

# **SEL-735**

## **Power Quality and Revenue Meter**

### **Instruction Manual**

20141107

 **SCHWEITZER ENGINEERING LABORATORIES, INC.**



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**⚠CAUTION**

Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

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**⚠CAUTION**

There is danger of explosion if the battery is incorrectly replaced. Replace only with Ray-O-Vac® no. BR2335 or equivalent recommended by manufacturer. Dispose of used batteries according to the manufacturer's instructions.

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**⚠CAUTION**

Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.

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**⚠CAUTION**

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

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**⚠DANGER**

Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

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**⚠DANGER**

Contact with instrument terminals can cause electrical shock that can result in injury or death.

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**⚠WARNING**

Have only qualified personnel service this equipment. If you are not qualified to service this equipment, you can injure yourself or others, or cause equipment damage.

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**⚠WARNING**

Use of this equipment in a manner other than specified in this manual can impair operator safety safeguards provided by this equipment.

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**⚠WARNING**

This device is shipped with default passwords. Default passwords should be changed to private passwords at installation. Failure to change each default password to a private password may allow unauthorized access. SEL shall not be responsible for any damage resulting from unauthorized access.

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**⚠ATTENTION**

Les composants de cet équipement sont sensibles aux décharges électrostatiques (DES). Des dommages permanents non-décelables peuvent résulter de l'absence de précautions contre les DES. Raccordez-vous correctement à la terre, ainsi que la surface de travail et l'appareil avant d'en retirer un panneau. Si vous n'êtes pas équipés pour travailler avec ce type de composants, contacter SEL afin de retourner l'appareil pour un service en usine.

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**⚠ATTENTION**

Il y a un danger d'explosion si la pile électrique n'est pas correctement remplacée. Utiliser exclusivement Ray-O-Vac® No. BR2335 ou un équivalent recommandé par le fabricant. Se débarrasser des piles usagées suivant les instructions du fabricant.

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**⚠ATTENTION**

L'utilisation de commandes ou de réglages, ou l'application de tests de fonctionnement différents de ceux décrits ci-après peuvent entraîner l'exposition à des radiations dangereuses.

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**⚠ATTENTION**

Les changements ou modifications qui ne sont pas expressément approuvés par l'autorité responsable de se prononcer sur la conformité pourraient annuler le pouvoir de l'utilisateur à actionner l'équipement.

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**⚠DANGER**

Débrancher tous les raccordements externes avant d'ouvrir cet appareil. Tout contact avec des tensions ou courants internes à l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.

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**⚠DANGER**

Tout contact avec les bornes de l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.

---

**⚠AVERTISSEMENT**

Seules des personnes qualifiées peuvent travailler sur cet appareil. Si vous n'êtes pas qualifiés pour ce travail, vous pourriez vous blesser avec d'autres personnes ou endommager l'équipement.

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**⚠AVERTISSEMENT**

L'utilisation de cet appareil suivant des procédures différentes de celles indiquées dans ce manuel peut désarmer les dispositifs de protection d'opérateur normalement actifs sur cet équipement.

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**⚠AVERTISSEMENT**

Cet appareil est expédié avec des mots de passe par défaut. À l'installation, les mots de passe par défaut devront être changés pour des mots de passe confidentiels. Dans le cas contraire, un accès non-autorisé à l'équipement peut être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accès non-autorisé.

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This product is covered by the standard SEL 10-year warranty. For warranty details, visit [www.selinc.com](http://www.selinc.com) or contact your customer service representative.

PM735-01

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**Glossary****SEL-735 Meter Command Summary**

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# Preface

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## Manual Overview

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The SEL-735 Power Quality and Revenue Meter provides high-accuracy revenue metering and power quality metering for electric utilities and industrial applications. The SEL-735 has flexible, user-programmable SELOGIC<sup>®</sup> control equations that include mathematical functions. The metering and control functions are ideal for complete automation applications.

The *SEL-735 Power Quality and Revenue Meter Instruction Manual* describes common aspects of power quality and revenue meter applications. It includes the necessary information to install, set, test, and operate the meter and more detailed information about settings and commands.

An overview of each manual section and topics follows.

**Preface.** This section describes the manual organization and the conventions used to present information.

**Section 1: Introduction and Specifications.** This section describes the basic features and functions of the SEL-735 Meter; lists the meter specifications.

**Section 2: Installation.** This section describes how to mount and wire the SEL-735 Meter, including connections for several applications; includes the SEL-735 front- and rear-panel diagrams.

**Section 3: Front-Panel Operation.** This section describes security access levels, menu and control pushbutton operations, LCD display points functionality, and normal front- panel indications.

**Section 4: ACSELERATOR QuickSet.** This section describes how to use the ACSELERATOR QuickSet<sup>®</sup> SEL-5030 Software with the SEL-735.

**Section 5: Metering.** This section describes the operation of instantaneous metering, demand metering, energy metering, crest factor metering, minimum/maximum metering, transformer/line loss compensation, and harmonic metering.

**Section 6: Logging.** This section describes how to log and retrieve data via the load profile recorders, waveform capture event reports, Sequential Events Recorders, and voltage sag swell and interruption reports.

**Section 7: Inputs/Outputs and SELOGIC Control Equations.** This section describes the operation of optoisolated inputs **IN101–IN102** and **IN401–IN404**; remote control switches (remote bit outputs **RB01–RB16**); latch control switches (latch bit outputs **LT01–LT16**); programmable timers (timer outputs **SV01T–SV16T**); math variables (math variable outputs **MV01–MV16**); output contacts **OUT101–OUT103** and **OUT401–OUT404**; and rotating displays.

**Section 8: Communications.** This section explains port options and configurations, internal modem use, communications cables, basic protocol descriptions, and summarizes ASCII commands.

**Section 9: Testing and Troubleshooting.** This section describes how to perform a meter calibration check through each available interface, test wiring, basic testing philosophies, gain adjustments, error codes, and common troubleshooting techniques.

Appendix A: Firmware and Manual Versions. This appendix lists the present meter firmware version and details differences among the present and previous versions. Provides a record of changes made to the instruction manual since the initial release.

Appendix B: SEL-735 Upgrade Instructions. This appendix describes how to perform a firmware upgrade to the meter.

Appendix C: SEL Communications Processors. This appendix describes how SEL communications processors and PC software use SEL protocols optimized for performance and reliability.

Appendix D: Distributed Network Protocol. This appendix describes DNP and includes the DNP Port Settings Sheets.

Appendix E: Modbus Communications Protocol. This appendix describes Modbus® RTU communications features supported by the SEL-735 Meter communications port.

Appendix F: MIRRORING BITS Communications. This appendix contains a summary of MIRRORING BITS® settings and describes how MIRRORING BITS function with the SEL-735.

Appendix G: Analog Quantities and Device Word Bits. This appendix contains a summary of analog quantities available for use in load profile, displaying points, etc. and how to set the control elements (Device Word bits) in the SELOGIC control equations.

SEL-735 Meter Command Summary. This section summarizes all ASCII commands.

## Conventions

### Typographic Conventions

There are three ways to communicate with the SEL-735.

- Using ACSELERATOR QuickSet Software.
- Using a command line interface on a PC terminal emulation window.
- Using the front-panel menus and pushbuttons.

The instructions in this manual indicate these options with specific font and formatting attributes. The following table lists these conventions.

Example	Description
<b>STATUS</b>	Commands typed at a command line interface on a PC.
<b>&lt;Enter&gt;</b>	Single keystroke on a PC keyboard.
<b>&lt;Ctrl+D&gt;</b>	Multiple/combinaton keystroke on a PC keyboard.
<b>Start &gt; Settings</b>	PC dialog boxes and menu selections. The > character indicates submenus.
<b>RESET</b>	Meter front-panel pushbuttons.
<b>ENABLE</b>	Meter front- or rear-panel labels.
<b>MAIN &gt; METER</b>	Meter front-panel LCD menus and meter responses. The > character indicates submenus.

## Examples

This instruction manual uses several example illustrations and instructions to explain how to effectively operate the SEL-735. These examples are for demonstration purposes only; the firmware identification information or settings values included in these examples may not necessarily match those in the current version of your SEL-735.

# Safety and General Information

## Safety Information

This manual uses three kinds of hazard statements, formatted as follows.

### **CAUTION**

Indicates a potentially hazardous situation that, if not avoided, **may** result in minor or moderate injury or equipment damage.

### **WARNING**

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

### **DANGER**







Indicates an imminently hazardous situation that, if not avoided, **will** result in death or serious injury.

## Hazardous Locations Approval

In North America, the meter is approved for Class 1 Division 2, Groups A, B, C, D, and T4 in the –40 to 70 degree Celsius range.

## Symbols

The following symbols from EN 61010-1 are often marked on SEL products.

Symbol 14		Consult Documentation for Additional Information
Symbol 6		Protective (Safety) Ground Conductor Terminal
Symbol 1		Direct Current
Symbol 2		Alternating Current
Symbol 3		Direct and Alternating Current
Symbol 5		Earth (Ground) Terminal

### **FCC CLASS A CAUTION**

Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

## Instructions for Cleaning and Decontamination

Use care when cleaning the SEL-735. Use a mild soap or detergent solution and a damp cloth to clean the chassis. Do not use abrasive materials, polish compounds, or harsh chemical solvents (such as xylene or acetone) on any surface.

## Technical Assistance

Obtain technical assistance from the following address.

Schweitzer Engineering Laboratories, Inc.  
 2350 NE Hopkins Court  
 Pullman, WA 99163-5603 U.S.A.  
 Tel: +1.509.332.1890  
 Fax: +1.509.332.7990  
 Internet: [www.selinc.com](http://www.selinc.com)  
 E-mail: [info@selinc.com](mailto:info@selinc.com)

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# Section 1

## Introduction and Specifications

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### Overview

---

This section includes the following overviews of the SEL-735 Power Quality and Revenue Meter.

- *SEL-735 Meter Forms and Models*
- *Applications on page 1.3*
- *Hardware Connection Features on page 1.4*
- *Communications Connections on page 1.5*
- *Specifications on page 1.6*

### SEL-735 Meter Forms and Models

---

This instruction manual covers the following SEL-735 meter forms and models.

**Table 1.1 SEL-735 Form Numbers**

Meter Form	Type
Form 5	3 wire delta
Form 36	4 wire wye
Form 9	4 wire wye

You may order the SEL-735 as a Form 5, Form 36, or Form 9 meter, but you may change the form using the **FORM** command from a terminal session at the 2AC level. The line-to-neutral voltage range of each model is 28 V to 277 V. Model numbers are derived from the SEL-735 Model Option Table (MOT). For the available options, associated option codes, or to order an SEL-735, refer to the MOT for this product at the SEL website.

The SEL-735 offers a standard current measurement range from 1 mA to 22 A. You therefore do not have to specify a CL 2, CL 10, or CL 20 meter thanks to the wide dynamic measurement range. This model's Slot Z Current and Voltage Inputs option is titled Current Class CL2/10/20, Optimized for Low-End Accuracy.

The SEL-735 also offers a fault recording measurement range from 5 mA to 100 A. The meter can measure fault currents of 22–100 A for 25 seconds and normal currents of 0.005–22 A continuously. This model's Slot Z Current and Voltage Inputs option is titled Current Class CL10/20, Optimized for 100 A Fault Recording.

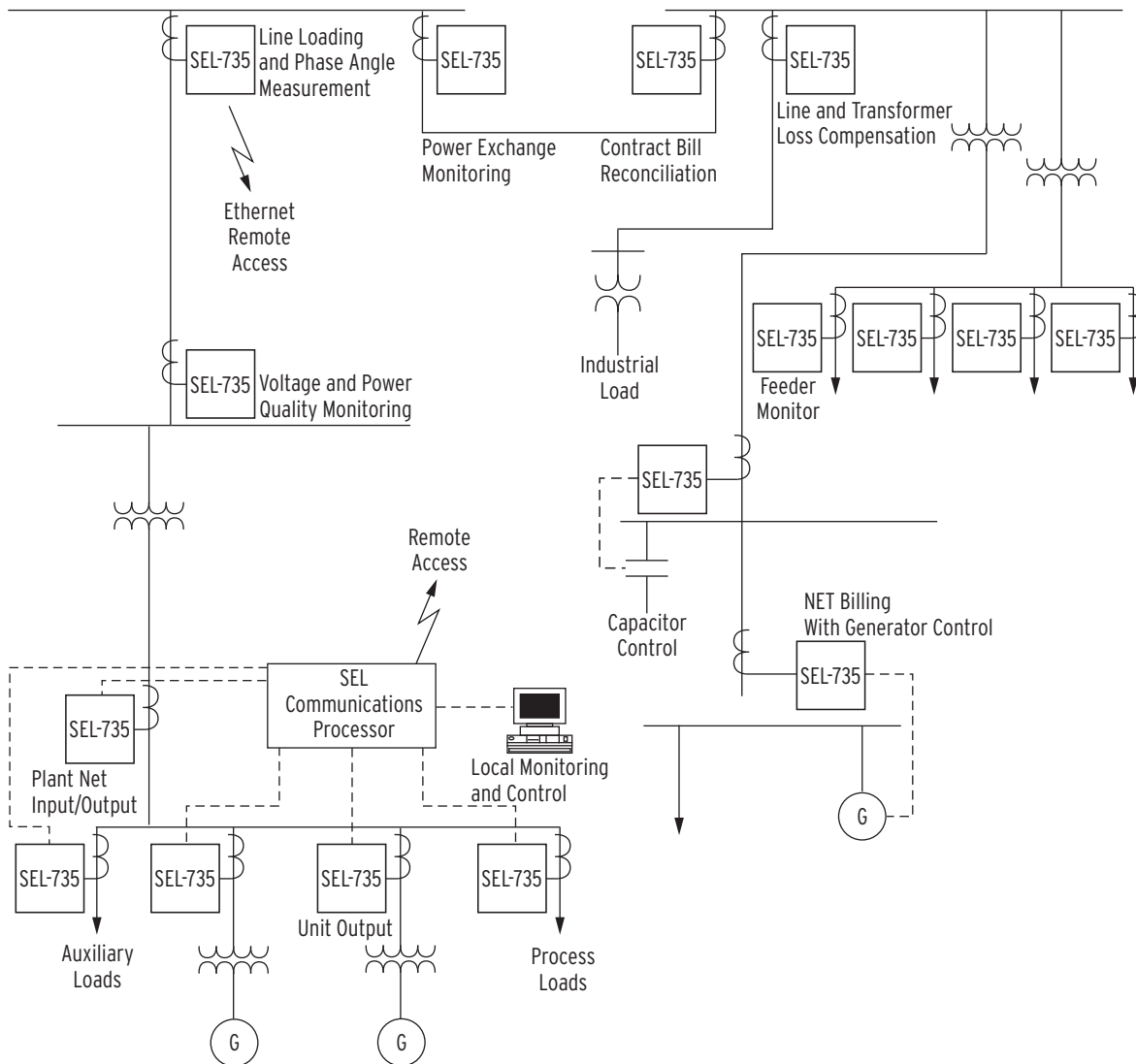
The SEL-735 is available with three different power quality and recording options. *Table 1.2* shows these features and their IEC 61000-4-30 class.

**Table 1.2 SEL-735 Feature Availability**

IEC 61000-4-30 Power Quality	SEL-735 Basic PQ	SEL-735 Intermediate PQ	SEL-735 Advanced PQ
<b>Measurement Aggregation</b>			
10/12 Cycle Intervals	A	A	A
150/180 cycles, 10 min., 120 min. Intervals	–	A	A
Voltage and Current	A	A	A
Voltage and Current Unbalance	A	A	A
Individual Voltage and Current Harmonics	S	S	S
Voltage and Current THD	A	A	A
Real, Reactive, and Apparent Power	A	A	A
<b>Power Quality Parameters</b>			
Real-Time Clock	S	S	S
Frequency	A	A	A
Flicker	–	S	S
Voltage Dips, Swells, and Interruptions	A	A	A
Voltage and Current Interharmonics	–	–	S
Harmonic Power	–	–	S
Harmonic Phase Angles	–	–	S
Transient Detection	–	–	(future)
<b>Maximum Harmonic Order</b>	15th	63rd	63rd
<b>Waveform Capture</b>			
Samples per cycle	16	16 and 128	16, 128, and 512
Duration (cycles)	15	15, 30, 60, 120, 300, 600	15, 30, 60, 120, 300, 600
Number of Events	64	16–3155	4–3155
COMTRADE Reports	Y	Y	Y

A = IEC 6100-4-30 Class A compliant.  
S = IEC 61000-4-30 Class S compliant.

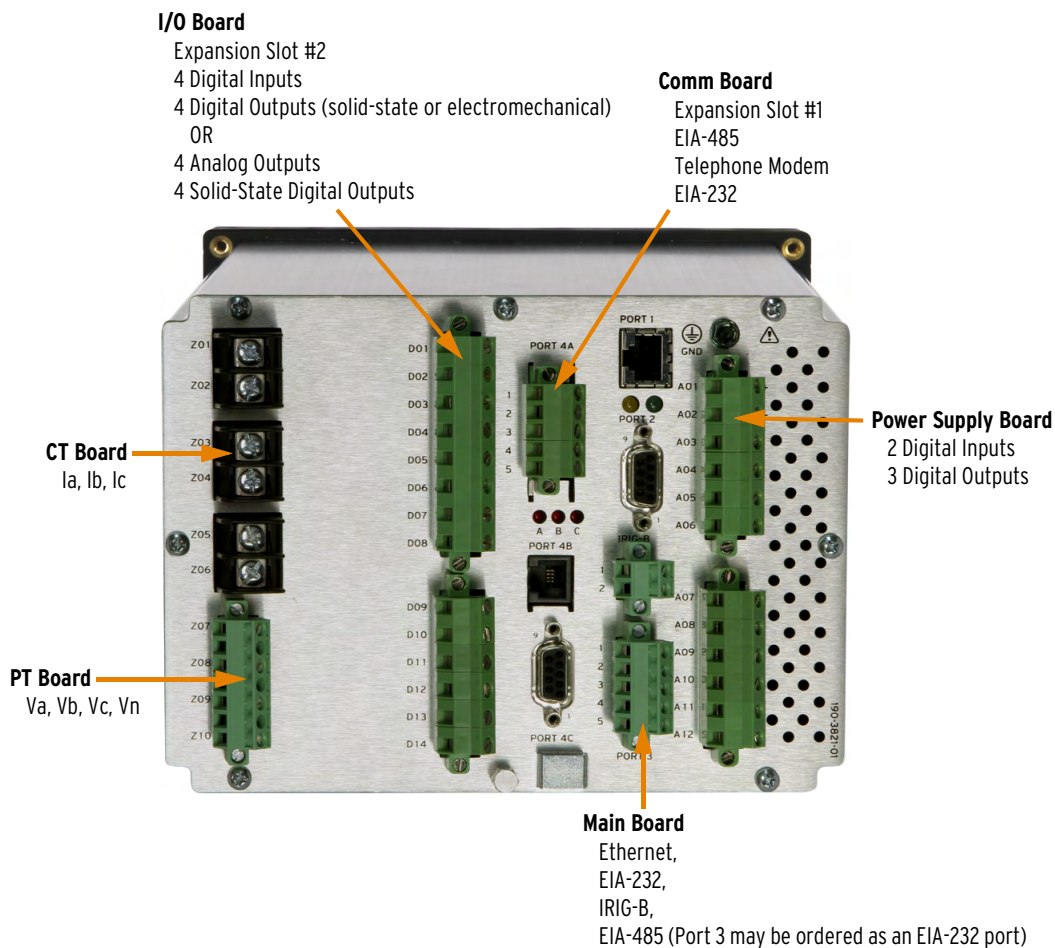
# Applications



**Figure 1.1 SEL-735 Applied at Billing Points Throughout the Power System**

# Hardware Connection Features

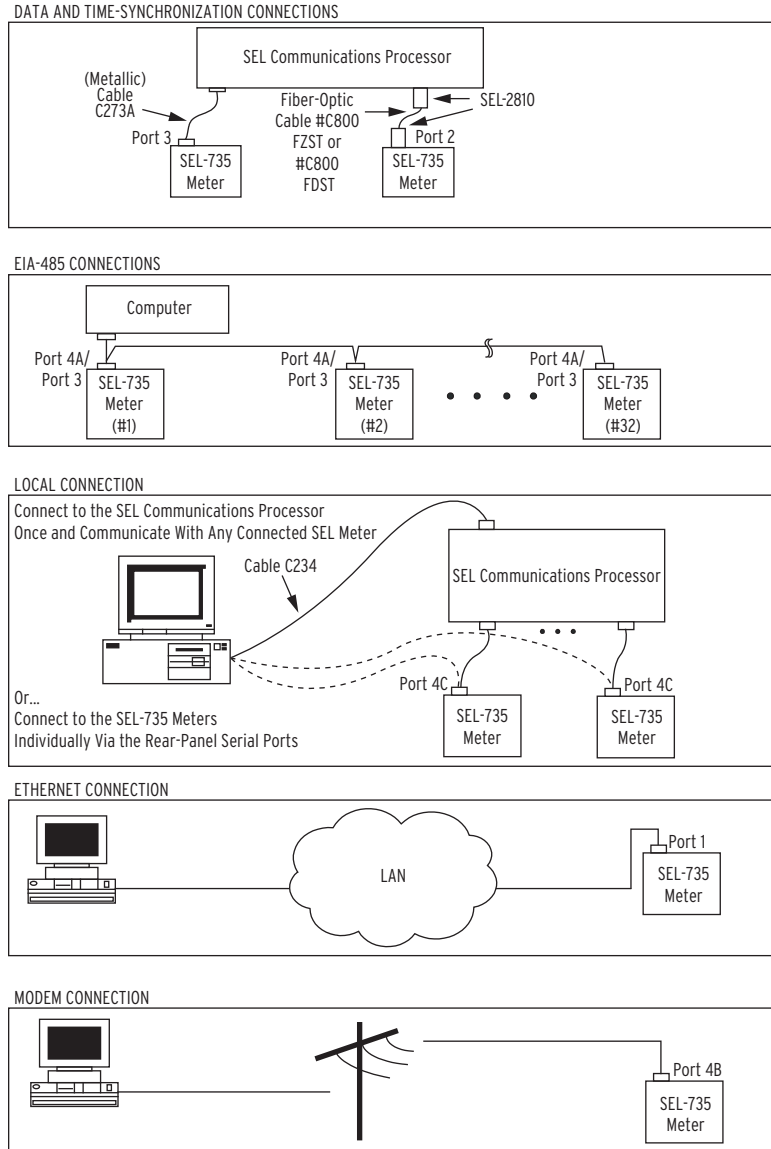
See *Specifications* on page 1.6 and *Section 2: Installation* for more information on hardware and connections.



**Figure 1.2 SEL-735 Inputs, Outputs, and Communications Ports**

# Communications Connections

See *Port Connector and Communications Cables* on page 8.5 for more communications connection information.



**Figure 1.3 SEL-735 Communications Connection Examples**

# Specifications

## General

### AC Voltage Inputs

Maximum Rating:	300 V <sub>L-N</sub> , 520 V <sub>L-L</sub> continuous 600 V <sub>L-N</sub> , 1039 V <sub>L-L</sub> for 10 seconds
Range:	
Revenue:	28–300V <sub>L-N</sub> , 57–520 V <sub>L-L</sub>
Measurement:	5–300 V <sub>L-N</sub> , 9–520 V <sub>L-L</sub>
Burden:	10 MΩ

### AC Current Inputs

Maximum Rating:	22 A continuous 500 A for 1 second
Range:	
Current Class CL2/CL10/CL20, optimized for low-end accuracy:	
Revenue:	0.010–22 A
Measurement:	0.001–22 A continuous
Current Class CL10/CL20, optimized for 100 A fault recording:	
Revenue:	0.050–22 A
Measurement:	0.005–22 A continuous 22–100 A symmetrical for 25 seconds
Burden:	≤0.5 VA
Measurement Category:	II

### Frequency and Rotation

60 or 50 Hz system frequency specified at time of order. User selectable ABC/ACB phase rotation.  
Frequency tracking range: 40 to 70 Hz based on V<sub>A</sub> or V<sub>C</sub>.

### Power Supply

Continuous Operating Limits	
125/250 Volt Supply:	85–264 Vac (50/60 Hz) 85–275 Vdc
24/48 Volt Supply:	19–58 Vdc
12/24 Volt Supply:	9.6–30 Vdc
VA Rating:	<40 VA/15 W maximum <20 VA/7 W typical
Interruption (IEC 60255-11:1979)	50 ms at 125 Vac/Vdc 50 ms at 48 Vdc 10 ms at 24 Vdc 2 ms at 12 Vdc
Ripple (IEC 60255-11:1979)	12% for dc inputs
Terminal Voltage Dropout:	<40 V within 1 minute of power removal
Rated Insulation Voltage (IEC 60664-1:2002):	300 Vac
Dielectric Test Voltage:	3.1 kVdc

### 100BASE-FX Fast Ethernet Fiber-Optic Port

Fiber Type:	Multimode
Data Rate:	100 Mbps
Wavelength:	1300 nm
Optical Connector Type:	LC
Link Budget:	11.8 dB
Min. TX Power:	–20 dBm

Min. RX Sensitivity:	–31.8 dBm
Fiber Size:	62.5/125 μm or 50/125 μm
Approximate Range:	2 km

### 100BASE-LX10 Fast Ethernet Fiber-Optic Port

Fiber Type:	Single-mode
Data Rate:	100 Mbps
Wavelength:	1310 nm
Optical Connector Type:	LC
Link Budget:	10 dB
Min. TX Power::	–15 dBm
Min. RX Sensitivity:	–25 dBm
Fiber Size:	9/125 μm or 8/125 μm
Approximate Range:	10 km

### Communications Protocols

SEL ASCII/Compressed ASCII, SEL Fast Operate/Fast Meter, MIRRORRED BITS, SEL Distributed Port Switch (LMD), Modbus RTU/TCP, DNP3 serial and LAN/WAN, FTP, TCP/IP, SNTP, IEC 61850, Telnet, MV-90, and C37.118 (future)

### Output Contacts

Ratings determined by IEC 60255-23:1994.

#### Standard (Electromechanical)

Make:	30 A per IEEE C37.90-1989 3.6 kVA, Cos φ = 0.3
Break Rating:	360 VA, Cos φ = 0.3
Breaking Capacity (10000 operations):	
12/24 Vdc	0.75 A L/R = 40 ms
48 Vdc	0.50 A L/R = 40 ms
125 Vdc	0.30 A L/R = 40 ms
250 Vdc	0.20 A L/R = 40 ms

Carry:	3 A at 120 Vac, 50/60 Hz 1.5 A at 240 Vac, 50/60 Hz 50 A for 1 second
--------	-----------------------------------------------------------------------------

Durability: >10,000 cycles at rated conditions

Pickup/Dropout Time: <16 ms

Maximum Operating Voltage (U<sub>e</sub>): 250 V

Rated Insulation Voltage (U<sub>i</sub>) (excluding EN 61010): 300 V

#### Optional (Solid State)

Voltage: 250 Vdc or Peak ac maximum

Current: 100 mA maximum

Capacity: 0.6 VA at 25°C, 0.2 VA at 85°C

Pulse Rate: 20 pulses per second

Maximum On Resistance: Typical: 50 Ω  
Guaranteed: <100 Ω

Minimum Off Resistance: 10 MΩ

Pickup/Dropout Time: <25 ms

**Analog Outputs**

$\pm 1$ mA Output	
Maximum Firmware Update Rate:	100 ms
Maximum Settling Time For Full Range Change to 0.1% Full-Scale:	500 ms
Bandwidth:	0 to 4 Hz
Range:	$\pm 1.2$ mA
Minimum Output Impedance:	100 M $\Omega$
Maximum Load:	10 k $\Omega$ , 100 $\mu$ H
Accuracy:	$\pm 0.15\%$ $\pm 2.0$ $\mu$ A at 25°C
4-20 mA Output	
Range:	$\pm 24$ mA
Minimum Output Impedance:	100 M $\Omega$
Maximum Load:	500 $\Omega$ , 100 $\mu$ H
Accuracy:	$\pm 0.20\%$ $\pm 10$ $\mu$ A at 25°C

**Optoisolated Input Ratings**

## DC Control Signal

250 Vdc:	Pickup 200–275 Vdc Dropout 150 Vdc
220 Vdc:	Pickup 176–242 Vdc Dropout 132 Vdc
125 Vdc:	Pickup 100–137.5 Vdc Dropout 75 Vdc
110 Vdc:	Pickup 88–121 Vdc Dropout 66 Vdc
48 Vdc:	Pickup 38.4–52.8 Vdc Dropout 28.8 Vdc
24 Vdc:	Pickup 15–30 Vdc Dropout <5 Vdc
12 Vdc:	Pickup 9.6–13.2 Vdc Dropout <6 Vdc

## AC Control Signal

250 Vac:	Pickup 170.6–300 Vac Dropout 106 Vac
220 Vac:	Pickup 150.3–264 Vac Dropout 93.2 Vac
125 Vac:	Pickup 85–150 Vac Dropout 53 Vac
110 Vac:	Pickup 75.1–132 Vac Dropout 46.6 Vac
48 Vac:	Pickup 32.8–57.6 Vac Dropout 20.3 Vac
24 Vac:	Pickup 14–27 Vac Dropout <5 Vac

Current Draw at Nominal DC Voltage: 2–6 mA

**Time-Code Input**

Meter accepts demodulated IRIG-B time-code input at EIA-232 Port 3, Port 2, or 2-pin Phoenix connector. Meter time is synchronized to within  $\pm 10$   $\mu$ s of time-source input.

Nominal Voltage:	5 Vdc
Maximum Voltage:	8 Vdc

**Operating Temperature**

IEC 60068-2-2:1993:  $-40^{\circ}$  to  $+85^{\circ}$ C ( $-40^{\circ}$  to  $+185^{\circ}$ F)

**Note:** Not applicable to UL applications.

LCD:  $-20^{\circ}$  to  $+70^{\circ}$ C ( $-4^{\circ}$  to  $+158^{\circ}$ F)

**Operating Environment**

Pollution Degree:	2
Overvoltage Category:	II
Indoor Use	
Maximum Altitude:	2000 M
Maximum Humidity:	95% RH

**Weight**

2.3 kg (5.0 lbs)

**Dimensions**

Refer to *Figure 2.1* and *Figure 2.2* for meter dimensions.

**Routine Dielectric Test**

Current Inputs:	2.75 kVac for 1 s
Voltage Inputs:	2.2 kVac for 1 s
Inputs and Outputs:	2.2 kVac for 1 s
Power Supply:	3.11 kVdc for 1 s
EIA-485 Port:	1.5 kVdc for 1 s
IEC 60255-5:2000 Dielectric tests performed on all units with the CE mark:	2200 Vdc for 1 s on EIA-485 communications port 2000 Vac for 1 s on contact inputs, contact outputs, and analog inputs

**Terminal Connections**

## Rear Screw-Terminal Tightening Torque

Current Input Terminal Block (ring terminals are recommended)

Minimum:	0.9 Nm (8 in-lb)
Maximum:	1.4 Nm (12 in-lb)

## Connectorized®

Minimum:	0.5 Nm (4.4 in-lb)
Maximum:	1.0 Nm (8.8 in-lb)

Connectorized terminals accept wire size 12–24 AWG.

User terminals or stranded copper wire should be at a minimum temperature rating of 105°C (221°F).

**Processing Specifications****AC Voltage and Current Inputs**

512 samples per power system cycle.

**Control Processing**

1/2-cycle processing interval

**SELOGIC Pickup and Accuracies**

SELOGIC Timers:	$\pm 1/2$ cycle
Analog Values:	$\pm 3\%$

**Metering/Monitoring****Metering Accuracy (Form 5 and Form 9 only)**

Voltage, Current, Power, and Energy

Unity Power Factor:	$\pm 0.06\%$ $\pm 0.02\%$ typical
0.5 Power Factor:	$\pm 0.16\%$ $\pm 0.06\%$ typical

Frequency:	±0.001 Hz
Power Quality:	IEC 61000-4-30:2008

**Flicker**

P <sub>ST</sub> :	±5% over the range 0.5–25 P <sub>ST</sub> (10-min. interval)
P <sub>LT</sub> :	±5% over the range 0.5–25 P <sub>LT</sub> (2-hour interval)

**Type Tests**

**Electromagnetic Compatibility Immunity**

Surge Withstand Capability:	IEC 60255-22-1:2007, Severity Level: 2.5 kV common mode, 1.0 kV differential mode 1.0 kV peak common mode on communications ports IEEE C37.90.1-2002 Severity Level: 2.5 kV oscillatory, 4 kV fast transient
Electrostatic Discharge Immunity:	IEC 60255-22-2:2008 Severity Level: 4 (both polarities at Levels 1, 2, 3, and 4) IEC 61000-4-2:2008 Severity Level: 4
Radiated Electromagnetic Field Immunity:	IEC 60255-22-3:2007 IEC 61000-4-3:2010, Severity Level: 10 V/m ANSI C12.20-1998, Severity Level: 15 V/m
Electrical Fast Transient Burst Immunity:	IEC 61000-4-4:2011, Severity Level: 4 kV
Surge Immunity:	IEC 62052-11:2003, 4 kV for Current, Voltage, and Power Supply Mains 1 kV for Auxiliary Circuits
Conducted Radio Frequency Immunity:	IEC 61000-4-6:2008, Severity Level: 10 V <sub>rms</sub>
Power Frequency Magnetic Field Immunity:	IEC 61000-4-8:2009, Severity Level: 100 A/m for 60 seconds; 1000 A/m for 3 seconds, Level 5 excludes optional modem
Pulse Magnetic Field Immunity:	IEC 61000-4-9:2001, Severity Level: 1000 A/m, Level 5

**Environmental**

Cold:	IEC 60068-2-1:2007 Test Ad: 16 hours at –40°C IEEE 1613-2009 + A1-2011
Dry Heat:	IEC 60068-2-2:2007, Test Bd: 16 hours at +85°C IEEE 1613-2009 + A1-2011
Damp Heat, Cyclic:	IEC 60068-2-30:2005 Test Db: 5% RH, 25° to 55°C, 6 cycles (12 + 12 hour cycle)
Enclosure Protection:	IEC 60529:2001, IP65, enclosed in panel with available gasket (P/N: 915900097); IP41 without gasket; IP20 for rear panel

**Vibration**

Vibration Resistance:	IEC 60255-21-1:1988 Class 1 Vibration Endurance Class 2 Vibration Response
Shock Resistance:	IEC 60255-21-2:1988 Class 1 Shock Withstand Class 2 Shock Response Class 1 Bump Withstand
Seismic:	IEC 60255-21-3:1993 Class 2 Quake Response

**Safety**

Dielectric Strength/Impulse:	IEC 60255-5:2000 IEEE C37.90:2005 IEEE 1613-2009 + A1-2011 Severity Level: 2500 Vac for 1 minute, 3100 Vdc for 1 minute on power supply Severity Level: 0.5 Joules, 5 kV
High-Voltage Line Surges:	IEEE C62.41-1991 100 kHz Ring Wave for Location Category B3, Peak Voltage of 6 kV and Short-Circuit Peak Current of 3 kA 1.2/50 μs Combination Wave for Location Category B3, Peak Voltage of 6 kV and Short-Circuit Peak Current of 3 kA
Rated Impulse Withstand Voltage (U <sub>imp</sub> ):	IEC 60664-1:2007 4 kV on power supply, ac current inputs, and voltage inputs

**Compliance**

ISO 9001: This product was designed and manufactured under an ISO 9001 certified quality management system.

ANSI C12.20:2010 Accuracy; class 0.2, CL2, and CL10/CL20 (applies to Blondel-compliant Form 5 and Form 9 only)

ANSI C12.1 (Form 36)

IEC 62053-22:2003; class 0.2 S

IEC 62052-11; rack-mounted meters

IEC 62053-23:2003; class 2 S

C22.2 No. 61010-1-04

CAN/CSA C22.2 No. 142

UL 508

ERCOT Compliant (applies to Blondel-compliant Form 5 and Form 9 only)

CAISO Compliant (applies to Blondel-compliant Form 5 and Form 9 only)

CFG G0000-48-2010 Compliant per LAPEM

CE: Mark–EMC Directive, Low Voltage Directive

**Note:** Optional modem not CE compliant.

# Section 2

## Installation

---

### Overview

---

This section provides instructions and guidelines required to correctly install and check the SEL-735 in the field. SEL recommends that you complete the following steps to install the SEL-735 correctly.

- *Mount Meter*
- *Make Rear-Panel Connections on page 2.5*
- *Configure and Check Meter Status on page 2.8*

### Device Placement

#### Physical Location

You can mount the SEL-735 in a sheltered indoor environment, a building, or an enclosed cabinet that does not exceed the temperature and humidity ratings for the device. For voltage and current inputs, the SEL-735 is rated for Measurement Category III (LEA inputs are rated for Measurement Category II), and Pollution Degree 2. This rating allows mounting of the meter indoors or in an outdoor enclosure where the meter is protected against exposure to direct sunlight, precipitation, and full wind pressure, but neither temperature nor humidity are controlled. You can place the meter in extreme temperature and humidity locations. The temperature range over which the meter operates is  $-40^{\circ}$  to  $+80^{\circ}\text{C}$  ( $-40^{\circ}$  to  $+176^{\circ}\text{F}$ ). The meter operates in a humidity range from 5 percent to 95 percent, no condensation. The power supply supports voltage fluctuations to as much as  $\pm 10$  percent of nominal voltage. For IEC 61010 certification, the SEL-735 rating is 2000 meters (6560 feet) above mean sea level.

# Mount Meter

Figure 2.1, Figure 2.2, and Figure 2.3 give the SEL-735 dimensions for the panel-mount applications.

This section explains how to mount the device in a panel or bracket.

## CHASSIS

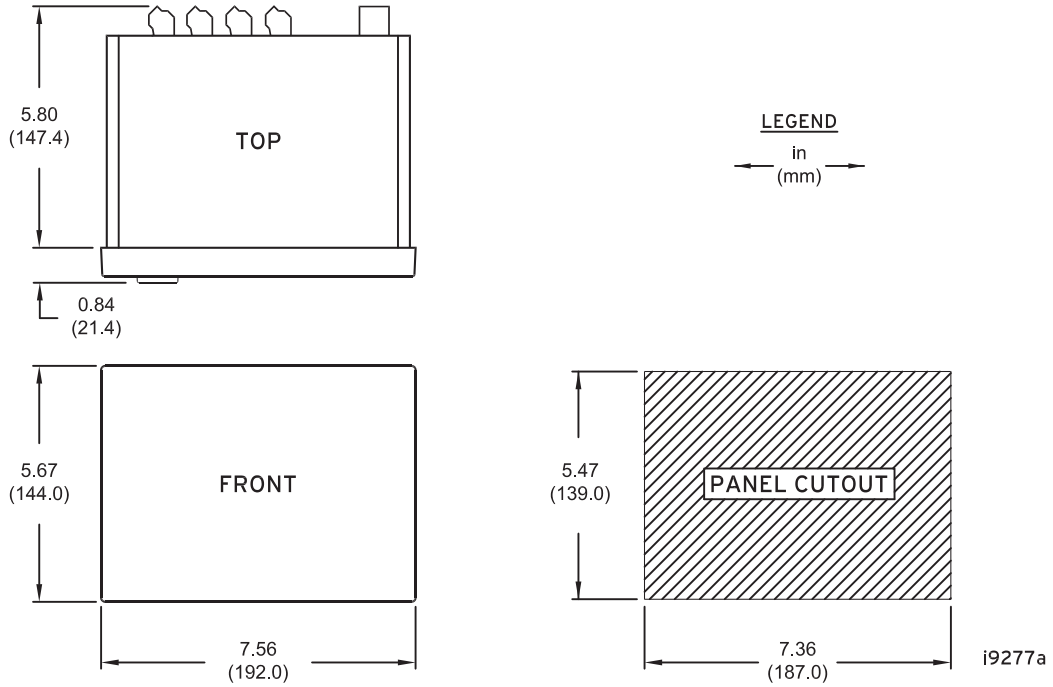


Figure 2.1 SEL-735 Horizontal Panel-Mount Dimensions

## CHASSIS

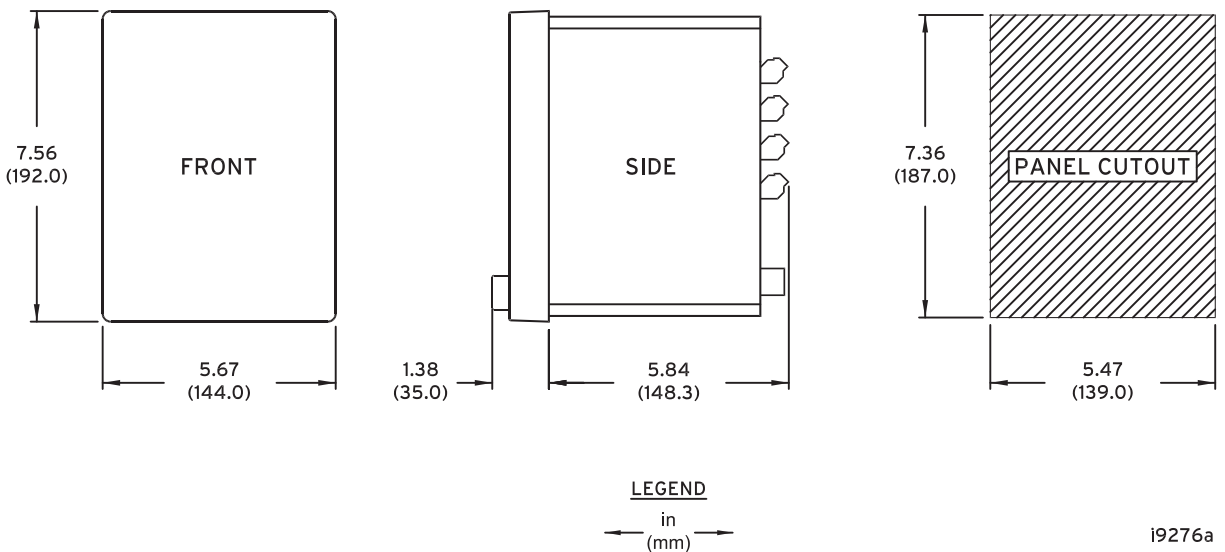
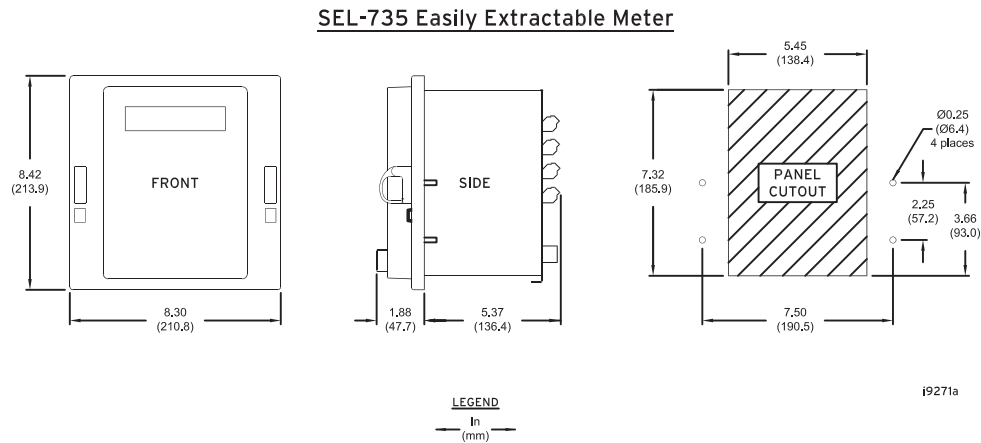


Figure 2.2 SEL-735 Vertical Panel-Mount Dimensions



**Figure 2.3 SEL-735 Easily Extractable Meter Panel-Mount Dimensions**

## Panel-Based or Bracket Mounting

A #3 Phillips® slotted screwdriver with 152.4 mm (6") shaft is required for panel mounting.

