USER MANUAL

RGM40 Compact DIN rail mounted energy and power quality meter

Table of contents

1. Introduction

1.1 Disclaimer

The data, examples and diagrams in this manual are included solely for the concept or product description and are not a statement of guaranteed properties. All persons responsible for applying the equipment described in this manual must ensure that each intended application is suitable and acceptable, and that all applicable safety or other operational requirements are met.

In particular, all risks in applications where a system failure and/or product failure would create a risk of harm to property or persons (including but not limited to personal injuries or death) shall be the sole responsibility of the person or entity who applies the equipment, and such parties are hereby requested to ensure that all measures are taken to exclude or mitigate such risks.

This document has been carefully checked for accuracy by ABB, but discrepancies cannot be completely discounted. If you discover something you think is inaccurate or incorrect, please notify ABB. With the exception of explicit contractual commitments, in no event shall ABB be responsible or liable for any loss or damage resulting from use of this manual or application of the equipment.

1.2 Safety information

WARNING

Dangerous voltages can occur on the connectors, even when the auxiliary voltage has been disconnected.

Failure to follow instructions and standard safety procedures can result in death, personal injury or substantial property damage.

Only a qualified electrician must be allowed to perform the electrical installation tasks.

National and local electrical safety regulations must always be followed.

RGM40 must be grounded.

1.3 Symbols

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

DANGER

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

DANGER HIGH VOLTAGE

Danger High Voltage alerts you to the presence of high voltage, which can cause dangerous electrical shock.

Grounding 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.

WARNING

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

CAUTION

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

NOTICE

Notice is used to address practices not related to physical injury.

2. Meter overview and specifications

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01 Figure 1:
RGM40 meter

2.1 RGM40 meter overview
The RGM40 meter is a compact energy and power quality meter designed for DIN rail installation. The unit provides multifunction measurement of all electrical parameters and makes the data available in multiple formats via display and communication systems.

The RGM40 offers extensive onboard memory for data logging, load profiling and power quality analysis. The unit provides you with three historical logs, a log of limit alarms, a power quality log, a waveform log and a system events log. The purpose of these features includes historical load profiling, voltage analysis and recording power factor distribution. The RGM40 meter's real-time clock allows all events to be time stamped.

The RGM40 meter is designed with advanced measurement capabilities, allowing it to achieve high performance accuracy. It is specified as a 0.2% class energy meter for billing applications as well as a highly accurate panel indication meter. It supplies 0.001 Hz frequency resolution, which meets generating stations' requirements.

The RGM40 meter provides robust communication capabilities, including a standard micro-USB port and one of the following ports: a standard RS485 port communicating Modbus and DNP3 protocols, a standard 10/100BaseT Ethernet port communicating Modbus TCP/IP protocol or a standard BACnet/IP module communicating BACnet/IP and Modbus TCP/IP.

UL 61010-1 does not address performance criteria for revenue-generating watt-hour meters for use in metering of utilities and/or communicating directly with utilities, or use within a substation. Use in revenue metering, communicating with utilities and use in substations was verified according to the ANSI and IEC standards listed in the Compliance section on page 10.

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Features of the RGM40 meter include:

- 0.2% class revenue certifiable energy and demand metering
  - Meets ANSI C12.20 0.2 CL and IEC 62053-22 0.2S classes
- Multifunction measurement including voltage, current, power, frequency, energy, etc.
- mV option supports 0.333 V CTs and Rogowski coil CTs
- Optional secondary voltage display
- Power quality measurements (THD and alarm limits) — for meters with V-Switch™ keys 3–6, symmetrical components, voltage unbalance and current unbalance are also available and can be used with the limits functionality
- 0.001% frequency resolution for generating stations
- Interval energy logging
- Line frequency time synchronization
- LED display for high visibility
- Easy-to-use faceplate programming
- USB port for laptop PC read
- Choice between RS485, 10/100BaseT Ethernet or BACnet/IP communication
- Sampling rate of up to 512 samples per cycle for waveform recording
- Compact size DIN rail mounted
- Transformer/line loss compensation

2.1.1: Voltage and current inputs

Voltage inputs

Voltage inputs allow measurement up to nominal 576 V AC line to neutral (300 V max per UL 61010-1) and 721 V AC, line to line, (600 V max per UL 61010-1). The unit will perform to specification when directly connected to 69 volt, 120 volt, 230 volt, 277 volt and 347 volt power systems. See chapter 3. Electrical installation, page 12, for more details.

Note:

Higher voltages require the use of potential transformers (PTs).

Current inputs

For secondary measurements, the unit supports a 5 A, 1 A or a 0.333 V (mV option) secondary output.

Note:

The secondary current must be specified and ordered with the meter — see ordering information on the following page.

NOTICE

Important!

- For all models: The current inputs are only to be connected to listed energy-monitoring external current transformers.
- For the mV option: Rogowski coil CTs are also supported.

2.1.2: Ordering information for ABB ReliaGear™ neXT power panel only

Power panel RGM40 nomenclature

R G M 4 0 V 1 M X

Digit 1–5

Description	Code
Main meter	R G M 4 0

Digit 8

Description	Code
Modbus RTU	M
Modbus TCP	T
BACnet	B

Digit 6–7

Description	Code
Standard	V 1
Standard + basic datalog	V 2
Advanced: datalog, PQ, waveform	V 6

Advanced: data logging, harmonics analysis, 512 samples per cycle waveform recorder.

Digit 9

Description	Code
No transformer 120/240 V single-phase, 120/240 V delta high-leg, 208/120 V wye, 480/277 V wye	X
With transformer 240, 480, 600 V delta, 600/347 V wye	T

Example:
RGM40V1MX is a standard plug-in meter for ReliaGear neXT power panels with 333 mV secondary, multifunction meter only capabilities (no data logging), Modbus RTU and intended for 120/240 V single-phase, 120/240 V delta high-leg, 208/120 V wye or 480/277 V wye power systems.

2.1.3 Measured values

The RGM40 meter provides the following measured values all in real time instantaneous. As the table below shows, some values are also available in average, maximum and minimum.

Measured values	Instantaneous	Avg	Max	Min
Voltage l-n	X		X	X
Voltage l-l	X		X	X
Current per phase	X	X	X	X
Current neutral	X	X	X	X
Watt (a, b, c, tot.)	X	X	X	X
Var (a, b, c, tot.)	X	X	X	X
Va (a, b, c, tot.)	X	X	X	X
Pf (a, b, c, tot.)	X	X	X	X
+Watt-hour (a, b, c, tot.)	X			
-Wh (a, b, c, tot.)	X			
Wh net	X			
+VARh (a, b, c, tot.)	X			
-VARh (a, b, c, tot.)	X			
VARh net (a, b, c, tot.)	X			
Vah (a, b, c, tot.)	X			
Frequency	X		X	X
Harmonics to the 40^{th} order	X			
THD	X		X	X
Voltage angles	X			
Current angles	X			
Waveform scope	X			

2.1.5 Utility peak demand

The RGM40 meter provides user-configured block 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. Voltage provides An instantaneous max and min reading that displays the highest surge and lowest sag seen by the meter. All other parameters offer max and min capability over the user-selectable averaging period.

2.2 Specifications

Power supply	
Range:	(90 to 300) V AC
Power consumption:	(6 to 13) VA, (4.5 to 10) W depending on the meter's hardware configuration
Burden:	10 VA max (8 VA nominal)

Voltage inputs	
Absolute Maximum Range:	Auto-ranging: Line to neutral to (Va, Vb, Vc to Vref): (20 to 576*) V AC *300 V max per UL 61010-1 for current input models; (0-600) V AC for the mV option Line to line (Va to Vb, Vb to Vc, Vc to Va): (0 to 721*) V AC *600 V max per UL 61010-1 for all models
Supported hookups:	(6 to 13) VA, (4.5 to 10) W depending on the meter's hardware configuration
Input impedance:	4 MΩ/phase
Burden:	0.36 VA/phase max at 600 volts; 0.014 VA at 120 volts
Pickup voltage:	20 V AC
Connection:	7-pin 0.400 inch pluggable terminal block #14–26 AWG/ (0.129 - 2.08) mm^2
Surge withstand:	Meets IEEE C37.90.1
Reading:	Programmable full scale to any PT ratio

(For accuracy specifications, see 2.4: Accuracy, on page 10.)
See 3. Electrical installation, page 12 for more details.

Current inputs	
Class 10:	5 A nominal CT secondary; 10 A maximum
Class 2:	1 A nominal CT secondary; 2 A maximum
Burden:	0.005 VA/phase max at 11 A
Burden:	0.36 VA/phase pax at 600 volts; 0.014 VA at 120 volts
Pickup current:	0.1% of nominal (0.2% of nominal if using current only mode, that is, there is no connection to the voltage inputs)
Fault withstand (at 23 °C):	100 A for 10 seconds
Continuous Current withstand:	20 A
Mv option:	0.333 V input
Option input impedance:	2 MΩ
Option maximum voltage:	5 V
Pickup current:	0.004 V

(For Accuracy specifications, see 2.4: Accuracy, on page 10.)

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RS485 specifications	
RS485 transceiver; meets or exceeds EIA/TIA-485 standard	
Type:	Two-wire, half duplex
Min. input impedance:	96 MΩ
Max. output current:	±60 mA

Ethernet specifications	
Type:	RJ45 port — used by both the INP10 (10/100BaseT Ethernet) and INP10B (BACnet/IP) options

Isolation	
I/Os isolation from power line rated connections:	2500 V AC (Hi-pot tested)

Environmental rating	
Storage:	(-20 to +70) °C
Operating:	(-20 to +70*) °C
Humidity:	to 95% RH non-condensing
Pollution degree:	2
Ingress protection:	IP30 (front and back)

*UL evaluated to 65 °C

Measurement methods	
Voltage, current:	True RMS
Power:	Sampling at over 400 samples per cycle on all channels

Update rate	
Watts, VAR and VA:	Every 6 cycles (e.g., 100 ms at 60 Hz)
All other parameters:	Every 60 cycles (e.g., 1 s at 60 Hz) 1 second for current only measurement, if reference voltage is not available

Communication	
Standard:	
Micro USB port through faceplate:	
Protocol	Modbus ASCII
Com port baud rate	9600 to 57600 bps
Com port address	001-247
Data format:	8-bit, no parity
Either RS485, 10/100BaseT Ethernet or BACnet/IP (only one of these communication options is allowed per meter)	
Rs485:	
Protocol	Serial Modbus RTU, DNP3
Com port baud rate	1200, 2400, 4800 bps
Com port address	001-247; DNP only - 001 - 65520
Data format	8-bit; even, odd or no parity
10/100BaseT Ethernet:	
Protocol	Modbus TCP/IP
Com port baud rate	9600 to 57600 bps
Com port address	001-247
BACnet/IP	
Protocol	BACnet/IP, Modbus TCP/IP*
Com port baud rate	9600 to 57600 bps
Com port address	001-247

*Modbus TCP/IP implementation is limited.

Mechanical parameters	
Dimensions:	4.89 in. wide 4.60 in. high 2.44 in. deep
WABBht:	2 lbs./0.91 kg

2.3 Compliance

- ANSI C12.20 2015 0.2 CL and ANSI C12.1*
- IEC 62053-22 0.2S*
- Certified to UL 61010-1 and CSA C22.2 No. 61010-1, UL File: E250818
- REACH/RoHS
- CE Marked

* ANSI and IEC compliance apply to the Class 10 version of the meter. For the mV option, the meter must be paired with a high accuracy CT to test for ANSI and IEC compliance.

2.4: Accuracy

For full range specifications, see 2.2: Specifications, on page 9.

RGM40 clock accuracy:

Max. ±2 seconds per day at 25 °C

For 23 °C, 3-phase balanced wye or delta load, at 50 or 60 Hz (as per order), 5 A (Class 10) nominal unit, accuracy as follows:

Parameter	Accuracy	Accuracy input range[1]
Voltage L-N [V]	0.1% of reading	(69 to 480) V5
Voltage L-L [V]	0.2% of reading 2	(120 to 600) V
Current phase [A]	0.2% of reading 1, 3	(0.15 to 5) A
Current neutral (calculated) [A]	2% of full scale 1	(0.15 to 5) A at (45 to 65)Hz
Active power total [W]	0.2% of reading 1, 2	(0.15 to 5) A at (69 to 480) V5 at ± (0.5 to 1) lag/lead P
Active energy total [Wh]	0.2% of reading 1, 2	(0.15 to 5) A at (69 to 480) V5 at ± (0.5 to 1) lag/lead PF
Reactive power total [VAR]	0.2% of reading 1, 2	(0.15 to 5) A at (69 to 480) V5 at ± (0 to 0.8) lag/lead PF
Reactive energy total [VARh]	0.2% of reading 1, 2	(0.15 to 5) A at (69 to 480) V5 at ± (0 to 0.8) lag/lead PF
Apparent power total [VA]	0.2% of reading 1, 2	(0.15 to 5) A at (69 to 480) V5 at ± (0.5 to 1) lag/lead PF
Apparent energy total [VAh]	0.2% of reading 1, 2	(0.15 to 5) A at (69 to 480) V5 at ± (0.5 to 1) lag/lead PF
Power factor	0.2% of reading 1, 2	(0.15 to 5) A at (69 to 480) V5 at ± (0.5 to 1) lag/lead PF
Frequency [Hz]	±0.007 Hz	(45 to 65) Hz
Total harmonic distortion [%]	±2% 1, 4	(0.5 to 10) A or (69 to 480) V5, measurement range (1 to 99.99)%

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

   For 1 A (Class 2) nominal, degrade accuracy to 0.5% of reading for watts and energy; all other values 2 times rated accuracy.

   For 1 A (Class 2) nominal, the input current range for accuracy specification is 20% of the values listed in the table.

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

3. With reference voltage applied (VA, VB, or VC). Otherwise, degrade accuracy to 0.2%. See hookup diagrams 8, 9 and 10 in 3.5: Electrical Connection Diagrams, on page 13.

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

5. Up to 300 V as per UL.

3. Electrical installation

3.1 Considerations when installing meters

WARNING

Installation of the RGM40 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 RGM40, dangerous voltages are present in many parts of the meter, including terminals and any connected CTs (current transformers) and PTs (potential transformers).

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 for primary protection or in an energy-limiting capacity. The meter can only be used as secondary protection.

Do not use the meter for applications where failure of the meter may cause harm or death. Do not use the meter for any application where there may be a risk of fire.

All meter terminals should be inaccessible after installation.

Do not apply more than the maximum voltage the meter or any attached device can withstand. Refer to meter and/or device labels and to the specifications for all devices before applying voltages. Do not HIPOT/dielectric test any outputs, inputs or communications terminals.

ABB 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. CT grounding is optional, but recommended.

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

WARNING

To reduce risk of electric shock, always open or disconnect circuit from power-distribution system (or service) of building before installing or servicing current transformers

NOTICE

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

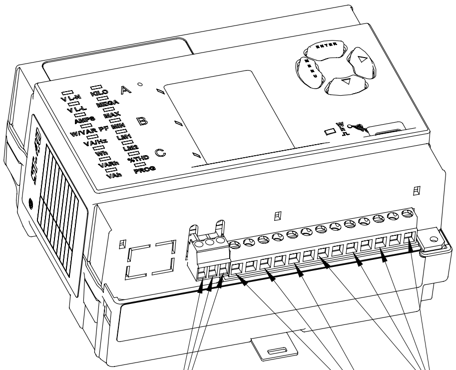
- There is no required preventive maintenance or inspection necessary for safety. However, any repair or maintenance should be performed by the factory.

Disconnect device
The following part is considered the equipment disconnect device: A switch or circuit breaker shall be included in the end-use equipment or building installation. The switch shall be in close proximity to the equipment and within easy reach of the operator. The switch shall be marked as the disconnecting device for the equipment.

—
01 RGM40
meter connections

3.2 Voltage and power supply connections

Voltage inputs are connected to the back of the unit via optional wire connectors. The connectors accommodate #14–26 AWG (0.129–2.08 mm²) wire.



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You will not see the RS485 connections if your RGM40 meter has the Ethernet or BACnet option.

3.3 Ground connections

The meter's ground terminals should be connected directly to the installation's protective earth ground. Use #14 AWG (2.08 mm²) wire for this connection.

3.4 Voltage fuses

ABB requires the use of fuses on each of the sense voltages and on the control power.

- Use a 0.1 A fuse on each voltage input.
- Use a 3 A slow-blow fuse on the power supply.

3.5 Electrical connection diagrams

The following pages contain electrical connection diagrams for the RGM40. Choose the diagram that best suits your application. Be sure to maintain the CT polarity when wiring.

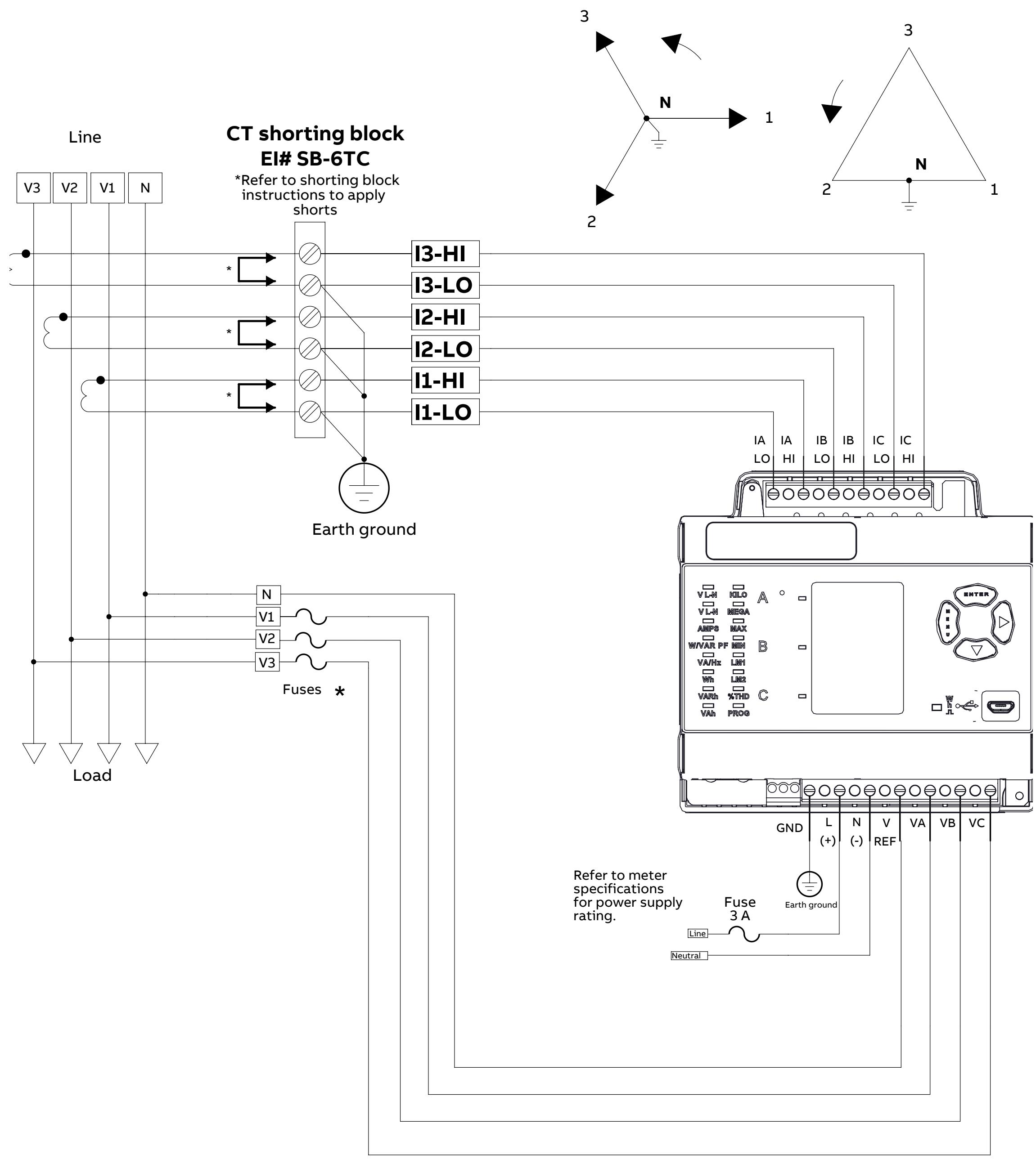
NOTICE

- Any unused sense voltage inputs must be shorted to Vref input.
- When using a 0.333 V input for current, a maximum of 5 V should be applied.
- When using a 0.333 V input for current, shorting blocks are optional.

1. A priority client is never disconnected at the initiative of the server to make room for another client.
   a. Example of dual-phase hookup
   b. Example of single-phase hookup
2. Three-phase, four-wire wye with direct voltage, 3 CTs, 2.5-element
3. Three-phase, four-wire wye/delta with PTs, 3 CTs, 3-element
4. Three-phase, four-wire wye with 2 PTs, 3 CTs, 2.5-element
5. Three-phase, three-wire delta with direct voltage, 2 CTs
6. Three-phase, three-wire delta with 2 PTs, 2 CTs
7. Current only measurement (three-phase)
8. Current only measurement (dual-phase)
9. Current only measurement (single-phase)

03

1. Service: Wye/delta, 4-wire with no PTs, 3 CTs



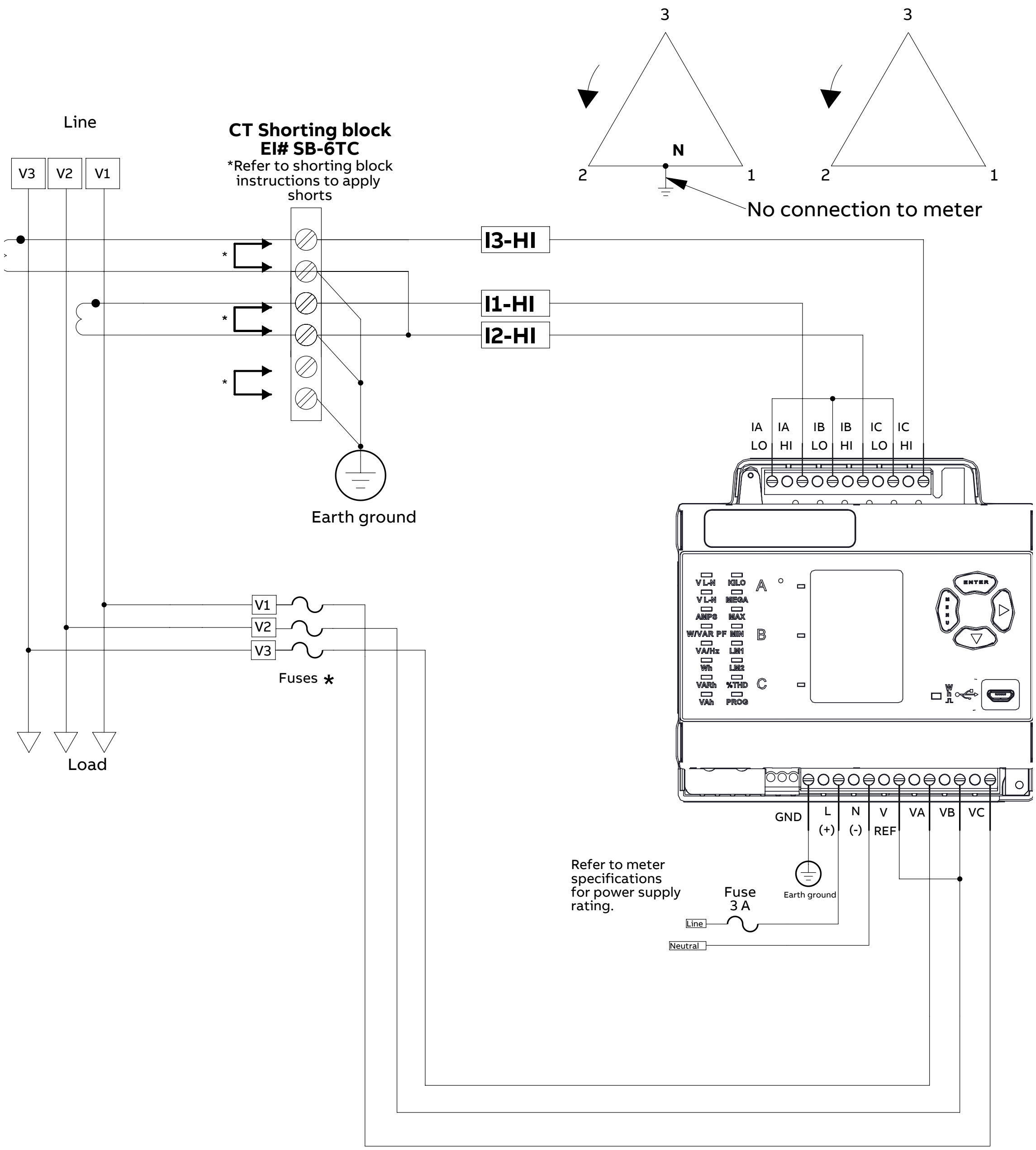
For ratings, see voltage fuses on page 13.

Select:
“ 3 EL wye ” (3-element wye) from the RGM40 meter’s front panel display (see Chapter 5).

WARNING

Important
For delta connections, do not exceed 480 V ungrounded or 240 V corner grounded.

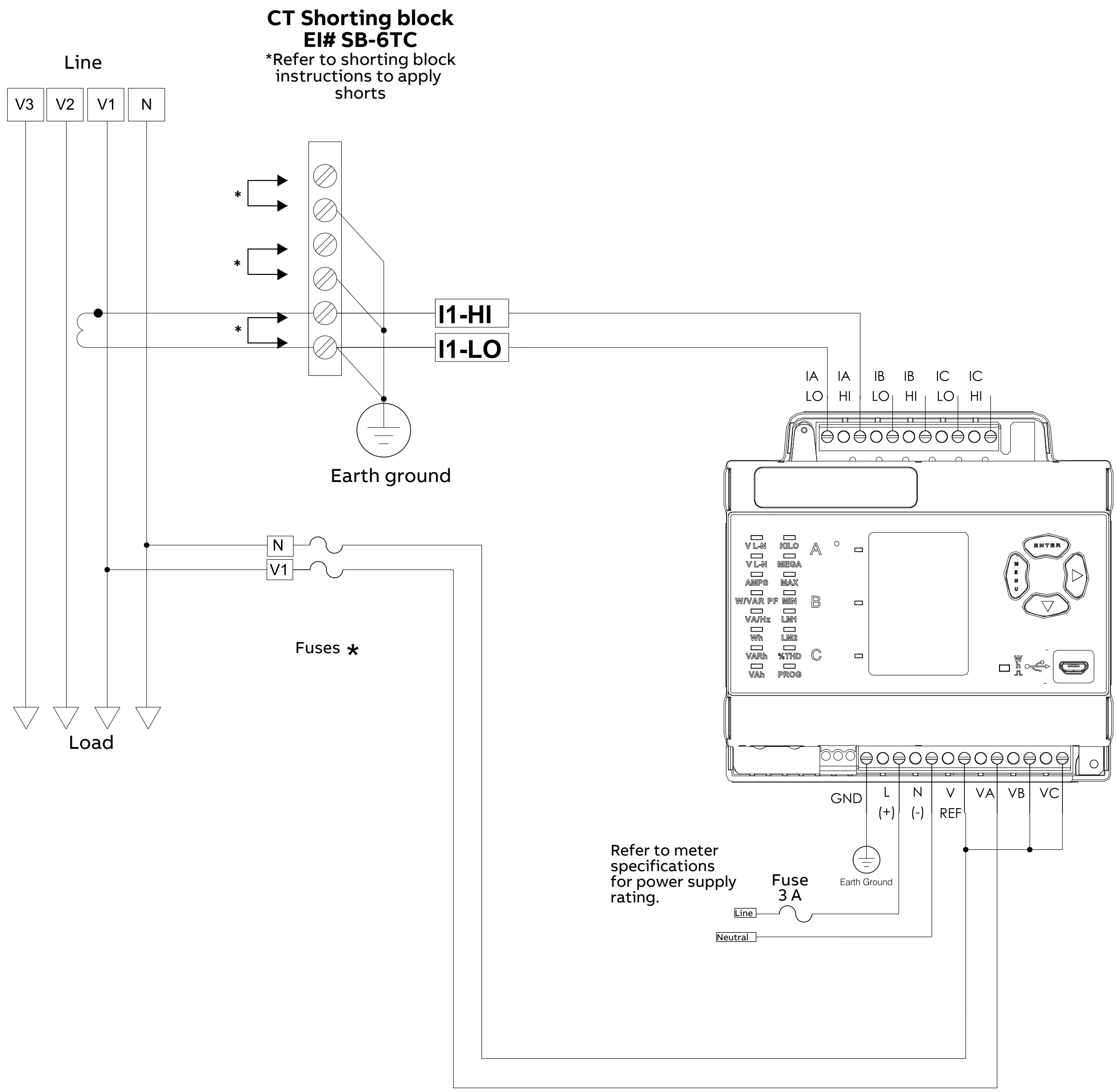
1a. Example of dual-phase hookup



For ratings, see voltage fuses on page 13.

Select:
" 3 EL wye " (3-element wye) from the RGM40 meter's front panel display (see Chapter 5).

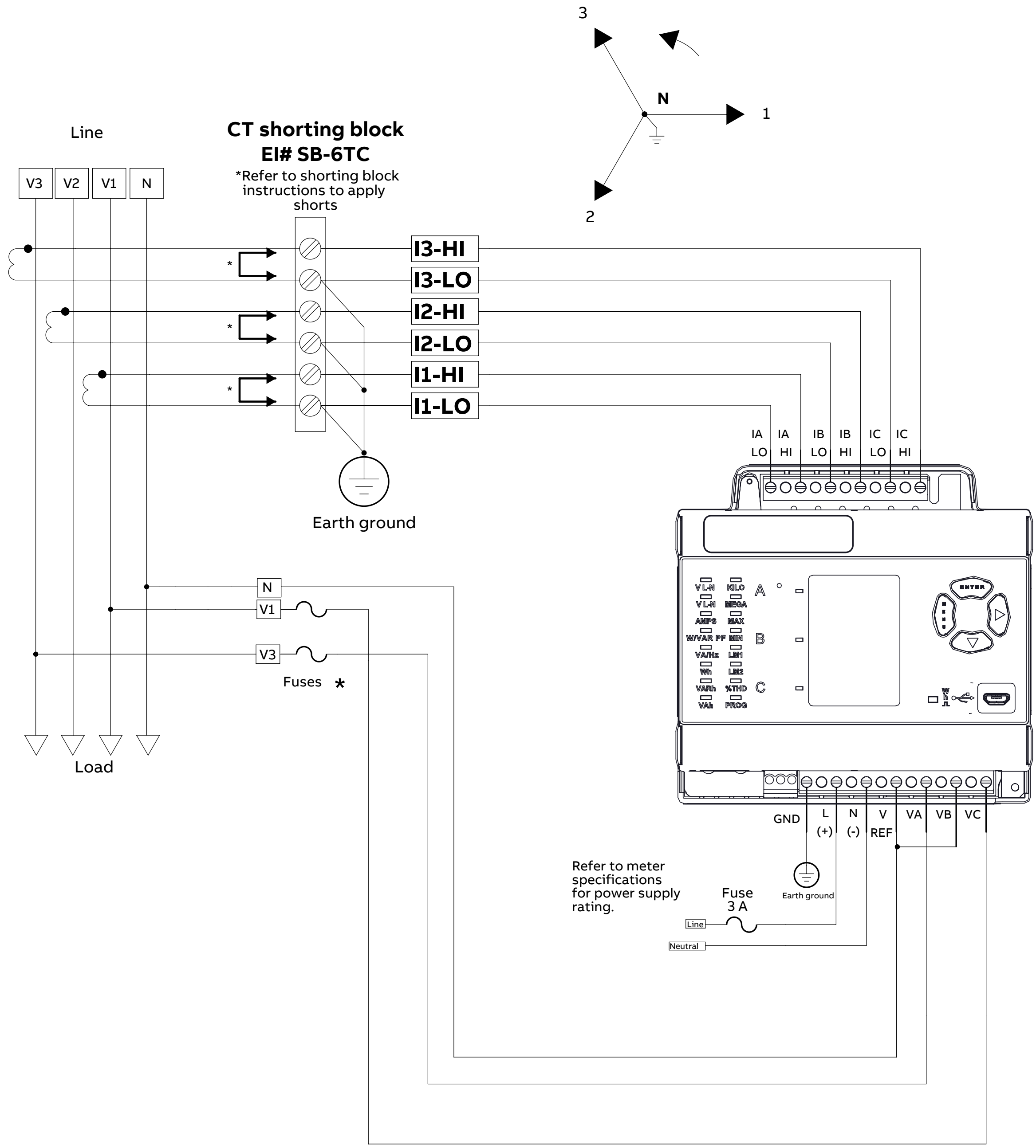
1b. Example of single-phase hookup



For ratings, see voltage fuses on page 13.

Select:
" 3 EL wye " (3-element wye) from the RGM40 meter's front panel display (see Chapter 5).

2. Service: 2.5-element wye, 4-wire with no PTs, 3 CTs

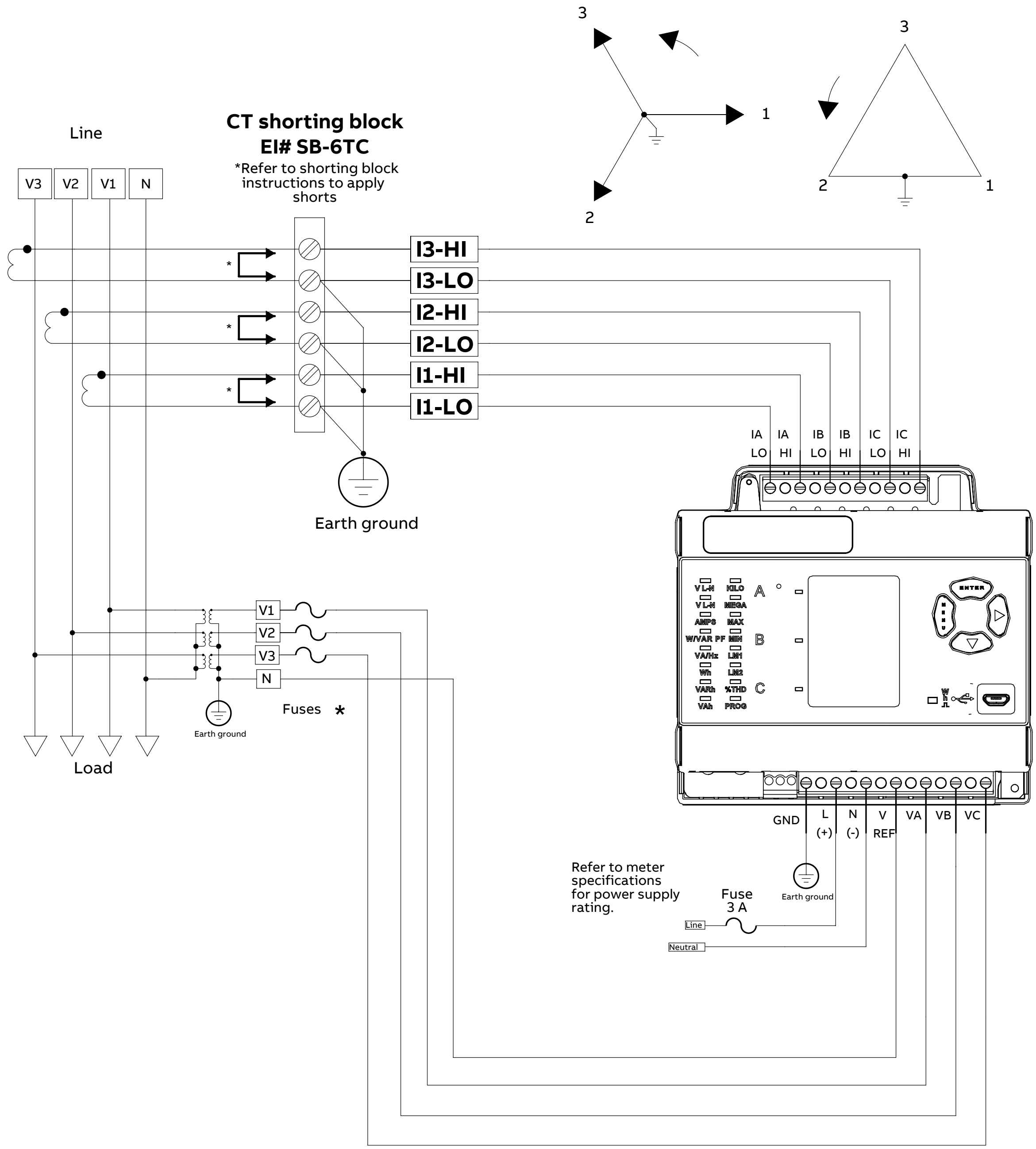


For ratings, see voltage fuses on pages 13.

Select:
“ 2.5 EL wye ” (2.5-element wye) from the RGM40 meter’s front panel display (see Chapter 5).

3. Service: Wye/delta, 4-wire with 3 PTs, 3 CTs

For ratings, see voltage fuses on page 13.

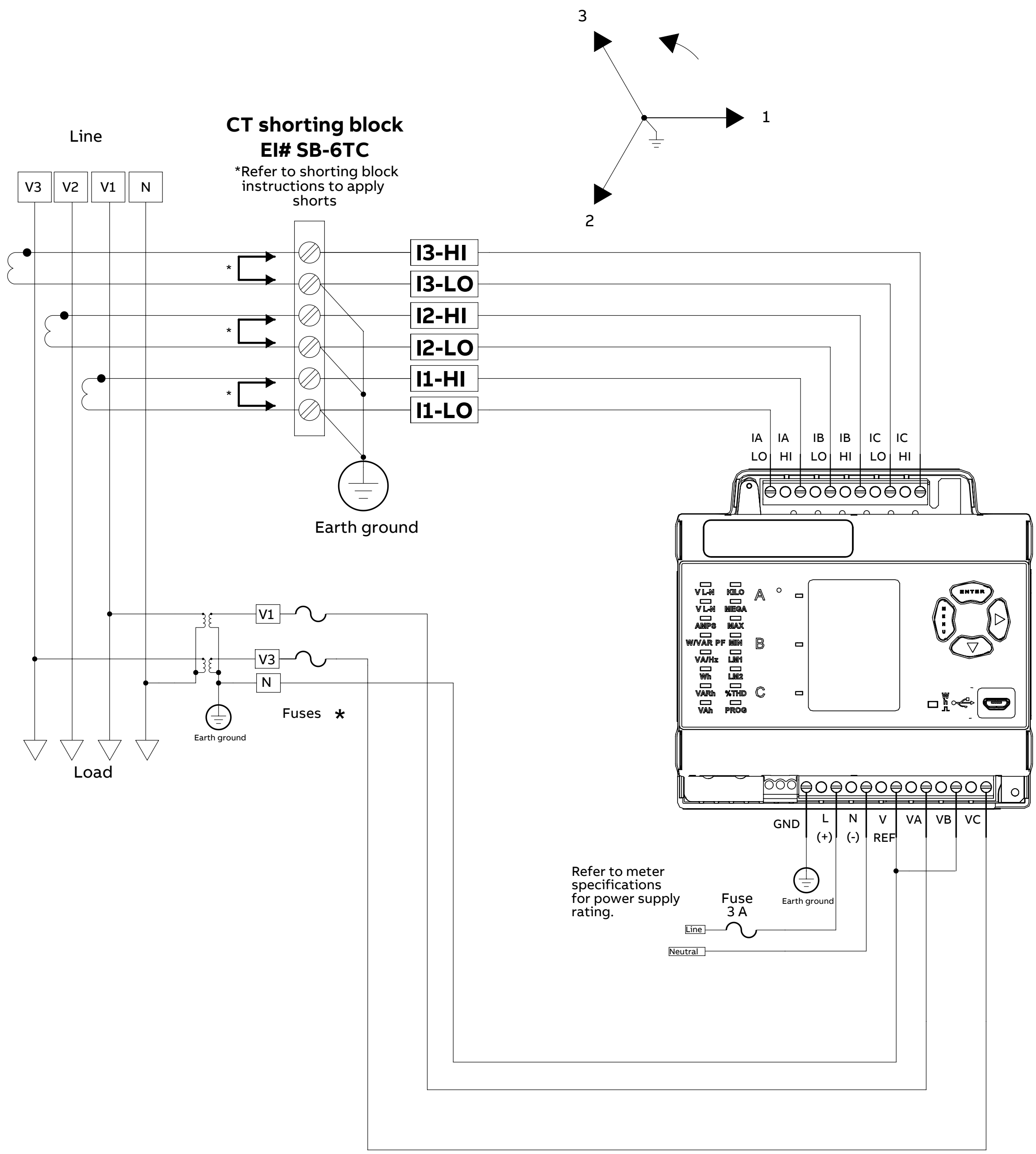


Select:
"3 EL wye" (3-element wye) from the RGM40 meter's front panel display (see Chapter 5).

WARNING

Important
For delta connections, do not exceed 480 V ungrounded or 240 V corner grounded.

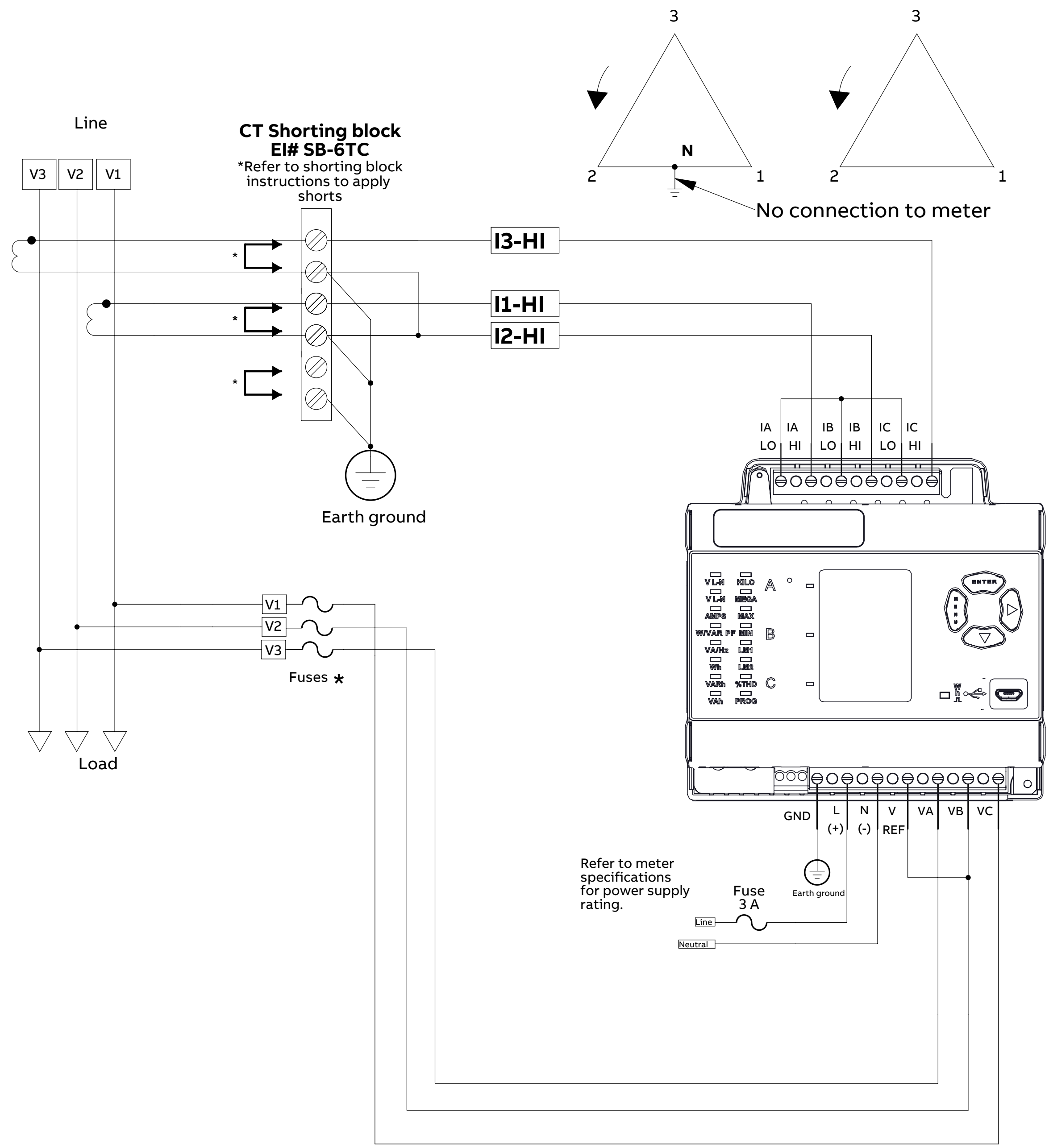
4. Service: 2.5-element wye, 4-wire with 2 PTs, 3 CTs



For ratings, see voltage fuses on pages 13.

Select:
“ 2.5 EL wye ” (2.5-element wye) from the RGM40 meter’s front panel display (see Chapter 5).

5. Service: Delta, 3-wire with no PTs, 2 CTs



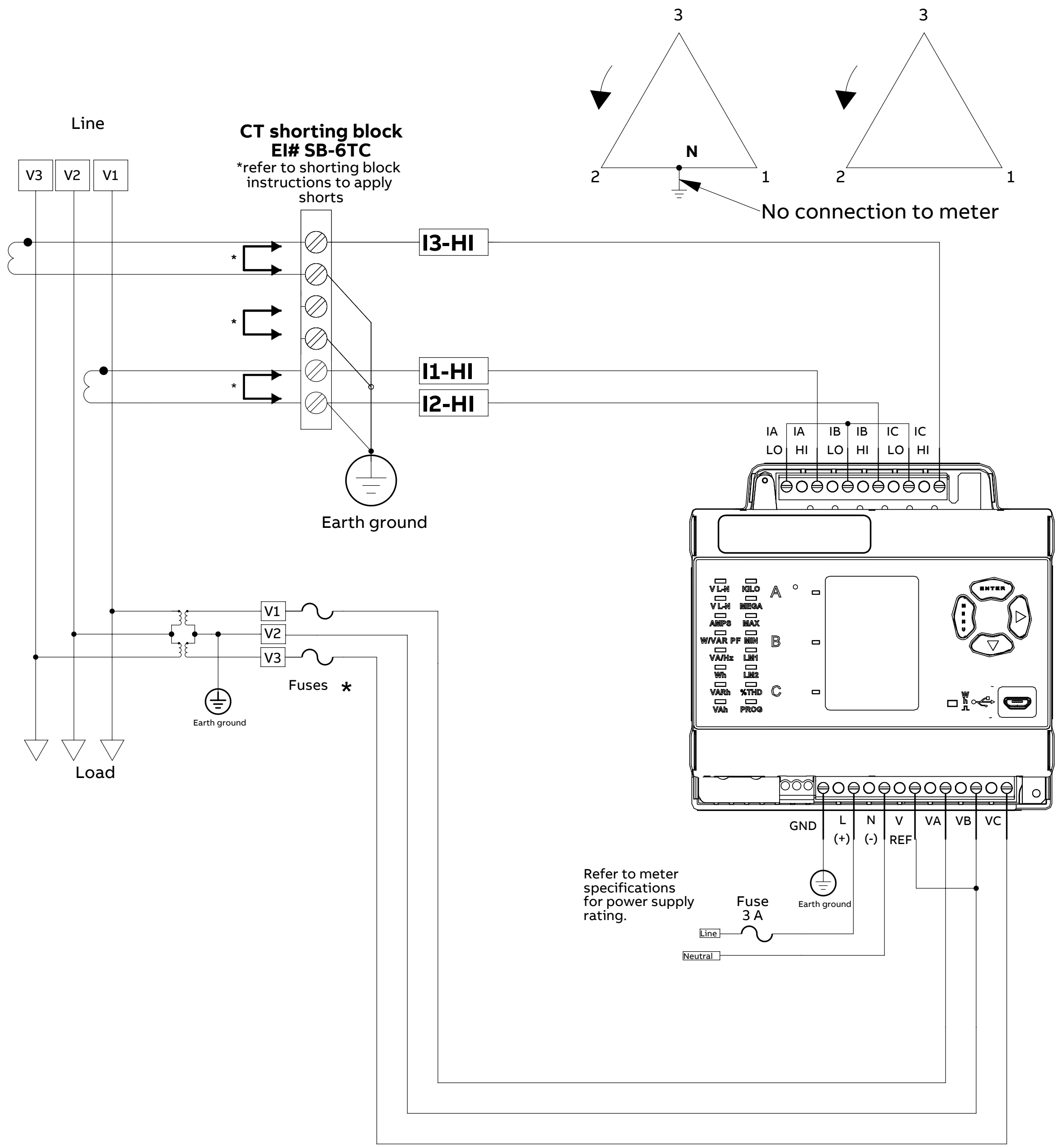
For ratings, see voltage fuses on page 13.

