg Demand	SINT16	-32768 to +32767	(4500 / 32768)	W	
30	16	4	Positive VARs, 3-Ph, Maximum Avg Demand	SINT16	-32768 to +32767	(4500 / 32768)	VAR	
30	17	4	Negative Watts, 3-Ph, Maximum Avg Demand	SINT16	-32768 to +32767	(4500 / 32768)	W	
30	18	4	Negative VARs, 3-Ph, Maximum Avg Demand	SINT16	-32768 to +32767	(4500 / 32768)	VAR	
30	19	4	VAs, 3-Ph, Maximum Avg Demand	SINT16	-32768 to +32767	(4500 / 32768)	VA	
30	20	4	Angle, Phase A Current	SINT16	-1800 to +1800	0.1	degree	
30	21	4	Angle, Phase B Current	SINT16	-1800 to +1800	0.1	degree	
30	22	4	Angle, Phase C Current	SINT16	-1800 to +1800	0.1	degree	
30	23	4	Angle, Volts A-B	SINT16	-1800 to +1800	0.1	degree	
30	24	4	Angle, Volts B-C	SINT16	-1800 to +1800	0.1	degree	
30	25	4	Angle, Volts C-A	SINT16	-1800 to +1800	0.1	degree	
30	26	4	CT numerator	SINT16	1 to 9999	N/A	none	CT ratio = numerator / denominator
30	27	4	Reserved	SINT16	0	N/A	none	
30	28	4	CT denominator	SINT16	1 or 5	N/A	none	
30	29	4	PT numerator (high word)	SINT16	1 to 65535	N/A	none	PT numerator is a 32 bit value, sent out as 2 16 bit words, high word first
30	30	4	PT numerator (low word)	SINT16	1 to 65535	N/A	none	
30	31	4	PT denominator	SINT16	1 to 9999	N/A	none	PT ratio = numerator / denominator

Object	Point	Var	Description	Format	Range	Multiplier	Units	Comments
30	32	4	Neutral Current	SINT16	0 to 32767	(10 / 32768)	A	For 1A model, multiplier is (2 / 32768) and values above 2A secondary read 32767
30	33	4	PowerFactor, Phase A	SINT16	-1000 to +1000	0.001	None	
30	34	4	Power Factor, Phase B	SINT16	-1000 to +1000	0.001	None	
30	35	4	Power Factor, Phase C	SINT16	-1000 to +1000	0.001	None	
30	36	4	Watts, Phase A	SINT16	-32768 to +32767	(4500/32768)	W	
30	37	4	Watts, Phase B	SINT16	-32768 to +32767	(4500/32768)	W	
30	38	4	Watts, Phase C	SINT16	-32768 to +32767	(4500/32768)	W	
30	39	4	VARs, Phase A	SINT16	-32768 to +32767	(4500/32768)	VAR	
30	40	4	VARS, Phase B	SINT16	-32768 to +32767	(4500/32768)	VAR	
30	41	4	VARs, Phase C	SINT16	-32768 to +32767	(4500/32768)	VAR	

Object 30 - Analog Inputs (Primary Readings)

Read with Object 30, Var 4, and Qualifiers 0, 1, 2, or 6. (Included in Class 0 responses.)

NOTE: Multipliers for Volts, Amps, and Power points are per user setup options.

Object	Point	Var	Description	Format	Range	Multiplier	Units	Comments
30	0	4	Meter Health	SINT16	0 or 1	N/A	None	0 = OK
30	1	4	Volts A-N	SINT16	0 to 32767	1, 10, or 100	V	Point value = Actual Volts/divisor
30	2	4	Volts B-N	SINT16	0 to 32767	1, 10, or 100	V	
30	3	4	Volts C-N	SINT16	0 to 32767	1, 10, or 100	V	
30	4	4	Volts A-B	SINT16	0 to 32767	1, 10, or 100	V	
30	5	4	Volts B-C	SINT16	0 to 32767	1, 10, or 100	V	
30	6	4	Volts C-A	SINT16	0 to 32767	1, 10, or 100	V	
30	7	4	Amps A	SINT16	0 to 32767	1 or 10	A	Point value = Actual Amps/divisor
30	8	4	Amps B	SINT16	0 to 32767	1 or 10	A	
30	9	4	Amps C	SINT16	0 to 32767	1 or 10	A	
30	10	4	Watts, 3-Ph total	SINT16	-32768 to +32767	1, 10, 100 or 1000	W	Point value = Actual kWatts/divi-sor
30	11	4	VARs, 3-Ph total	SINT16	-32768 to +32767	1, 10, 100 or 1000	VAR	
30	12	4	VAs, 3-Ph total	SINT16	0 to +32767	1, 10, 100 or 1000	VA	
30	13	4	Power Factor, 3-Ph total	SINT16	-1000 to +1000	0.001	None	
30	14	4	Frequency	SINT16	0 to 9999	0.01	Hz	
30	15	4	Positive Watts, 3-Ph, Maximum Avg Demand	SINT16	-32768 to +32767	1, 10, 100, or 1000	W	