Perform the following steps to safely mount the SEL-735.

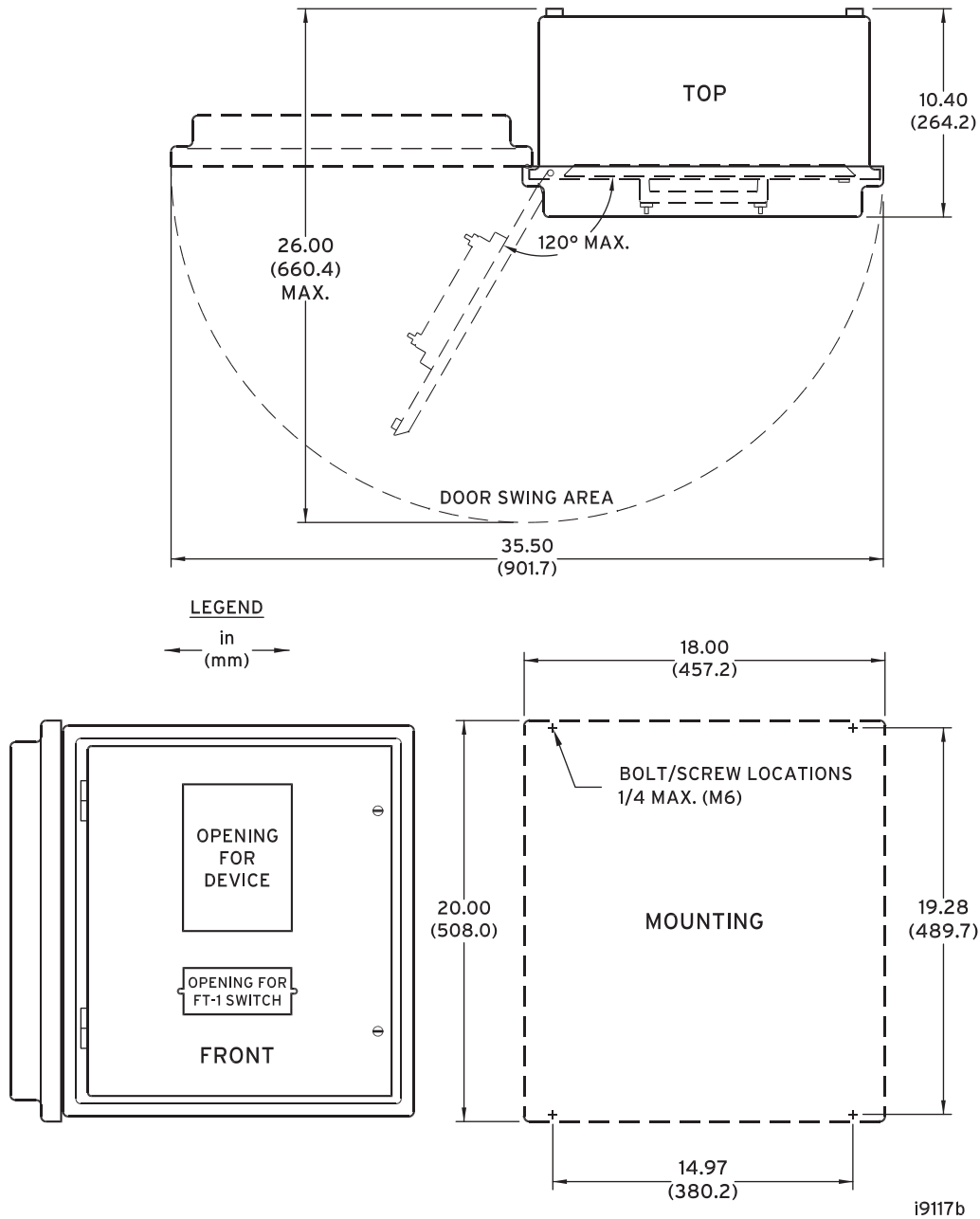
- Step 1. Ensure that the installation site is ready for the installation.
  - a. Ensure the site is well lit and free from debris, and ensure that personnel are safe from contact with any energized circuits.
  - b. Ensure that the panel or bracket cutout is in accordance with the associated dimensions.
  - c. Ensure there is at least about 152 mm (6") of clearance behind the panel cutout. The SEL-735 with Connectorized® connectors extends 148.34 mm (5.84") behind the panel.
- Step 2. If you have a gasket for the SEL-735 front panel, place the seal around the device. Ensure that the seal sits flush against the rear edge of the front panel and is not twisted.
- Step 3. Insert the SEL-735 into the panel cutout and hold the device flush against the panel.
- Step 4. While holding the SEL-735 flush against the panel, screw the four Phillips #3 screws into the rear of the device front panel.

## Outdoor Enclosure Mounting

**NOTE:** The outdoor enclosure weighs approximately 14 kg (30 lbs).

You can order the SEL-735 prewired outdoor enclosure option with mounting hardware for either pole mounting or flush mounting.

Use *Figure 2.4* as a guide to installing mounting hardware.



**Figure 2.4 Outdoor Enclosure Dimensions**

Install adequate hardware to secure the enclosure to a solid structure.

## Chassis Ground (Earthing)

Ground the meter chassis at the ground terminal located on the rear of the meter.

You must connect the ground terminal labeled **GND** on the rear of the panel to a rack frame or switchgear ground for safety and performance. Use 10 AWG (6 mm<sup>2</sup>) to 12 AWG (4 mm<sup>2</sup>) less than 2 m (6.6 feet) in length for the ground connection.



**Figure 2.5 Grounding Terminal Symbol**

# Make Rear-Panel Connections

SEL terminals accelerate and simplify connection and disconnection of wiring from the back of the SEL-735.

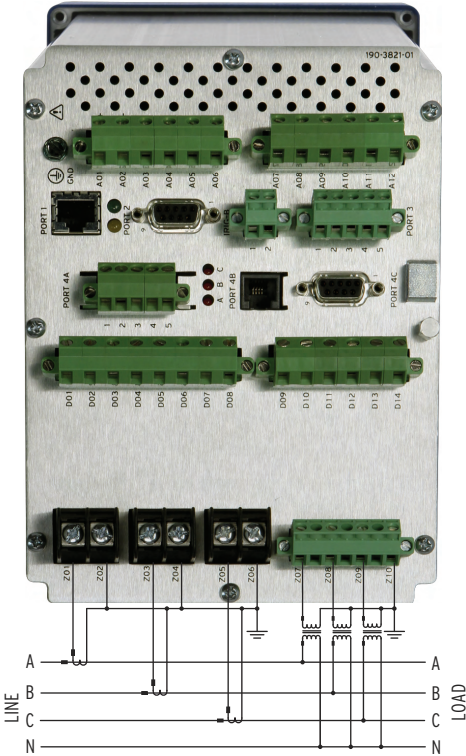


Figure 2.6 Form 9, 3-Element, Four-Wire Wye Wiring Diagram

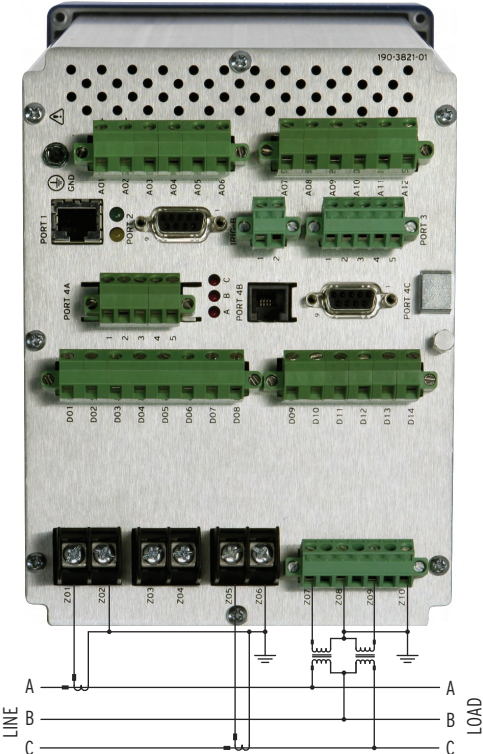
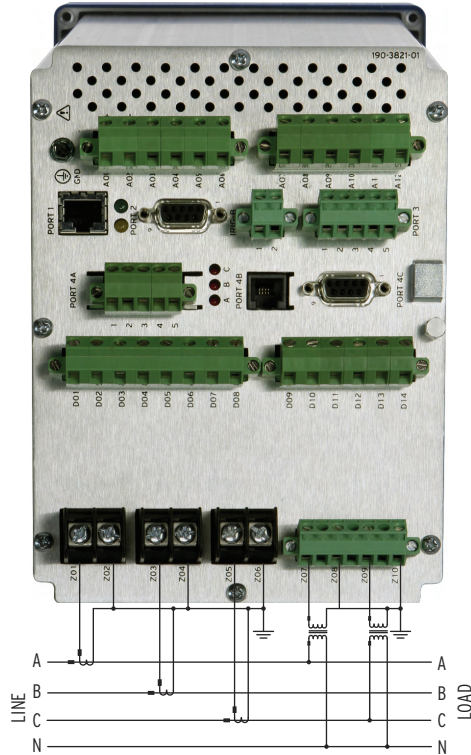


Figure 2.7 Form 5, 2-Element, Three-Wire Delta Wiring Diagram



**Figure 2.8 Form 36, 2 1/2-Element, Four-Wire Wye Wiring Diagram**

Follow these steps to connect Connectorized terminals.

- Step 1. Ensure that the conductor size is between 0.25 mm<sup>2</sup> (24 AWG) and 4 mm<sup>2</sup> (12 AWG).
- Step 2. Strip the conductor end to ensure an electrical connection is made.
- Step 3. Insert the bare conductor into the connection and past the connection jaw.
- Step 4. Tighten the connector to about 0.79 Nm (7 in-lbs) of torque.
- Step 5. Complete other wiring connections.
- Step 6. Hand-tighten the Connectorized connection mounting screws to the proper terminal on the SEL-735.

**NOTE:** The minimum torque is 0.49 Nm (4.4 in-lbs) and the maximum torque is 0.994 Nm (8.8 in-lbs).

Table 2.1 lists the minimum connections necessary for three-phase voltage and current metering.

**Table 2.1 Required Rear-Panel Connections (Sheet 1 of 2)**

Voltage/Current Input Card	Connection Type	Rear-Panel Connection Label	Side-Panel Connection Label	Rear-Panel Connection Input
N/A	Chassis Ground	GND	GND	Ground Reference
N/A	Power Supply	A01	+/H	Positive Voltage Supply
		A02	-/N	Neutral Voltage Supply

**Table 2.1 Required Rear-Panel Connections (Sheet 2 of 2)**

Voltage/Current Input Card	Connection Type	Rear-Panel Connection Label	Side-Panel Connection Label	Rear-Panel Connection Input
Voltage/Current Transformer	Secondary Current Measurement	Z01	IA+	Phase A Current (IA) IN
		Z02	IA-	Phase A Current (IA) OUT
		Z03	IB+	Phase B Current <sup>a</sup> (IB) IN
		Z04	IB-	Phase B Current <sup>a</sup> (IB) OUT
		Z05	IC+	Phase C Current (IC) IN
		Z06	IC-	Phase C Current (IC) OUT
	Secondary Voltage Measurement	Z07	VA	Phase A Voltage (VA)
		Z08	VB	Phase B Voltage <sup>a,b</sup> (VB)
		Z09	VC	Phase C Voltage (VC)
		Z10	VN	VA, VB, VC Neutral

<sup>a</sup> For Form 5 metering: Phase B voltage measurement input must be connected to neutral; Phase B current measurement input may be connected but will not be used in measurements.  
<sup>b</sup> For Form 36 metering: Phase B voltage measurement input must be connected to neutral.

Perform the following steps to make the necessary wiring connection to the SEL-735.

- Step 1. Ensure that power supply and metering instrument wiring is safe.
- Step 2. Route the power supply and metering instrument wiring to the rear of the device.
- Step 3. Ensure the power supply voltage source is within the SEL-735 power supply input range, and connect the positive and neutral power supply wires to connections **E01** and **E02**, respectively.  
 The power supply input range is printed on the side-panel (vertical option) or top-panel (horizontal option) label. Refer to this label for the power supply input range to your SEL-735.
- Step 4. Refer to *Table 2.1* and *Figure 2.6* and connect all necessary rear-panel connections. Ensure that connected circuits conform to the SEL-735 specifications, given in *Specifications on page 1.6*.
- Step 5. Refer to the panel label to connect other necessary rear-panel connections.
- Step 6. Ensure that conductors are properly supported, free from hazards, and installed in accordance with local electrical codes.
- Step 7. Provide power to the power supply connections you wired in *Step 3*.

- Step 8. View the front-panel LCD of the device. Verify that the front-panel LCD illuminates.
- Step 9. Continue to *Configure and Check Meter Status*.

## Configure and Check Meter Status

---

This step describes how to check the status and make the necessary initial configuration settings through the front-panel LCD and menu pushbuttons, or any communications port. Please refer to *Section 4: ACSELERATOR QuickSet* for a complete description of how to perform settings changes.

This step separates into three different substeps based on the interface you use: front-panel interface, port communications, and IRIG-B input; you only need to complete certain steps, depending on the physical interface requirements. The following list explains the recommended installation procedures. Complete each step that pertains to your installation requirements.

- Front-panel pushbutton menu. A PC is not required to perform this step.
- Front optical port, serial port, or Ethernet communications. Perform this step during meter installations, using a PC to program the device.
- IRIG-B port. Carry out this step if an IRIG-B time source is used.

### Configure and Check Meter Status Through the Front-Panel Pushbuttons

The front-panel pushbutton interface eliminates the need for a PC to gain access to meter settings. Front-panel pushbuttons provide access to communications settings, general meter settings, and diagnostics. This section explains only essential meter settings configuration.

Please follow these guidelines when navigating the front-panel menu tree.

- Front-panel pushbuttons **ENT**, **ESC**, **UP**, **DOWN**, **LEFT**, and **RIGHT** navigate through the front-panel LCD menu tree.
- At any time, you can press **ESC** to exit the active menu.
- Appearance of the cursor under a menu item indicates that that menu item is active.
- Press **ENT** to view and configure the active menu structure. A blinking cursor indicates a meter request for a user prompt.
- Use the pushbuttons to interact with the LCD text entry display and enter new text strings.
- Press and hold the **ESC** pushbutton to adjust the contrast of the front-panel LCD.

Follow the instructions below to configure the meter identifier, the terminal identifier, and the potential and current transformer ratios through the front-panel pushbuttons.

- Step 1. Configure the initial device settings.
  - a. Press **ENT**.

The meter displays the top of the menu structure. The menu structure allows for viewing and changing meter measurements and settings.

- b. Press **DOWN** to scroll down until **Set/Show** is active.
- c. Press **ENT**.

The meter displays the top of the setting groups available for configuration and display.

- d. Press **ENT**.

The meter displays the beginning of the front-panel General Settings group. The following *Table 2.2* shows a list of essential initial settings available through the front-panel pushbuttons. Note that *Table 2.2* lists only those settings necessary for initial installation.

**Table 2.2 Essential Initial Settings**

Setting Name	Description	Default Setting	Range
MID	Meter Identifier	FEEDER 1	String
TID	Terminal Identifier	STATION A	String
CTR	Current Transformer Ratio	1.0000	1.0000–6000.0000
PTR	Potential Transformer Ratio	1.0000	1.0000–6000.0000
VOLT_SCA	Voltage Scaling	KILO	UNITY, KILO, MEGA
POWR_SCA	Power Scaling	KILO	UNITY, KILO, MEGA
ENRG_SCA	Energy Scaling	KILO	UNITY, KILO, MEGA
PRI_SCA	Analog Quantity Scaling	Y	Y, N

- e. Press **ENT**.
- f. Enter the Access Level 2 (2AC) password by following the text entry prompts on the LCD.  
 The default EAC password is BLONDEL, and the default 2AC password is TAIL.
- g. Enter the new **MID** by following the text entry prompts on the LCD.  
 The MID is a user-defined text string that is available to the communication protocols. For example, Itron MV-90 communications read the MID or TID strings as one step toward validating the meter.
- h. Repeat *Step g*, except scroll down further to enter new terminal identifier, potential and current transformer ratios, and any other necessary settings.
- i. Press **ESC** to escape the menu item until the LCD prompts `SAVE SETTINGS (Y/N)?`
- j. Enter **Y** to indicate Yes and press **ENT**.
- k. Press **ESC** to exit the menu.

**Step 2. Check the measured voltage quantities.**

- a. Press **ENT**, and then activate **MAIN > Meter > Voltage**.  
 The meter displays the rms voltage quantities and their scaling.
- b. Ensure the measured quantities are correct.

Optionally, repeat *Step a* and *Step b*, but check the rms current quantities from the menu item **MAIN > Meter > Current**.

**NOTE:** Instrument ratios have either 1 V or 1 A base.

## Configure and Check Meter Status Through the Front Optical Port, Serial Port, or Ethernet Port

- c. Press **ENT**, and then activate **MAIN > Status**.
- d. Press **DOWN** to scroll down and view the following diagnostic points.
  - Device Status (STATUS)
  - Firmware Identifier (FID)
  - Part Number (PARTNO)
  - Power Supply Status (Batt, Temp)
- e. Record the FID string of the device for use in subsequent steps.

The front optical, serial, and Ethernet ports of the SEL-735 allow fast communications through a secure communications channel from your PC to the SEL-735. Once you have established a communications link, you can use ACSELERATOR QuickSet® SEL-5030 Software to configure the meter. Refer to *Section 4: ACSELERATOR QuickSet* for complete details of the features of the software.

For connection to a serial port, complete the following steps.

Step 1. Connect the communications cable from your PC to the SEL-735.

- a. For front optical communications, connect the optical probe from your PC to the SEL-735 front optical port. Ensure that you have installed drivers properly for the type of optical probe you will be using.

The following list shows the known compatible optical probes of the SEL-735.

Abacus Electris A9U, USB (Requires additional software drivers)

Abacus Electris A7Z

Abacus Electris A6Z

ABB Unicom III

GE SmartCoupler SC-1A

Microtex Electronics FR3 (Requires additional software drivers)

P+E Technik K01-USB (Requires additional software drivers)

uData Net PM500-300

- b. For serial communications, connect a C234, C272, C287, or equivalent cable from your PC's DB-9 serial port to any SEL-735 EIA-232 serial port.

*Table 2.3* shows the pin functions of serial ports.

**Table 2.3 Serial Port Pin Function** (Sheet 1 of 2)

EIA-232 Port Pin Number	Pin Function
1	+5 VDC
2	RXD
3	TXD
4	+IRIG-B <sup>a</sup>
5	GND
6	-IRIG-B <sup>a</sup>
7	RTS

**Table 2.3 Serial Port Pin Function** (Sheet 2 of 2)

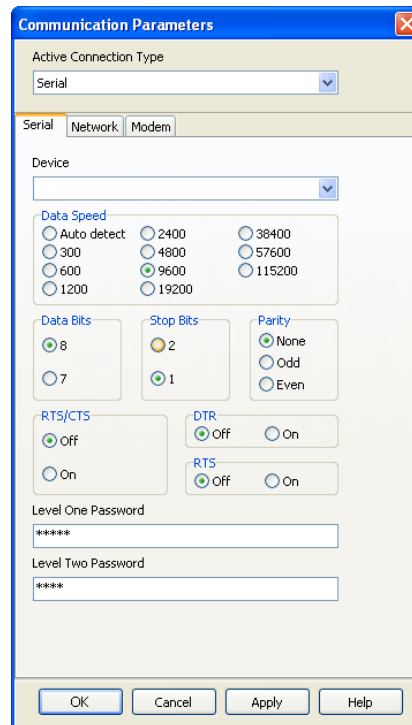
EIA-232 Port Pin Number	Pin Function
8	CTS
9	GND

<sup>a</sup> Not available on Port F.

- c. For Ethernet communications, connect a C627 or equivalent Ethernet cable from your PC Ethernet port to the SEL-735 Ethernet port (Port 1).

Step 2. Open ACSELERATOR QuickSet on the PC.

Step 3. Activate the Communication Parameters window through the menu, toolbar, or by pressing **<Ctrl+R>**. *Figure 2.9* shows the ACSELERATOR QuickSet Communication Parameters window.



**Figure 2.9 ACSELERATOR QuickSet Communication Parameters**

*Table 2.4* shows the default communications settings and corresponding ACSELERATOR communications settings necessary for initial communications to the device. Use this table for basic communications setup. For advanced communications, such as DNP3, MIRRORED BITS<sup>®</sup> communications, and EIA-485, associated *SEL-735 Instruction Manual* sections provide details.

**Table 2.4 Default SEL-735 Settings and Required ACSELERATOR QuickSet Communications Parameters**

Communications Connection Type	SEL-735 Setting Name	SEL-735 Default Setting	ACSELERATOR QuickSet Communications Setting Name	ACSELERATOR QuickSet Communications Required Setting
All Communications Protocols and Channels	PAS 1	“OTTER”	Level One Password	“OTTER”
	PAS E	“BLONDEL”	N/A	N/A
	PAS 2	“TAIL”	Level Two Password	“TAIL”
	PAS C	“PAPOULIS”	Calibration Level Password	N/A
All Ports, Port Specific	EPORT	Y	N/A	N/A
	MAXACC	2	N/A	N/A
Front Optical Port (Port F)	PROTO	SEL	Active Connection Type	Serial
	SPEED	9600	Data Speed	9600
	BITS	8	Data Bits	8
	PARITY	N	Parity	None
	STOP	1	Stop Bits	1
	N/A	N/A	RTS/CTS	(see Table 2.5)
	N/A	N/A	DTR	(see Table 2.5)
Serial Ports (EIA-232 Ports 2, 4, or F; Port 3)	COMMINF	232	Active Connection Type	Serial
	PROTO	SEL		
	SPEED	9600	Data Speed	9600
	BITS	8	Data Bits	8
	STOP	0	Stop Bits	0
	PARITY	N	Parity	None
Ethernet Communications (Port 1)	ETELNET	Y	Active Connection Type	Network
			File Transfer Option	Telnet
	IPADDR	192.168.0.2	Host IP Address	192.168.0.2
	TPORT	23	Port Number	23

Each port has an Enable Port (EPORT) setting and a Maximum Access Level (MAXACC) setting specific to that port. The EPORT setting opens or closes all port communication. The MAXACC setting controls the maximum access level allowed on the port.

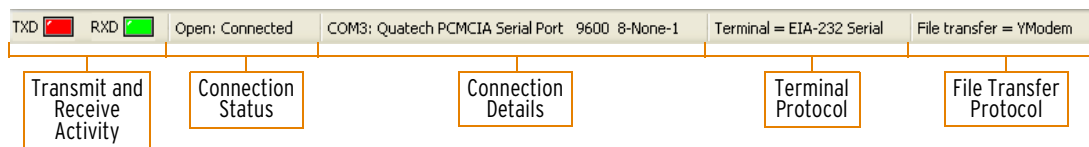
Table 2.5 shows the necessary ACSELERATOR QuickSet Communication Parameter settings associated with the specific optical probe type. Ensure that you have set these settings properly before attempting to communicate to the meter via optical probes.

**Table 2.5 Optical Probe Required Communications Settings**

Optical Probe Type	ACSELERATOR QuickSet Communications Setting Name	ACSELERATOR QuickSet Communications Required Setting
Abacus Electris A9U, USB (SEL part #C661)	RTS/CTS	Off
	DTR	Off
	RTS	On
Abacus Electris A7Z, ABB Unicom III, GE SmartCoupler SC-1A	DTR	Off
Microtex Electronics FR3	Data Speed	19200 or slower

- Step 4. Enter the proper ACSELERATOR QuickSet Communication Parameters that correspond to the communications link you have chosen, shown in *Table 2.4* and *Table 2.5*.
- Step 5. Click **Apply**.
- Step 6. Verify that the TXD and RXD indicators flash green and red, indicating transmitted and received communication activity, respectively. These are located in the lower left-hand corner of ACSELERATOR QuickSet, as shown in *Figure 2.10*.
- Step 7. Verify that the connection status indicates Connected, also shown in *Figure 2.10*.

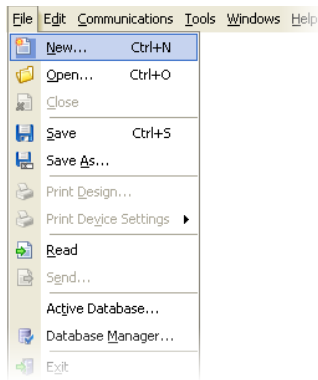
The Transmit and Receive indicators only illuminate during communications activity. The connection status shows whether the link is connected or disconnected. The connection details show the communications settings. The terminal protocol shows the protocol that terminal sessions use. Finally, the file transfer protocol shows the protocol of file transfer communications.



**Figure 2.10 ACSELERATOR QuickSet Communications Activity and Status**

If the communications fail to connect, please verify operation of the applicable port communications through the front-panel pushbuttons.

- Step 8. Click **OK**.
- ACSELERATOR QuickSet is now connected to the SEL-735, and you can use this interface to configure device settings and access all meter data.



Step 9. Complete either *Step 9a* or *Step 9b* to create a new settings file.

- a. Create New Settings.

When you create new settings from ACSELERATOR QuickSet, all default settings load into the new device Settings Editor instance. ACSELERATOR QuickSet displays an interactive part number selector, so you can easily choose the correct part number of your SEL-735 Settings Editor instance. By default, ACSELERATOR QuickSet hides the advanced and nonapplicable settings in the new Settings Editor.

- i. Click **File > New** (or **Ctrl+N**).
- ii. Select the correct part number for your device.
- iii. Click **OK**.

Figure 2.11 shows the default options for the SEL-735.

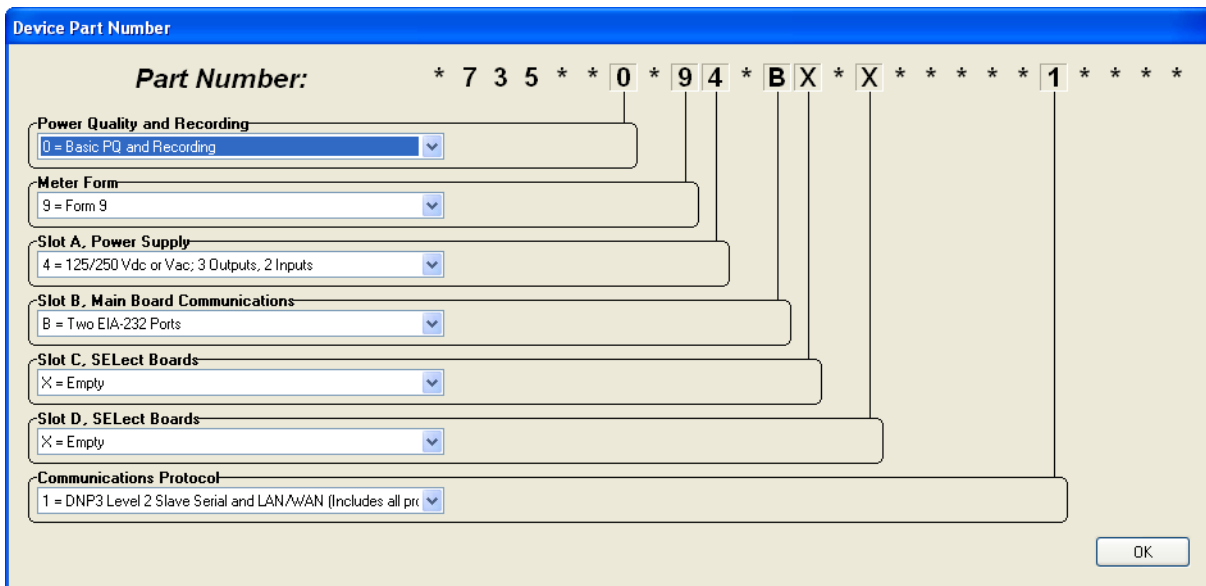


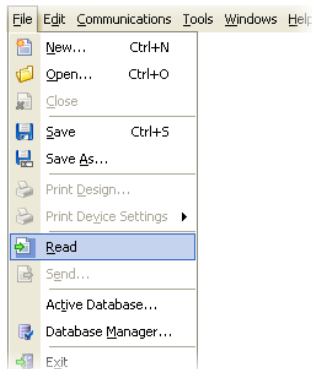
Figure 2.11 SEL-735 Model Option Table

- b. Read Settings.

The following steps and ACSELERATOR QuickSet menu/toolbar diagrams show how to read device settings from the SEL-735 and the reading process behavior. SEL recommends you read and save settings before and after each settings change.

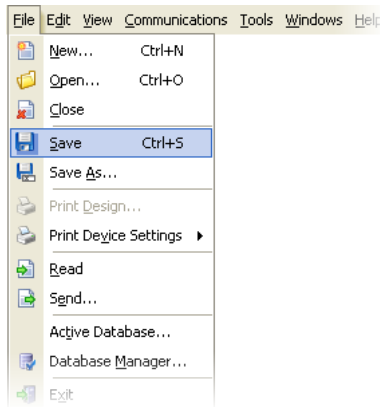
- i. Click **File > Read** (or **Alt+F+R**).
- ii. Click **OK**.

ACSELERATOR QuickSet reads the settings from the SEL-735, and populates the settings into a new Settings Editor instance. Any settings groups that ACSELERATOR QuickSet did not read will open with default values in the Settings Editor. You can then compare old and new settings with each other, and you can have ACSELERATOR QuickSet produce a settings change report. To compare settings, select **Edit > Compare**.



### Step 10. Save Settings

The following steps and ACSELERATOR QuickSet menu/toolbar diagrams show how to save device settings to your PC.



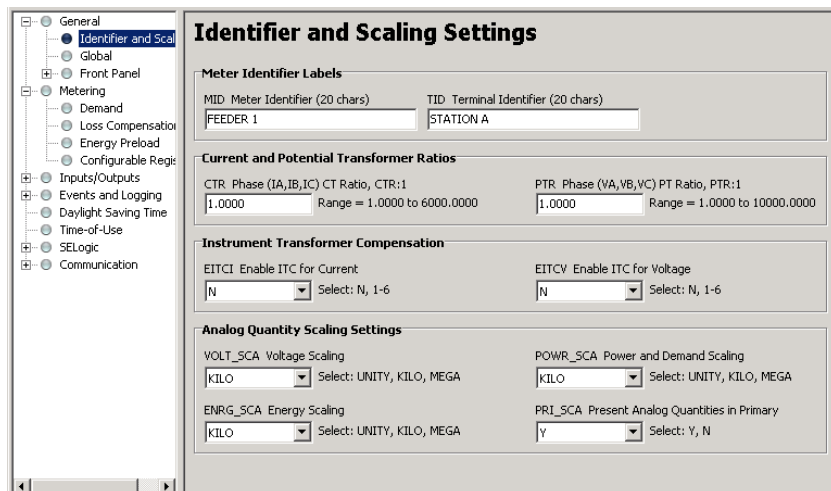
- a. Click **File > Save** (or **Ctrl+S**).
- b. Type a new settings name to save the active settings as a new settings file, or select a previously saved settings file to save over the selected file.
- c. Click **OK**, or press **<Enter>**.

ACSELERATOR QuickSet saves the active device settings in the Active Database. The default database is normally stored as C:\Program Files\SEL\acSELERator\Quickset\Relay.rdb, but you can also use other databases. Please refer to the Database Manager instructions. You can then compare old and new settings with each other, and have ACSELERATOR QuickSet produce a settings change report. To compare settings, select **Edit > Compare**.

### Step 11. Configure Identifier and Scaling Settings

The Identifier and Scaling settings are essential for proper metering operations. These settings define the identifier of your device, the instrument transformer ratios, and the scaling the meter applies to external interfaces. *Figure 2.12* shows the default Identifier and Scaling settings.

- a. Enter the new meter identifier (MID). This is a user-defined text string that is available to communication channels. Allowed characters are A–Z, 0–9, /, and –.
- b. Enter the current transformer ratio (CTR), the neutral current transformer ratio (CTR<sub>N</sub>), and the potential transformer ratio (PTR).



**Figure 2.12 Identifier and Scaling Settings**

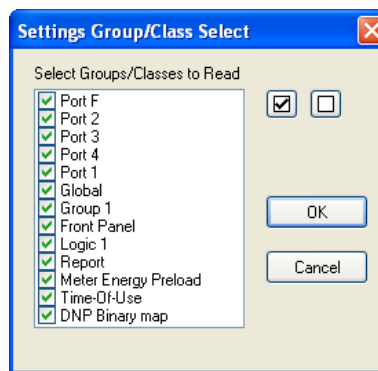
- c. Enter the scale factor for voltage (VOLT\_SCA), power (POWR\_SCA), and energy (ENRG\_SCA) values that the meter applies to the respective analog quantity on all external interfaces. You can also use one of the 1000 available configurable registers to perform custom scaling and formatting of analog quantities.
- d. Configure scale factors (PRI\_SCA) to scale all analog quantities in either primary or secondary units. The scale factor applies to all external interfaces.

Step 12. Send Settings

The following steps and ACSELERATOR QuickSet menu/toolbar diagrams explain how to send active device settings to the SEL-735 and the writing process behavior. SEL recommends that you save settings with a unique name before sending them.

- a. Click **Send**.

The Settings Group/Class Select window opens as shown in *Figure 2.13*. ACSELERATOR QuickSet automatically selects any setting groups that have changed since the last read.



**Figure 2.13 Settings Group/Class Select to Send Window**

- b. Select or deselect the appropriate group settings.
- c. Click **OK**.  
ACSELERATOR QuickSet sends the selected groups to the device.

# Section 3

## Front-Panel Operation

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### Overview

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This section details the physical operations of the device and contains details necessary for front-panel LCD communication. The front-panel display provides access to many menus and meter features, which this section describes.

The *Section 9: Testing and Troubleshooting* contains information on TEST mode access, communications, operations, and recommended practices.

Configurable Registers are variables to which you can assign metered quantities and communicate results through various channels, including the front-panel LCD. Custom formatting and scaling aid in understanding the information. Please see *Section 5: Metering* for Configurable Register details.

Sixteen custom front-panel displays, known as display points, are also very useful tools for quick access to information and interfacing with the device.

### Access Levels

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#### Overview

The SEL-735 has three normal access levels: Access Level 1 (ACC), Access Level E (EAC), and Access Level 2 (2AC). From these three access levels, you can fully configure and operate the meter. You can gain access to the access levels through certain communications protocols. For example, you can write to some registers via DNP and Modbus® only after gaining EAC access through the same communications channel. The meter also allows you to configure different maximum levels of access for each communications port.

#### ACC

From this level, you can only view meter settings and quantities. This is the front-panel LCD default access level mode. Please ensure that only those allowed to view meter settings and quantities can access the front panel.

#### EAC

From this level you can set the date; force IRIG-B synchronization; set the date and time; and clear load profile recorders, crest factor metering, maximum/minimum metering, and peak demand metering.

#### 2AC

From this level, you can configure all settings and control functions of the SEL-735. Please see *Section 4: ACSELERATOR QuickSet* for details on configuration settings and control functions.

### Access Level C

The CAL access level is intended for use by the SEL factory, and for use by SEL field service personnel to help diagnose troublesome installations. A list of commands available at the CAL level is available from SEL upon request. Do not enter the CAL access level except as directed by SEL.

The **CAL** command allows the meter to go to Access Level C. Enter the **CAL** command at the Access Level 2 prompt.

### SEL Communications

SEL protocols confirm the password for each new SEL communications channel instance. Access to each communications channel session times out after three minutes of inactivity or when the port times out, whichever is shorter.

### Port Security

You can configure each port to allow a maximum access of ACC, EAC, or 2AC or to turn the port completely off to any communications. Please see *Section 4: ACCELERATOR QuickSet* for more details on port security.

## Front-Panel Operations

### Layout

The SEL-735 front-panel interface consists of six programmable LEDs, an LCD display, a menu keypad, a TEST LED, an optical communications port, and four control pushbuttons.

Figure 3.1 shows the front-panel layout of the SEL-735 horizontal unit, and Figure 3.2 shows the vertical unit.