Select:
“2 CT del” (2 CT delta) from the RGM40 meter’s front panel display (see Chapter 5).

WARNING

Important
For delta connections, do not exceed 480 V ungrounded or 240 V corner grounded.

6. Service: Delta, 3-wire with 2 PTs, 2 CTs



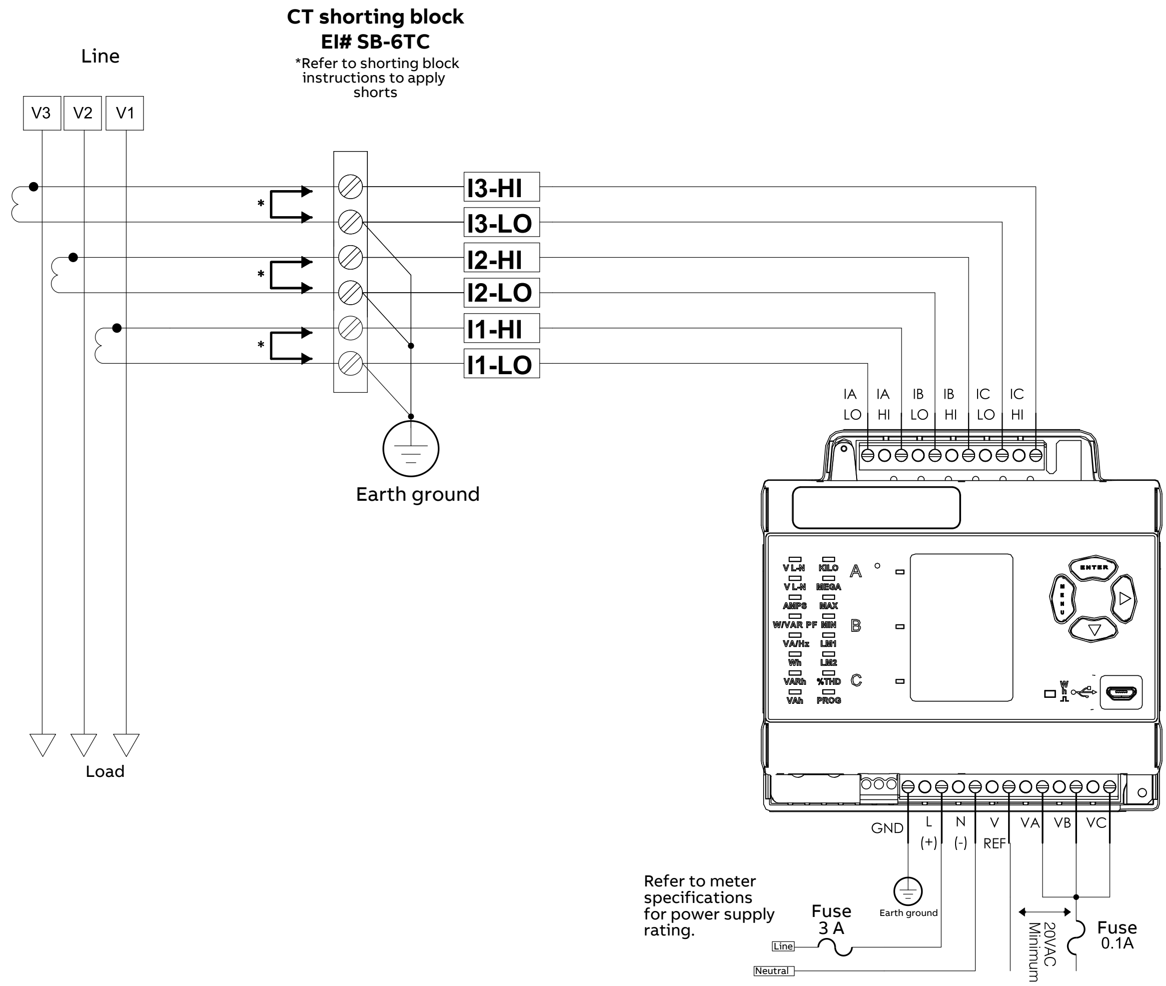
For ratings, see voltage fuses on pages 13.

Select:
"2 CT del" (2 CT delta) from the RGM40 meter's front panel display (see Chapter 5).

WARNING

Important
For delta connections, do not exceed 480 V ungrounded or 240 V corner grounded.

7. Service: Current only measurement (three-phase)

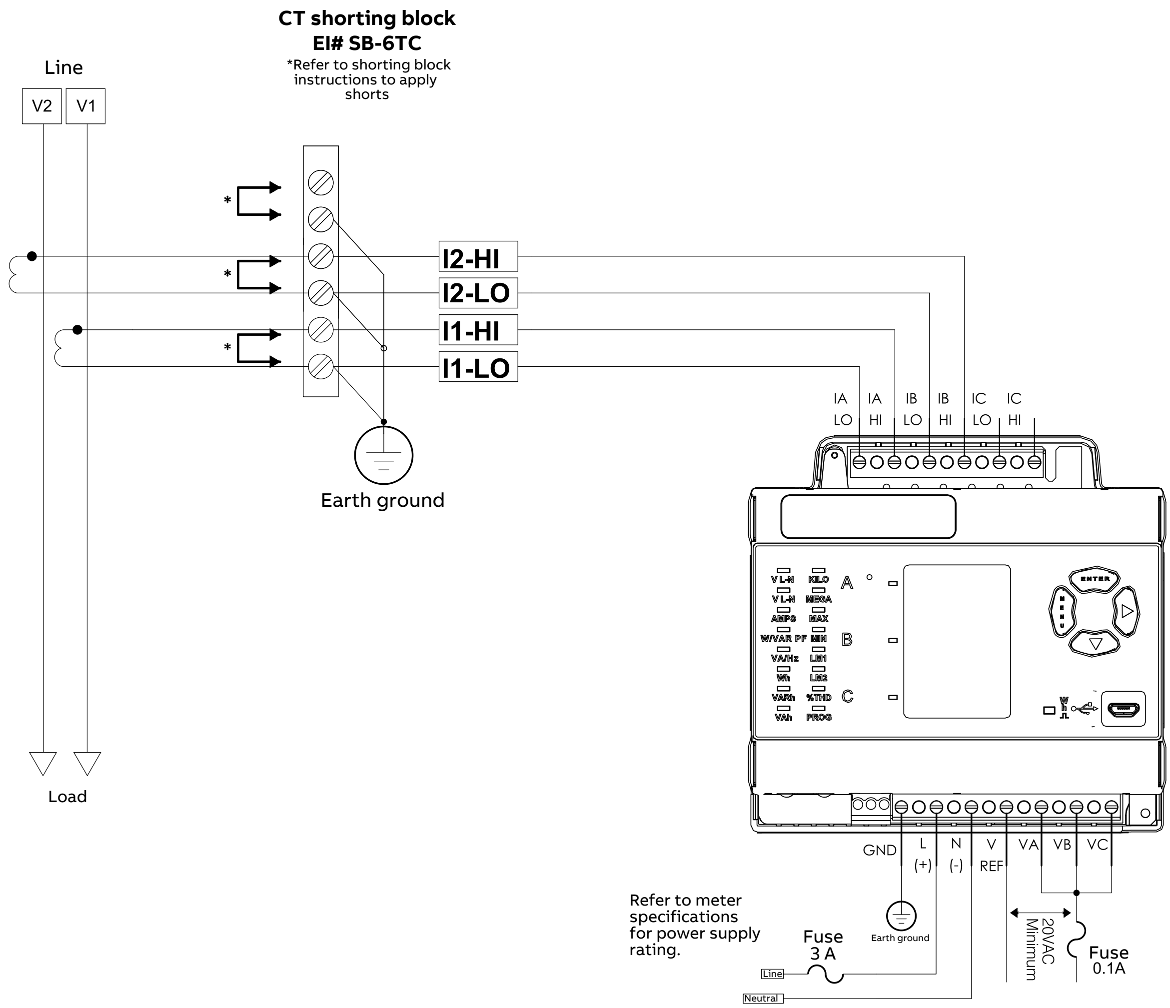


For ratings, see voltage fuses on page 13.

Select:
"3 EL wye" (3-element wye) from the RGM40 meter's front panel display (see Chapter 5.)

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

8. Service: Current only measurement (dual-phase)

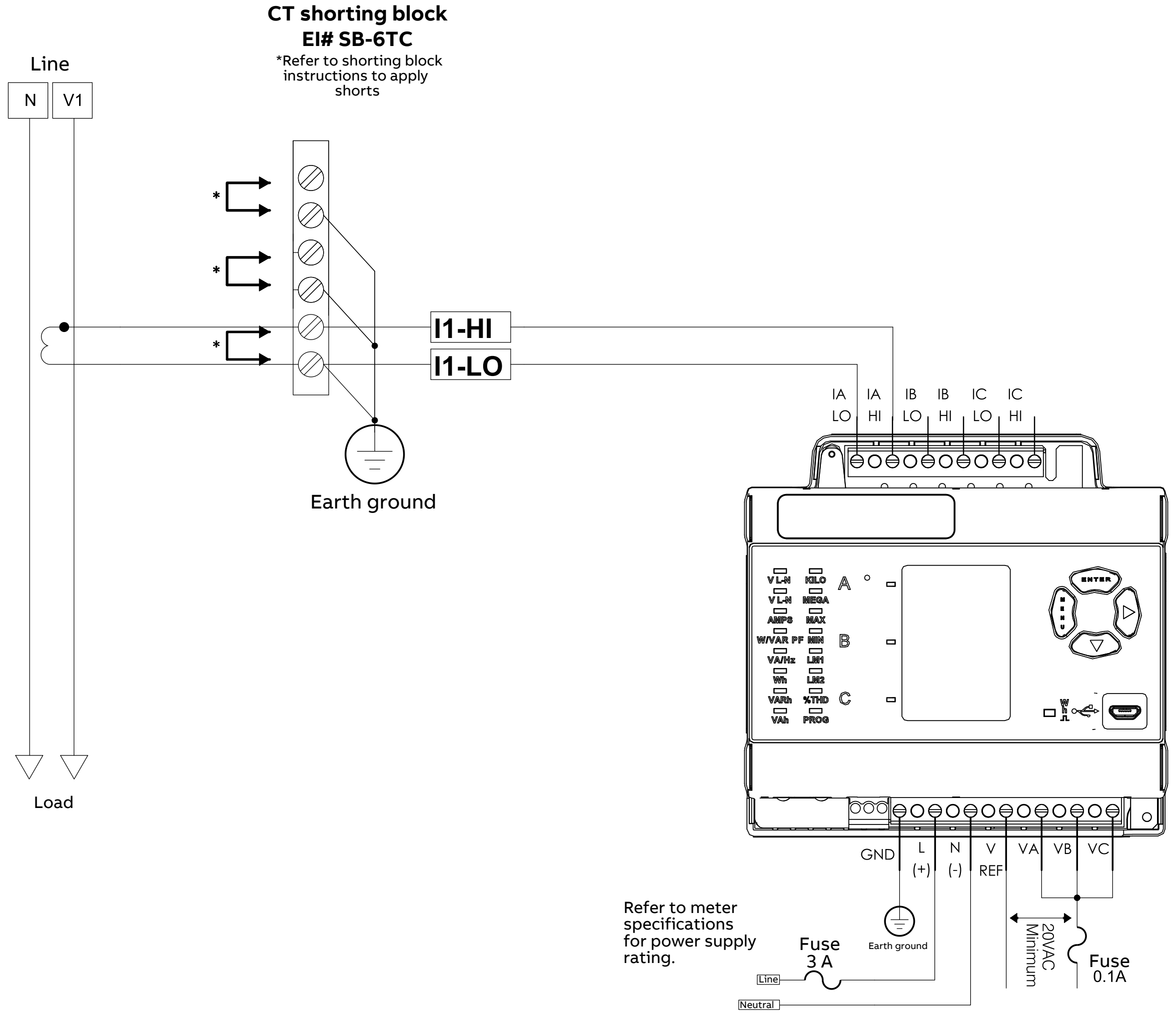


For ratings, see voltage fuses on pages 13.

Select:
"3 EL wye" (3-element wye) from the RGM40 meter's front panel display (see Chapter 5.)

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

9. Service: Current only measurement (single-phase)



For ratings, see voltage fuses on page 13.

Select:
"3 EL wye" (3-element wye) from the RGM40 meter's front panel display (see Chapter 5.)

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

4. Communication installation

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02 Figure 4.1:
RGM40 location
of USB port (Com 1)

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03 Figure 4.2:
RGM40 location
of RS485 port

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04 Figure 4.3:
RGM40 2-wire
RS485 connection

4.1 RGM40 meter communication
The RGM40 meter provides two independent communication ports. The first port, Com 1, is a micro USB port. The second port, Com 2, is either an RS485 port, providing communication Modbus RTU and DNP3 protocols, a 10/100BaseT port, providing communication via Modbus TCP/IP, or a 10/100BaseT BACnet/IP port.
See the appropriate sections:

- For the USB port: 4.2: USB port (Com 1) on this page.
- For the RS485 port: 4.3: RS485 port (optional for Com 2) on this page.
- For the Ethernet port: 4.4: 10/100BaseT Ethernet port (optional for Com 2 INP10) on page 27.
- For the BACnet/IP port: chapter 7: using the RGM40 meter's BACnet port on page 44.

4.2 USB port (Com 1)
The RGM40 meter's Com 1 micro-B USB port is on the face of the meter. The USB port allows the unit to be read and programmed using a laptop or other PC.

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Note:

- Settings for Com 1 are configured using CommunicatorPQA® software.
- This port only communicates via Modbus ASCII protocol.
- The default baud rate for the USB port is 57600.

4.3 RS485 port (optional for Com 2)
One of the options for Com 2 is an RS485 port.

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RS485 allows you to connect one or multiple RGM40 meters to a PC or other device, at either a local or remote site. All RS485 connections are viable for up to 4000 feet (1219.20 meters).

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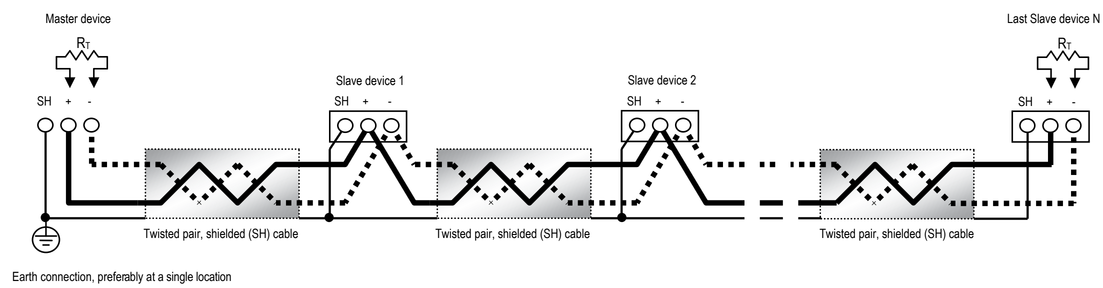
04

From other RS485 device, connect:

- (-) to (-)
- (+) to (+)
- Shield (SH) to shield (SH)

Note:
For all RS485 connections:

- Use a shielded twisted pair cable and ground the shield, preferably at one location only.
- Establish point-to-point configurations for each device on an RS485 bus: Connect (+) terminals to (+) terminals; connect (-) terminals to (-) terminals.
- You may connect up to 31 meters on a single bus using RS485. Before assembling the bus, each meter must have a unique address: Refer to the CommunicatorPQA® and MeterManagerPQA® software user manual for instructions.
- Protect cables from sources of electrical noise.
- Avoid both "star" and "tee" connections (see figure 4.5).
- No more than two cables should be connected at any one point on an RS485 network, whether the connections are for devices, converters or terminal strips.
- Include all segments when calculating the total cable length of a network. If you are not using an RS485 repeater, the maximum length for cable connecting all devices is 4000 feet (1219.20 meters).
- Connect shield to RS485 master and individual devices as shown in figure 4.4. You may also connect the shield to earth-ground at one point.
- Termination resistors (RT) may be needed on both ends for longer length transmission lines. However, since the meter has some level of termination internally, termination resistors may not be needed. When they are used, the value of the termination resistors is determined by the electrical parameters of the cable.



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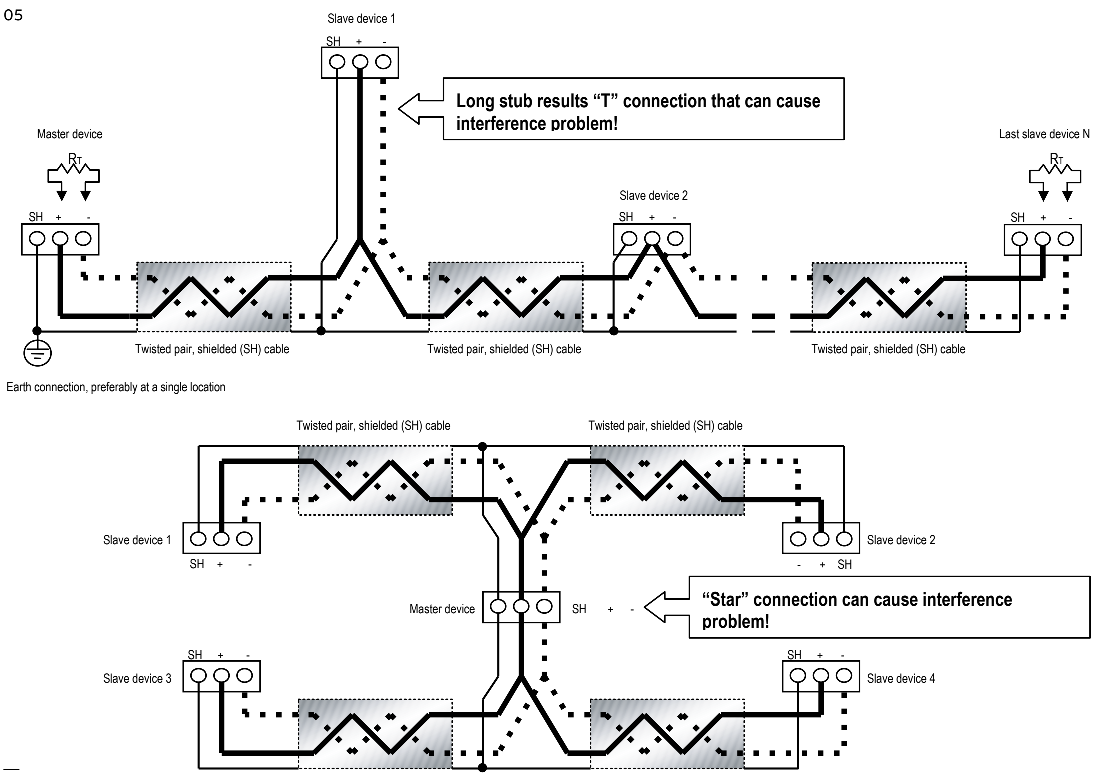
05

05 Figure 4.4: RS485 daisy chain connection



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06

06 Figure 4.5: Incorrect "T" and "star" topologies

4.3.2 Accessing the meter in default communication mode

Using the meter's RS485 port, you can connect to the RGM40 meter even if you don't know the meter's programmed settings. This feature is also useful in debugging. For five seconds after the RGM40 meter is powered up, you can use default communication mode to poll the name register. You do this by connecting to the meter with the following default settings (see 4.6: Connecting to the meter using software on page 31):

Serial port
Address: 1
Protocol: Modbus RTU
Baud rate: 9600

The meter continues to operate with these default settings for 5 minutes. During this time, you can access the meter's device profile to ascertain/change meter information. After 5 minutes of no activity, the meter reverts to the programmed device profile settings.

NOTICE

In normal operating mode, the initial factory communication settings for the RS485 port are:
Address: 1
Protocol: Modbus RTU
Baud rate: 57600

NOTICE

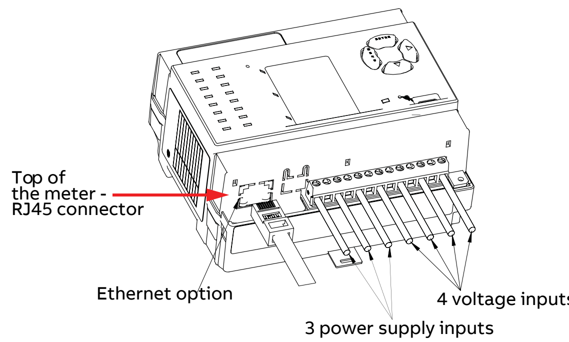
For INP10 and INP10B options, keep the initial factory RS485 settings shown above. See chapter 30 in the CommunicatorPQA® and MeterManagerPQA® software user manual for instructions on programming the communication settings.

Note: If the associated IED was imported from a CID file, unavailable information is displayed as N/A.

4.4 10/100BaseT Ethernet port (optional for Com 2 INP10)

One of the options for Com 2 is the 10/100BaseT Ethernet port. It allows the RGM40 to communicate on a local area network (LAN).

The meter's Ethernet port has an RJ45 connection. Use a standard Ethernet cable to connect from the meter to a PC.



The meter's Ethernet option is easily configured through a host PC, using a Telnet connection. Once configured, you can access the meter directly through any computer on your LAN.

The following sections outline the procedures for setting up the parameters for Ethernet communication:

- Host PC setup — 4.4.1: Setting up the host PC to communicate with the RGM40 meter on page 28.
- RGM40 setup — 4.4.2: Setting up the RGM40 meter for Ethernet communication on page 29.

NOTICE

For the INP10 options, keep the RS485 settings shown on this page.

4.4.1 Setting up the host PC to communicate with the RGM40 meter

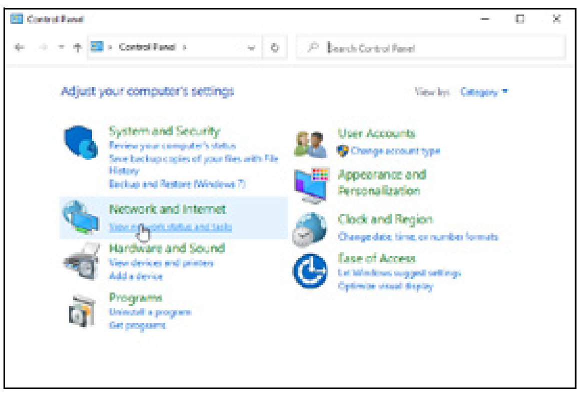
Consult with your network administrator before performing these steps because some of the functions may be restricted to administrator privileges.

The PC's Ethernet adapter must be set up for point-to-point communication when configuring the RGM40 meter's Ethernet option. The factory default IP parameters programmed for the Ethernet port are:

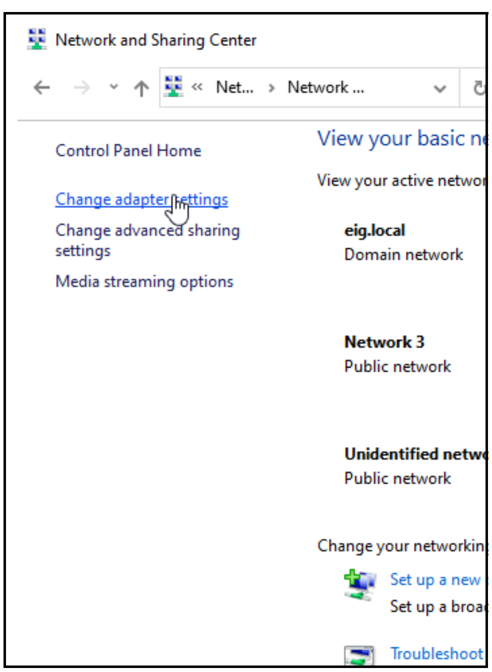
- IP address: 10.0.0.1
- Subnet mask: 255.255.255.0
- Telnet password: 5555

4.4.1.1 Configuring the host PC's Ethernet adapter

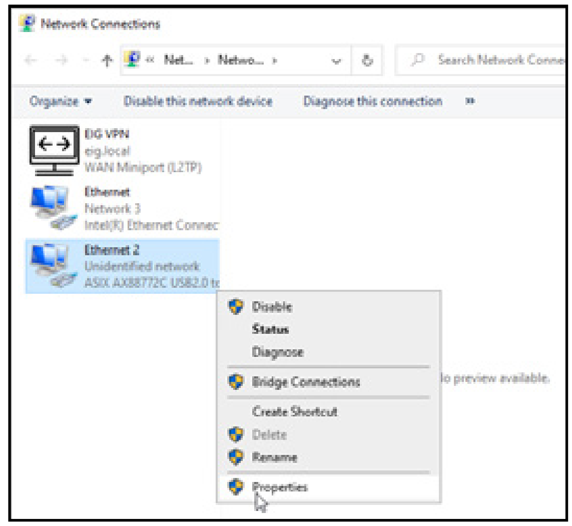
1. From your PC's control panel, click network status and tasks.



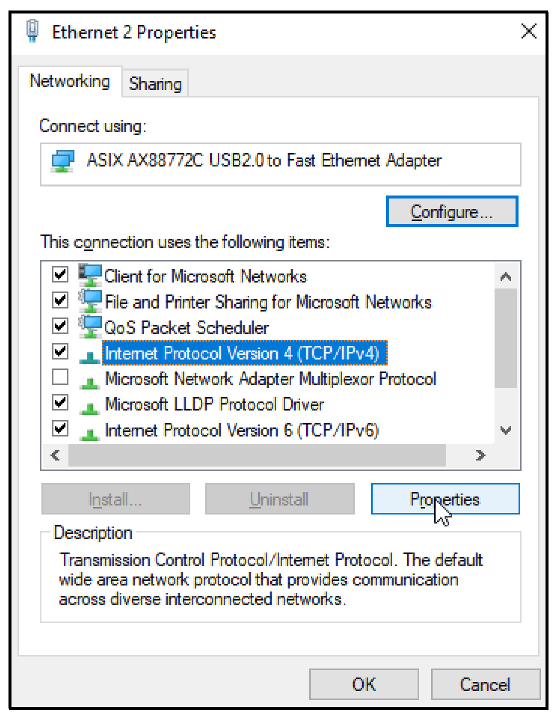
2. Click change adapter settings.



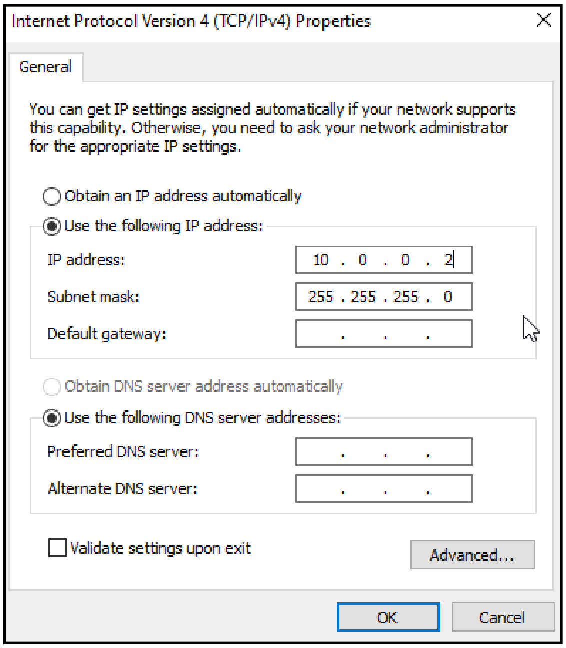
3. Plug the cable connected to the RGM40 meter's Ethernet port into your PC (you may need to use an RJ45 to USB adapter, depending on your PC's available Com ports).
4. Once connected, the Ethernet adapter for the RGM40 meter will be displayed on the screen. Right click it and select properties from the drop-down menu.



5. Click on internet protocol version 4 [TCP/IPv4] and then click the properties button.



7. Click the use the following IP address radio button and enter these parameters:
IP address: 10.0.0.x, where x is anything other than 1; e.g., 10.0.0.2
Subnet Mask: 255.255.255.0



8. Click the OK button. You have completed the setup procedure.

4.4.2 Setting up the RGM40 meter for Ethernet communication

Below are the factory default settings for the RGM40 meter's Ethernet port. These are programmed into the meter before it is shipped from the factory. Parameters in group 1 may need to be altered to satisfy the local Ethernet configuration requirements.

NOTICE

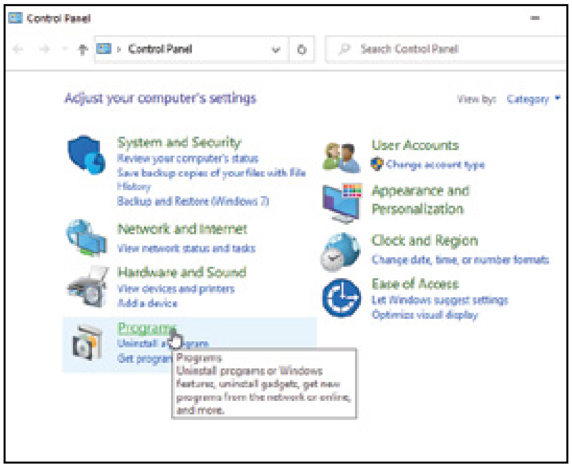
Other parameters (2 and 3) should not be altered.

The Ethernet port can be locally or remotely configured using a Telnet connection over the network.

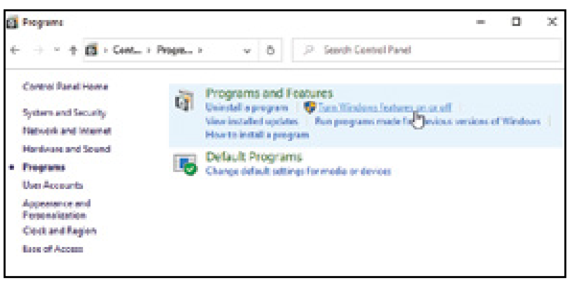
- The configuration parameters can be changed at any time and are retained when the meter is not powered up. After the configuration has been changed and saved, the Ethernet card performs a reset.
- Only one person at a time should be logged into the network port used for setting up the meter. This eliminates the possibility of several people trying to configure the Ethernet interface simultaneously.
- It is possible to reset the Ethernet card to its default values. Follow the procedure in 4.4.3: Resetting the Ethernet (or BACnet) port on page 31.

Note:
With Windows 10 OS, you need to enable Telnet if you haven't used it before.
To do so:

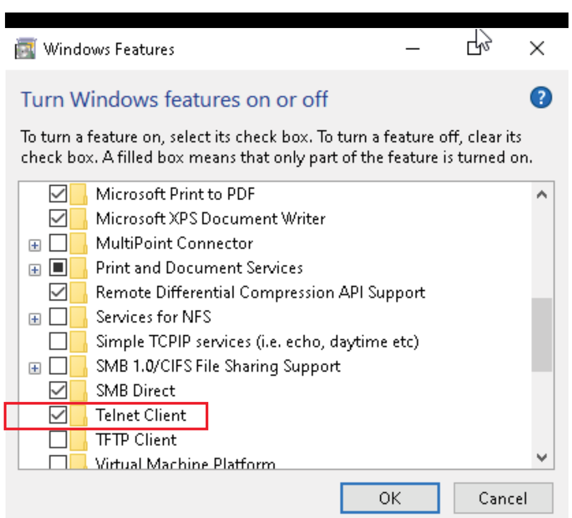
1. From the control panel, click programs.



2. Click turn windows features on and off.



3. Scroll to see Telnet client and check the box next to it.



4. Click OK. You will see a message that the requested changes are complete.

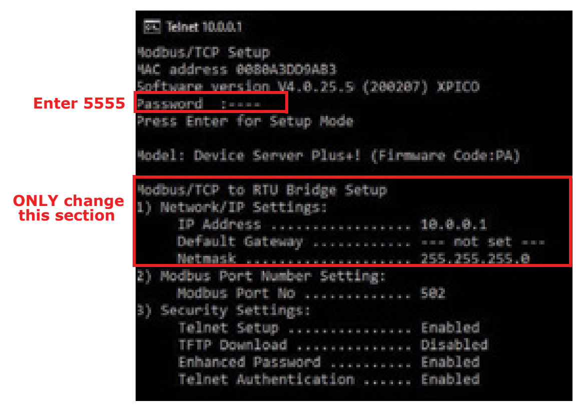
4.4.2.1 Configuring the RGM40 meter's Ethernet connection on the host computer

Establish a Telnet connection on port 9999.
Follow these steps:

1. From the Windows start menu, click run and type "cmd".
2. Click the OK button to bring up the Windows command prompt window.
3. In the command prompt window, type: "telnet 10.0.0.1 9999" and press the enter key. **Note:** Make sure there is a space between the IP address and 9999. When the Telnet connection is established, you will see a message similar to the example shown below.

```
Serial Number 5415404  MAC Address  00:20:4A:54:3C:2C
Software Version V01.2 (000719)
Press Enter to go into Setup Mode
```

4. To proceed to setup mode, press enter again. You will see a screen similar to the one shown below. Be sure to enter the Telnet password, 5555.



5. Change ONLY the parameters in group 1.
   To do so:
   a. Type number "1".
   b. Once group 1 is selected, the individual parameters display for editing. Either:
      - Enter a new parameter if a change is required.
      - Press enter to proceed to the next parameter without changing the current setting.

NOTICE

Settings 2 and 3 must have the default values shown above.
(Example: Setting device with static IP address.)

—
07 Figure 4.4.3:
Location of reset button

IP Address <010> 192.<000> 168.<000> .<000> .<001>
Set Gateway IP Address <N>? Y
Gateway IP Address: <192> .<168> .<000> .<001>
Set Netmask <N for default> <Y>? Y

6. Continue setting up parameters as needed. After you finish your modifications, make sure to press the “S” key on the keyboard. This saves the new values and causes a reset in the Ethernet card.

NOTICE

Do not press “D” because it will overwrite any changes and save the default values.

4.4.3 Resetting the Ethernet (or BACnet) port
If the IP address of the Ethernet port is lost, you can restore the factory default settings by pressing the Ethernet port’s reset button, located on the front of the RGM40 meter.

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07
Using an implement such as a straightened paper clip, press and hold the reset button for 30 seconds.

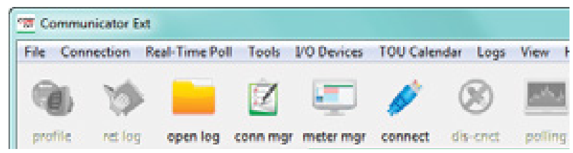
4.5 BACnet/IP port (Com 2 option INP10B)
The third option for Com 2 is the BACnet port. Chapter 7 has detailed instructions for using this standard port.

NOTICE

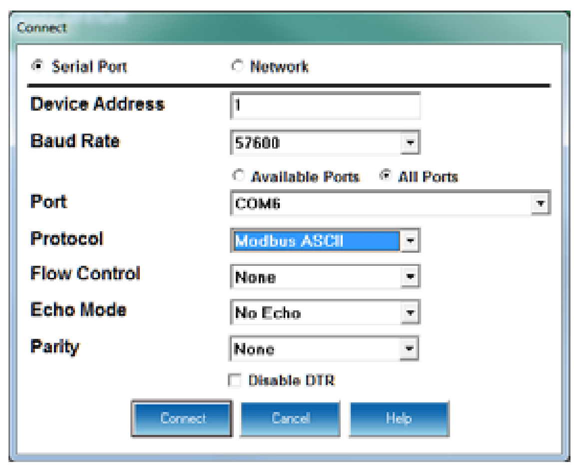
For the INP10 option, keep the RS485 settings shown on page 27.

4.6 Connecting to the meter using software
You can program the meter using the front panel buttons. This section explains how to use the software to connect to the meter in order to configure settings, poll meter readings, view logs, set up security, etc. The connection steps are explained here. See chapter 30 in the CommunicatorPQA® and MeterManagerPQA® software user manual for detailed instructions on performing other tasks.

4.6.1 Connecting to the meter
1. Open the CommunicatorPQA® software.
2. Click the connect icon in the icon bar.



3. The connect screen opens, showing the default settings. Make sure your settings are the same as shown here: The first screen shows the settings for a USB connection, the second screen shows the setting for the RS485 connection, and the third screen shows the settings for the Ethernet connection. Use the pull-down menus to make any necessary changes to the settings.



—
USB connection

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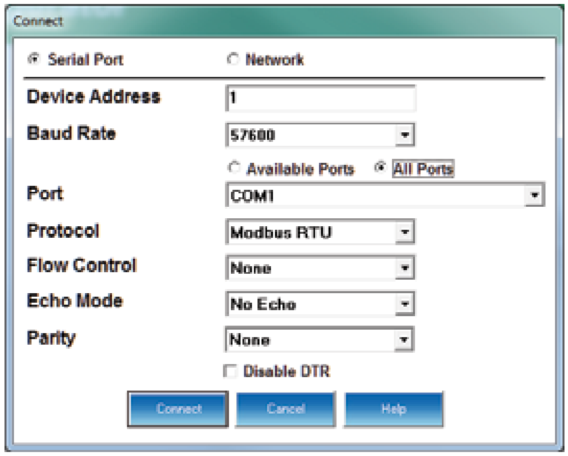
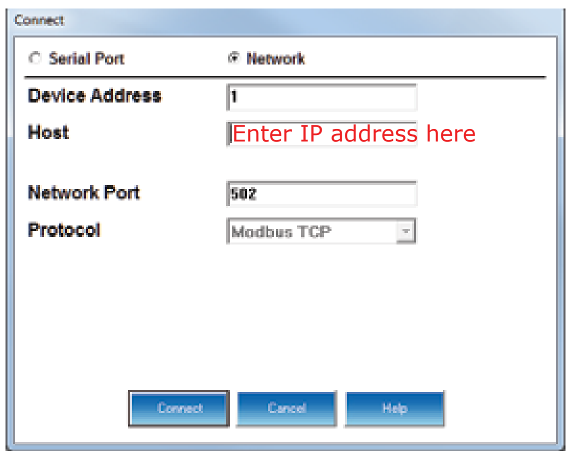
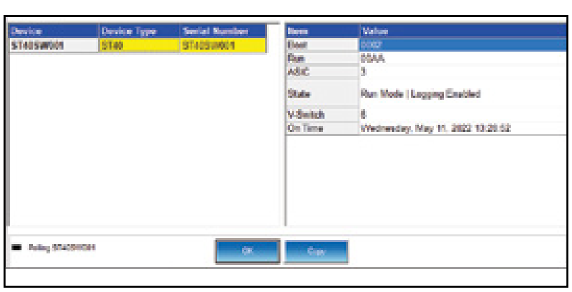


—
RS485 connection



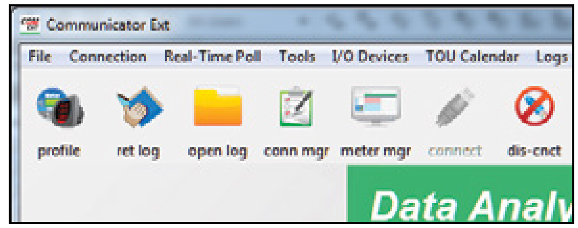
—
Ethernet connection - RJ45 or BACnet Port

4. Click the connect button. If you have a problem connecting, you may have to disconnect power to the meter, then reconnect power and click the connect button again.
5. You will see the device status screen, confirming connection to your meter. Click OK.

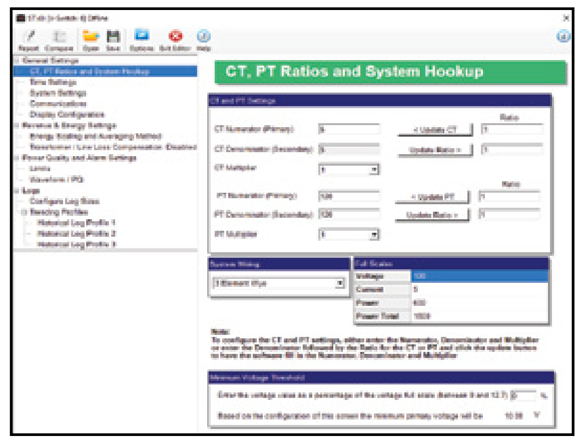


4.6.2 Accessing the meter's device profile

1. Click the profile icon, located at the top of the main screen.



2. You will see the RGM40 meter's device profile screen. The menu on the left side of the screen lets you navigate between settings screens (see below).



3. See chapter 30 in the CommunicatorPQA® and MeterManagerPQA® software user manual for instructions on programming the meter's device profile.

5. Using the RGM40 meter

—
08 Figure 5.1:
RGM40 meter face

—
09 Figure 5.2:
RGM40 face buttons

5.1 Introduction

You can use the front of the RGM40 meter to view meter readings, reset and/or configure the meter and perform related functions. The following sections explain the meter's elements, buttons and display screen.

5.1.1 Understanding meter face indicators

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- The left side of the meter face has LED light indicators, which light when certain conditions occur:
  - Parameter designator: e.g., V/L-N, tells what readings are showing in the three-line display in the middle of the meter face.
  - Kilo/mega: Scaling indicator that shows the multiplier for the readings in the three-line display in the middle of the meter face.
  - Max: This LED lights when the right arrow button is used to scroll to a secondary screen showing maximum values; e.g., V/L-N. The LED will only light if there are maximum values for that reading. The supported screen groups for the max LED are V/L-N, V/L-L, amps, W/VAR/PF and VA/Hz.
  - Min: This LED lights when the right arrow button is used to scroll to a secondary screen showing minimum values; e.g., V/L-N. The LED will only light if there are minimum values for that reading. The supported screen groups for the min LED are V/L-N, V/L-L, amps, W/VAR/PF and VA/Hz.
  - LM1: This LED lights when any of the 16 above limits have been exceeded. Note that the LED lighting is not related to the data on the screen at the time.
  - LM2: This LED lights when any of the 16 below limits have been exceeded. Note that the LED lighting is not related to the data on the screen at the time.
  - PRG: This LED lights when the meter is in front panel edit mode and a configuration value has changed.
- The right bottom of the meter face shows the Kh pulse indicator, which is the energy pulse output used to test accuracy.
- The micro USB port is located to the right of the Kh pulse.

5.1.2 Understanding meter face buttons

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09

The right side of the meter face has menu, enter, right and down buttons, which let you perform the following functions:
- View meter information
- Enter display modes
- Configure parameters (may be password protected)
- Perform resets (may be password protected)
- Perform LED checks
- Change settings
- View parameter values
- Scroll parameter values
- View limit states

5.1.3 Understanding meter face display

The center of the meter face has the three-line LED display.

— 10

— 10 Figure 5.3: RGM40 meter face display

The next section explains how to use the RGM40 meter's display to view meter readings and perform other tasks, e.g., entering a password.

5.2 Using the meter face display

You can access four display modes, using the RGM40 meter's front panel buttons:

- Operating mode (default)
- Reset mode
- Configuration mode
- Information mode — information mode displays a sequence of screens that show model information, such as frequency, amps, V-switch, etc.

Use the menu, enter, down and right buttons to navigate through each mode and its related screens.

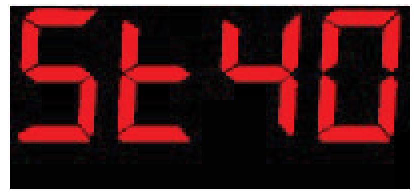
Note:

- See appendix A: RGM40 meter navigation maps on page 56, for the display's navigation maps.
- The meter can also be configured using software; see chapter 30 in the CommunicatorPQA® and MeterManagerPQA® software user manual for instructions.

5.2.1 Understanding startup and default displays

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

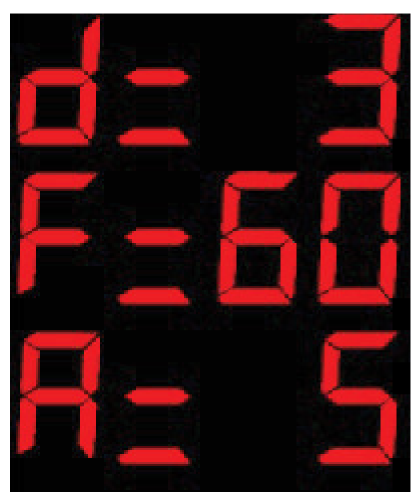
- Lamp test screen where all LEDs are lit.
- Lamp test screen where all digits are lit.
- Title screen — this will indicate whether or not your meter has the mV option.
  - If your meter does not have the mV option, the title screen display looks like this:



  - If your meter has the mV option, your title screen display looks like this:

- Startup screen showing the power chip die number, frequency and CT denominator.

  - If your meter does not have the mV option, but has the Class 10 option, the startup screen display looks like this (if your meter has the Class 2 option, it will look the same except you will see A = 1):



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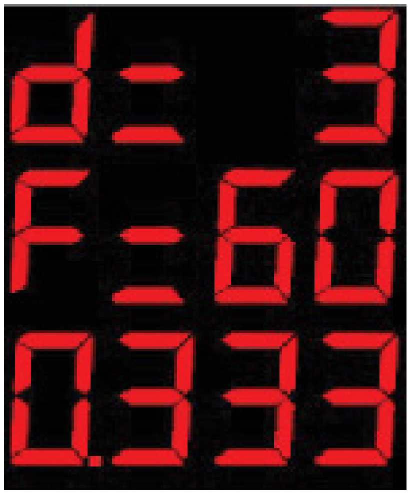
- If your meter has the mV option, your title screen display looks like this:



- Firmware screen showing the build number.
- Error screen (if an error exists).

After startup, if auto-scrolling is enabled, the RMG40 meter scrolls the parameter readings on the right side of the front panel. The kilo or mega LED lights, showing the scale for the Wh, VARh and VAh readings. Figure 5.4 shows an example of a V L-N reading.

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11

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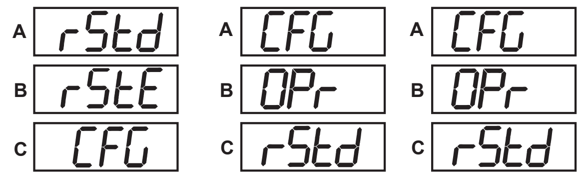
11 Figure 5.4: Display detail showing V L-N reading

The RGM40 meter continues to provide scrolling readings until one of the buttons on the front panel is pressed, causing the meter to enter one of the other modes.

5.2.2: Using the main menu

1. Press the menu button. The main menu screen appears.
   - The reset: Demand mode (rStd) appears in the A window. Use the down button to scroll, causing the reset: energy (rStE), configuration (CFG), operating (OPr) and information (InFo) modes to move to the A window.
   - The mode that is currently flashing in the A window is the “active” mode, which means it is the mode that can be configured.



For example: Press down twice — CFG moves to A window. Press down twice — OPr moves to A window.

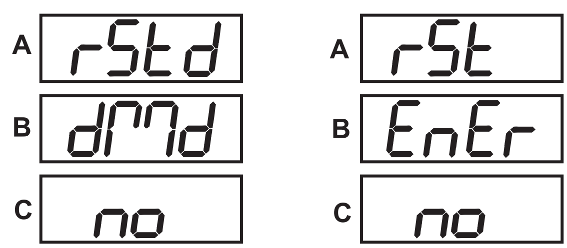
2. Press the enter button from the main menu to view the parameters screen for the mode that is currently active.