Object	Point	Var	Description	Format	Range	Multiplier	Units	Comments
30	16	4	Positive VARs, 3-Ph, Maximum Avg Demand	SINT16	-32768 to +32767	1, 10, 100, or 1000	VAR	
30	17	4	Negative Watts, 3-Ph, Maximum Avg Demand	SINT16	-32768 to +32767	1, 10, 100, or 1000	W	
30	18	4	Negative VARs, 3-Ph, Maximum Avg Demand	SINT16	-32768 to +32767	1, 10, 100, or 1000	VAR	
30	19	4	VAs, 3-Ph, Maximum Avg Demand	SINT16	-32768 to +32767	1, 10, 100, or 1000	VA	
30	20	4	Angle, Phase A Current	SINT16	-1800 to +1800	0.1	degree	
30	21	4	Angle, Phase B Current	SINT16	-1800 to +1800	0.1	degree	
30	22	4	Angle, Phase C Current	SINT16	-1800 to +1800	0.1	degree	
30	23	4	Angle, Volts A-B	SINT16	-1800 to +1800	0.1	degree	
30	24	4	Angle, Volts B-C	SINT16	-1800 to +1800	0.1	degree	
30	25	4	Angle, Volts C-A	SINT16	-1800 to +1800	0.1	degree	
30	26	4	CT numerator	SINT16	1 to 9999	N/A	none	CT ratio = numerator / denominator
30	27	4	Reserved	SINT16	0	N/A	none	
30	28	4	CT denominator	SINT16	1 or 5	N/A	none	
30	29	4	PT numerator (high word)	SINT16	1 to 65535	N/A	none	PT numerator is a 32 bit value, sent out as 2 16 bit words, high word first
30	30	4	PT numerator (low word)	SINT16	1 to 65535	N/A	none	
30	31	4	PT denominator	SINT16	1 to 9999	N/A	none	PT ratio = numerator / denominator
30	32	4	Neutral Current	SINT16	0 to 32767	(10 / 32768)	A	Point value = Actual Amps/divisor
30	33	4	PowerFactor, Phase A	SINT16	-1000 to +1000	0.001	None	

Object	Point	Var	Description	Format	Range	Multiplier	Units	Comments
30	34	4	Power Factor, Phase B	SINT16	-1000 to +1000	0.001	None	
30	35	4	Power Factor, Phase C	SINT16	-1000 to +1000	0.001	None	
30	36	4	Watts, Phase A	SINT16	-32768 to +32767	(4500/32768)	W	
30	37	4	Watts, Phase B	SINT16	-32768 to +32767	(4500/32768)	W	
30	38	4	Watts, Phase C	SINT16	-32768 to +32767	(4500/32768)	W	
30	39	4	VARs, Phase A	SINT16	-32768 to +32767	(4500/32768)	VAR	
30	40	4	VARS, Phase B	SINT16	-32768 to +32767	(4500/32768)	VAR	
30	41	4	VARs, Phase C	SINT16	-32768 to +32767	(4500/32768)	VAR	

Object 80 - Internal Indicator

Object	Point	Var	Description	Format	Range	Multiplier	Units	Comments
80	7	1	Device Restart Bit	N/A	N/A	N/A	none	Clear via Function 2 (Write), Qualifier Code 0.