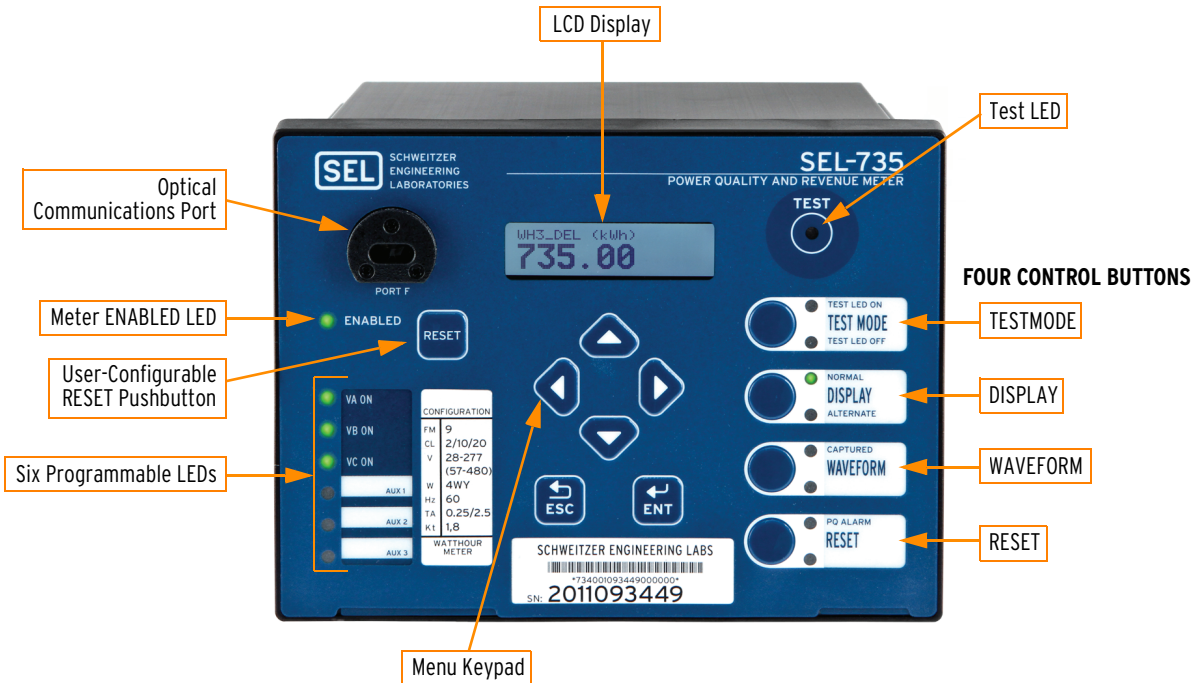
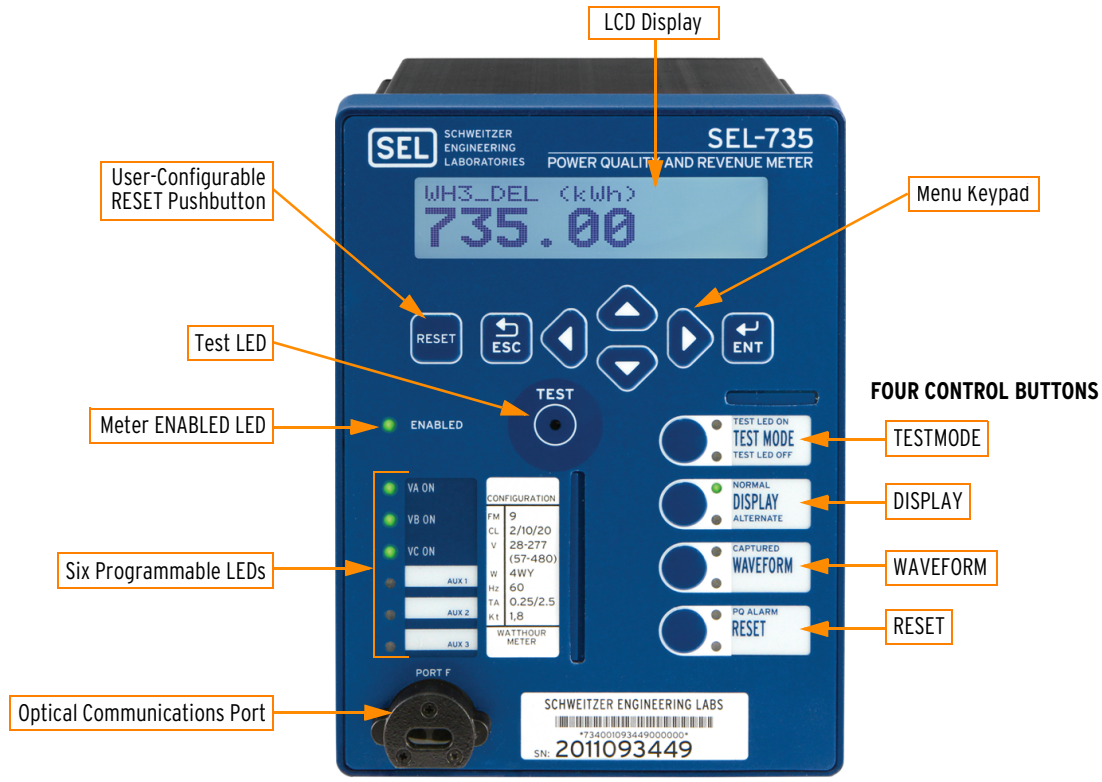


Figure 3.1 SEL-735 Horizontal Unit Front-Panel Layout



**Figure 3.2 SEL-735 Vertical Unit Front-Panel Layout**

The following list gives a brief explanation of each of the previously shown front-panel functions.

### Six Programmable LEDs

Control the front-panel LED states via SELOGIC control equations. By default, three LEDs show the undervoltage status of each phase.

### LCD Display

Use the front-panel LCD to view metered quantities, view diagnostics, configure meter settings, reset metered quantities, and enter TEST mode. You can configure different display points for Normal and Alternate modes.

### Menu Keypad

Use the menu keypad in conjunction with the LCD to navigate menus. With the Menu keypad, you can access metering data, reset certain quantities, and configure meter settings. Please see the *Section 2: Installation* and the *SEL-735 Quick-Start Guide* for more information.

### TEST LED

The TEST LED outputs infrared light pulses that follow the state of the KYZ test pulses. The TEST LED is only active when the meter is in TEST mode.

### Optical Communications Port

This port is an ANSI Type 2 Optical port. Use this port for easy front-panel serial communications. The optical communications port also outputs test pulses when the meter is in TEST mode.

## Four Control Pushbuttons

The meter performs default functions when the control Pushbutton Default Function (PBDFLT) setting is set to **Yes** and you press any of the four control pushbuttons. The following list summarizes the default functions of each button.

### TEST MODE

Press this button to quickly enter TEST mode through the front-panel LCD (you must enter a valid 2AC level password). The LEDs next to the control button replicate the state of the KYZ test pulses.

### DISPLAY

Press this button to toggle between normal and alternate displays. The LEDs next to the control button show the present display mode state.

### WAVEFORM

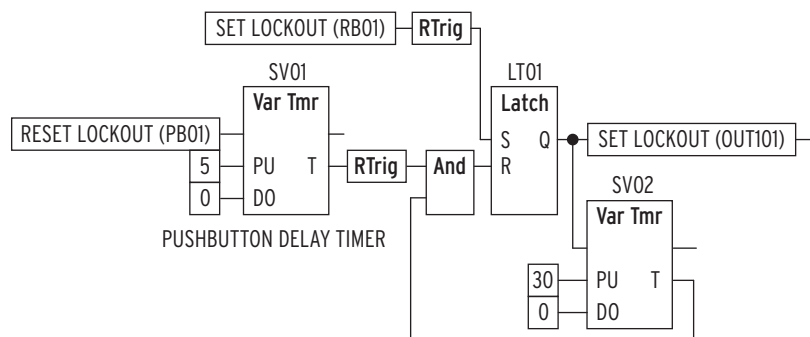
Press this button to trigger an event and capture a waveform. The LED next to the control button shows the status of the waveform capture.

### RESET

Press this button to reset the latched power quality alarm. The LED next to the control button shows the state of the power quality alarm.

## Custom Pushbutton Control

Set the Pushbutton Default Function setting to N to program these four pushbuttons and their associated LEDs with custom control equations to perform different tasks. For example, program a pushbutton to reset a remote lockout protection function after you depress the pushbutton for a length of time. The following *Figure 3.3* shows an example logic diagram to perform this function. The SELOGIC Variable 01 pickup timer (SV01 and titled Pushbutton Delay Timer) does not assert output SV01T until PB01 is held for at least 5 seconds. A rising edge from the output of this timer while SELOGIC Latch 01 is asserted resets the lockout condition. SELOGIC Variable 02 pickup timer ensures the lockout condition has been asserted for at least 30 seconds before it resets. This minimizes the chance of hunting or race conditions from occurring.



**Figure 3.3 Graphical Logic Editor Lockout Latch Control Example**

*Figure 3.4* shows the Compile tool window in the graphical ACSELERATOR QuickSet® SEL-5030 Software Logic Editor. The settings highlighted in yellow indicate that the present device setting differs from the new setting the logic editor derived. Click the **Apply to Settings** button to apply the new settings shown to the active settings.

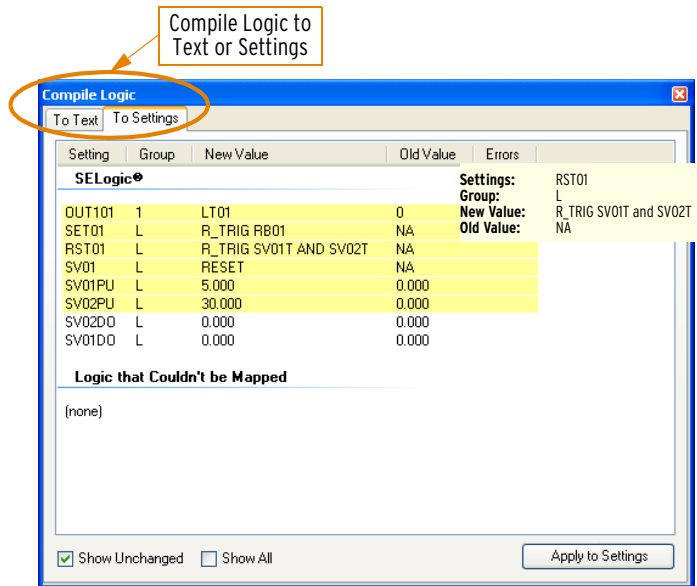


Figure 3.4 Graphical Logic Editor Compile Logic Window

## Normal Operation

In normal operation, the meter **ENABLED** LED illuminates and the LCD display screen displays the programmed display points. The LCD screen normally rotates display of display points, showing each for about six seconds before moving to the next.



Figure 3.5 Default Light Illuminated

In any front-panel access level, the device automatically times out after three minutes of inactivity. The LCD illumination turns off, but the active menu item remains selected.

Certain diagnostics results write messages to the front-panel LCD. For a list of the diagnostic messages shown on the LCD, please see the *Section 9: Testing and Troubleshooting*.

The SEL-735 settings T01\_LED–T14\_LED control the 14 front-panel LEDs. You can set these settings through use of SELOGIC control equations available in the front-panel LED logic settings and cited in *Section 4: ACCELERATOR QuickSet*.

### LCD Automatic Messages

Under normal conditions, the SEL-735 displays the programmed display points based on the display point logic expressions. If a diagnostics error occurs, the meter displays a message and turns off the **ENABLE** light. For complete details on error messages, please see *Section 9: Testing and Troubleshooting*. If this or any abnormality with the device occurs, please contact SEL.








# Menus and Operations

The SEL-735 front panel provides you access to most meter information.

The meter front panel typically operates at Access Level 1 and allows any user to view meter measurements and settings. Some activities, such as editing settings, are restricted to operators with Access Level 2 privileges.

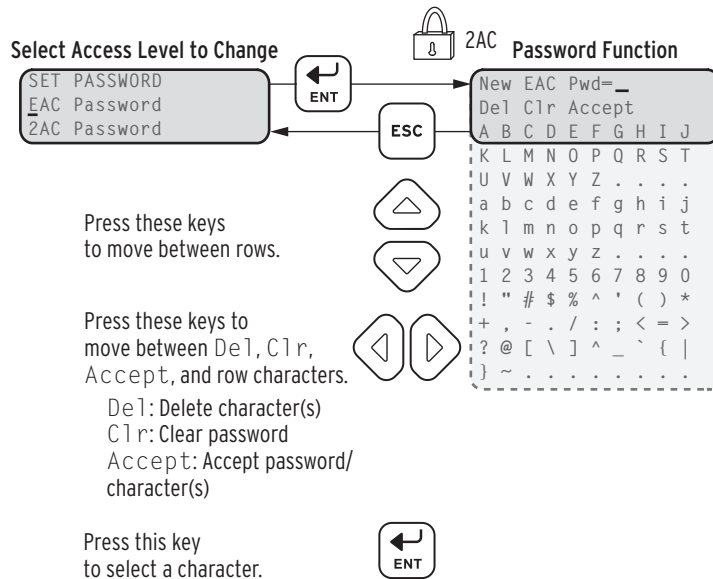
Use the seven-button keypad and LCD display to access meter information and settings. Use the keypad to maneuver within the front-panel menu structure, described in detail throughout the remainder of this section. *Table 3.1* describes the function of each front-panel pushbutton.

**Table 3.1 Front-Panel Pushbutton Functions**

Pushbutton	Function
 UP ARROW	Move up within a menu or data list. While editing a setting value, increase the value of the underlined digit.
 DOWN ARROW	Move down within a menu or data list. While editing a setting value, decrease the value of the underlined digit.
 LEFT ARROW	Move the cursor to the left. While viewing Event Data, move to data for a newer event.
 RIGHT ARROW	Move the cursor to the right. While viewing Event Data, move to the data for an older event.
 ESC	Wake up the front-panel display. Escape from the current menu or display. Hold to adjust the contrast.
 ENT	Wake up the front-panel display. Move from the default display to the main menu. Select the menu item at the cursor. Select the displayed setting to edit the setting.
 RESET	Test front-panel LEDs, reset the timer when in TEST mode, and assert the RESET bit.

Please follow these guidelines when navigating the front-panel menu tree.

- The front-panel pushbuttons **ENT**, **ESC**, **UP**, **DOWN**, **LEFT**, and **RIGHT** navigate through the front-panel LCD menu tree.
- At any time, press **ESC** to exit the active menu.
- A blinking-cursor under menu items indicates that the menu item is active.
- Press **ENT** to view and configure the active menu structure.
- A blinking cursor indicates the need for a user prompt.
- Use the pushbuttons to enter new text strings by interaction of the LCD text entry display, as shown in *Figure 3.6*.
- Hold the **ESC** pushbutton to adjust the contrast of the front-panel LCD.



**Figure 3.6 Keypad Entry Through Front-Panel LCD**

## Main Menu

All access to information and meter settings through the front panel starts at the meter Main Menu.

Table 3.2 shows the menus and submenus available via the front panel.

When you change any settings, the SEL-735 prompts you with the message *Save Changes to Settings?* before it saves any settings.

**Table 3.2 SEL-735 Front-Panel Menu Structure (Sheet 1 of 2)**

Menu Option		Function	
Meter	Voltage	Display Voltages	
	Current	Display Currents	
	Power	Display Powers	
	Max/Min	Display Max/Min	Display Max/Min Values and the Date/Time of Last Max/Min Reset, and Reset Max/Min Values
		Last Max/Min Reset	
		Reset Max/Min <sup>a</sup>	
	Energy	Display Energy	Display Energy Values and the Date/Time of Last Energy Reset, and Reset Energy Values
		Last Energy Reset	
		Reset Energy <sup>a</sup>	
	Demand/Peak	Display Demand Reset	Display Demand Values and the Date/Time of Last Demand Reset, Display Peak and Previous Peak Values and the Date/Time of Last Peak Reset, Display Number of Peak Demand Resets, Reset Demand or Peak Demand
		Display Peak	
		Last Peak Reset	
		Previous Peak	
Resets			
Reset Demand <sup>a</sup>			
Reset Peak <sup>b</sup>			
Harmonics	Display THD, K-Factor, and Distortion Power		

**Table 3.2 SEL-735 Front-Panel Menu Structure (Sheet 2 of 2)**

Menu Option		Function
Events	Display Events	Display Events
	Reset Events <sup>a</sup>	Reset Events
Targets		Display Device Word Bits
Status		Display Device Status, FID, Part Number, Power Supply Status, Battery Voltage, and Operating Temperature.
Set/Show	General Settings <sup>a</sup>	Set or Show Identifier and Scaling, Global, Demand, Loss Compensation, KYZ Pulse Outputs, and Fast Messages Settings
	Port Settings <sup>a</sup>	Set or Show Front Port, Port 1, Port 2, Port 3, or Port 4 Settings
	Front-Panel Settings <sup>a</sup>	Set or Show Display Points Settings
	Date/Time <sup>b</sup>	Set or Show the Date and Time
	Set Password	Set EAC <sup>b</sup> and 2AC <sup>a</sup> Passwords
Reset <sup>c</sup>		Reset Device
TEST Mode <sup>a</sup>	Select Test Quantity	Select the Energy Analog Quantity for testing
	Watt-hour Constant	Adjust the pulse constant for the test
	Compensation Setting	Toggle Transformer and Line Loss Compensation On or Off for the test
	Gain Settings	Adjust Watt and VAR Gain

<sup>a</sup> 2AC access required to reset quantity or change setting.  
<sup>b</sup> EAC access required to reset quantity or change setting.  
<sup>c</sup> Only displays if the meter is disabled.

## Passwords via Front Panel

Before you can perform a front-panel menu activity that is marked in the instruction manual with the necessary access level, you must enter the correct Access Level 2 (2AC) password or Access Level E (EAC) password. After you have correctly entered the password, you can perform other activities at equal and lower access levels without having to reenter the password. You can only configure display points through communications channels other than the front panel.

## Display Points

You can customize the LCD through the use of 16 different display points, which can display both analog and binary data in customized messages and formats. For easier and more flexible display configurations, you may use Configurable Registers in Display Points. The meter can display 20 small-font characters on a single line and 9 large-font characters on a single line. If the number of characters exceeds the length of the LCD viewing area, the line scrolls to show all of the text.

If the display point is set to display binary data, then the point can have two text strings: one set text string and one clear text string. Either the set or clear text string displays when the associated binary point is either set or clear, respectively. You can use any Device Word bit as the binary display point.

If the display point is set to display analog data, then you can change the scaling and choose to view quantities in primary or secondary values.

By default, the front-panel LCD displays each display point for six seconds before displaying the next point. Adjust the Display Update Rate setting (SCROLL) to change the length of time each point displays.

SELOGIC display point control equations DP $nn$  ( $nn = 01-16$ ) control the display status of each corresponding text string DP $nn$ \_0 and DP $nn$ \_1. For example, the following settings demonstrate how display points function when the Device Word bit ALTMODE asserts and deasserts.

```
DP01 := ALTMODE
DP01_1 := "ALTERNATE MODE"
DP01_0 := "Normal Mode"
```

The SELOGIC control equation DP01 is True (asserted) when the Device Word bit ALTMODE asserts. When DP01 is True the device displays ALTERNATE MODE on the LCD, and when DP01 is False the device displays Normal Mode.

## Default Display

The device comes with default display point settings for normal and alternate displays. The front-panel control pushbutton PB02 toggles (by default) between normal and alternate displays. The device reverts back to the normal display after the Front-Panel Timeout, FP\_TO, expires without any front-panel activity.

Table 3.3 lists the default display points for the normal and alternate display modes.

**Table 3.3 Default Normal and Alternate Display Points (Sheet 1 of 2)**

Normal Display Points		Alternate Display Points	
Analog Quantity	Description	Analog Quantity	Description
WH3_DEL	Watt-hours Delivered	CWH3_DEL	Consumed Watt-hours Delivered in the present month
WH3_REC	Watt-hours Received	CWH3_REC	Consumed Watt-hours Received in the previous month
QH3_DEL	VAR-hours Delivered	PRES_W_1_PD	Peak Demand Watts of the present season
QH3_REC	VAR-hours Received	CWH3_DEL_1M	Consumed Watt-hours Delivered in the previous month
PFT3	True Power Factor	CWH3_REC_1M	Consumed Watt-hours Received in the previous month
WP3_DEL	Peak Watts Delivered	PREV_W_1_PD	Peak Demand Watts of the previous season
WP3_REC	Peak Watts Received		
QP3_DEL	Peak VARs Delivered		
QP3_REC	Peak VARs Received		
IA	Phase A RMS Current		
IB	Phase B RMS Current		
IC	Phase C RMS Current		
VA	Phase A RMS Voltage		

**Table 3.3 Default Normal and Alternate Display Points (Sheet 2 of 2)**

Normal Display Points		Alternate Display Points	
Analog Quantity	Description	Analog Quantity	Description
VB	Phase B RMS Voltage		
VC	Phase C RMS Voltage		

See *Display Point Builder* on page 4.7 for information on how to configure display points through an intuitive interface.

## Customize Strings

Each display point setting contains one or more of the following: Analog Quantity, Device Word bit, user-defined text, and/or user-defined numerical formatting. Device Word bits and Analog Quantities are displayed as default form or as user-defined text.

Display point setting strings have a maximum length of 64 characters. Quotes are optional and are required only if the given string contains commas or spaces. If the entire string is empty the meter does not display it. *Table 3.4* shows the elements of display point string settings.

**Table 3.4 Display Point Setting Definitions**

Term	Definition
<i>Name</i>	Any valid Analog Quantity or Device Word bit you want to display
<i>Alias</i>	An alternate name (string) displayed, replacing the Analog Quantity or Device Word bit assigned in <i>Name</i>
<i>Set String</i>	A user-defined string displayed when the Device Word bit assigned in <i>Name</i> asserts (logical 1)
<i>Clear String</i>	A user-defined string displayed when the Device Word bit assigned in <i>Name</i> deasserts (logical 0)
<i>User text {numerical formatting}</i>	A user-defined text string ( <i>Alias</i> ) replacing the {numerical formatting} with {width.dec,scale} where the value of Name is scaled by “scale,” formatted with total width “width” and “dec” decimal places. Maximum width and dec total 20 digits.

The following text shows the correct format of display point string elements. The meter displays an error message if you configure it with an incorrect format.

*Name*—Displays the given entry exactly as seen on the setting line (name, value, and units). *Name* is any valid analog quantity or a Device Word bit. See *Section 8: Communications* and *Appendix G: Analog Quantities and Device Word Bits* for valid display point names.

*Name*, “*Alias*”—Display given entry, replacing *Name* with the given *Alias* string.

*Name*, “*Alias*”, “*Set String*”, “*Clear String*”—This format requires that *Name* be a Device Word bit. Display the given entry as *Alias*. If the Device Word bit state is asserted (logical 1), display the *Set String* as the value. If the Device Word bit state is deasserted (logical 0), display the *Clear String* as the value. *Alias*, *Set String*, or *Clear String* can be empty. If *Alias* is empty, then only the *Set String* or *Clear String* will be displayed. If either *Set String* or *Clear String* is empty, then the item will not be visible when the bit matches that state. If an empty line is necessary in this case (instead of hiding the line), then you should use empty curly braces ({}). If either *Set String* or *Clear String* is empty, then the item will not be visible when the bit matches that state. If an empty line is necessary in this case (instead of hiding the line), then you should use empty curly braces ({}). *Alias* and *Set String*/*Clear String* are all displayed on the same line of the front-panel display.

Name, “User text {numerical formatting}”—Display given entry, replacing Name with User text and displaying the value of Name in the user-defined format {width.dec,scale}, {numerical formatting}. The value is scaled by “scale,” formatted with a total digit width “width” and “dec” decimal places as defined in {numerical formatting} ({width.dec,scale}). Name can be either an analog quantity or a Device Word bit. The width value should include the decimal point and sign character, if applicable. The “scale value” is 1 if omitted. If the numeric value is smaller than the field size you requested, the SEL-735 pads fields with spaces to the left of the number. If the numeric value will not fit in the given field width, the field grows (to the left of the decimal point) to accommodate the number. All user-formatted display points occupy one line on the display. The SEL-735 uses multiple display points to simulate multiple lines.

Set Name to 1 to create fixed text, placing the text in brackets as the Alias or using empty brackets to leave a blank line.

**Table 3.5 Display Point Formatting**

Display Point Setting Format	Example Display Point Setting	Example Display
DPnn_n := Name	IN101	IN101=0
DPnn_n := Name	IA_MAG	IA MAG (A) 1234.567
DPnn_n := Name	MVAADI	MVAADI (MVA) 1234.56
DPnn_n := Name, Alias	MVAADO, “APPARENT DEM. A”	APPARENT DEM. A (MVA) 1234.56
DPnn_n := Name, Alias, Set String, Clear String	SV01, “CONTROL”, ON, OFF	CONTROL=ON  CONTROL=OFF
DPnn_n := Name, Alias, Set String	SV02, BREAKER, TRIPPED,	BREAKER=TRIPPED <i>Entry is hidden</i>
DPnn_n := Name, {}, Clear String	RB03, {}, “OVERCURRENT”	<i>Empty line displayed</i> OVERCURRENT
DPnn_n := Name, “User {numerical width} text”	MVRADI, “VAR DEM {4}MVAR”	VAR DEM 1234MVAR
DPnn_n := Name, “User text = {numerical width.dec}”	MVR3PO, “REACT P OUT={4.1}”	REACT P OUT= 12.1a
DPnn_n := Name, “User {numerical width} text”	ICD, “C DEMAND={5}”	C DEMAND= 1234a
DPnn_n := Name, “User text = {width.dec,scale}”	ICD, “C DEMAND={4.2,0.001}kA”	C DEMAND=1.23 kA
DPnn_n := Name, “User text = {width,scale}”	MVRHAO, “KVARH OUT A={4,1000}”	KVARH OUT A=1234
DPnn_n := Name, {Alias}	1, “FIXED TEXT”	FIXED TEXT
DPnn_n := 1, {}	1, {}	<i>Empty line</i>

### Values Displayed for Incorrect Settings

If the display point setting string is formatted incorrectly, one of the following errors will replace the display point on the rotating display.

Syntax Error in DPnn\_n—The setting string syntax is incorrect.

Name Error in DPnn\_n—The name in the setting string is not a valid Analog Quantity or Device Word bit.

User Format Error in DPnn\_n—The user formatting for the display point value is not valid.

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# Section 4

## ACSELERATOR QuickSet

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### Overview

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Each SEL-735 ships with the ACSELERATOR QuickSet® SEL-5030 Software program, which allows meter configuration, monitoring, testing, and data retrieval. ACSELERATOR QuickSet offers the following capabilities.

- Store, retrieve, and send settings.
- Retrieve real-time and stored power system data and control meter functions via the human machine interface (HMI).
- Analyze power system events with integrated waveform and harmonic analysis tools.

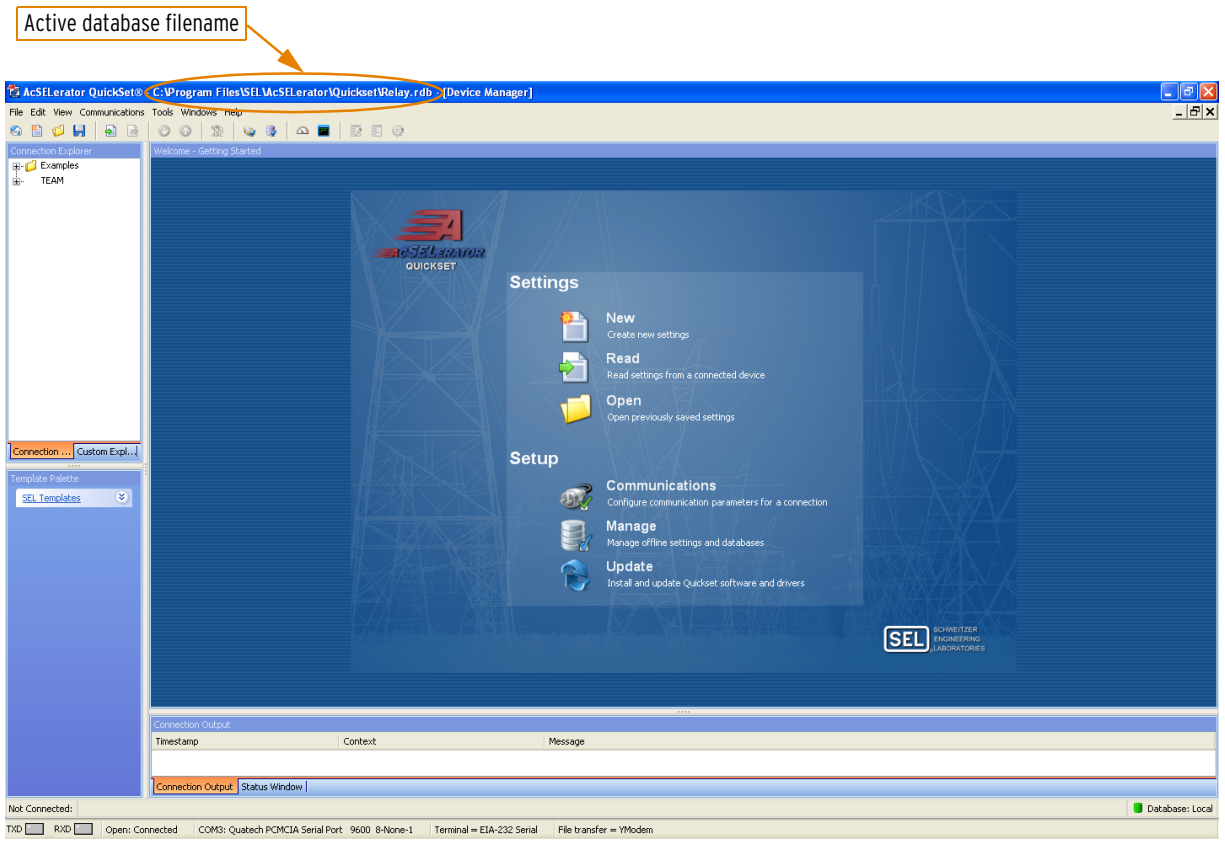
### Settings

---

This section describes how to use advanced features of ACSELERATOR QuickSet to configure the meter.

#### Store and Retrieve Settings

ACSELERATOR QuickSet stores setting configurations in a settings database file (with an .rdb extension). The default settings database is Relay.rdb, which is saved in the ACSELERATOR QuickSet folder of the installation. When you save settings configurations, ACSELERATOR QuickSet saves the configuration files to the active database. ACSELERATOR QuickSet displays the active database file name in the window title bar, as shown in *Figure 4.1*.



**Figure 4.1 ACSELERATOR QuickSet Initial View**

You can save multiple setting configurations to a single settings database, and you can save multiple setting databases to your computer. ACSELERATOR QuickSet allows you to copy and move setting configurations between setting databases. ACSELERATOR TEAM® SEL-5045 Software manages databases and communications among multiple SEL devices, giving you excellent management control over entire systems.

### Create New Database

From ACSELERATOR QuickSet, perform the following steps to create new database files.

- Step 1. Click **File > Database Manager**.

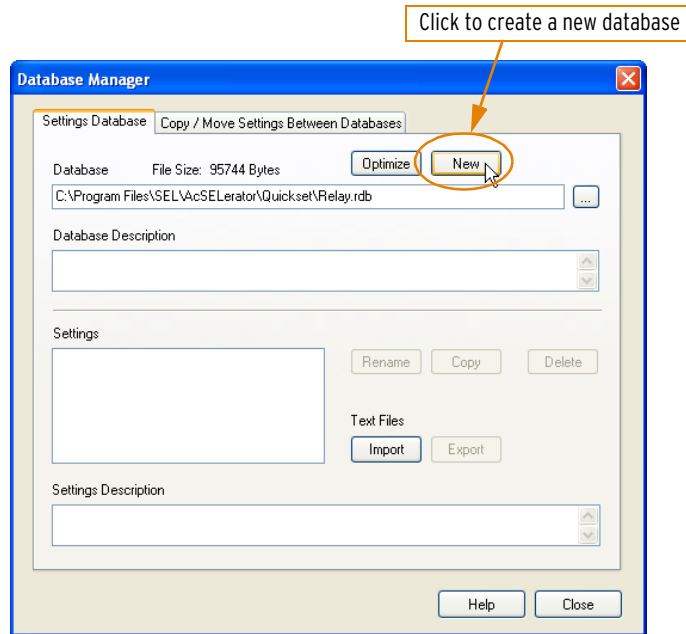
The **Database Manager** window opens similar to *Figure 4.2*, with the **Database** text box displaying the active database name.

- Step 2. Click **New**.

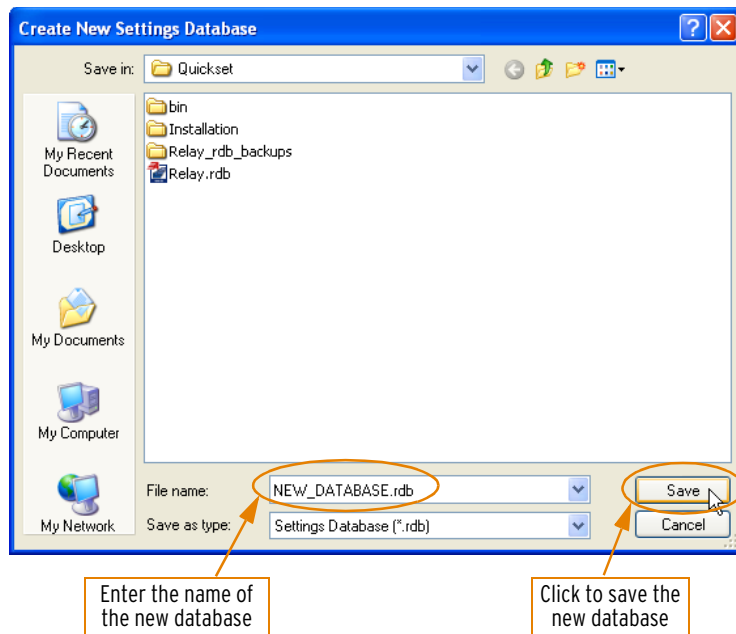
The **Create New Settings Database** window opens, shown in *Figure 4.3*.

- Step 3. Browse to the directory's location to save the new database file.
- Step 4. Type the name of the new database in the **File name** text box.
- Step 5. Click **Save**.

ACSELERATOR QuickSet creates the new database and prompts you the result of the operation. In order to save the current settings editor's configuration to the new database, activate the newly created database as shown in *Activate Database*.



**Figure 4.2 Database Manager, Create New Database**



**Figure 4.3 Create New Settings Database Window**

## Activate Database

ACSELERATOR QuickSet saves current settings configurations to the active database. Follow the steps below to activate a settings database.

Step 1. Click **File > Active Database**.

The **Set Active Settings Database** window opens (see *Figure 4.4*).

Step 2. Browse to the location of the database.

Step 3. Click **Open**.

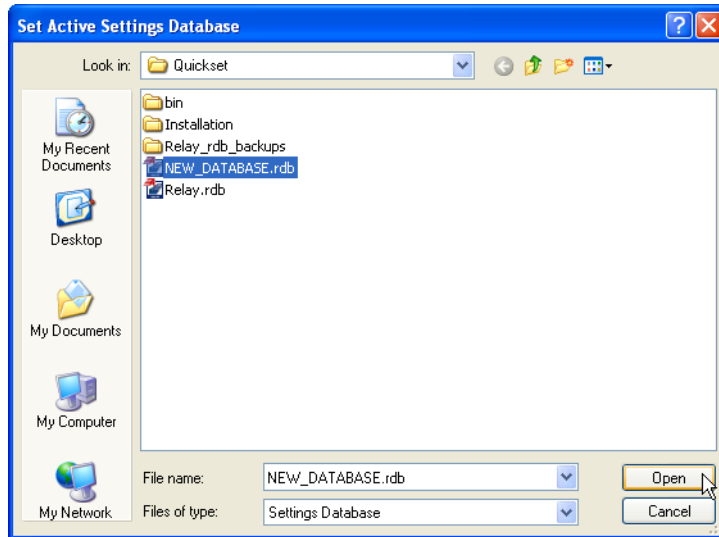


Figure 4.4 Set Active Settings Database Window

## Create New Settings Configuration Editor

ACSELERATOR QuickSet populates new settings editors with all default setting values loaded. Sending these new settings to devices is a good way to reset the device back to factory-default settings. Follow the steps below to create a new settings configuration editor in the active database.

Step 1. Click **File > New**.

The **Settings Editor Selection** window opens similar to *Figure 4.5*, but only your installed settings editor drivers display in the **Device Family** list.

Step 2. Select the appropriate SEL-735 **Device Family**, **Device Model**, and **Version** of the meter to which to send the settings.

Step 3. Click **OK**.

ACSELERATOR QuickSet opens the **Device Part Number** window shown in *Figure 4.6*.

Step 4. Select the part number that matches your meter. You can find the part number on the top or side label of the SEL-735.

Step 5. Click **OK**.

ACSELERATOR QuickSet opens a new settings configuration editor with default settings and displays the settings group tree on the left-hand side of the editor, shown in *Figure 4.7*. Click on any settings tree category to view and configure the associated settings.

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**NOTE:** If you changed the original meter's hardware or form factor, the part number label may not match the actual part number of the meter. ACSELERATOR QuickSet prompts you for the mismatched part number digits.

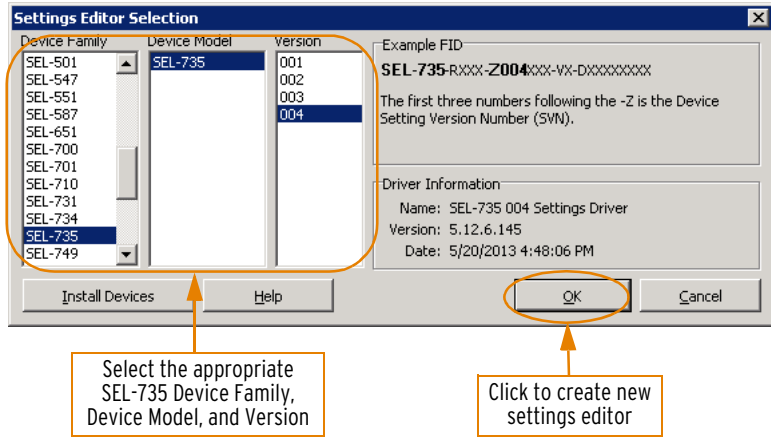


Figure 4.5 Settings Editor Selection Window

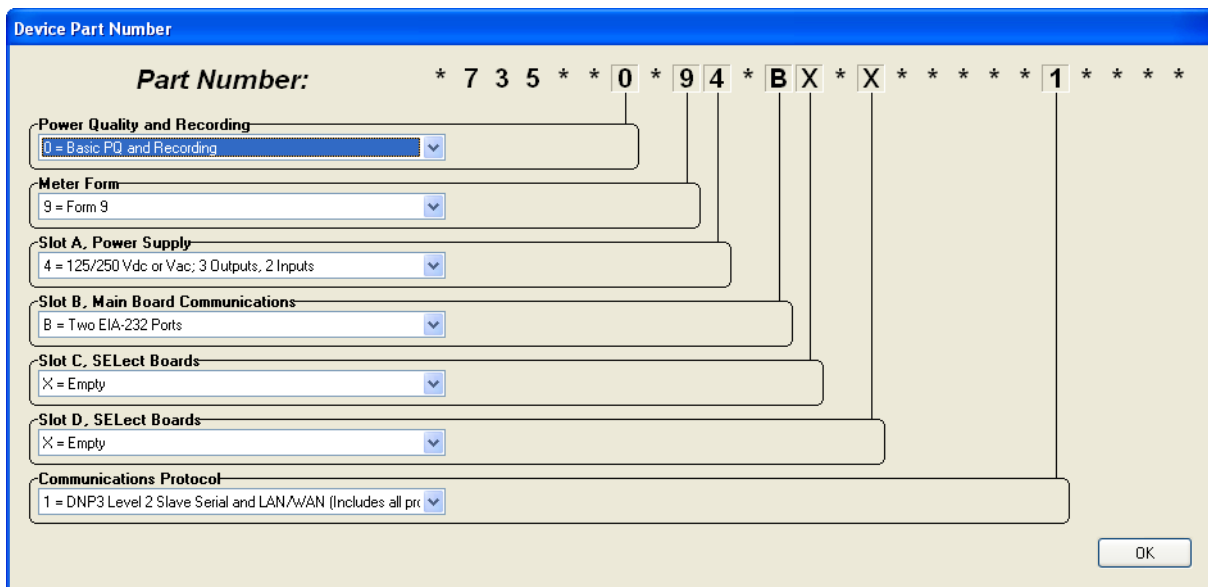


Figure 4.6 Device Part Number Window

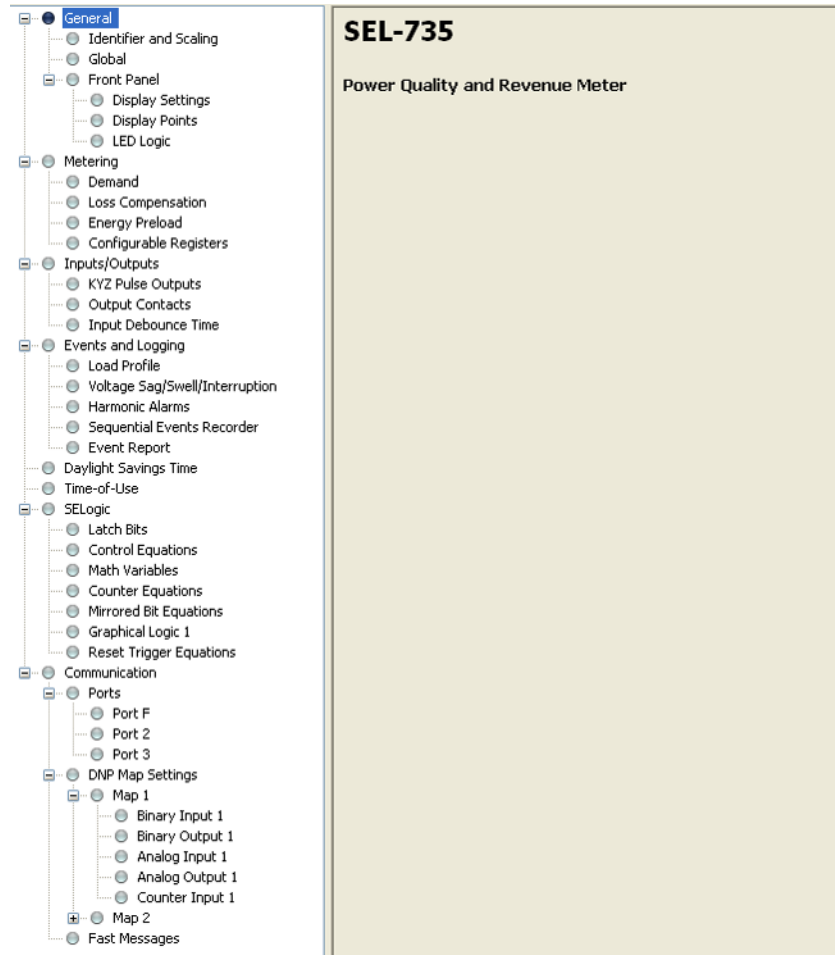


Figure 4.7 SEL-735 Settings Editor Window and Settings Tree

### Read Settings From Meter

ACSELERATOR QuickSet reads the settings from the meter and populates a new editor with the read settings. Follow the steps below to read settings from a meter.