5.2.3 Using reset mode

Reset mode has two options:

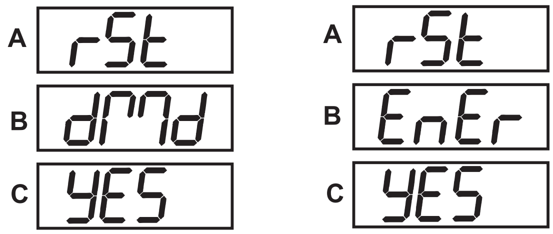
- Reset: Demand (rStd): resets the max and min values
- Reset: Energy (rStE): resets the energy accumulator fields

1. Press the enter button while either rStd or rStE is in the A window. The reset demand no or reset energy no screen appears.



   - If you press the enter button again, the main menu appears, with the next mode in the A window. (The down button does not affect this screen.)

- If you press the right button, the reset demand yes or reset energy yes screen appears. Press enter to perform a reset.



Note:
If password protection is enabled for reset, you must enter the four-digit password before you can reset the meter. (See Chapter 4: Communication installation on page 25, for information on password protection.) To enter a password, follow the instructions in 5.2.4: Entering a password on this page.

NOTICE

Reset demand yes resets all max and min values.

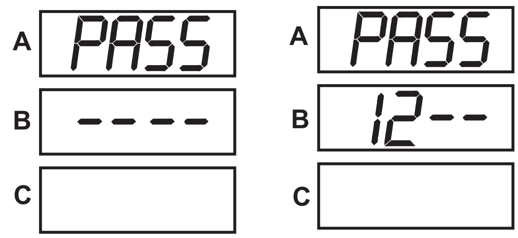
2. Once you have performed a reset, the screen displays either “rSt dMd donE” or “rSt EnEr donE” and then resumes auto-scrolling parameters.

5.2.4 Entering a password

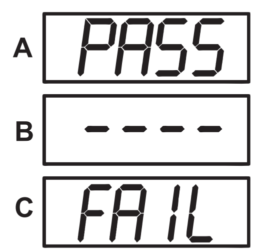
If password protection has been enabled in the software for reset and/or configuration (see Chapter 4: Communication installation on page 25, for more information), a screen appears requesting a password when you try to reset the meter and/or configure settings through the front panel.

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

1. Press the down button to scroll numbers from 0 to 9 for the flashing dash. When the correct number appears for that dash, use the right button to move to the next dash.
2. Example: The left screen, below, shows four dashes. The right screen shows the display after the first two digits of the password have been entered.



3. When all four digits of the password have been selected, press the enter button.
   - If you are in reset mode and you enter the correct password, “rSt dMd donE” or “rSt EnEr donE” appears and the screen resumes auto-scrolling parameters.
   - If you are in configuration mode and you enter the correct password, the display returns to the screen that required a password.
   - If you enter an incorrect password, “PASS ---- FAIL” appears and:
     - The previous screen is redisplayed, if you are in reset mode.
     - The previous operating mode screen is redisplayed, if you are in configuration mode.



5.2.5 Using configuration mode

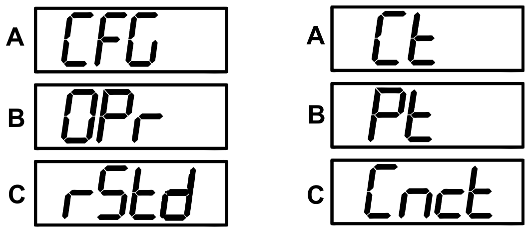
Configuration mode follows reset: energy on the main menu.

To access configuration mode:

1. Press the menu button while the meter is auto-scrolling parameters.
2. Press the down button until the configuration mode option (CFG) is in the A window.
3. Press the enter button. The configuration parameters screen appears.
4. Press the down button to scroll through the configuration parameters: scroll (SCRL), CT, PT, connection (CNCT) and port. The parameter currently “active,” i.e., configurable, flashes in the A window.

5. Press the enter button to access the setting screen for the currently active parameter.

Note:
You can use the enter button to scroll through all of the configuration parameters and their setting screens, in order.

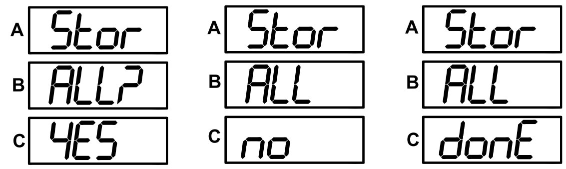


Press enter when CFG is in the A window — parameter screen appears — press down — press enter when the parameter you want is in the A window.

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

Note:
When you try to change the current setting and password protection is enabled for the meter, the password screen appears. See 5.2.4: Entering a password on page 36, for instructions on entering a password.

7. Once you have entered the new setting, press the menu button twice.
8. The store all yes screen appears. You can either:
   - Press the enter button to save the new setting.
   - Press the right button to access the store all no screen; then press the enter button to cancel the save.
9. If you have saved the settings, the store all done screen appears and the meter resets.



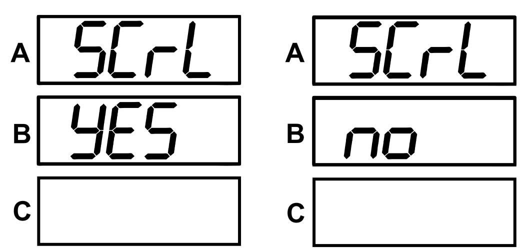
Press the enter button to save the settings. Press the right button for store all no screen.

Press the enter button to cancel the save.

The settings have been saved.

5.2.5.1 Configuring the scroll feature
When in auto-scrolling mode, the meter performs a scrolling display, showing each parameter for 7 seconds, with a 1-second pause between parameters. The parameters displayed by the meter are determined by the following conditions:
- They have been selected through software (see Chapter 30 in the CommunicatorPQA® and MeterManagerPQA® software user manual for instructions).

To enable or disable auto-scrolling:
1. Press the enter button when SCrl is in the A window. The scroll yes screen appears.
2. Press either the right or down button if you want to access the scroll no screen. To return to the scroll yes screen, press either button.
3. Press the enter button on either the scroll yes screen (to enable auto-scrolling) or the scroll no screen (to disable auto-scrolling).
4. The CT-n screen appears (this is the next configuration mode parameter).



Note:
- To exit the screen without changing scrolling options, press the menu button.
- To return to the main menu screen, press the menu button twice.
- To return to the scrolling (or non-scrolling) parameters display, press the menu button three times.

5.2.5.2 Configuring CT setting

The CT setting has three parts: Ct-n (numerator), Ct-d (denominator), and Ct-S (scaling).

1. Press the enter button when Ct is in the A window. The Ct-n screen appears. You can either:
   - Change the value for the CT numerator.
   - Access one of the other CT screens by pressing the enter button: press enter once to access the Ct-d screen, twice to access the Ct-S screen.

Note:
The Ct-d screen is preset to a 5 (for 5 A), 1 (for 1 A), or 0.333 (for mV option) value at the factory and cannot be changed.

a. To change the value for the CT numerator: From the Ct-n screen:
   - Use the down button to select the number value for a digit.
   - Use the right button to move to the next digit.

b. To change the value for CT scaling: From the Ct-S screen, use the right button or the down button to choose the scaling you want. The Ct-S setting can be 1, 10 or 100.

Note:
If you are prompted to enter a password, refer to section 6.2.4 for instructions on doing so.

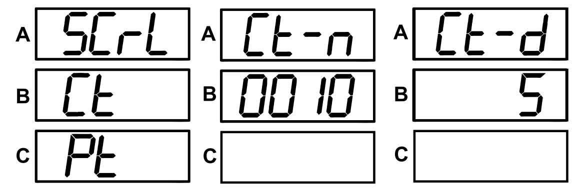
2. When the new setting is entered, press the menu button twice.
3. The store all yes screen appears. Press enter to save the new CT setting.

Example CT settings:

- 200/5 A: Set the Ct-n value for 200 and the Ct-S value for 1.
- 800/5 A: Set the Ct-n value for 800 and the Ct-S value for 1.
- 2,000/5 A: Set the Ct-n value for 2000 and the Ct-S value for 1.
- 10,000/5 A: Set the Ct-n value for 1000 and the Ct-S value for 10.

Note:

- The value for A is a product of the Ct-n value and the Ct-S value.
- Ct-n and Ct-S are dictated by primary current; Ct-d is secondary current.



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

5.2.5.3 Configuring PT setting

The PT setting has three parts: Pt-n (numerator), Pt-d (denominator), and Pt-S (scaling).

1. Press the enter button when Pt is in the A window. The PT-n screen appears. You can either:
   - Change the value for the PT numerator.
   - Access one of the other PT screens by pressing the enter button: Press enter once to access the Pt-d screen, twice to access the Pt-S screen.

   a. To change the value for the PT numerator or denominator: From the Pt-n or Pt-d screen:
      - Use the down button to select the number value for a digit.
      - Use the right button to move to the next digit.

   b. To change the value for PT scaling: From the Pt-S screen, use the right button or the down button to choose the scaling you want. The Pt-S setting can be 1, 10, 100 or 1000.

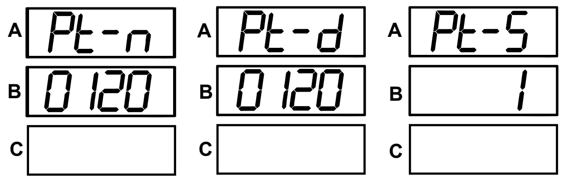
Note:
If you are prompted to enter a password, refer to section 6.2.4 for instructions on doing so.

2. When the new setting is entered, press the menu button twice.
3. The store all yes screen appears. Press enter to save the new PT setting.

Example PT settings:

- 277/277 volts: Pt-n value is 277, Pt-d value is 277, Pt-S value is 1.
- 14,400/120 volts: Pt-n value is 1440, Pt-d value is 120, Pt-S value is 10.
- 138,000/69 volts: Pt-n value is 1380, Pt-d value is 69, Pt-S value is 100.
- 345,000/115 volts: Pt-n value is 3450, Pt-d value is 115, Pt-S value is 100.
- 345,000/69 volts: Pt-n value is 345, Pt-d value is 69, Pt-S value is 1000.

Note:
Pt-n and Pt-S are dictated by primary voltage; Pt-d is secondary voltage.



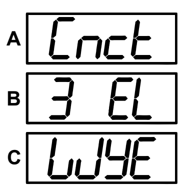
Use buttons to set Pt-n | Use buttons to set Pt-d | Use buttons to select scaling

5.2.5.4 Configuring connection setting

1. Press the enter button when Cnct is in the A window. The Cnct screen appears.
2. Press the right button or down button to select a configuration. The choices are:
   - 3-element wye (3 EL wye)
   - 2.5-element wye (2.5 EL wye)
   - 2 CT delta (2 Ct del)

Note:
If you are prompted to enter a password, refer to 5.2.4: Entering a password on page 36, for instructions on doing so.

3. When you have made your selection, press the menu button twice.
4. The store all yes screen appears. Press enter to save the setting.



Use buttons to select configuration.

5.2.5.5 Configuring communication port setting

Port configuration consists of: Address (a three-digit number), baud rate (9600; 19200; 38400; or 57600) and protocol (DNP3; Mod(bus) RTU; or Mod(bus) ASCII).

1. Press the enter button when POrt is in the A window. The Adr (address) screen appears. You can either:
   - Enter the address.
   - Access one of the other port screens by pressing the enter button: Press enter once to access the bAUd screen (baud rate), twice to access the Prot screen (protocol).

   a. To enter the address:
   From the Adr screen:
   - Use the down button to select the number value for a digit.
   - Use the right button to move to the next digit.

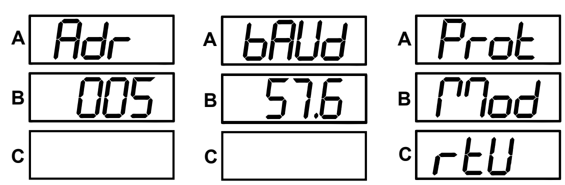
     Note:
     Using the faceplate, you can enter addresses between 1 and 247; if you want to enter a DNP address over 247, you need to enter the address through software settings. Refer to 5.2.5.5: Configuring communication port setting on this page.

   b. To select the baud rate:
   From the bAUd screen, use the right button or the down button to select the setting you want.

   c. To select the protocol:
   From the Prot screen, press the right button or the down button to select the setting you want.

Note:
If you are prompted to enter a password, refer to section 6.2.4 for instructions on doing so.

2. When you have finished making your selections, press the menu button twice.
3. The stor all yes screen appears. Press enter to save the settings.



Use buttons to enter address | Use buttons to select baud rate | Use buttons to select protocol

5.2.5.5 Using operating mode

Operating mode is the RGM40 meter's default mode, that is, the standard front panel display. After starting up, the meter automatically scrolls through the parameter screens if scrolling is enabled. Each parameter is shown for 7 seconds, with a 1-second pause between parameters. Scrolling is suspended for 3 minutes after any button is pressed.

1. Press the down button to scroll all the parameters in operating mode. The currently "active," i.e., displayed, parameter has the indicator light next to it, on the right face of the meter.
2. Press the right button to view additional readings for that parameter. The table below shows possible readings for operating mode. Sheet 2 in appendix A shows the operating mode navigation map.

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

Operating mode parameters					**Possible readings**
Voltage L to neutral display	Voltage line to neutral	Voltage line to neutral max	Voltage line to neutral min	voltage line to neutral THD (V3 and above)	
Voltage line to line display	Voltage line to line	Voltage line to line max	Voltage line to line min	Voltage line to line THD (V3 and above)	
Current display	Current	Neutral current	Current max	Current min	Current THD (V3 and above)
Power display	Watt VAR PF	Watt max Q1,4 VAR max Q1,2 PF max Q1,4	Watt min Q1,4 VAR min Q1,2 PF min Q1,4	Watt max Q2,3 VAR max Q3,4 PF max Q2,3	Watt min Q2,3 VAR min Q3,4 PF min Q2,3
Apparent power/ frequency display	VA Frequency	VA max Frequency max	VA min Frequency min		
Active energy display	Watt hour Q1,4	Watt hour Q2,3	Watt hour net	Watt hour total	
Reactive energy display	VAR hour Q1,2	VAR hour Q3,4	VAR hour net	VAR hour total	
Apparent energy display	VA hour				

12 Figure 5.5: Location of Wh test pulse

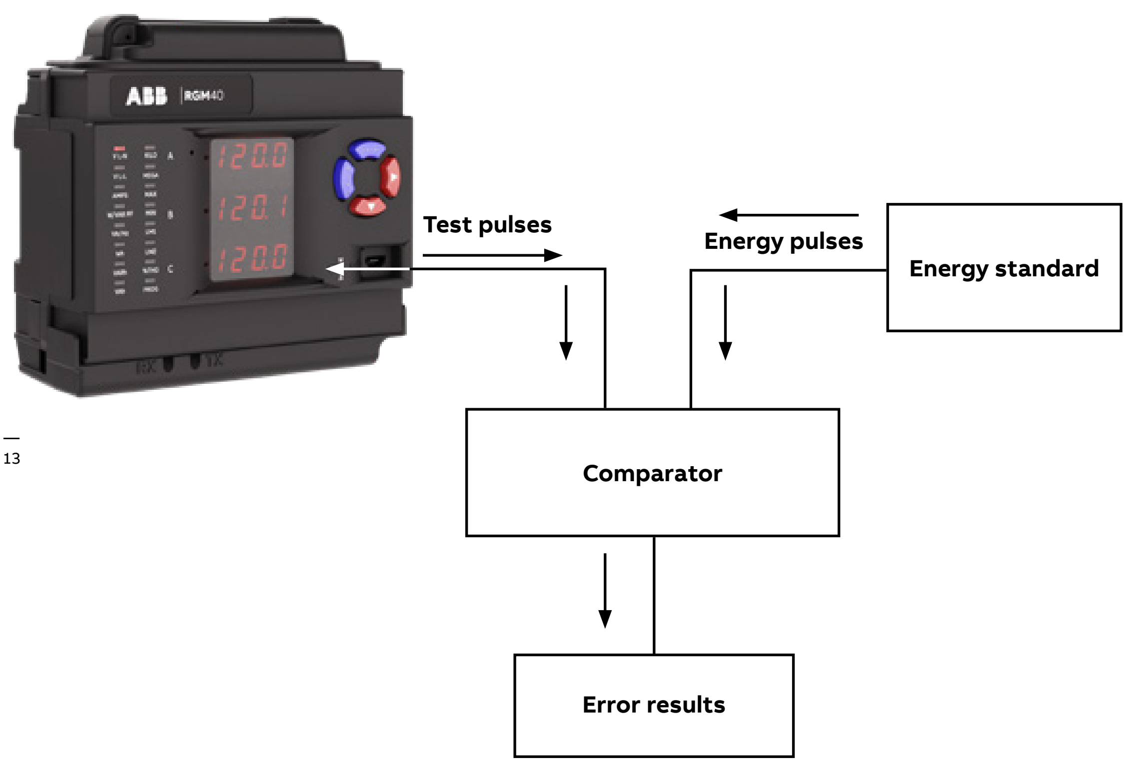
13 Figure 5.6: Using the Wh test pulse

5.3 Performing watt hour accuracy testing (verification)

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 RGM40 meter is a traceable revenue meter, it contains a utility-grade test pulse that can be used to gate an accuracy standard. This is an essential feature required of all billing-grade meters.

- Refer to figure 5.6 for an example of how this process works.
- Refer to table 5.1 for the Wh/pulse constants for accuracy testing.

12



13

Table 5.1: Infrared pulse constants for accuracy testing — Kh hour per pulse

Input voltage level	Class 10 models	Class 2 models
Below 150 V	0.500017776	0.1000035555
Above 150 V	2.000071103	0.400014221

Note:
- Minimum pulse width is 90 milliseconds.
- Typical standards are: Radian Research RD20 and RD21 or a Watthour Engineering Company three-phase automated test system.

Note:
Watt hour standards offer pulse inputs that take in the CPU's test pulses. The accuracy is computed by ratio-metrically comparing the period of the meter's pulse to the period of the standard's internal pulse. You must program the test pulse value (Kh) into the standard for the results to be accurate.

05

The example test procedure that follows covers the testing of the RGM40 meter. The test procedure used for the standard shall be determined by the manufacturer of the standard used.

Test procedure

1. All circuits and equipment must be de-energized.
2. Connect the three phase potential input lines to “Va,” “Vb” and “Vc” and the neutral to “V-Ref” and “GND.”
3. Connect power leads to the “L” and “N” connections.
4. Monitor the #1 test pulse by placing the photo detector over the #1 LED.
5. Connect the three phase current inputs to the current terminals associated with the test pulse LED being monitored. No other current inputs should be connected.
6. Energize the standard and the RGM40 meter. To ensure accuracy, both must be on for a minimum of 30 minutes.
7. Energize the sources and wait for the outputs to stabilize before starting the test.
8. Start the test as per the appropriate procedure for the standard and/or comparator used.
9. When the test is completed, de-energize the sources.
10. Place the photo detector over the next test pulse to be monitored.
11. Repeat steps 5 through 10 until all test pulses are checked.
12. De-energize all circuits and remove power from the standard, sources and the RGM40 meter.
13. Disconnect all connections from the RGM40 meter.

6. Data logging

6.1: Overview
Optional V-Switch™ keys 2–6 (V2–V6) give the RGM40 meter memory for extensive data logging. The RGM40 meter can log historical trends, limit alarms, sequence of events and waveforms (V5 and V6 only). In addition, the meter has a real-time clock that allows all events to be time-stamped when they occur.

6.2: Available logs
The following logs are available for an RGM40 meter equipped with V2–V4.

- Historical logs: The RGM40 meter has three historical logs. Each log can be independently programmed with individual trending profiles; that is, each can be used to measure different values. You can program up to 64 parameters per log. You also have the ability to allocate available system resources between the three logs to increase or decrease the size of the individual historical logs. See chapter 29 (configuring historical logs and allocating historical log sectors sections) and chapter 19 (viewing historical logs and snapshots section) of the CommunicatorPQA® and MeterManagerPQA® software user manual for additional information and instructions.
- Limit/alarm log: This log provides the magnitude and duration of events that fall outside of configured acceptable limits. Time stamps and alarm value are provided in the log. Up to 2,048 events can be logged. See chapter 30 (configuring limits section) and chapter 19 (viewing the limits log section) of the CommunicatorPQA® and MeterManagerPQA® software user manual for additional information and instructions.
- System events log: To protect critical billing information, the RGM40 meter records and logs the following information with a timestamp:
  - Demand resets
  - Password requests
  - System startup
  - Energy resets
  - Log resets
  - Log reads
  - Programmable settings changes
  - Critical data repairs

RGM40 meters equipped with V5 and above have additional memory for data logging. These meters also have waveform recording capabilities so they offer the following additional log:

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

All of the RGM40 meter logs can be viewed through the ABB log viewer. See chapter 19 of the CommunicatorPQA® and MeterManagerPQA® software user manual for additional information and instructions regarding logs and the log viewer.

7. Using the RGM40 meter's BACnet port

7.1: Introduction
The RGM40 meter with BACnet option for Com 2 supports two sockets of Modbus TCP/IP and BACnet/IP communication that lets it act as a BACnet server in any BACnet application. The meter has a web interface you can use to remotely set up the BACnet/IP and Modbus configuration and to track energy readings via the internet using any standard web browser.

7.1.1: About BACnet
BACnet is a data communication protocol developed for building control applications in 1987. BACnet allows applications to process data from many different kinds of equipment and manufacturers. Originally it was used for HVAC control systems, but it has been extended to other building systems, including lighting and energy management. Today BACnet is one of the two most widely used building automation protocols. It is an ASHRAE/ANSI/ISO standard protocol.

The BACnet protocol consists of objects that contain different kinds of information. Each object has properties that contain data related to it. Below is the example of an:
Object for total watts:
Object_Name, PWR_ELEC
Object_Type, analog input
Object_Instance, AI-101018
Present_Value, watt, tot (value in watts)

BACnet operates in a client-server environment. A client machine sends a service request (message) to a server machine; once the service is performed, the results are reported back to the client machine. BACnet defines 5 groups (or classes) of 35 message types. For example, one class contains messages for retrieving and manipulating the object properties described above. An example of a common service request in this class is "ReadProperty." When the server machine receives this message from a client machine, it locates the requested property of the requested object and sends the value to the client. Other classes of service requests have to do with alarms and events, file uploading and downloading, managing remote device operation and virtual terminal functions.

BACnet/IP, which is used by the RGM40 meter, is a newer implementation of the BACnet standard, which allows users to perform BACnet communication through the internet or intranet.

For more detailed information, visit the BACnet website at www.bacnet.org.

7.2: RGM40 meter's BACnet objects
The RGM40 meter's BACnet/IP has 41 predefined objects of electrical measurements. No programming or mapping is necessary to use the BACnet objects. The objects' names easily identify the measurements they contain. All of the objects except for POLL_DELAY are AI (analog input) object type. The following table lists each of the objects with their unit of measurement and description.

Object name	Unit of measurement	Description
POLL_DELAY	Seconds	Polling delay
VOLTAGE_LN-A	Volt	Voltage A-N
VOLTAGE_LN-B	Volt	Voltage B-N
VOLTAGE_LN-C	Volt	Voltage C-N
VOLTAGE_LL-AB	Volt	Voltage A-B
VOLTAGE_LL-BC	Volt	Voltage B-C
VOLTAGE_LL-CA	Volt	Voltage C-A
CURRENT_LN-A	Amp	Current A
CURRENT_LN-B	Amp	Current B
CURRENT_LN-C	Amp	Current C
PWR_ELEC	Watt	Total active power
PWR_ELEC_REACT	Volt-amp-reactive	Total reactive power
PWR_ELEC_APPAR	Volt-amp	Total apparent power
PWR_FACTOR	—	Total power factor
FREQUENCY	Hertz	Frequency
CURRENT_NG	Amp	Neutral current
ENERGY_ELEC_TOTAL_REC*	Watt-hour	Active energy received
ENERGY_ELEC_TOTAL_DEL*	Watt-hour	Active energy delivered
ENERGY_ELEC_TOTAL_NET*	Watt-hour	Active energy net
ENERGY_ELEC_TOTAL*	Watt-hour	Total active energy
ENERGY_ELEC_TOTAL_REACT_REC*	Volt-amp-hours-reactive	Positive reactive energy
ENERGY_ELEC_TOTAL_REACT_DEL*	Volt-amp-hours-reactive	Negative reactive energy
ENERGY_ELEC_TOTAL_REACT_NET*	Volt-amp-hours-reactive	Reactive energy net
ENERGY_ELEC_TOTAL_REACT*	Volt-amp-hours-reactive	Total reactive energy

Object name	Unit of measurement	Description
ENERGY_ELEC_TOTAL_APPAR*	Volt-amp-hours	Total apparent energy
DEMAND_POS	Watt	Positive active demand, 3-phase, average demand
DEMAND_REACT_POS	Volt-amp-reactive	Positive reactive demand, 3-phase, average demand
DEMAND_NEG	Watt	Negative active demand, 3-phase, average demand
DEMAND_REACT_NEG	Volt-amp-reactive	Negative reactive demand, 3-phase, average demand
DEMAND_APPAR	Volt-amp	Apparent demand, 3-phase, average demand
DEMAND_PEAK_POS	Watt	Positive active demand, 3-phase, max average demand
DEMAND_REACT_PEAK_POS	Volt-amp-reactive	Positive reactive demand, 3-phase, max average demand
DEMAND_PEAK_NEG	Watt	Negative active demand, 3-phase, max average demand
DEMAND_REACT_PEAK_NEG	Volt-amp-reactive	Negative reactive demand, 3-phase, max average demand
DEMAND_APPAR_PEAK	Volt-amp	Apparent demand, 3-phase, max average demand
VOLTAGE_THD-A	Percent	Voltage A-N %THD
VOLTAGE_THD-B	Percent	Voltage, B-N %THD
VOLTAGE_THD-C	Percent	Voltage, C-N % THD
CURRENT-THD-A	Percent	Current, A %THD
CURRENT-THD-B	Percent	Current, B % THD
CURRENT-THD-C	Percent	Current, C % THD

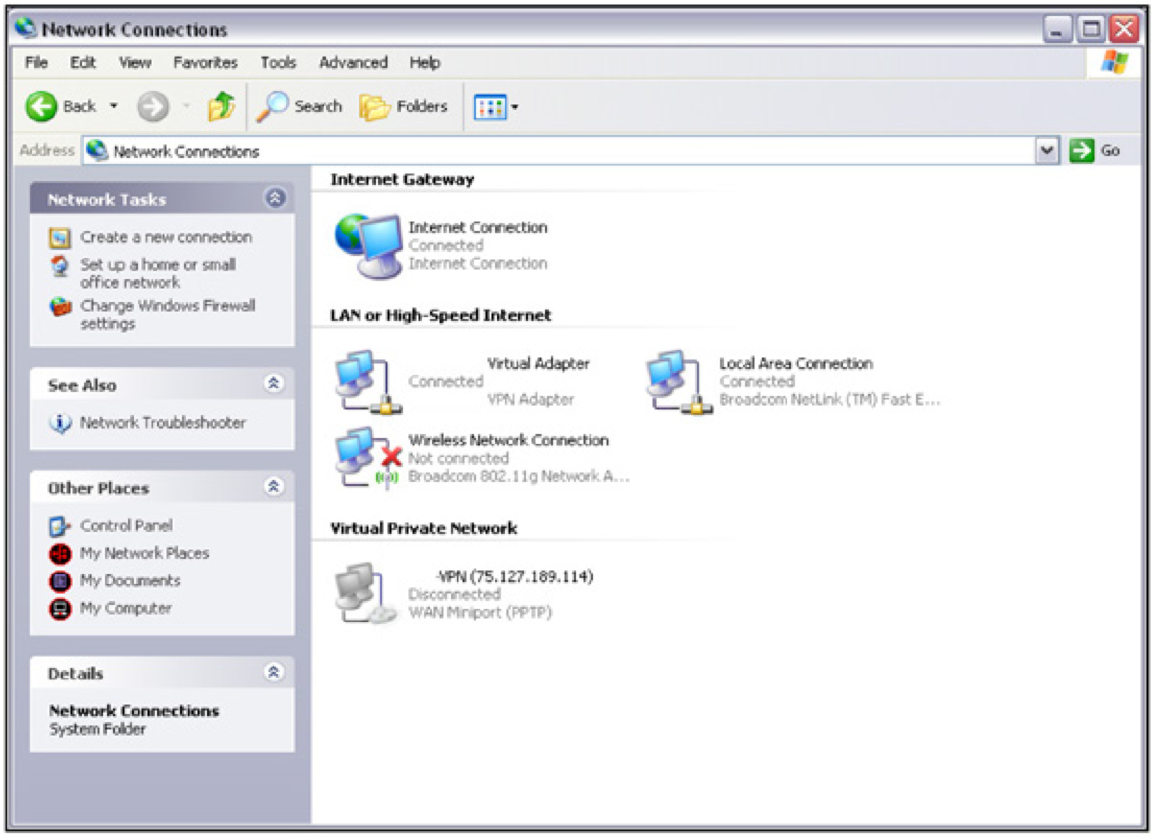
* For optimal accuracy and resolution, these accumulators' attributes are factory preset to: 6 digits, no fractions, zero decimal places and kilo multiplier (Modbus register address: 30,006, decimal). We recommended you maintain these settings at all times.

7.3: Configuring the RGM40 meter
You must first set the network configuration so you can communicate with the RGM40 meter. Follow these steps:

1. Configure your LAN connection to IP address 10.0.0.100, subnet mask 255.255.255.0:

a. Click **Start>Control Panel>Network Connections**. You will see a screen like the one shown below.

b. Right-click on the LAN connection you want to use and click **Properties**. You will see the screen shown below.

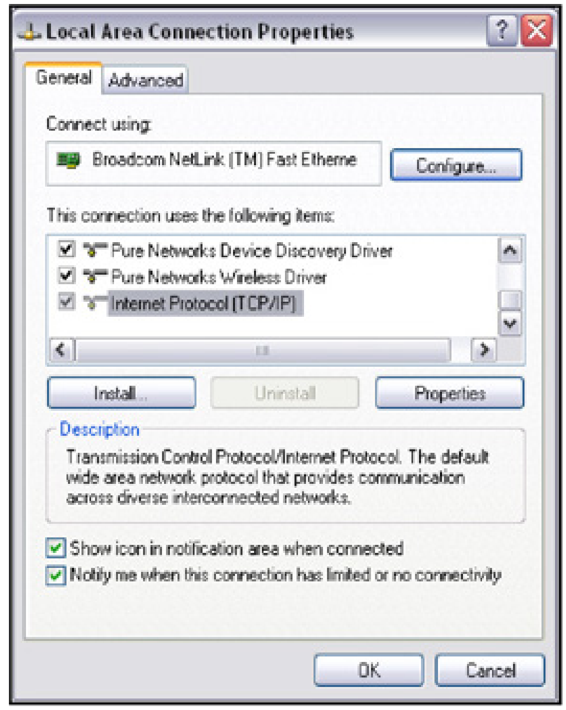


c. Scroll and highlight Internet Protocol TCP/IP and then click the **Properties** button. You will see the screen shown below.

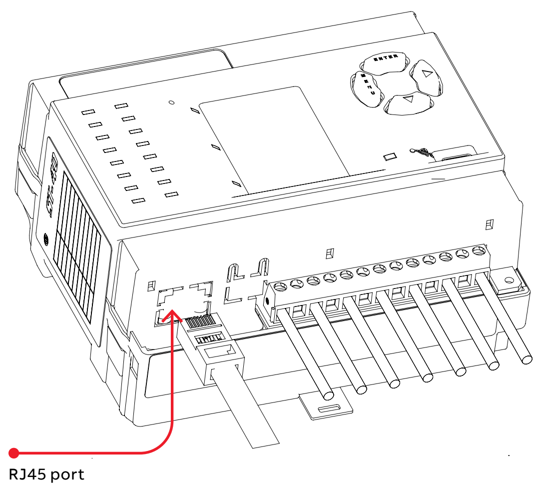
d. Click the **Use the Following IP address** radio button and enter these default values:
IP address: 10.0.0.100
Subnet mask: 255.255.255.0

e. Click **OK**.

f. The Local Area Connection Properties screen redisplays. Click **OK** (or **Close**, depending on your operating system).



2. Use an Ethernet cable to connect from the meter's RJ45 port to your PC.

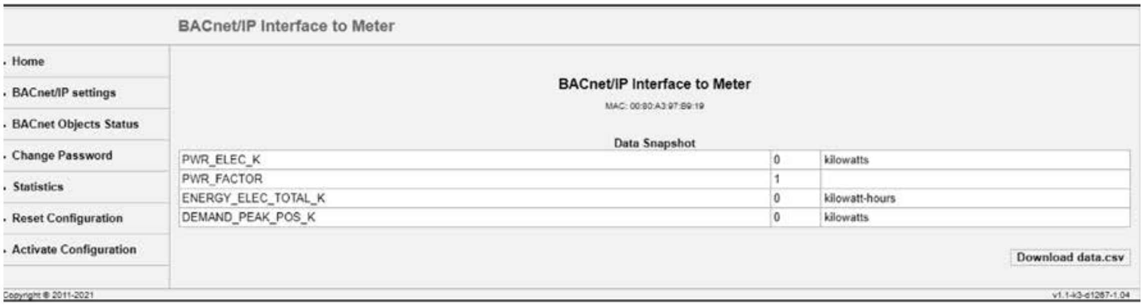


3. Open your web browser and connect to the meter at the default address by typing http://10.0.0.1.

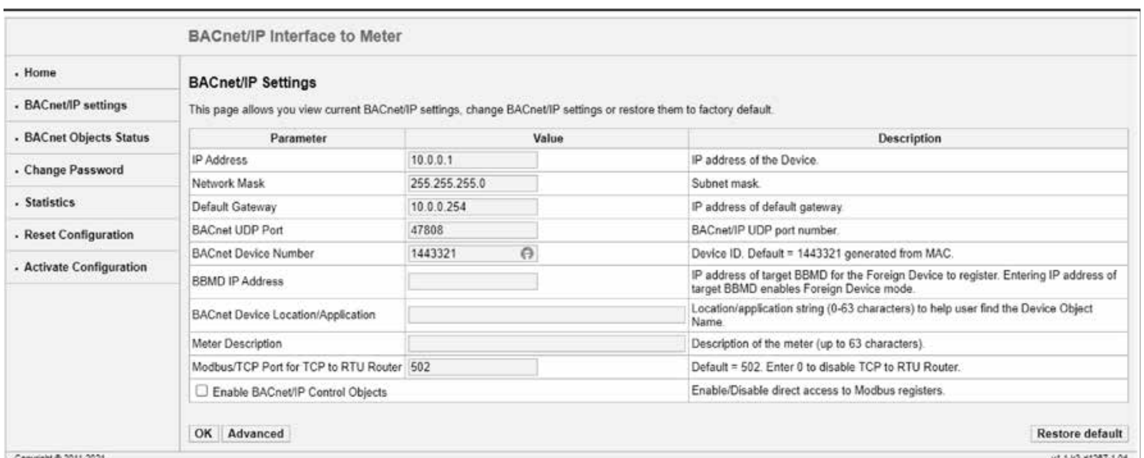
Note: If this doesn't work, reset the meter to this default address by pressing the reset button for 30 seconds. See 4.4.3: Resetting the Ethernet (or BACnet) port, on page 31 for instructions.

4. You will see a user authentication screen. Enter the following default settings:
User name: admin
Password: admin

5. Click **OK**. You will see the BACnet home webpage, shown below.



6. Click BACnet/IP settings on the left side of the webpage to see the page shown below. Use this page to change the default IP address (10.0.0.1) to an IP address in the same subnet as your network. Contact your system administrator if you are unsure of the correct address to use.



You can also change the following fields:

- Network mask — The subnet mask. The default is 255.255.255.0.
- Default gateway — The IP address of the gateway. The default is 10.0.0.254.
- BACnet UDP port — The BACnet/IP UDP port number. The default is 47808. In some cases (e.g., if it is necessary for two groups of BACnet devices to be set up independently on the same IP subnet), the UDP port can be configured locally to a different value.
- BACnet device number — A numeric code used to identify the meter. This number is auto-generated from the MAC address.
- BBMD IP address — When a BBMD IP address is entered here, it enables foreign device mode.
- BACnet device location/application — A readable string of up to 63 characters that you can use to find the device object name.
- Meter description — Optional field where you can enter a description of up to 63 characters that will be added as a prefix in the name of all registers representing the meter's BACnet objects.
- Modbus TCP port for TCP to RTU router — The default port is 502. As long as this field is not 0, the router is enabled, which lets the meter communicate with Modbus TCP/IP master devices.

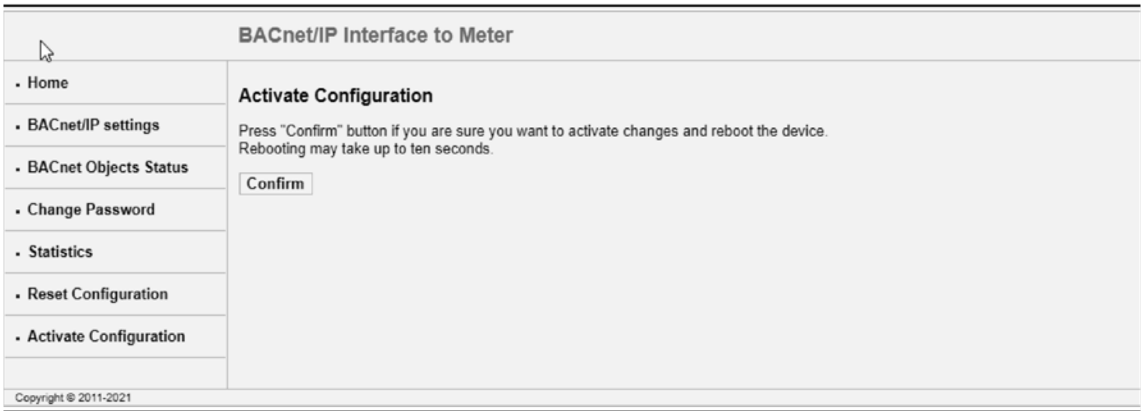
Note: Using the Modbus connection, the meter cannot be connected to multiple Modbus masters at the same time; only one Modbus master will work properly.

- Enable BACnet/IP control objects — Check this box to allow direct access to Modbus registers. If enabled, the control objects are represented by the following three analog-value BACnet objects:
    1. 500001 is a writeable object called MOD_ID_TARGET ("target device identifier to be read/written"). Since the meter has a hard-coded Modbus address of "1," only this value needs to be entered before first access to a Modbus register. The default = -1.0. -1.0 also means do not execute #500003 (neither read nor write).
    2. 500002 is a writeable object called MOD_REGISTER ("register to be read/written"); for example, "1000" to access the first register of volts A-N. The default = -1.0 after any reboot. -1.0 also means do not execute #500003 (neither read nor write).
    3. 500003 is a readable/writeable value called MOD_VALUE ("value to be read from or written to select register"). The MOD_REGISTER resets with -1.0 after each read/write (whether or not successful), from/to MOD_VALUE with valid MOD_ID_TARGET and MOD_REGISTER. MOD_REGISTER will also be set to -1.0 30 seconds after it is written to.

7. Click the **Advanced** button to display additional settings. **We recommend you do not change any advanced setting**.
8. Click **OK** process your changes. You will see the message "Changes are not activated yet" on the left side of the screen under the menu items. You still need to activate the configuration for the changes to take effect.

Note: You can change all settings back to their default by clicking the **restore default** button at the bottom of the page.

9. Click Activate Configuration from the left side of the webpage to implement any changes you made. You will see the page shown below.



10. Click the **Confirm** button to process the changes. You will see the message shown below.

11. The meter resets. You are now ready to place the meter into your network. Connect the meter's Ethernet cable to your network (remove it from your PC). Connect to the meter through your network using the new IP address.

NOTICE

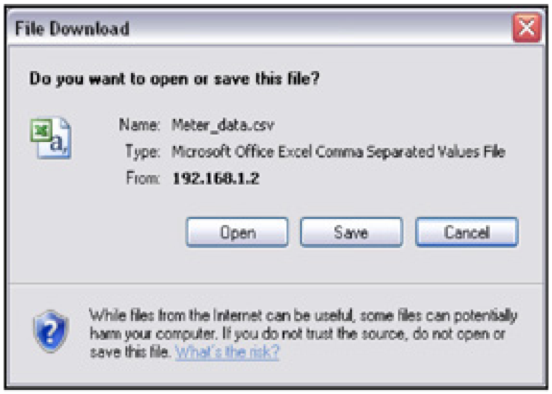
Important! For the INP10 option, keep the RS485 settings shown on page 27.

7.4: Using the RGM40 meter's web interface
As shown in 7.3: Configuring the RGM40 meter, on page 46, you can use the meter's web interface to change the IP address and other network parameters. You can also view information and readings using the web interface. This section explains the webpages other than the BACnet/IP settings and activate configuration webpages, which are explained in 7.3: Configuring the RGM40 meter, on page 46.

Home webpage
The home webpage is shown at the top of page 48. It is the first page you see when you connect to the meter.

Note: To access this webpage from any other page, click Home on the left side of the page.

This webpage shows the current power, power factor, accumulated energy and peak demand readings from the meter. You can download all of the meter's BACnet data by clicking the **Download data.csv** button. You will see the following screen:



This screen gives you the option to open or save an Excel file with the BACnet meter data.

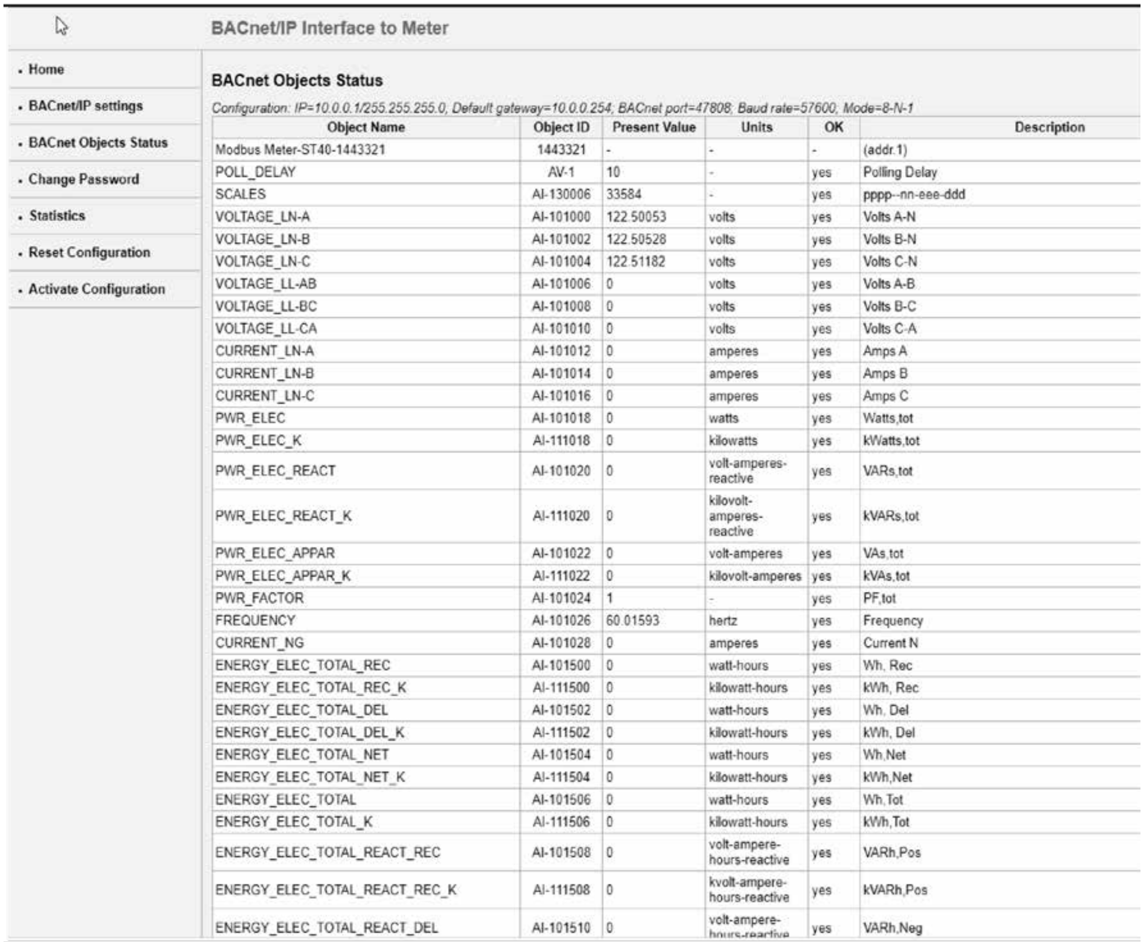
- Click **Open** to open an Excel file with the meter's BACnet data.
- Click **Save** to save a copy of the Excel file.

- Click **Cancel** to close the screen without opening or saving the file.

An example file is shown below:

	A	B	C	D	E	F
1	Name	Object	Value	Units	Reliable	Description
3	VOLTAGE_LN-A	AI-101000	122.14421	volts	yes	Volts A-N
4	VOLTAGE_LN-B	AI-101002	122.14384	volts	yes	Volts B-N
5	VOLTAGE_LN-C	AI-101004	122.14751	volts	yes	Volts C-N
6	VOLTAGE_LL-AB	AI-101006	0	volts	yes	Volts A-B
7	VOLTAGE_LL-BC	AI-101008	0	volts	yes	Volts B-C
8	VOLTAGE_LL-CA	AI-101010	0	volts	yes	Volts C-A
9	CURRENT_LN-A	AI-101012	0	amperes	yes	Amps A
10	CURRENT_LN-B	AI-101014	0	amperes	yes	Amps B
11	CURRENT_LN-C	AI-101016	0	amperes	yes	Amps C
12	PWR_ELEC	AI-101018	0	watts	yes	Watts,tot
13	PWR_ELEC_K	AI-111018	0	kilowatts	yes	kWatts,tot
14	PWR_ELEC_REACT	AI-101020	0	volt-amperes-reactive	yes	VARs,tot
15	PWR_ELEC_REACT_K	AI-111020	0	kilovolt-amperes-reactive	yes	kVARs,tot
16	PWR_ELEC_APPAR	AI-101022	0	volt-amperes	yes	VAs,tot
17	PWR_ELEC_APPAR_K	AI-111022	0	kilovolt-amperes	yes	kVAs,tot
18	PWR_FACTOR	AI-101024	1	-	yes	PF,tot
19	FREQUENCY	AI-101026	60.01795	hertz	yes	Frequency
20	CURRENT_NG	AI-101028	0	amperes	yes	Current N
21	ENERGY_ELEC_TOTAL_REC	AI-101500	0	watt-hours	yes	Wh, Rec
22	ENERGY_ELEC_TOTAL_REC_K	AI-111500	0	kilowatt-hours	yes	kWh, Rec
23	ENERGY_ELEC_TOTAL_DEL	AI-101502	0	watt-hours	yes	Wh, Del
24	ENERGY_ELEC_TOTAL_DEL_K	AI-111502	0	kilowatt-hours	yes	kWh, Del
25	ENERGY_ELEC_TOTAL_NET	AI-101504	0	watt-hours	yes	Wh,Net
26	ENERGY_ELEC_TOTAL_NET_K	AI-111504	0	kilowatt-hours	yes	kWh,Net
27	ENERGY_ELEC_TOTAL	AI-101506	0	watt-hours	yes	Wh,Tot
28	ENERGY_ELEC_TOTAL_K	AI-111506	0	kilowatt-hours	yes	kWh,Tot
29	ENERGY_ELEC_TOTAL_REACT_REC	AI-101508	0	volt-ampere-hours-reactive	yes	VARh,Pos
30	ENERGY_ELEC_TOTAL_REACT_REC_K	AI-111508	0	kvolt-ampere-hours-reactive	yes	kVARh,Pos
31	ENERGY_ELEC_TOTAL_REACT_DEL	AI-101510	0	volt-ampere-hours-reactive	yes	VARh,Neg
32	ENERGY_ELEC_TOTAL_REACT_DEL_K	AI-111510	0	kvolt-ampere-hours-reactive	yes	kVARh,Neg
33	ENERGY_ELEC_TOTAL_REACT_NET	AI-101512	0	volt-ampere-hours-reactive	yes	VARh,Net
34	ENERGY_ELEC_TOTAL_REACT_NET_K	AI-111512	0	kvolt-ampere-hours-reactive	yes	kVARh,Net
35	ENERGY_ELEC_TOTAL_REACT	AI-101514	0	volt-ampere-hours-reactive	yes	VARh,Tot

BACnet objects status webpage
Click BACnet Objects Status on the left side of the webpage to view readings for the meter's embedded BACnet objects. You will see a screen like the one shown below.