C.8: DNP Message Layouts

Legend

All numbers are in hexadecimal base. In addition the following symbols are used.

dst	16 bit frame destination address
src	16 bit frame source address
crc	DNP Cyclic redundant checksum (polynomial $x^{16}+x^{13}+x^{12}+x^{11}+x^{10}+x^{7}+x^{6}+x^{5}+x^{2}+1$)
x	transport layer data sequence number
y	application layer data sequence number

Link Layer related frames

Reset Link

Request	05	64	05	C0	dst	src	crc
Reply	05	64	05	00	src	dst	crc

Reset User

Request	05	64	05	C1	dst	src	crc
Reply	05	64	05	00	src	dst	crc

Link Status

Request	05	64	05	C9	dst	src	crc
Reply	05	64	05	0B	src	dst	crc

Application Layer related frames

Clear Restart

Request	05	64	0E	C4	dst	src	crc			
	Cx	Cy	02	50	01	00	07	07	00	crc
Reply	05	64	0A	44	src	dst	crc			
	Cx	Cy	81	int. ind.	crc					

Class 0 Data

NOTE: Point numbers are in decimal.

Request	05	64	0B	C4	dst	src	crc
	Cx	Cy	01	3C	01	06	crc

Request	05	64	14	C4	dst	src	crc									
(alter-nate)	Cx	Cy	01	3C	02	06	3C	03	06	3C	04	06	3C	01	06	crc

Reply (same for either request)	05	64	A1	44	src	dst	crc							
	Cx	Cy	81	int. ind.	14	05	00	00	08	0	1	crc		
	1	2	3	4	5	crc								
	5	6	7	8	1E	04	crc							
	0	0	29	0	1	2	3	4	5	6	crc			
	6	7	8	9	10	11	12	13	14	crc				
	14	15	16	17	18	19	20	21	22	crc				
	22	23	24	25	26	27	28	29	30	crc				
	30	31	32	33	34	35	36	37	38	crc				
	38	39	40	41	01	02	00	00	00	03	0	1	2	3	crc
	0A	02	00	00	06	0	1	2	3	4	5	6	crc		

Reset Energy

Request	05	64	18	C4	dst		src		crc								
	Cx	Cy	05	0C	01	17	01	00	03	00	00	00	00	00	01	00	crc
	00	00	00	crc													
Reply	05	64	1A	44	src		dst		crc								
	Cx	Cy	81	int. ind.		0C	01	17	01	00	03	00	00	00	00	00	crc
	01	00	00	00	00	crc											

Request (alternate)	05	64	1A	C4	dst		src		crc								
	Cx	Cy	05	0C	01	28	01	00	00	00	03	00	00	00	00	00	crc
	01	00	00	00	00	crc											
Reply	05	64	1C	44	src		dst		crc								
	Cx	Cy	81	int. ind.		0C	01	28	01	00	00	00	03	00	00	00	crc
	00	00	01	00	00	00	00	crc									

Switch to Modbus

Request	05	64	18	C4	dst		src		crc								
	Cx	Cy	06	0C	01	17	01	01	03	00	00	00	00	00	01	00	crc
	00	00	00	crc													
No Reply																	

Reset Demand (Maximums & Minimums)

Request	05	64	18	C4	dst		src		crc								
	Cx	Cy	05	0C	01	17	01	02	03	00	00	00	00	00	01	00	crc
	00	00	00	crc													
Reply	05	64	1A	44	src		dst		crc								
	Cx	Cy	81	int. ind.		0C	01	17	01	02	03	00	00	00	00	00	crc
	01	00	00	00	00	crc											

Request (alternate)	05	64	1A	C4	dst		src		crc								
	Cx	Cy	05	0C	01	28	01	02	00	00	03	00	00	00	00	00	crc
	01	00	00	00	00	crc											
Reply	05	64	1C	44	src		dst		crc								
	Cx	Cy	81	int. ind.		0C	01	28	01	02	00	00	03	00	00	00	crc
	00	00	01	00	00	00	00	crc									

Error Reply

Reply	05	64	0A	44	src		dst		crc
	Cx	Cy	81	int. ind.		crc			

C.9: Internal Indication Bits

Bits implemented in the Shark® 270 meter are listed below. All others are always reported as zeros.

Bad Function

Occurs if the function code in a User Data request is not Read (0x01), Write (0x02), Direct Operate (0x05), or Direct Operate, No Ack (0x06).

Object Unknown

Occurs if an unsupported object is specified for the Read function. Only objects 10, 20, 30, and 60 are supported.

Out of Range

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

Occurs if a read request or a read response is too large for its respective buffer. In general, if the request overflows, there will be no data in the response while if the response overflows at least the first object will be returned. The largest acceptable request has a length field of 26, i.e. link header plus 21 bytes more, not counting checksums. The largest possible response has 7 blocks plus the link header.

Restart
All Stations

These 2 bits are reported in accordance with standard practice.