- Step 1. Connect to the meter. Please view *Section 2: Installation* for further information on this step.

### Send Settings Configuration to Meter

After you have the settings configured and are ready to send them to the meter, follow the steps below to send the settings to the meter.

- Step 1. Connect to the meter. Please view the *SEL-735 QuickStart Guide* for further information on this step.

- Step 2. Click on the desired settings editor’s window, ensuring to activate it.

ACSELERATOR QuickSet sends settings from the active settings editor window.

- Step 3. Click **File > Send**.

ACSELERATOR QuickSet opens the **Settings Group/Class Select** window (*Figure 4.8*), but ACSELERATOR QuickSet may automatically select certain settings groups.

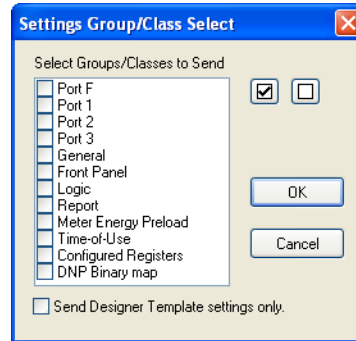
Step 4. Select the settings groups to send to the meter.

ACSELERATOR QuickSet automatically selects the settings groups that you changed after you read the meter's settings.

Step 5. Click **OK**.

ACSELERATOR QuickSet sends only the selected settings groups to the meter.

**NOTE:** If you attempt to send settings to an incompatible device, ACSELERATOR QuickSet prompts you and allows you to convert the settings to the appropriate version.

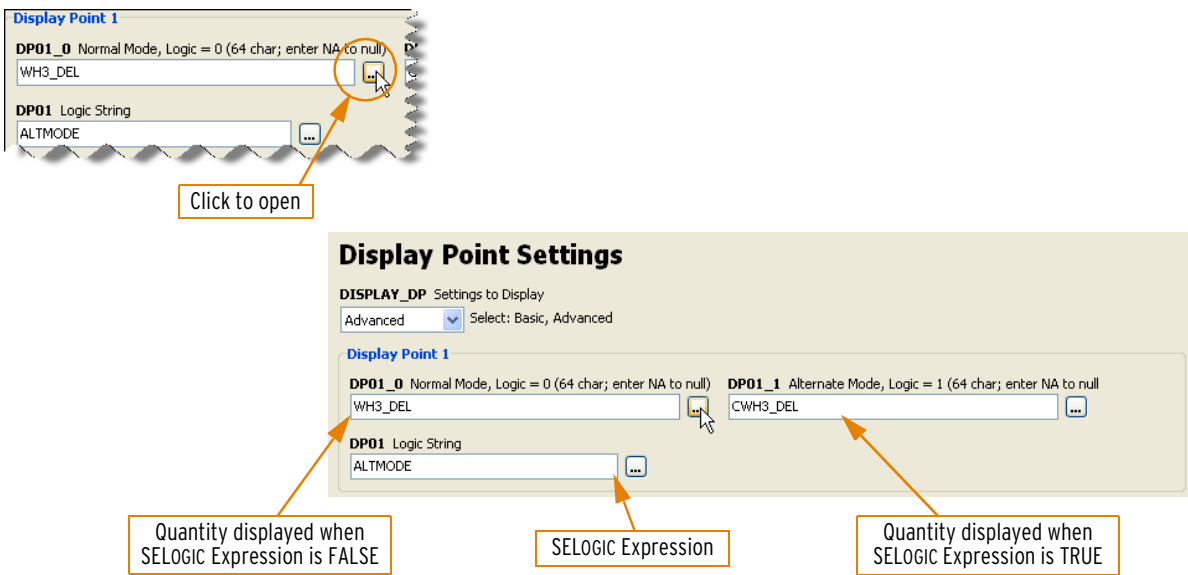


**Figure 4.8** Settings Group/Class Select Window

## Display Point Builder

ACSELERATOR QuickSet has a Display Point builder that greatly simplifies configuration of the display points. The Display Point Builder allows you to configure front-panel display points through an intuitive visual interface.

Each display point displays two different quantities based on the display point control equation,  $DP_n$ , where  $n$  is the display point number. *Figure 4.9* shows the default display point settings associated with Display Point 1. In this example, WH3\_DEL displays when the DP01 SELOGIC® control equation is FALSE and CWH3\_DEL displays when the DP01 SELOGIC control equation is TRUE. Note that the SELOGIC control equation DP01 is set to ALTMODE. ALTMODE is the alternate display mode Device Word bit. ALTMODE toggles when PBDFLT = Y (Pushbutton Default Function is set to Y) and you press PB02. ALTMODE deasserts after the front-panel time-out expires.

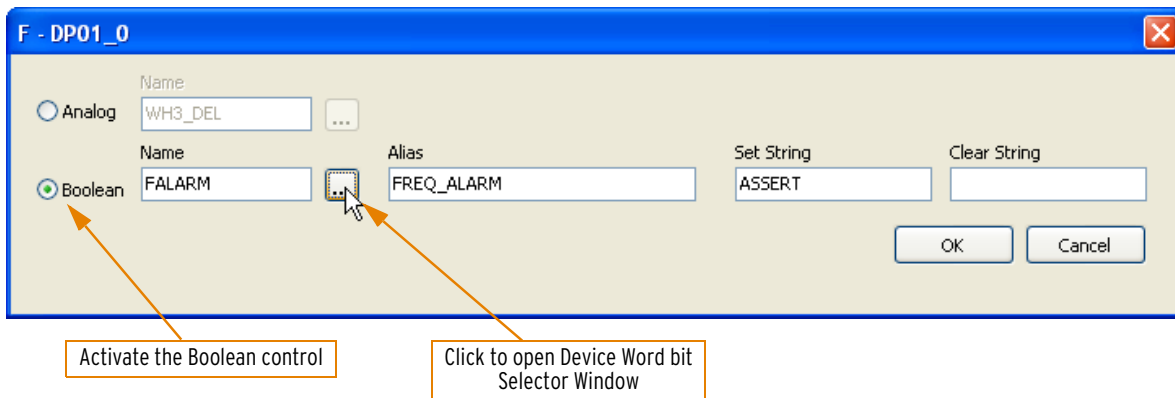


**Figure 4.9** Display Point Settings

Figure 4.10 shows a Boolean Quantity Display Point configuration example. To configure a Boolean display point, refer to Figure 4.10 and perform the following steps.

- Step 1. Click the ellipse button next to the **DP01\_0** setting or the **DP01\_1** setting to open the **Display Point Builder** window. This example shows the Boolean point configured for **DP01\_0**.
- Step 2. Activate the Boolean control.
- Step 3. Click the ellipse button next to the **Boolean Name** text box to open the Device Word Bit selector window.
- Step 4. Select the Device Word Bit you want and click **OK**. The Device Word bit name populates the **Boolean Name** text box.
- Step 5. If you like, enter an Alias string.  
If this field is left blank, the device displays the Device Word bit name in the display point.
- Step 6. Enter the Set String and Clear String.  
You can also choose to leave one of these fields blank. If any string entries are left blank, the meter does not display this point when scrolling through each display point.

The selected Device Word bit controls whether the meter displays the Set String or the Clear String. The Set String displays when the DP01\_0 SELOGIC equation is FALSE and the configured Device Word bit asserts. The Clear String displays when the DP01\_0 SELOGIC equation is FALSE and the configured Device Word bit deasserts. In this example, the meter displays ASSERT when DP01 deasserts and FALARM asserts.



**Figure 4.10 Boolean Quantity Display Point Builder**

An analog quantity display point configuration example is shown in the following Figure 4.11. Click the ellipse button next to the **Analog Name** text box to select from a list of available analog quantities.

In this example, WH3\_DEL displays when the SELOGIC control equation DP01 is TRUE.

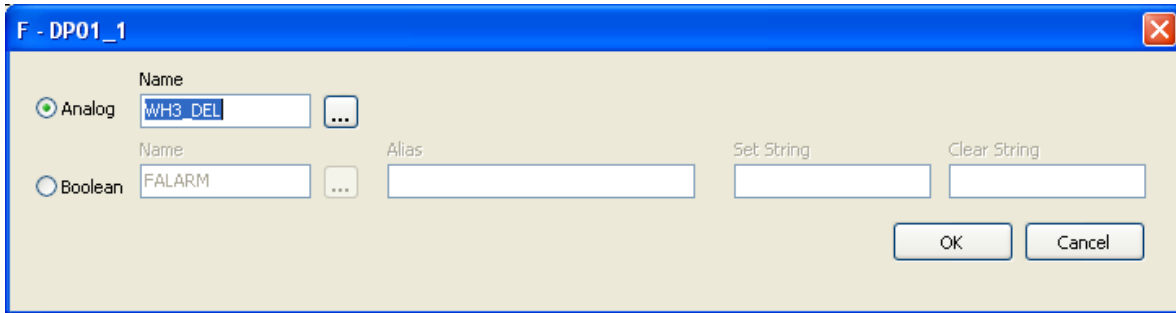
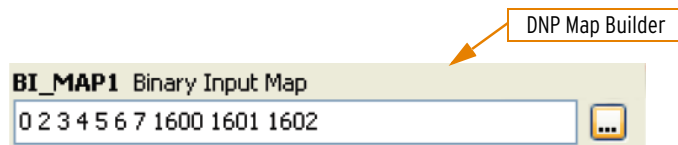


Figure 4.11 Analog Quantity Display Point Configuration Example

## DNP Map Builder

The DNP Map Builder allows you to configure DNP maps through an intuitive visual interface. Press **F1** from the DNP Map Builder for help.

To access the DNP Map Builder, click on the ellipse button next to the associated DNP object group.



The ACSELERATOR QuickSet DNP Map Builder presents two different lists: Available DNP Points and Mapped Elements.

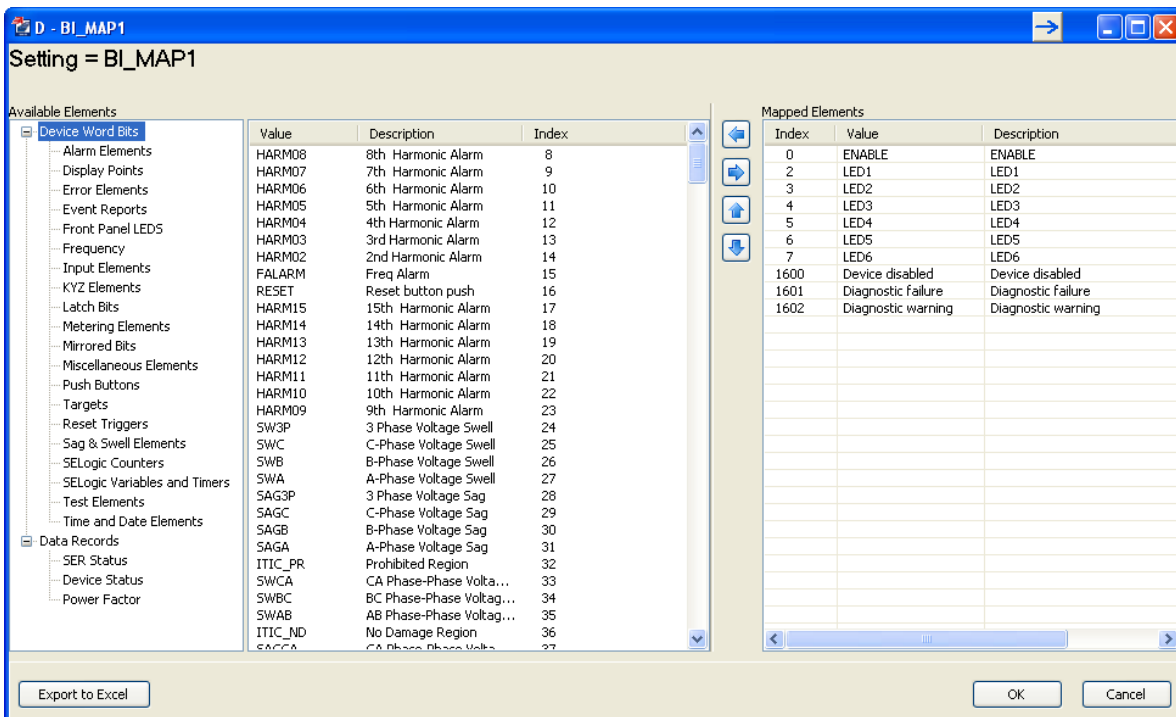


Figure 4.12 DNP Map Builder Window

DNP points named **Reserved** are not registered points in the DNP Map Builder. You can configure reserved points in the DNP Map, but these points provide no metering data.

You can drag any DNP point from one list and drop it into the other and drop it in whatever order you want. You can also reorder DNP points by selecting the point you want and clicking the **UP** or **DOWN** arrow.

If the DNP point has a per-point scaling factor associated with it, you can enter the scale factor in the Selected DNP Points list.

Click **Export to Excel** to export the Selected DNP Points to a Microsoft® Excel® spreadsheet.

## Using the Human Machine Interface (HMI)

### Device Overview

The Device Overview displays the state of various Device Word bits and shows a graphical representation of the SEL-735 front panel.

The front-panel LEDs display in graphical representation in the same state as on the actual front-panel LED. You can change the color of each LED shown in the HMI Device Overview by double-clicking on any of the LEDs.

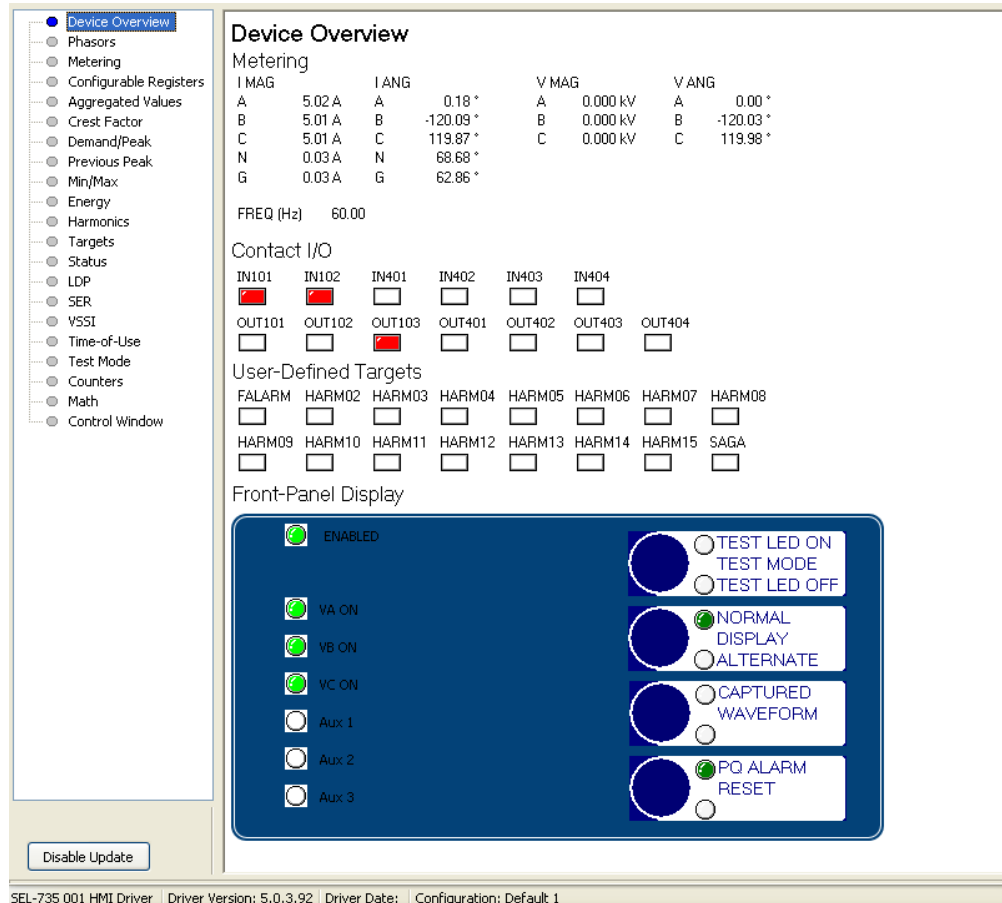


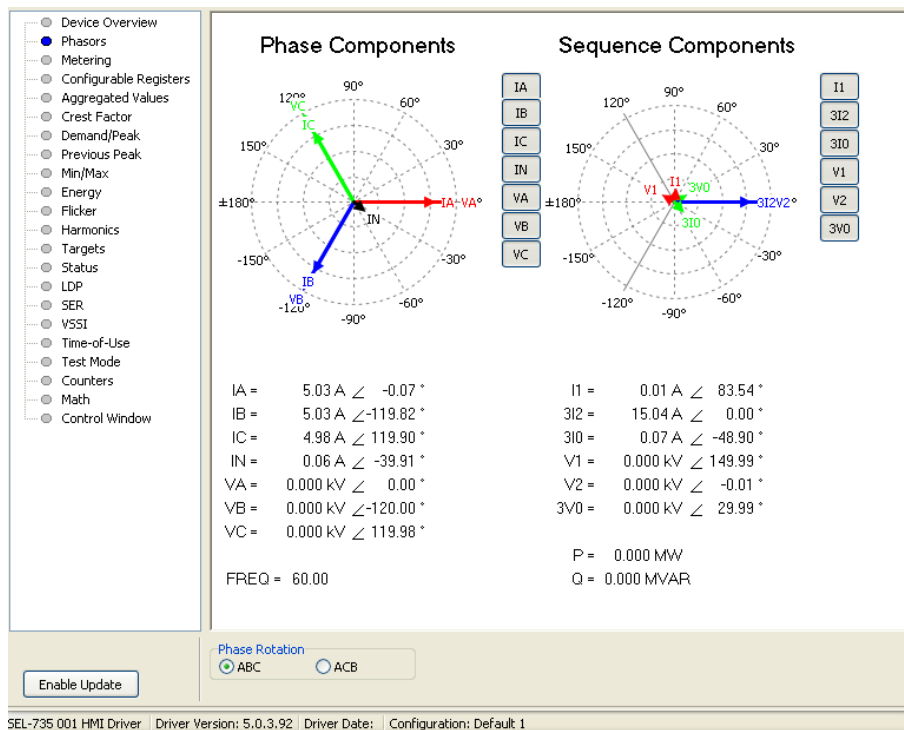
Figure 4.13 Device Overview HMI Window

Follow these guidelines to control the Device Overview HMI.

- Left-click on any simulated LED to change the displayed color to correspond with asserted and deasserted states.
- Left-click on the text label next to each control pushbutton to create custom text labels. *Figure 4.13* shows the window in which you can configure the text labels.
- Click **Disable Update** to stop updating the data.
- Click **Enable Update** to continuously update the data.

## Phasors

The Phasor HMI window displays the voltage and current magnitudes and angles applied to the meter. The Phasor HMI window displays the voltage and current magnitudes and angles of the sequence components. *Figure 4.14* shows an example of the Phasors window.



**Figure 4.14 Phasors HMI Window**

Follow these guidelines to control the Phasors HMI.

- Click on the control buttons next to each phasor plot to toggle the associated quantity on and off.
- Click **Enable Update** to continuously update the data.

## Metering

The Metering HMI window reports to root-mean-square (rms) and fundamental analog quantities. *Figure 4.15* shows the Metering HMI with rms quantities.

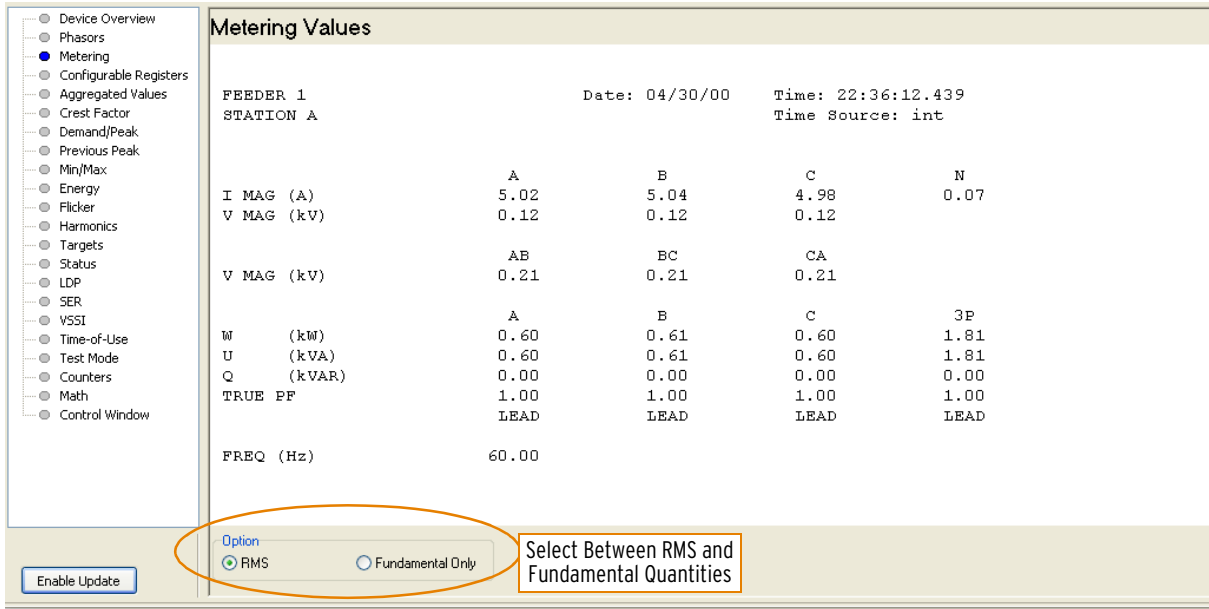


Figure 4.15 Metering HMI Window With RMS Quantities Shown

### Configurable Registers

The Configurable Registers HMI displays each Configurable Registers instantaneous value.

### Aggregated Registers

The Configurable Registers HMI displays each Aggregated Values analog quantity.

### Crest Factor

The Crest Factor HMI displays each Crest Factor instantaneous value and allows you to reset the crest factor.

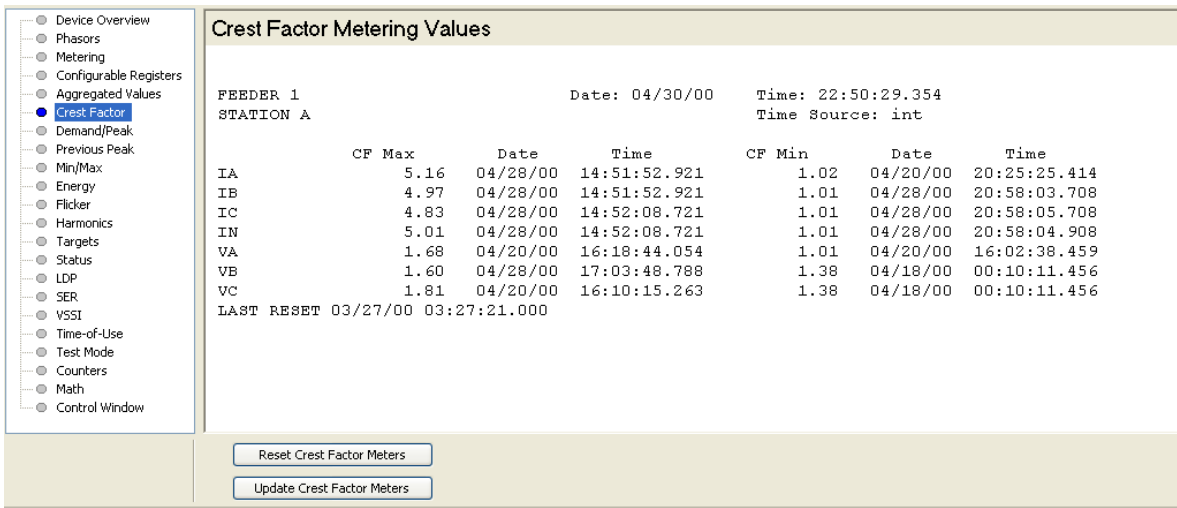


Figure 4.16 Crest Factor HMI Window

Click **Reset Crest Factor Meters** to reset crest factor data and record the date and time of the reset.



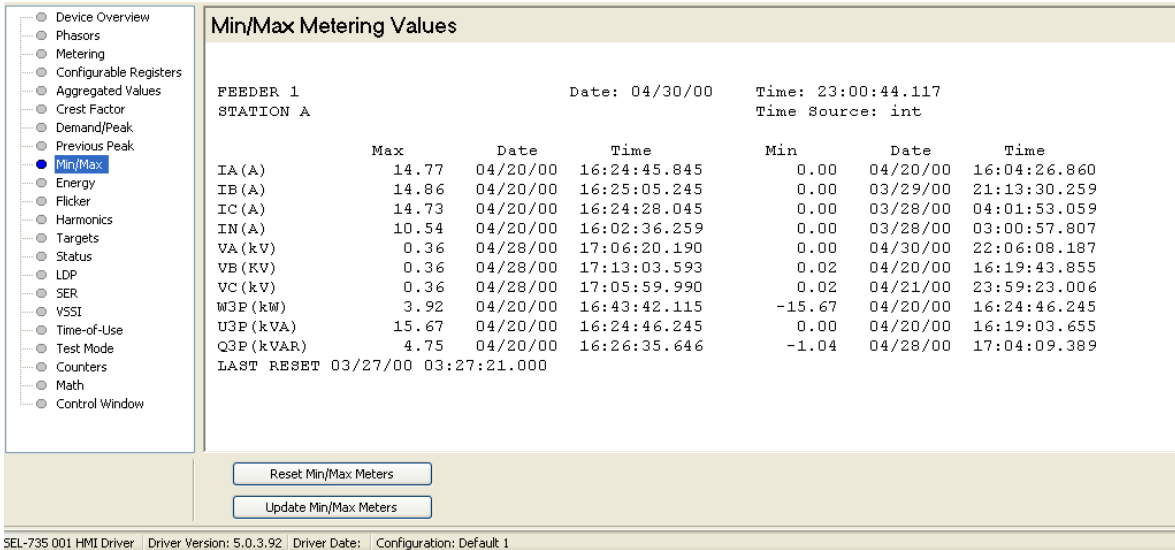


Figure 4.18 Min/Max HMI Window

Follow these guidelines to control the Min/Max HMI.

- Click **Update Min/Max Meters** to update the Min/Max HMI with the most recent data.
- Click **Reset Min/Max Meters** to reset the Min/Max data and record the date and time of the reset.

### Flicker

The Flicker HMI displays the flicker measurements of the SEL-735. When you first enter the Flicker HMI, the SEL-735 updates and displays all flicker values. Update the flicker values by clicking on the **Update Flicker** button near the lower left-hand corner of the Flicker HMI, as shown in *Figure 4.19*.

The Flicker HMI is only available for advanced and intermediate power quality SEL-735 devices.

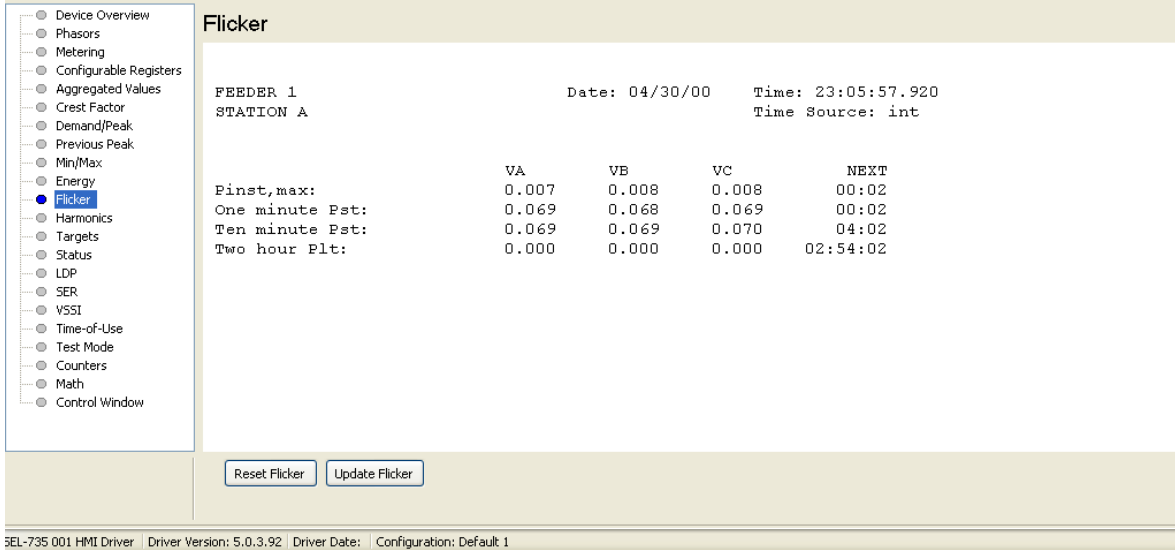


Figure 4.19 Flicker HMI Window

## Harmonics

The Harmonics HMI displays meter harmonic quantities in several user-selectable formats. You can then chart the harmonic data from the HMI.

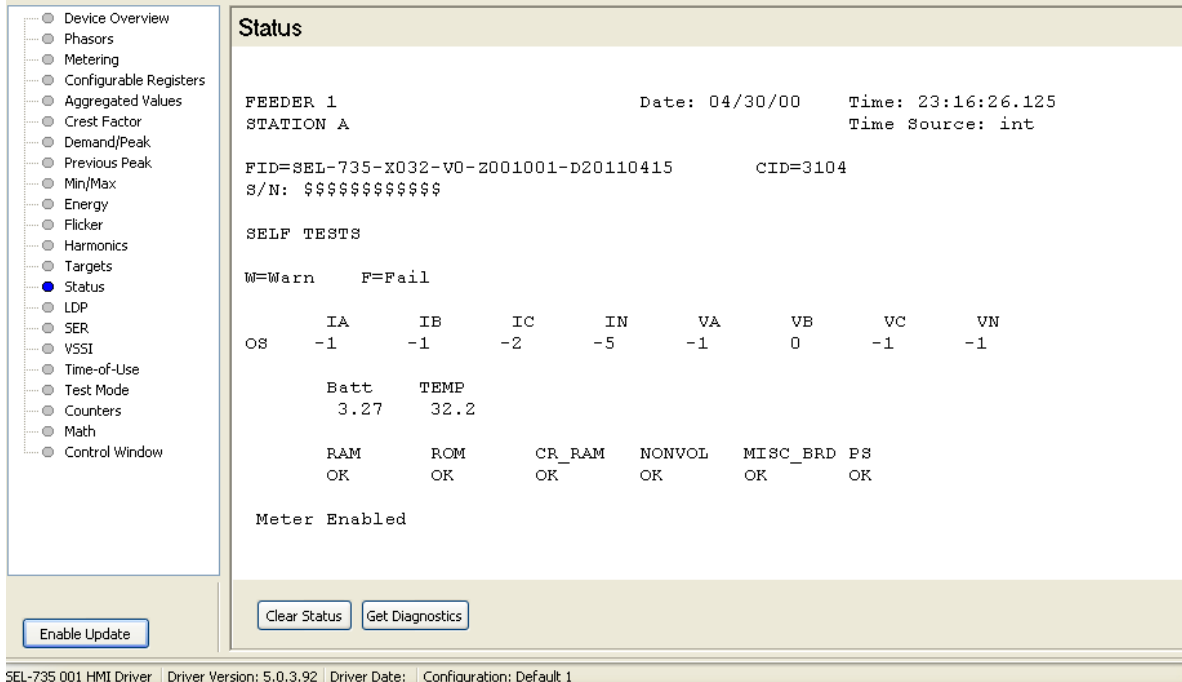
Please see *Section 5: Metering* for a description of the Harmonics HMI window.

## Targets

The Targets HMI displays all Device Word bit states.

## Status

The Status HMI displays device diagnostics data. *Figure 4.20* shows the Status HMI window.



**Figure 4.20** Status HMI Window

Follow these guidelines to control the Status HMI.

- Click **Clear Status** to reset any locked-in diagnostics points.
- Click **Get Diagnostics** to download a diagnostics file from the meter. The file can then be sent to SEL for help in troubleshooting the device.

## LDP (Load Profile), Sequential Events Recorders, VSSI, Time-of-Use

Please see *Section 6: Logging* for details on the following functions.

- Load Profile (LDP)
- Sequential Events Recorders
- Voltage Sag, Swell, Interruptions (VSSI)
- Time-of-Use

## Test Mode

Please see *Section 9: Testing and Troubleshooting* for details on the Time-of-Use HMI window.

## Counters

The Counters HMI displays instantaneous SELOGIC Counters values.

## Math

The Math HMI displays instantaneous SELOGIC Math values.

## Control Window

The Control HMI allows you to use the meter to perform the following.

- Reset Crest Factor data
- Reset Demand data
- Reset Peak Demand data
- Reset Energy data
- Reset Min/Max data
- Clear VSSI data
- Clear SER data
- Clear MIRRORRED BITS® communications by channel
- Clear Event data
- Trigger and Event
- Pulse Output Contacts for a variable amount of time
- Reset Device Word bits
- Issue an IRIG time-synchronization command
- Set the Date and Time
- Set, Clear, and Pulse Remote Bits
- Change ACC, EAC, and 2AC passwords

Figure 4.21 shows an example of the Control Window HMI.

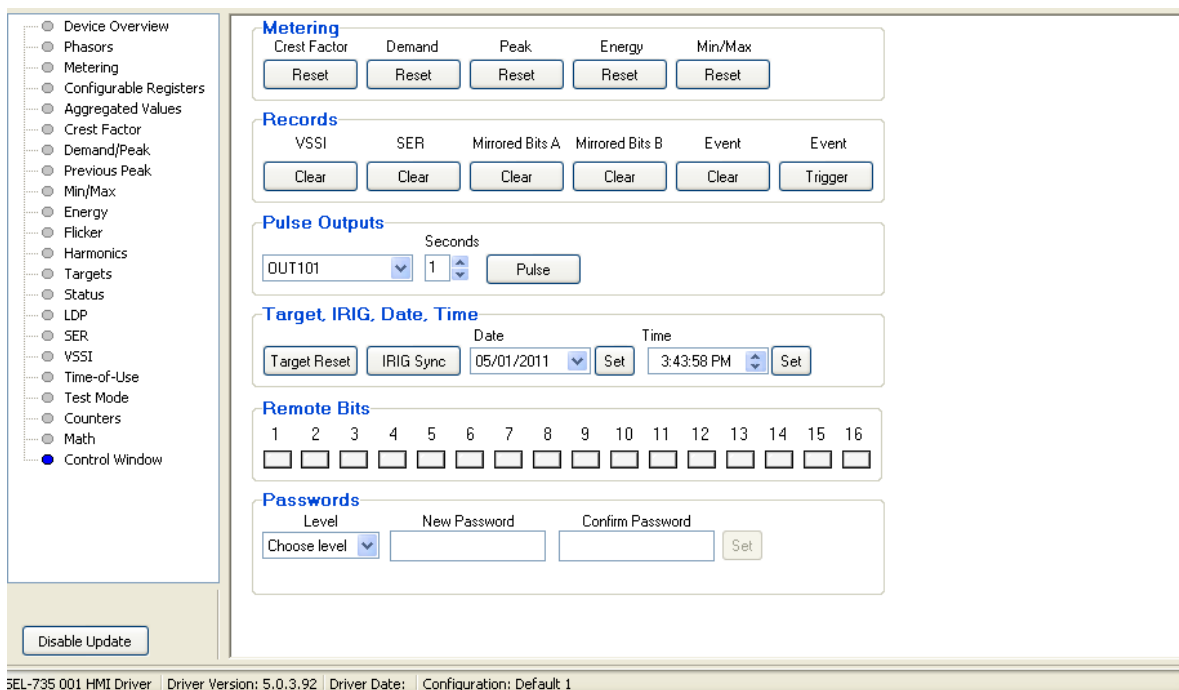


Figure 4.21 Control Window HMI

## Retrieve Event Reports

You may use ACSELERATOR QuickSet to retrieve and view event reports. In order to view event reports you need to retrieve them from the meter and save them to a computer. Follow the steps below to retrieve events from the meter and save them to your computer.

Step 1. Click **Tools > Events > Get Event Files**.

If the meter contains events, then the **Event History** window opens similar to *Figure 4.22*, except ACSELERATOR QuickSet lists all of the events stored on the meter. If the meter does not contain any events, ACSELERATOR QuickSet prompts you with this information.

Step 2. Select the event or events to retrieve.

Step 3. Choose the event type.

ACSELERATOR QuickSet filters 16 Samples/cycle events at the fundamental frequency; these event types do not contain harmonics. Raw event reports contain all of the original event information.

Step 4. Click **Get Selected Events** to retrieve the selected events.

ACSELERATOR QuickSet retrieves the selected events from the meter and opens the **Save Event Report** window similar to *Figure 4.23*.

Step 5. Browse to a location to save the event report.

Step 6. Click **Save**.

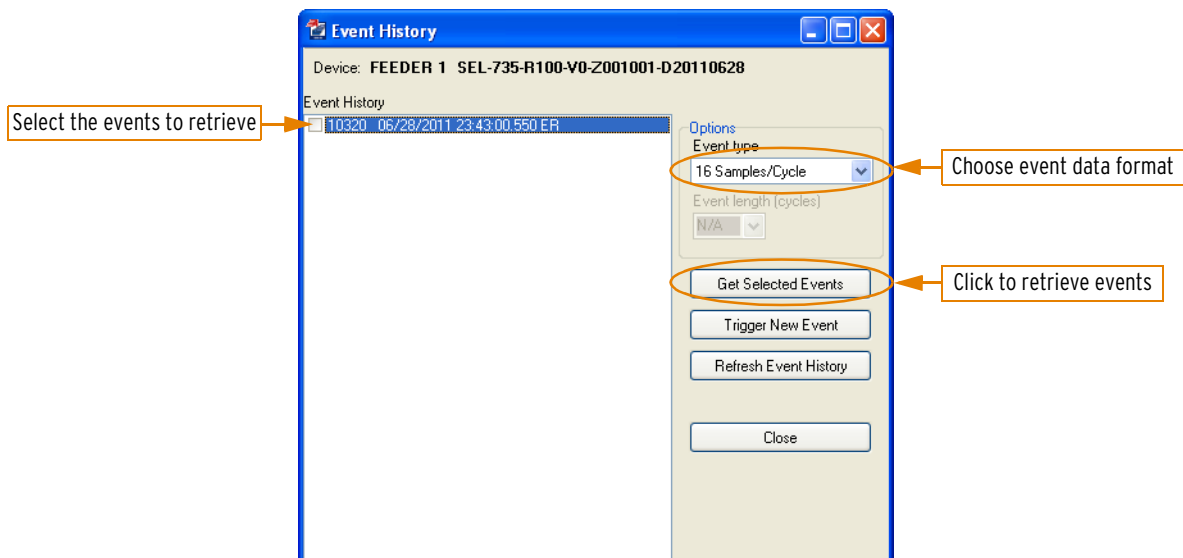


Figure 4.22 Event History Window

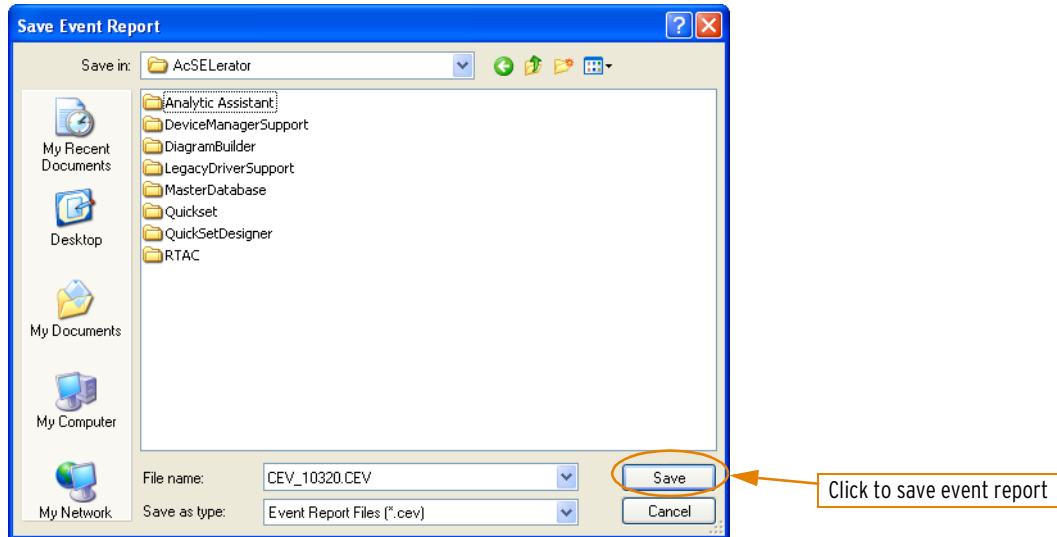


Figure 4.23 Save Event Report Window

## View Event Reports

In order to view event reports from ACSELERATOR QuickSet, you must install ACSELERATOR Analytic Assistant® SEL-5601 Software. You may download the unlicensed program free of charge from [www.selinc.com](http://www.selinc.com) or by using SEL Compass®. Follow the steps below to view an event report.