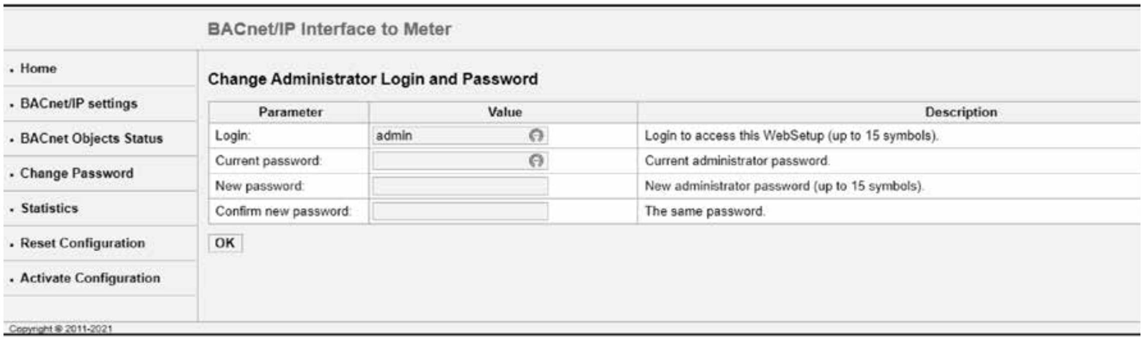


Object Name	Object ID	Present Value	Units	OK	Description
Modbus Meter-ST40-1443321	1443321	-	-	-	(addr.1)
POLL_DELAY	AV-1	10	-	yes	Polling Delay
SCALES	AI-130006	33584	-	yes	pppp--nn-eee-ddd
VOLTAGE_LN-A	AI-101000	122.50053	volts	yes	Volts A-N
VOLTAGE_LN-B	AI-101002	122.50528	volts	yes	Volts B-N
VOLTAGE_LN-C	AI-101004	122.51182	volts	yes	Volts C-N
VOLTAGE_LL-AB	AI-101006	0	volts	yes	Volts A-B
VOLTAGE_LL-BC	AI-101008	0	volts	yes	Volts B-C
VOLTAGE_LL-CA	AI-101010	0	volts	yes	Volts C-A
CURRENT_LN-A	AI-101012	0	amperes	yes	Amps A
CURRENT_LN-B	AI-101014	0	amperes	yes	Amps B
CURRENT_LN-C	AI-101016	0	amperes	yes	Amps C
PWR_ELEC	AI-101018	0	watts	yes	Watts,tot
PWR_ELEC_K	AI-111018	0	kilowatts	yes	kWatts,tot
PWR_ELEC_REACT	AI-101020	0	volt-amperes-reactive	yes	VARs,tot
PWR_ELEC_REACT_K	AI-111020	0	kilovolt-amperes-reactive	yes	kVARs,tot
PWR_ELEC_APPAR	AI-101022	0	volt-amperes	yes	VAs,tot
PWR_ELEC_APPAR_K	AI-111022	0	kilovolt-amperes	yes	kVAs,tot
PWR_FACTOR	AI-101024	1	-	yes	PF,tot
FREQUENCY	AI-101026	60.01593	hertz	yes	Frequency
CURRENT_NG	AI-101028	0	amperes	yes	Current N
ENERGY_ELEC_TOTAL_REC	AI-101500	0	watt-hours	yes	Wh, Rec
ENERGY_ELEC_TOTAL_REC_K	AI-111500	0	kilowatt-hours	yes	kWh, Rec
ENERGY_ELEC_TOTAL_DEL	AI-101502	0	watt-hours	yes	Wh, Del
ENERGY_ELEC_TOTAL_DEL_K	AI-111502	0	kilowatt-hours	yes	kWh, Del
ENERGY_ELEC_TOTAL_NET	AI-101504	0	watt-hours	yes	Wh,Net
ENERGY_ELEC_TOTAL_NET_K	AI-111504	0	kilowatt-hours	yes	kWh,Net
ENERGY_ELEC_TOTAL	AI-101506	0	watt-hours	yes	Wh,Tot
ENERGY_ELEC_TOTAL_K	AI-111506	0	kilowatt-hours	yes	kWh,Tot
ENERGY_ELEC_TOTAL_REACT_REC	AI-101508	0	volt-ampere-hours-reactive	yes	VARh,Pos
ENERGY_ELEC_TOTAL_REACT_REC_K	AI-111508	0	kvolt-ampere-hours-reactive	yes	kVARh,Pos
ENERGY_ELEC_TOTAL_REACT_DEL	AI-101510	0	volt-ampere-hours-reactive	yes	VARh,Neg

Scroll to see all of the objects on the screen. The following items are shown for each BACnet object:

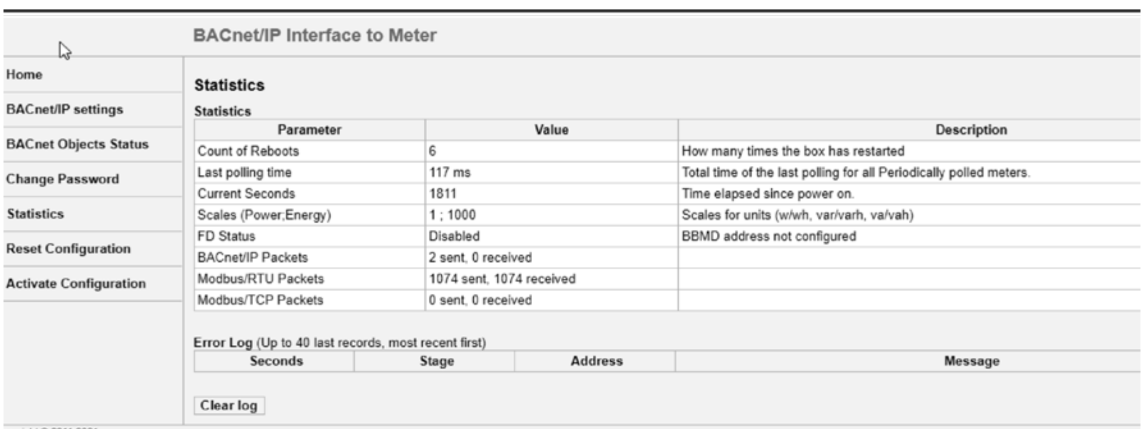
- Object name
- Object ID
- Present value
- Units
- OK (reliability)
- Description

Change password webpage
Click Change Password on the left side of the webpage to access the page shown below.



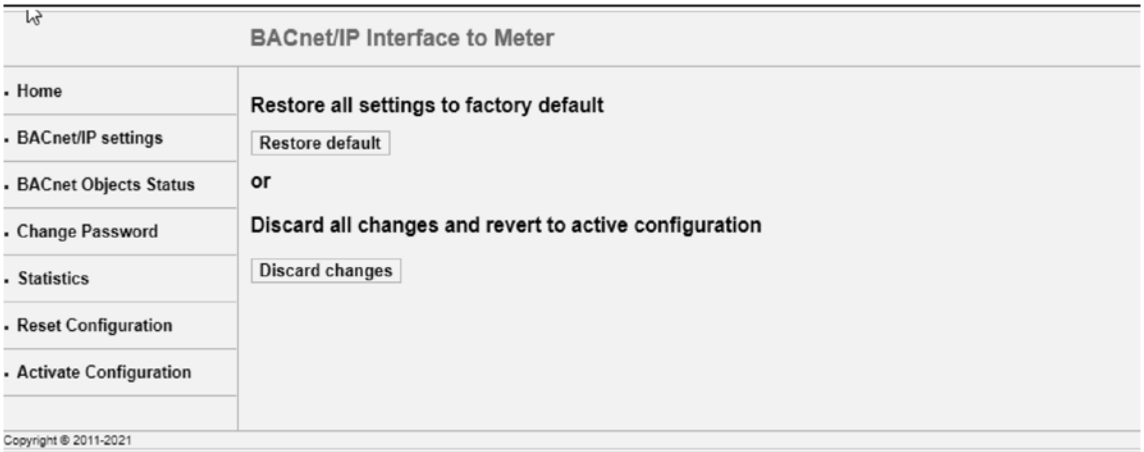
Use this page to change the administrator login and password for this interface. We recommend that you change the login and password rather than continuing to use the default sign-on, and be sure to store the information somewhere safe.

Statistics webpage
Click Statistics on the left side of the webpage to access the page shown below.



This page lists information and any error log for the meter. To erase the error log, click the **Clear Log** button.

Reset configuration webpage
If you want to set the configuration back to its default or last configuration, click Reset Configuration on the left side of the webpage. You will see the page shown below.



- Click the **Restore Default** button to restore all settings to the factory default values.
- Click the **Discard Changes** button to restore all settings to the last saved configuration.

7.5: Using the RGM40 in a BACnet application
Once you have configured the RGM40 meter, you can use it as a standard BACnet server in any BACnet application. Because there are many kinds of BACnet applications, we recommend you consult your application's instructions for details. In addition to integrating with BACnet applications, the RGM40 meter can also be accessed through CommunicatorPQA® software (see chapter 6)and the CommunicatorPQA ® and MeterManagerPQA® software user manual). Additionally, all of the BACnet data can be polled through the Modbus registers (see Appendix B: Modbus map and retrieving logs, on page 61 for the Modbus map).

07

A. RGM40 meter navigation maps

A.1: Introduction

You can configure the RGM40 meter and perform related tasks using the buttons on the meter face. Chapter 5 contains a description of the buttons on the meter face and instructions for programming the meter using them. The meter can also be programmed using software (see chapter 30 in the CommunicatorPQA® and MeterManagerPQA® software user manual).

A.2: Navigation maps (sheets 1 to 4)

The RGM40 meter's navigation maps begin on the next page. The maps show in detail how to move from one screen to another and from one display mode to another using the buttons on the face of the meter. All display modes automatically return to operating mode after 10 minutes with no user activity.

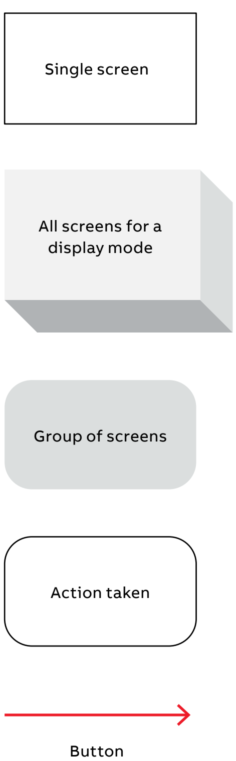
RGM40 meter navigation map titles:

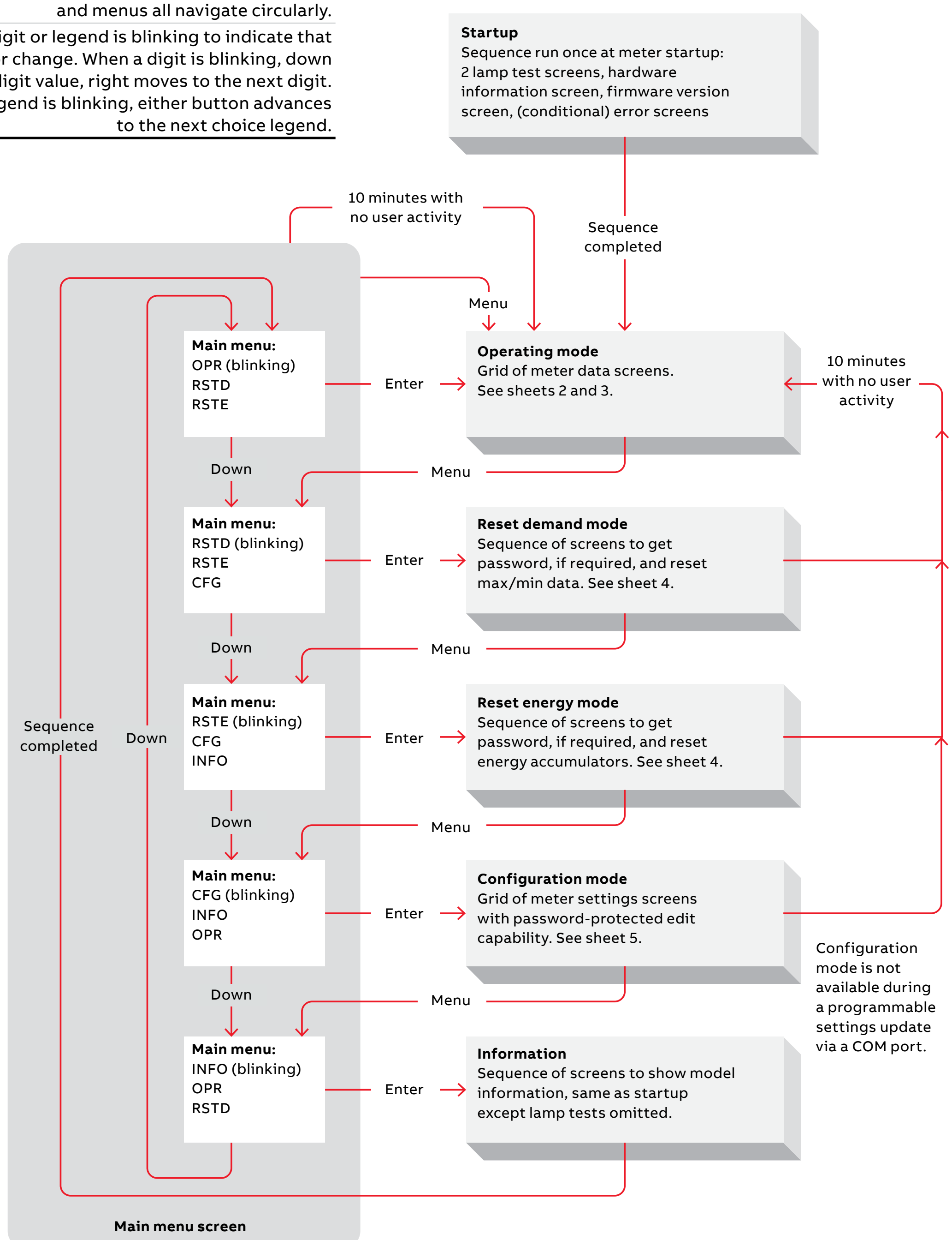
- Main menu screens (sheet 1)
- Operating mode screens (sheets 2)
- Reset mode screens (sheet 3)
- Configuration mode screens (sheet 4)

Main menu screens (sheet 1)

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

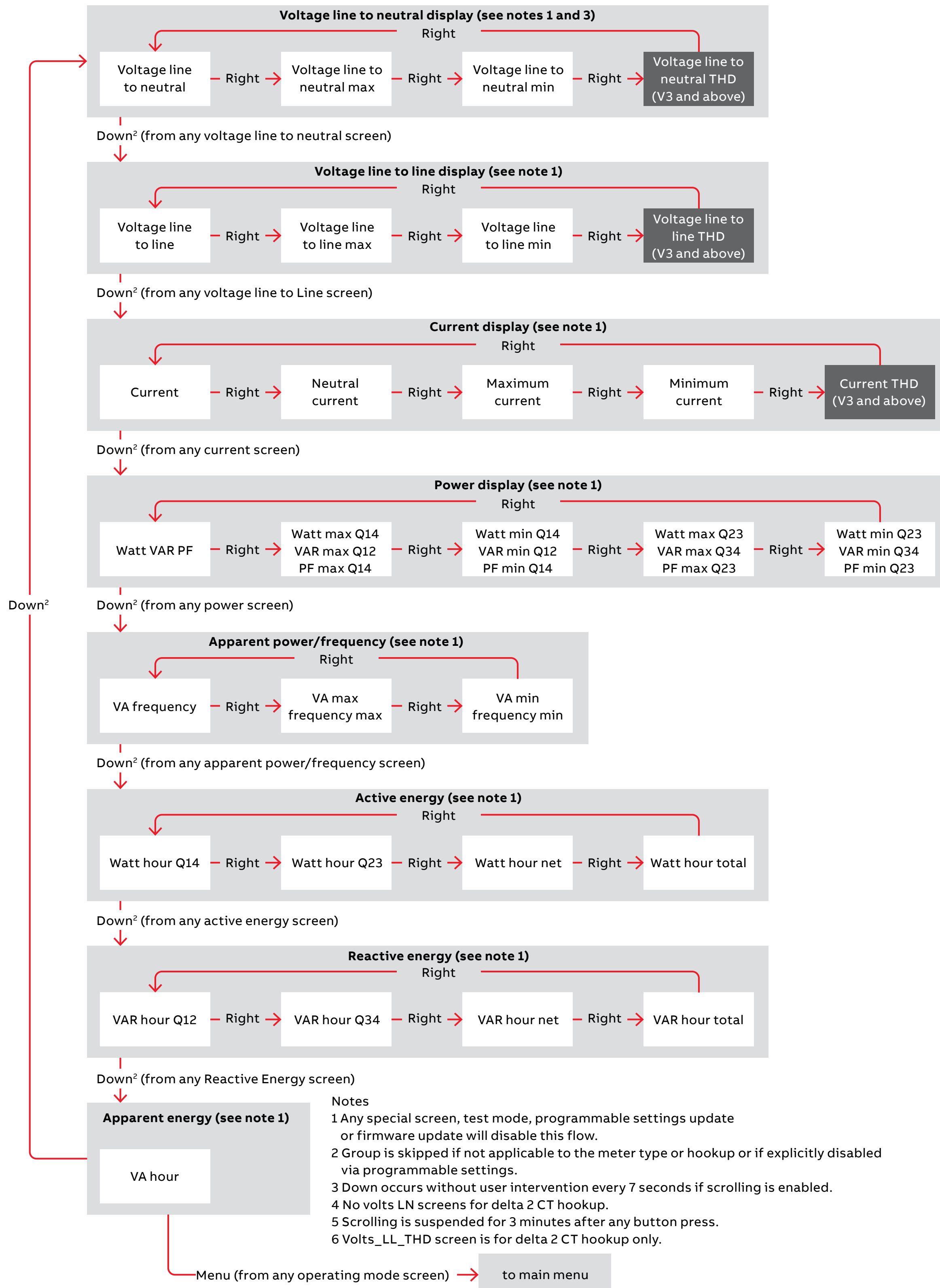
Symbols





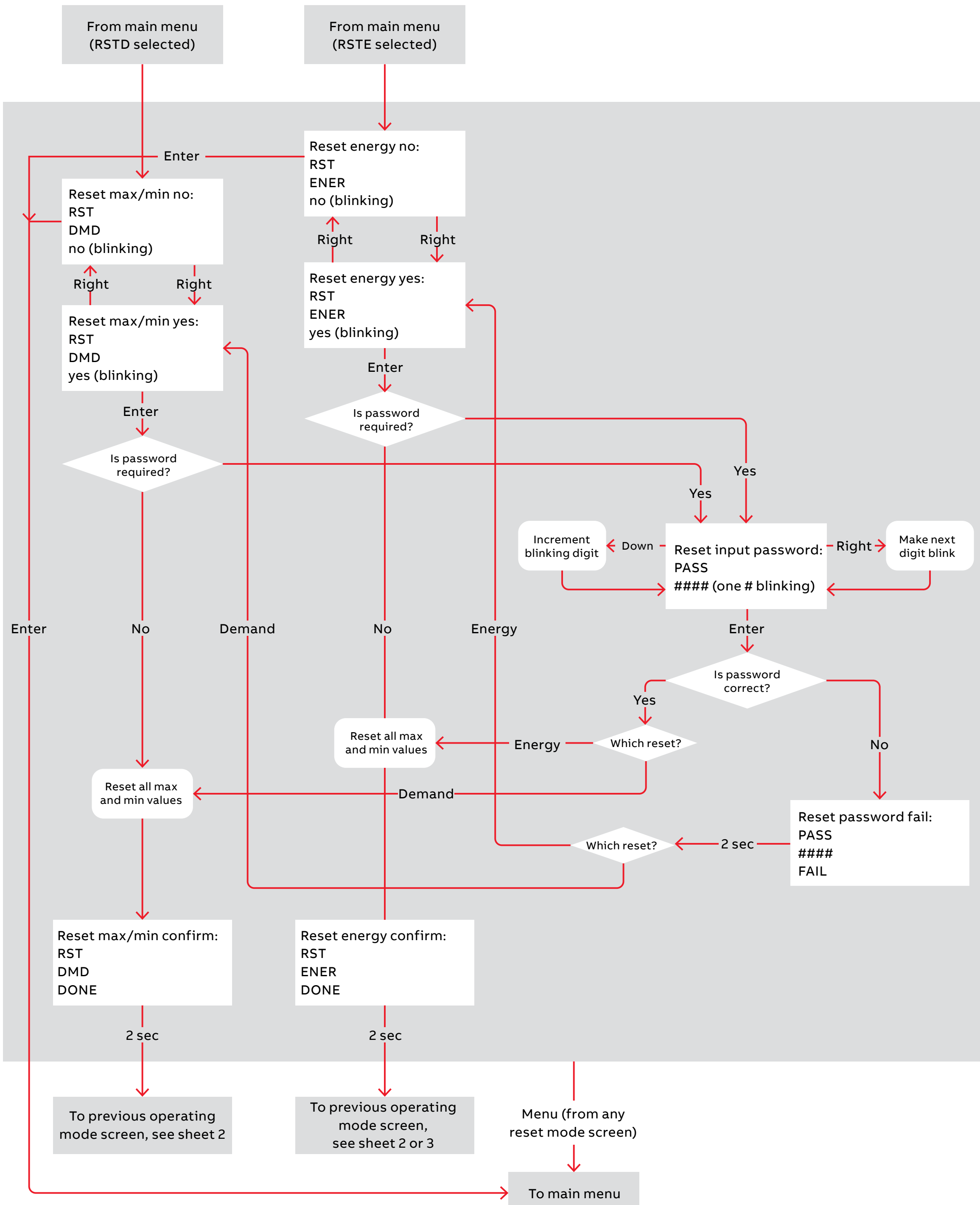
Main menu screen scrolls through five choices, showing three at a time. The top choice is always the “active” one, which is indicated by the blinking legend.

Operating mode screens



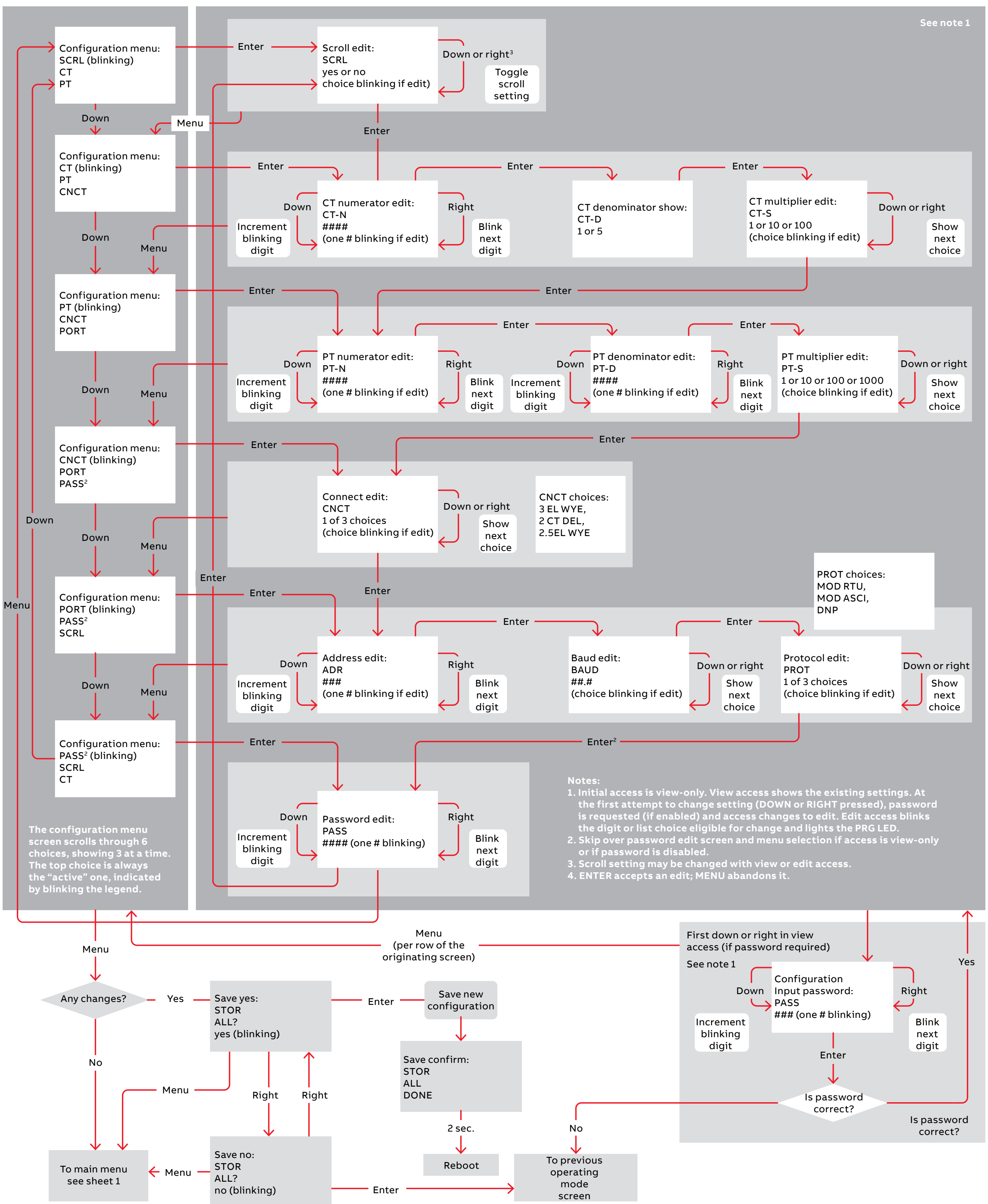
Notes
1 Any special screen, test mode, programmable settings update or firmware update will disable this flow.
2 Group is skipped if not applicable to the meter type or hookup or if explicitly disabled via programmable settings.
3 Down occurs without user intervention every 7 seconds if scrolling is enabled.
4 No volts LN screens for delta 2 CT hookup.
5 Scrolling is suspended for 3 minutes after any button press.
6 Volts_LL_THD screen is for delta 2 CT hookup only.

Reset mode screens



A

Configuration mode screens



B. Modbus map and retrieving logs

B.1: Introduction
The Modbus map for the RGM40 meter gives details and information about the possible readings of the meter and its programming. The RGM40 can be programmed using the buttons on the face of the meter (chapter 5), or by using software. For software configuration instructions, see chapter 30 in the CommunicatorPQA® and MeterManagerPQA® software user manual.

B.2: Modbus register map sections
The RGM40 meter's Modbus register map includes the following sections:

Fixed data section, registers 1–47, details the meter's fixed information.

Meter data section, registers 1000–12031, details the meter's readings, including primary readings, energy block, demand block, phase angle block, status block, THD block, minimum and maximum in regular and time stamp blocks, and accumulators. Operating mode readings are described in section 6.2.6.

Commands section, registers 20000–26011, details the meter's resets block, programming block, other commands block and encryption block.

Programmable settings section, registers 30000–33575, details all the setups you can program to configure your meter.

Secondary readings section, registers 40001–40100, details the meter's secondary readings.

Log retrieval section, registers 49997–51127, details log and retrieval. See B.5: Retrieving logs using the RGM40 meter's Modbus map on page 62.

B.3: Data formats
ASCII: ASCII characters packed 2 per register in high, low order and without any termination characters

SINT16/UINT16: 16-bit signed/unsigned integer

SINT32/UINT32: 32-bit signed/unsigned integer spanning 2 registers — the lower-addressed register is the high order half

Float: 32-bit IEEE floating point number spanning 2 registers — the lower-addressed register is the high order half (i.e., contains the exponent)

B.4: Floating point values
Floating point values are represented in the following format:

Register	0																1															
Byte	0								1								0								1							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Meaning	s	e	e	e	e	e	e	e	e	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
Sign		Exponent								Mantissa																						

The formula to interpret a floating point value is:

$-1^{sign} \times 2^{exponent-127} \times 1.mantissa =$ 0x0C4E11DB9

$-1^{sign} \times 2^{137-127} \times 1\cdot 10000100011101101110 01$

$-1 \times 2^{10} \times 1.75871956$

-1800.929

Register	0x0C4E1																0x01DB9															
Byte	0x0C4								0x0E1								0x01D								0x0B9v							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
	1	1	0	0	0	1	0	0	1	1	1	0	0	0	0	1	0	0	0	1	1	1	0	1	1	0	1	1	1	0	0	1
Meaning	s	e	e	e	e	e	e	e	e	m	m	m	m	m	m	m																
	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m																
Sign		Exponent								Mantissa																						
1		0x089 + 137								0b011000010001110110111001																						

Formula explanation:

C4E11DB9 (hex) 11000100 11100001 00011101 10111001 (binary)

The sign of the mantissa (and therefore the number) is 1, which represents a negative value.

The exponent is 10001001 (binary) or 137 decimal.

The exponent is a value in excess of 127.
So, the exponent value is 10.

The mantissa is 11000010001110110111001 binary. With the implied leading 1, the mantissa is (1).611DB9 (hex).

The floating point representation is therefore -1.75871956 times 2 to the 10.

Decimal equivalent: -1800.929

Notes:
- Exponent = the whole number before the decimal point.
- Mantissa = the positive fraction after the decimal point.

B.5: Retrieving logs using the RGM40 meter's Modbus map
This section describes the log interface system of the RGM40 meter from a programming point of view. It is intended for programmers implementing independent drivers for log retrieval from the meter. It describes the meaning of the meter's Modbus registers related to log retrieval and conversion and details the procedure for retrieving a log's records.

Notes:
- All references assume the use of Modbus function codes 0x03, 0x06 and 0x10, where each register is a 2-byte MSB (most significant byte) word, except where otherwise noted.
- The carat symbol (^) notation is used to indicate mathematical "power." For example, 2^8 means 2^8; which is 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2, which equals 256.

B.5.1: Data formats

Time stamp: Stores a date from 2000 to 2099. Time stamp has a minimum resolution of 1 second.

Byte	0	1	2	3	4	5
Value	Year	Month	Day	Hour	Minute	Second
Range	0–99 (+2000)	1–12	1–31	0–23	0–59	0–59
Mask	0x7F	0x0F	0x1F	0x1F	0x3F	0x3F

The high bits of each time stamp byte are used as flags to record meter state information at the time of the time stamp. These bits should be masked out unless needed.

B.5.2: RGM40 meter logs

The RGM40 meter has 7 logs: System event, alarm (limits), 3 historical, and waveform. Each log is described below.

1. **System event (0):** The system event log is used to store events that happen in, and to, the meter. Events include startup, reset commands, log retrievals, etc. The system event log record takes 20 bytes, 14 bytes of which are available when the log is retrieved.

Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Value						Timestamp	Group	Event	Mod	Chan	Param1	Param2	Param3	Param4

Note: The complete systems events table is shown in section B.5.5, step 1, on page 74.

2. **Alarm log (1):** The alarm log records the states of the 8 limits programmed in the meter.

- Whenever a limit goes out (above or below), a record is stored with the value that caused the limit to go out.
- Whenever a limit returns within limit, a record is stored with the "most out of limit" value for that limit while it was out of limit.

The alarm log record uses 16 bytes, 10 bytes of which are available when the log is retrieved.

Byte	0	1	2	3	4	5	6	7	8	9
Value						Timestamp	Direction	Limit#		Value%

The limit # byte is broken into a type and an ID.

Bit	0	1	2	3	4	5	6	7
Value	type	0	0	0	0			Limit ID

3. **Historical log 1 (2):** The historical log records the values of its assigned registers at the programmed interval.

Note: See B.5.3: block definitions on page 64 for details on programming and interpreting the log.

Byte	0	1	2	3	4	5	6	-	-	N
Value						Timestamp				Values . . .

4. **Historical log 2 (3):** Same as historical log 1.

5. **Historical log 3 (4):** Same as historical log 1.

6. **PQ event log (10):** The power quality event log records the information regarding RGM40 trigger conditions, including the cause of the trigger, conditions at the time of the trigger and duration of the event.

7. **Waveform log (11):** The waveform log records the waveform samples of a capture, along with information about the capture. Due to the large amount of data involved in a waveform capture (approximately 24 kb), a single waveform capture is split over 26 log records. All 26 of these records must be retrieved to build up the single capture. Every waveform record contains a record header, capture number, record number and record payload.

B.5.3: Block definitions

This section describes the Modbus registers involved in retrieving and interpreting an RGM40 meter log. Other sections refer to certain “values” contained in this section. See the corresponding value in this section for details.

Notes:

- “Register” is the Modbus register address in 0-based hexadecimal notation. To convert it to 1-based decimal notation, convert from hex16 to decimal10 and add 1. For example: 0x03E7 = 1000.
- “Size” is the number of Modbus registers (2 byte) in a block of data.

Historical log programmable settings:

The historical logs are programmed using a list of Modbus registers that will be copied into the historical log record. In other words, historical log uses a direct copy of the Modbus registers to control what is recorded at the time of record capture.

To supplement this, the programmable settings for the historical logs contain a list of descriptors, which group registers into items. Each item descriptor lists the data type of the item and the number of bytes for that item. By combining these two lists, the historical log record can be interpreted.

For example: Registers 0x03E7 and 0x03E8 are programmed to be recorded by the historical log. The matching descriptor gives the data type as float, and the size as 4 bytes. These registers program the log to record “primary readings volts A-N.”

Historical log blocks:

Start register:	0x7917 (historical log 1)
	0x79D7 (historical log 2)
	0x7A97 (historical log 3)
Block size:	192 registers per log (384 bytes)

The historical log programmable settings are comprised of three blocks, one for each log.

Each is identical to the others, so only historical log 1 is described here. All register addresses in this section are given as the historical log 1 address (0x7917).

Each historical log block is composed of three sections: The header, the list of registers to log and the list of item descriptors.

Header:

Registers:	0x7917 - 0x7918
Size:	2 registers

Byte	0	1	2	3
Value	# Registers	# Sectors		Interval

- # Registers: The number of registers to log in the record. The size of the record in memory is [12 + (# registers x 2)]. The size during normal log retrieval is [6 + (# registers x 2)]. If this value is 0, the log is disabled. Valid values are {0–117}.
- # Sectors: The number of flash sectors allocated to this log. Each sector is 64 kb, minus a sector header of 20 bytes. 15 sectors are available for allocation between historical logs 1, 2 and 3. The sum of all historical logs may be less than 15. If this value is 0, the log is disabled. Valid values are {0–15}.
- Interval: The interval at which the historical log's records are captured. This value is an enumeration:

0x01	1 minute
0x02	3 minute
0x04	5 minute
0x08	10 minute
0x10	15 minute
0x20	30 minute
0x40	60 minute

Note: The interval between records will not be even (fixed), and thus should not be used with programs that expect a fixed interval.

Register List:

Registers:	0x7919 - 0x798D
Size:	1 register per list item, 117 list items

The register list controls what Modbus registers are recorded in each record of the historical log. Since many items, such as voltage, energy, etc., take up more than 1 register, multiple registers need to be listed to record those items.

For example: Registers 0x03E7 and 0x03E8 are programmed to be recorded by the historical log. These registers program the log to record "primary readings volts A-N."

- Each unused register item should be set to 0x0000 or 0xFFFF to indicate that it should be ignored.
- The actual size of the record and the number of items in the register list that are used is determined by the # registers in the header.
- Each register item is the Modbus address in the range of 0x0000 to 0xFFFF.

Item descriptor list:

Registers:	0x798E - 0x79C8
Size:	1 byte per item, 117 bytes (59 registers)

While the register list describes what to log, the item descriptor list describes how to interpret that information. Each descriptor describes a group of register items and what they mean.

Each descriptor is composed of 2 parts:

- Type: The data type of this descriptor, such as signed integer, IEEE floating point, etc. This is the high nibble of the descriptor byte, with a value in the range of 0–14. If this value is 0xFF, the descriptor should be ignored.

0	ASCII: An ASCII string, or byte array
1	Bitmap: A collection of bit flags
2	Signed integer: A 2's complement integer
3	Float: An IEEE floating point
4	Energy: Special signed integer, where the value is adjusted by the energy settings in the meter's programmable settings.
5	Unsigned integer
6	Signed integer 0.1 scale: Special signed integer, where the value is divided by 10 to give a 0.1 scale.
7–14	Unused
15	Disabled: Used as end list marker.

- Size: The size in bytes of the item described. This number is used to determine the pairing of descriptors with register items.

For example: If the first descriptor is 4 bytes, and the second descriptor is 2 bytes, then the first two register items belong to the first descriptor, and the third register item belongs to the second descriptor.

Note: As can be seen from the example, above, there is not a 1-to-1 relation between the register list and the descriptor list. A single descriptor may refer to multiple register items.

Register items	Descriptors
0x03C7/0x03C8	Float, 4 byte
0x1234	Signed int, 2 byte

Note: The sum of all descriptor sizes must equal the number of bytes in the data portion of the historical log record.

Log status block:
The log status block describes the current status of the log in question. There is one header block for each of the logs. Each log's header has the following base address:

Log	Base address
Alarms:	0xC737
System:	0xC747
Historical 1:	0xC757
Historical 2:	0xC767
Historical 3:	0xC777
PQ event:	0xC797
Waveform:	0xC7A7

Bytes	Value	Type	Range	# Bytes
0–3	Max records	UINT32	0 to 4,294,967,294	4
4–7	Number of records used	UINT32	1 to 4,294,967,294	4
8–9	Record size in bytes	UINT16	4 to 250	2
10–11	Log availability	UINT16		2
12–17	Timestamp, first record	TSTAMP	1Jan2000–31Dec2099	6
18–23	Timestamp, last record	TSTAMP	1Jan2000–31Dec2099	6
24–31	Reserved			8

- Max records: The maximum number of records the log can hold given the record size and sector allocation. The data type is an unsigned integer from 0–2^32.
- Records used: The number of records stored in the log. This number will equal the max records when the log has filled. This value will be set to 1 when the log is reset. The data type is an unsigned integer from 1–2^32.

Note: The first record in every log before it has rolled over is a “dummy” record, filled with all 0xFFs. When the log is filled and rolls over, this record is overwritten.

- Record size: The number of bytes in this record, including the timestamp. The data type is an unsigned integer in the range of 14–242.
- Log availability: A flag indicating if the log is available for retrieval, or if it is in use by another port.

0	Log available for retrieval
1	In use by COM1 (USB)
2	In use by COM2 (RS485)
0xFFFF	Log not available — the log cannot be retrieved. This indicates the log is disabled.

Note: To query the port by which you are currently connected, use the port ID register:

Register: 0x1193
Size: 1 register

Description: A value from 1–4 that enumerates the port on which the requestor is currently connected.

Note:

- When log retrieval is engaged, the log availability value will be set to the port that engaged the log. The log availability value will stay the same until either the log has been disengaged, or 5 minutes have passed with no activity. It will then reset to 0 (available).
- Each log can only be retrieved by one port at a time.
- Only one log at a time can be retrieved.
- First timestamp: Timestamp of oldest record.
- Last timestamp: Timestamp of newest record.

Log retrieval block:
The log retrieval block is the main interface for retrieving logs. It is comprised of two parts: the header and the window. The header is used to program the particular data the meter presents when a log window is requested. The window is a sliding block of data that can be used to access any record in the specified log.

Session com port: The RGM40 meter’s com port that is currently retrieving logs. Only one com port can retrieve logs at any one time.

Registers:	0xC34E - 0xC34E
Size:	1 register
0	No session active
1	COM1 (USB)
2	COM2 (RS485)

To get the current com port, see note above about how to query the port.

Log retrieval header:
The log retrieval header is used to program the log to be retrieved, the record(s) of that log to be accessed and other settings concerning the log retrieval.

Registers: 0xC34F - 0xC350
Size: 2 registers

Bytes	Value	Type	Format	Description	# Bytes
0–1	Log number, enable, scope	UINT16	nnnnnnnn esssssss	nnnnnnnn - log to retrieve, e - retrieval session enable sssssss - retrieval mode	2
2–3	Records per window, number of repeats	UINT16	wwwwwwww nnnnnnnn	wwwww-www - records per window, nnnnnnnn - repeat count	2

- Log number: The log to be retrieved. Write this value to set which log is being retrieved.
  0 System events
  1 Alarms
  2 Historical log 1
  3 Historical log 2
  4 Historical log 3
  10 PQ event log
  11 Waveform log
- Enable: This value sets if a log retrieval session is engaged (locked for retrieval) or disengaged (unlocked, ready for another to engage). Write this value with 1 (enable) to begin log retrieval. Write this value with 0 (disable) to end log retrieval.
  0 Disable
  1 Enable
- Scope: Sets the amount of data to be retrieved for each record. The default should be 0 (normal).
  0 Normal
  1 Timestamp only
  2 Image
  - Normal [0]: The default record. Contains a 6-byte timestamp at the beginning, then N data bytes for the record data.
  - Timestamp [1]: The record only contains the 6-byte timestamp. This is most useful to determine a range of available data for non-interval based logs, such as alarms and system events.
  - Image [2]: The full record, as it is stored in memory. Contains a 2-byte checksum, 4-byte sequence number, 6-byte timestamp and then N data bytes for the record data.
- Records per window: The number of records that fit evenly into a window. This value is settable, as less than a full window may be used. This number tells the retrieving program how many records to expect to find in the window.

  Note: This must be set to 1 for waveform retrieval.

  (RecPerWindow x RecSize) = #bytes used in the window.

  This value should be ((123 x 2) \ recSize), rounded down.

  For example, with a record size of 30, the RecPerWindow = ((123 x 2) \ 30) = 8.2 ~= 8

- Number of repeats: Specifies the number of repeats to use for the Modbus function code 0x23 (35). Since the meter must pre-build the response to each log window request, this value must be set once, and each request must use the same repeat count. Upon reading the last register in the specified window, the record index will increment by the number of repeats if auto-increment is enabled. Section B.5.4.2 has additional information on function code 0x23.

  Note: This must be set to 4 for waveform retrieval.

  0 Disables auto-increment
  1 No repeat count, each request will only get 1 window.
  2–8 2–8 windows returned for each function code 0x23 request.

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Bytes	Value	Type	Format	Description	# Bytes
0–3	Offset of first record in window	UINT32	ssssssss nnnnnnnn nnnnn-nnn nnnnnnnn	ssssssss - window status nn…nn - 24-bit record index number	4
4–249	Log retrieve window	UINT16			246

Log retrieval window block:
The log retrieval window block is used to program the data you want to retrieve from the log. It also provides the interface used to retrieve that data.
Registers: 0xC351 - 0xC3CD
Size: 125 registers

- Window status: The status of the current window. Since the time to prepare a window may exceed an acceptable Modbus delay (1 second), this acts as a state flag, signifying when the window is ready for retrieval. When this value indicates that the window is not ready, the data in the window should be ignored. Window status is read-only, any writes are ignored.
  0 Window is ready
  0xFF Window is not ready
- Record number: The record number of the first record in the data window. Setting this value controls which records will be available in the data window.
  - When the log is engaged, the first (oldest) record is “latched.” This means that record number 0 will always point to the oldest record at the time of latching, until the log is disengaged (unlocked).
  - To retrieve the entire log using auto-increment, set this value to 0, and retrieve the window repeatedly until all records have been retrieved.

  Notes:
  - When auto-increment is enabled, this value will automatically increment so that the window will “page” through the records, increasing by RecordsPerWindow each time that the last register in the window is read.
  - When auto-increment is not enabled, this value must be written to manually for each window to be retrieved.

- Log retrieval data window: The actual data of the records, arranged according to the above settings.

B.5.4: Log retrieval
Log retrieval is accomplished in three basic steps:
1. Engage the log.
2. Retrieve each of the records.
3. Disengage the log.

B.5.4.1: Auto-increment
In ABB’s traditional Modbus retrieval system, you write the index of the block of data to retrieve,
then read that data from a buffer (window). To improve the speed of retrieval, the index can be automatically incremented each time the buffer is read.

In the RGM40 meter, when the last register in the data window is read, the record index is incremented by the records per window.

B.5.4.2: Modbus function code 0x23
Query

Field name	Example (hex)
Slave address	01
Function	23
Starting address hi	C3
Starting address lo	51
# Points hi	00
# Points lo	7D
Repeat count	04

Response

Field name	Example (hex)
Slave address	01
Function	23
# Bytes hi	03
# Bytes lo	E0
Data	...

Function code 0x23 is a user-defined Modbus function code that has a format similar to function code 0x03 except for the inclusion of a “repeat count.” The repeat count (RC) is used to indicate that the same N registers should be read RC number of times. (See the number of repeats bullet on page 67.)

Notes:
- By itself, this feature would not provide any advantage, because the same data will be returned RC times. However, when used with auto-incrementing, this function condenses up to eight requests into one request, which decreases communication time due to fewer transactions being made.

- Keep in mind that the contents of the response data is the block of data you requested, repeated N times. For example, when retrieving log windows, you normally request both the window index and the window data. This means that the first couple of bytes of every repeated block will contain the index of that window.
- In the RGM40 meter, repeat counts are limited to eight times for Modbus RTU, and four times for Modbus ASCII.

The response for function code 0x23 is the same as for function code 0x03, with the data blocks in sequence.

Important! Before using function code 0x23, always check to see if the current connection supports it. Some relay devices do not support user-defined function codes; if that is the case, the message will stall. Other devices don't support eight repeat counts.

B.5.4.3: Log retrieval procedure
The following procedure documents how to retrieve a single log from the oldest record to the newest record, using the "normal" record type (see Scope). All logs are retrieved using the same method. See B.5.4.4: log retrieval example on page 70.

Notes:
- This example uses auto-increment.
- In this example, function code 0x23 is not used.
- You will find referenced topics in section B.5.3 block definitions.
- Modbus register numbers are listed in brackets.

1. Engage the log:
   a. Read the log status block.
      i. Read the contents of the specific logs' status block [0xC737+, 16 reg] (see Log headers).
      ii. Store the # of records used, the record size and the log availability.
      iii. If the log availability is not 0, stop log retrieval; this log is not available at this time. If log availability is 0, proceed to step 1b (engage the log).

      This step is performed to ensure that the log is available for retrieval, as well as retrieving information for later use.
   b. Engage the log: Write log to engage to log number, 1 to enable, and the desired mode to scope (default 0 (normal)) [0xC34F, 1 reg].
      This is best done as a single-register write. This step will latch the first (oldest) record to index 0, and lock the log so that only this port can retrieve the log until it is disengaged.
   c. Verify the log is engaged: Read the contents of the specific logs' status block [0xC737+, 16 reg] again to see if the log is engaged for the current port (see Log availability). If the log is not engaged for the current port, repeat step 1b (Engage the log).
   d. Write the retrieval information.
      i. Compute the number of records per window, as follows:
         RecordsPerWindow = (246 \ RecordSize)
         - If using 0x23, set the repeat count to 2–8. Otherwise, set it to 1.
         - Since we are starting from the beginning for retrieval, the first record index is 0.
      ii. Write the records per window, the number of repeats (1), and record index (0) [0xC350, 3 reg].