Step 1. Click **Tools > Events > View Event Files**.

ACSELERATOR QuickSet prompts you with a window to open the event report.

Step 2. Browse to the event report's directory.

Step 3. Click **Open**.

ACSELERATOR QuickSet opens ACSELERATOR Analytic Assistant main control window and displays the oscillography of the event report. *Figure 4.24* shows the ACSELERATOR Analytic Assistant main control window and the available options to view the event report.

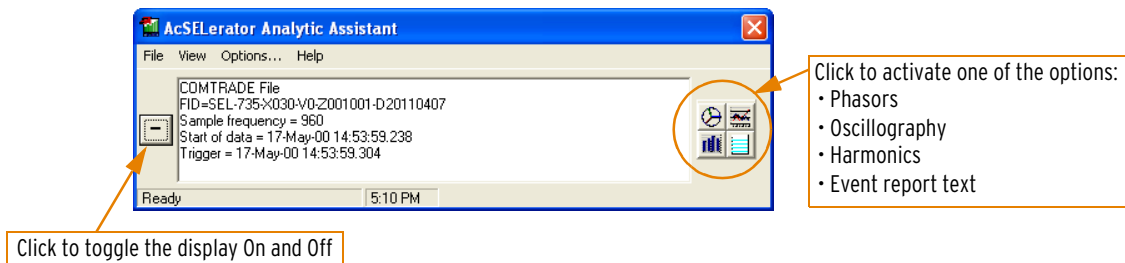


Figure 4.24 ACSELERATOR Analytic Assistant Main Control Window

# SEL-735 Settings Sheets

## General Settings

General settings are available from the front panel and communications ports.

### Identifier and Scaling Settings

#### Meter Identifier Labels

Meter Identifier (20 characters)	<b>MID</b>	:= _____
Terminal Identifier (20 characters)	<b>TID</b>	:= _____

#### Current and Potential Transformer Ratios

Phase Current Transformer Ratio CTR:1 (1.0000–6000)	<b>CTR</b>	:= _____
Potential Transformer Ratio PTR:1 (1.0000–10000)	<b>PTR</b>	:= _____

#### Analog Quantity Scaling Settings

Voltage Scaling (UNITY, KILO, MEGA)	<b>VOLT_SCA</b>	:= _____
Power and Demand Scaling (UNITY, KILO, MEGA)	<b>POWR_SCA</b>	:= _____
Energy Scaling (UNITY, KILO, MEGA)	<b>ENRG_SCA</b>	:= _____
Present Analog Quantities in Primary (Y, N)	<b>PRI_SCA</b>	:= _____

### Instrument Transformer Compensation

For the following settings, replace x with the Phase A, B (Form 9 only), or C, and replace n with the calibration point number.

Enable ITC for Current (N, 1–6)	<b>EITCI</b>	:= _____
Secondary Amps for Calibration Point n (0.01–20.00 A)	<b>ICAL<sub>n</sub></b>	:= _____
CT Ratio Correction Factor (0.9800–1.0200)	<b>IRCF<sub>x_n</sub></b>	:= _____
CT Phase Angle Minutes (–300.0 to 300.0)	<b>IPAM<sub>x_n</sub></b>	:= _____
Enable ITC for Voltage (N, 1–6)	<b>EITCV</b>	:= _____
Secondary Volts for Calibration Point n (5.00–300.00 V)	<b>VCAL<sub>n</sub></b>	:= _____
PT Ratio Correction Factor (0.9800–1.0200)	<b>VRCF<sub>x_n</sub></b>	:= _____
PT Phase Angle Minutes (–300.0 to 300.0)	<b>VPAM<sub>x_n</sub></b>	:= _____

# Global Settings

## Gain Adjustment Settings

Watt Gain % (-10.00 to 10.00)	<b>WGAIN</b>	:= _____
VAR Gain % (-10.00 to 10.00)	<b>VARGAIN</b>	:= _____

## Advanced Global Settings

Watt/VAR angle cutoff (OFF, 1–10 degrees)	<b>ANGCUT</b>	:= _____
Starting Current Threshold ( $x$ –10 mA) ( $x$ is 1.0 mA for CL2/10/20 meters and 5.0 mA for CL10/20 meters)	<b>IST</b>	:= _____
Starting Current Type (ALL, RMS_ONLY)	<b>IST_TYPE</b>	:= _____
Phase rotation (ABC, ACB)	<b>PHROT</b>	:= _____
Date format (MDY, YMD, DMY)	<b>DATE_F</b>	:= _____
Synchrophasor Time Source Type (IRIG, IEEE)	<b>TSTYPE</b>	:= _____
Offset from UTC (-24.00 to 24.00 hours)	<b>UTC_OFF</b>	:= _____

# Front Panel

## Front-Panel Display Settings

Front-Panel Time-out (OFF, 1–120 min)	<b>FP_TO</b>	:= _____
Front-Panel Contrast (1–8)	<b>FP_CONT</b>	:= _____
Display Update Rate in seconds (1–60)	<b>SCROLL</b>	:= _____

## Front-Panel Display Point Settings

Replace  $n$  with the display point value 01-16.

Logic String	<b>DP<math>n</math></b>	:= _____
Display when Logic = 1 (64 characters, NA to null)	<b>DP<math>n</math>_1</b>	:= _____
Display when Logic = 0 (64 characters, NA to null)	<b>DP<math>n</math>_0</b>	:= _____

## Front-Panel LED Logic Settings

Replace  $n$  with the LED value 01-14. T07\_LED–T14\_LED is available only when PBDFLT = Y.

Pushbutton Default Function (Y, N)	<b>PBDFLT</b>	:= _____
Front-Panel LED $n$ Logic	<b>T<math>n</math>_LED</b>	:= _____

# Metering Settings

## Demand

### EDEM Enable Demand Metering Method

Demand Metering (THM = Thermal, ROL = Rolling, BLOK = Block)

**EDEM** := \_\_\_\_\_

### EDEM Enable Demand Metering Method

Time constant (1, 5, 10, 15, 30, 60 minutes)

**DMTC** := \_\_\_\_\_

Sub-interval time constant (see *Table SET.1*)  
(Hidden if EDEM set to THM or BLOK)

**DMSI** := \_\_\_\_\_

**Table SET.1 DMSI Range**

DMTC Value	DMSI Range
1	1 min
5	5, 1 min
10	10, 5, 2, 1 min
15	15, 5, 3 min
30	30, 15, 10, 6, 5, 3 min
60	60, 30, 20, 15, 12, 10, 6, 5 min

Demand Block Time (OFF, 1–300 minutes)

**DBLOCK** := \_\_\_\_\_

Fault Bit Block (SELOGIC control equation)

**FLTBLK** := \_\_\_\_\_

End of Interval Pulse Timer (OFF, 1–5 s)

**EOIPT** := \_\_\_\_\_

Predicted Peak Demand Quantity (any present interval Demand Analog Quantity) (Hidden if EDEM = THRM)

**PRED** := \_\_\_\_\_

Peak Demand Alarm Level (Primary; kilo scaling for power quantities, unity scaling for current quantities units 0.00–1,000,000.00) (Hidden if EDEM = THRM)

**PREDAL** := \_\_\_\_\_

## Loss Compensation Settings

The following settings are available when ETLLC = Y.

### ETLLC Enable Transformer/Line Losses Compensation

Enable Transformer/Line Losses Compensation (Y, N)

**ETLLC** := \_\_\_\_\_

### Meter Position Settings

System Billing Point (1–4)

**BPOS** := \_\_\_\_\_

System Metering Point (1–4)

**MPOS** := \_\_\_\_\_

## Transformer Losses Settings

Transformer Copper Losses Compensation (Y, N) <i>(Hidden if ETLIC = N)</i>	<b>ELCU</b>	:= _____
Transformer Iron Losses Compensation (Y, N) <i>(Hidden if ETLIC = N)</i>	<b>ELFE</b>	:= _____
Transformer Copper Watt Losses (0.00001–10000.00000 kW)	<b>LWCU</b>	:= _____
Transformer Iron Watt Losses (0.00001–10000.00000 kW)	<b>LWFE</b>	:= _____
Transformer 3-Phase MVA Rating (0.00001–10000.00000 MVA)	<b>MVA</b>	:= _____
Primary Line-to-Line Metered Voltage (0.00001–10000.00000 kV)	<b>KVLL</b>	:= _____
Transformer Percentage Impedance (0.001–19.999%)	<b>%Z</b>	:= _____
Transformer Percentage Exciting Current (0.001–19.999%)	<b>%IMAG</b>	:= _____

## Supply and Load Line Losses Settings

Supply Line Resistance (0.0000–999.9999 Ohms, primary)	<b>SLR</b>	:= _____
Supply Line Reactance (0.0000–999.9999 Ohms, primary)	<b>SLX</b>	:= _____
Load Line Resistance (0.0000–999.9999 Ohms, primary)	<b>LLR</b>	:= _____
Load Line Reactance (0.0000–999.9999 Ohms, primary)	<b>LLX</b>	:= _____
Power Transformer Turns Ratio (VSupply/VLoad)	<b>XFTR</b>	:= _____

## Energy Preload Settings

Replace n with the phase number of A, B, or C, or 3 for three-phase. Single-phase settings are only available with Form 9 and Form 36 meters.

### Meter Energy Preload Settings (Compensated)

Load Profile Acquisition Rate (5, 10, 15, 30, 60 min)	<b>LDAR</b>	:= _____
Phase n kWh Delivered (0–9999999999.999 kWh)	<b>KWHn_DEL</b>	:= _____
Phase n kWh Received (0–9999999999.999 kWh)	<b>KWHn_REC</b>	:= _____
Phase n kVAh Delivered (0–9999999999.999 kVAh)	<b>KUHn_DEL</b>	:= _____
Phase n kVAh Received (0–9999999999.999 kVAh)	<b>KUHn_REC</b>	:= _____
Phase n KVARh Delivered Lag (0–9999999999.999 kVARh)	<b>KQHn_DEL_LG</b>	:= _____
Phase n KVARh Delivered Lead (0–9999999999.999 kVARh)	<b>KQHn_DEL_LG</b>	:= _____
Phase n KVARh Received Lag (0–9999999999.999 kVARh)	<b>KQHn_REC_LG</b>	:= _____
Phase n KVARh Received Lead (0–9999999999.999 kVARh)	<b>KQHn_REC_LG</b>	:= _____

## Meter Energy Preload Settings (Uncompensated)

Phase <i>n</i> kWh Delivered (0–99999999999.999 kWh)	<b>KWH<sub>n</sub>_DEL_UC</b>	:= _____
Phase <i>n</i> kWh Received (0–99999999999.999 kWh)	<b>KWH<sub>n</sub>_REC_UC</b>	:= _____
Phase <i>n</i> KVARh Delivered Lag (0–99999999999.999 kVARh)	<b>KQH<sub>n</sub>_DEL_LG_UC</b>	:= _____
Phase <i>n</i> KVARh Delivered Lead (0–99999999999.999 kVARh)	<b>KQH<sub>n</sub>_DEL_LD_UC</b>	:= _____
Phase <i>n</i> KVARh Received Lag (0–99999999999.999 kVARh)	<b>KQH<sub>n</sub>_REC_LG_UC</b>	:= _____
Phase <i>n</i> KVARh Received Lead (0–99999999999.999 kVARh)	<b>KQH<sub>n</sub>_REC_LD_UC</b>	:= _____

## Configurable Registers

The Configurable Registers settings cannot be preconfigured when ordering an SEL-735.

Configurable Register (1–1000)	<b>CONFIGREG</b>	:= _____
Analog Quantity (Analog Quantity)	<b>NAME</b>	:= _____
Alias String (39 chars max)	<b>ALIAS</b>	:= _____
Units String (15 chars max)	<b>UNITS</b>	:= _____
Decimal Places (0–6)	<b>DECIMALS</b>	:= _____
Leading Zeros (Y, N)	<b>LEADINGZEROS</b>	:= _____
Large Font (Y, N)	<b>LARGEFONT</b>	:= _____
User Scale (Y, N)	<b>SCALEUSER</b>	:= _____
Scale (–1 x 10 <sup>10</sup> to 1 x 10 <sup>10</sup> )	<b>SCALEVALUE</b>	:= _____
Offset (–1 x 10 <sup>10</sup> to 1 x 10 <sup>10</sup> )	<b>OFFSET</b>	:= _____
Scale Type (PRIMARY, SECONDARY)	<b>SCALETYPE</b>	:= _____
Units Type (UNITY, KILO, MEGA)	<b>UNITSTYPE</b>	:= _____
Rollover Type (DIALS, VALUE)	<b>ROLLOVERTYPE</b>	:= _____
Rollover Dials (5–12)	<b>ROLLOVERDIALS</b>	:= _____
Rollover Value (0 to 1 x 10 <sup>15</sup> )	<b>ROLLOVERVALUE</b>	:= _____

## Inputs/Outputs

### KYZ Pulse Outputs

#### KYZ Pulse *n* Settings

Replace *n* with the KYZ channel number 1-4.

KE <sub>n</sub> Scale (PRI, SEC)	<b>KE<sub>n</sub>_SCALE</b>	:= _____
Wathour Constant <i>n</i> (0.0001–9,999.0000)	<b>KE<sub>n</sub></b>	:= _____
KE <sub>n</sub> Units (UNITY, KILO, MEGA)	<b>KE<sub>n</sub>_UNIT</b>	:= _____
Demand Type to Output <i>n</i>	<b>KYZD<sub>n</sub></b>	:= _____

KYZ Minimum Pulse Width *n* (25, 50, 75, 100 ms)

**MYZPW*n*** := \_\_\_\_\_

KYZ Output Contact

**KE*n*\_OUT** := \_\_\_\_\_

(Available only with solid-state output contacts.)

### KYZ Pulse Test Mode Setting

Wathour Constant (0.0001–9999)

**KET** := \_\_\_\_\_

## Output Contacts

### Output Contact Equations

Replace *n* with the output contact number 01-03.

Output Contact 1*n*

**OUT1*n*** := \_\_\_\_\_

### Output Contact Equations (Extra I/O Board)

Replace *n* with the output contact number 01-04.

Output Contact 4*n*

**OUT4*n*** \_\_\_\_\_

### Optoisolated Input Timers 101-102

Replace *n* with the optoisolated input number 01-02.

Input IN1*n* debounce time (0–8 ms, AC)

**IN1*n*D** := \_\_\_\_\_

### Optoisolated Input Timers 401-404

Replace *n* with the optoisolated input number 01-04.

Input IN4*n* debounce time (0–8 ms, AC)

**IN4*n*D** := \_\_\_\_\_

### Analog Output Settings

Replace *n* with a value 01-04.

A*On* Analog Quantity

**A*On*AQ** := \_\_\_\_\_

A*On* Analog Quantity Low (–2147483647.000–2147483647)

**A*On*AQL** := \_\_\_\_\_

A*On* Analog Quantity High (–2147483647.000–2147483647)

**A*On*AQH** := \_\_\_\_\_

A*On* Low Analog Output Value (±1.200 or ±24.000)

**A*On*L** := \_\_\_\_\_

A*On* High Analog Output Value (±1.200 or ±24.000)

**A*On*H** := \_\_\_\_\_

# Events and Logging

## Load Profile Settings

### Billing Recorder

Load profile settings consist of 1-12 recorders, each containing as many as 16 elements from Analog Quantities.

Recorder Function (EOI, AVG, COI, MAX, MIN)	<b>LDFUNC1</b>	:= _____
Load Profile List (16 elements max., NA to null)	<b>LDLIST1</b>	:= _____
Load Profile Acquisition Rate (3–59 s; 1, 2, 3, 5, 10, 15, 30, 60, 120 minutes)	<b>LDAR1</b>	:= _____
Load Profile Maximum Duration (0.05–5000.00 days) (3–59 s requires Advanced or Intermediate PQ and Recording)	<b>LMDUR1</b>	:= _____

### Recorder n

For additional recorders, replace n with a value of 2-12. Additional recorders require Advanced or Intermediate PQ and Recording.

Recorder Function (EOI, AVG, COI, MAX, MIN)	<b>LDFUNCn</b>	:= _____
Load Profile List (16 elements max., NA to null)	<b>LDLISTn</b>	:= _____
Load Profile Acquisition Rate (3–59 s; 1, 2, 3, 5, 10, 15, 30, 60, 120 minutes)	<b>LDARn</b>	:= _____
Load Profile Maximum Duration (0.05–5000.00 days) (3–59 s requires Advanced or Intermediate PQ and Recording)	<b>LMDURn</b>	:= _____

## Voltage Sag/Swell/Interruption Settings

L-N Voltage Base (20.00–300.00 V)	<b>VBASE</b>	:= _____
AVG_TIME (OFF, 1–10 min)	<b>AVG_TIME</b>	:= _____

The following Voltage/Sag/Swell/Interruption Settings are in percent of VBASE.

L-N Voltage Interrupt (OFF, 5.00–99.00)	<b>VINT</b>	:= _____
Voltage Interruption Hysteresis (0.00–10.00)	<b>VINTHYS</b>	:= _____
L-N Voltage Sag (OFF, 10.00–99.00)	<b>VSAG</b>	:= _____
Voltage Sag Hysteresis (0.00–10.00)	<b>VSAGHYS</b>	:= _____
L-N Voltage Swell (OFF, 101.00–180.00)	<b>VSWELL</b>	:= _____
Voltage Swell Hysteresis (0.00–10.00)	<b>VSWELHYS</b>	:= _____

## Harmonic Alarms

### Harmonic Triggers

Replace n with the harmonic component 02-15.

The following Harmonic Alarm settings are in percent of VBASE.

Harmonic Trigger Quantities (ALL, VOLTAGE, CURRENT)	<b>HARMTRIG</b>	:= _____
<i>n</i> th Harmonic Threshold (OFF, 3–100%)	<b>HARM<i>n</i></b>	:= _____

### Interharmonic Quantities

Include Interharmonic Quantities (Y, N)	<b>INCIHQ</b>	:= _____
(Requires Advanced or Intermediate PQ and Recording.)		

### Sequential Events Recorder Settings

Replace n with the Sequential Events Recorder number 1-3.

Sequential Events Recorder <i>n</i> (24 elements max., NA to null)	<b>SER<i>n</i></b>	:= _____
--------------------------------------------------------------------	--------------------	----------

## Event Report

Replace n with the Event Report Trigger List number 1-3. Includes optional features.

ER Trigger List <i>n</i>	<b>ER<i>n</i></b>	:= _____
Waveform Capture Sample Rate (16, 128, 512 samples per cycle)	<b>SRATE</b>	:= _____
Event Length (15, 30, 60, 120, 300, 600 cycles)	<b>LER</b>	:= _____
(15 cycles only available with Basic PQ and Recording.)		
(600 cycles not available when SRATE = 512.)		
Prefault Length (1–595 cycles)	<b>PRE</b>	:= _____
(The Prefault Length must be at least 5 cycles less than the Event Length.)		

# SELogic Control Equations

---

## Latch Bits

### Latch Bit Settings

Replace *n* with the Latch Bit number 01-16.

Set Latch Bit <i>LT<sub>n</sub></i>	<b>SET<sub>n</sub></b>	:= _____
LReset Latch Bit <i>LT<sub>n</sub></i>	<b>RST<sub>n</sub></b>	:= _____

## Control Equations

Replace *n* with the SELogic control equation number 01-16.

SELogic Control Equation Variable <i>SV<sub>n</sub></i>	<b>SV<sub>n</sub></b>	:= _____
<i>SV<sub>n</sub></i> Timer Pickup (0.000–1000000.000 seconds)	<b>SV<sub>n</sub>PU</b>	:= _____
<i>SV<sub>n</sub></i> Timer Dropout (0.000–1000000.000 seconds)	<b>SV<sub>n</sub>DO</b>	:= _____

## Math Variables

### Math Variable Equations

Replace *n* with the Math Variable number 01-16.

SELogic Math Equation Variable <i>MV<sub>n</sub></i>	<b>MV<sub>n</sub></b>	:= _____
------------------------------------------------------	-----------------------	----------

## Counter Equations

### Counter Equation Settings

Replace *n* with the Counter number 01-16.

Current Value (0–999999) ( <i>SCnCV</i> must be less than or equal to <i>SCnPV</i> )	<b>SC<sub>n</sub>CV</b>	:= _____
Counter Preset Value (1–999999)	<b>SC<sub>n</sub>PV</b>	:= _____
Reset (SELogic Equation)	<b>SC<sub>n</sub>R</b>	:= _____
Load (SELogic Equation)	<b>SC<sub>n</sub>LD</b>	:= _____
Count Up (SELogic Equation)	<b>SC<sub>n</sub>CU</b>	:= _____
Count Down (SELogic Equation)	<b>SC<sub>n</sub>CD</b>	:= _____

## MIRRORED BITS® Communications Equations

Replace *n* with the Transmit MIRRORED BIT number 1-8.

### MIRRORED BITS Channel A

Channel A, transmit bit <i>n</i>	<b>TMB<sub>n</sub>A</b>	:= _____
----------------------------------	-------------------------	----------

### MIRRORED BITS Channel B

Channel B, transmit bit <i>n</i>	<b>TMB<sub>n</sub>B</b>	:= _____
----------------------------------	-------------------------	----------

## Reset Trigger Equations

### Reset Trigger SELOGIC Equations

Demand Reset (SELOGIC Equation)

**RSTDEM** := \_\_\_\_\_

Peak Demand Reset (SELOGIC Equation)

**RSTPKDM** := \_\_\_\_\_

Reset Energy (SELOGIC Equation)

**RSTENRG** := \_\_\_\_\_

# Communication

## Ports

### Port Security Settings

Enable Port (Y, N) **EPORT** := \_\_\_\_\_

Enable Telnet (Y, N) **ETELNET** := \_\_\_\_\_

Enable Modbus (Y, N) **EMODBUS** := \_\_\_\_\_

Maximum Access Level (1, E, 2) **MAXACC** := \_\_\_\_\_

(If the password jumper is installed, MAXACC does not limit the port's access level and all ports enable regardless of the EPORT setting.)

Enable TCP Keep-Alive (Y, N) **ETCPKA** := \_\_\_\_\_

Enable FTP (Y, N) **EFTPSERV** := \_\_\_\_\_

Enable IEC 61850 Protocol (0–6) **E61850** := \_\_\_\_\_

Enable IEC 61850 GSE (Y, N) **EGSE** := \_\_\_\_\_

EGSE is only available if E61850 > 0.

Enable SNTP (OFF, UNICAST, MANYCAST, BROADCAST) **ESNTP** := \_\_\_\_\_

Enable DNP3 LAN/WAN Sessions (0–5) **EDNP** := \_\_\_\_\_

(ETELNET, EMODBUS, E61850, EGSE, ESNTP, EFTPSERV, ETCPKA, and EDNP only apply to Ethernet ports [Port 1].)

## Communications Settings

### Port 1 (Ethernet) Settings

Telnet Port One (23, 1025–65534) **TPORT** := \_\_\_\_\_

Telnet Port One Idle Time (OFF, 1–30 min) **TIDLE** := \_\_\_\_\_

IP Address **IPADDR** := \_\_\_\_\_

Subnet Mask **SUBNETM** := \_\_\_\_\_

Default Router **DEFRTR** := \_\_\_\_\_

Table SET.2 defines the valid IP Address settings. The most significant byte (MSB) of the IP Address determines the valid range of the setting. For example, if the IP Address MSB is 192, then valid IP Addresses range from 192.0.1 to 192.255.254.254.

**Table SET.2 Valid IP Addresses**

IP Address MSB	Valid IP Address Range	
	From	To
1–126	1.0.0.1	126.255.255.254
128–191	128.1.0.1	191.255.255.254
192–223	192.0.1.1	223.255.254.254

### Keep-Alive Settings

The following settings are used if ETCPKA = Y.

TCP Keep-Alive Idle Range (1–20 s)	<b>KAIDLE</b>	:= _____
TCP Keep-Alive Interval Range (1–20 s)	<b>KAINTV</b>	:= _____
TCP Keep-Alive Count Range (1–20 s)	<b>KACNT</b>	:= _____

### FTP Settings

The following settings are used if EFTPSERV = Y.

FTP User Name	<b>FTPUSER</b>	:= _____
FTP Connect Banner	<b>FTPCBAN</b>	:= _____
FTP Idle Timeout (5–255 min)	<b>FTPIDLE</b>	:= _____

### SNTP Settings

The following settings are only used if ESNTP ≠ OFF.

Primary Server IP Address	<b>SNTPPSIP</b>	:= _____
Backup Server IP Address (SNTPBSIP only available if ESNTP = UNICAST)	<b>SNTPBSIP</b>	:= _____
SNTP IP (Local) Port Number (1–65534)	<b>SNTPPORT</b>	:= _____
SNTP Update Rate (15–3600 s)	<b>SNTPRATE</b>	:= _____
SNTP Timeout (5–20 s) (SNTPTO only available if ESNTP = UNICAST or MANYCAST)	<b>SNTPTO</b>	:= _____

### Port F, Port 2, Port 3, Port 4 Settings

Communications Interface (232, 485, Modem) (COMMINF is only available on Port 4.)	<b>COMMINF</b>	:= _____
Protocol (SEL, MOD, DNP, LMD*, MBA*, MB8A*, MBB*, MB8B*) *Not available on Port F.	<b>PROTO</b>	:= _____

#### Protocol Settings:

Set PROTO = SEL for standard SEL ASCII protocol and MV-90 protocol.

Set PROTO = MOD for Modbus RTU Protocol. Refer to Appendix E: Modbus Communications Protocol for details on Modbus protocol.

Set PROTO = DNP for Distributed Network Protocol (DNP). Refer to Appendix D: Distributed Network Protocol for details on DNP protocol.

Set PROTO = LMD for SEL Distributed Port Switch Protocol.

Set PROTO = MBA, MBB, MB8A, or MB8B for MIRRORRED BITS protocol. Refer to Appendix F: MIRRORRED BITS Communications for details on MIRRORRED BITS communications.

SPEEDs 57600 and 115200 are not available on Port F.

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200)	<b>SPEED</b>	:= _____
Data Bits (6, 7, 8)	<b>BITS</b>	:= _____

Parity (O, E, N) {Odd, Even, None}	<b>PARITY</b>	:= _____
Stop Bits (1, 2)	<b>STOP</b>	:= _____
Enable Hardware Handshaking (Y, N, MBT)	<b>RTSCTS</b>	:= _____

RTSCTS not available on Port 1 (Ethernet), Port 4A (EIA-485), EIA-485 Port 3, or a port configured for SEL Distributed Port Switch Protocol (LMD). With RTSCTS = Y, the meter will not send characters until the CTS input is asserted. If the meter is unable to receive characters, it deasserts the RTS line.

RTSCTS = MBT is only available when SPEED = 9600. In this mode, the meter deasserts the RTS line and does not monitor the CTS line. This selection is normally used with MIRRORED BITS communications, PROTO = MBA or MBB. See Appendix F: MIRRORED BITS Communications for more detail.

Set RTSCTS = Y to enable hardware handshaking.

Minutes to Port Time-out (0–30)	<b>T_OUT</b>	:= _____
---------------------------------	--------------	----------

Set T\_OUT = 0 for no port time out.

Enable Port Power (Y, N)	<b>EPP</b>	:= _____
--------------------------	------------	----------

Enable or disable Pin 1 +5 V power on EIA-232 Port 2 or Port 3. Port power is disabled by default.

Send Auto Messages to Port (Y, N)	<b>AUTO</b>	:= _____
-----------------------------------	-------------	----------

AUTO only available if PROTO = SEL or LMD. Set AUTO = Y to allow automatic messages at the serial port.

Fast Operate Enable (Y, N)	<b>FASTOP</b>	:= _____
----------------------------	---------------	----------

FASTOP only available if PROTO = SEL or LMD.

Set FASTOP = Y to enable binary Fast Operate messages at the serial port. Set FASTOP = N to block binary Fast Operate messages. Refer to Appendix C: SEL Communications Processors for the description of the SEL-735 Fast Operate commands.

Sync. Phasor Transmission Data Set (V1, V, A)	<b>PMDATA</b>	:= _____
-----------------------------------------------	---------------	----------

PMDATA only available if PROTO = SEL or LMD.

Address of Sync. Phasor Measurement Data (0x–FFFFFFFh)	<b>PMADDR</b>	:= _____
--------------------------------------------------------	---------------	----------

PMADDR only available if PROTO = SEL or LMD.

## LMD Protocol Settings

The following settings are used if PROTO = LMD.

LMD Prefix (@, #, \$, %, &)	<b>PREFIX</b>	:= _____
LMD Address (1–99)	<b>ADDR</b>	:= _____
LMD Settling Time (0.00–30.00 s)	<b>SETTLE</b>	:= _____

## Modem Settings

Modem Initialization AT String	<b>ATSTRING</b>	:= _____
--------------------------------	-----------------	----------

ATSTRING is only available if COMMINF = MODEM.

## DNP Serial Settings

The following settings are only available on Port F, Port 2, Port 3, and Port 4.

DNP Address (0–65519)	<b>DNPADR</b>	:= _____
DNP Address to Report to (1–65519)	<b>REPADR</b>	:= _____

DNP Session Map (1, 2)

**DNPMAP** := \_\_\_\_\_

### Event Data by Class

Class for Binary Event Data (0–3)

**ECLASSB** := \_\_\_\_\_

Class for Counter Event Data (0–3)

**ECLASSC** := \_\_\_\_\_

Class for Analog Event Data (0–3)

**ECLASSA** := \_\_\_\_\_

### Scaling Decimal Places

Amps Scaling Decimal Places (0–6)

**DECPLA** := \_\_\_\_\_

Voltages Scaling Decimal Places (0–6)

**DECPLV** := \_\_\_\_\_

Misc Data Scaling Decimal Places (0–6)

**DECPLM** := \_\_\_\_\_

Energy Counter Scaling Decimal Places (0–6)

**DECPLE** := \_\_\_\_\_

### Reporting Dead-band Counts

Amps Reporting Dead-band Counts (0–32767)

**ANADBA** := \_\_\_\_\_

Volts Reporting Dead-band Counts (0–32767)

**ANADBV** := \_\_\_\_\_

Misc Data Reporting Dead-band Counts (0–32767)

**ANADBM** := \_\_\_\_\_

### Timeouts

Minutes for Request Interval (I, M, 1–32767)

**TIMERQ** := \_\_\_\_\_

Seconds to Select/Operate Time-Out (0.0–30)

**STIMEO** := \_\_\_\_\_

Event Message Confirm Timeout (1–50 s)

**ETIMEO** := \_\_\_\_\_

### Data Link

Retries (0–15)

**DRETRY** := \_\_\_\_\_

Seconds to Time-Out (0–5)

**DTIMEO** := \_\_\_\_\_

(DTIMEO only available if DRETRY > 0.)

### Class 0 Reporting

Class 0 Response Counter Object (20, 21, Both)

**CZPCT** := \_\_\_\_\_

### Unsolicited Messages

Enable Unsolicited Reporting (Y, N)

**UNSOL** := \_\_\_\_\_

The following Unsolicited Message settings are only available if UNSOL = Y.

Enable Unsolicited Reporting at Power-Up (Y, N)

**PUNSOL** := \_\_\_\_\_

Number of Events to Transmit On (1–200)

**NUMEVE** := \_\_\_\_\_

Oldest Event to Transmit On (0–99999 s)

**AGEEVE** := \_\_\_\_\_

Unsolicited Message Max Retry Attempts (2–10)	<b>URETRY</b>	:= _____
Unsolicited Message Offline Timeout (1–5000 s)	<b>UTIMEO</b>	:= _____

### Serial Control Lines

Minimum Seconds from DCD to TX (0.00–1)	<b>MINDLY</b>	:= _____
Maximum Seconds from DCD to TX (0.00–1)	<b>MAXDLY</b>	:= _____
Settle Time from RTS On to TX (OFF, 0.00–30 s)	<b>PREDLY</b>	:= _____
Settle Time from TX to RTS OFF (0.00–30 s)	<b>PSTDLY</b>	:= _____

## DNP Ethernet Session Settings

The following settings are only available on Port 1 and when EDNP > 0.

DNP TCP and UDP Port (1–65534)	<b>DNPNUM</b>	:= _____
DNPNUM applies to all Ethernet DNP sessions.		
DNP Address (0–65519)	<b>DNPADR</b>	:= _____
DNPADR applies to all Ethernet DNP sessions.		

### DNP Ethernet Session n

Replace n with the DNP session number 2-5. If n is omitted, then the setting applies to DNP Session 1.

### DNP IP Network

DNP Session Map (1, 2)	<b>DNPMAP[n]</b>	:= _____
Transport Protocol (UDP, TCP)	<b>DNPTR[n]</b>	:= _____
Master IP Address (zzz.yyy.xxx.www)	<b>DNPIP[n]</b>	:= _____
UDP Response Port (REQ, 1–65534)	<b>DNPUDP[n]</b>	:= _____
DNP Address to Report To (1–65519)	<b>REPADR[n]</b>	:= _____

### Event Data by Class

Class for Binary Event Data (0–3)	<b>ECLASSB[n]</b>	:= _____
Class for Counter Event Data (0–3)	<b>ECLASSC[n]</b>	:= _____
Class for Analog Event Data (0–3)	<b>ECLASSA[n]</b>	:= _____

### Scaling Decimal Places

Amps Scaling Decimal Places (0–6)	<b>DECPLA[n]</b>	:= _____
Voltages Scaling Decimal Places (0–6)	<b>DECPLV[n]</b>	:= _____
Misc Data Scaling Decimal Places (0–6)	<b>DECPLM[n]</b>	:= _____
Energy Counter Scaling Decimal Places (0–6)	<b>DECPLE[n]</b>	:= _____

## Reporting Dead-band Counts

Amps Reporting Dead-band Counts (0–32767)	<b>ANADBA</b> [ <i>n</i> ] := _____
Volts Reporting Dead-band Counts (0–32767)	<b>ANADBV</b> [ <i>n</i> ] := _____
Misc Data Reporting Dead-band Counts (0–32767)	<b>ANADBM</b> [ <i>n</i> ] := _____

## Timeouts

Minutes for Request Interval (I, M, 1–32767)	<b>TIMERQ</b> [ <i>n</i> ] := _____
Seconds to Select/Operate Time-Out (0.0–30)	<b>STIMEO</b> [ <i>n</i> ] := _____
Event Message Confirm Timeout (1–50 s)	<b>ETIMEO</b> [ <i>n</i> ] := _____

## Data Link

Seconds to Send Data Link Heartbeat (0–7200)	<b>DNPINA</b> [ <i>n</i> ] := _____
----------------------------------------------	-------------------------------------

## Class 0 Reporting

Class 0 Response Counter Object (20, 21, Both)	<b>CZPCT</b> [ <i>n</i> ] := _____
------------------------------------------------	------------------------------------

## Unsolicited Messages

Enable Unsolicited Reporting (Y, N)	<b>UNSOL</b> [ <i>n</i> ] := _____
The following Unsolicited Message settings are only available if UNSOL = Y.	
Enable Unsolicited Reporting at Power-Up (Y, N)	<b>PUNSOL</b> [ <i>n</i> ] := _____
Number of Events to Transmit On (1–200)	<b>NUMEVE</b> [ <i>n</i> ] := _____
Oldest Event to Transmit On (0–99999 s)	<b>AGEEVE</b> [ <i>n</i> ] := _____
Unsolicited Message Max Retry Attempts (2–10)	<b>URETRY</b> [ <i>n</i> ] := _____
Unsolicited Message Offline Timeout (1–5000 s)	<b>UTIMEO</b> [ <i>n</i> ] := _____

## DNP Map Settings

### DNP Map *n*

Replace *n* with the DNP map number 1 or 2.

Binary Input <i>n</i>	<b>BI_MAP</b> <i>n</i> := _____
Binary Output <i>n</i>	<b>BO_MAP</b> <i>n</i> := _____
Analog Input <i>n</i>	<b>AI_MAP</b> <i>n</i> := _____
Analog Output <i>n</i>	<b>AO_MAP</b> <i>n</i> := _____
Counter Input <i>n</i>	<b>CO_MAP</b> <i>n</i> := _____

## Fast Messages

Enable Energy Message (Y, N)	<b>FMR1</b>	:= _____
Enable 4–Quadrant Demand Message (Y, N)	<b>FMR2</b>	:= _____
Enable 4–Quadrant Peak Demand Message (Y, N)	<b>FMR3</b>	:= _____
Enable 4–Quadrant Meter Message (Y, N)	<b>FMR4</b>	:= _____
Uncompensated Quantities in Fast Message (Y, N)	<b>FMQ_UC</b>	:= _____

## Modem Settings

The following settings are only available when COMMINF = MODEM.

Dial Out When a New Event Is Recorded (Y, N)	<b>DIALOUT</b>	:= _____
DIALOUT only available on Modem ports and PROTO = SEL.		
Event Notification String (30 chars max.)	<b>EVE_STR</b>	:= _____
EVESTR only available on Modem port and DIALOUT = Y.		
ID Command String (20 chars max.)	<b>ID_CMD</b>	:= _____
ID_CMD only available on Modem port and DIALOUT = Y.		
Connection ID String (20 chars max.)	<b>CONN_ID</b>	:= _____
CONN_ID only available on Modem ports and DIALOUT = Y.		
Modem Connected to Port (Y, N)	<b>MODEM</b>	:= _____
MODEM only available when PROTO = DNP and COMMINF = 232 or the physical port is an EIA-232 port.		
Modem Initialization at String (30 chars max.)	<b>ATSTRING</b>	:= _____
ATSTRING only available on Modem port.		
Modem Startup String (30 chars max.)	<b>MSTR</b>	:= _____
Phone Number for Dial-Out (30 chars max.)	<b>PH_NUM</b>	:= _____
Time to Attempt Dial (5–300 s)	<b>MDTIME</b>	:= _____
Time Between Dial-Out Attempts (5–3600 s)	<b>MDRET</b>	:= _____

MSTR, PH\_NUM, MDTIME, and MDRET are only available on EIA-232 serial ports and MODEM = Y with PROTO = DNP; or PROTO = SEL with DIALOUT = Y. Additionally, MSTR is not available on Port 4.

## Modbus Protocol Settings

Modbus Slave ID (1–247)	<b>SLAVEID</b>	:= _____
SLAVEID is only available when PROTO = MOD.		

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# Section 5

## Metering

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### Overview

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This section explains the following SEL-735 functions.

- *IEC 61000-4-30 Testing and Measurement Techniques—Power Quality Measurement Methods*
- *Measurement Aggregation on page 5.2*
- *Four-Quadrant VAR Metering on page 5.5*
- *Demand Metering on page 5.10*
- *Energy Metering on page 5.31*
- *Minimum/Maximum Metering on page 5.36*
- *Crest Factor Metering on page 5.38*
- *Harmonic Metering on page 5.39*
- *Flicker Metering on page 5.44*
- *Transformer/Line Loss Compensation on page 5.45*
- *Configurable Registers on page 5.51*
- *Voltage, Current, and Power Calculations on page 5.55*

Each section also describes how to access the metered data. Analog quantities are divided into similar measurement categories and are available to all interfaces. Please see *Appendix G* for a list of all supported analog quantities.

### Form Factor Support

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The SEL-735 supports the three following metering form factors:

1. Form 5, 2-Element, Three-Wire Delta
2. Form 9, 3-Element, Four-Wire Wye
3. Form 36, 2 1/2-Element, Four-Wire Wye

Form 5 and Form 9 meters are Blondel compliant, whereas Form 36 meters are not Blondel compliant. Form 36 metering relies on the assumption that the three-phase voltages are balanced and that voltage VBN can be calculated by  $VBN = -(VAN + VCN)$ . If the voltages are not balanced, the reported values will not be accurate.

To change the meter's form factor, issue the **FORM** command from the **2AC** access level. The command syntax is shown below.

Syntax: **FORM x** [*x* is the desired form factor 5 (form 5), 6 (form 36), or 9 (form 9)]

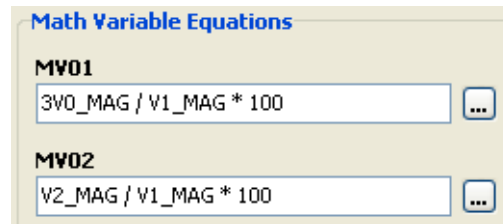
# IEC 61000-4-30 Testing and Measurement Techniques—Power Quality Measurement Methods

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The SEL-735 uses the IEC standard 61000-4-30 *Testing and Measurement Techniques—Power Quality Measurement Methods* when calculating quantities.

The standard describes very specific calculation and aggregation methods. The list below defines the SEL-735 deviations from the exact definition of the standard.

- All 10/12 cycle quantities synchronize to the 10-minute real-time clock tick without overlap.
- For zero-sequence unbalance, use SELOGIC math variable equations as demonstrated below.



- Interharmonic quantities update every 10 cycles. The SEL-735 load profile recorder can average interharmonics over 3-second, 10-minute, and 2-hour intervals.
- Harmonic reports include individual components, groups, and phase angles, but not subgroups.
- Voltage sag/swell/interruption disturbances sample over a half-cycle window instead of a 1-cycle window.
- The time window for harmonic calculations is within  $\pm 0.06$  percent.
- Harmonic and interharmonic calculations use a Hanning window to improve accuracy.

## Measurement Aggregation

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The SEL-735 performs aggregation of metered quantities for 3 seconds, 10 minutes, and 2 hours in accordance with IEC 61000-4-30 Edition 2.0 2008-10 Class A.

### Analog Quantities

The following quantities are available as aggregated quantities:

- Voltage, Current, and Power
- Current and Voltage Imbalance
- Voltage and Current Harmonic Magnitudes
- Voltage and Current Total Harmonic distortion

## Processing

The SEL-735 uses the following equation to perform aggregation.

$$\text{Value}_{\text{Aggregate}} = \sqrt{\frac{1}{N} \sum_{i=0}^{N-1} \text{input}[i]^2}$$

where:

Value<sub>Aggregate</sub> = the time-aggregated value.

Input = the value to aggregate.

N = the number of accumulations performed during the aggregation period.

N	Aggregation Interval
3000 <sup>a</sup>	10 minutes
12	2 hours
15	150/180 cycles

<sup>a</sup> This value varies depending on the system frequency.

## Aggregation Time Periods

### 150/180 Cycles

Aggregation calculates 15 consecutive 10/12 cycle data synchronized to the system frequency.

### 10 Minute

Each 10-minute aggregation calculation begins on an absolute 10-minute boundary of the RTC.

### 2 Hour

Each 2-hour aggregation calculates from 12 consecutive sets of 10-minute values.

## Aggregation Reset

The 10-minute and 2-hour aggregated values and time stamps reset any time the device resets or the system time changes by more than 5 seconds. The values report zero until the conclusion of the next whole aggregation period.

## Flagging

The SEL-735 Sequential Events Recorder (SER) flag analog data stored in the load profile recorder to meet the requirements of IEC 61000-4-30. Add the Device Word bits in *Table 5.1* to the SEL-735 SER equation, as shown in *Figure 5.1*.

During an event, the SEL-735 records every Device Word bit change with a time stamp. View the LDP records to determine if any logged quantity is associated with an event flag.

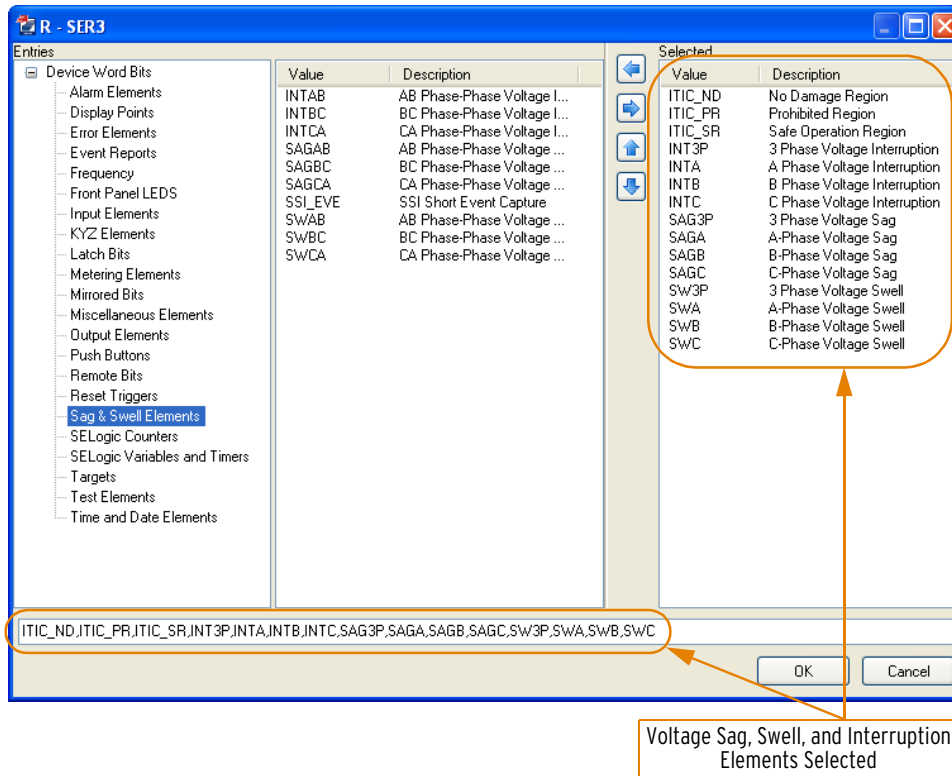
**Table 5.1 Device Word Bits Associated With Voltage Sags, Swells, and Interruptions (Sheet 1 of 2)**

Device Word Bit	Definition
ITIC_ND	ITIC No Damage Region
ITIC_PR	ITIC Prohibited Region
ITIC_SR	ITIC Safe Operation Region

**NOTE:** When the SEL-735 is set up as a Form 36 meter, the B-phase voltage is calculated, not measured. The SEL-735 will not assert any B-phase voltage Sag, Swell, or Interrupt Device Word bits. The B-phase voltage quantities that do appear in power quality reports are calculated. These quantities should not be considered to reflect actual system conditions.

**Table 5.1 Device Word Bits Associated With Voltage Sags, Swells, and Interruptions (Sheet 2 of 2)**

Device Word Bit	Definition
SAGx	Voltage sag on phase x
SWx	Voltage swell on phase x
INTx	Voltage interruption on phase x
SAG3P	Voltage sag on all three phases
SW3P	Voltage swell on all three phases
INT3P	Voltage interruption on all three phases



**Figure 5.1 Selected Sag and Swell Elements in a Sequential Events Recorder**

## Logging

By default, advanced intermediate recording meters have load profile records configured to log aggregated data in accordance with *Table 5.2*.

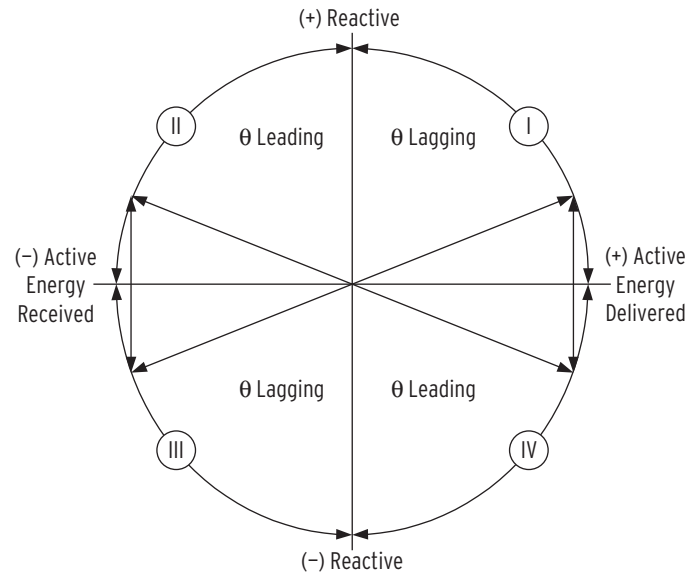
**Table 5.2 Default Load Profile Recorder Aggregated Data**

Load Profile Record Number	Aggregated Data
4	10-minute aggregated voltages, currents, voltage THD, current THD, and voltage imbalance
6	2-hour aggregated voltages, currents, voltage THD, current THD, and voltage imbalance

Aggregated values in load profile include time stamps with +12/-0 cycle precision at each 10-minute and 2-hour boundary. For example, on a 60 Hz system, time stamps range from 0.000 to 0.199 seconds because 12 cycles is 200 milliseconds long.

# Four-Quadrant VAR Metering

The SEL-735 calculates four-quadrant voltampere reactive (VAR) values, following the IEEE VAR sign convention as illustrated in *Figure 5.2*. *Appendix G: Analog Quantities and Device Word Bits* lists each four-quadrant quantity the meter reports.



Quadrant	Power Factor	Watts	Vars
I	Lag	Delivered (+)	Delivered (+)
II	Lead	Received (-)	Delivered (+)
III	Lag	Received (-)	Received (-)
IV	Lead	Delivered (+)	Received (-)

**Figure 5.2 IEEE VAR Sign Convention**

The SEL-735 displays VARs in four separate quadrants I–IV.

Delivered-Lagging (I)

Delivered-Leading (II)

Received-Lagging (III)

Received-Leading (IV)

The SEL-735 displays watts in four separate quadrants I–IV.

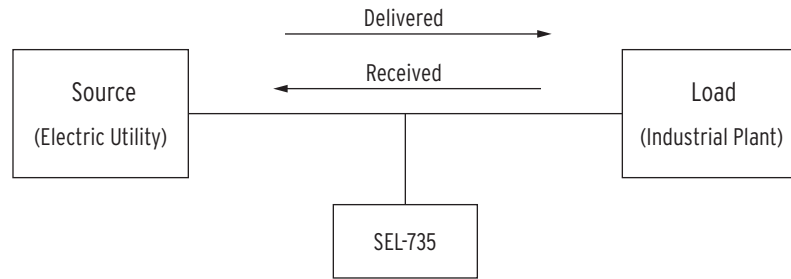
Delivered-Lagging (I)

Delivered-Leading (IV)

Received-Lagging (III)

Received-Leading (II)

Figure 5.3 demonstrates the power flow convention of the SEL-735.



**Figure 5.3 SEL-735 Power Flow Notations**

## Four-Quadrant Device Word Bits

In addition to displaying analog VAR quantities in all four quadrants, Device Word bits describe the instantaneous VAR quadrants. When the VAR measurement is in the associated quadrant, the Device Word bit asserts. These bits are useful when monitoring unsigned VARs and are shown in *Table 5.3*.

**Table 5.3 Four-Quadrant Device Word Bits**

Device Word Bit	Definition
EQx1	VARs in Quadrant 1
EQx2	VARs in Quadrant 2
EQx3	VARs in Quadrant 3
EQx4	VARs in Quadrant 4

where:

$x = A, B, \text{ or } C$

# Instrument Transformer Compensation

Ideal instrument transformers produce a secondary signal in ratio and in phase with the primary signal. In reality, instrument transformers normally cause a ratio and phase shift in the secondary signal. Instrument Transformer Compensation (ITC) in the SEL-735 compensates the sampled values, affecting all metered quantities.

Current transformers may shift the phase angle of the signal nonlinearly over the range of the CT. To account for this, the SEL-735 allows you to program six calibration points, each with a unique phase angle measurement and ratio correction factor. You may elect to use only one calibration point or all six.

When you program the SEL-735 with one calibration point, the meter applies the correction factors across the entire range of applied signals. If you program more than one point, the SEL-735 linearly interpolates based on the applied signal to determine which correction factors it should use. If the measured value lies below the calibration points, the SEL-735 uses the lowest calibration point values. If the measured value lies above the calibration points, the SEL-735 uses the highest calibration point values.

You may compensate instrument transformers on each phase with different ratio correction factors and phase angle measurements. To configure the SEL-735 for ITC, first test the instrument transformer and record the ratio correction factors and phase angle measurements at each calibration point.

Next, enable ITC and configure the number of calibration points you want. Lastly, program the ITC settings recorded from the instrument transformer test.

The Ratio Correction Factor setting cancels out the ratio error associated with the instrument transformer. For example, if you apply 100 primary amperes to a 100:1 current transformer and you measure 0.925 secondary amperes, the ratio correction factor is 1.081. You may use the following equation to determine the proper Ratio Correction Factor setting.

$$RCF = \frac{\text{Ideal Secondary Current}}{\text{Measured Secondary Current}} = \frac{\text{Primary Test Current}}{\text{Measured Secondary Current} \cdot \text{CTR}}$$

The Phase Angle Minutes setting cancels out the phase error associated with the instrument transformer. For example, if you apply primary current with a zero degree phase angle reference and you measure the secondary current with a 1 degree leading phase angle, you should set the Phase Angle Minutes setting to 60 minutes. You may use the following equation to determine the proper Phase Angle Minutes setting.

$$PAM = (\text{Secondary Phase Angle} - \text{Primary Phase Angle}) \cdot \frac{60 \text{ minutes}}{1 \text{ degree}}$$

For example, assume you test a current transformer with a CTR of 100:1 and find the results as shown in *Table 5.4*.

**Table 5.4 Example Current Transformer Test Data**

Test Data						
Calibration Point n	1	2	3	4	5	6
Test Load (A primary)	1.0000	10.0000	20.0000	50.0000	100.0000	200.0000
Ideal Secondary Current	0.01	0.10	0.20	0.50	1.00	2.00
Measured Secondary Current (A secondary)	0.0098	0.0985	0.1972	0.4950	0.9950	1.9980
Phase Angle Error (degrees)	4.50	4.00	1.20	1.10	1.00	0.95
SEL-735 Settings						
Ratio Correction Factor	1.02	1.015	1.0142	1.0101	1.0050	1.0010
Phase Angle Minutes	270	240	72	66	60	57

Configure the following settings as shown to correct for inaccuracies in this instrument (where x is the phase A, B, or C):

- EITCI := 6
- ICAL\_1 := 0.01
- IRCFx\_1 := 1.02
- IPAMx\_1 := 270
- ICAL\_2 := 0.10
- IRCFx\_2 := 1.015
- IPAMx\_2 := 240
- ICAL\_3 := 0.20
- IRCFx\_3 := 1.0142
- IPAMx\_3 := 72
- ICAL\_4 := 0.50
- IRCFx\_4 := 1.0101

IPAMx\_4 := 60  
ICAL\_5 := 1.00  
IRCFx\_5 := 1.0050  
IPAMx\_5 := 60  
ICAL\_6 := 2.00  
IRCFx\_6 := 1.0010  
IPAMx\_6 := 57

Figure 5.4 shows the Ratio Correction Factor vs. the calibration point of the CT example given.

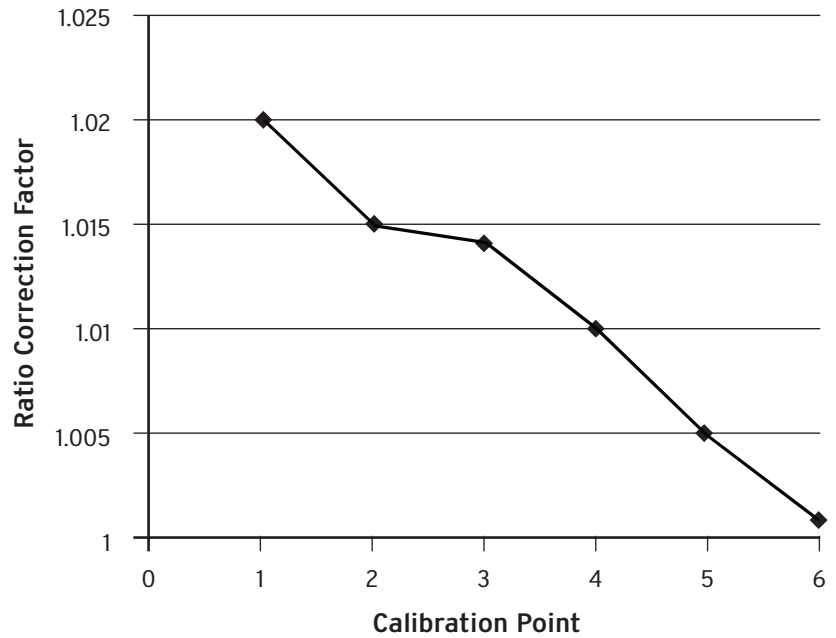
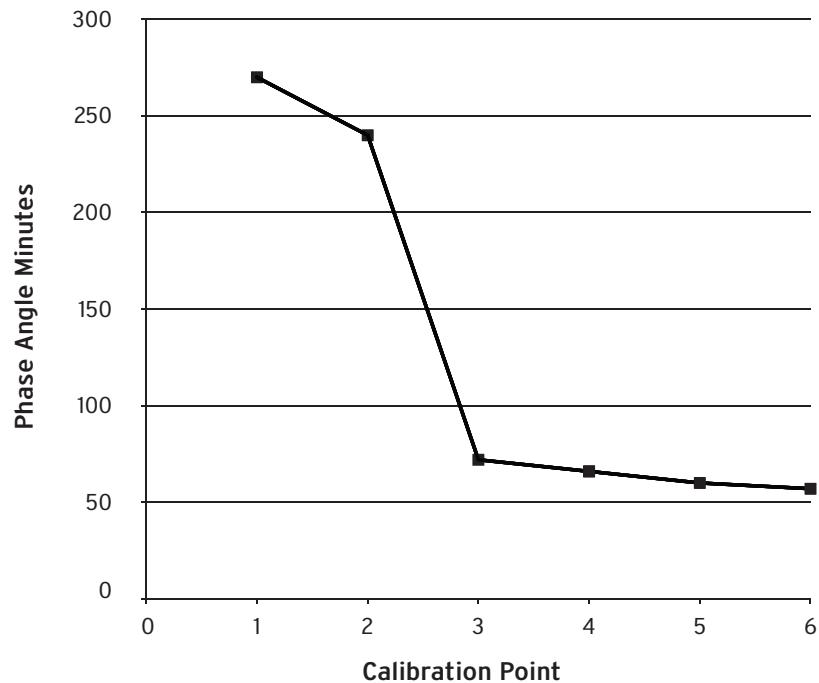


Figure 5.4 Ratio Correction Factor vs. Calibration Point

Figure 5.5 shows the CT Phase Angle Minutes correction vs. the calibration point of the CT example given.



**Figure 5.5 Phase Angle Minutes vs. Calibration Point**

## Frequency Tracking

The SEL-735 uses two different algorithms to calculate two different frequency analog quantities.

- 10-Second Average Frequency (FREQ\_PQ)
- Fundamental Frequency (FREQ)

### Frequency, 10-Second Average

The 10-Second Average Frequency, FREQ\_PQ, calculation complies with the IEC 61000-4-30 2008, Class A standard. The quantity updates every 10 seconds.

If the A-phase rms voltage drops below 13 volts, then FREQ\_PQ defaults to the nominal frequency. If the measured frequency is outside a range of 40.0 Hz to 70.0 Hz and A-phase rms voltage is below 13 volts, then FREQ\_PQ clamps to the maximum or minimum frequency (40.0 Hz or 70.0 Hz). If the device measures an invalid 10-second average frequency, the Device Word bit PFREQY asserts.

### Frequency, Fundamental

The standard frequency, FREQ, follows A-phase and C-phase rms voltages. If either A-phase or C-phase rms voltage drops below 13 volts, then FREQ returns to the nominal frequency, where the nominal frequency is either 50 Hz or 60 Hz, depending on the ordering option. If the device measures an invalid frequency, the Device Word bit FREQY asserts.

# Demand Metering

You can choose between three types of demand metering with the enable setting.

- EDEM = THM (Thermal Demand Meter)
- EDEM = ROL (Rolling Demand Meter)
- EDEM = BLOK (Block Demand Meter)

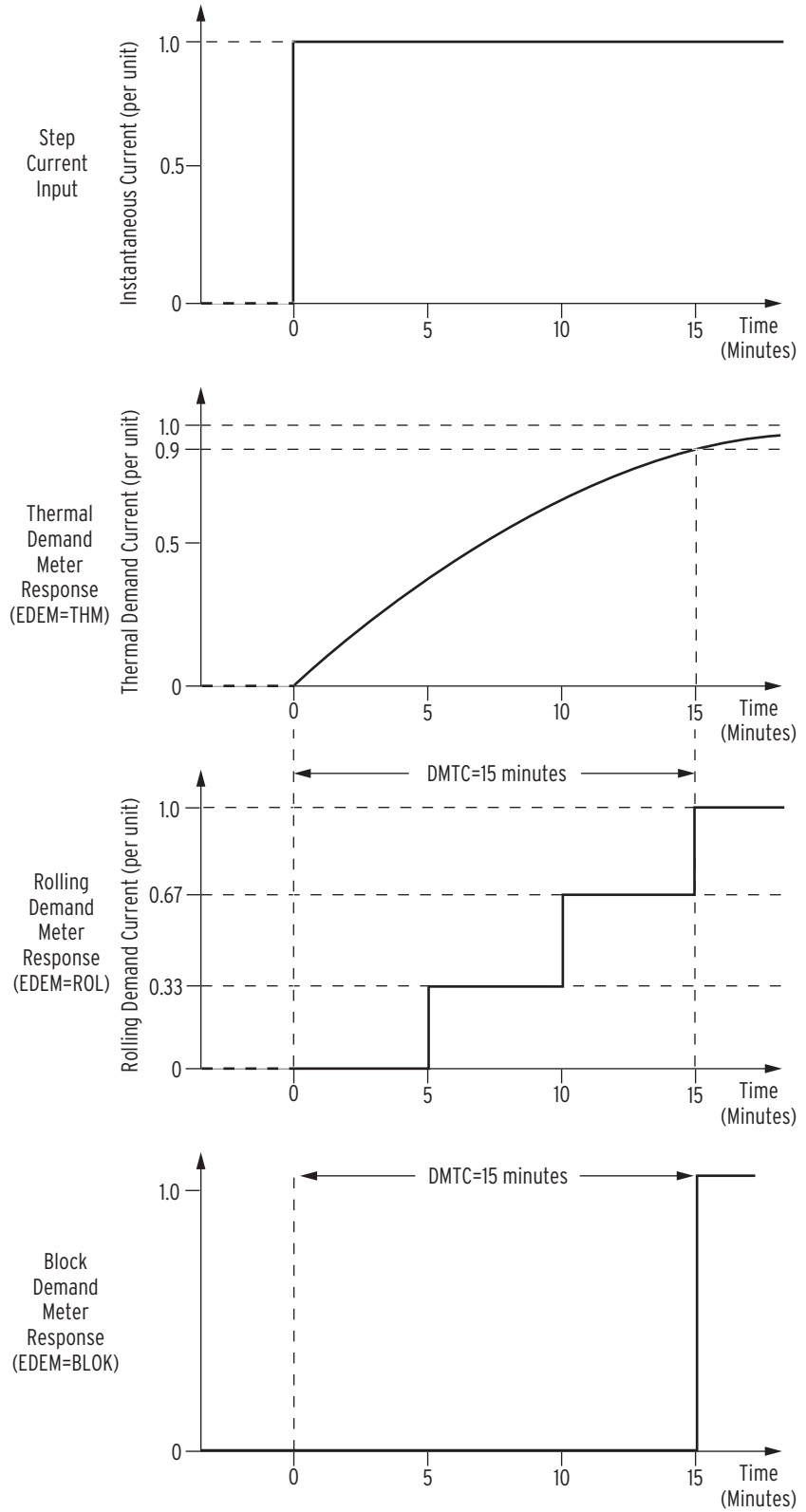
The SEL-735 provides demand and peak demand metering for the values listed in *Table 5.5*.

**Table 5.5 Demand and Peak Demand Metering Values**

Quantity	Abbreviations	Description
Current	$I_{A, B, C}$	Input Currents
Real Power	$W_{A, B, C} (P)$	Single-phase watts delivered/received (Form 9 and Form 36 only)
	$W_{3P} (P)$	Three-phase watts
Reactive Power	$VAR_{A, B, C} (Q)$	Single-phase VARs (Form 9 and Form 36 only)
	$VAR_{3P} (Q)$	Three-phase VARs
	$VAR_{A, B, C} (Q)$	Single-phase VARs, 4-quadrant (delivered/received, leading/lagging)
Apparent Power	$VA_{A, B, C} (S)$	Single-phase VAs
	$VA_{3P} (S)$	Three-phase VAs

## Comparison of Thermal, Rolling, and Block Demand Meters

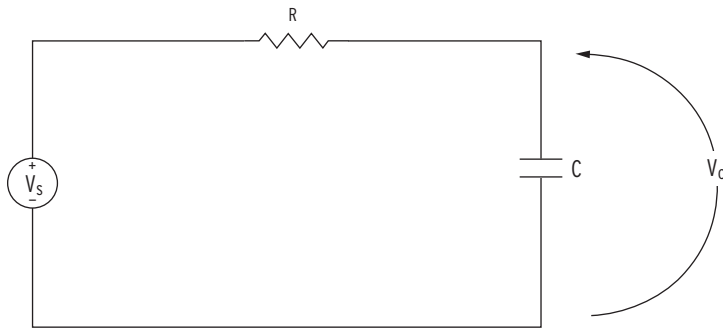
The example in *Figure 5.6* shows the response of thermal, rolling, and block demand meters to a 1.0 per unit step energy input.



**Figure 5.6 Response of Thermal, Rolling, and Block Demand Meters to a Step Input (Setting DMTC = 15 Minutes)**

## Thermal Demand Meter Response (EDEM = THM)

The thermal demand meter response in *Table 5.5* to the step current input is analogous to the series RC circuit in *Figure 5.7*.



**Figure 5.7** Voltage  $V_S$  Applied to Series RC Circuit

Thermal demand uses the following algorithm.

$$\text{Demand}_n = [(|\text{Sample}| - \text{Demand}_{n-1}) \cdot T_{\text{constant}} \cdot \text{Delay}] + \text{Demand}_{n-1}$$

where:

$$T_{\text{constant}} = \frac{\ln(10)}{\text{DMTC} \cdot 60}$$

Delay = number of seconds since last iteration

Sample = The analog quantity to calculate demand

$n$  = sample number

In the following analogy:

Voltage  $V_S$  in *Figure 5.7* corresponds to the step current input in *Figure 5.6* (top).

Voltage  $V_C$  across the capacitor in *Figure 5.7* corresponds to the response of the thermal demand meter in *Figure 5.6* (middle).

If voltage  $V_S$  in *Figure 5.7* has been at zero ( $V_S = 0.0$  per unit) for some time, voltage  $V_C$  across the capacitor in *Figure 5.7* is also at zero ( $V_C = 0.0$  per unit).

If voltage  $V_S$  suddenly steps up to some constant value ( $V_S = 1.0$  per unit), voltage  $V_C$  across the capacitor starts to rise toward the 1.0 per unit value. This voltage rise across the capacitor is analogous to the response of the thermal demand meter in *Figure 5.6* (middle) to the step current input (top).

In general, because voltage  $V_C$  across the capacitor in *Figure 5.7* cannot change instantaneously, the thermal demand meter response to increasing or decreasing applied instantaneous current is also not immediate. The thermal demand meter response time is based on the demand meter time constant setting DMTC. Note in *Figure 5.6* that the thermal demand meter response (middle) is at 90 percent (0.9 per unit) of full applied value (1.0 per unit) after a time period equal to setting DMTC = 15 minutes, referenced to when the step energy input is first applied.

The SEL-735 updates thermal demand values approximately every second.

### Rolling Demand Meter (EDEM = ROL)

The response of the rolling demand meter in *Figure 5.6* to the step current input uses a sliding time window arithmetic average. The width of the sliding time window is equal to the demand meter time constant setting DMTC. Notice in *Figure 5.6* that the rolling demand meter response (bottom) is at 100 percent (1.0 per unit) of full applied value (1.0 per unit) after a time period equal to setting DMTC = 15 minutes, referenced to the first application of step current input.

The SEL-735 uses the following algorithm to calculate rolling demand.

$$\text{Rolling Demand Result} = \frac{\frac{1}{N} \sum_{i=0}^{N-1} \text{Subinterval Result}_i}{\frac{\text{DMTC}}{60}}$$

where:

$$\text{Subinterval Result} = \frac{1}{N} \sum_{i=0}^{N-1}$$

N = number of input values accumulated in the subinterval

sample = the analog quantity to calculate demand

**Table 5.6 Demand Meter Settings and Settings Ranges**

Interval Length (DMTC Minutes)						
DMSI	1	5	10	15	30	60
Subinterval Length (minutes)	1	5	10	15	30	60
		1	5	5	15	30
			2	3	10	20
			1		6	15
					5	12
					3	10
						6
						5

The following is a step-by-step calculation of the rolling demand response example in *Figure 5.6* (bottom).

#### Time = 0 Minutes

Presume that the instantaneous energy has been at zero for at least 15 minutes before Time = 0 minutes (or the demand meters were reset). The three 5-minute intervals in the sliding time window at Time = 0 minutes each integrate to zero.

$$\text{Rolling demand meter response at Time = 0 minutes} = \frac{0.0}{3} = 0.0 \text{ per unit.}$$

### Time = 5 Minutes

The three 5-minute intervals in the sliding time window at Time = 5 minutes each integrate into the 5-minute totals in *Table 5.7*.

**Table 5.7 Time = 5-Minute Intervals**

5-Minute Totals	Corresponding 5-Minute Interval
0.0 per unit	-10 to -5 minutes
0.0 per unit	-5 to 0 minutes
1.0 per unit	0 to 5 minutes
1.0 per unit total	

Rolling demand meter response at Time = 5 minutes =  $1.0/3 = 0.33$  per unit.

### Time = 10 Minutes

The three 5-minute intervals in the sliding time window at Time = 10 minutes each integrate into the 5-minute totals in *Table 5.8*.

**Table 5.8 Time = 10-Minute Intervals**

5-Minute Totals	Corresponding 5-Minute Interval
0.0 per unit	-5 to 0 minutes
1.0 per unit	0 to 5 minutes
1.0 per unit	5 to 10 minutes
2.0 per unit total	

Rolling demand meter response at Time = 10 minutes =  $2.0/3 = 0.67$  per unit.

### Time = 15 Minutes

The three 5-minute intervals in the sliding time window at Time = 15 minutes each integrate into the 5-minute totals in *Table 5.9*.

**Table 5.9 Time = 15-Minute Intervals**

5-Minute Totals	Corresponding 5-Minute Interval
1.0 per unit	0 to 5 minutes
1.0 per unit	5 to 10 minutes
1.0 per unit	10 to 15 minutes
3.0 per unit total	

Rolling demand meter response at Time = 15 minutes =  $3.0/3 = 1.0$  per unit.

### Block Demand (EDEM = BLOK)

The block demand meter calculations are similar to rolling demand except where the block demand meter integrates the applied signal (e.g., step current) input over the entire DMTC setting instead of DMSI-minute subintervals.

### End of Interval Pulse (EOIP)

The end of each demand interval is represented by the Device Word bit EOIP. The EOIP Device Word bit is pulsed for a given time adjusted by the End of Interval Pulse Timer (EOIPT) setting. The EOIPT setting has a range of 1–5 seconds or OFF. If rolling demand (ROL) is enabled, the EOIP Device Word bit asserts at the end of every subinterval.

### Predictive Demand Meter Response (EPRED = Y and EDEM = ROL or BLOK)

The SEL-735 supports the processing of predictive demand of the demand analog quantities. Predictive demand calculation and updating occur every processing cycle. Equation 5.1 shows the predictive demand calculation.

$$\text{PredDemand} = \frac{\text{Avg} \cdot T_{\text{Elapsed(seconds)}} + \text{Present} \cdot T_{\text{Remaining(seconds)}}}{\text{DMTC} \cdot 60}$$

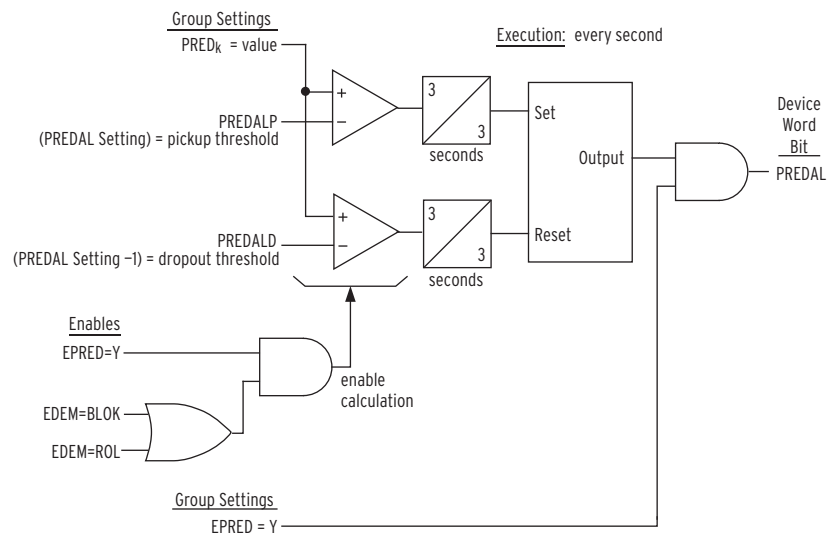
**Equation 5.1**

where:

- Avg = Average of input values observed during the demand interval
- TElapsed = Seconds elapsed in the current demand interval
- Present = Most recent input value
- TRemaining = Seconds remaining in demand interval
- DMTC = Demand Metering time constant

If the predictive demand settings change, predictive demand resets to zero.

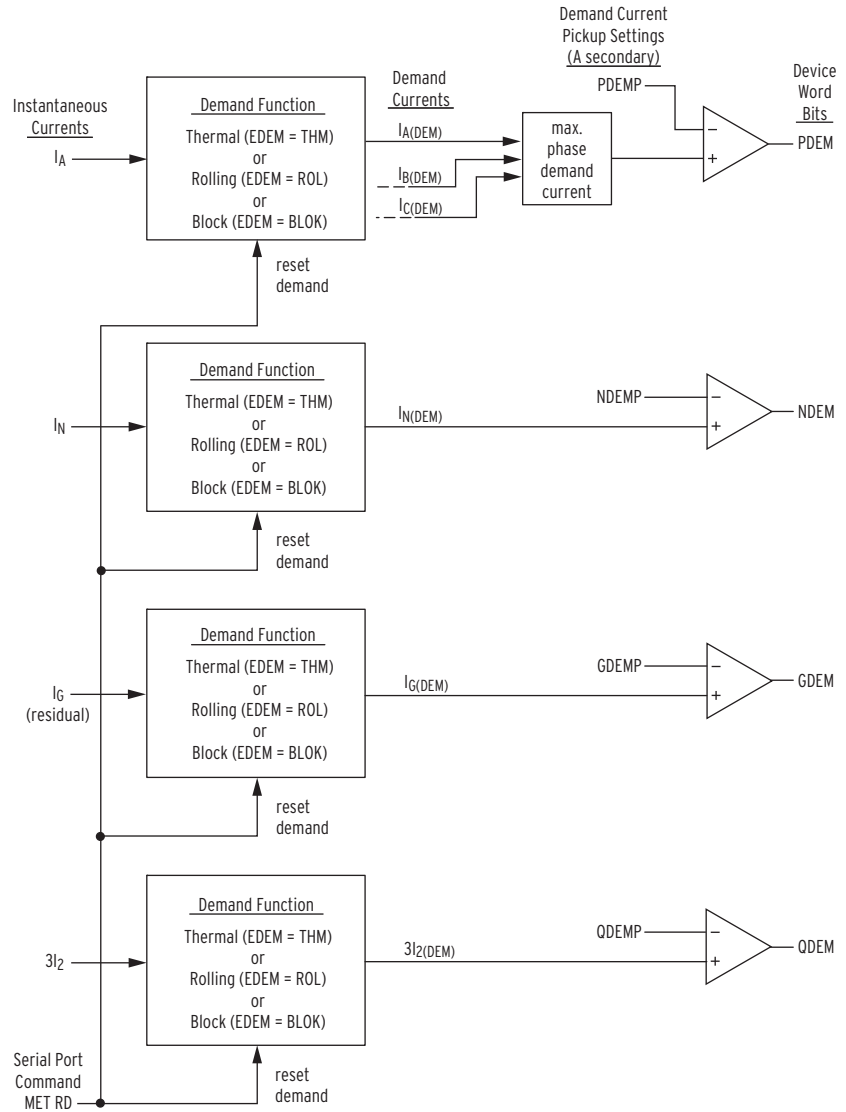
If the calculation value is above the PREDAL (predictive demand alarm threshold) setting for approximately three seconds, the meter asserts the PREDAL Device Word bit. When the value drops below the PREDAL level for approximately three seconds, the meter deasserts the PREDAL Device Word bit. Figure 5.8 shows the PREDAL alarm logic.



**Figure 5.8 PREDAL Logic**

The following examples in this section illustrate demand current.

The SEL-735 applies demand current pickup settings to demand current meter outputs as shown in Figure 5.9. For example, when residual ground demand current IG(DEM) exceeds corresponding demand pickup GDEMP, Device Word bit GDEM asserts to logical 1. Use demand current logic outputs PDEM, NDEM, GDEM, and QDEM to alarm for high loading conditions or unbalance conditions.



**Figure 5.9 Demand Current Logic Outputs**

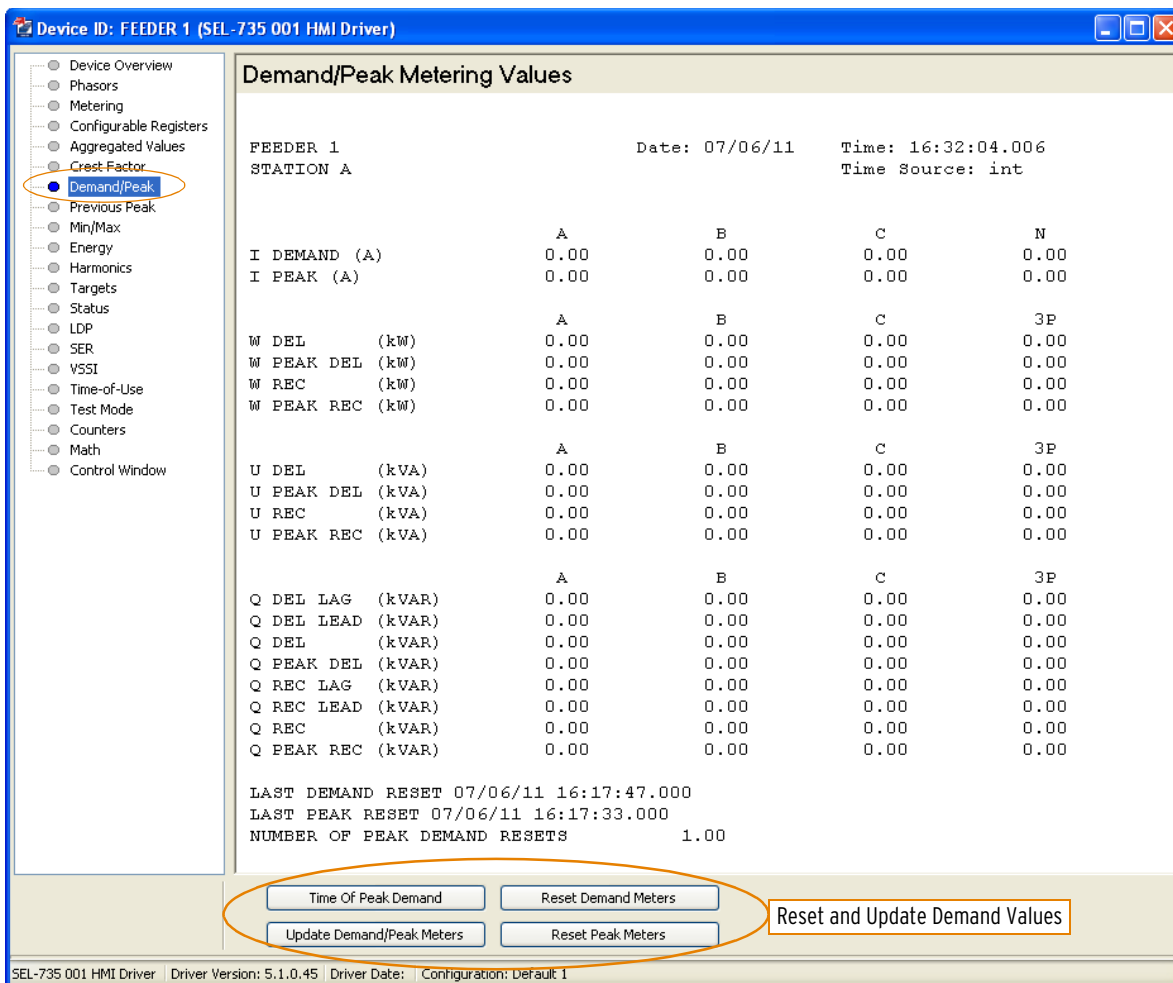
### View or Reset Demand Metering Information Via ACSELERATOR QuickSet HMI

The ACSELERATOR QuickSet® SEL-5030 Software HMI can display and reset present and peak demand metering. *Table 5.10* shows the demand values available through the ACSELERATOR QuickSet HMI.

**Table 5.10 Present and Peak Demand Values**

Currents	$I_{A,B,C}$	Input currents
Real Power	$W_{A,B,C} (P)$	Single-phase watts delivered/received
	$W_{3P} (P)$	Three-phase watts delivered/received
Apparent Power	$U_{A,B,C} (U)$	Single-phase volt-amperes delivered/received
	$U_{3P} (U)$	Three-phase volt-amperes delivered/received
Reactive Power	$Q_{A,B,C} (Q)$	Single-phase VARs delivered/received
	$Q_{3P} (Q)$	Three-phase VARs delivered/received

Figure 5.10 shows the Demand/Peak Metering Values HMI window.