      This step tells the RGM40 meter what data to return in the window.
2. Retrieve the records:
   a. Read the record index and window: Read the record index and the data window [0xC351, 125 reg].
      - If the meter returns a slave busy exception, repeat the request.
      - If the window status is 0xFF, repeat the request.
      - If the window status is 0, go to step 2b (Verify record index).

      Notes:
      - We read the index and window in 1 request to minimize communication time and to ensure that the record index matches the data in the data window returned.
- Space in the window after the last specified record (RecordSize x RecordPerWindow) is padded with 0xFF, and can be safely discarded.

   b. Verify that the record index incremented by records per window. The record index of the retrieved window is the index of the first record in the window. This value will increase by records per window each time the window is read, so it should be 0, N, N x 2, N x 3... for each window retrieved.
      - If the record index matches the expected record index, go to step 2c (Compute next expected record index).

   - If the record index does not match the expected record index, go to step 1d (Write the retrieval information), where the record index will be the same as the expected record index. This will tell the RGM40 meter to repeat the records you were expecting.
 c. Compute next expected record Index.
   - If there are no remaining records after the current record window, go to step 3 (Disengage the log).
   - Compute the next expected record index by adding records per window to the current expected record index. If this value is greater than the number of records, re-size the window so it only contains the remaining records and go to step 1d (Write the retrieval information), where the records per window will be the same as the remaining records.

3. Disengage the log: Write the log number (of log being disengaged) to the log index and 0 to the enable bit [0xC34F, 1 reg].

B.5.4.4: Log retrieval example

The following example illustrates a log retrieval session. The example makes the following assumptions:

- Log retrieved is historical log 1 (log index 2).
- Auto-incrementing is used.
- Function code 0x23 is not used (repeat count of 1).
- The log contains volts-AN, volts-BN, volts-CN (12 bytes).
- 100 records are available (0–99).
- COM port 2 (RS485) is being used (see log availability).
- There are no errors.
- Retrieval is starting at record index 0 (oldest record).
- Protocol used is Modbus RTU. The checksum is left off for simplicity.
- The RGM40 meter is at device address 1.
- No new records are recorded to the log during the log retrieval process.

1. Read [0xC757, 16 reg], historical log 1 header block.

Send: 0103 C757 0010

Command:
Register address: 0xC757
Registers: 16

Receive: 010320 00000100 00000064 0012 0000 060717101511 060718101511 0000000000000000

Data:
Max records: 0x100 = 256 records maximum
Num records: 0x64 = 100 records currently logged
Record size: 0x12 = 18 bytes per record
Log availability: 0x00 = 0, not in use, available for retrieval
First timestamp: 0x060717101511 = July 23, 2006, 16:21:17
Last timestamp: 0x060717101511 = July 24, 2006, 16:21:17

Note: This indicates that historical log 1 is available for retrieval.

2. Write 0x0280 -> [0xC34F, 1 reg], log enable.

Send: 0106 C34F 0280

Command:
Register address: 0xC34F
Registers: 1 (write single register command)

Data:
Log number: 2 (historical log 1)
Enable: 1 (engage log)
Scope: 0 (normal mode)

Receive: 0106C34F0280 (echo)

Note: This engages the log for use on this COM port and latches the oldest record as record index 0.

3. Read [0xC757, 16 reg], availability is 0.

Send: 0103 C757 0010

Command:
Register address: 0xC757
Registers: 16

Receive: 010320 00000100 00000064 0012 0002 060717101511 060718101511 0000000000000000

Data:

Max records:	0x100 = 256 records maximum
Num records:	0x64 = 100 records currently logged
Record size:	0x12 = 18 bytes per record
Log availability:	0x02 = 2, in use by COM2, RS485 (the current port)
First timestamp:	0x060717101511 = July 23, 2006, 16:21:17
Last timestamp:	0x060717101511 = July 24, 2006, 16:21:17

Note: This indicates that the log has been engaged properly in step 2. Proceed to retrieve the log.

4. Compute #RecPerWin as (246\18)=13. Write 0x0D01 0000 0000 -> [0xC350, 3 reg]. Write retrieval info. Set current index as 0.

Send:	0110 C350 0003 06 0D01 00 000000

Command:

Register address:	0xC350
# Registers:	3, 6 bytes

Data:

Records per window:	13. Since the window is 246 bytes, and the record is 18 bytes, 246\18 = 13.66, which means that 13 records evenly fit into a single window. This is 234 bytes, which means later on, we only need to read 234 bytes (117 registers) of the window to retrieve the records.
# of repeats:	1. We are using auto-increment (so not 0), but not function code 0x23.
Window status:	0 (ignore)
Record index:	0, start at the first record

Receive:	0110C3500003 (command ok)

Note:

- This sets up the window for retrieval; now we can start retrieving the records.
- As noted previously, we compute the records per window as 246\18 = 13.66, which is rounded to 13 records per window. This allows the minimum number of requests to be made to the meter, which increases retrieval speed.

5. Read [0xC351, 125 reg], first 2 reg is status/ index, last 123 reg is window data. Status OK.

Send:	0103 C351 007D

Command:

Register address:	0xC351
# Registers:	0x7D, 125 registers

Receive:	0103FA 00000000 060717101511FFFFFFFFFFFF FFFFFFFFFFF 06071710160042FAA ACF42FAAD1842FAA9A8 . . .

Data:

Window status:	0x00 = the window is ready
Index:	0x00 = 0, The window starts with the 0'th record, which is the oldest record
Record 0:	The next 18 bytes is the 0'th record (filler)
Timestamp:	0x060717101511, = July 23, 2006, 16:21:17
Data:	This record is the "filler" record. It is used by the meter so that there is never 0 records. It should be ignored. It can be identified by the data being all 0xFF. **Note**: Once a log has rolled over, the 0'th record will be a valid record, and the filler record will disappear.
Record 1:	The next 18 bytes is the 1'st record.
Timestamp:	0x060717101600 July 23, 2006, 16:22:00

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Data:

Volts AN:	0x42FAAACF, float = 125.33~
Volts BN:	0x42FAAD18, float = 125.33~
Volts CN:	0x42FAA9A8, float = 125.33~

. . . 13 records

Notes:
- This retrieves the actual window. Repeat this command as many times as necessary to retrieve all of the records when auto-increment is enabled.
- Note the filler record. When a log is reset (cleared) in the meter, the meter always adds a first “filler” record, so that there is always at least 1 record in the log. This “filler” record can be identified by the data being all 0xFF, and it being index 0. If a record has all 0xFF for data, the timestamp is valid, and the index is NOT 0, then the record is legitimate.
- When the “filler” record is logged, its timestamp may not be “on the interval.” The next record taken will be on the next “proper interval,” adjusted to the hour. For example, if the interval is 1 minute, the first “real” record will be taken on the next minute (no seconds). If the interval is 15 minutes, the next record will be taken at :15, :30, :45 or :00 — whichever of those values is next in sequence.

6. Compare the index with current index.

Notes:
- The current index is 0 at this point, and the record index retrieved in step 5 is 0: thus we go to step 8.
- If the current index and the record index do not match, go to step 7. The data that was received in the window may be invalid and should be discarded.

7. Write the current index to [0xC351, 2 reg].

Send: 0110 C351 0002 04 00 00000D

Command:

Register address:	0xC351
# Registers:	2, 4 bytes

Data:

Window status:	0 (ignore)
Record index:	0x0D = 13, start at the 14th record

Receive:	0110C3510002 (command OK)

Notes:
- This step manually sets the record index and is primarily used when an out-of-order record index is returned on a read (step 6).
- The example assumes that the second window retrieval failed somehow, and we need to recover by requesting the records starting at index 13 again.

8. For each record in the retrieved window, copy and save the data for later interpretation.

9. Increment current ondex by RecordsPerWindow.

Notes:
- This is the step that determines how much more of the log we need to retrieve.
- On the first N passes, records per window should be 13 (as computed in step 4), and the current index should be a multiple of that (0, 13, 26...). This amount will decrease when we reach the end (see step 10).
- If the current index is greater than or equal to the number of records (in this case 100), then all records have been retrieved; go to step 12. Otherwise, go to step 10 to check if we are nearing the end of the records.

10. If number records - current index is < RecordsPerWindow, decrease to match.

Notes:
- Here we bounds-check the current index, so we don’t exceed the records available.
- If the number of remaining records (#records - current index) is less than the records per window, then the next window is the last and contains less than a full window of records. Make records per window equal to remaining records (#records-current index). In this example, this occurs when current index is 91 (the 8’th window). There are now 9 records available (100-91), so make records per window equal 9.

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11. Repeat steps 5 through 10.

Notes:
- Go back to step 5, where a couple of values have changed.

Pass	CurIndex	FirstRecIndex	RecPerWindow
0	0	0	13
1	13	13	13
2	26	26	13
3	39	39	13
4	52	52	13
5	65	65	13
6	78	78	13
7	91	91	9
8	100	—	—

- At pass 8, since current index is equal to the number of records (100), log retrieval should stop; go to step 12 (see step 9 notes).

12. No more records available, clean up.

13. Write 0x0000 -> [0xC34F, 1 reg], disengage the log.

Send: 0106 C34F 0000

Command:
Register address: 0xC34F

Registers: 1 (write single register command)

Data:
Log number: 0 (ignore)

Enable: 0 (disengage log)

Scope: 0 (ignore)

Receive: 0106C34F0000 (echo)

Notes:
- This disengages the log, allowing it to be retrieved by other COM ports.
- The log will automatically disengage if no log retrieval action is taken for 5 minutes.

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B.5.5: Log record interpretation

The records of each log are composed of a 6-byte timestamp and N data. The content of the data portion depends on the log.

—

System event record:

Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Value					Timestamp		Group	Event	Mod	Chan	Param1	Param2	Param3	Param4

Size: 14 bytes (20 bytes image).

Data: The system event data is 8 bytes; each byte is an enumerated value.

- Group: Group of the event.
- Event: Event within a group.
- Modifier: Additional information about the event, such as number of sectors or log number.
- Channel: The port of the RGM40 meter that caused the event.

0	Firmware
1	COM 1 (USB)
2	COM 2 (RS485)
7	User (face plate)

Param 1–4: These are defined for each event (see following table).

Note: The system log record is 20 bytes, consisting of the record header (12 bytes) and payload (8 bytes). The timestamp (6 bytes) is in the header. Typically, software will retrieve only the timestamp and payload, yielding a 14-byte record. The table below shows all defined payloads.

Group (event group)	Event (event within group)	Mod (event modifier)	Channel (1-4 for coms, 7 for user, 0 for FW)	Param1	Param2	Param3	Param4	Comments
0								Startup
	0	0	0				FW version	Meter run firmware startup
1								Log activity
	1	Log#	1–4	0xFF	0xFF	0xFF	0xFF	Reset
	2	Log#	1–4	0xFF	0xFF	0xFF	0xFF	Log retrieval begin
	3	Log#	0–4	0xFF	0xFF	0xFF	0xFF	Log retrieval end
2								Clock activity
	1	0	1–4	0xFF	0xFF	0xFF	0xFF	Clock changed
	2	0	0	0xFF	0xFF	0xFF	0xFF	Daylight time on
	3	0	0	0xFF	0xFF	0xFF	0xFF	Daylight time off
	4	Sync method	0	0xFF	0xFF	0xFF	0xFF	Auto clock sync failed
	5	Sync method	0	0xFF	0xFF	0xFF	0xFF	Auto clock sync resumed

Group (event group)	Event (event within group)	Mod (event modifier)	Channel (1-4 for coms, 7 for user, 0 for FW)	Param1	Param2	Param3	Param4	Comments
3								System resets
	1	0	0–4, 7	0xFF	0xFF	0xFF	0xFF	Max and min reset
	2	0	0–4, 7	0xFF	0xFF	0xFF	0xFF	Energy reset
	3	Slot#	0-4	1 (inputs) or 2 (outputs)	0xFF	0xFF	0xFF	Accumulators reset
4								Settings activity
	1	0	1–4, 7	0xFF	0xFF	0xFF	0xFF	Password changed
	2	0	1–4	0xFF	0xFF	0xFF	0xFF	V-switch changed
	3	0	1–4, 7	0xFF	0xFF	0xFF	0xFF	Programmable settings changed
	4	0	1–4, 7	0xFF	0xFF	0xFF	0xFF	Measurement stopped
5								Boot activity
	1	0	1–4	FW version				Exit to boot
6								Error reporting and recovery
	4	Log #	0	0xFF	0xFF	0xFF	0xFF	Log babbling detected
	5	Log #	0	# records discarded		Time in seconds		Babbling log periodic summary
	6	Log #	0	# records discarded		Time in seconds		Log babbling end detected
	7	Sector#	0	Error count		Stimulus	0xFF	Flash sector error
	8	0	0	0xFF	0xFF	0xFF	0xFF	Flash error counters reset
	9	0	0	0xFF	0xFF	0xFF	0xFF	Flash job queue overflow
	10	1	0	0xFF	0Xff	0xFF	0xFF	Bad NTP configuration
	11	0	0	Repair flags				Critical data repaired
0x88								
	1	Sector#	0	log #	0xFF	0xFF	0xFF	Acquire sector
	2	Sector#	0	log #	0xFF	0xFF	0xFF	Release sector
	3	Sector#	0	Erase count				Erase sector
	4	Log#	0	0xFF	0xFF	0xFF	0xFF	Write log start record

- Log# values: 0 = system log, 1 = alarms log, 2–4 = historical logs 1–3
- Sector# values: 0–63
- Slot# values: 1–2

Notes:

- The clock changed event shows the clock value just before the change in the mod and param bytes. Params are bit-mapped:
  - b31–b28 month
  - b27–b23 day
  - b22 daylight savings time flag
  - b20–b16 hour
  - b13–b8 minute
  - b5–b0 second
  - Unused bits are always 0
- Sync method: 1 = NTP.
- Stimulus for a flash sector error indicates what the flash was doing when the error occurred: 1 = acquire sector, 2 = startup, 3 = empty sector, 4 = release sector, 5 = write data.
- Flash error counters are reset to zero in the unlikely event that both copies in EEPROM are corrupted.
- The flash job queue is flushed (and log records are lost) in the unlikely event that the queue runs out of space.

- A “babbling log” is one that is saving records faster than the meter can handle long term. When babbling is detected, the log is frozen and no records are appended until babbling ceases. As long as babbling persists, a summary of records discarded is logged every 60 minutes. Normal logging resumes when there have been no new append attempts for 30 seconds. Onset of babbling occurs when a log fills a flash sector in less than an hour (applies only to alarm, historical and power quality logs), when the log fills or wraps around in less than two minutes (applies only to waveform log), when the number of unassigned sectors becomes dangerously low (applies only to waveform log) or when a log grows so far beyond its normal bounds that it is in danger of crashing the system. This applies to all logs except the system log, which does not babble. While possible for the other logs during an extended log retrieval session, it is extremely unlikely to occur for any logs except waveform.
- Logging of diagnostic records may be suppressed via a bit in programmable settings.

Alarm record:

Byte	0	1	2	3	4	5	6	7	8	9
Value						Timestamp	Direction	Limit#		Value%

Size: 10 bytes (16 bytes image)

Data: The alarm record data is 4 bytes and specifies which limit the event occurred on and the direction of the event (going out of limit or coming back into limit).

- Direction: The direction of the alarm event: Whether this record indicates the limit going out, or coming back into limit.

1 Going out of limit
2 Coming back into limit

Bit	0	1	2	3	4	5	6	7
Value	Type	0	0	0	0			Limit ID

- Limit type: Each limit (1–8) has both an above condition and a below condition. Limit type indicates which of those the record represents.

0 High limit
1 Low limit

- Limit ID: The specific limit this record represents. A value in the range 0–7, limit ID represents limits 1–8. The specific details for this limit are stored in the programmable settings.
- Value: Depends on the direction:
  - If the record is "going out of limit," this is the value of the limit when the "out" condition occurred.
  - If the record is "coming back into limit," this is the "worst" value of the limit during the period of being "out." For high (above) limits, this is the highest value during the "out" period; for low (below) limits, this is the lowest value during the "out" period.

Byte	0	1	2	3	4	5	6	7	8	9
Value		Identifier		Above setpoint		Above hysteresis		Below setpoint		Below hysteresis

Interpretation of alarm data:
To interpret the data from the alarm records, you need the limit data from the programmable settings [0x754B, 40 registers].

There are eight limits, each with an above setpoint,
and a below setpoint. Each setpoint also has a threshold (hysteresis), which is the value at which the limit returns "into" limit after the setpoint has been exceeded. This prevents "babbling" limits, which can be caused by the limit value fluttering over the setpoint, causing it to go in and out of limit continuously.

- Identifier: The first Modbus register of the value that is being watched by this limit.
- While any Modbus register is valid, only values that can have a full scale will be used by the RGM40 meter.
- Above setpoint: The percent of the full scale above which the value for this limit will be considered "out."
  - Valid in the range of -200.0% to +200.0%
  - Stored as an integer with 0.1 resolution. (Multiply % by 10 to get the integer, divide integer by 10 to get %. For example, 105.2% = 1052.)
- Above hysteresis: The percent of the full scale below which the limit will return "into" limit, if it is out. If this value is above the above setpoint, this above limit will be disabled.
  - Valid in the range of -200.0% to +200.0%.
  - Stored as an integer with 0.1 resolution. (Multiply % by 10 to get the integer, divide integer by 10 to get %. For example, 104.1% = 1041.)
- Below setpoint: The percent of the full scale below which the value for this limit will be considered "out."
  - Valid in the range of -200.0% to +200.0%.
  - Stored as an integer with 0.1 resolution. (Multiply % by 10 to get the integer, divide integer by 10 to get %. For example, 93.5% = 935.)
- Below hysteresis: The percent of the full scale above which the limit will return "into" limit, if it is out. If this value is below the below setpoint, this below limit will be disabled.
  - Valid in the range of -200.0% to +200.0%.
  - Stored as an integer with 0.1 resolution. (Multiply % by 10 to get the integer, divide integer by 10 to get %. For example, 94.9% = 949.)

Notes:

- The full scale is the ”nominal” value for each of the different types of readings. To compute the full scale, use the following formulas:

Current	[CT numerator] x [CT multiplier]
Voltage	[PT numerator] x [PT multiplier]
Power 3-phase (WYE)	[CT numerator] x [CT multiplier] x [PT numerator] x [PT multiplier] x 3
Power 3-phase (Delta)	[CT numerator] x [CT multiplier] x [PT numerator] x [PT multiplier] x 3 x sqrt(3)
Power single-phase (WYE)	[CT numerator] x [CT numerator] x [PT numerator] x [PT multiplier]
Power single-phase (Delta)	[CT numerator] x [CT multiplier] x [PT numerator] x [PT multiplier] x sqrt(3)
Frequency (calibrated at 60 Hz)	60
Frequency (calibrated at 50 Hz)	50
Power factor	1.0
THD, harmonics	100.0%
Angles	180°

- To interpret a limit alarm fully, you need both the start and end record (for duration).
- There are a few special conditions related to limits:
  - When the meter powers up, it detects limits from scratch. This means that multiple “out of limit” records can be in sequence with no “into limit” records.
    - Cross- reference the system events for power-up events.
    - This also means that if a limit is “out,” and it goes back in during the power off condition, no “into limit” record will be recorded.
    - The “worst” value of the “into limit” record follows the above restrictions; it only represents the values since power up. Any values before the power up condition are lost.

Size: 6+2 x N bytes (12 + 2 x N bytes), where N is the number of registers stored.

Data: The historical log record data is 2 x N bytes, which contains snapshots of the values of the associated registers at the time the record was taken. Since the meter uses specific registers to log, with no knowledge of the data it contains, the programmable settings need to be used to interpret the data in the record. See historical logs programmable settings for details.

—
Historical log record:

Byte	0	1	2	3	4	5	6	-	-	N
Value						Timestamp				Values . . .

Waveform log record:

Byte	0	1	2	3	4	5	6	7	8	-	-	969
Value	Timestamp						Capture #	Record #	Record payload			

Size: 970 bytes

Data: Each waveform record is 970 bytes, which contains the timestamp, the capture number it is associated with (all 26 will have the same capture number), its own record number (numbered 0–25) and the payload.

Note: Waveform records must be in sequential order. Verify that the record numbers are sequential. If they are not, the retrieval of that capture must be restarted.

PQ event record:

Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	...	31	32	...	43	44	...	57
Value	Timestamp						Present states		Event channels		Capture #	Flags	Event cycle tag		Worst excursion RMS			Sample calibrations			Not used (0X0)		

Size: 58 bytes

Data: See the first table in the PQ event log retrieval section for detailed information about the data.

Note: The "not used" section of the PQ event record byte-map is simply 0.

B.5.6: Examples

Log retrieval section:

send:	01	03	75	40	00	08	-	Meter designation												
recv:	01	03	10	4D	65	74	72	65	44	65	73	69	6E	67	5F	20	20	20	20	00 00
send:	:01	03	C7	57	00	10	-	Historical log 1 status block												
recv:	:01	03	20	00	00	05	1E	00	00	05	1E	00	2C	00	00	06	08	17	51	08
	00	06	08	18	4E	39	00	00	00	00	00	00	00	00	00	00	00			
send:	:01	03	79	17	00	40	-	Historical log 1 PS settings												
recv:	:01	03	80	13	01	00	01	23	75	23	76	23	77	1F	3F	1F	40	1F	41	1F
	42	1F	43	1F	44	06	0B	06	0C	06	0D	06	0E	17	75	17	76	17	77	18
	67	18	68	18	69	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
	00	00	00	00	00	00	00	00	00	00	00	00	00							
send:	:01	03	79	57	00	40	-	" "												
recv:	:01	03	80	00	00	00	00	00"	00	00	00	00	00	00	00	00	00	00	00	00
	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
	00	00	00	00	00	00	00	00	00	00	00	00	00	62	62	62	34	34	34	44
	44	62	62	62	62	62	62	00	00	00	00	00	00							
send:	:01	03	75	35	00	01	-	Energy PS settings												
recv:	:01	03	02	83	31	00	00													

```
send:   :01  03  11  93  00  01  -   Connected port ID
recv:   :01  03  02  00  02  00  00

send:   :01  03  C7  57  00  10  -   Historical log 1 status block
recv:   :01  03  20  00  00  05  1E  00  00  05  1E  00  2C  00  00  06  08  17  51  08
        00   06  08  18  4E  39  00  00  00  00  00  00  00  00  00  00  00

send:   :01  03  C3  4F  00  01  -   Log retrieval header
recv:   :01  03  02  FF  FF  00  00

send:   :01  10  C3  4F  00  04  08  02  80  05  01  00  00  00  00  -   - Engage the log
recv:   :01  10  C3  4F  00  04

send:   :01  03  C7  57  00  10  -   Historical log 1 status block
recv:   :01  03  20  00  00  05  1E  00  00  05  1E  00  2C  00  02  06  08  17  51  08
        00   06  08  18  4E  39  00  00  00  00  00  00  00  00  00  00  00

send:   :01  10  C3  51  00  02  04  00  00  00  00  -   Set the retrieval index
recv:   :01  10  C3  51  00  02

send:   :01  03  C3  51  00  40  -   Read first half of window
recv:   :01  03  80  00  00  00  00  06  08  17  51  08  00  00  19  00  2F  27  0F  00
        00   00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  03
        E8   00  01  00  05  00  00  00  00  00  00  06  08  17  51  09  00  00  19  00
        2F   27  0F  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00
        00   00  00  03  E8  00  01  00  04  00  00  00  00  00  00  06  08  17  51  0A
        00   00  19  00  2F  27  0F  00  00  00  00  00  00  00  00  00  00  00  00  00
        00   00  00  00  00  00  00  03  E8  00  00  00  00

send:   :01  03  C3  91  00  30  -   Read second half of window
recv:   :01  03  60  00  05  00  00  00  00  00  00  06  08  17  51  0B  00  00  19  00
        2F   27  0F  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00
        00   00  00  03  E8  00  01  00  04  00  00  00  00  00  00  06  08  17  51  0C
        00   00  19  00  2F  27  0F  00  00  00  00  00  00  00  00  00  00  00  00  00
        00   00  00  00  00  00  00  03  E8  00  01  00  04  00  00  00  00  00  00  00
        00

send:   :01  03  C3  51  00  40  -   Read first half of last window
recv:   :01  03  80  00  00  05  19  06  08  18  4E  35  00  00  19  00  2F  27  0F  00
        00   00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  03
        E8   00  01  00  04  00  00  00  00  00  00  06  08  18  4E  36  00  00  19  00
        2F   27  0F  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00
        00   00  00  03  E8  00  01  00  04  00  00  00  00  00  00  06  08  18  4E  37
        00   00  19  00  2F  27  0F  00  00  00  00  00  00  00  00  00  00  00  00  00
        00   00  00  00  00  00  00  03  E8  00  00  00  00

send:   :01  03  C3  91  00  30  -   Read second half of last window
recv:   :01  03  60  00  05  00  00  00  00  00  00  06  08  18  4E  38  00  00  19  00
        2F   27  0F  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00  00
        00   00  00  03  E8  00  01  00  04  00  00  00  00  00  00  06  08  18  4E  39
        00   00  19  00  2F  27  0F  00  00  00  00  00  00  00  00  00  00  00  00  00
        00   00  00  00  00  00  00  03  E8  00  00  00  05  00  00  00  00  00  00  00
        00

send:   :01  06  C3  4F  00  00  -   Disengage the log
recv:   :01  06  C3  4F  00  00
```

Sample historical log 1 record:

Historical log 1 record and programmable settings

```
13|01|00   01|23   75|23   76|23   77|1F   3F    1F    40|1F   41
1F 42|1F   43 1F   44|06   0B 06   0C|06   0D    06    0E|17   75|
17 76|17   77|18   67|18   68|18   69|00   00    .     .   .   .
62 62 62   34 34   34 44   44 62   62 62   62    62    62  .   .
```

B

These are the item values:				These are the type and size:		These are the descriptions:
13						- # registers
01						- # sectors
01						- interval
23	75			6	2	- (SINT 2-byte) volts A THD maximum
23	76			6	2	- (SINT 2-byte) volts B THD maximum
23	77			6	2	- (SINT 2-byte) volts C THD maximum
1F	3F	1F	40	3	4	- (Float 4-byte) volts A minimum
1F	41	1F	42	3	4	- (Float 4-byte) volts B minimum
1F	43	1F	44	3	4	- (Float 4-byte) volts C minimum
06	0B	06	0C	4	4	- (Energy 4-byte) VARhr negative phase A
06	0D	06	0E	4	4	- (Energy 4-byte) VARhr negative phase B
17	75			6	2	- (SINT 2-byte) volts A 1st harmonic magnitude
17	76			6	2	- (SINT 2-byte) magnitude volts A 2nd harmonic
17	77			6	2	- (SINT 2-byte) magnitude volts A 3rd harmonic
18	67			6	2	- (SINT 2-byte) Ib 3rd harmonic magnitude
18	68			6	2	- (SINT 2-byte) Ib 4th harmonic magnitude
18	69			6	2	- (SINT 2-byte) Ib 5th harmonic magnitude

Sample record

06	08	17	51	08	00|00	19|00	2F|27	0F|00	00	00	00|00	
00	00	00|00	00	00	00|00	00	00	00|00	00	00	00|03	E8|
00	01|00	05|00	00|00	00|00	00	. . .						

11	08	17	51	08	00	- August 23, 2011 17:08:00
00	19					- 2.5%
00	2F					- 4.7%
27	0F					- 999.9% (indicates the value isn't valid)
00	00	00	00			- 0
00	00	00	00			- 0
00	00	00	00			- 0
00	00	00	00			- 0
00	00	00	00			- 0
03	E8					- 100.0% (fundamental)
00	01					- 0.1%
00	05					- 0.5%
00	00					- 0.0%
00	00					- 0.0%
00	00					- 0.0%

B.5.7: Waveform log retrieval

The waveform log is unique among the logs in that each capture is composed of 26 waveform records, and each record requires four windows to retrieve. For more information on record retrieval, see B.5.4.3: Log retrieval procedure on page 69. The 26 waveform records adhere to the following byte-map.

Size	Content	Notes	Offset
6 bytes	Timestamp	All 26 records have the same time-stamp	0
1 byte	Capture number	All 26 records have the same capture number	6
1 byte	Record number	Records are numbered 0–25	7
962 bytes	Record payload	Waveform record payload — all 26 waveform record payloads combined create a waveform capture	8

A single waveform capture is the aggregation of all 26 waveform record payloads, thus totaling 25,012 bytes in size. The resulting waveform capture contains the following byte structure:

Bytes	Block
36	Header
388	Reserved (0xFF)
4098	Channel AN (wye) or AB (delta)
4098	Channel IA
4098	Channel BN (wye) or BC (delta)
4098	Channel IB
4098	Channel CN (wye) or CA (delta)
4098	Channel IC

Note: The order of the channels is not fixed. The channel ID (first 2 bytes of the 4098 bytes) must be used to determine which channel block is being presented.

Breaking the waveform capture down further, the specific blocks (header and channel blocks) are as follows:
(**Note:** 1b = 1 byte, 2b = 2 bytes.)

Trigger source (2b)		SmpRate (1b)	Flags (1b)
TriggerType	TrigCap#	Trigger cycle tag (2b)	
First sample tag		Last sample tag	
Trigger cycle RMS Va		Trigger cycle RMS Ia	
Trigger cycle RMS Vb		Trigger cycle RMS Ib	
Trigger cycle RMS Vc		Trigger cycle RMS Ic	
Sample calibration Va		Sample calibration Ia	
Sample calibration Vb		Sample calibration Ib	
Sample calibration Vc		Sample calibration Ic	

—

Channel sample block definition (4098 bytes)

Channel ID (2b)	Sample 1 (2b)
Sample 2 (2b)	Sample 3 (2b)
Sample 4 (2b)	Sample 5 (2b)
...	...
Sample 2046 (2b)	Sample 2047 (2b)
Sample 2048 (2b)	

Parsing a waveform capture

To parse the waveform capture, follow this procedure:

1. Download the entire capture. When engaging the log for retrieval, the number of records will always be one, and the repeat count will always be four. Because of the large records (970 bytes), you must use function code 0x23, with four repeat counts. An example request message would be: 0123C351007C04. See B.5.4.3: Log retrieval procedure on page 69 for details.

   It may take a while to get a response, so if you get a slave busy Modbus exception, try again.

2. The data that comes back will be the window index and window data, repeated four times. For each block, you must check that the window status and window index are correct.

   If the window status is 0xFF, then the data is not ready, and you should request that record again. See B.5.4.4: Log retrieval example on page 70 for an example of this point.

3. Once you know you have the right data, check the waveform record header to make sure you have received the correct record and then parse the data by copying out the window data and skipping the window indices.

   You should be receiving waveform records sequentially, from 0 to 25. If the number is out of order or invalid, the waveform may be corrupt, and you should retrieve the waveform capture from the beginning by manually setting the record index to start at 0.

   Once you know you have the right record, from window index 0, the first 8 bytes (the timestamp and record info) must be skipped. This will result in a stripping of the record header, capture and record numbers, which will leave only the waveform record payload (see table on page B-43). You only need to store the timestamp from the first record, because each of the 26 records have the same timestamp.

4. Copy the record data (record payload) to the output (e.g., an array of byte arrays — each byte array representing a waveform record) and repeat this stripping process for all 26 waveform records. Once done, combine all 26 header-stripped records into a single byte array, thus creating the waveform capture:

```
const uint RECORD_PAYLOAD_SIZE = 962;

const uint MAX_WAVEFORM_CAPTURE_SIZE =
25012;

...
byte[] waveform_capture = new byte
[MAX_WAVEFORM_CAPTURE_SIZE];

...

// combine all binary data from waveform
records to create waveform capture

for (int i = 0; i < 26; ++i)

{

waveform_record[i].CopyTo(waveform_capture,
RECORD_PAYLOAD_SIZE * i);

}
```

Here is an example of the beginning of a waveform capture from the above instruction:

// Snippet starts from header block (address 0x00) and ends some bytes past first channel block

```
00000000  01  80  06  00  00  47  02  00  00  00  07  FF  07  4C  00  26
00000010  00  21  00  20  00  22  00  25  D3  21  19  6C  1C  B0  02  64
00000020  D3  AA  1A  F3  FF  FF  FF  FF  FF  FF  FF  FF  FF  FF  FF  FF
...
000001a0  FF  FF  FF  FF  FF  FF  FF  FF  41  4E  00  00  1A  70  19  50  //414E = "AN"
000001b0  18  88  17  78  16  60  15  80  14  98  13  70  12  E0  12  10
000001c0  11  18  10  68  0F  90  0E  90  0E  00  0D  68  0C  D8  0C  D0
000001d0  0C  A8  0C  48  0C  70  0C  68  0C  30  0C  60  0C  98  0D  00
...
```

```
waveform_capture[424] // 41 = 'A'

waveform_capture[425] // 4E = 'N'
```

Processing a waveform capture

Once the waveform capture has been created, you can use the waveform capture byte-map (see tables earlier in this section) to extract the RMS and channel sample data values desired. Take note that the waveform capture byte-map is in MSB (hi-byte, lo-byte) form.

The following is an example snippet in which we first parse the waveform capture header values and then each waveform capture channel block using a predefined function. (NOTE: We assume the channel blocks to be in order in this example, e.g., AN, IA, BN, IB, CN, IC. These channels can be in any order, and it is up to you to check which channel ID values you are currently processing).

```
// HEADER BLOCK PARSING - Get Waveform Capture header values (hi-byte, lo-byte)

trigger_source = BitConverter.ToUInt16(new byte[2] { waveform_capture[0], waveform_capture[1] }, 0);

sample_rate = waveform_capture[2];

flags = waveform_capture[3];

...

rms_va = BitConverter.ToUInt16(new byte[2] { waveform_capture[12], waveform_capture[13] }, 0);

rms_ia = BitConverter.ToUInt16(new byte[2] { waveform_capture[14], waveform_capture[15] }, 0);
...
calibration_va = BitConverter.ToUInt16(new byte[2] { waveform_capture[ 24], waveform_capture[25] }, 0);

calibration_ia = BitConverter.ToUInt16(new byte[2] { waveform_capture[26], waveform_capture[27] }, 0);

...
```

```
// CHANNEL BLOCK PARSING - predefined function

public static List<int> GetChannelSampleData(byte[] waveform_capture,
int start_byte)

{

int temp;

int begin = start_byte + 2; // skip Channel ID (e.g. "AN","IA",etc) and get data start

int end = start_byte + 4098;

List<int> list = new List<int>();

for (int i = begin; i < end; i += 2)

{

// hi-byte, lo-byte

temp = BitConverter.ToUInt16(new byte[2] {waveform_capture[i], waveform_capture[i+1] }, 0);

list.Add(temp);

}

return list;

}

// store the starting byte positions of the channel blocks

public enum Channel_ID

{

        VOLTS_AN = 424,

        CURRENT_IA = 4522,

        VOLTS_BN = 8620,
```

```
    CURRENT_IB = 12718,

    VOLTS_CN = 16816,

    CURRENT_IC = 20914

}
```

// **CHANNEL BLOCK PARSING - get sample values from capture**

```
List<int> volts_an =
GetChannelSampleData(waveform_capture,
(int)Channel_ID.VOLTS_AN);

List<int> current_ia =
GetChannelSampleData(waveform_capture,
(int)Channel_ID.CURRENT_IA);

List<int> volts_bn =
GetChannelSampleData(waveform_capture,
(int)Channel_ID.VOLTS_BN);

List<int> current_ib =
GetChannelSampleData(waveform_capture,
(int)Channel_ID.CURRENT_IB);

List<int> volts_cn =
GetChannelSampleData(waveform_capture,
(int)Channel_ID.VOLTS_CN);
```

To convert the acquired RMS and channel sample data values into their primary values, the following formula must be applied:

$$\text{primary value} = \left(\frac{\text{ADC value} + \text{calibration}}{1000000} \right) + \text{ratio}$$

- ADC value is the primary value desired to be acquired. Can refer to either:
  - RMS values (trigger cycle RMS, trigger cycle RMS, etc.)
  - Sample values (volts AN, current IA, volts BN, etc.)
- Calibration is the sample calibration value for corresponding channel.
- Ratio is either PT ratio or CT ratio (acquired from programmable settings)
  - PT ratio for voltage
  - CT ratio for current

For example, if you are looking for the primary trigger RMS Va value and given the following:
PT numerator = 1200 V
PT denominator = 120 V
CT numerator = 1000 A
CT denominator = 5 A
Trigger cycle RMS Va = 4505
Trigger cycle RMS Ia = 30133
Trigger cycle RMS Vb = 5408
Sample calibration Va = 42049
Sample calibration Ia = 7329
Sample calibration Vb = 29183

The desired result would be:
Primary RMS Va = ((4505 * 42049) / 1000000) * (1200V/120 V) = 1894.3 V

// **Convert rms values to primary values**

```
public static double GetPrimaryValue(int adc_
value, double calibration, double ratio)

{

return ( (adc_value * calibration) / 1000000 ) *
ratio;

}

double primary_rms_va = GetPrimaryValue(rms_
va, calibration_va, pt_ratio);

double primary_rms_ia = GetPrimaryValue(rms_
ia, calibration_ia, ct_ratio);

double primary_rms_vb = GetPrimaryValue(rms_
vb, calibration_vb, pt_ratio);

double primary_rms_ib = GetPrimaryValue(rms_
ib, calibration_ib, ct_ratio);

double primary_rms_vc = GetPrimaryValue(rms_
vc, calibration_vc, pt_ratio);

double primary_rms_ic = GetPrimaryValue(rms_
ic, calibration_ic, ct_ratio);
```

// **Convert raw sample data values to primary values**

```
public static List<double> GetPrimaryValues(int[]
adc_value, double calibration, double ratio)

{

double temp;

List<double> list = new List<double>();
```

```
for (int i = 0; i < adc_value.Length; ++i)

{

temp = ((adc_value[i] * calibration) / 1000000) * ratio;

list.Add(temp);

}

return list;

}

List<double> primary_an = GetPrimaryValues(volts_an.ToArray(), calibration_va, pt_ratio);

List<double> primary_ia = GetPrimaryValues(current_ia.ToArray(), calibration_ia, ct_ratio);

List<double> primary_bn = GetPrimaryValues(volts_bn.ToArray(), calibration_vb, pt_ratio);

List<double> primary_ib = GetPrimaryValues(current_ib.ToArray(), calibration_ib, ct_ratio);

List<double> primary_cn = GetPrimaryValues(volts_cn.ToArray(), calibration_vc, pt_ratio);

List<double> primary_ic = GetPrimaryValues(current_ic.ToArray(), calibration_
ic, ct_ratio);
```

Additional waveform processing
Waveform trigger condition information can also be collected from the waveform capture. As processed in the previous section, the following header values will be used for the trigger conditions:

```
trigger_source = BitConverter.ToUInt16(new byte[2] { waveform_capture[0], waveform_capture[1] }, 0);

sample_rate = waveform_capture[2];

trigger_type= waveform_capture[4];

trigger_capture_num = waveform_capture[5];

trigger_cycle_tag = BitConverter.ToUInt16(new byte[2] { waveform_capture[6], waveform_capture[7] }, 0);
```

The trigger source value acquired from the waveform capture header must be parsed to get the specific trigger condition error string (for example, voltage surge or voltage sag).

```
bool deltaHookup; // hookup flag

...

int[] trigger_state = new int[16]; // to represent 16 individual "bits"

Array.Clear(trigger_state, 0, trigger_state.Length); // set all "bits" to 0

// set the individual trigger_state bit flags using trigger_ source from waveform capture

for (int i = 0; i < trigger_state.Length; ++i)

{

trigger_state[i] = (trigger_source / (2 ^ i)) & 1;// remember hi-byte+lo-byte order

}

...

String triggered_str = "";

for (int i = 0; i < trigger_state.Length; ++i)

{

if (trigger_state[i] > 0)

{

switch (i)

{

case 0:

if (deltaHookup)

triggered_str = triggered_str + "Vab=Surge";
else
```

```
triggered_str = triggered_str + "Van=Surge";

break;

case 1:

if (deltaHookup)

triggered_str = triggered_str + "Vab=Surge";

else

triggered_str = triggered_str + "Van=Surge";

break;

case 2:

if (deltaHookup)

triggered_str = triggered_str + "Vcb=Surge";

else

triggered_str = triggered_str + "Vcn=Surge";

break;

case 3:

triggered_str = triggered_str + "Ia=Surge";

break;

case 4:

triggered_str = triggered_str + "Ib=Surge";

break;

case 5:

triggered_str = triggered_str + "Ic=Surge";

break;

case 6:

if (deltaHookup)

triggered_str = triggered_str + "Vab=Sag";

else

triggered_str = triggered_str + "Van=Sag";

break;

case 7:

if (deltaHookup)

triggered_str = triggered_str + "Vbc=Sag";

else

triggered_str = triggered_str + "Vbn=Sag";

break;

case 8:

if (deltaHookup)
triggered_str = triggered_str + "Vcb=Sag";

else

triggered_str = triggered_str + "Vcn=Sag";

break;

case 15:

triggered_str = triggered_str + "Manual Trigger";
break;

}

}

}
```

The trigger cycle tag value from the waveform capture header provides the specific cycle within the waveform capture on which the trigger condition occurred.

To give an example of what the trigger cycle tag provides, the following is a snippet from a CSV-generated output of the raw sample values (non-primary values) from a waveform capture. The index at which the samples are located within the CSV file is specified in the first column. With a trigger cycle tag of 512 and the following table:

B

Samples

Index	Volts AN	Current IA	Volts BN	Current IB	Volts CN	Current IC
27	0	0	0	0	0	0
28	6768	6792	5840	6800	5784	6880
29	6480	6736	5872	6816	5792	6936
30	6280	6776	5864	6872	5816	6960
31	6008	6784	5872	6792	5768	6904
32	5728	6736	5864	6864	5856	6960
536	7408	6712	5832	6808	5800	6984
537	7248	6776	5880	6848	5848	6984
538	7000	6776	5896	6864	5848	6928
539	6712	6752	5864	6808	5800	6976
540	6536	6776	5888	6848	5856	6976
541	6280	6840	5920	6920	5880	6832
542	5960	6752	5856	6800	5776	6912

Seeing as the samples began being recorded at index 27 within the CSV output, that value must be added to the trigger cycle tag value as an offset to get the exact cycle where the trigger condition occurred, which would be at index 539.

Sample rate is the number of samples in a single cycle at a nominal 60 hertz. For example, at a sample rate of 512, there are 512 samples in a single nominal (time-locked) cycle. Note that this means that there are 512 samples every 16.6~ms.

The sample rate also affects the duration of the capture. Since the capture records a fixed number of samples, the number of cycles recorded is dynamic based on the sampling rate. For example, at 512 samples per cycle, four cycles can be recorded. At 32 samples per cycle, 64 cycles can be recorded.

To calculate the duration of the capture, in milliseconds, the following formula must be applied:

$$\text{duration} = \left(\frac{\text{number of samples} * 1000}{\text{sample rate} * 60} \right)$$

- Number of samples is number of samples in the capture per channel (2048 samples)

  For example, given a sample rate of 1024, the duration would be:

  ((2048 * 1000) / (1024 * 60)) = (2048000 / 61440) = 33.333 ms

B.5.8: PQ event log retrieval

The following is a detailed breakdown of the PQ event record byte-map.

PQ event record definition 1

Size	Content	Notes	Offset
6 bytes	Timestamp	Timestamp of the record	0
2 bytes	Present states	Bit mapped per trigger events; 0 indicates an untriggered state	6
2 bytes	Event channels	Bit mapped per trigger events; 1 indicates a channel changed state and the change to the present state caused the event	8
1 byte	Capture number	0 if cycle was not captured, 1–255 if all or part of the cycle was captured	10
1 byte	Flags	Always 0	11
2 bytes	Event cycle tag	Tag of the last sample in the event cycle	12
18 bytes	Worst excursion RMS	For events ending a surge or sag episode (e.g., return to normal), RMS of the channel is the worst excursion (highest surge, lowest sag) for the episode; 0 for other channels; same units as waveform records	14
12 bytes	Sample calibrations	Same as sample calibrations in waveform log non-sample capture summary	32
14 bytes	Not used	Always 0	44

Here is a visual layout of the PQ event record definition shown (with the timestamp stripped): (**Note**: 1b = 1 byte, 2b = 2 bytes, 6b = 6 bytes)

PQ event record definition 2

Size: 52 bytes

—
Timestamp (6b)

Present states (2b)		**Event channels (2b)**	
Capture # (1b)	**Flags (1b)**	**Event cycle tag (2b)**	
Worst excursion RMS - Va surge		Worst excursion RMS - Vb surge	
Worst excursion RMS - Vc surge		Worst excursion RMS - Ia surge	
Worst excursion RMS - Ib surge		Worst excursion RMS - Ic surge	
Worst excursion RMS - Va sag		Worst excursion RMS - Vb sag	
Worst excursion RMS - Vc sag		Sample calibration Va (2b)	
Sample calibration Ia (2b)		Sample calibration Vb (2b)	
Sample calibration Ib (2b)		Sample calibration Vc (2b)	
Sample calibration Ic (2b)		unused	unused
unused	unused	unused	unused
unused	unused	unused	unused
unused	unused	unused	unused

Note: Byte order is in MSB.

Parsing a PQ event record

Use the table above to parse the PQ event record values you need. The following is an example binary snippet of a PQ event record (with a table map of the contents):

—
PQ event record binary content mapping

Superscript #	**Content**	**Superscript #**	**Content**
1	Timestamp	13	Va sag
2	Present states	14	Vb sag
3	Event channels	15	Vc sag
4	Capture number	16	Va calibration
5	Flags	17	Ia calibration
6	Event cycle tag	18	Vb calibration
7	Va surge	19	Ib calibration
8	Vb surge	20	Vc calibration
9	Vc surge	21	Ic calibration
10	Ia surge	22	Not used
11	Ib surge	23	Padded zeroes
12	Ic surge	-	-

From the above content, the values would be as follows:

timestamp= 2012/04/30 11:16:36 AM

present_states = 0000 0001 1100 0000 **(see pevious table for bit breakdown)**

Volts C Sag

Volts B Sag

Volts A Sag

event_channels = 0000 0001 1100 0000 **(see previous table for bit breakdown)**

Volts C Sag

Volts B Sag

Volts A Sag

capture_num = 0

flags= 0

event_cycle_tag = 0

we_rms_va_surge = 0

we_rms_vb_surge = 0

we_rms_vc_surge = 0

...

we_rms_va_sag = 0

we_rms_vb_sag = 0

we_rms_vc_sag = 0

calibration_va = 54049

calibration_ia = 6508

...

calibration_ic = 6899

[0C 04 1E 4B 10 24]1 [01 C0]2 00]7 [01 C0]3 [00]4 [00]5 [00 00]6 [00 00]7
[00 00]8 [00 00]9 [00 00]10 [00 00]11 [00 00]12 [00 00]13 [00 00]14 [00 00]15
[D3 00 21]16 [19 6C]17 [1C B0]18 [02 64]19 [D3 AA]20 [1A F3]21 [00 00 00 00
00 00 00 00 00 00 00 00 00 00]22 [00 00 00 00 00 00]23

Processing a PQ event record
The worst excursion RMS values are specified as ADC values, and to convert them to primary, you use the same primary value formula provided under processing a waveform capture on page 83.

PQ events come with numerous PQ records. From this numerous set, normally a specific pair of PQ records exists (special cases will be discussed later), one that is created at the beginning of the PQ event and one created at the end of the PQ event — an out and return PQ record. Using these two records along with all the other PQ records between the two, you will be able to calculate the duration of the PQ event.

To further elaborate, whenever an "out" event occurs (i.e., a voltage surge or sag), the "out" PQ record for that PQ event is created. Likewise, when this said "out" event ends (i.e., the voltage surge or sag returns to normal levels), the "return" PQ record for that PQ event is created. From these two particular PQ records, calculating the difference between their timestamps will provide the duration of the PQ event. However, neither of the two PQ records (i.e., the out and return) know of each other. In order to find a particular out and return PQ record pair, the present states and event channel byte arrays from all the PQ records, including and in between the out and return PQ records themselves, must be used (see instructions for parsing a PQ event record on page 83).

Here is the bitmap for both the present states and event channel byte arrays:

—
Present state/event channel definition (2 bytes)

bit	
0	Volts A surge
1	Volts B surge
2	Volts C surge
3	Current A surge
4	Current B surge
5	Current C surge
6	Volts A sag
7	Volts B sag
8	Volts C sag
9	Not used
10	Not used
11	Not used
12	Not used
13	Not used
14	Not used
15	Manual trigger

For example, a value of 0x0081 (00000000 10000001) in MSB indicates a surge on volts A and a sag on volts B.

Both the present states and event channels use their bits as a series of true/false flags to signify change. The present states byte array flags tell whether or not an out event has occurred (e.g., been triggered) on a specific channel (see previous table). In normal cases, after the out PQ record, all the succeeding PQ records until the return PQ record will all have triggered present states (e.g., true flags) for that same channel. The return PQ record, which represents the end of a PQ event, will end the true sequence by having its flag set to false for that channel.

From the event channel byte array perspective, when a change occurred within the present states byte array, it sets its flag for that channel to true. When that channel reverts back to its previous state, the event channel flag will be triggered again (set to true) for that channel.

The following is a snippet of the present state and event channel byte arrays:

Note: x = true, empty = false)

Present state (snippet)					Event channel (snippet)				
PQ record	Va surge	Vb surge	Vc surge	Timestamp	PQ record	Va surge	Vb surge	Vc surge	Timestamp
0				2013/04/01 02:10:13 PM	0				2013/04/01 02:10:13 PM
1				2013/04/01 02:10:14 PM	1				2013/04/01 02:10:14 PM
2		x		2013/04/01 02:10:15 PM	2		x		2013/04/01 02:10:15 PM
3	x	x		2013/04/01 02:10:16 PM	3				2013/04/01 02:10:16 PM
4		x	x	2013/04/01 02:10:17 PM	4			x	2013/04/01 02:10:17 PM
5		x	x	2013/04/01 02:10:18 PM	5				2013/04/01 02:10:18 PM
6		x		2013/04/01 02:10:19 PM	6				2013/04/01 02:10:19 PM
7		x		2013/04/01 02:10:20 PM	7				2013/04/01 02:10:20 PM
8				2013/04/01 02:10:21 PM	8		x		2013/04/01 02:10:21 PM
9				2013/04/01 02:10:22 PM	9				2013/04/01 02:10:22 PM
10		x		2013/04/01 02:10:22 PM	10		x		2013/04/01 02:10:23 PM

Only the first three bits are being shown for the present states and event channel byte arrays (along with their timestamps) in the example provided, and from the snippet above, three different example scenarios can be observed. The following example explanations serve only to show the behavior of the two byte arrays as well as show how to calculate the duration by determining the out and return PQ records in the given situations.

The surge occurring on channel Vb is an example of a normal PQ event where both the beginning (out) and end (return) can easily be determined. It is shown to have surged starting from PQ record 2. All the subsequent PQ records continued to surge on the same channel until reaching PQ record 8. Looking at the event channel byte array, a change had occurred on both PQ records 2 and 8. Using the information from both byte arrays, it is easy to see that PQ record 2 is the out record and PQ record 8 is the return record. Thus, the PQ event duration is simply the timestamp difference between those two records (e.g., 6 seconds). The following examples describe error conditions that may occur in the PQ records when PQ trigger conditions are missed. For example, if a surge comes back into limit while the meter is resetting, it may not record the return to normal event.

Channel Va shows an example of a special case where the surge on PQ record 3 is not recorded under the event channel for that same record. This shows a discrepancy where a PQ record or numerous PQ records may be missing before the entry of PQ record 3. In these situations, it may not be possible to find the out record (the beginning of a PQ event). This can be detected by an out condition in the present states table, with no matching change in the event channel table.

Channel Vc shows an example of a special case where the surge on PQ records 4–5 does not show a return to normal condition in the event channel in record 6. This shows a discrepancy where a PQ record or numerous PQ records may be missing between records 5 and 6. In these situations, it may not be possible to find the return to normal record (the end of a PQ event). This can be detected by an out condition in the present states table, followed by a normal condition in the present states table, with no matching change in the event channel table.

B.6: Important note concerning the RGM40 meter's Modbus map

In depicting Modbus registers (addresses), the RGM40 meter's Modbus map uses holding registers only.

B.6.1: Hex representation

The representation shown in the table below is used by developers of Modbus drivers and libraries, SEL 2020/2030 programmers and firmware developers. The RGM40 meter's Modbus map also uses this representation.

Hex	Description
0008–000F	Meter serial number

B.6.2: Decimal representation

The RGM40 meter's Modbus map defines holding registers as (4X) registers. Many popular SCADA and HMI packages and their Modbus drivers have user interfaces that require users to enter these registers starting at 40001. So, instead of entering two separate values, one for register type and one for the actual register, they have been combined into one number.

The RGM40 meter's Modbus map uses a shorthand version to depict the decimal fields, i.e., not all of the digits required for entry into the SCADA package UI are shown. For example:

You need to display the meter's serial number in your SCADA application. The RGM40 meter's Modbus map shows the following information for meter serial number:

Decimal	Description
9–16	Meter serial number

In order to retrieve the meter's serial number, enter 40009 into the SCADA UI as the starting register, and 8 as the number of registers.

- In order to work with SCADA and driver packages that use the 40001 to 49999 method for requesting holding registers, take 40000 and add the value of the register (address) in the decimal column of the Modbus map. Then enter the number (e.g., 4009) into the UI as the starting register.
- For SCADA and driver packages that use the 400001 to 465536 method for requesting holding registers, take 400000 and add the value of the register (address) in the decimal column of the Modbus map. Then enter the number (e.g., 400009) into the UI as the starting register. The drivers for these packages strip off the leading four and subtract 1 from the remaining value.
  This final value is used as the starting register or register to be included when building the actual Modbus message.

B.7: Modbus register map (MM-1 to MM-40)

The RGM40 meter's Modbus register map begins on the following page.

B

Modbus address							
Hex	**Decimal**	**Description (note 1)**	**Format**	**Range (note 6)**	**Units or resolution**	**Comments**	**# Reg**
Fixed data section							
Identification block						**Read-only**	
0000 - 0007	1 - 8	Meter name	ASCII	16 char	None		8
0008 - 000F	9 - 16	Meter serial number	ASCII	16 char	None		8
0010 - 0010	17 - 17	Meter type	UINT16	Bit-mapped	-----ost -----vvv	t = transducer model (1=yes, 0=no), s= submeter model(1=yes,0=no), n=RGM40 mV current input model (1=yes, 0-no), o= RGM40 model (1=yes,0=no), vvv = V-switch: V1 = standard 200, V2 = V1 plus logging, V3 = V2 plus THD, V4 = V3 plus relays, V5 = V4 plus waveform capture up to 64 samples/cycle and 3 MB, V6 = V4 plus waveform capture up to 512 samples/cycle and 4 MB.	1
0011 - 0012	18 - 19	Firmware version	ASCII	4 char	None		2
0013 - 0013	20 - 20	Map version	UINT16	0 to 65535	None		1
0014 - 0014	21 - 21	Meter configuration	UINT16	Bit-mapped	-----ccc --ffffff	ccc = CT denominator (1 or 5); note that 333 mV option is equal to 5A; ffffff = calibration frequency (50 or 60)	1
0015 - 0015	22 - 22	ASIC version	UINT16	0-65535	None		1
0016 - 0017	23 - 24	Boot firmware version	ASCII	4 char	None		2
0018 - 0018	25 - 25	Reserved				Reserved	1
0019 - 0019	26 - 26	Reserved				Reserved	1
001A - 001D	27 - 30	Meter type name	ASCII	8 char	None		4
001E - 0026	31 - 39	Reserved				Reserved	9
0027 - 002E	40 - 47	Reserved				Reserved	8
002F - 0115	48 - 278	Reserved				Reserved	231
0116 - 0130	279 - 305	Integer readings block occupies these registers, see below					
0131 - 01F3	306 - 500	Reserved				Reserved	194
01F4 - 0203	501 - 516	Reserved				Reserved	16
Meter data section (note 2)							
Readings block (integer values)						**Read-only**	
0116 - 0116	279 - 279	Volts A-N	UINT16	0 to 9999	Volts	1.Use the settings from programmable settings for scale and decimal point location (see user settings flags). 2. Per phase power and PF have values only for WYE hookup and will be zero for all other hookups. 3. If the reading is 10000, that means the value is out of range; please adjust the programmable settings. The display will also show '----' in case of over range.	1
0117 - 0117	280 - 280	Volts B-N	UINT16	0 to 9999	Volts		1
0118 - 0118	281 - 281	Volts C-N	UINT16	0 to 9999	Volts		1
0119 - 0119	282 - 282	Volts A-B	UINT16	0 to 9999	Volts		1
011A - 011A	283 - 283	Volts B-C	UINT16	0 to 9999	Volts		1
011B - 011B	284 - 284	Volts C-A	UINT16	0 to 9999	Volts		1
011C - 011C	285 - 285	Amps A	UINT16	0 to 9999	Amps		1
011D - 011D	286 - 286	Amps B	UINT16	0 to 9999	Amps		1
011E - 011E	287 - 287	Amps C	UINT16	0 to 9999	Amps		1
011F - 011F	288 - 288	Neutral current	UINT16	-9999 to +9999	Amps		1
0120 - 0120	289 - 289	Watts, 3-ph total	SINT16	-9999 to +9999	Watts		1
0121 - 0121	290 - 290	VARs, 3-ph total	SINT16	-9999 to +9999	VARs		1
0122 - 0122	291 - 291	VAs, 3-ph total	UINT16	0 to +9999	VAs		1
0123 - 0123	292 - 292	Power factor, 3-ph total	SINT16	-1000 to +1000	None		1

Modbus address							
Hex	**Decimal**	**Description (note 1)**	**Format**	**Range (note 6)**	**Units or resolution**	**Comments**	**# Reg**
0124 - 0124	293 - 293	Frequency	UINT16	0 to 9999	Hz		1
0125 - 0125	294 - 294	Watts, phase A	SINT16	-9999 M to +9999	Watts		1
0126 - 0126	295 - 295	Watts, phase B	SINT16	-9999 M to +9999	Watts		1
0127 - 0127	296 - 296	Watts, phase C	SINT16	-9999 M to +9999	Watts		1
0128 - 0128	297 - 297	VARs, phase A	SINT16	-9999 M to +9999 M	VARs		1
0129 - 0129	298 - 298	VARs, phase B	SINT16	-9999 M to +9999 M	VARs		1
012A - 012A	299 - 299	VARs, phase C	SINT16	-9999 M to +9999 M	VARs		1
012B - 012B	300 - 300	VAs, phase A	UINT16	0 to +9999	VAs		1
012C - 012C	301 - 301	VAs, phase B	UINT16	0 to +9999	VAs		1
012D - 012D	302 - 302	VAs, phase C	UINT16	0 to +9999	VAs		1
012E - 012E	303 - 303	Power factor, phase A	SINT16	-1000 to +1000	None		1
012F - 012F	304 - 304	Power factor, phase B	SINT16	-1000 to +1000	None		1
0130 - 0130	305 - 305	Power factor, phase C	SINT16	-1000 to +1000	None		1
						Block size:	27
Primary readings block						**Read-only**	
3E+7 - 3E+8	1000 - 1001	Volts A-N	FLOAT	0 to 9999 M	Volts		2
3E+9 - 03EA	1002 - 1003	Volts B-N	FLOAT	0 to 9999 M	Volts		2
03EB - 03EC	1004 - 1005	Volts C-N	FLOAT	0 to 9999 M	Volts		2
03ED - 03EE	1006 - 1007	Volts A-B	FLOAT	0 to 9999 M	Volts		2
03EF - 03F0	1008 - 1009	Volts B-C	FLOAT	0 to 9999 M	Volts		2
03F1 - 03F2	1010 - 1011	Volts C-A	FLOAT	0 to 9999 M	Volts		2
03F3 - 03F4	1012 - 1013	Amps A	FLOAT	0 to 9999 M	Amps		2
03F5 - 03F6	1014 - 1015	Amps B	FLOAT	0 to 9999 M	Amps		2
03F7 - 03F8	1016 - 1017	Amps C	FLOAT	0 to 9999 M	Amps		2
03F9 - 03FA	1018 - 1019	Watts, 3-ph total	FLOAT	-9999 M to +9999 M	Watts		2
03FB - 03FC	1020 - 1021	VARs, 3-ph total	FLOAT	-9999 M to +9999 M	VARs		2
03FD - 03FE	1022 - 1023	VAs, 3-ph total	FLOAT	-9999 M to +9999 M	VAs		2
03FF - 0400	1024 - 1025	Power factor, 3-ph total	FLOAT	-1.00 to +1.00	None		2
0401 - 0402	1026 - 1027	Frequency	FLOAT	0 to 65.00	Hz		2
0403 - 0404	1028 - 1029	Neutral current	FLOAT	0 to 9999 M	Amps		2
0405 - 0406	1030 - 1031	Watts, phase A	FLOAT	-9999 M to +9999 M	Watts	Per phase power and PF have values only for wye hookup and will be zero for all other hookups.	2
0407 - 0408	1032 - 1033	Watts, phase B	FLOAT	-9999 M to +9999 M	Watts		2
0409 - 040A	1034 - 1035	Watts, phase C	FLOAT	-9999 M to +9999 M	Watts		2
040B - 040C	1036 - 1037	VARs, phase A	FLOAT	-9999 M to +9999 M	VARs		2
040D - 040E	1038 - 1039	VARs, phase B	FLOAT	-9999 M to +9999 M	VARs		2
040F - 0410	1040 - 1041	VARs, phase C	FLOAT	-9999 M to +9999 M	VARs		2
0411 - 0412	1042 - 1043	VAs, phase A	FLOAT	-9999 M to +9999 M	VAs		2

Modbus address Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
0413 - 0414	1044 - 1045	VAs, phase B	FLOAT	-9999 M to +9999 M	VAs	Per phase power and PF have values only for wye hookup and will be zero for all other hookups.	2
0415 - 0416	1046 - 1047	VAs, phase C	FLOAT	-9999 M to +9999 M	VAs		2
0417 - 0418	1048 - 1049	Power factor, phase A	FLOAT	-1.00 to +1.00	None		2
0419 - 041A	1050 - 1051	Power factor, phase B	FLOAT	-1.00 to +1.00	None		2
041B - 041C	1052 - 1053	Power factor, phase C	FLOAT	-1.00 to +1.00	None		2
041D - 041E	1054 - 1055	Symmetrical component magnitude, 0 seq	FLOAT	0 to 9999 M	Volts	Voltage unbalance per IEC6100-4.30 Values apply only to WYE hookup and will be zero for all other hookups.	2
041F - 0420	1056 - 1057	Symmetrical component magnitude, + seq	FLOAT	0 to 9999 M	Volts		2
0421 - 0422	1058 - 1059	Symmetrical component magnitude, - seq	FLOAT	0 to 9999 M	Volts		2
0423 - 0423	1060 - 1060	Symmetrical component phase, 0 seq	SINT16	-1800 to +1800	0.1 degree		1
0424 - 0424	1061 - 1061	Symmetrical component phase, + seq	SINT16	-1800 to +1800	0.1 degree		1
0425 - 0425	1062 - 1062	Symmetrical component phase, - seq	SINT16	-1800 to +1800	0.1 degree		1
0426 - 0426	1063 - 1063	Unbalance, 0 sequence component	UINT16	0 to 65535	0.01%		1
0427 - 0427	1064 - 1064	Unbalance, -sequence component	UINT16	0 to 65535	0.01%		1
0428 - 0428	1065 - 1065	Current unbalance	UINT16	0 to 20000	0.01%		1
						Block size:	66
Primary energy block						**Read-only**	
05DB - 05DC	1500 - 1501	W-hours, received	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format	* Wh received and delivered always have opposite signs. * Wh received is positive for view as load; delivered is positive for view as generator. * 5 to 8 digits. * Decimal point implied, per energy format. * Resolution of digit before decimal point = units, kilo or mega, per energy format. * See note 10.	2
05DD - 05DE	1502 - 1503	W-hours, delivered	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
05DF - 05E0	1504 - 1505	W-hours, net	SINT32	-99999999 to 99999999	Wh per energy format		2
05E1 - 05E2	1506 - 1507	W-hours, total	SINT32	0 to 99999999	Wh per energy format		2
05E3 - 05E4	1508 - 1509	VAR-hours, positive	SINT32	0 to 99999999	VARh per energy format		2
O5E5 - 05E6	1510 - 1511	VAR-hours, negative	SINT32	0 to -99999999	VARh per energy format		2
05E7 - 05E8	1512 - 1513	VAR-hours, net	SINT32	-99999999 to 99999999	VARh per energy format		2
05E9 - 05EA	1514 - 1515	VAR-hours, total	SINT32	0 to 99999999	VARh per energy format		2
05EB - 05EC	1516 - 1517	VA-hours, total	SINT32	0 to 99999999	VAh per energy format		2
05ED - 05EE	1518 - 1519	W-hours, received, phase A	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
05EF - 05F0	1520 - 1521	W-hours, received, phase B	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2

B

Modbus address										
Hex		**Decimal**		**Description (note 1)**	**Format**	**Range (note 6)**	**Units or resolution**	**Comments**	**# Reg**
05F1 - 05F2		1522 - 1523		W-hours, received, phase C	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format	* Wh received and delivered always have opposite signs. * Wh received is positive for view as load; delivered is positive for view as generator. * 5 to 8 digits. * Decimal point implied, per energy format. * Resolution of digit before decimal point = units, kilo or mega, per energy format. * See note 10.	2
05F3 - 05F4		1524 - 1525		W-hours, delivered, phase A	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
05F5 - 05F6		1526 - 1527		W-hours, delivered, phase B	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
05F7 - 05F8		1528 - 1529		W-hours, delivered, phase C	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
05F9 - 05FA		1530 - 1531		W-hours, net, phase A	SINT32	-99999999 to 99999999	Wh per energy format		2
05FB - 05FC		1532 - 1533		W-hours, net, phase B	SINT32	-99999999 to 99999999	Wh per energy format		2
05FD - 05FE		1534 - 1535		W-hours, net, phase C	SINT32	-99999999 to 99999999	Wh per energy format		2
05FF - 0600		1536 - 1537		W-hours, total, phase A	SINT32	0 to 99999999	Wh per energy format		2
0601 - 0602		1538 - 1539		W-hours, total, phase B	SINT32	0 to 99999999	Wh per energy format		2
0603 - 0604		1540 - 1541		W-hours, total, phase C	SINT32	0 to 99999999	Wh per energy format		2
0605 - 0606		1542 - 1543		VAR-hours, positive, phase A	SINT32	0 to 99999999	VARh per energy format		2
0607 - 0608		1544 - 1545		VAR-hours, positive, phase B	SINT32	0 to 99999999	VARh per energy format		2
0609 - 060A		1546 - 1547		VAR-hours, Positive, Phase C	SINT32	0 to 99999999	VARh per energy format		2
060B - 060C		1548 - 1549		VAR-hours, negative, phase A	SINT32	0 to -99999999	VARh per energy format		2
060D - 060E		1550 - 1551		VAR-hours, negative, phase B	SINT32	0 to -99999999	VARh per energy format		2
060F - 0610		1552 - 1553		VAR-hours, negative, phase C	SINT32	0 to -99999999	VARh per energy format		2
0611 - 0612		1554 - 1555		VAR-hours, net, phase A	SINT32	-99999999 to 99999999	VARh per energy format		2
0613 - 0614		1556 - 1557		VAR-hours, net, phase B	SINT32	-99999999 to 99999999	VARh per energy format		2
0615 - 0616		1558 - 1559		VAR-hours, net, phase C	SINT32	-99999999 to 99999999	VARh per energy format		2
0617 - 0618		1560 - 1561		VAR-hours, total, phase A	SINT32	0 to 99999999	VARh per energy format		2
0619 - 061A		1562 - 1563		VAR-hours, total, phase B	SINT32	0 to 99999999	VARh per energy format		2
061B - 061C		1564 - 1565		VAR-hours, total, phase C	SINT32	0 to 99999999	VARh per energy format		2
061D - 061E		1566 - 1567		VA-hours, phase A	SINT32	0 to 99999999	VAh per energy format		2
061F - 0620		1568 - 1569		VA-hours, phase B	SINT32	0 to 99999999	VAh per energy format		2
0621 - 0622		1570 - 1571		VA-hours, phase C	SINT32	0 to 99999999	VAh per energy format		2
0623 - 0624		1572 - 1573		W-hours, received, rollover count	UINT32	0 to 4,294,967,294		These registers count the number of times their corresponding energy accumulators have wrapped from +max to 0. They are reset when energy is reset.	2

Modbus address		Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
Hex	Decimal						
0625 - 0626	1574 - 1575	W-hours, delivered, rollover count	UINT32	0 to 4,294,967,294		These registers count the number of times their corresponding energy accumulators have wrapped from +max to 0. They are reset when energy is reset.	2
0627 - 0628	1576 - 1577	VAR-hours, positive, rollover count	UINT32	0 to 4,294,967,294			2
0629 - 062A	1578 - 1579	VAR-hours, negative, rollover count	UINT32	0 to 4,294,967,294			2
062B - 062C	1580 - 1581	VA-hours, rollover count	UINT32	0 to 4,294,967,294			2
062D - 062E	1582 - 1583	W-hours in the interval, received	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format	* Wh received and delivered always have opposite signs. * Wh received is positive for view as load , delivered is positive for view as generator. * 5 to 8 digits. * Decimal point implied, per energy format. * Resolution of digit before decimal point = units, kilo, or mega, per energy format. * See note 10.	2
062F - 0630	1584 - 1585	W-hours in the interval, delivered	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
0631 - 0632	1586 - 1587	VAR-hours in the interval, positive	SINT32	0 to 99999999	VARh per energy format		2
0633 - 0634	1588 - 1589	VAR-hours in the interval, negative	SINT32	0 to -99999999	VARh per energy format		2
0635 - 0636	1590 - 1591	VA-hours in the interval, total	SINT32	0 to 99999999	VAh per energy format		2
0637 - 0638	1592 - 1593	W-hours in the Interval, Received, Phase A	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
0639 - 063A	1594 - 1595	W-hours in the interval, received, phase B	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
063B - 063C	1596 - 1597	W-hours in the interval, received, phase C	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
063D - 063E	1598 - 1599	W-hours in the interval, delivered, phase A	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
063F - 0640	1600 - 1601	W-hours in the interval, delivered, phase B	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
0641 - 0642	1602 - 1603	W-hours in the interval, delivered, phase C	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
0643 - 0644	1604 - 1605	VAR-hours in the interval, positive, phase A	SINT32	0 to 99999999	VARh per energy format		2
0645 - 0646	1606 - 1607	VAR-hours in the interval, positive, phase B	SINT32	0 to 99999999	VARh per energy format		2
0647 - 0648	1608 - 1609	VAR-hours in the interval, positive, phase C	SINT32	0 to 99999999	VARh per energy format		2
0649 - 064A	1610 - 1611	VAR-hours in the interval, negative, phase A	SINT32	0 to -99999999	VARh per energy format		2
064B - 064C	1612 - 1613	VAR-hours in the interval, negative, phase B	SINT32	0 to -99999999	VARh per energy format		2
063D - 064E	1614 - 1615	VAR-hours in the interval, negative, phase C	SINT32	0 to -99999999	VARh per energy format		2
064F - 0650	1616 - 1617	VA-hours in the interval, phase A	SINT32	0 to 99999999	VAh per energy format		2
0651 - 0652	1618 - 1619	VA-hours in the interval, phase B	SINT32	0 to 99999999	VAh per energy format		2

Modbus address		Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
Hex	**Decimal**						
0653 - 0654	1620 - 1621	VA-hours in the interval, phase C	SINT32	0 to 99999999	VAh per energy format		2
						Block size:	122
Primary demand block						**Read-only**	
07CC - 07CE	1997 - 1999	Demand interval end timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec	Ex. Timestamp hh:mm:ss is 03:15:00 and interval size is 15 minutes. Demand interval was 3:00:00 to 3:15:00. Note: Timestamp is zero until the end of the first interval after meter startup.	3
07CF - 07D0	2000 - 2001	Amps A, average	FLOAT	0 to 9999 M	Amps		2
07D1 - 07D2	2002 - 2003	Amps B, average	FLOAT	0 to 9999 M	Amps		2
07D3 - 07D4	2004 - 2005	Amps C, average	FLOAT	0 to 9999 M	Amps		2
07D5 - 07D6	2006 - 2007	Positive watts, 3-ph, average	FLOAT	-9999 M to +9999 M	Watts		2
07D7 - 07D8	2008 - 2009	Positive VARs, 3-ph, average	FLOAT	-9999 M to +9999 M	VARs		2
07D9 - 07DA	2010 - 2011	Negative watts, 3-ph, average	FLOAT	-9999 M to +9999 M	Watts		2
07DB - 07DC	2012 - 2013	Negative VARs, 3-ph, average	FLOAT	-9999 M to +9999 M	VARs		2
07DD - 07DE	2014 - 2015	VAs, 3-ph, average	FLOAT	-9999 M to +9999 M	VAs		2
07DF - 07E0	2016 - 2017	Positive PF, 3-ph, average	FLOAT	-1.00 to +1.00	None		2
07E1 - 07E2	2018 - 2019	Negative PF, 3-PF, average	FLOAT	-1.00 to +1.00	None		2
07E3 - 07E4	2020 - 2021	Neutral current, average	FLOAT	0 to 9999 M	Amps		2
07E5 - 07E6	2022 - 2023	Positive watts, phase A, average	FLOAT	-9999 M to +9999 M	Watts		2
07E7 - 07E8	2024 - 2025	Positive watts, phase B, average	FLOAT	-9999 M to +9999 M	Watts		2
07E9 - 07EA	2026 - 2027	Positive watts, phase C, average	FLOAT	-9999 M to +9999 M	Watts		2
07EB - 07EC	2028 - 2029	Positive VARs, phase A, average	FLOAT	-9999 M to +9999 M	VARs		2
07ED - 07EE	2030 - 2031	Positive VARs, phase B, average	FLOAT	-9999 M to +9999 M	VARs		2
07EF - 07F0	2032 - 2033	Positive VARs, phase C, average	FLOAT	-9999 M to +9999 M	VARs		2
07F1 - 07F2	2034 - 2035	Negative watts, phase A, average	FLOAT	-9999 M to +9999 M	Watts		2
07F3 - 07F4	2036 - 2037	Negative watts, phase B, average	FLOAT	-9999 M to +9999 M	Watts		2
07F5 - 07F6	2038 - 2039	Negative watts, phase C, average	FLOAT	-9999 M to +9999 M	Watts		2
07F7 - 07F8	2040 - 2041	Negative VARs, phase A, average	FLOAT	-9999 M to +9999 M	VARs		2
07F9 - 07FA	2042 - 2043	Negative VARs, phase B, average	FLOAT	-9999 M to +9999 M	VARs		2
07FB - 07FC	2044 - 2045	Negative VARs, phase C, average	FLOAT	-9999 M to +9999 M	VARs		2
07FD - 07FE	2046 - 2047	VAs, phase A, average	FLOAT	-9999 M to +9999 M	VAs		2
07FF - 0800	2048 - 2049	VAs, phase B, average	FLOAT	-9999 M to +9999 M	VAs		2

B

Modbus address Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
0801 - 0802	2050 - 2051	VAs, phase C, average	FLOAT	-9999 M to +9999 M	VAs		2
0803 - 0804	2052 - 2053	Positive PF, phase A, average	FLOAT	-1.00 to +1.00	None		2
0805 - 0806	2054 - 2055	Positive PF, phase B, average	FLOAT	-1.00 to +1.00	None		2
0807 - 0808	2056 - 2057	Positive PF, phase C, average	FLOAT	-1.00 to +1.00	None		2
0809 - 080A	2058 - 2059	Negative PF, phase A, average	FLOAT	-1.00 to +1.00	None		2
080B - 080C	2060 - 2061	Negative PF, phase B, average	FLOAT	-1.00 to +1.00	None		2
080D - 080E	2062 - 2063	Negative PF, phase C, average	FLOAT	-1.00 to +1.00	None		2
						Block size:	64
Uncompensated readings block						**Read-only**	
0BB7 - 0BB8	3000 - 3001	Watts, 3-ph total	FLOAT	-9999 M to +9999 M	Watts		2
0BB9 - 0BBA	3002 - 3003	VARs, 3-ph total	FLOAT	-9999 M to +9999 M	VARs		2
0BBB - 0BBC	3004 - 3005	VAs, 3-ph total	FLOAT	-9999 M to +9999 M	VAs		2
0BBD - 0BBE	3006 - 3007	Power factor, 3-ph total	FLOAT	-1.00 to +1.00	None		2
0BBF - 0BC0	3008 - 3009	Watts, phase A	FLOAT	-9999 M to +9999 M	Watts	Per phase power and PF have values only for WYE hookup and will be zero for all other hookups.	2
0BC1 - 0BC2	3010 - 3011	Watts, phase B	FLOAT	-9999 M to +9999 M	Watts		2
0BC3 - 0BC4	3012 - 3013	Watts, phase C	FLOAT	-9999 M to +9999 M	Watts		2
0BC5 - 0BC6	3014 - 3015	VARs, phase A	FLOAT	-9999 M to +9999 M	VARs		2
OBC7 - 0BC8	3016 - 3017	VARs, phase B	FLOAT	-9999 M to +9999 M	VARs		2
0BC9 - 0BCA	3018 - 3019	VARs, phase C	FLOAT	-9999 M to +9999 M	VARs		2
0BCB - 0BCC	3020 - 3021	VAs, phase A	FLOAT	-9999 M to +9999 M	VAs		2
0BCD - 0BCE	3022 - 3023	VAs, phase B	FLOAT	-9999 M to +9999 M	VAs		2
0BCF - 0BD0	3024 - 3025	VAs, phase C	FLOAT	-9999 M to +9999 M	VAs		2
0BD1 - 0BD2	3026 - 3027	Power factor, phase A	FLOAT	-1.00 to +1.00	None		2
0BD3 - 0BD4	3028 - 3029	Power factor, phase B	FLOAT	-1.00 to +1.00	None		2
0BD5 - 0BD6	3030 - 3031	Power factor, phase C	FLOAT	-1.00 to +1.00	None		2
0BD7 - 0BD8	3032 - 3033	W-hours, received	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format	* Wh received and delivered always have opposite signs. * Wh received is positive for view as load, delivered is positive for view as generator. * 5 to 8 digits. * Decimal point implied, per energy format. * Resolution of digit before decimal point = units, kilo or mega, per energy format. * See note 10.	2
0BD9 - 0BDA	3034 - 3035	W-hours, delivered	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
0BDB - 0BDC	3036 - 3037	W-hours, net	SINT32	-99999999 to 99999999	Wh per energy format		2
0BDD - 0BDE	3038 - 3039	W-hours, total	SINT32	0 to 99999999	Wh per energy format		2
0BDF - 0BE0	3040 - 3041	VAR-hours, positive	SINT32	0 to 99999999	VARh per energy format		2
0BE1 - 0BE2	3042 - 3043	VAR-hours, negative	SINT32	0 to -99999999	VARh per energy format		2

Modbus address							
Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
0BE3 - 0BE4	3044 - 3045	VAR-hours, net	SINT32	-99999999 to 99999999	VARh per energy format	* Wh received and delivered always have opposite signs. * Wh received is positive for view as load, delivered is positive for view as generator. * 5 to 8 digits. * Decimal point implied, per energy format. * Resolution of digit before decimal point = units, kilo or mega, per energy format. * See note 10.	2
0BE5 - 0BE6	3046 - 3047	VAR-hours, total	SINT32	0 to 99999999	VARh per energy format		2
0BE7 - 0BE8	3048 - 3049	VA-hours, total	SINT32	0 to 99999999	VAh per energy format		2
0BE9 - 0BEA	3050 - 3051	W-hours, received, phase A	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
0BEB - 0BEC	3052 - 3053	W-hours, received, phase B	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
0BED - 0BEE	3054 - 3055	W-hours, received, phase C	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
0BEF - 0BF0	3056 - 3057	W-hours, delivered, phase A	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
0BF1 - 0BF2	3058 - 3059	W-hours, delivered, phase B	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
0BF3 - 0BF4	3060 - 3061	W-hours, delivered, phase C	SINT32	0 to 99999999 or 0 to -99999999	Wh per energy format		2
0BF5 - 0BF6	3062 - 3063	W-hours, net, phase A	SINT32	-99999999 to 99999999	Wh per energy format		2
0BF7 - 0BF8	3064 - 3065	W-hours, net, phase B	SINT32	-99999999 to 99999999	Wh per energy format		2
0BF9 - 0BFA	3066 - 3067	W-hours, net, phase C	SINT32	-99999999 to 99999999	Wh per energy format		2
0BFB - 0BFC	3068 - 3069	W-hours, total, phase A	SINT32	0 to 99999999	Wh per energy format		2
0BFD - 0BFE	3070 - 3071	W-hours, total, phase B	SINT32	0 to 99999999	Wh per energy format		2
0BFF - 0C00	3072 - 3073	W-hours, total, phase C	SINT32	0 to 99999999	Wh per energy format		2
0C01 - 0C02	3074 - 3075	VAR-hours, positive, phase A	SINT32	0 to 99999999	VARh per energy format		2
0C03 - 0C04	3076 - 3077	VAR-hours, positive, phase B	SINT32	0 to 99999999	VARh per energy format		2
0C05 - 0C06	3078 - 3079	VAR-hours, positive, phase C	SINT32	0 to 99999999	VARh per energy format		2
0C07 - 0C08	3080 - 3081	VAR-hours, negative, phase A	SINT32	0 to -99999999	VARh per energy format		2
0C09 - 0C0A	3082 - 3083	VAR-hours, negative, phase B	SINT32	0 to -99999999	VARh per energy format		2
0C0B - 0C0C	3084 - 3085	VAR-hours, negative, phase C	SINT32	0 to -99999999	VARh per energy format		2
0C0D - 0C0E	3086 - 3087	VAR-hours, net, phase A	SINT32	-99999999 to 99999999	VARh per energy format		2
0C0F - 0C10	3088 - 3089	VAR-hours, net, phase B	SINT32	-99999999 to 99999999	VARh per energy format		2
0C11 - 0C12	3090 - 3091	VAR-hours, net, phase C	SINT32	-99999999 to 99999999	VARh per energy format		2
0C13 - 0C14	3092 - 3093	VAR-hours, total, phase A	SINT32	0 to 99999999	VARh per energy format		2
0C15 - 0C16	3094 - 3095	VAR-hours, total, phase B	SINT32	0 to 99999999	VARh per energy format		2
0C17 - 0C18	3096 - 3097	VAR-hours, total, phase C	SINT32	0 to 99999999	VARh per energy format		2
0C19 - 0C1A	3098 - 3099	VA-hours, phase A	SINT32	0 to 99999999	VAh per energy format		2

Modbus address							
Hex	**Decimal**	**Description (note 1)**	**Format**	**Range (note 6)**	**Units or resolution**	**Comments**	**# Reg**
0C1B - 0C1C	3100 - 3101	VA-hours, phase B	SINT32	0 to 99999999	VAh per energy format		2
0C1D - 0C1E	3102 - 3103	VA-hours, phase C	SINT32	0 to 99999999	VAh per energy format		2
						Block size:	104
Phase angle block						**Read-only**	
1003 - 1003	4100 - 4100	Phase A current	SINT16	-1800 to +1800	0.1 degree		1
1004 - 1004	4101 - 4101	Phase B current	SINT16	-1800 to +1800	0.1 degree		1
1005 - 1005	4102 - 4102	Phase C current	SINT16	-1800 to +1800	0.1 degree		1
1006 - 1006	4103 - 4103	Angle, volts A-B	SINT16	-1800 to +1800	0.1 degree		1
1007 - 1007	4104 - 4104	Angle, volts B-C	SINT16	-1800 to +1800	0.1 degree		1
1008 - 1008	4105 - 4105	Angle, volts C-A	SINT16	-1800 to +1800	0.1 degree		1
						Block size:	6
Status block						**Read-only**	
1193 - 1193	4500 - 4500	Port ID	UINT16	1 to 4	None	Identifies which COM port a master is connected to: 1 for COM1, 2 for COM2, etc.	1
1194 - 1194	4501 - 4501	Meter status	UINT16	Bit-mapped	mmmpch-- tffeeccc	mmm = measurement state (0=off, 1=running normally, 2=limp mode, 3=warmup, 6-7=boot, others unused). See note 16. pch = NVMEM block OK flags (p=profile, c=calibration, h=header), flag is 1 if OK. t - CT PT compensation status. (0=disabled, 1=enabled). ff = flash state (0=initializing, 1=logging disabled by Vswitch, 3=logging). ee = edit state (0=startup, 1=normal, 2=privileged command session, 3=profile update mode). ccc = port enabled for edit (0=none, 1-2=COM1-COM2, 7=front panel).	1
1195 - 1195	4502 - 4502	Limits status	UINT16	Bit-mapped	87654321 87654321	High byte is setpt 1, 0=in, 1=out. Low byte is setpt 2, 0=in, 1=out. See notes 11, 12, 17.	1
1196 - 1197	4503 - 4504	Time since reset	UINT32	0 to 4294967294	4 msec	Wraps around after max count.	2
1198 - 119A	4505 - 4507	Meter on time	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
119B - 119D	4508 - 4510	Current date and time	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
119E - 119E	4511 - 4511	Clock sync status	UINT16	Bit-mapped	mmmp pppe 0000 000s	mmmp pppe = configuration per programmable settings (see register 30011, 0x753A). s = status: 1=working properly, 0=not working.	1
119F - 119F	4512 - 4512	Current day of week	UINT16	1 to 7	1 day	1=Sun, 2=Mon, etc.	1
						Block size:	13
THD block (note 13)						**Read-only**	
176F - 176F	6000 - 6000	Volts A-N, %THD	UINT16	0 to 10000	0.01%	AN for wye hookups, AB for delta 1	1
1770 - 1770	6001 - 6001	Volts B-N, %THD	UINT16	0 to 10000	0.01%		1

Modbus address Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
1771 - 1771	6002 - 6002	Volts C-N, %THD	UINT16	0 to 10000	0.01%		1
1772 - 1772	6003 - 6003	Amps A, %THD	UINT16	0 to 10000	0.01%		1
1773 - 1773	6004 - 6004	Amps B, %THD	UINT16	0 to 10000	0.01%		1
1774 - 1774	6005 - 6005	Amps C, %THD	UINT16	0 to 10000	0.01%		1
1775 - 179C	6006 - 6045	Phase A voltage harmonic magnitudes	UINT16	0 to 10000	0.01%	In each group of 40 registers, the first register represents the fundamental frequency or first harmonic, the second represents the second harmonic, and so on, up to the 40th register, which represents the 40th harmonic. Harmonic magnitudes are given as % of the fundamental magnitude. Thus, the first register in each group of 40 will typically be 9999. A reading of 10000 indicates invalid.	40
179D - 17C4	6046 - 6085	Phase A voltage harmonic phases	SINT16	-1800 to +1800	0.1 degree		40
17C5 - 17EC	6086 - 6125	Phase A current harmonic magnitudes	UINT16	0 to 10000	0.01%		40
17ED - 1814	6126 - 6165	Phase A current harmonic phases	SINT16	-1800 to +1800	0.1 degree		40
1815 - 183C	6166 - 6205	Phase B voltage harmonic magnitudes	UINT16	0 to 10000	0.01%		40
183D - 1864	6206 - 6245	Phase B voltage harmonic phases	SINT16	-1800 to +1800	0.1 degree		40
1865 - 188C	6246 - 6285	Phase B current harmonic magnitudes	UINT16	0 to 10000	0.01%		40
188D - 18B4	6286 - 6325	Phase B current harmonic phases	SINT16	-1800 to +1800	0.1 degree		40
18B5 - 18DC	6326 - 6365	Phase C voltage harmonic magnitudes	UINT16	0 to 10000	0.01%		40
18DD - 1904	6366 - 6405	Phase C voltage harmonic phases	SINT16	-1800 to +1800	0.1 degree		40
1905 - 192C	6406 - 6445	Phase C current harmonic magnitudes	UINT16	0 to 10000	0.01%		40
192D - 1954	6446 - 6485	Phase C current harmonic phases	SINT16	-1800 to +1800	0.1 degree		40
1955 - 1955	6486 - 6486	Wave scope scale factor for channel Va	UINT16	0 to 32767		Convert individual samples to volts or amps: V or A = (sample * scale factor) / 1,000,000. Samples update in conjunction with THD and harmonics; samples not available (all zeroes) if THD not available.	1
1956 - 1956	6487 - 6487	Wave scope scale factors for channel Ib	UINT16	0 to 32767			1
1957 - 1958	6488 - 6489	Wave scope scale factors for channels Vb and Ib	UINT16	0 to 32767			2
1959 - 195A	6490 - 6491	Wave scope scale factors for channels Vc and Ic	UINT16	0 to 32767			2
195B - 199A	6492 - 6555	Wave scope samples for channel Va	SINT16	-32768 to +32767			64
199B - 19DA	6556 - 6619	Wave scope samples for channel Ia	SINT16	-32768 to +32767			64
19DB - 1A1A	6620 - 6683	Wave scope samples for channel Vb	SINT16	-32768 to +32767			64
1A1B - 1A5A	6684 - 6747	Wave scope samples for channel Ib	SINT16	-32768 to +32767			64
1A5B - 1A9A	6748 - 6811	Wave scope samples for channel Vc	SINT16	-32768 to +32767			64
1A9B - 1ADA	6812 - 6875	Wave scope samples for channel Ic	SINT16	-32768 to +32767			64
						Block size:	876
Short term primary minimum block						**Read-only**	
1F27 - 1F28	7976 - 7977	Volts A-N, previous demand interval short term minimum	FLOAT	0 to 9999 M	Volts	Minimum instantaneous value measured during the demand interval before the one most recently completed.	2
1F29 - 1F2A	7978 - 7979	Volts B-N, previous demand interval short term minimum	FLOAT	0 to 9999 M	Volts		2

Modbus address							
Hex	**Decimal**	**Description (note 1)**	**Format**	**Range (note 6)**	**Units or resolution**	**Comments**	**# Reg**
1F2B - 1F2C	7980 - 7981	Volts C-N, previous demand interval short term minimum	FLOAT	0 to 9999 M	Volts	Minimum instantaneous value measured during the demand interval before the one most recently completed.	2
1F2D - 1F2E	7982 - 7983	Volts A-B, previous demand interval short term minimum	FLOAT	0 to 9999 M	Volts		2
1F2F - 1F30	7984 - 7985	Volts B-C, previous demand interval short term minimum	FLOAT	0 to 9999 M	Volts		2
1F31 - 1F32	7986 - 7987	Volts C-A, previous demand interval short term minimum	FLOAT	0 to 9999 M	Volts		2
1F33 - 1F34	7988 - 7989	Volts A-N, short term minimum	FLOAT	0 to 9999 M	Volts	Minimum instantaneous value measured during the most recently completed demand interval.	2
1F35 - 1F36	7990 - 7991	Volts B-N, short term minimum	FLOAT	0 to 9999 M	Volts		2
1F37 - 1F38	7992 - 7993	Volts C-N, short term minimum	FLOAT	0 to 9999 M	Volts		2
1F39 - 1F3A	7994 - 7995	Volts A-B, short term minimum	FLOAT	0 to 9999 M	Volts		2
1F3B - 1F3C	7996 - 7997	Volts B-C, short term minimum	FLOAT	0 to 9999 M	Volts		2
1F3D - 1F3E	7998 - 7999	Volts C-A, short term minimum	FLOAT	0 to 9999 M	Volts		2
						Block size:	24
Primary minimum block						**Read-only**	
1F3F - 1F40	8000 - 8001	Volts A-N, minimum	FLOAT	0 to 9999 M	Volts		2
1F41 - 1F42	8002 - 8003	Volts B-N, minimum	FLOAT	0 to 9999 M	Volts		2
1F43 - 1F44	8004 - 8005	Volts C-N, minimum	FLOAT	0 to 9999 M	Volts		2
1F45 - 1F46	8006 - 8007	Volts A-B, minimum	FLOAT	0 to 9999 M	Volts		2
1F47 - 1F48	8008 - 8009	Volts B-C, minimum	FLOAT	0 to 9999 M	Volts		2
1F49 - 1F4A	8010 - 8011	Volts C-A, minimum	FLOAT	0 to 9999 M	Volts		2
1F4B - 1F4C	8012 - 8013	Amps A, minimum avg demand	FLOAT	0 to 9999 M	Amps		2
1F4D - 1F4E	8014 - 8015	Amps B, minimum avg demand	FLOAT	0 to 9999 M	Amps		2
1F4F - 1F50	8016 - 8017	Amps C, minimum avg demand	FLOAT	0 to 9999 M	Amps		2
1F51 - 1F52	8018 - 8019	Positive watts, 3-ph, minimum avg demand	FLOAT	0 to +9999 M	Watts		2
1F53 - 1F54	8020 - 8021	Positive VARs, 3-ph, minimum avg demand	FLOAT	0 to +9999 M	VARs		2
1F55 - 1F56	8022 - 8023	Negative watts, 3-ph, minimum avg demand	FLOAT	0 to +9999 M	Watts		2
1F57 - 1F58	8024 - 8025	Negative VARs, 3-ph, minimum avg demand	FLOAT	0 to +9999 M	VARs		2
1F59 - 1F5A	8026 - 8027	VAs, 3-ph, minimum avg demand	FLOAT	-9999 M to +9999 M	VAs		2
1F5B - 1F5C	8028 - 8029	Positive power factor, 3-ph, minimum avg demand	FLOAT	-1.00 to +1.00	None		2
1F5D - 1F5E	8030 - 8031	Negative power factor, 3-ph, minimum avg demand	FLOAT	-1.00 to +1.00	None		2
1F5F - 1F60	8032 - 8033	Frequency, minimum	FLOAT	0 to 65.00	Hz		2
1F61 - 1F62	8034 - 8035	Neutral current, minimum avg demand	FLOAT	0 to 9999 M	Amps		2