**Figure 5.10 Demand/Peak Metering Values HMI Window**

Use the control buttons near the bottom of the window to perform the following functions.

- Show Demand/Peak Meters  
Click the **Update Demand/Peak Meters** button to show the demand values listed in *Table 5.10*.
- Show Time of Peak Demand  
Click the **Time of Peak Demand** button to show the time and date of all peak demands.

**NOTE:** There may be a delay of up to two times the DMTC setting before the rolling demand values update.

- **Reset Demand Meters**  
Click the **Reset Demand Meters** button to reset all Demand values and record the time and date of reset.
- **Reset Peak Meters**  
Click the **Reset Peak Meters** button to reset all Peak Demand values and record the time and date of reset.

### Via Front Panel

Use the front-panel menu pushbuttons to perform the following functions.

#### Show Demand and Peak Demand Data

- Step 1. Press **ENT**.
- Step 2. Select **METER** and press **ENT**.
- Step 3. Select one of the following options to perform the associated function.

Option	Associated Function
Display Demand	Display demand values
Last Demand Reset	Display time and date of last demand reset
Display Peak	Display peak demand values
Last Peak Reset	Display time and date of last peak demand reset
Previous Peak	Display the previous peak demand values
Peak Demand Resets	Display the number of peak demand resets

- Step 4. Press **ENT**.
- Step 5. Scroll up and down to view the quantity you want.

#### Reset Demand Meters

- Step 1. Press **ENT**.
- Step 2. Select **METER** and press **ENT**.
- Step 3. Select one of the following options to perform the associated function.

Option	Associated Function
Reset Demand	Reset all demand values and record the time and date of reset 2AC access is required.
Reset Peak	Reset all peak demand values and record the time and date of reset EAC access is required.

- Step 4. Press **ENT**.
- Step 5. Enter a valid password.
- Step 6. When prompted to Reset Demand/Peak Data, select **Yes** and press **ENT**.  
The SEL-735 displays **Reset Complete** upon a successful reset.
- Step 7. Press **ESC** to exit the front-panel menu.

## Via Remote Bits and DNP

Three settings allow configuration of remote bits to reset demand, peak demand, or energy values in the SEL-735. Add a remote bit, RB01–RB16, to the global settings RSTDEM, RSTPKDM, or RSTENGY to remotely reset each value. A DNP master can now write a binary output corresponding to a remote bit to reset values in the SEL-735. Optionally, add a remote analog quantity, RA00–RA31, as a password.

For example, set setting RSTPLDM as follows.

RSTPKDM := **RB01 AND RA00 = 12345**

Now, to reset the peak demand value in the SEL-735, the DNP master writes a value of 12345 to RA00 and asserts RB01 to force the SEL-735 to reset the peak demand value. After resetting the value, the master should write a new value to RA00 to clear the password.

## Demand Metering Updating and Storage

Should the meter lose control power, it will restore the peak demand values the meter saved during the last save to nonvolatile memory.

To avoid influencing the demand metering peak recording for a system fault, peak recording is momentarily suspended when Device Word bit FAULT is asserted (= logical 1). See the explanation for the FAULT setting in *Minimum/Maximum Metering on page 5.36*.

# Time-of-Use (TOU)

---

To program the SEL-735 for TOU metering, use ACSELERATOR QuickSet to create a TOU program. A TOU program defines the Calendar, Season Schedule, and Rate Schedule the TOU function uses.

To create a TOU program, read the existing settings from the meter and make the necessary settings changes. You can also use ACSELERATOR QuickSet to create new settings. The following pages describe TOU setup through use of ACSELERATOR QuickSet.

After you create the TOU program, use ACSELERATOR QuickSet to send the TOU settings.

# TOU Setup

---

The dialog box shown in *Figure 5.11* enables TOU and establishes TOU configuration for the SEL-735.

## Setup Tab

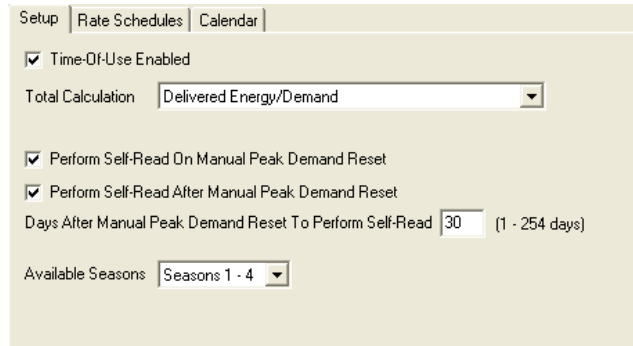


Figure 5.11 Setup Page

### Time-of-Use Enabled

**Time-of-Use Enabled** enables or disables TOU metering. Until you enable TOU, other TOU settings are unavailable.

### Total Calculation

Use **Total Calculation** to set the method the meter uses to calculate Total Energy. The options are as follows.

- Delivered Energy/Demand
- Received Energy/Demand
- Sum Delivered and Received Energy/Demand
- Subtract Received from Delivered Energy/Demand

### Self-Read Options

Select **Perform Self-Read On Manual Peak Demand Reset** if you want the meter to perform a self read when you issue a demand reset from the front panel.

Select **Perform Self-Read After Manual Peak Demand Reset** when you want the meter to perform a self read a specified number of days after a demand reset. You must specify the number of days.

### Available Seasons

Select **Available Seasons** to set the number of seasons available for use in the TOU calendar.

## Rate Schedules Tab

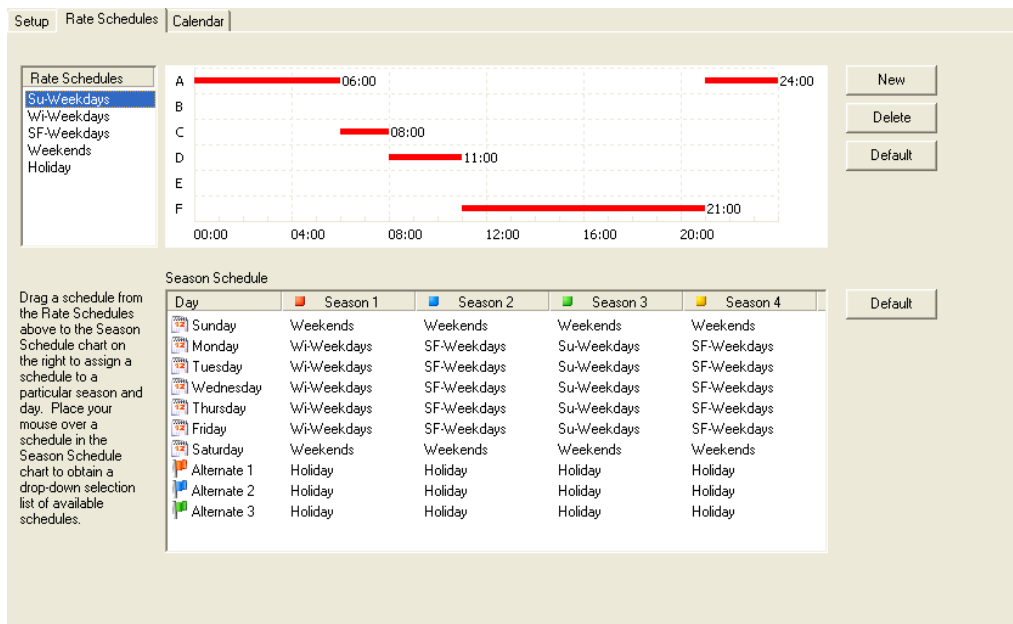


Figure 5.12 Rate Schedules Page

A Rate Schedule defines the rates to apply throughout a 24-hour day. A graphical representation of a day appears to the right of each **Rate Schedules** window. Rates (A to F) appear on the vertical axis, while time (00:00 to 24:00 hours) appears on the horizontal axis.

### Create a New Rate Schedule

To create a new Rate Schedule, click on the **New** button, or right-click in the **Rate Schedules** window and select **New** from the drop-down menu shown in *Figure 5.13*.

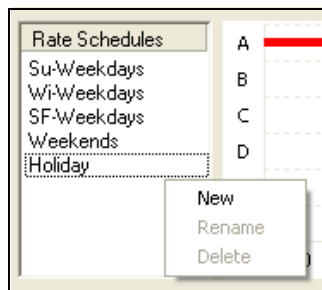
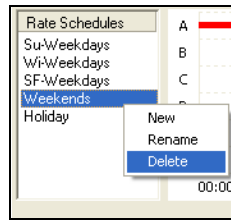


Figure 5.13 Schedule Drop-Down Menu

## Delete a Rate Schedule

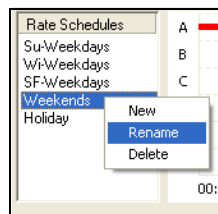


**Figure 5.14 Deleting a Rate Schedule**

- Step 1. Highlight in the **Rate Schedules** list the schedule you want to delete.
- Step 2. Click the **Delete** button or right-click and select **Delete**.

## Rename a Rate Schedule

You can rename a schedule by selecting it from the **Rate Schedules** list. Right-click on the schedule you want to change, select **Rename** from the menu, and type in the new name. User-defined names are limited to 20 characters.



**Figure 5.15 Renaming a Rate Schedule**

- Step 1. Select the **Rate Schedule** in the list of schedules.
- Step 2. Right-click and select **Rename**.

## Modify a Rate Schedule

Make assignments to a schedule by highlighting the rate schedule you want to change. The selected rate schedule appears as a chart on the right.

Double-click (right or left) on the chart (see *Figure 5.16*) to insert a new rate.

- Double-click the left mouse button on the chart to insert a new rate.
- Each right-click of the mouse on an existing rate adds 1 minute.
- Each left-click of the mouse on an existing rate removes 1 minute.
- Keep the right mouse button depressed over an existing rate to expand the rate in 15-minute intervals until the mouse button is released or until you reach the maximum interval limit.
- Keep the left mouse button depressed over an existing rate to reduce the rate in 15-minute intervals until the mouse button is released or until the interval disappears.

- Right-click on a rate interval bar that has an interval of 5 minutes or less to delete that interval.
- Keep the left mouse button depressed on the chart location where you want the new rate to begin, drag to the right to specify the length of the rate you want, then release the left mouse button.

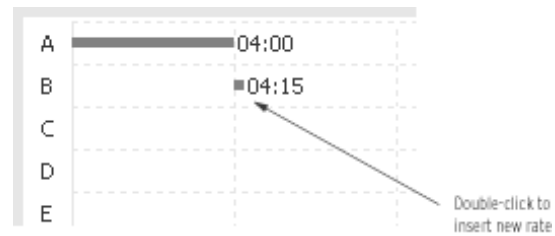


Figure 5.16 Modifying a Rate Schedule

### Assign a Rate Schedule

Once you have created all necessary rate schedules, you must assign a specific schedule to each day type. You can use any schedule for any day type, during any season. To assign a rate schedule for an entire season (e.g., Season 1), you can click and drag from the list the schedule you want and drop it onto the name of your chosen season in the season table.

To assign a rate schedule for use on a specific day type during every season (e.g., Saturday), click and drag from the Rate Schedules list the desired rate schedule you want and drop it onto the day you chose in the table.

To assign a rate schedule to a specific day and season, click and drag a rate schedule from the Schedules list and drop it onto the table entry corresponding to the specific day and season. Alternatively, place your mouse over the table entry you want and click the **Edit** button that appears on the screen. In the drop-down menu that appears, select the rate schedule you want.




## Calendar Tab



Setup | Rate Schedules | Calendar

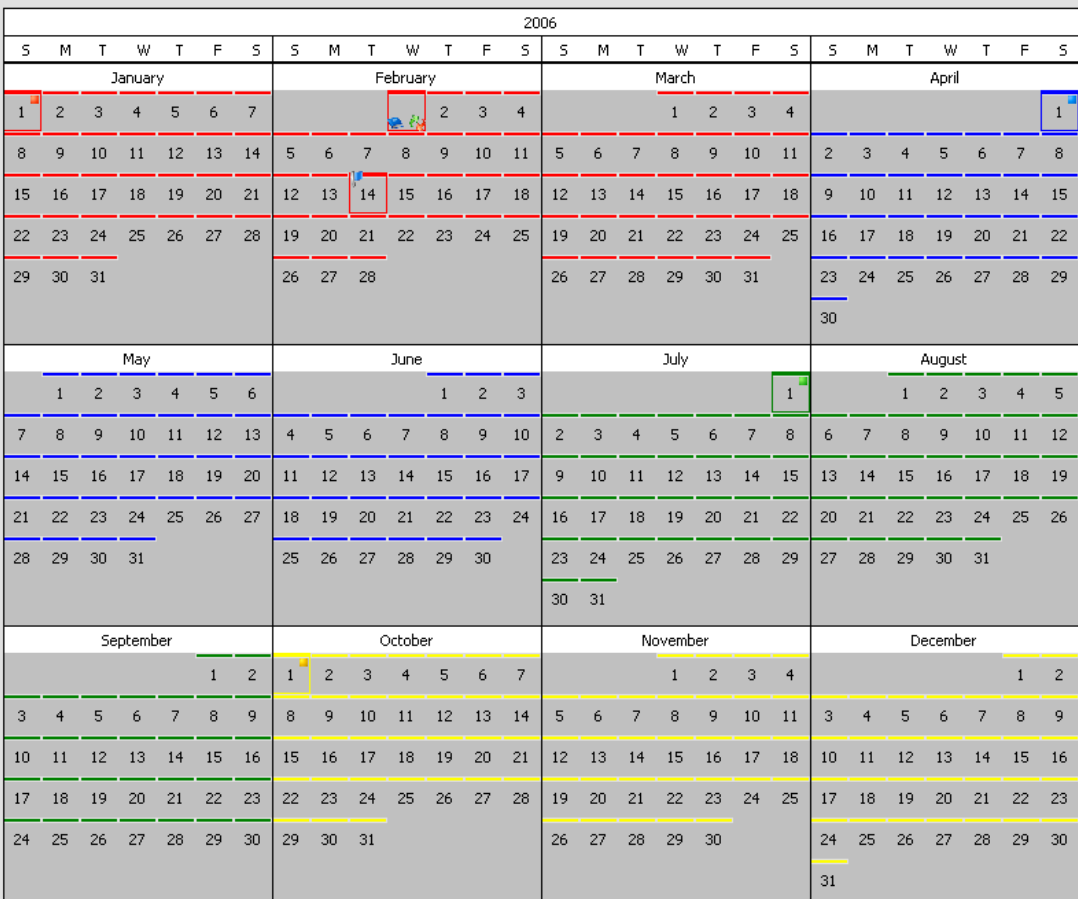
Display Year: 2006

Drag actions from options at right onto the calendar to program performance of those actions. Drag actions off the calendar to remove actions. Double-click an action on the calendar to change action properties.

Season Changes:  
■ Season 1  
■ Season 2  
■ Season 3  
■ Season 4

Alternates:  
 Alternate 1  
 Alternate 2  
 Alternate 3

Self Read  
 Demand Reset  




The calendar grid shows the months of 2006. Each month is represented by a grid of days. Actions are placed on specific dates:

- January:** Season 1 (red) on Jan 1; Season 2 (blue) on Jan 14.
- February:** Demand Reset (green) on Feb 8.
- March:** Season 3 (green) on Mar 1.
- April:** Season 2 (blue) on Apr 1.
- May:** Season 2 (blue) on May 1.
- June:** Season 2 (blue) on Jun 1.
- July:** Season 3 (green) on Jul 1.
- August:** Season 3 (green) on Aug 1.
- September:** Season 3 (green) on Sep 1.
- October:** Season 4 (yellow) on Oct 1.
- November:** Season 4 (yellow) on Nov 1.
- December:** Season 4 (yellow) on Dec 1.

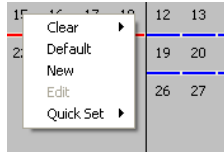
Figure 5.17 Calendar Page

Each entry instructs the TOU program to perform a specific action on that day, such as defining the beginning and ending of seasons or assigning alternate days (e.g., holidays), self-read days, and demand reset days for that year.

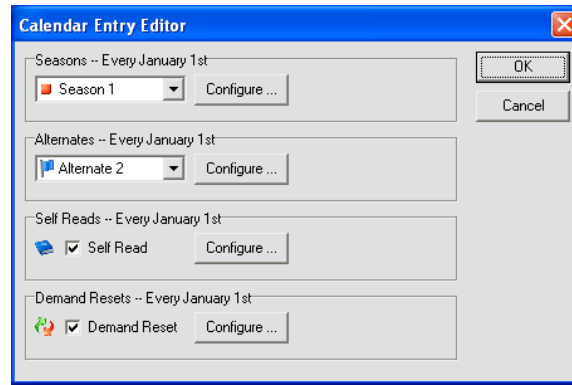
Season changes, day type changes, self-reads, and demand resets execute at 00:00.001 on the day you specified. Self-reads occur before demand resets.

### Add an Action to the Calendar

To add an action to the calendar, use the **Display Year** menu to select the year you want to edit. Click and drag an action (Season Changes, Alternates, Self Read, Demand Reset, or Daylight Saving) from the top of the page, and drop the action icon onto the calendar date. You can also right-click on a calendar date and select **New** from the drop-down menu shown in *Figure 5.18*. The **Calendar Entry Editor** will appear as in *Figure 5.19*. Select the action you want and determine how you want this action to repeat.



**Figure 5.18 Calendar Entry Drop-Down Menu**



**Figure 5.19 Calendar Entry Editor**

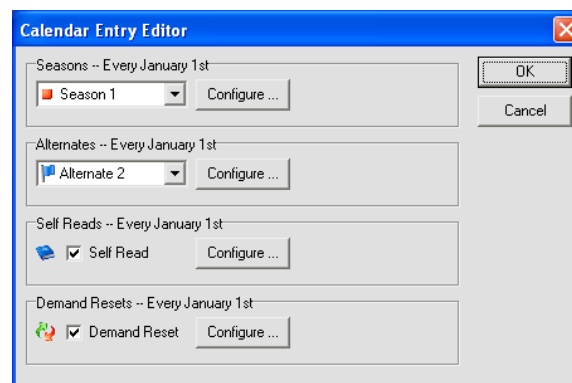
### Moving an Action on the Calendar

Drag the action icon from one day to another. Drop the action icon on the day for which you want the action to occur.

### Delete an Action from the Calendar

Select and drag an action icon off the calendar or into the recycle bin at the top of the form.

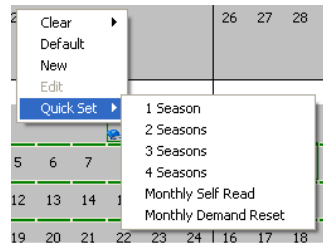
### Edit an Action on the Calendar



**Figure 5.20 Calendar Entry Editor**

- Step 1. Double-click on the calendar entry for the action you want to change.
- Step 2. Right-click on the calendar entry you want to change, and select **Edit**.
- Step 3. Left-click on a **Configure** button to modify date patterns.

## Establish Quick Set Defaults



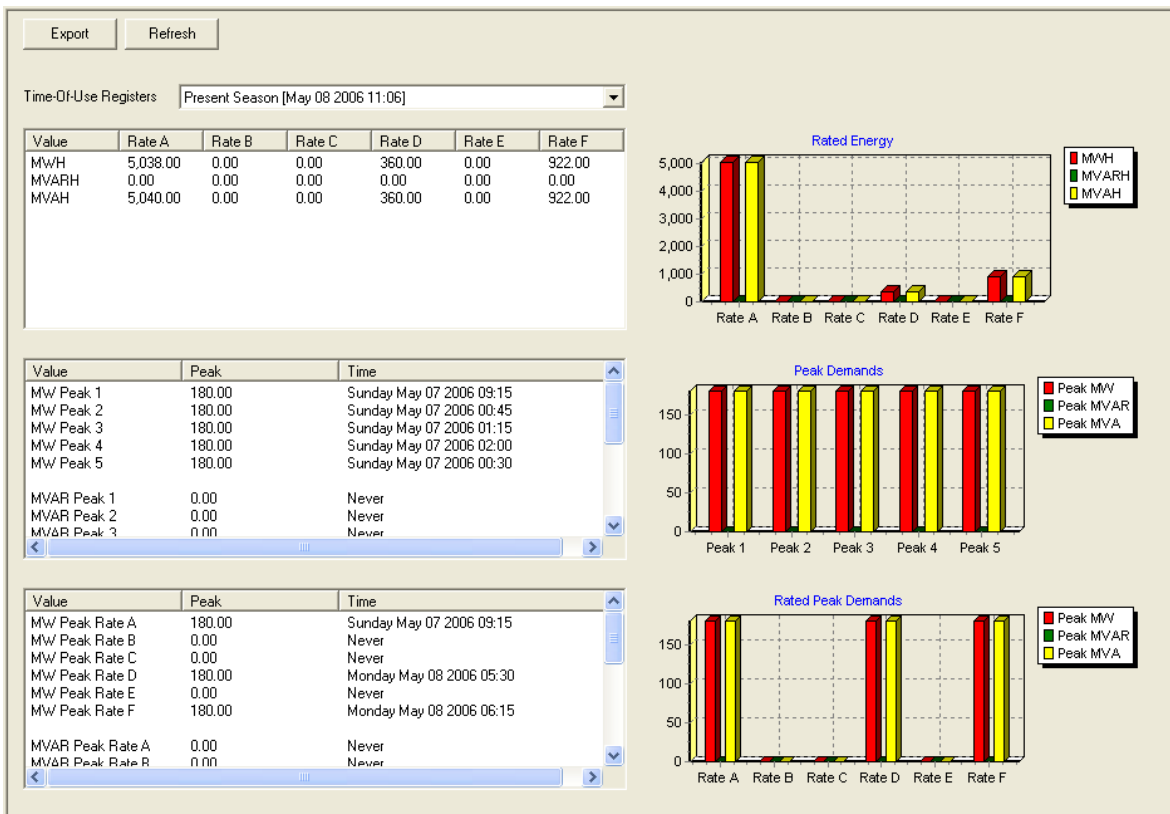
**Figure 5.21 Quick Set Menu**

Use the **Quick Set** options to return common TOU settings to factory defaults. To use a **Quick Set** option, perform the following.

- Step 1. Right-click on the calendar, and select the **Quick Set** menu option.
- Step 2. Select the appropriate item from the **Quick Set** submenu (see *Figure 5.21*).
- Step 3. Click **Yes** when prompted.

## TOU Register Data

Click on the Human Machine Interface icon and select **Time-of-Use** from the HMI tree view to view all TOU register data. Use the **Time-of-Use Registers** drop-down menu to select the season data you want to view. The SEL-735 displays data in bar graph and text formats (see *Figure 5.22*).



**Figure 5.22 TOU Data Page**

## TOU Registers

Choose which block of TOU registers you want to view. These blocks, available from the drop-down list, are as follows.

### Present Season

This first block (the default) is for presently accumulated season data since the last season change.

### Previous Season

This block provides data accumulated throughout the previous season.

### Self-Reads

There are 15 pairs of TOU register blocks that operate in the following manner.

- The self-read block provides TOU registers for the season in which the self-read occurs and shows accumulated data from the time of the last season change to the time of the self-read.
- The previous self-read block provides TOU registers for data accumulated throughout the previous season.

## Data Export

Use the **Export** button to create an Excel spreadsheet containing TOU register data and program-setting information.

## Billing Data

Access to TOU billing data is available on any communications port. Refer to *Appendix E: Modbus Communications Protocol* for more information on using the Modbus protocol to access TOU data. TOU billing data are also used as display points in the rotating display or for viewing from the front-panel main menu via the front-panel HMI. Refer to *Section 3: Front-Panel Operation* for information on front-panel setup and use.

*Appendix G: Analog Quantities and Device Word Bits* lists all TOU billing quantities available in the SEL-735 and describes their usage.

**Table 5.11 Available Time-of-Use Data (Sheet 1 of 3)**

Rated Energy Block
Rate X MWH "Total" <sup>a</sup>
Rate X VARH "Total" <sup>a</sup>
Rate X VAH "Total" <sup>a</sup>
Rate X WH Received <sup>a</sup>
Rate X VARH Received <sup>a</sup>
Rate X UH Received <sup>a</sup>
Total WH Received
Total URH Received
WH "Total" at Demand Reset
WH "Total" since Demand Reset
UH "Total" at Demand Reset
UH "Total" since Demand Reset

**Table 5.11 Available Time-of-Use Data (Sheet 2 of 3)**

<b>Rated Peak Demand Block</b>
5 Max MW "Total" Peak Demands
5 Max UR "Total" Peak Demands
5 Max U "Total" Peak Demands
Rate X MW "Total" Peak Demand <sup>a</sup>
PF at Max MW "Total" Peak Demand <sup>a</sup>
PF at Rate X MW "Total" Peak Demand <sup>a</sup>
Rate X UR "Total" Peak Demand <sup>a</sup>
PF at Max UR "Total" Peak Demand
PF at Rate X UR "Total" Peak Demand <sup>a</sup>
Rate X U "Total" Peak Demand <sup>a</sup>
PF at Max U "Total" Peak Demand
PF at Rate X U "Total" Peak Demand <sup>a</sup>
<b>Rated Peak Demand Time Block</b>
Time stamps of 5 Max MW "Total" Peak Demands
Time stamps of 5 Max UR "Total" Peak Demands
Time stamps of 5 Max U "Total" Peak Demands
Time stamp of Rate X MW "Total" Peak Demand <sup>a</sup>
Time stamp of Rate X UR "Total" Peak Demand <sup>a</sup>
Time stamp of Rate X U "Total" Peak Demand <sup>a</sup>
<b>Rated Cumulative Demand Block</b>
MW "Total" Cumulative Peak Demand
Rate X MW "Total" Cumulative Peak Demand <sup>a</sup>
UR "Total" Cumulative Peak Demand
Rate X UR "Total" Cumulative Peak Demand <sup>a</sup>
U "Total" Cumulative Peak Demand
Rate X U "Total" Cumulative Peak Demand <sup>a</sup>
<b>Demand Reset Block</b>
Max MW "Total" Peak Demand at last demand reset
Max UR "Total" Peak Demand at last demand reset
MW "Total" Peak Demand at Min Total PF at last demand reset
MW "Total" Peak Demand at Min Total PF since last demand reset
Min "Total" PF at last demand reset
Min "Total" PF since last demand reset
Average "Total" PF at last demand reset
Average "Total" PF since last demand reset
Number of demand resets

**Table 5.11 Available Time-of-Use Data (Sheet 3 of 3)**

Demand Reset Timestamp Block
Time stamp of Max MW "Total" Peak Demand at last demand reset
Time stamp of Max UR "Total" Peak Demand at last demand reset
Time stamp of Min "Total" PF at last demand reset
Time stamp of Min "Total" PF since last demand reset
Time stamp of last demand reset

<sup>a</sup> X = A–F.

# TOU Glossary

## TOU Register Data

Contains all registers included in a Rate X register set for each of the rates you have defined. These are the data necessary to produce a bill for the consumer.

## Cumulative Demand

The sum of the peak demand readings after each demand reset during the same billing period. At each demand reset, the meter adds the peak demand from the most recent billing period to the previously accumulated total of all peak demands.

## Day Type

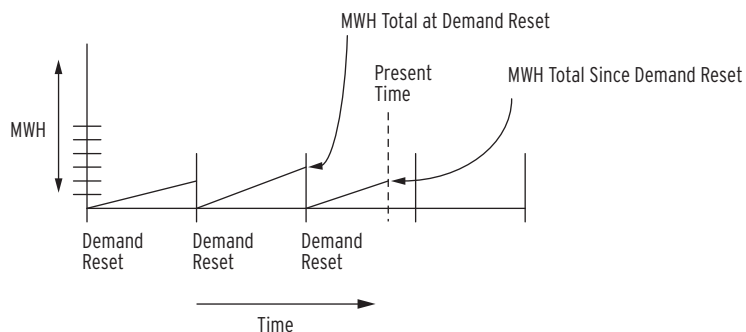
A day (24 hours) that has a specific rate assigned for each season through the Rate-Schedule table. Day types are Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday, Alternate 1, Alternate 2, and Alternate 3. These represent the typical days of the week and three alternate days for holidays or special occasions.

## Five Maximum MW/UR/U "Total" Demands

The five maximum megawatt/VAR/volt-ampere demand values recorded since the last demand reset. The values are nonrated and are listed from highest to lowest. The meter uses the Total Calculation setting to calculate these registers, and includes time stamps for each of the five maximum demands. The maximum demand includes the coincident power factor.

## WH/MVAH Total At/Since Demand Reset

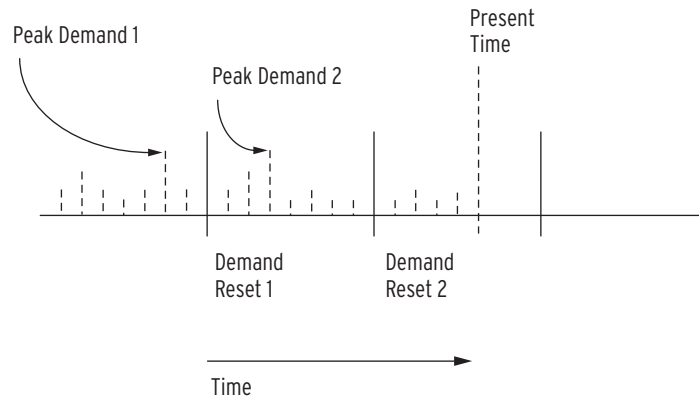
Each demand reset resets to zero the values the meter has collected since the previous demand reset (see *Figure 5.23*).



**Figure 5.23 Total At/Since Demand Reset**

## MW/MVAR “Total” Cumulative Demand

The sum of the peak demand between each demand reset without regard to rate (see *Figure 5.24*).



$$\text{Cumulative Demand} = \text{Peak Demand 1} + \text{Peak Demand 2}$$

**Figure 5.24 Peak Cumulative Demand**

## Rate X MW/MVAR “Total” Cumulative Demand

Where X = A–F. Similar to the definition for MW/MVAR “Total” Cumulative Demand, except that the meter sums peaks according to rate.

## Rate Schedule

A schedule spanning one day (24 hours) that specifies the Rate X register set into which the meter records energy and maximum demand data. For example, the meter records data from midnight until 07:59 into Rate A registers. The meter will record data in this manner until midnight, when the rate schedule for the following day applies.

## Rate X WH, MVARH, MVAH Received

Where X = A–F. The number of received megawatt/VAR/volt-ampere hours the meter records during periods defined for a given day type within a given season. These values constitute received quantities only.

## Rate X WH, MVARH, MVAH “Total”

Where X = A–F. The number of megawatt/VAR/volt-ampere hours the meter records during periods defined for a given day type within a season. The meter uses the Total Calculation setting to calculate these registers.

## Rate X MW/MVAR/MVA “Total” Peak Demand

Where X = A–F. The peak total demand recorded at each rate since the last demand reset.

The meter uses the Total Calculation setting to calculate these registers, and includes time stamps and coincident power factors.

## Rated Demand or Energy

The value that the TOU program in the SEL-735 stores for each rate schedule defined in the ACCELERATOR QuickSet Time-Of-Use setting window.

## Season

A consecutive period delimited by one-day boundaries such as January 1–March 31. You must define one or more seasons that span an entire calendar year and specify which rate schedule applies to each day type. The seasons typically repeat for each year of the 20-year calendar. Use the TOU calendar to specify seasons.

## Self-Read

The SEL-735 copies and stores the present values in demand and energy registers.

## Total Calculation

The meter calculates a total energy value according to the following Total Calculation setting options.

- Delivered
- Received
- Delivered + Received
- Delivered – Received

## Total WH, MVARH Received

The total number of received MWH/MVAR hours recorded during this season. These energy values are unrated registers, accumulated without regard to rate.

# Energy Metering

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## Energy Calculations

The SEL-735 calculates energy by integrating power over time. This is accomplished through the use of a numerical approximation of the integral. As an example, using active power, P, as described previously, the SEL-735 calculates watthours by adding watthours for the most recent interval to the previously accumulated watthour value.

$$Wh(n)_x = \frac{P \cdot \Delta t}{3600} + Wh(n-1)_x$$

**Equation 5.2**

where:

- P = the active power measured over the time interval  $\Delta t$
- n = the index for the most recent, nonoverlapping interval  $\Delta t$
- Wh(n-1) = the accumulated energy from all prior intervals
- $\Delta t$  = the time interval in seconds, normally 10/12 cycles

In the previous example, P can be a per-phase or polyphase quantity. Separate registers are available for bidirectional and four-quadrant energy metering. These calculations use a similar algorithm for reactive and apparent power.

## Scaling

### Load Profile Recorder

The SEL-735 configures Load Profile Recorder 1 as the billing recorder, with fixed scaling to ensure compatibility with Itron® MV-90 and other meter-reading software. *Table 5.12* lists the scaling differences between fixed scaling Recorder 1 and configurable scaling for recorders 2–12.

**Table 5.12 Load Profile Recorder Scaling**

Load Profile Recorder	Quantity	Scaling Applied
1 (Billing Recorder)	Energy	Primary, Kilo
	Volts and Power	Primary, Kilo
	Current	Primary, Unity
2–12 (PQ Recorders)	Energy	PRI_SCA, ENRG_SCA
	Power	PRI_SCA, POWR_SCA
	Volts	PRI_SCA, VOLT_SCA
	Current	PRI_SCA, Unity

Energy data in the billing recorder report as the change-over-interval from the beginning to the end of the interval. These data comprise the consumed energy during each LDP interval.

When energy data are in the PQ recorders and you have set the recorder function to End-of-Interval, then energy data roll over at nine dials. For example, if energy is 9,999,999.99 Wh, an increment in energy causes a rollover and a reset of the energy value to 0.00.

If you need different scaling, create a configurable register in the load profile recorder.

### Fast Meter Messages

The SEL-735 reports Fast Meter messages energy data in Mega units that rollover at 999,999,999.

### Other Interfaces

The SEL-735 reports energy data on all other interfaces in accordance with the ENRG\_SCA and PRI\_SCA settings.

## View or Reset Energy Metering Information

### Via ACSELERATOR Quickset HMI

**NOTE:** Single-phase quantities are available only in Form 9 and Form 36 models.

The ACSELERATOR Quickset HMI displays and controls all energy data. *Figure 5.25* shows the Energy Metering Values HMI Window.

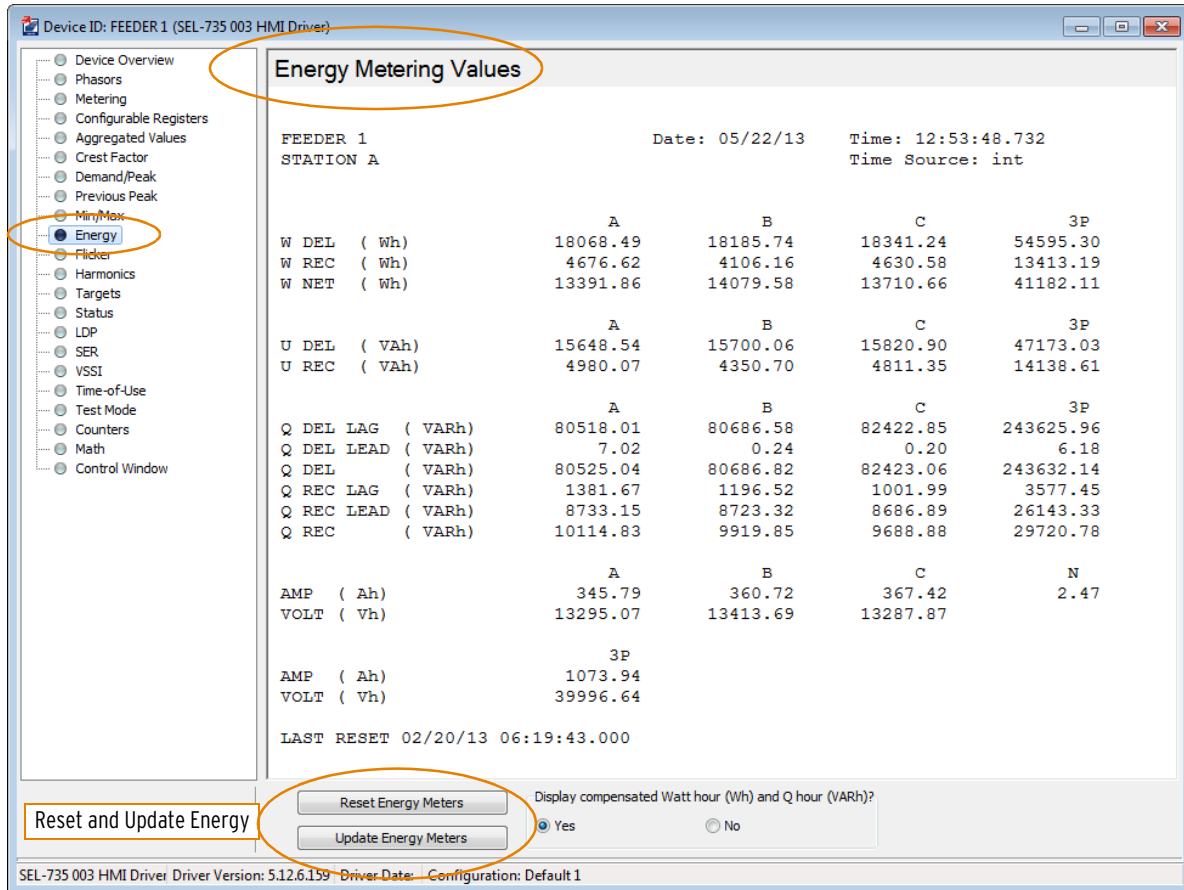


Figure 5.25 Energy Metering Values HMI Window

Use the control buttons near the bottom of the window to perform the following functions.

- **Reset Energy Meter Data**  
Click the **Reset Energy Meters** button to reset all energy data and record the time and date of reset.
- **Show Energy Meter Data**  
Click the **Update Energy Meters** button to show the most recent energy data.

### Via Front Panel

Use the front-panel menu pushbuttons to perform the following functions.

#### Show Energy Data

- Step 1. Press **ENT**.
- Step 2. Select **METER** and press **ENT**.
- Step 3. Select **Energy** and press **ENT**.

Step 4. Select one of the following options to perform the associated function.

Option	Associated Function
Display Energy	Display energy data
Last Energy Reset	Display time and date of last Energy reset
Display Peak	Display peak demand values
Last Peak Reset	Display time and date of last peak demand reset
Previous Peak	Display the previous peak demand values
Peak Demand Resets	Display the number of peak demand resets

Step 5. Press **ENT**.

#### Reset Energy

Step 1. Press **ENT**.

Step 2. Select **METER** and press **ENT**.

Step 3. Select **Energy** and press **ENT**.

Step 4. Select Reset Energy and press **ENT**.

Step 5. Enter a valid 2AC password.

Step 6. When prompted to Reset Energy Data, select **Yes** and press **ENT**.

The SEL-735 displays *Reset Complete* upon a successful reset.

Step 7. Press **ESC** to exit the front-panel menu.

### Via Remote Bits and DNP

See *Via Remote Bits and DNP* on page 5.34.

### Energy Cut-Off Point

As the power factor approaches zero, small phase angle measurement errors result in relatively large errors in real power (watts) measurements. This is because of the sensitivity of the cosine function as the phase angle approaches 90° (PF = 0).

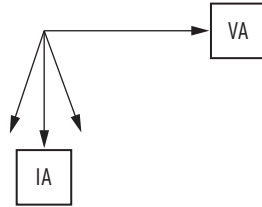
To prevent erroneous real power measurements under near PF = 0 conditions, the SEL-735 uses the ANGCUT setting to support an energy cut-off angle. When the phase angle between the current and voltage reaches the cut-off setting, the meter zeroes rms watts. The ANGCUT setting supports cut-off angles from 1° to 10°.

When the vectors VA and IA have a relative phase angle difference of 0°, only real power (watts) flows through a power system. For example, 120 V • 5 A • Cos(0°) = 600 W.

When the vectors VA and IA have a relative phase angle difference of 90°, only reactive power (VARs) flows through a power system. For example, 120 V • 5 A • Cos(90°) = 0 W = 600 VARs.

In a real power system, and during accuracy testing, the phase angles of the current and voltage will fluctuate slightly. If IA is 90 degrees off from AV, the relative VAR measurement changes little as the IA phase angle fluctuates, but the relative watt measurement will change noticeably. In addition, some of the watts will report as delivered and some of the watts will report as received.

The ANGCUT setting prevents the SEL-735 from recording these small watt values when the power factor is close to 0 and prevents VARs from recording when the power factor is close to 1.



**Figure 5.26 Power Factor = ±0.02**

See *Table 5.13* for an example of when the ANGCUT setting affects power and energy calculations.

**Table 5.13 Example ANGCUT Setting**

ANGCUT Setting	Watts Zeroed Between	VARs Zeroed Between
OFF	n/a	n/a
2	88° to 92° and -88° to -92°	2° to -2° and 178° to -178°
10	80° to 100° and -80° to -100°	10° to -10° and 170° to -170°

## Preload Energy Values

You can preload the energy values in the meter from 0 to 999,999,999,999.999. Amp-hour and volt-hour quantities are set in unity units, while all other energy values are set in kilo units. When you read settings from an SEL-735, the energy preload settings of the settings file populate with the meter energy values at the time of the read. This simplifies meter swapping, while maintaining the same energy data between the two meters.