Modbus address												
Hex			Decimal			Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
1F63	-	1F64	8036	-	8037	Positive watts, phase A, minimum avg demand	FLOAT	-9999 M to +9999 M	Watts		2
1F65	-	1F66	8038	-	8039	Positive watts, phase B, minimum avg demand	FLOAT	-9999 M to +9999 M	Watts		2
1F67	-	1F68	8040	-	8041	Positive watts, phase C, minimum avg demand	FLOAT	-9999 M to +9999 M	Watts		2
1F69	-	1F6A	8042	-	8043	Positive VARs, phase A, minimum avg demand	FLOAT	-9999 M to +9999 M	VARs		2
1F6B	-	1F6C	8044	-	8045	Positive VARs, phase B, minimum avg demand	FLOAT	-9999 M to +9999 M	VARs		2
1F6D	-	1F6E	8046	-	8047	Positive VARs, phase C, minimum avg demand	FLOAT	-9999 M to +9999 M	VARs		2
1F6F	-	1F70	8048	-	8049	Negative watts, phase A, minimum avg demand	FLOAT	-9999 M to +9999 M	Watts		2
1F71	-	1F72	8050	-	8051	Negative watts, phase B, minimum avg demand	FLOAT	-9999 M to +9999 M	Watts		2
1F73	-	1F74	8052	-	8053	Negative watts, phase C, minimum avg demand	FLOAT	-9999 M to +9999 M	Watts		2
1F75	-	1F76	8054	-	8055	Negative VARs, phase A, minimum avg demand	FLOAT	-9999 M to +9999 M	VARs		2
1F77	-	1F78	8056	-	8057	Negative VARs, phase B, minimum avg demand	FLOAT	-9999 M to +9999 M	VARs		2
1F79	-	1F7A	8058	-	8059	Negative VARs, phase C, minimum avg demand	FLOAT	-9999 M to +9999 M	VARs		2
1F7B	-	1F7C	8060	-	8061	VAs, phase A, minimum avg demand	FLOAT	-9999 M to +9999 M	VAs		2
1F7D	-	1F7E	8062	-	8063	VAs, phase B, minimum avg demand	FLOAT	-9999 M to +9999 M	VAs		2
1F7F	-	1F80	8064	-	8065	VAs, phase C, minimum avg demand	FLOAT	-9999 M to +9999 M	VAs		2
1F81	-	1F82	8066	-	8067	Positive PF, phase A, minimum avg demand	FLOAT	-1.00 to +1.00	None		2
1F83	-	1F84	8068	-	8069	Positive PF, phase B, minimum avg demand	FLOAT	-1.00 to +1.00	None		2
1F85	-	1F86	8070	-	8071	Positive PF, phase C, minimum avg demand	FLOAT	-1.00 to +1.00	None		2
1F87	-	1F88	8072	-	8073	Negative PF, phase A, minimum avg demand	FLOAT	-1.00 to +1.00	None		2
1F89	-	1F8A	8074	-	8075	Negative PF, phase B, minimum avg demand	FLOAT	-1.00 to +1.00	None		2
1F8B	-	1F8C	8076	-	8077	Negative PF, phase C, minimum avg demand	FLOAT	-1.00 to +1.00	None		2
1F8D	-	1F8D	8078	-	8078	Volts A-N, %THD, minimum	UINT16	0 to 9999	0.01%		1
1F8E	-	1F8E	8079	-	8079	Volts B-N, %THD, minimum	UINT16	0 to 9999	0.01%		1
1F8F	-	1F8F	8080	-	8080	Volts C-N, %THD, minimum	UINT16	0 to 9999	0.01%		1
1F90	-	1F90	8081	-	8081	Amps A, %THD, minimum	UINT16	0 to 9999	0.01%		1

B

Modbus address		Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
Hex	Decimal						
1F91 - 1F91	8082 - 8082	Amps B, %THD, minimum	UINT16	0 to 9999	0.01%		1
1F92 - 1F92	8083 - 8083	Amps C, %THD, minimum	UINT16	0 to 9999	0.01%		1
1F93 - 1F94	8084 - 8085	Symmetrical component magnitude, 0 seq, minimum	FLOAT	0 to 9999 M	Volts		2
1F95 - 1F96	8086 - 8087	Symmetrical component magnitude, + seq, minimum	FLOAT	0 to 9999 M	Volts		2
1F97 - 1F98	8088 - 8089	Symmetrical component magnitude, - seq, minimum	FLOAT	0 to 9999 M	Volts		2
1F99 - 1F99	8090 - 8090	Symmetrical component phase, 0 seq, minimum	SINT16	-1800 to +1800	0.1 degree		1
1F9A - 1F9A	8091 - 8091	Symmetrical component phase, + seq, minimum	SINT16	-1800 to +1800	0.1 degree		1
1F9B - 1F9B	8092 - 8092	Symmetrical component phase, - seq, minimum	SINT16	-1800 to +1800	0.1 degree		1
1F9C - 1F9C	8093 - 8093	Unbalance, 0 sequence, minimum	UINT16	0 to 65535	0.01%		1
1F9D - 1F9D	8094 - 8094	Unbalance, -sequence, minimum	UINT16	0 to 65535	0.01%		1
1F9E - 1F9E	8095 - 8095	Current unbalance, minimum	UINT16	0 to 20000	0.01%		1
						Block size:	96
Primary minimum timestamp block						**Read-only**	
20CF - 20D1	8400 - 8402	Volts A-N, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
20D2 - 20D4	8403 - 8405	Volts B-N, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
20D5 - 20D7	8406 - 8408	Volts C-N, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
20D8 - 20DA	8409 - 8411	Volts A-B, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
20DB - 20DD	8412 - 8414	Volts B-C, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
20DE - 20E0	8415 - 8417	Volts C-A, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
20E1 - 20E3	8418 - 8420	Amps A, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
20E4 - 20E6	8421 - 8423	Amps B, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
20E7 - 20E9	8424 - 8426	Amps C, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
20EA - 20EC	8427 - 8429	Positive watts, 3-ph, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
20ED - 20EF	8430 - 8432	Positive VARs, 3-ph, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
20F0 - 20F2	8433 - 8435	Negative watts, 3-ph, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3

Modbus address		Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
Hex	Decimal						
20F3 - 20F5	8436 - 8438	Negative VARs, 3-ph, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
20F6 - 20F8	8439 - 8441	VAs, 3-ph, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
20F9 - 20FB	8442 - 8444	Positive power factor, 3-ph, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
20FC - 20FE	8445 - 8447	Negative power factor, 3-ph, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
20FF - 2101	8448 - 8450	Frequency, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2102 - 2104	8451 - 8453	Neutral current, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2100	1 sec		3
2105 - 2107	8454 - 8456	Positive watts, phase A, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2108 - 210A	8457 - 8459	Positive watts, phase B, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
210B - 210D	8460 - 8462	Positive watts, phase C, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
210E - 2110	8463 - 8465	Positive VARs, phase A, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2111 - 2113	8466 - 8468	Positive VARs, phase B, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2114 - 2116	8469 - 8471	Positive VARs, phase C, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2117 - 2119	8472 - 8474	Negative watts, phase A, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
211A - 211C	8475 - 8477	Negative Watts, phase B, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
211D - 211F	8478 - 8480	Negative watts, phase C, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2120 - 2122	8481 - 8483	Negative VARs, phase A, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2123 - 2125	8484 - 8486	Negative VARs, phase B, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2126 - 2128	8487 - 8489	Negative VARs, phase C, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2129 - 212B	8490 - 8492	VAs, phase A, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
212C - 212E	8493 - 8495	VAs, phase B, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
212F - 2131	8496 - 8498	VAs, phase C, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2132 - 2134	8499 - 8501	Positive PF, phase A, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3

B

Modbus address		Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
Hex	Decimal						
2135 - 2137	8502 - 8504	Positive PF, phase B, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2138 - 213A	8505 - 8507	Positive PF, phase C, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
213B - 213D	8508 - 8510	Negative PF, phase A, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
213E - 2140	8511 - 8513	Negative PF, phase B, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2141 - 2143	8514 - 8516	Negative PF, phase C, min avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2144 - 2146	8517 - 8519	Volts A-N, %THD, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2147 - 2149	8520 - 8522	Volts B-N, %THD, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
214A - 214C	8523 - 8525	Volts C-N, %THD, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
214D - 214F	8526 - 8528	Amps A, %THD, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2150 - 2152	8529 - 8531	Amps B, %THD, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2153 - 2155	8532 - 8534	Amps C, %THD, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2156 - 2158	8535 - 8537	Symmetrical comp magnitude, 0 seq, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2159 - 215B	8538 - 8540	Symmetrical comp magnitude, + seq, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
215C - 215E	8541 - 8543	Symmetrical comp magnitude, - seq, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
215F - 2161	8544 - 8546	Symmetrical comp phase, 0 seq, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2162 - 2164	8547 - 8549	Symmetrical comp phase, + seq, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2165 - 2167	8550 - 8552	Symmetrical comp phase, - seq, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2168 - 2170	8553 - 8555	Unbalance, 0 seq, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2171 - 2173	8556 - 8558	Unbalance, - seq, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2174 - 2176	8559 - 8561	Current unbalance, min timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
						Block size:	162
Short term primary maximum block						**Read-only**	
230F - 2310	8976 - 8977	Volts A-N, previous demand interval short term maximum	FLOAT	0 to 9999 M	Volts	Maximum instantaneous value measured during the demand interval before the one most recently completed.	
2311 - 2312	8978 - 8979	Volts B-N, previous demand interval short term maximum	FLOAT	0 to 9999 M	Volts		

B

Modbus address Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
2313 - 2314	8980 - 8981	Volts C-N, previous demand interval short term maximum	FLOAT	0 to 9999 M	Volts	Maximum instantaneous value measured during the demand interval before the one most recently completed.	
2315 - 2316	8982 - 8983	Volts A-B, previous demand interval short term maximum	FLOAT	0 to 9999 M	Volts		
2317 - 2318	8984 - 8985	Volts B-C, previous demand interval short term maximum	FLOAT	0 to 9999 M	Volts		
2319 - 231A	8986 - 8987	Volts C-A, previous demand interval short term maximum	FLOAT	0 to 9999 M	Volts		
231B - 231C	8988 - 8989	Volts A-N, maximum	FLOAT	0 to 9999 M	Volts	Maximum instantaneous value measured during the most recently completed demand interval.	2
231D - 231E	8990 - 8991	Volts B-N, maximum	FLOAT	0 to 9999 M	Volts		2
232F - 2320	8992 - 8993	Volts C-N, maximum	FLOAT	0 to 9999 M	Volts		2
2321 - 2322	8994 - 8995	Volts A-B, maximum	FLOAT	0 to 9999 M	Volts		2
2323 - 2324	8996 - 8997	Volts B-C, maximum	FLOAT	0 to 9999 M	Volts		2
2325 - 2326	8998 - 8999	Volts C-A, maximum	FLOAT	0 to 9999 M	Volts		2
						Block size:	12
Primary maximum block						**Read-only**	
2327 - 2328	9000 - 9001	Volts A-N, maximum	FLOAT	0 to 9999 M	Volts		2
2329 - 232A	9002 - 9003	Volts B-N, maximum	FLOAT	0 to 9999 M	Volts		2
232B - 232C	9004 - 9005	Volts C-N, maximum	FLOAT	0 to 9999 M	Volts		2
232D - 232E	9006 - 9007	Volts A-B, maximum	FLOAT	0 to 9999 M	Volts		2
232F - 2330	9008 - 9009	Volts B-C, maximum	FLOAT	0 to 9999 M	Volts		2
2331 - 2332	9010 - 9011	Volts C-A, maximum	FLOAT	0 to 9999 M	Volts		2
2333 - 2334	9012 - 9013	Amps A, maximum avg demand	FLOAT	0 to 9999 M	Amps		2
2335 - 2336	9014 - 9015	Amps B, maximum avg demand	FLOAT	0 to 9999 M	Amps		2
2337 - 2338	9016 - 9017	Amps C, maximum avg demand	FLOAT	0 to 9999 M	Amps		2
2339 - 233A	9018 - 9019	Positive watts, 3-ph, maximum avg demand	FLOAT	0 to +9999 M	Watts		2
233B - 233C	9020 - 9021	Positive vars, 3-ph, maximum avg demand	FLOAT	0 to +9999 M	VARs		2
233D - 233E	9022 - 9023	Negative watts, 3-ph, maximum avg demand	FLOAT	0 to +9999 M	Watts		2
233F - 2340	9024 - 9025	Negative VARs, 3-ph, maximum avg demand	FLOAT	0 to +9999 M	VARs		2
2341 - 2342	9026 - 9027	VAs, 3-ph, maximum avg demand	FLOAT	-9999 M to +9999 M	VAs		2
2343 - 2344	9028 - 9029	Positive power factor, 3-ph, maximum avg demand	FLOAT	-1.00 to +1.00	None		2
2345 - 2346	9030 - 9031	Negative power factor, 3-ph, maximum avg demand	FLOAT	-1.00 to +1.00	None		2
2347 - 2348	9032 - 9033	Frequency, maximum	FLOAT	0 to 65.00	Hz		2
2349 - 234A	9034 - 9035	Neutral current, maximum avg demand	FLOAT	0 to 9999 M	Amps		2
234B - 234C	9036 - 9037	Positive watts, phase A, maximum avg demand	FLOAT	-9999 M to +9999 M	Watts		2
234D - 234E	9038 - 9039	Positive watts, phase B, maximum avg demand	FLOAT	-9999 M to +9999 M	Watts		2

Modbus address		Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
Hex	Decimal						
234F - 2350	9040 - 9041	Positive watts, phase C, maximum avg demand	FLOAT	-9999 M to +9999 M	Watts		2
2351 - 2352	9042 - 9043	Positive VARs, phase A, maximum avg demand	FLOAT	-9999 M to +9999 M	VARs		2
2353 - 2354	9044 - 9045	Positive VARs, phase B, maximum avg demand	FLOAT	-9999 M to +9999 M	VARs		2
2355 - 2356	9046 - 9047	Positive VARs, phase C, maximum avg demand	FLOAT	-9999 M to +9999 M	VARs		2
2357 - 2358	9048 - 9049	Negative watts, phase A, maximum avg demand	FLOAT	-9999 M to +9999 M	Watts		2
2359 - 235A	9050 - 9051	Negative watts, phase B, maximum avg demand	FLOAT	-9999 M to +9999 M	Watts		2
235B - 235C	9052 - 9053	Negative watts, phase C, maximum avg demand	FLOAT	-9999 M to +9999 M	Watts		2
235D - 235E	9054 - 9055	Negative VARs, phase A, maximum avg demand	FLOAT	-9999 M to +9999 M	VARs		2
235F - 2360	9056 - 9057	Negative VARs, phase B, maximum avg demand	FLOAT	-9999 M to +9999 M	VARs		2
2361 - 2362	9058 - 9059	Negative VARs, phase C, maximum avg demand	FLOAT	-9999 M to +9999 M	VARs		2
2363 - 2364	9060 - 9061	VAs, phase A, maximum avg demand	FLOAT	-9999 M to +9999 M	VAs		2
2365 - 2366	9062 - 9063	VAs, phase B, maximum avg demand	FLOAT	-9999 M to +9999 M	VAs		2
2367 - 2368	9064 - 9065	VAs, phase C, maximum avg demand	FLOAT	-9999 M to +9999 M	VAs		2
2369 - 236A	9066 - 9067	Positive PF, phase A, maximum avg demand	FLOAT	-1.00 to +1.00	None		2
236B - 236C	9068 - 9069	Positive PF, phase B, maximum avg demand	FLOAT	-1.00 to +1.00	None		2
236D - 236E	9070 - 9071	Positive PF, phase C, maximum avg demand	FLOAT	-1.00 to +1.00	None		2
236F - 2370	9072 - 9073	Negative PF, phase A, maximum avg demand	FLOAT	-1.00 to +1.00	None		2
2371 - 2372	9074 - 9075	Negative PF, phase B, maximum avg demand	FLOAT	-1.00 to +1.00	None		2
2373 - 2374	9076 - 9077	Negative PF, phase C, maximum avg demand	FLOAT	-1.00 to +1.00	None		2
2375 - 2375	9078 - 9078	Volts A-N, %THD, maximum	UINT16	0 to 9999	0.01%		1
2376 - 2376	9079 - 9079	Volts B-N, %THD, maximum	UINT16	0 to 9999	0.01%		1
2377 - 2377	9080 - 9080	Volts C-N, %THD, maximum	UINT16	0 to 9999	0.01%		1
2378 - 2378	9081 - 9081	Amps A, %THD, maximum	UINT16	0 to 9999	0.01%		1
2379 - 2379	9082 - 9082	Amps B, %THD, maximum	UINT16	0 to 9999	0.01%		1
237A - 237A	9083 - 9083	Amps C, %THD, maximum	UINT16	0 to 9999	0.01%		1

Modbus address										
Hex			Decimal			Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
237B	-	237C	9084	-	9085	Symmetrical component magnitude, 0 seq, maximum	FLOAT	0 to 9999 M	Volts		2
237D	-	237E	9086	-	9087	Symmetrical component magnitude, + seq, maximum	FLOAT	0 to 9999 M	Volts		2
237F	-	2380	9088	-	9089	Symmetrical component magnitude, - seq, maximum	FLOAT	0 to 9999 M	Volts		2
2381	-	2381	9090	-	9090	Symmetrical component phase, 0 seq, maximum	SINT16	-1800 to +1800	0.1 degree		1
2382	-	2382	9091	-	9091	Symmetrical component phase, + seq, maximum	SINT16	-1800 to +1800	0.1 degree		1
2383	-	2383	9092	-	9092	Symmetrical component phase, - seq, maximum	SINT16	-1800 to +1800	0.1 degree		1
2384	-	2384	9093	-	9093	Unbalance, 0 seq, maximum	UINT16	0 to 65535	0.01%		1
2385	-	2385	9094	-	9094	Unbalance, - seq, maximum	UINT16	0 to 65535	0.01%		1
2386	-	2386	9095	-	9095	Current unbalance, maximum	UINT16	0 to 20000	0.01%		1
										Block size:	96
Primary maximum timestamp block										**Read-only**	
24B7	-	24B9	9400	-	9402	Volts A-N, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24BA	-	24BC	9403	-	9405	Volts B-N, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24BD	-	24BF	9406	-	9408	Volts C-N, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24C0	-	24C2	9409	-	9411	Volts A-B, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24C3	-	24C5	9412	-	9414	Volts B-C, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24C6	-	24C8	9415	-	9417	Volts C-A, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24C9	-	24CB	9418	-	9420	Amps A, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24CC	-	24CE	9421	-	9423	Amps B, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24CF	-	24D1	9424	-	9426	Amps C, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24D2	-	24D4	9427	-	9429	Positive watts, 3-ph, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24D5	-	24D7	9430	-	9432	Positive VARs, 3-ph, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24D8	-	24DA	9433	-	9435	Negative watts, 3-ph, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24DB	-	24DD	9436	-	9438	Negative VARs, 3-ph, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24DE	-	24E0	9439	-	9441	VAs, 3-ph, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3

B

Modbus address						
Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
24E1 - 24E3	9442 - 9444	Positive power factor, 3-ph, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24E4 - 24E6	9445 - 9447	Negative power factor, 3-ph, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24E7 - 24E9	9448 - 9450	Frequency, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24EA - 24EC	9451 - 9453	Neutral current, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2100	1 sec		3
24ED - 24EF	9454 - 9456	Positive watts, phase A, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24F0 - 24F2	9457 - 9459	Positive watts, phase B, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24F3 - 24F5	9460 - 9462	Positive watts, phase C, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24F6 - 24F8	9463 - 9465	Positive VARs, phase A, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24F9 - 24FB	9466 - 9468	Positive VARs, phase B, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24FC - 24FE	9469 - 9471	Positive VARs, phase C, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
24FF - 2501	9472 - 9474	Negative watts, phase A, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2502 - 2504	9475 - 9477	Negative watts, phase B, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2505 - 2507	9478 - 9480	Negative watts, phase C, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2508 - 250A	9481 - 9483	Negative VARs, phase A, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
250B - 250D	9484 - 9486	Negative VARs, phase B, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
250E - 2510	9487 - 9489	Negative VARs, phase C, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2511 - 2513	9490 - 9492	VAs, phase A, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2514 - 2516	9493 - 9495	VAs, phase B, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2517 - 2519	9496 - 9498	VAs, phase C, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
251A - 251C	9499 - 9501	Positive PF, phase A, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
251D - 251F	9502 - 9504	Positive PF, phase B, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2520 - 2522	9505 - 9507	Positive PF, phase C, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3

B

Modbus address		Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
Hex	Decimal						
2523 - 2525	9508 - 9510	Negative PF, phase A, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2526 - 2528	9511 - 9513	Negative PF, phase B, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2529 - 252B	9514 - 9516	Negative PF, phase C, max avg dmd timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
252C - 252E	9517 - 9519	Volts A-N, %THD, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
252F - 2531	9520 - 9522	Volts B-N, %THD, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2532 - 2534	9523 - 9525	Volts C-N, %THD, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2535 - 2537	9526 - 9528	Amps A, %THD, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2538 - 253A	9529 - 9531	Amps B, %THD, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
253B - 253D	9532 - 9534	Amps C, %THD, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
253E - 2540	9535 - 9537	Symmetrical comp magnitude, 0 seq, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2541 - 2543	9538 - 9540	Symmetrical comp magnitude, + seq, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2544 - 2546	9541 - 9543	Symmetrical comp magnitude, - seq, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2547 - 2549	9544 - 9546	Symmetrical comp phase, 0 seq, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
254A - 254C	9547 - 9549	Symmetrical comp phase, + seq, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
254D - 254F	9550 - 9552	Symmetrical comp phase, - seq, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2550 - 2552	9553 - 9555	Unbalance, 0 seq, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2553 - 2555	9556 - 9558	Unbalance, - seq, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
2556 - 2558	9559 - 9561	Current unbalance, max timestamp	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
						Block size:	159
270F - 270F	10000 - 10000	Reserved				Reserved	1
2710 - 2710	10001 - 10001	Reserved				Reserved	1
2711 - 2718	10002 - 10009	Reserved				Reserved	8
2719 - 2720	10010 - 10017	Reserved				Reserved	8
2721 - 2722	10018 - 10019	Reserved				Reserved	2
2723 - 2746	10020 - 10055	Reserved				Reserved	36
2747 - 274A	10056 - 10059	Reserved				Reserved	4
274B - 274E	10060 - 10063	Reserved				Reserved	4
						Block size:	64
274F - 274F	10064 - 10064	Reserved				Reserved	1
2750 - 2750	10065 - 10065	Reserved				Reserved	1
2751 - 2751	10066 - 10066	Reserved				Reserved	1
2752 - 2752	10067 - 10067	Reserved				Reserved	1

Modbus address							
Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
2753 - 2756	10068 - 10071	Reserved				Reserved	4
						Block size:	8
2757 - 2790	10072 - 10129	Reserved				Reserved	58
						Block size:	66
2757 - 2757	10072 - 10072	Reserved				Reserved	1
2758 - 2758	10073 - 10073	Reserved				Reserved	1
2759 - 2759	10074 - 10074	Reserved				Reserved	1
275A - 275A	10075 - 10075	Reserved				Reserved	1
275B - 275B	10076 - 10076	Reserved				Reserved	1
275C - 275C	10077 - 10077	Reserved				Reserved	1
275D - 275E	10078 - 10079	Reserved				Reserved	2
275F - 275F	10080 - 10080	Reserved				Reserved	1
2760 - 2760	10081 - 10081	Reserved				Reserved	1
2761 - 2762	10082 - 10083	Reserved				Reserved	2
2763 - 2763	10084 - 10084	Reserved				Reserved	1
2764 - 2764	10085 - 10085	Reserved				Reserved	1
2765 - 2790	10086 - 10129	Reserved				Reserved	44
						Block size:	58
2757 - 2757	10072 - 10072	Reserved				Reserved	1
2758 - 2758	10073 - 10073	Reserved				Reserved	1
2759 - 2759	10074 - 10074	Reserved				Reserved	1
275A - 275A	10075 - 10075	Reserved				Reserved	1
275B - 275E	10076 - 10079	Reserved				Reserved	4
275F - 275F	10080 - 10080	Reserved				Reserved	1
2760 - 2760	10081 - 10081	Reserved				Reserved	1
2761 - 2761	10082 - 10082	Reserved				Reserved	1
2762 - 2762	10083 - 10083	Reserved				Reserved	1
2763 - 2763	10084 - 10084	Reserved				Reserved	1
2764 - 2764	10085 - 10085	Reserved				Reserved	1
2765 - 2765	10086 - 10086	Reserved				Reserved	1
2766 - 2766	10087 - 10087	Reserved				Reserved	1
2767 - 2790	10088 - 10129	Reserved				Reserved	42
						Block size:	58
2757 - 2757	10072 - 10072	Reserved				Reserved	1
2758 - 2790	10073 - 10129	Reserved				Reserved	57
						Block size:	58
2757 - 2757	10072 - 10072	Reserved				Reserved	1
2758 - 2758	10073 - 10073	Reserved				Reserved	1
2759 - 275B	10074 - 10076	Reserved				Reserved	3
275C - 275F	10077 - 10080	Reserved				Reserved	4
2760 - 2760	10081 - 10081	Reserved				Reserved	1
2761 - 2762	10082 - 10083	Reserved				Reserved	2
2763 - 2764	10084 - 10085	Reserved				Reserved	2
2765 - 2790	10086 - 10129	Reserved				Reserved	44
2791 - 27F2	10130 - 10227	Reserved				Reserved	98
						Block size:	156
2AF7 - 2AF7	11000 - 11000	Reserved				Reserved	1
2AF8 - 2AF8	11001 - 11001	Reserved				Reserved	1
2AF9 - 2B00	11002 - 11009	Reserved				Reserved	8
2B01 - 2B08	11010 - 11017	Reserved				Reserved	8
2B09 - 2B0A	11018 - 11019	Reserved				Reserved	2
2B0B - 2B28	11020 - 11055	Reserved				Reserved	36

B

Modbus address							
Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
2B2F - 2B32	11056 - 11059	Reserved				Reserved	4
2B33 - 2B36	11060 - 11063	Reserved				Reserved	4
						Block size:	64
2B37 - 2B37	11064 - 11064	Reserved				Reserved	1
2B38 - 2B38	11065 - 11065	Reserved				Reserved	1
2B39 - 2B39	11066 - 11066	Reserved				Reserved	1
2B3A - 2B3A	11067 - 11067	Reserved				Reserved	1
2B3B - 2B3E	11068 - 11071	Reserved				Reserved	4
						Block size:	8
2B3F - 2B78	11072 - 11129	Reserved				Reserved	58
						Block size:	66
2B3F - 2B3F	11072 - 11072	Reserved				Reserved	1
2B40 - 2B40	11073 - 11073	Reserved				Reserved	1
2B41 - 2B41	11074 - 11074	Reserved				Reserved	1
2B42 - 2B42	11075 - 11075	Reserved				Reserved	1
2B43 - 2B43	11076 - 11076	Reserved				Reserved	1
2B44 - 2B44	11077 - 11077	Reserved				Reserved	1
2B45 - 2B46	11078 - 11079	Reserved				Reserved	2
2B47 - 2B47	11080 - 11080	Reserved				Reserved	1
2B48 - 2B48	11081 - 11081	Reserved				Reserved	1
2B49 - 2B4A	11082 - 11083	Reserved				Reserved	2
2B4B - 2B4B	11084 - 11084	Reserved				Reserved	1
2B4C - 2B4C	11085 - 11085	Reserved				Reserved	1
2B4D - 2B78	11086 - 11129	Reserved				Reserved	44
						Block size:	58
Data and control block — digital I/O pulse output card overlay (note 15)						**Read-only except as indicated**	
2B3F - 2B3F	11072 - 11072	Reserved				Reserved	1
2B40 - 2B40	11073 - 11073	Reserved				Reserved	1
2B41 - 2B41	11074 - 11074	Reserved				Reserved	1
2B42 - 2B42	11075 - 11075	Reserved				Reserved	1
2B43 - 2B46	11076 - 11079	Reserved				Reserved	4
2B47 - 2B47	11080 - 11080	Reserved				Reserved	1
2B48 - 2B48	11081 - 11081	Reserved				Reserved	1
2B49 - 2B49	11082 - 11082	Reserved				Reserved	1
2B4A - 2B4A	11083 - 11083	Reserved				Reserved	1
2B4B - 2B4B	11084 - 11084	Reserved				Reserved	1
2B4C - 2B4C	11085 - 11085	Reserved				Reserved	1
2B4D - 2B4D	11086 - 11086	Reserved				Reserved	1
2B4E - 2B4E	11087 - 11087	Reserved				Reserved	1
2B4F - 2B78	11088 - 11129	Reserved				Reserved	42
						Block size:	58
Data and control block — analog out 0–1 mA / analog out 4–20 mA (note 15)						**Read-only**	
2B3F - 2B3F	11072 - 11072	Reserved				Reserved	1
2B40 - 2B78	11073 - 11129	Reserved				Reserved	57
						Block size:	58
Data and control block — network card overlay (note 15)						**Read-only**	
2B3F - 2B3F	11072 - 11072	Reserved				Reserved	1
2B40 - 2B40	11073 - 11073	Reserved				Reserved	1
2B41 - 2B43	11074 - 11076	Reserved				Reserved	3
2B44 - 2B47	11077 - 11080	Reserved				Reserved	4
2B48 - 2B48	11081 - 11081	Reserved				Reserved	1
2B49 - 2B4A	11082 - 11083	Reserved				Reserved	2

Modbus address							
Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
2B4B - 2B4C	11084 - 11085	Reserved				Reserved	2
2B4D - 2B78	11086 - 11129	Reserved				Reserved	44
2B79 - 2BDA	11130 - 11227	Reserved				Reserved	98
						Block size:	156
Accumulators block						**Read-only**	
2EDF - 2EE0	12000 - 12001	Reserved				Reserved	2
2EE1 - 2EE6	12002 - 12007	Reserved				Reserved	6
2EE7 - 2EE8	12008 - 12009	Reserved				Reserved	2
2EE9 - 2EEE	12010 - 12015	Reserved				Reserved	6
2EEF - 2EF6	12016 - 12023	Reserved				Reserved	8
2EF7 - 2EFE	12024 - 12031	Reserved				Reserved	8
						Block size:	32
Commands section (note 4)							
Resets block (note 9)						**Write-only**	
4E1F - 4E1F	20000 - 20000	Reset max/min blocks	UINT16	Password (note 5)			1
4E20 - 4E20	20001 - 20001	Reset energy accumulators	UINT16	Password (note 5)			1
4E21 - 4E21	20002 - 20002	Reset alarm log (note 21)	UINT16	Password (note 5)		Reply to a reset log command indicates that the command was accepted but not necessarily that the reset is finished. Poll log status block to determine this.	1
4E22 - 4E22	20003 - 20003	Reset system log (note 21)	UINT16	Password (note 5)			1
4E23 - 4E23	20004 - 20004	Reset historical log 1 (note 21)	UINT16	Password (note 5)			1
4E24 - 4E24	20005 - 20005	Reset historical log 2 (note 21)	UINT16	Password (note 5)			1
4E25 - 4E25	20006 - 20006	Reset historical log 3 (note 21)	UINT16	Password (note 5)			1
4E26 - 4E26	20007 - 20007	Reserved				Reserved	1
4E27 - 4E27	20008 - 20008	Reset power quality log	UINT16	Password (note 5)			1
4E28 - 4E28	20009 - 20009	Reset waveform capture log	UINT16	Password (note 5)			1
4E29 - 4E2A	20010 - 20011	Reserved				Reserved	2
4E2B - 4E2B	20012 - 20012	Reserved				Reserved	1
4E2C - 4E2C	20013 - 20013	Reserved				Reserved	1
4E2D - 4E2D	20014 - 20014	Reserved				Reserved	1
4E2E - 4E2E	20015 - 20015	Reserved				Reserved	1
						Block size:	16
Privileged commands block						**Conditional write**	
5207 - 5207	21000 - 21000	Initiate meter firmware reprogramming	UINT16	Password (note 5)			1
5208 - 5208	21001 - 21001	Force meter restart	UINT16	Password (note 5)		Causes a watchdog reset, always reads 0	1
5209 - 5209	21002 - 21002	Open privileged command session	UINT16	Password (note 5)		Meter will process command registers (this register through ’close privileged command session’ register below) for 5 minutes or until the session is closed, whichever comes first.	1
520A - 520A	21003 - 21003	Initiate programmable settings update	UINT16	Password (note 5)		Meter enters programmable settings update mode	1
520B - 520B	21004 - 21004	Calculate programmable settings checksum (note 3)	UINT16	0000 to 9999		Meter calculates checksum on ram copy of programmable settings block	1

Modbus address		Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
Hex	**Decimal**						
520C - 520C	21005 - 21005	Programmable settings checksum (note 3)	UINT16	0000 to 9999		Read/write checksum register; programmable settings block saved in nonvolatile memory on write (note 8).	1
520D - 520D	21006 - 21006	Write new password (note 3)	UINT16	0000 to 9999		Write-only register; always reads zero.	1
520E - 520E	21007 - 21007	Terminate programmable settings update (note 3)	UINT16	Any value		Meter leaves programmable settings update mode via reset.	1
520F - 5211	21008 - 21010	Set meter clock	TSTAMP	1Jan2000 - 31Dec2099	1 sec	Saved only when 3rd register is written.	3
5212 - 5212	21011 - 21011	Manually trigger waveform capture	UINT16	Any value		Returns busy exception if blocked by another capture in progress.	1
5213 - 5219	21012 - 21018	Reserved				Reserved.	7
521A - 521A	21019 - 21019	Close privileged command session	UINT16	Any value		Ends an open command session.	1
						Block size:	20
Encryption block						**Read/write**	
658F - 659A	26000 - 26011	Perform a secure operation	UINT16			Encrypted command to read password or change meter type.	12
						Block size:	12
Programmable settings section							
Basic setups block						**Write only in PS update mode**	
752F - 752F	30000 - 30000	CT multiplier and denominator	UINT16	Bit-mapped	dddddddd mmmmmmmm	High byte is denominator (1 or 5, read-only), low byte is multiplier (1, 10 or 100).	1
7530 - 7530	30001 - 30001	CT numerator	UINT16	1 to 9999	None		1
7531 - 7531	30002 - 30002	PT numerator	UINT16	1 to 9999	None		1
7532 - 7532	30003 - 30003	PT denominator	UINT16	1 to 9999	None		1
7533 - 7533	30004 - 30004	PT multiplier and hookup	UINT16	Bit-mapped	mmmmmmmm mmmmhhhh	mm…mm = PT multiplier (1, 10, 100, or 1000). hhhh = hookup enumeration (0 = 3 element wye[9S], 1 = delta 2 CTs[5S], 3 = 2.5 element wye[6S]).	1
7534 - 7534	30005 - 30005	Averaging method	UINT16	Bit-mapped	--iiiiii b----sss	iiiiii = interval (5, 15, 30, 60) . b = 0-block or 1-rolling. sss = # subintervals (1, 2, 3, 4).	1
7535 - 7535	30006 - 30006	Power and energy format	UINT16	Bit-mapped	ppppiinn feee-ddd	pppp = power scale (0-unit, 3-kilo, 6-mega, 8-auto). ii = power digits after decimal point (0–3), applies only if f=1 and pppp is not auto. nn = number of energy digits (5–8 --> 0–3). eee = energy scale (0-unit, 3-kilo, 6-mega). f = decimal point for power (0=data-dependant placement, 1=fixed placement per ii value). ddd = energy digits after decimal point (0–6). See note 10.	1
7536 - 7536	30007 - 30007	Operating mode screen enables	UINT16	Bit-mapped	-------x eeeeeeee	eeeeeeee = op mode screen rows on/off, rows top to bottom are bits low order to high order. x = set to suppress PF on W/VAR/PF screens.	1

B

Modbus address							
Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
7537 - 7537	30008 - 30008	Daylight saving on rule	UINT16	Bit-mapped	hhhhhwww -dddmmmm	Applies only if daylight savings in user settings flags = on; specifies when to make changeover. hhhhh = hour, 0-23. www = week, 1-4 for 1st-4th, 5 for last. ddd = day of week, 1-7 for Sun-Sat. mmmm = month, 1-12. Example: 2AM on the 4th Sunday of March is hhhhh=2, www=4, ddd=1, mmmm=3.	1
7538 - 7538	30009 - 30009	Daylight saving off rule	UINT16	Bit-mapped	hhhhhwww -dddmmmm		1
7539 - 7539	30010 - 30010	Time zone UTC offset	UINT16	Bit-mapped	z000 0000 hhhh hhmm	mm = minutes/15; 00=00, 01=15, 10=30, 11=45. hhhhhh = hours; -23 to +23 z = Time zone valid (0=no, 1=yes). i.e., register=0 indicates time zone is not set while register=0x8000 indicates UTC offset=0.	1
753A - 753A	30011 - 30011	Clock sync configuration	UINT16	Bit-mapped	0000 0000 mmmp pppe	e = enable automatic clock sync (0=no, 1=yes). mmm = sync method (4=line, all other values=no sync). pppp = method-dependent parameter. Line pppp=expected frequency (0=60 Hz, 1=50 Hz).	1
753B - 753B	30012 - 30012	Reserved				Reserved	1
753C - 753C	30013 - 30013	User settings 2	UINT16	Bit-mapped	----vfpr ccccccs	v= IEEE setting for view as generator (flip VAR, unflip PF) (0=off, 1=on). f = force 6 cycle energy/power processing (1=yes, 0=no). p = suppress filtering on power readings (1=yes, 0=no). r = suppress filtering on current and voltage readings (1=yes, 0=no). ccccccc = under range voltage cutoff, 0 to 12.7% full scale in 0.1% steps. Vrms below this value is reported as 0. See note 12 for full scale information. s = display secondary volts (1=yes, 0=no).	1
753D - 753D	30014 - 30014	DNP options	UINT16	Bit-mapped	-------- ww-i-vvp	p selects primary or secondary values for DNP voltage, current and power registers (0=secondary, 1=primary). vv sets divisor for voltage scaling (0=1, 1=10, 2=100). i sets divisor for current scaling (0=1, 1=10). ww sets divisor for power scaling in addition to scaling for kilo (0=1, 1=10, 2=100, 3=1000). Example: 120 kV, 500 A, 180 MW is p=1, vv=2, i=0, and ww=3; voltage reads 1200, current reads 500, watts reads 180.	1

B

Modbus address							
Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
753E - 753E	30015 - 30015	User settings flags	UINT16	Bit-mapped	vvkgeinn srpdywfa	vv = number of digits after decimal point for voltage display: 0 for voltage range 0-9999 V, 1 for voltage range 100-999.9 kV, 2 for voltage range 10-99.99 kV. 3 for voltage range 0-9.999 kV; this setting is used only when k=1. k = enable fixed scale for voltage display (0=autoscale, 1=unit if vv=0 and kV if vv=1, 2, 3). g = enable alternate full scale bar graph current (1=on, 0=off). e = enable CT PT compensation (0=disabled, 1=enabled). i = fixed scale and format current display (0=normal autoscaled current display, 1=always show amps with no decimal places). nn = number of phases for voltage and current screen (3=ABC, 2=AB, 1=A, 0=ABC). s = scroll (1=on, 0=off). r = password for reset in use (1=on, 0=off). p = password for configuration in use (1=on, 0=off). d = daylight saving time changes (0=off, 1=on). y = diagnostic events in system log (1=yes, 0=no). w = power direction (0=view as load, 1=view as generator). f = flip power factor sign (1=yes, 0=no). a = apparent power computation method (0=arithmetic sum, 1=vector sum).	1
753F - 753F	30016 - 30016	Full scale current (for load % bar graph)	UINT16	0 to 9999	None	If non-zero and user settings bit g is set, this value replaces CT numerator in the full scale current calculation. (See Note 12.)	1
7540 - 7547	30017 - 30024	Meter designation	ASCII	16 char	None		8
7548 - 7548	30025 - 30025	COM1 setup	UINT16	Bit-mapped	----dddd -0100110	yy = parity (0-none, 1-odd, 2-even). dddd = reply delay (* 50 msec). ppp = protocol (1-Modbus RTU, 2-Modbus ASCII, 3-DNP) bbbb = baud rate (1-9600, 2-19200, 4-38400, 6-57600, 13-1200, 14-2400, 15-4800).	1
7549 - 7549	30026 - 30026	COM2 setup	UINT16	Bit-mapped	yy--dddd -pppbbbb		1
754A - 754A	30027 - 30027	COM2 address	UINT16	1 to 247	None		1
754B - 754B	30028 - 30028	Limit #1 Identifier	UINT16	0 to 65535		Use Modbus address as the identifier (see notes 7, 11, 12).	1
754C - 754C	30029 - 30029	Limit #1 out high setpoint	SINT16	-200.0 to +200.0	0.1% of full scale	Setpoint for the above limit (LM1), see notes 11-12.	1
754D - 754D	30030 - 30030	Limit #1 in high threshold	SINT16	-200.0 to +200.0	0.1% of full scale	Threshold at which above limit clears; normally less than or equal to the above setpoint; see notes 11-12.	1
754E - 754E	30031 - 30031	Limit #1 out low setpoint	SINT16	-200.0 to +200.0	0.1% of full scale	Setpoint for the below limit (LM2), see notes 11-12.	1
754F - 754F	30032 - 30032	Limit #1 in low threshold	SINT16	-200.0 to +200.0	0.1% of full scale	Threshold at which below limit clears; normally greater than or equal to the below setpoint; see notes 11-12.	1

Modbus address Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
7550 - 7554	30033 - 30037	Limit #2	SINT16	Same as limit #1	Same as limit #1	Same as Limit #1	5
7555 - 7559	30038 - 30042	Limit #3	SINT16				5
755A - 755E	30043 - 30047	Limit #4	SINT16				5
755F - 7563	30048 - 30052	Limit #5	SINT16				5
7564 - 7568	30053 - 30057	Limit #6	SINT16				5
7569 - 756D	30058 - 30062	Limit #7	SINT16				5
756E - 7572	30063 - 30067	Limit #8	SINT16				5
7573 - 7582	30068 - 30083	Reserved				Reserved	16
7583 - 75C2	30084 - 30147	Reserved				Reserved	64
75C3 - 75C3	30148 - 30148	Watts loss due to iron when watts positive	UINT16	0 to 99.99	0.01%		1
75C4 - 75C4	30149 - 30149	Watts loss due to copper when watts positive	UINT16	0 to 99.99	0.01%		1
75C5 - 75C5	30150 - 30150	VAR loss due to iron when watts positive	UINT16	0 to 99.99	0.01%		1
75C6 - 75C6	30151 - 30151	VAR loss due to copper when watts positive	UINT16	0 to 99.99	0.01%		1
75C7 - 75C7	30152 - 30152	Watts loss due to iron when watts negative	UINT16	0 to 99.99	0.01%		1
75C8 - 75C8	30153 - 30153	Watts loss due to copper when watts negative	UINT16	0 to 99.99	0.01%		1
75C9 - 75C9	30154 - 30154	VAR loss due to iron when watts negative	UINT16	0 to 99.99	0.01%		1
75CA - 75CA	30155 - 30155	VAR loss due to copper when watts negative	UINT16	0 to 99.99	0.01%		1
75CB - 75CB	30156 - 30156	Transformer loss compensation user settings flag	UINT16	bit-mapped	-------- ----cfwv	c = 0 for disable compensation for losses due to copper, 1 for enable compensation for losses due to copper. f = 0 for disable compensation for losses due to iron, 1 for enable compensation for losses due to iron. w = 0 for add watt compensation, 1 for subtract watt compensation. v = 0 for add VAR compensation, 1 for subtract VAR compensation.	1
75CC - 75E5	30157 - 30182	Reserved				Reserved	26
75E6 - 75E6	30183 - 30183	Programmable settings update counter	UINT16	0-65535		Increments each time programmable settings are changed; occurs when new checksum is calculated.	1
75E7 - 7626	30184 - 30247	Reserved for software use				Reserved	64
7627 - 7627	30248 - 30248	A phase PT compensation @ 69 V (% error)	SINT16	-15 to 15	0.01%		1
7628 - 7628	30249 - 30249	A phase PT compensation @ 120 V (% error)	SINT16	-15 to 15	0.01%		1
7629 - 7629	30250 - 30250	A phase PT compensation @ 230 V (% error)	SINT16	-15 to 15	0.01%		1
762A - 762A	30251 - 30251	A phase PT compensation @ 480 V (% error)	SINT16	-15 to 15	0.01%		1

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Modbus address							
Hex	**Decimal**	**Description (note 1)**	**Format**	**Range (note 6)**	**Units or resolution**	**Comments**	**# Reg**
762B - 762E	30252 - 30255	B phase PT compensation @ 69 V, 120 V, 230 V, 480 V (% error)	SINT16	-15 to 15	0.01%		4
762F - 7632	30256 - 30259	C phase PT compensation @ 69 V, 120 V, 230 V, 480 V (% error)	SINT16	-15 to 15	0.01%		4
7633 - 7633	30260 - 30260	A phase CT compensation @ c1 (% error)	SINT16	-15 to 15	0.01%	For Class 10 unit: c1=0.25 A, c2=0.5 A, c3=1 A, c4=5 A. For Class 2 unit: c1=0.05 A, c2=0.1 A, c3=0.2 A, c4=1 A.	1
7634 - 7634	30261 - 30261	A phase CT compensation @ c2 (% error)	SINT16	-15 to 15	0.01%		1
7635 - 7635	30262 - 30262	A phase CT compensation @ c3 (% error)	SINT16	-15 to 15	0.01%		1
7636 - 7636	30263 - 30263	A phase CT compensation @ c4 (% error)	SINT16	-15 to 15	0.01%		1
7637 - 763A	30264 - 30267	B phase CT compensation @ c1, c2, c3, c4 (% error)	SINT16	-15 to 15	0.01%		4
763B - 763E	30268 - 30271	C phase CT compensation @ c1, c2, c3, c4 (% error)	SINT16	-15 to 15	0.01%		4
763F - 7642	30272 - 30275	A phase PF compensation @ c1, c2, c3, c4	SINT16	-50 to 50			4
7643 - 7646	30276 - 30279	B phase PF compensation @ c1, c2, c3, c4	SINT16	-50 to 50			4
7647 - 764A	30280 - 30283	C phase PF compensation @ c1, c2, c3, c4	SINT16	-50 to 50			4
						Block size:	284
Log setups block						**Write only in PS update mode**	
7917 - 7917	31000 - 31000	Historical log #1 sizes	UINT16	Bit-mapped	eeeeeeee ssssssss	High byte is number of registers to log in each record (0- 117). Low byte is number of flash sectors for the log (see note 19). 0 in either byte disables the log.	1
7918 - 7918	31001 - 31001	Historical log #1 interval	UINT16	Bit-mapped	00000000 hgfedcba	Only 1 bit set: a=1 min, b=3 min, c=5 min, d=10 min, e=15 min, f=30 min, g=60 min, h=EOI pulse.	1
7919 - 7919	31002 - 31002	Historical log #1, register #1 identifier	UINT16	0 to 65535		Use Modbus address as the identifier (see note 7).	1
791A - 798D	31003 - 31118	Historical log #1, register #2 - #117 identifiers	UINT16	0 to 65535		Same as register #1 identifier.	116
798E - 79D6	31119 - 31191	Historical log #1 software buffer				Reserved for software use.	73
79D7 - 7A96	31192 - 31383	Historical log #2 sizes, interval, registers and software buffer	Same as historical log #1	Same as historical log #1	Same as historical log #1	Same as historical log #1	192
7A97 - 7B56	31384 - 31575	Historical log #3 sizes, interval, registers and software buffer					192

Modbus address							
Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
7B57 - 7B57	31576 - 31607	Waveform log sample rate and pretrigger	UINT16	Bit-mapped	ssssssss pppppppp	High byte is samples/60Hz cycle = 5 (32), 6 (64), 7 (128), 8 (256) or 9 (512). Low byte is number of pretrigger cycles.	1
7B58 - 7B58	31577 - 31577	Power quality log triggers	UINT16	Bit-mapped	-------8 76543210	Set bits to enable PQ events/ waveform captures: 2,1,0 = voltage surge, channel C,B,A; 5,4,3 = current surge, channel C,B,A; 8,7,6 = voltage sag, channel C,B,A.	1
7B59 - 7B59	31578 - 31578	Waveform log triggers	UINT16	Bit-mapped	-------8 76543210		1
7B5A - 7B5A	31579 - 31579	Waveform and PQ log sizes	UINT16	Bit-mapped	pppppppp wwwwwwww	High byte is number of flash sectors for PQ log. Low byte is number of flash sectors for waveform log.	1
7B5B - 7B5B	31580 - 31580	Reserved				Reserved	1
7B5C - 7B5C	31581 - 31581	Channel A voltage surge threshold	UINT16	0 to 3276.7	0.1% of full scale	Thresholds are % of full scale; see note 12.	1
7B5D - 7B5D	31582 - 31582	Channel A current surge threshold	UINT16	0 to 3276.7	0.1% of full scale		1
7B5E - 7B5E	31583 - 31583	Channel A voltage sag threshold	UINT16	0 to 3276.7	0.1% of full scale		1
7B5F - 7B61	31584 - 31586	Reserved				Reserved	3
7B62 - 7B67	31587 - 31592	Channel B surge and sag thresholds	Same as channel A	Same as channel A	Same as channel A	Same as channel A	6
7B68 - 7B6D	31593 - 31598	Channel C surge and sag thresholds					6
7B6E - 7B76	31599 - 31607	Reserved				Reserved	9
						Block size:	608
7CFF - 7CFF	32000 - 32000	Reserved				Reserved	1
7D00 - 7D3E	32001 - 32063	Reserved				Reserved	63
7D3F - 7F3E	32064 - 32575	Reserved				Reserved	512
						Block size:	576
7D00 - 7D00	32001 - 32001	Reserved				Reserved	1
7D01 - 7D01	32002 - 32002	Reserved				Reserved	1
7D02 - 7D02	32003 - 32003	Reserved				Reserved	1
7D03 - 7D03	32004 - 32004	Reserved				Reserved	1
7D04 - 7D04	32005 - 32005	Reserved				Reserved	1
7D05 - 7D3E	32006 - 32063	Reserved				Reserved	58
						Block size:	63
7D00 - 7D00	32001 - 32001	Reserved				Reserved	1
7D01 - 7D01	32002 - 32002	Reserved				Reserved	1
7D02 - 7D02	32003 - 32003	Reserved				Reserved	1
7D03 - 7D08	32004 - 32009	Reserved				Reserved	6
7D09 - 7D09	32010 - 32010	Reserved				Reserved	1
7D0A - 7D0A	32011 - 32011	Reserved				Reserved	1
7D0B - 7D20	32012 - 32033	Reserved				Reserved	22
7D21 - 7D21	32034 - 32034	Reserved				Reserved	1
7D22 - 7D22	32035 - 32035	Reserved				Reserved	1
7D23 - 7D23	33036 - 33036	Reserved				Reserved	1
7D24 - 7D3E	32037 - 32063	Reserved				Reserved	27
						Block size:	63
7D00 - 7D00	32001 - 32001	Reserved				Reserved	1
7D01 - 7D01	32002 - 32002	Reserved				Reserved	1
7D02 - 7D02	32003 - 32003	Reserved				Reserved	1
7D03 - 7D04	32004 - 32005	Reserved				Reserved	2
7D05 - 7D06	32006 - 32007	Reserved				Reserved	2

Modbus address							
Hex	**Decimal**	**Description (note 1)**	**Format**	**Range (note 6)**	**Units or resolution**	**Comments**	**# Reg**
7D07 - 7D08	32008 - 32009	Reserved				Reserved	2
7D09 - 7D09	32010 - 32010	Reserved				Reserved	1
7D0A - 7D0A	32011 - 32011	Reserved				Reserved	1
7D0B - 7D0B	32012 - 32012	Reserved				Reserved	1
7D0C - 7D3E	32013 - 32063	Reserved				Reserved	51
						Block size:	63
7D3F - 7D46	32064 - 32071	Reserved				Reserved	8
7D47 - 7D4E	32072 - 32079	Reserved				Reserved	8
7D4F - 7D56	32080 - 32087	Reserved				Reserved	8
7D57 - 7D6E	32088 - 32111	Reserved				Reserved	24
7D6F - 7D9E	32112 - 32159	Reserved				Reserved	48
7D9F 7DA6	32160 - 32167	Reserved				Reserved	8
7DA7 7DAE	32168 - 32175	Reserved				Reserved	8
7DAF - 7DB6	32176 - 32183	Reserved				Reserved	8
7DB7 - 7DCE	32184 - 32207	Reserved				Reserved	24
7DCF - 7DFE	32208 - 32255	Reserved				Reserved	48
7DFF - 7E06	32256 - 32263	Reserved				Reserved	8
7E07 - 7E0E	32264 - 32271	Reserved				Reserved	8
7E0F - 7E1E	32272 - 32287	Reserved				Reserved	16
7E1F - 7E1F	32288 - 32288	Reserved				Reserved	1
7E20 - 7E20	32289 - 32289	Reserved				Reserved	1
7E21 - 7F3E	32290 - 32575	Reserved				Reserved	286
						Block size:	512
7D3F - 7D46	32064 - 32071	Reserved				Reserved	8
7D47 - 7D4E	32072 - 32079	Reserved				Reserved	8
7D4F - 7D56	32080 - 32087	Reserved				Reserved	8
7D57 - 7D6E	32088 - 32111	Reserved				Reserved	24
7D6F - 7D86	32112 - 32135	Reserved				Reserved	24
7D87 - 7D9E	32136 - 32159	Reserved				Reserved	24
7D9F - 7DA6	32160 - 32167	Reserved				Reserved	8
7DA7 - 7DAE	32168 - 32175	Reserved				Reserved	8
7DAF - 7DB6	32176 - 32183	Reserved				Reserved	8
7DB7 - 7DCE	32184 - 32207	Reserved				Reserved	24
7DCF - 7DE6	32208 - 32231	Reserved				Reserved	24
7DE7 - 7DFE	32232 - 32255	Reserved				Reserved	24
7DFF - 7E06	32256 - 32263	Reserved				Reserved	8
7E07 - 7E0E	32264 - 32271	Reserved				Reserved	8
7E0F - 7E16	32272 - 32279	Reserved				Reserved	8
7E17 - 7E1E	32280 - 32287	Reserved				Reserved	8
7E1F - 7E1F	32288 - 32288	Reserved				Reserved	1
7E20 - 7E20	32289 - 32289	Reserved				Reserved	1
7E21 - 7E21	32290 - 32290	Reserved				Reserved	1
7E22 - 7E22	32291 - 32291	Reserved				Reserved	1
7E23 - 7F3E	32292 - 32575	Reserved				Reserved	284
						Block size:	512
7D3F - 7D3F	32064 - 32064	Reserved				Reserved	1
7D40 - 7D40	32065 - 32065	Reserved				Reserved	1
7D41 - 7D41	32066 - 32066	Reserved				Reserved	1
7D42 - 7D42	32067 - 32067	Reserved				Reserved	1
7D43 - 7D44	32068 - 32069	Reserved				Reserved	2
7D45 - 7D46	32070 - 32071	Reserved				Reserved	2
7D47 - 7D4C	32072 - 32077	Reserved				Reserved	6

Modbus address		Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
Hex	Decimal						
7D4D - 7D52	32078 - 32083	Reserved				Reserved	6
7D53 - 7D58	32084 - 32089	Reserved				Reserved	6
7D59 - 7F3E	32090 - 32575	Reserved				Reserved	486
						Block size:	512
7D3F - 7D3F	32064 - 32064	Reserved				Reserved	1
7D40 - 7D40	32065 - 32065	Reserved				Reserved	1
7D41 - 7D48	32066 - 32073	Reserved				Reserved	8
7D49 - 7D4C	32074 - 32077	Reserved				Reserved	4
7D4D - 7D4D	32078 - 32078	Reserved				Reserved	1
7D4E - 7D51	32079 - 32082	Reserved				Reserved	4
7D52 - 7D55	32083 - 32086	Reserved				Reserved	4
7D56 - 7D59	32087 - 32090	Reserved				Reserved	4
7D5A - 7D5A	32091 - 32091	Reserved				Reserved	1
7D5B - 7D5B	32092 - 32092	Reserved				Reserved	1
7D5C - 7D5C	32093 - 32093	Reserved				Reserved	1
7D5D - 7D5D	32094 - 32094	Reserved				Reserved	1
7D5E - 7D61	32095 - 32098	Reserved				Reserved	4
7D62 - 7D65	32099 - 32102	Reserved				Reserved	4
7D66 - 7D66	32103 - 32103	Reserved				Reserved	1
7D67 - 7D67	32104 - 32104	Reserved				Reserved	1
7D68 - 7D6C	32105 - 32109	Reserved				Reserved	5
7D6D - 7D8C	32110 - 32141	Reserved				Reserved	32
7D8D - 7DAC	32142 - 32173	Reserved				Reserved	32
7DAD - 7F3E	32174 - 32575	Reserved				Reserved	402
						Block size:	512
80E7 - 80E7	33000 - 33000	Reserved				Reserved	1
80E8 - 8126	33001 - 33063	Reserved				Reserved	63
8127 - 8326	33064 - 33575	Reserved				Reserved	512
						Block size:	576
80E8 - 80E8	33001 - 33001	Reserved				Reserved	1
80E9 - 80E9	33002 - 33002	Reserved				Reserved	1
80EA - 80EA	33003 - 33003	Reserved				Reserved	1
80EB - 80EB	33004 - 33004	Reserved				Reserved	1
80EC - 80EC	33005 - 33005	Reserved				Reserved	1
80ED - 8126	33006 - 33063	Reserved				Reserved	58
						Block size:	63
80E8 - 80E8	33001 - 33001	Reserved				Reserved	1
80E9 - 80E9	33002 - 33002	Reserved				Reserved	1
80EA - 80EA	33003 - 33003	Reserved				Reserved	1
80EB - 80F0	33004 - 33009	Reserved				Reserved	6
80F1 - 80F1	33010 - 33010	Reserved				Reserved	1
80F2 - 80F2	33011 - 33011	Reserved				Reserved	1
80F3 - 8108	33012 - 33033	Reserved				Reserved	22
8109 - 8109	33034 - 33034	Reserved				Reserved	1
810A - 810A	33035 - 33035	Reserved				Reserved	1
810B - 810B	33036 - 33036	Reserved				Reserved	1
810C - 8126	33037 - 33063	Reserved				Reserved	27
						Block size:	63
80E8 - 80E8	33001 - 33001	Reserved				Reserved	1
80E9 - 80E9	33002 - 33002	Reserved				Reserved	1
80EA - 80EA	33003 - 33003	Reserved				Reserved	1
80EB - 80EC	33004 - 33005	Reserved				Reserved	2

B

Modbus address							
Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
80ED - 80EE	33006 - 33007	Reserved				Reserved	2
80EF - 80F0	33008 - 33009	Reserved				Reserved	2
80F1 - 80F1	33010 - 33010	Reserved				Reserved	1
80F2 - 80F2	33011 - 33011	Reserved				Reserved	1
80F3 - 80F3	33012 - 33012	Reserved				Reserved	1
80F4 - 8126	33013 - 33063	Reserved				Reserved	51
						Block size:	63
8127 - 812E	33064 - 33071	Reserved				Reserved	8
812F - 8136	33072 - 33079	Reserved				Reserved	8
8137 - 813E	33080 - 33087	Reserved				Reserved	8
813F - 8156	33088 - 33111	Reserved				Reserved	24
8157 - 8186	33112 - 33159	Reserved				Reserved	48
8187 - 818E	33160 - 33167	Reserved				Reserved	8
818F - 8196	33168 - 33175	Reserved				Reserved	8
8197 - 819E	33176 - 33183	Reserved				Reserved	8
819F - 81B6	33184 - 33207	Reserved				Reserved	24
81B7 - 81E6	33208 - 33255	Reserved				Reserved	48
81E7 - 81EE	33256 - 33263	Reserved				Reserved	8
81EF - 81F6	33264 - 33271	Reserved				Reserved	8
8208 - 8208	33289 - 33289	Reserved				Reserved	1
8209 - 8326	33290 - 33575	Reserved				Reserved	286
						Block size:	512
8127 - 812E	33064 - 33071	Reserved				Reserved	8
812F - 8136	33072 - 33079	Reserved				Reserved	8
8137 - 813E	33080 - 33087	Reserved				Reserved	8
813F - 8156	33088 - 33111	Reserved				Reserved	24
8157 - 816E	33112 - 33135	Reserved				Reserved	24
816F - 8186	33136 - 33159	Reserved				Reserved	24
8187 - 818E	33160 - 33167	Reserved				Reserved	8
818F - 8196	33168 - 33175	Reserved				Reserved	8
8197 - 819E	33176 - 33183	Reserved				Reserved	8
819F - 81B6	33184 - 33207	Reserved				Reserved	24
81B7 - 81CE	33208 - 33231	Reserved				Reserved	24
81CF - 81E6	33232 - 33255	Reserved				Reserved	24
81E7 - 81EE	33256 - 33263	Reserved				Reserved	8
81EF - 81F6	33264 - 33271	Reserved				Reserved	8
81F7 - 81FE	33272 - 33279	Reserved				Reserved	8
81FF - 8206	33280 - 33287	Reserved				Reserved	8
8207 - 8207	33288 - 33288	Reserved				Reserved	1
8208 - 8208	33289 - 33289	Reserved				Reserved	1
8209 - 8209	33290 - 33290	Reserved				Reserved	1
820A - 820A	33291 - 33291	Reserved				Reserved	1
820B - 8326	33292 - 33575	Reserved				Reserved	284
						Block size:	512
8127 - 8127	33064 - 33064	Reserved				Reserved	1
8128 - 8128	33065 - 33065	Reserved				Reserved	1
8129 - 8129	33066 - 33066	Reserved				Reserved	1
812A - 812A	33067 - 33067	Reserved				Reserved	1
812B - 812C	33068 - 33069	Reserved				Reserved	2
812D - 812E	33070 - 33071	Reserved				Reserved	2
812F - 8134	33072 - 33077	Reserved				Reserved	6
8135 - 813A	33078 - 33083	Reserved				Reserved	6

B

Modbus address							
Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
813B - 8140	33084 - 33089	Reserved				Reserved	6
8141 - 8326	33090 - 33575	Reserved				Reserved	486
						Block size:	512
8127 - 8127	33064 - 33064	Reserved				Reserved	1
8128 - 8128	33065 - 33065	Reserved				Reserved	1
8129 - 8130	33066 - 33073	Reserved				Reserved	8
8131 - 8134	33074 - 33077	Reserved				Reserved	4
8135 - 8135	33078 - 33078	Reserved				Reserved	1
8136 - 8139	33079 - 33082	Reserved				Reserved	4
813A - 813D	33083 - 33086	Reserved				Reserved	4
813E - 8141	33087 - 33090	Reserved				Reserved	4
8142 - 8142	33091 - 33091	Reserved				Reserved	1
8143 - 8143	33092 - 33092	Reserved				Reserved	1
8144 - 8144	33093 - 33093	Reserved				Reserved	1
8145 - 8145	33094 - 33094	Reserved				Reserved	1
8146 - 8149	33095 - 33098	Reserved				Reserved	4
814A - 814D	33099 - 33102	Reserved				Reserved	4
814E - 814E	33103 - 33103	Reserved				Reserved	1
814F - 814F	33104 - 33104	Reserved				Reserved	1
8150 - 8154	33105 - 33109	Reserved				Reserved	5
8155 - 8174	33110 - 33141	Reserved				Reserved	32
8175 - 8194	33142 - 33173	Reserved				Reserved	32
8195 - 8326	33174 - 33575	Reserved				Reserved	402
						Block size:	512
Secondary readings section							
Secondary block						**Read-only except as noted**	
9C40 - 9C40	40001 - 40001	System sanity indicator	UINT16	0 or 1	None	0 indicates proper meter operation	1
9C41 - 9C41	40002 - 40002	Volts A-N	UINT16	2047 to 4095	Volts	2047= 0, 4095= +150 Volts = 150 * (register - 2047) / 2047	1
9C42 - 9C42	40003 - 40003	Volts B-N	UINT16	2047 to 4095	Volts		1
9C43 - 9C43	40004 - 40004	Volts C-N	UINT16	2047 to 4095	Volts		1
9C44 - 9C44	40005 - 40005	Amps A	UINT16	0 to 4095	Amps	0= -10, 2047= 0, 4095= +10 Amps = 10 * (register - 2047) / 2047	1
9C45 - 9C45	40006 - 40006	Amps B	UINT16	0 to 4095	Amps		1
9C46 - 9C46	40007 - 40007	Amps C	UINT16	0 to 4095	Amps		1
9C47 - 9C47	40008 - 40008	Watts, 3-ph total	UINT16	0 to 4095	Watts	0= -3000, 2047= 0, 4095= +3000 Watts, VARs, VAs = 3000 * (register - 2047) / 2047	1
9C48 - 9C48	40009 - 40009	VARs, 3-ph total	UINT16	0 to 4095	VARs		1
9C49 - 9C49	40010 - 40010	VAs, 3-ph total	UINT16	2047 to 4095	VAs		1
9C4A - 9C4A	40011 - 40011	Power factor, 3-ph total	UINT16	1047 to 3047	None	1047= -1, 2047= 0, 3047= +1 PF = (register - 2047) / 1000	1
9C4B - 9C4B	40012 - 40012	Frequency	UINT16	0 to 2730	Hz	0= 45 or less, 2047= 60, 2730= 65 or more Freq = 45 + ((register / 4095) * 30)	1
9C4C - 9C4C	40013 - 40013	Volts A-B	UINT16	2047 to 4095	Volts	2047= 0, 4095= +300 Volts = 300 * (register - 2047) / 2047	1
9C4D - 9C4D	40014 - 40014	Volts B-C	UINT16	2047 to 4095	Volts		1
9C4E - 9C4E	40015 - 40015	Volts C-A	UINT16	2047 to 4095	Volts		1
9C4F - 9C4F	40016 - 40016	CT numerator	UINT16	1 to 9999	None	CT = numerator * multiplier / denominator	1
9C50 - 9C50	40017 - 40017	CT multiplier	UINT16	1, 10, 100	None		1
9C51 - 9C51	40018 - 40018	CT denominator	UINT16	1 or 5	None		1
9C52 - 9C52	40019 - 40019	PT numerator	UINT16	1 to 9999	None	PT = numerator * multiplier / denominator	1
9C53 - 9C53	40020 - 40020	PT multiplier	UINT16	1, 10, 100, 1000	None		1
9C54 - 9C54	40021 - 40021	PT denominator	UINT16	1 to 9999	None		1

Modbus address							
Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
9C55 - 9C56	40022 - 40023	W-hours, positive	UINT32	0 to 99999999	Wh per energy format	* 5 to 8 digits. * Decimal point implied, per energy format. * Resolution of digit before decimal point = units, kilo or mega, per energy format. * See note 10.	2
9C57 - 9C58	40024 - 40025	W-hours, negative	UINT32	0 to 99999999	Wh per energy format		2
9C59 - 9C5A	40026 - 40027	VAR-hours, positive	UINT32	0 to 99999999	VARh per energy format		2
9C5B - 9C5C	40028 - 40029	VAR-hours, negative	UINT32	0 to 99999999	VARh per energy format		2
9C5D - 9C5E	40030 - 40031	VA-hours	UINT32	0 to 99999999	VAh per energy format		2
9C5F - 9C60	40032 - 40033	W-hours, positive, phase A	UINT32	0 to 99999999	Wh per energy format		2
9C61 - 9C62	40034 - 40035	W-hours, positive, phase B	UINT32	0 to 99999999	Wh per energy format		2
9C63 - 9C64	40036 - 40037	W-hours, positive, phase C	UINT32	0 to 99999999	Wh per energy format		2
9C65 - 9C66	40038 - 40039	W-hours, negative, phase A	UINT32	0 to 99999999	Wh per energy format		2
9C67 - 9C68	40040 - 40041	W-hours, negative, phase B	UINT32	0 to 99999999	Wh per energy format		2
9C69 - 9C6A	40042 - 40043	W-hours, negative, phase C	UINT32	0 to 99999999	Wh per energy format		2
9C6B - 9C6C	40044 - 40045	VAR-hours, positive, phase A	UINT32	0 to 99999999	VARh per energy format		2
9C6D - 9C6E	40046 - 40047	VAR-hours, positive, phase B	UINT32	0 to 99999999	VARh per energy format		2
9C6F - 9C70	40048 - 40049	VAR-hours, positive, phase C	UINT32	0 to 99999999	VARh per energy format		2
9C71 - 9C72	40050 - 40051	VAR-hours, negative, phase A	UINT32	0 to 99999999	VARh per energy format		2
9C73 - 9C74	40052 - 40053	VAR-hours, negative, phase B	UINT32	0 to 99999999	VARh per energy format		2
9C75 - 9C76	40054 - 40055	VAR-hours, negative, phase C	UINT32	0 to 99999999	VARh per energy format		2
9C77 - 9C78	40056 - 40057	VA-hours, phase A	UINT32	0 to 99999999	VAh per energy format		2
9C79 - 9C7A	40058 - 40059	VA-hours, phase B	UINT32	0 to 99999999	VAh per energy format		2
9C7B - 9C7C	40060 - 40061	VA-hours, phase C	UINT32	0 to 99999999	VAh per energy format		2
9C7D - 9C7D	40062 - 40062	Watts, phase A	UINT16	0 to 4095	Watts	0= -3000, 2047= 0, 4095= +3000 Watts, VARs, VAs = 3000 * (register - 2047) / 2047	1
9C7E - 9C7E	40063 - 40063	Watts, phase B	UINT16	0 to 4095	Watts		1
9C7F - 9C7F	40064 - 40064	Watts, phase C	UINT16	0 to 4095	Watts		1
9C80 - 9C80	40065 - 40065	VARs, phase A	UINT16	0 to 4095	VARs		1
9C81 - 9C81	40066 - 40066	VARs, Phase B	UINT16	0 to 4095	VARs		1
9C82 - 9C82	40067 - 40067	VARs, Phase C	UINT16	0 to 4095	VARs		1
9C83 - 9C83	40068 - 40068	VAs, Phase A	UINT16	2047 to 4095	VAs		1
9C84 - 9C84	40069 - 40069	VAs, Phase B	UINT16	2047 to 4095	VAs		1
9C85 - 9C85	40070 - 40070	VAs, Phase C	UINT16	2047 to 4095	VAs		1
9C86 - 9C86	40071 - 40071	Power factor, phase A	UINT16	1047 to 3047	None	1047= -1, 2047= 0, 3047= +1 PF = (register - 2047) / 1000	1
9C87 - 9C87	40072 - 40072	Power factor, phase B	UINT16	1047 to 3047	None		1
9C88 - 9C88	40073 - 40073	Power factor, phase C	UINT16	1047 to 3047	None		1
9C89 - 9CA2	40074 - 40099	Reserved	N/A	N/A	None	Reserved	26
9CA3 - 9CA3	40100 - 40100	Reset energy accumulators	UINT16	password (Note 5)		Write-only register; always reads as 0	1
						Block size:	100

Modbus address Hex	Decimal	Description (note 1)	Format	Range (note 6)	Units or resolution	Comments	# Reg
Log retrieval section							
Log retrieval block						**Read/write except as noted**	
C34C - C34D	49997 - 49998	Log retrieval session duration	UINT32	0 to 4294967294	4 msec	0 if no session active; wraps around after max count.	2
C34E - C34E	49999 - 49999	Log retrieval session COM port	UINT16	0 to 4		0 if no session active, 1-4 for session active on COM1 - COM4.	1
C34F - C34F	50000 - 50000	Log number, enable, scope	UINT16	Bit-mapped	nnnnnnnn essssss	High byte is the log number (0-system, 1-alarm, 2-history1, 3-history2, 4-history3, 5-I/O changes, 10-PQ, 11-waveform. e is retrieval session enable(1) or disable(0). sssssss is what to retrieve (0-normal record, 1-timestamps only, 2-complete memory image (no data validation if image)).	1
C350 - C350	50001 - 50001	Records per window or batch, record scope selector, number of repeats	UINT16	Bit-mapped	wwwwwwww snnnnnnn	High byte is records per window if s=0 or records per batch if s=1. Low byte is number of repeats for function 35 or 0 to suppress auto-incrementing; max number of repeats is 8 (RTU) or 4 (ASCII) total windows; a batch is all the windows.	1
C351 - C352	50002 - 50003	Offset of first record in window	UINT32	Bit-mapped	ssssssss nnnnnnnn nnnnnnnn nnnnnnnn	ssssssss is window status (0 to 7-window number, 0xFF- not ready); this byte is read-only. nn…nn is a 24-bit record number. The log's first record is latched as a reference point when the session is enabled. This offset is a record index relative to that point. Value provided is the relative index of the whole or partial record that begins the window.	2
C353 - C3CD	50004 - 50126	Log retrieve window	UINT16	See comments	None	Mapped per record layout and retrieval scope, read-only.	123
						Block size:	130
Log status block						**Read only**	
		Alarm log status block					
C737 - C738	51000 - 51001	Log size in records	UINT32	0 to 4,294,967,294	Record		2
C739 - C73A	51002 - 51003	Number of records used	UINT32	1 to 4,294,967,294	Record		2
C73B - C73B	51004 - 51004	Record size in bytes	UINT16	14 to 242	Byte		1
C73C - C73C	51005 - 51005	Log availability	UINT16		None	0=available, 1-2=in use by COM1-2, 0xFFFF=not available (log size=0)	1
C73D - C73F	51006 - 51008	Timestamp, first record	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
C740 - C742	51009 - 51011	Timestamp, last record	TSTAMP	1Jan2000 - 31Dec2099	1 sec		3
C743 - C746	51012 - 51015	Reserved				Reserved	4
						Individual log status block size:	16
C747 - C756	51016 - 51031	System log status block		Same as alarm log status block	Same as alarm log status block	Same as alarm log status block	16
C757 - C766	51032 - 51047	Historical log 1 status block					16
C767 - C776	51048 - 51063	Historical log 2 status block					16
C777 - C786	51064 - 51079	Historical log 3 status block					16

B

Modbus address							
Hex	**Decimal**	**Description (note 1)**	**Format**	**Range (note 6)**	**Units or resolution**	**Comments**	**# Reg**
C787 - C796	51080 - 51095	Reserved				Reserved	16
C797 - C7A6	51096 - 51111	Power quality log status block		Same as alarm log status block	Same as alarm log status block	Same as alarm log status block	16
C7A7 - C7B6	51112 - 51127	Waveform capture log status block					16
						Block size:	128
End of map							

Data formats

ASCII — ASCII characters packed 2 per register in high, low order without any termination characters. For example, RGM7000 would be 4 registers containing 0x5378, 0x6172, 0x6B32, 0x3030.

SINT16 / UINT16 — 16-bit signed / unsigned integer.

SINT32 / UINT32 — 32-bit signed / unsigned integer spanning 2 registers. The lower-addressed register is the high order half.

FLOAT — 32-bit IEEE floating point number spanning 2 registers. The lower-addressed register is the high order half (i.e., contains the exponent).

TSTAMP — 3 adjacent registers, 2 bytes each. First (lowest-addressed) register high byte is year (0-99), low byte is month (1-12). Middle register high byte is day (1-31), low byte is hour (0-23 plus DST bit). DST (daylight saving time) bit is bit 6 (0x40). Third register high byte is minutes (0-59), low byte is seconds (0-59). For example, 9:35:07AM on October 12, 2049 would be 0x310A, 0x0C49, 0x2307, assuming DST is in effect.

Notes

1 All registers not explicitly listed in the table read as 0. Writes to these registers will be accepted but won't actually change the register (since it doesn't exist).

2 Meter data section items read as 0 until first readings are available or if the meter is not in operating mode. Writes to these registers will be accepted but won't actually change the register.

3 Register valid only in programmable settings update mode. In other modes, these registers read as 0 and return an illegal data address exception if a write is attempted.

4 Meter command registers always read as 0. They may be written only when the meter is in a suitable mode. The registers return an illegal data address exception if a write is attempted in an incorrect mode.

5 If the password is incorrect, a valid response is returned, but the command is not executed. Use 5555 for the password if passwords are disabled in the programmable settings.

6 M denotes a 1,000,000 multiplier.

7 Each identifier is a Modbus register. For entities that occupy multiple registers (FLOAT, SINT32, etc.), all registers making up the entity must be listed, in ascending order. For example, to log phase A volts, VAs, voltage THD and VA hours, the register list would be 0x3E7, 0x3E8, 0x411, 0x412, 0x176F, 0x61D, 0x61E, and the number of registers (0x7917 high byte) would be 7.

8 Writing this register causes data to be saved permanently in nonvolatile memory. Reply to the command indicates that it was accepted but not whether or not the save was successful. This can only be determined after the meter has restarted.

9 Reset commands make no sense if the meter state is LIMP. An illegal function exception will be returned.

10 Energy registers should be reset after a format change.

Notes continued

11 Entities to be monitored against limits are identified by Modbus address. Entities occupying multiple Modbus registers, such as floating point values, are identified by the lower register address. If any of the 8 limits is unused, set its identifier to zero. If the indicated Modbus register is not used or is a nonsensical entity for limits, it will behave as an unused limit.

12 There are 2 setpoints per limit, one above and one below the expected range of values. LM1 is the "too high" limit, LM2 is "too low." The entity goes "out of limit" on LM1 when its value is greater than the setpoint. It remains "out of limit" until the value drops below the in threshold. LM2 works similarly, in the opposite direction. If limits in only one direction are of interest, set the in threshold on the "wrong" side of the setpoint. Limits are specified as % of full scale, where full scale is automatically set appropriately for the entity being monitored:

Current FS	=	CT numerator * CT multiplier
Voltage FS	=	PT numerator * PT multiplier
3-phase power FS	=	CT numerator * CT multiplier * PT numerator * PT multiplier * 3 [* SQRT(3) for delta hookup]
Single-phase power FS	=	CT numerator * CT multiplier * PT numerator * PT multiplier [* SQRT(3) for delta hookup]
Frequency FS	=	60 (or 50)
Power factor FS	=	1.0
Percentage FS	=	100.0
Angle FS	=	180.0

13 THD not available shows 10000 in all THD and harmonic magnitude and phase registers for the channel. THD may be unavailable due to low V or I amplitude, delta hookup (V only) or V-switch setting.

14 A block of data and control registers is allocated for each option slot. Interpretation of the register data depends on what card is in the slot.

15 Measurement states: Off occurs during programmable settings updates; run is the normal measuring state; limp indicates that an essential non-volatile memory block is corrupted; and warmup occurs briefly (approximately 4 seconds) at startup while the readings stabilize. Run state is required for measurement, historical logging, demand interval processing, limit alarm evaluation, min/max comparisons and THD calculations. Resetting min/max or energy is allowed only in run and off states; warmup will return a busy exception. In limp state, the meter reboots at
5-minute intervals in an effort to clear the problem.

16 Limits evaluation for all entites except demand averages commences immediately after the warmup period. Evaluation for demand averages, maximum demands and minimum demands commences at the end of the first demand interval after startup.

17 Autoincrementing and function 35 must be used when retrieving waveform logs.

18 Depending on the V-switch setting, there are 15, 29 or 45 flash sectors available in a common pool for distribution among the three historical and waveform logs. The pool size, number of sectors for each log and the number of registers per record together determine the maximum number of records a log can hold.

19 S = number of sectors assigned to the log.
H = number of Modbus registers to be monitored in each historical record (up to 117).
R = number of bytes per record = (12 + 2H) for historical logs.
N = number of records per sector = 65516 / R, rounded down to an integer value (no partial records in a sector).
T = total number of records the log can hold = S * N.
T = S * 2 for the waveform log.

20 Logs cannot be reset during log retrieval. Waveform log cannot be reset while storing a capture. Busy exception will be returned.

B

C. DNP mapping

C.1: Overview

This appendix describes the functionality of the RGM40 meter's version of the DNP protocol. A DNP programmer needs this information to retrieve data from the RGM40 meter using this protocol.

The RGM40 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 RGM40 meter. The RGM40 meter's DNP version supports Class 0 object/qualifiers 0, 1, 2 and 6 only. No event generation is supported. The RGM40 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 30 in the CommunicatorPQA® and MeterManagerPQA® software user manual for instructions).

C.2: Physical layer

DNP uses the meter's RS485 serial communication, which is Port 2. Serial speed and data format are transparent for DNP: they can be set to any supported value. The USB port cannot use DNP. DNP packets should be directed to the port assigned for DNP during the meter's device profile configuration (see chapter 30 in the CommunicatorPQA® and MeterManagerPQA® software user manual for instructions). The DNP implementation is identical, regardless of the physical layer being used.

C.3: Data link layer

The RGM40 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 four functions are implemented: reset link, reset user, unconfirmed user data, and link status, as depicted in the following table.

—

Table C.1: Supported link functions

Function	Function code
Reset link	0
Reset user	1
Unconfirmed user data	4
Link status	9

Refer to Section C.7 for more detail on supported frames for the data link layer.

To establish clean communication with the RGM40 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 an FT3 frame, the frame will be dropped.

C.4: Application layer

The RGM40 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 136).

- 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, can 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 Section C.6). 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 132 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. C.7: DNP object point map on page 132, 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 C.7: DNP object point map on page 132.
- 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 msec on and 1 msec 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. C.7: DNP object point map on page 132 shows the constructed frame to perform DNP to Modbus RTU protocol change.

C.5: Error reply

In the case of an unsupported function, or any other recognizable error, an error reply is generated from the RGM40 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 — Not used for the RGM40 meter.
- Object 10 — Binary output states — points 0–2 reference internal controls.
- Object 12 — Control relay outputs — points 0–2 reference internal controls.
- Object 20 — Binary counters (primary readings) — points 0–4 are mapped to primary energy readings.
- 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.

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- 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 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 — This object is not used by the RGM40 meter.

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	

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

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 energy format. n = 0, 3 or 6 per energy format scale and d = number of decimal places	Whr	Example: energy format = 7.2K and Whours counter = 1234567 n=3 (K scale), d=2 (2 digits after decimal point), multiplier = 10(3-2) = 101 = 10, so energy is 1234567 * 10 Whrs, or 12345.67 KWhrs
20	1	5	1 W-hours, negative	UINT32	0 to 99999999		Whr	
20	2	5	1 W-hours, negative	UINT32	0 to 99999999		VARhr	
20	3	5	1 W-hours, negative	UINT32	0 to 99999999		VARhr	
20	3	5	1 W-hours, negative	UINT32	0 to 99999999		VARhr	

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 135 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 150 V 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 300 V 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 10 A 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	

C

Object	Point	Var	Description	Format	Range	Multiplier	Units	Comments
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	(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 * multiplier) / denominator 333 mV option is equal to 5 A
30	27	4	CT multiplier	SINT16	1, 10 or 100	N/A	None	
30	28	4	CT denominator	SINT16	1 or 5	N/A	None	
30	29	4	PT numerator	SINT16	1 to 9999	N/A	None	PT ratio = (numerator * multiplier) / denominator
30	30	4	PT multiplier	SINT16	1, 10 or 100	N/A	None	
30	31	4	PT denominator	SINT16	1 to 9999	N/A	None	
30	32	4	Neutral current	SINT16	0 to 32767	(10 / 32768)	A	For 1 A model, multiplier is (2 / 32768) and values above 2 A secondary read 32767
30	33	4	Power factor, 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	

C

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/divisor
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	
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 * multiplier) / denominator
30	27	4	CT multiplier	SINT16	1, 10 or 100	N/A	None	
30	28	4	CT denominator	SINT16	1 or 5	N/A	None	
30	29	4	PT numerator	SINT16	1 to 9999	N/A	None	PT ratio = (numerator * multiplier) / denominator

Object	Point	Var	Description	Format	Range	Multiplier	Units	Comments
30	30	4	PT multiplier	SINT16	1, 10 or 100	N/A	None	
30	31	4	PT denominator	SINT16	1 to 9999	N/A	None	
30	32	4	Neutral current	SINT16	0 to 32767	(10 / 32768)	A	Point value = actual amps/divisor
30	33	4	Power factor, 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 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 (alternate)	05	64	14	C4	dst		src		crc							
	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																	

C

Reset demand (maximums and 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 RGM40 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 seven blocks plus the link header.

Restart
All stations
These two bits are reported in accordance with standard practice.

D. Three-phase power measurement

14 Figure D.1: Three-phase wye winding

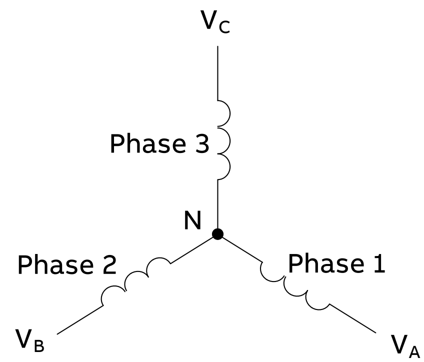
15 Figure D.2: Phasor diagram showing three-phase voltages and currents

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.

D.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.

D.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 D.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).



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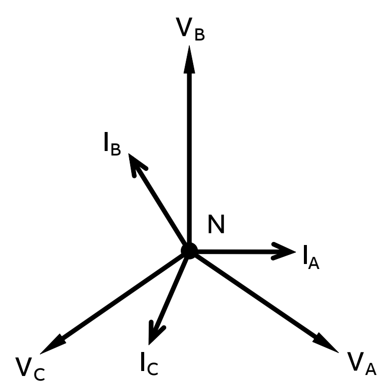
The three voltages are separated by 120° electrically. Under balanced load conditions, the currents are also separated by 120°. However, unbalanced loads and other conditions can cause the currents to depart from the ideal 120° separation. Three-phase voltages and currents are usually represented with a phasor diagram. A phasor diagram for the typical connected voltages and currents is shown in Figure D.2.



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D

The phasor diagram shows the 120° angular separation between the phase voltages. The phase-to-phase voltage in a balanced three-phase wye system is 1.732 times the phase-to-neutral voltage. The center point of the wye is tied together and is typically grounded. Table D.1 shows the common voltages used in the United States for wye-connected systems.

Table D.1: Common phase voltages on wye services

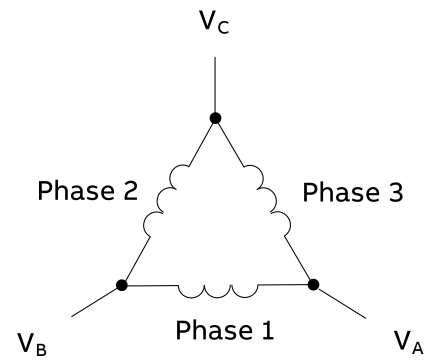
Phase-to-ground voltage	Phase-to-phase voltage
120 volts	208 volts
277 volts	480 volts
2,400 volts	4,160 volts
7,200 volts	12,470 volts
7,620 volts	13,200 volts

Usually a wye-connected service will have four wires: three wires for the phases and one for the neutral. The three phase wires connect to the three phases (as shown in Figure D.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 D.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.

D.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 D.3 shows the physical load connections for a delta service.



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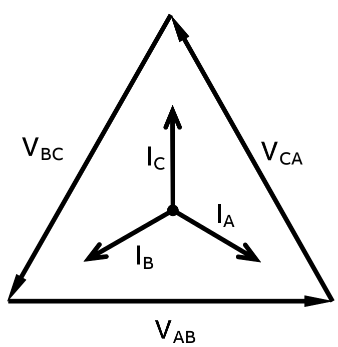
16 Figure D.3: Three-phase delta winding relationship

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 D.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.



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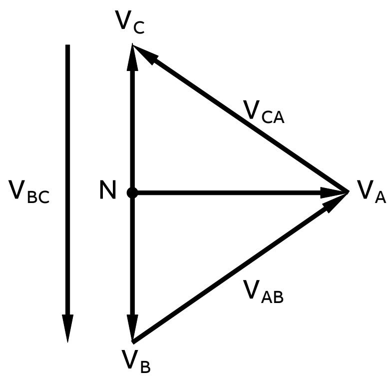
17 Figure D.4: Phasor diagram, three-phase voltages and currents, delta-connected

18 Figure D.5: Phasor diagram showing three-phase four-wire delta-connected system

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



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

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

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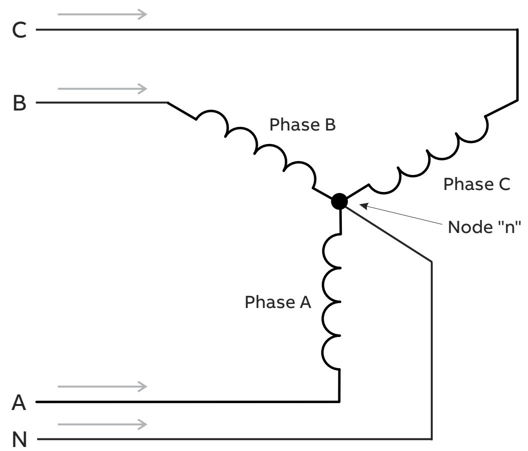
19 Figure D.6: Three-phase wye load illustrating Kirchhoff's Law and Blondel's Theorem



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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 D.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 D.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.

D.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.

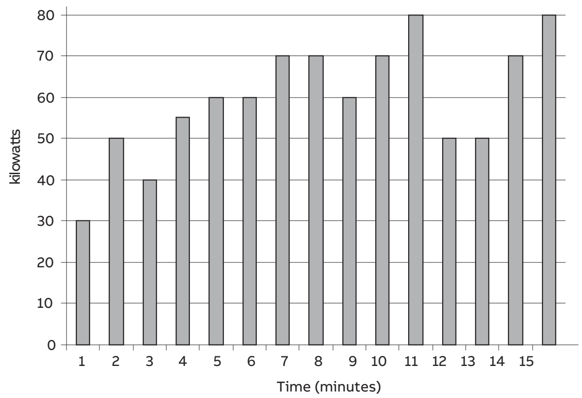
Power is an instantaneous reading. The power reading provided by a meter is the present flow of watts. Power is measured immediately just like current. In many digital meters, the power value is actually measured and calculated over a one-second interval because it takes some amount of time to calculate 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 kilowatthour 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 one-quarter of that total or one kWh.

Figure D.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 D.7 is reproduced in Table D.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).



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20 Figure D.7: Power use over time

Table D.2: Power and energy relationship over time

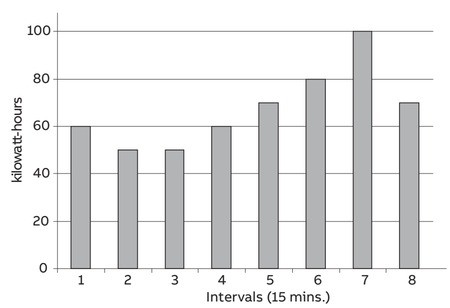
Time interval (minutes)	Power (kW)	Energy (kWh)	Accumulated energy (kWh)
1	30	0.50	0.50
2	50	0.83	1.33
3	40	0.67	2.00
4	55	0.92	2.92
5	60	1.00	3.92
6	60	1.00	4.92
7	70	1.17	6.09
8	70	1.17	7.26
9	60	1.00	8.26
10	70	1.17	9.43
11	80	1.33	10.76
12	50	0.83	12.42
13	50	0.83	12.42
14	70	1.17	13.59
15	80	1.33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

As in Table D.2, the accumulated energy for the power load profile of Figure D.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 D.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 D.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.



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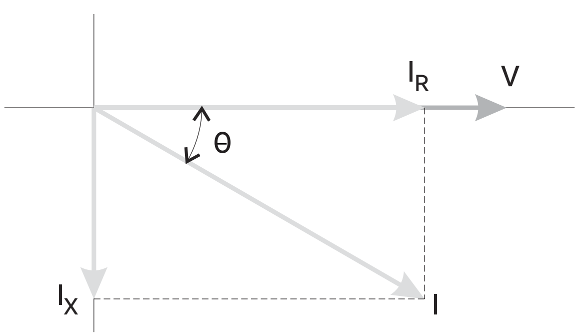
21 Figure D.8: Energy use and demand

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.

D.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 measure only real power and energy. Reactive power is a critical component of the total power picture because almost all real-life applications have an impact on reactive power. Reactive power and power factor concepts relate to both load and generation applications. However, this discussion will be limited to analysis of reactive power and power factor as they relate to loads. To simplify the discussion, generation will not be considered.

Real power (and energy) is the component of power that is the combination of the voltage and the value of corresponding current that is directly in phase with the voltage. However, in actual practice, the total current is almost never in phase with the voltage. Since the current is not in phase with the voltage, it is necessary to consider both the in-phase component and the component that is at quadrature (angularly rotated 90° or perpendicular) to the voltage. Figure D.9 shows a single-phase voltage and current and breaks the current into its in-phase and quadrature components.



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— 22 Figure D.9: Voltage and complex current

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

The quadrature current may be lagging the voltage (as shown in Figure D.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

23 Figure D.10: Nondistorted current waveform

24 Figure D.11: Distorted Current Waveform

25 Figure D.12: Waveforms of the harmonics

differences. As a result, it does not include the impact of harmonic distortion. Displacement power factor is calculated using the following equation:

Displacement PF = cosΘ

where Θ is the angle between the voltage and the current (see Figure D.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.

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

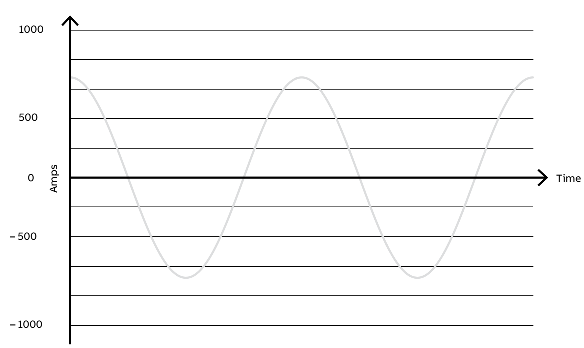

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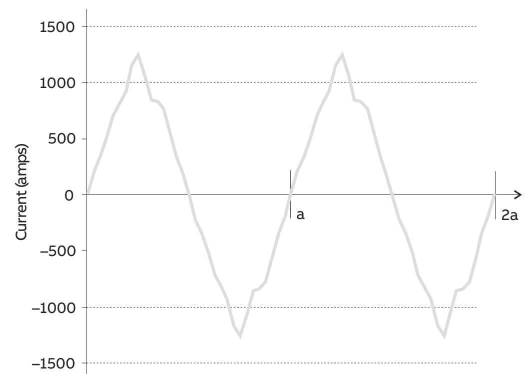
Figure D.11 shows a current waveform with a slight amount of harmonic distortion. The waveform is still periodic and is fluctuating at the normal 60 Hz frequency. However, the waveform is not a smooth sinusoidal form as seen in Figure D.10.



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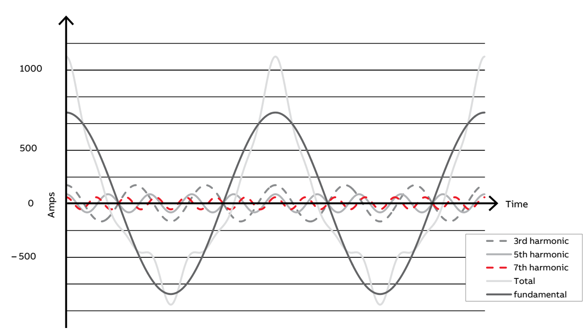
The distortion observed in Figure D.11 can be modeled as the sum of several sinusoidal waveforms of frequencies that are multiples of the fundamental 60 Hz frequency. This modeling is performed by mathematically disassembling the distorted waveform into a collection of higher frequency waveforms.

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



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

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

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

XL = jωL and

XC = 1/jωC

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

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

Since much voltage monitoring and almost all current monitoring is performed using instrument transformers, the higher order harmonics are often not visible. Instrument transformers are designed to pass 60 Hz quantities with high accuracy. These devices, when designed for accuracy at low frequency, do not pass high frequencies with high accuracy; at frequencies above about 1200 Hz, they pass almost no information. So when instrument transformers are used, they effectively filter out higher frequency harmonic distortion, making it impossible to see.

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

It is common in advanced meters to perform a function often 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 i s 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.

D.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 D.3.

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Table D.3: Typical power quality problems and sources

Cause	Disturbance type	Source
Impulse transient	Transient voltage disturbance, sub-cycle duration	Lightning, electrostatic discharge, load switching, capacitor switching
Oscillatory transient with decay	Transient voltage, sub-cycle duration	Line/cable switching, capacitor switching, load switching
Sag/swell	RMS voltage, multiple cycle duration	Remote system faults
Interruptions	RMS voltage, multiple seconds or longer duration	System protection, circuit breakers, fuses, maintenance
Under voltage/ over voltage	RMS voltage, steady state, multiple seconds or longer duration	Motor starting, load variations, load dropping
Voltage flicker	RMS voltage, steady state, repetitive condition	Intermittent loads, motor starting, arc furnaces
Harmonic distortion	Steady-state current or voltage, long-term duration	Non-linear loads, system resonance

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

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

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