# Minimum/Maximum Metering

## View or Reset Minimum/Maximum Metering Information

The power maximum and minimum values can be negative or positive, indicating the range of power flow that has occurred since the last Min/Max reset. These functions simulate analog meter drag-hands, with the maximum value representing the upper drag-hand and the minimum value representing the lower drag-hand.

### Via ACSELERATOR HMI

The ACSELERATOR Quickset HMI displays and controls all Minimum/Maximum meter data.

Figure 5.27 shows the Min/Max meter data.

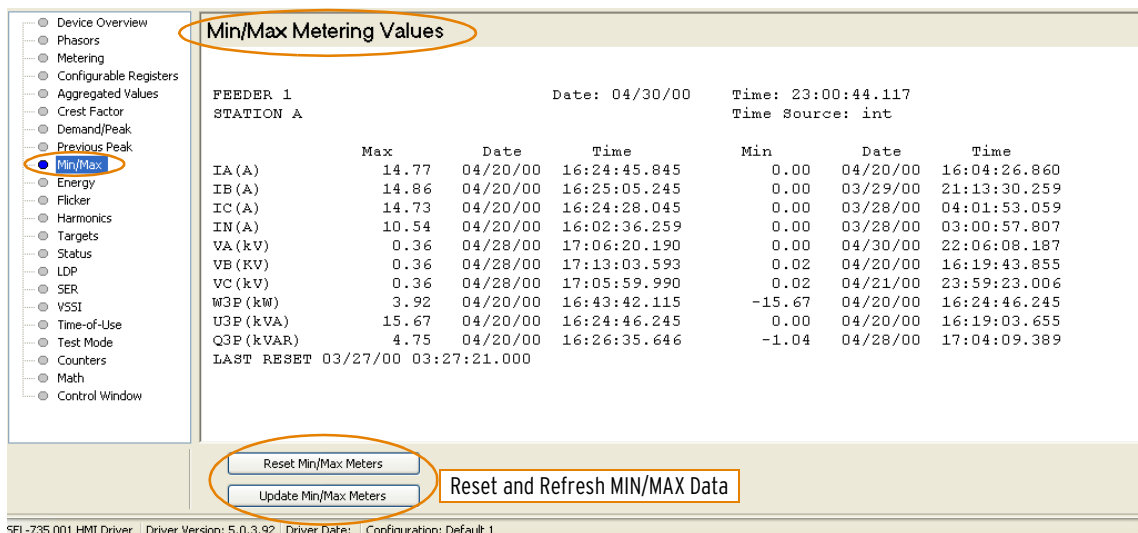


Figure 5.27 Min/Max Metering Values HMI Window

Use the control buttons near the bottom of the window to perform the following functions.

- **Reset Min/Max Meter Data**  
Click the **Reset Min/Max Meters** button to reset all Min/Max data and record the date and time of reset.
- **Show Min/Max Meter Data**  
Click the **Update Energy Meters** button to show the most recent Min/Max data.

### Via Front Panel

Use the front-panel menu pushbuttons to perform the following functions.

#### Show Latest Min/Max Data

- Step 1. Press **ENT**.
- Step 2. Select **Meter > Max/Min** and press **ENT**.

Step 3. Select one of the following options and press **ENT**.

Option	Associated Function
Display Max/Min	Display most recent Max/Min data
Last Max/Min Reset	Display time and date of last Max/Min rest

Step 4. Scroll up and down to view the quantity you want.

#### Reset Min/Max Data

Step 1. Press **ENT**.

Step 2. Select **Meter > Max/Min** and press **ENT**.

Step 3. Select **Reset Max/Min** and press **ENT**.

Step 4. Enter a valid 2AC password.

Step 5. When prompted to Reset Min/Max Data, select **Yes** and press **ENT**.

The SEL-735 displays *Reset Complete* upon a successful reset.

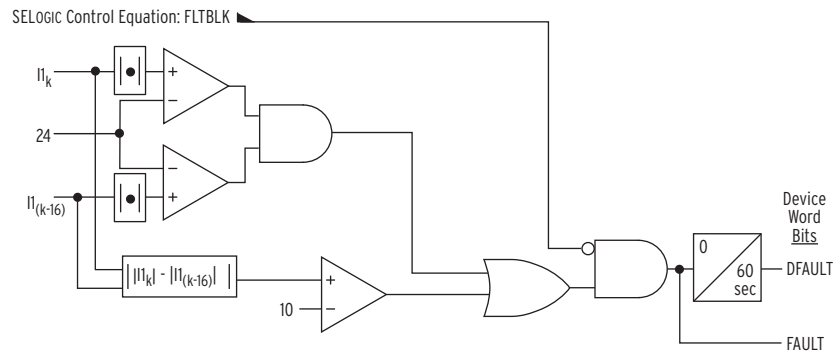
Step 6. Press **ESC** to exit the front-panel menu.

## Minimum/Maximum Metering Update and Storage

The minimum/maximum metering function is intended to reflect normal load variations rather than fault conditions or outages. Therefore, maximum/minimum values update only if the following conditions are met.

- DFAULT is deasserted (= logical 0).
- The metering value is above the previous maximum or below the previous minimum for two 10/12 cycle intervals.

**NOTE:** Device Word bit FAULT and DFAULT also control other meter functions.



**Figure 5.28** FAULT and DFAULT Device Word Bit Logic

**NOTE:** The minimum/maximum metering function updates every second. These values are relatively immune to transient conditions.

The meter saves minimum/maximum values to nonvolatile memory once every minute and overwrites the previous stored value if it is exceeded. Should the meter lose control power, it will restore the minimum/maximum values saved by the meter during the last save to nonvolatile memory.

## Fault Detection

The SEL-735 will not meter certain values during faults, to ensure that it records only billable quantities. When asserted, the overcurrent elements ensure that the meter does not record peak demand, maximum metering, energy, and crest factors.



Use the control buttons near the bottom of the window to perform the following functions.

- **Reset Crest Factor Data**  
 Click the **Reset Crest Factor Meters** button to reset all crest factor data and record the date and time of reset.
- **Show Crest Factor Data**  
 Click the **Update Crest Factor Meters** button to show the most recent crest factor data.

## Crest Factor Metering Update and Storage

The crest factor metering function reflects normal load variations, rather than fault conditions or outages. Therefore, crest factor values only update if the following conditions are met.

- DFAULT is deasserted (= logical 0).
- For Form 9 and Form 36 voltage values  $V_{A,B,C}$  or Form 5 voltage values  $V_{AB,BC,CA}$ , the voltage is above the corresponding 25.0 V secondary threshold.
- For current values  $I_{A,B,C,N}$ , the current is above the corresponding 105 mA secondary threshold.
- The metering value is above the previous maximum or below the previous minimum for two 10/12 cycles.

The SEL-735 stores crest factor values into nonvolatile memory every minute.

# Harmonic Metering

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The SEL-735 provides harmonic measurements for the following values.

- Harmonic magnitudes for voltage, current, and power
- Percent of fundamental harmonic magnitudes for voltage and current
- SELOGIC voltage and current harmonic threshold alarms for the 2nd harmonic order to the 15th harmonic order
- Harmonic measurement to the 63rd harmonic order (optional feature)
- Harmonic voltage and current angles (optional feature)
- Harmonic power (optional feature)
- Interharmonic measurement (optional feature)

## Harmonic Components and Harmonic Groups

The SEL-735 supports component harmonics and harmonic groups as defined by IEC 61000-4-7:2009-2010 and the following.

### Definitions

**Harmonic Component:** Rms value of one of the components having a harmonic frequency in the analysis of a nonsinusoidal waveform.

**Harmonic Group:** Square root of the sum of squares of the rms value of a harmonic and the spectral components adjacent to it within the time window. Please refer to IEC 61000-4-7:2002-08 for further explanation of harmonic group calculations.

## Explanation

The Include Interharmonics Quantities (INCIHQ) setting determines if harmonic values report according to the Harmonic Group definition or the Harmonic Component definition.

If the INCIHQ setting is **Y**, harmonic magnitudes report in accordance with the Harmonic Group definition. The meter uses all frequencies in a 50 Hz or 60 Hz window centered on the integer harmonic frequency in the harmonic calculation.

If the INCIHQ setting is **N**, harmonic magnitudes report in accordance with the Harmonic Component definition. The meter uses only the harmonic frequency in the harmonic calculation.

For example, in a 60 Hz system, the meter will report the third harmonic (180 Hz) inclusive of frequencies from 150 Hz to 210 Hz when INCIHQ is set to **Y**. *Figure 5.30* exemplifies a harmonic report with and without interharmonic frequencies with the INCIHQ setting equal to **Y** and **N**.

## Harmonic Metering in Form 36 Meters

Because Phase-B voltage is not measured in Form 36 metering, the Phase-B harmonic quantities are not fully representative of the actual harmonics on the system. Any harmonic quantity associated with Phase-B voltage is only a result of a mathematical computation based on Phase-A and Phase-C voltages. Further, any harmonic quantity that mathematically uses the Phase-B voltage harmonic quantity should not be considered to reflect actual system conditions (i.e., three-phase distortion power ratio and three-phase harmonic power).

## Harmonic Percentage

The meter converts the 2nd to 15th harmonics into a percentage of the fundamental.

**Table 5.14 Minimum Required Magnitudes for Harmonic Percentage Calculations**

Harmonic Quantity	Minimum Required Magnitude
Voltage	3.0 V <sub>RMS</sub>
Current	3 mA <sub>RMS</sub>

**NOTE:** When the SEL-735 is set up as a Form 36 meter, the Phase-B voltage is calculated, not measured. The harmonic quantities reported for Phase B are a result of calculations and should not be considered to reflect actual system conditions. Therefore, the SEL-735 will not include any Phase-B harmonic quantities in the calculation of harmonic triggering. The calculated harmonics reported on Phase B will not cause HARMTRIG to assert.

If the voltage or current harmonic is below the minimum threshold, the meter reports zero for that particular harmonic percentage.

The HARMTRIG setting determines whether HARM02–HARM15 are triggered on voltage and/or current harmonics. Set HARMTRIG to **ALL** to trigger on both voltage and current, to **VOLTAGE** to trigger on voltage only, or to **CURRENT** to trigger on current-only harmonics. If the threshold is enabled and the harmonic is above the set threshold, then the respective harmonic Device Word bit (HARM02–HARM15) asserts. The bit deasserts when the respective harmonic falls below the set threshold. Harmonics for currents and voltages are calculated on a per-phase basis; any single-phase harmonic value asserts the HARM02–HARM15 Device Word bits. If any harmonic Device Word bit is set, then the FALARM Device Word bit is set.

Surpassing the given harmonic threshold causes the meter Device Word bit to assert (logical 1).

**EXAMPLE 5.1 Harmonic Alarm Example**

Suppose you notice that approximately once a month the system experiences a power failure. You believe the cause is the starting of some large loads that induced harmonics into the system, but this was not verified. With the SEL-735, you made the following settings.

```
SET HARM02 = 10
HARM03 = 10
.
.
.
HARM07 = 10
SET L OUT101 = HARM02 OR HARM03 OR HARM04 OR HARM05
OR HARM06 OR HARM07
SET R SER1 = HARM02, HARM03, HARM04, HARM05, HARM06,
HARM07
```

You then can monitor OUT101 via the SCADA system and notice that every time the certain load starts, the 3<sup>rd</sup> harmonic generates significant levels.

## Harmonic Magnitudes and Angles

The harmonic magnitude calculations are in accordance with the Harmonic Component and Harmonic Group definitions, controlled by the INCIHQ setting. All harmonic angles reference VA when the VA magnitude is greater than 13 volts, otherwise harmonic angles reference IA. All harmonic angles have a range of  $-179.99^\circ$  to  $180.00^\circ$ .

Each harmonic magnitude and angle has an associated analog quantity (see *Appendix G: Analog Quantities and Device Word Bits*) that uses the following format.

HRM $xx\_yy$ M = Harmonic Magnitude

HRMA $xx\_yy$ M = Harmonic Angle

where:

$xx$  = the harmonic number (2–50 or 2–15)

$yy$  = the specific current or voltage phase (IA, IB, IC, IN, VA, VB, or VB)

You can use the ACSELERATOR QuickSet HMI to view harmonic magnitudes and angles.

## Interharmonic Magnitudes

Advanced power quality meters calculate interharmonic magnitudes up to the 63rd harmonic. The ACSELERATOR QuickSet HMI displays individual interharmonic magnitudes, with text and graphical views up to the 63rd harmonic.

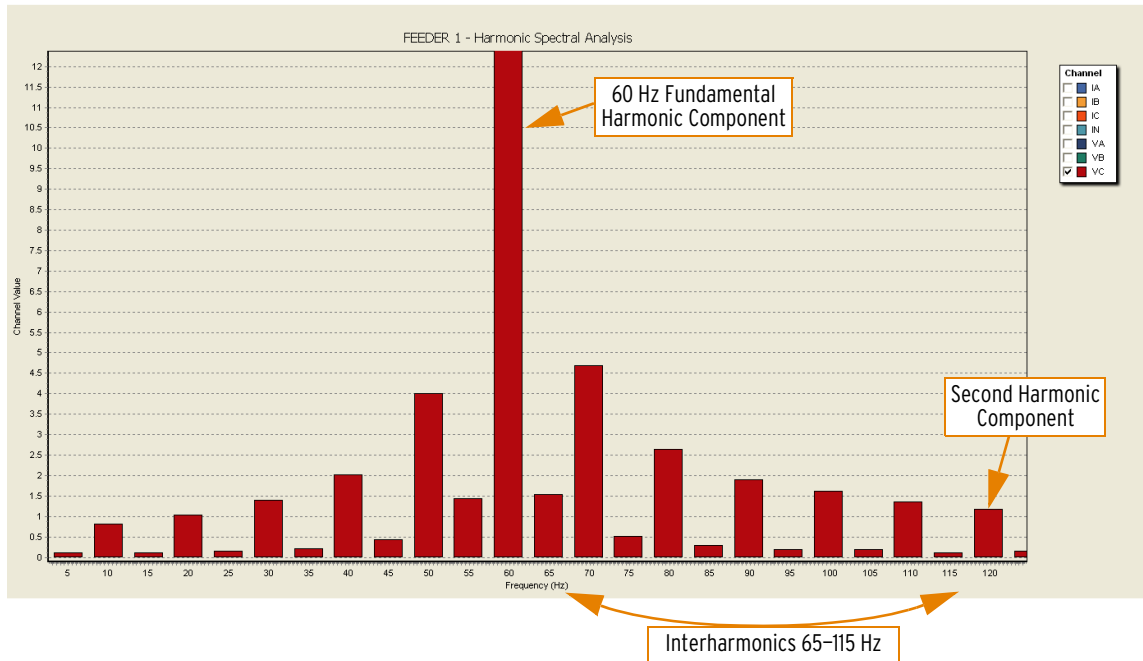


Figure 5.30 Interharmonics vs. Integer-Harmonics Example

### K-Factor Calculation

Another use for harmonic metering is to prevent transformer overheating as a result of harmonics. The meter calculates K-factor on a per-phase and three-phase basis for use in the detection and monitoring of harmonics. The meter uses the following equation to calculate K-factor for each phase current channel.

$$K\text{-FACTOR}_x = \frac{\sum_{h=1}^{25} I_{xh}^2 h^2}{\sum I^2_1}$$

Equation 5.4

where:

- x = the channel (A, B, C)
- h = the harmonic number (1 to 25)

You can use the ACSELERATOR QuickSet HMI or the front-panel LCD to display K-Factor data.

### Distortion Power

The meter calculates distortion power as the ratio of average power to fundamental power and reports this power in a percentage. The calculation is on a per-phase and three-phase basis for wye-connected systems and on a three-phase basis only for delta-connected systems. The meter calculates distortion power as follows.

$$Dx = \left( \frac{P_{x\_avg}}{P_x} - 1 \right) 100$$

Equation 5.5

where:

- Dx = the distortion power ratio for the respective phase
- P<sub>x\_avg</sub> = the average power for the respective phase
- P<sub>x</sub> = the fundamental power for the respective phase

You can use the ACSELERATOR QuickSet HMI or the front-panel LCD to display distortion power data.

## Total Harmonic Distortion (THD)

The meter calculates THD as the ratio of the rms value of the sum of harmonic components (to the specified order) to the rms value of the fundamental component.

The meter calculates THD per phase as follows.

$$\text{THDX} = \left( \frac{\sqrt{\sum_{n=2}^{\text{ht}} \text{HX}_n^2}}{\text{HX}_1} \right) 100$$

**Equation 5.6**

where:

- X = the appropriate channel IA, IB, IC, VA, VB, VC, etc.
- ht = the total number of harmonics (15 or 63, based on meter class)
- $\text{HX}_n$  = the harmonic value of the respective harmonic
- $\text{HX}_1$  = the harmonic value of the fundamental frequency
- n = the harmonic number

## Group Total Harmonic Distortion (THDG)

Group total harmonic distortion is very similar to THD, except the calculation uses harmonic groups instead of harmonic components.

The meter calculates THDG as the ratio of the rms value of the sum of harmonic groups (to the specified order) to the rms value of the fundamental component.

The meter calculates THDG per phase as follows.

$$\text{THDGX} = \left( \frac{\sqrt{\sum_{n=2}^{\text{ht}} \text{HX}_{gn}^2}}{\text{HX}_{g1}} \right) 100$$

**Equation 5.7**

where:

- X = the appropriate channel IA, IB, IC, VA, VB, VC, etc.
- ht = the total number of harmonics (15 or 63, based on meter class)
- $\text{HX}_{gn}$  = the harmonic group value of the respective harmonic<sup>a</sup>
- $\text{HX}_{g1}$  = the harmonic group value of the fundamental frequency
- n = the harmonic number

<sup>a</sup> Refer to IEC 61000-4-7:2002-2008 for THDG calculations.

The ACSELERATOR QuickSet HMI software displays THD and THDG data.

## View Harmonic Data via ACSELERATOR QuickSet HMI

Use the following guidelines to view harmonic data via the ACSELERATOR QuickSet HMI.

- View voltage and current harmonic component percentages, THD, THDG, K-factor, and distortion power  
 Click the **Percentages (I, V)** button.

- View current and voltage harmonic component magnitudes  
Click the **Magnitudes (I, V)** button.
- View current harmonic component magnitudes and angles  
Click the **Magnitudes, Angles (I)** button.
- View voltage harmonic component magnitudes and angles  
Click the **Magnitudes, Angles (V)** button.
- View distortion power  
Click the **Power** button.
- View interharmonics  
Click the **Spectral Analysis** button.

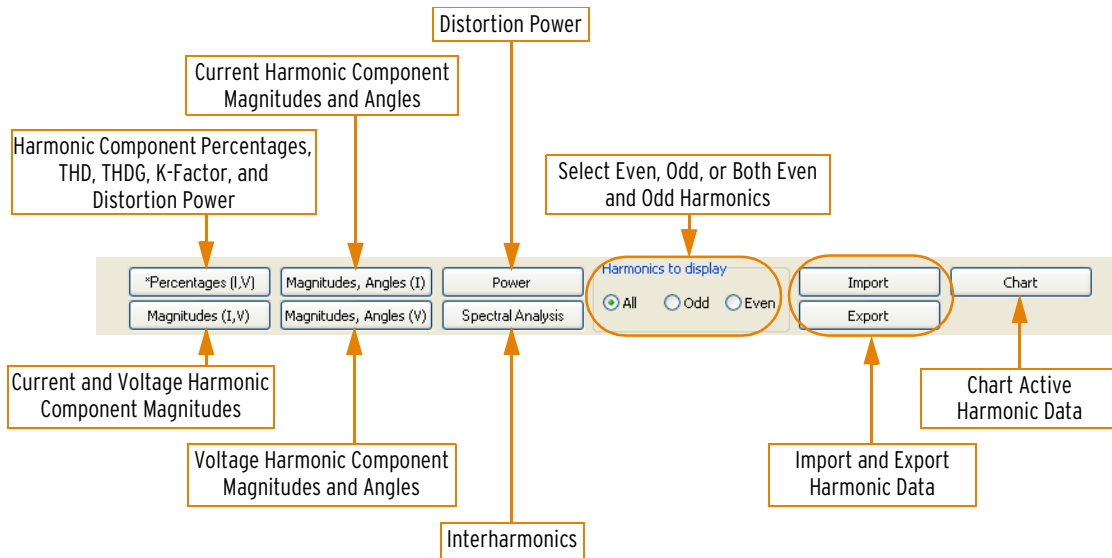


Figure 5.31 Harmonics HMI Toolbar

## View Harmonic Data via the Front-Panel LCD

Use the front-panel LCD to view THD, K-factor, and distortion power following the steps below.

- Step 1. Press **ENT**.
- Step 2. Select **Meter** and press **ENT**.
- Step 3. Select **Harmonics** and press **ENT**.
- Step 4. Press **Up** or **Down** to view the quantity you want.

## Flicker Metering

**NOTE:** When the SEL-735 is set up as a Form 36 meter, the Phase-B voltage is calculated, not measured. The flicker quantities reported for Phase B are a result of calculations, and should not be considered to reflect actual system conditions.

Light flicker from incandescent bulbs caused by fluctuation of voltage magnitude can interfere with the human eye, human brain, and sensitive electrical equipment. The SEL-735 calculates short- and long-term flicker values in accordance to IEC 61000-4-15, Edition 2.0 2010-08, Flickermeter and IEC 61000-4-30.

Inputs to the Flickermeter algorithm include the nominal voltage of the system, which may be either 120 V or 230 V. The VBASE setting allows you to configure any nominal meter voltage over a wide range. When the VBASE setting is between 20.00 V and 175.99 V, the SEL-735 calculates flicker based

on a 120 V nominal voltage. When the VBASE setting is between 176.00 V and 300.00 V, the SEL-735 calculates flicker based on a 230 V nominal voltage.

The meter calculates the following quantities available in flicker analog quantities, depending on the meter power quality and recording option.

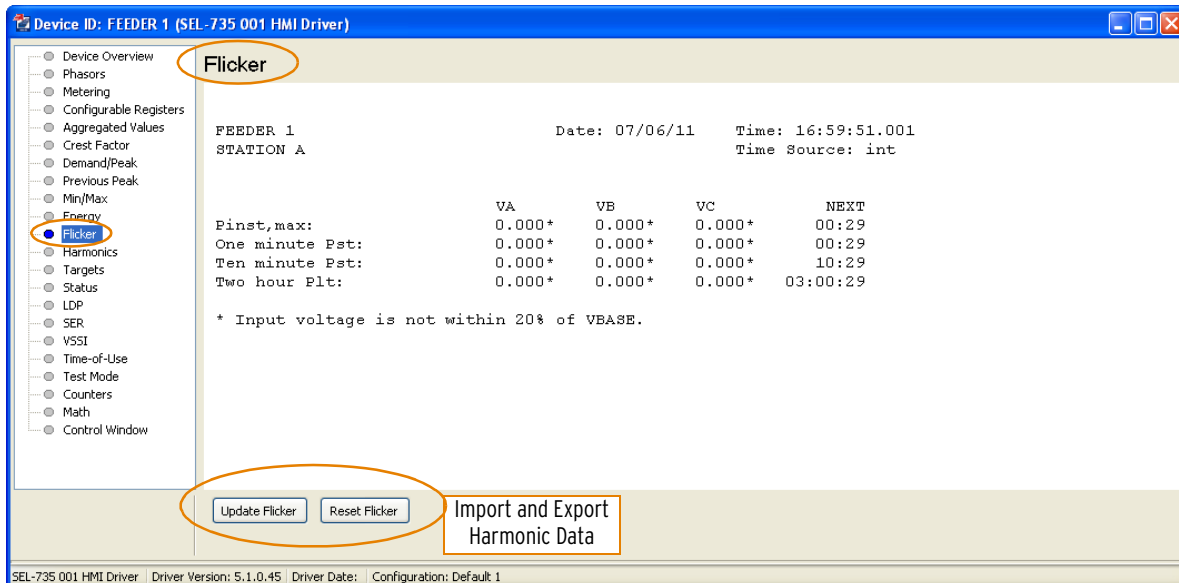
**Table 5.15 Flicker Quantities Available**

Power Quality and Recording Option	Quantity Description	Analog Quantity
Intermediate	Ten-minute short-term flicker	PST_10MIN_Vx <sup>a</sup>
	Two-hour long-term flicker	PLT_Vx
Intermediate and Advanced	Instantaneous flicker	PINST_Vx
	One-minute short-term flicker	PST_1MIN_Vx
	Ten-minute short-term flicker	PST_10MIN_Vx
	Two-hour long-term flicker	PLT_Vx

<sup>a</sup> Replace x with A-, B-, or C-phase.

## View Flicker Data via the ACSELERATOR QuickSet HMI

Use ACSELERATOR QuickSet HMI to view and reset flicker data. *Figure 5.32* shows the flicker window as it displays on the ACSELERATOR QuickSet HMI.



**Figure 5.32 Flicker HMI Window**

## Transformer/Line Loss Compensation

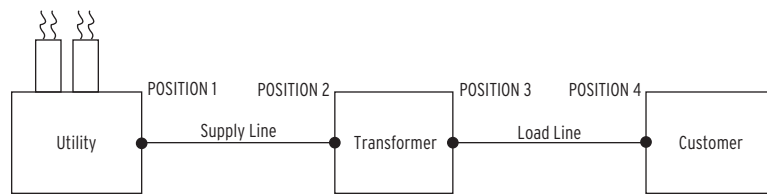
Use known system parameters with transformer/line-loss compensation (TLLC) to estimate power transmission and distribution losses. Manual calculations to implement loss compensation in the SEL-735 are unnecessary. Inputs to the meter use given nameplate transformer specifications and line parameters. The meter adds or subtracts the losses based on these inputs and the location of the metering point versus the billing point.

Power delivery from a power supplier to a point of consumption occurs over a network of transmission lines and through transformers. In addition to generating power for customer loads, the power supplier must supply power to overcome transmission system losses. To increase billing precision, the SEL-735 can compensate for these resistive and inductive power transmission losses. Without loss compensation, power suppliers are unable to bill customers for losses that occur before the metering point.

In a basic system, there are four possible billing points and four possible meter points. *Figure 5.33* shows the diagram of the billing and metering points. *Table 5.16* shows the addition and subtraction of line and transformer loss compensation. The meter uses the transformer constants, T1 and T2, in the line loss calculations and then adds calculated losses to or subtracts these losses from the energy, demand, and power quantities.

When transformer/line-loss compensation is enabled (ETLLC is enabled) power quantities (W, Wh, etc) and reactive power quantities (VAR, VARh, etc) are compensated. For each compensated value, there is an Analog Quantity that always remains uncompensated, as listed in *Appendix G: Analog Quantities and Device Word Bits*. The names of these analog quantities end in “\_UC” and their descriptions specify “uncompensated.”

Voltage, current and apparent power quantities are never compensated.



**Figure 5.33 Meter and Billing Positions**

**Table 5.16 Transformer and Line Loss Adjustments**

Billing Position (BPOS)	Meter Position (MPOS)	Supply Line Constant, T1 <sup>a</sup>	Load Line Constant, T2	Change to Calculated Power
1	1	1	XFTR	No adjustment
2				Supply line losses subtracted
3				Supply line and transformer losses subtracted
4				Transformer, supply line, and load line losses subtracted
1	2	1	XFTR	Supply line losses added
2				No adjustment
3				Transformer losses subtracted
4				Transformer and load line losses subtracted
1	3	1/XFTR	1	Transformer losses and supply line losses added
2				Transformer losses added
3				No adjustment
4				Load side line losses subtracted
1	4	1/XFTR	1	Transformer, supply line, and load line losses added
2				Load line and transformer losses added
3				Load line losses added
4				No adjustment

<sup>a</sup> XFTR is the main Transformer Turns Ratio setting.

## View and Set Transformer/Line Loss Compensation

Add transformer and line loss compensation values to configurable registers for use on external interfaces. The following *Figure 5.34* shows all transformer and line loss analog quantities in configurable registers. See *Configurable Registers on page 5.51* for an example on how to set the transformer and line loss compensation in configurable registers.

Register	Name	Alias	Units	Scale User	Scale Value	Offset	Units Type	Scale Type	Rollover	Rollover Value	Total Digits	Decimal Places	Leading Zeros	Large Font
CFG0001	3PWFE	XFMR 3P FE	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0002	3PVFE	XFMR 3P FE	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0003	LWFECB	XFMR PhA FE	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0004	LWFECB	XFMR PhB FE	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0005	LWFECB	XFMR PhC FE	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0006	LWFECA	XFMR PhA FE	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0007	LWFECB	XFMR PhB FE	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0008	LWFECB	XFMR PhC FE	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0009	3PWCU	XFMR 3P CU	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0010	3PVCU	XFMR 3P CU	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0011	LWCUCB	XFMR PhA CU	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0012	LWCUCB	XFMR PhB CU	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0013	LWCUCC	XFMR PhC CU	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0014	LVCUCA	XFMR PhA CU	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0015	LVCUCB	XFMR PhB CU	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0016	LVCUCC	XFMR PhC CU	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0017	TTL	XFMR TOT	kVA	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0018	TVALA	XFMR PhA	kVA	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0019	TVALB	XFMR PhB	kVA	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0020	TVALC	XFMR PhC	kVA	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0021	SPLL	SOURCE LINE 3P	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0022	SQLL	SOURCE LINE 3P	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0023	SPALL	SOURCE LINE PhA	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0024	SPBL	SOURCE LINE PhB	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0025	SPCL	SOURCE LINE PhC	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0026	SQAL	SOURCE LINE PhA	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0027	SQBL	SOURCE LINE PhB	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0028	SQCL	SOURCE LINE PhC	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0029	LPLL	LOAD LINE 3P	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0030	LQLL	LOAD LINE 3P	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0031	LPAL	LOAD LINE PhA	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0032	LPBL	LOAD LINE PhB	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0033	LPCL	LOAD LINE PhC	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0034	LQAL	LOAD LINE PhA	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0035	LQBL	LOAD LINE PhB	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0036	LQCL	LOAD LINE PhC	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N

**Figure 5.34 Transformer and Line Loss Values in Configurable Registers**

You can also use the **MET L** command from the terminal to view the transformer/line losses the meter calculates. The meter performs calculations every second to compensate the average power, demand, peak demand, and energy values, as shown in *Table 5.18*.

You must enable transformer/line losses compensation (ETLLC) to compensate for losses or to program loss compensation settings. You can calculate copper (load) and iron (no load) transformer loss compensation independently by enabling the ELCU and ELFE settings.

The SEL-735 requires you to make the input shown in *Table 5.17* to calculate transformer/line loss compensation. The meter calculates the transformer and line loss analog quantities, shown in *Table 5.18*, automatically without further input from the operator.

**Table 5.17 Required User Input (Sheet 1 of 2)**

	Setting	Description
<b>Transformer Losses</b>	MVA	Base transformer 3-phase MVA rating
	KVLL	Primary line-to-line voltage at the metering point, kV
	%Z	Percent transformer impedance
	%IMAG	Percent transformer exciting current
	LWCU	Copper or load loss in kW
	LWFE	Iron or no load loss in kW

**Table 5.17 Required User Input (Sheet 2 of 2)**

<b>Line Losses</b>	SLR	Supply line resistance, ohms primary
	SLX	Supply line inductive reactance, ohms primary
	LLR	Load line resistance, ohms primary
	LLX	Load line inductive reactance, ohms primary
	XFTR	Power transformer turns ratio $\frac{V_{Supply}}{V_{Load}}$

**Table 5.18 Analog Quantities: Transformer and Line Losses**

	<b>Setting</b>	<b>Description</b>
<b>Transformer Losses</b>	3PWFE	Three-phase active power iron loss, watts
	3PVFE	Three-phase reactive power iron loss, VARs
	LWFECx	Individual phase transformer active power iron loss, watts
	LVFECx	Individual phase transformer reactive power iron loss, VARs
	3PWCU	Three-phase active power copper loss, watts
	3PVCU	Three-phase reactive power copper loss, VARs
	LWCUCx	Individual phase transformer active power copper loss, watts
	LVCUCx	Individual phase transformer active power copper loss, VARs
	TTL	Three-phase total transformer loss, VA
TVALx	Individual phase transformer loss, VA	
<b>Source Line Losses</b>	SPLL	Total source line active power loss, watts
	SQLL	Total source line reactive power loss, VARs
	SPxL	Individual phase source line active power loss, watts
	SQxL	Individual phase source line reactive power loss, VARs
<b>Load Line Losses</b>	LPLL	Total load line active power loss, watts
	LQLL	Total load line reactive power loss, VARs
	LPxL	Individual phase load line active power loss, watts
	PQxL	Individual phase load line reactive power loss, VARs

## Transformer Loss Calculations

Equation 5.8 and Equation 5.15 show transformer loss calculations. First, the meter uses the settings LWCU, LWFE, %Z, %IMAG, and MVA to calculate the base watt and VA losses. Enter the nameplate watt losses, LWCU and LWFE, in kilowatt units; enter the nameplate impedance values in percent (e.g., enter 8 percent impedance as 8; enter the power transformer rating MVA rating).

### Base Copper Loss, MW

$$LWCUB = \frac{LWCU}{1000} \quad \text{Equation 5.8}$$

### Base Iron Loss, MW

$$LWFEB = \frac{LWFE}{1000} \quad \text{Equation 5.9}$$

**Base Copper Loss, MVA**

$$VACUB = \frac{\% Z}{100} \cdot MVA \quad \text{Equation 5.10}$$

**Base Iron Loss, MVA**

$$VAFEB = \frac{\% IMAG}{100} \cdot MVA \quad \text{Equation 5.11}$$

The meter then converts the base watt and VA parameters into base VAR parameters, as shown in *Equation 5.12* and *Equation 5.13*.

**Base Copper Losses, MVAR**

$$LVCUB = \sqrt{VACUB^2 - LWCUB^2} \quad \text{Equation 5.12}$$

**Base Iron Losses, MVAR**

$$LVFEB = \sqrt{VAFEB^2 - LWFEB^2} \quad \text{Equation 5.13}$$

Next, the meter uses the settings KVLL and MVA as shown in *Equation 5.14* and *Equation 5.12* to calculate dynamic current and voltage correction factors. The meter uses these dynamic correction factors to proportion the measured current and voltage values in the loss calculations.

**Dynamic Current Correction Factor, Per Unit**

$$DICF = \frac{\sqrt{3} \cdot KVLL}{MVA \cdot 1000} \quad \text{Equation 5.14}$$

**Dynamic Voltage Correction Factor, Per Unit**

$$DVCF = \frac{\sqrt{3}}{KVLL} \quad \text{Equation 5.15}$$

Lastly, the meter uses the values it calculates and the voltage and current values it measures,  $I_x$  and  $V_x$ , as shown in *Equation 5.18–Equation 5.25* (replace  $x$  with the respective phase A, B, or C), to calculate the transformer losses incurred. Access the calculated losses in the transformer copper and iron losses analog quantities.

## Iron Losses

**Primary Iron Losses, MW**

$$LWFEC_x = LWFEB \cdot (V_x \cdot DVCF)^2 \quad \text{Equation 5.16}$$

**Primary Iron Losses, MVAR**

$$LVFEC_x = LVFEB \cdot (V_x \cdot DVCF)^4 \quad \text{Equation 5.17}$$

**Three-Phase Iron Loss, MW**

$$3PWFE = LWFECA + LWFECB + LWFEC C \quad \text{Equation 5.18}$$

**NOTE:** The metering industry has standardized on the principle that reactive iron losses are proportional to the fourth power of the voltage.

**Three-Phase Iron Loss, MVAR**

$$3PVFE = LVFECA + LVFECB + LVFECC \quad \text{Equation 5.19}$$

**Copper Losses**

**Primary Copper Losses, MW**

$$LWCUC_x = LWCUB \cdot (I_x \cdot DICF)^2 \quad \text{Equation 5.20}$$

**Primary Copper Losses, MVAR**

$$LVCUC_x = LVCUB \cdot (I_x \cdot DICF)^2 \quad \text{Equation 5.21}$$

**Three-Phase Copper Loss, MW**

$$3PWCU = LWCUCA + LWCUCB + LWCUC C \quad \text{Equation 5.22}$$

**Three-Phase Copper Loss, MVAR**

$$3PVCU = LVCUCA + LVCUCB + LVCUC C \quad \text{Equation 5.23}$$

**Iron and Copper Losses**

**Total Transformer Loss, MVA**

$$TTL = \sqrt{(3PWCU + 3PVFE)^2 + (3PVCU + 3PVFE)^2} \quad \text{Equation 5.24}$$

**Total Per-Phase Transformer Losses, MVA**

$$TVAL_x = (LWFEC_x + LWCUC_x)^2 + (LVFEC_x + LVCUC_x)^2 \quad \text{Equation 5.25}$$

**Line Loss Calculations**

If you know the conductor resistance and reactance of the supply and load lines, you can program the meter to calculate per-phase line losses. In a three-phase system, the SEL-735 assumes that each conductor has identical impedances and that only series losses are present.

The SEL-735 uses the following equations to calculate supply and load line loss compensation values. The supply and load line constants, T1 and T2, convert the supply and load losses to the metered side of the power transformer, according to *Table 5.16*.

**Supply Line Loss**

**Supply Line Watt Losses**

$$SPxL = (I_x \cdot T_1)^2 \cdot \frac{SLR}{1 \times 10^6} \quad \text{Equation 5.26}$$

**Supply Line VAR Losses**

$$SQxL = (I_x \cdot T_1)^2 \cdot \frac{SLX}{1 \times 10^6} \quad \text{Equation 5.27}$$

**Total Supply Line Watt Losses**

$$SPLL = SPAL + SPBL + SPCL \quad \text{Equation 5.28}$$

**Total Supply Line VAR Losses**

$$SQLL = SQAL + SQBL + SQCL \quad \text{Equation 5.29}$$

**Load-Line Loss**

**Load Line Watt Losses**

$$LPxL = (I_x \cdot T_2)^2 \cdot \frac{LLR}{1 \times 10^6} \quad \text{Equation 5.30}$$

**Load Line VAR Losses**

$$LQxL = (I_x \cdot T_2)^2 \cdot \frac{LLX}{1 \times 10^6} \quad \text{Equation 5.31}$$

**Total Load Line Watt Losses**

$$LPLL = LPAL + LPBL + LPCL \quad \text{Equation 5.32}$$

**Total Load Line VAR Losses**

$$LQLL = LQAL + LQBL + LQCL \quad \text{Equation 5.33}$$

# Configurable Registers

Configurable registers allow you to control the scaling, formatting, and labeling of metered quantities as these would appear to external interfaces. The registers allow you to present consistently scaled and formatted data among all interfaces.

## Attributes

Each configurable register contains several user-defined attributes that control the scaling and presentation of the value. *Table 5.19* lists available attributes, their default value, and range.

**Table 5.19 Configurable Register Attributes (Sheet 1 of 2)**

Attribute	Description	Default Value	Range
Register	The number of the configurable register.	N/A	1–1000
Name	The name of the analog quantity.	“ “	Analog Quantity
Alias	A user-defined text string of the alias to display on external interfaces.	“ “	“a–z”, “A–Z”, “0–9”, <space>, <underscore>
Decimals	User-defined number of decimal places to pass to external interfaces.	2	0–6
Leading_Zeros	Boolean setting determines if leading zeros are displayed on LCD.	N	Y, N
Large_Font	Boolean setting determines if the display is in large font on LCD.	Y	Y, N

**Table 5.19 Configurable Register Attributes (Sheet 2 of 2)**

Attribute	Description	Default Value	Range
Scale User	Boolean setting determines if a scale value will be applied	N	Y, N
Scale Value	User-defined scale factor. Scales both primary and secondary configurable register values. For example, if the PTR is 120, the Scale Type is PRIMARY, and the Scale Value is 10, then the SEL-735 scales voltage configurable register values by 1200. In the above example, if the Scale Type is set to secondary, the SEL-735 scales the configurable register value by 10 (the Scale Value). Hidden and forced to default value if Scale User is set to N.	1	-10x10 <sup>9</sup> to 10x10 <sup>9</sup>
Offset	User-defined offset. Hidden and forced to default value if Scale User is set to N.	0	-10x10 <sup>9</sup> to 10x10 <sup>9</sup>
Scale Type	PRIMARY converts all values to reference the high side of instrument transformers; SECONDARY presents all values as measured directly at the rear-panel connections.	PRIMARY	PRIMARY or SECONDARY
Units Type	MEGA multiplies all values by 1x10 <sup>6</sup> ; KILO multiplies all values by 1x10 <sup>3</sup> ; UNITY multiplies all values by 1.	UNITY	MEGA, KILO, or UNITY
Rollover	When set to DIALS, the meter rolls over the value according to the Total Digits setting; When set to VALUE, the meter rolls over the value according to the RolloverValue setting.	DIALS	DIALS or VALUE
Total Digits	When RolloverType is set to DIALS, then the meter rolls over the value when the maximum number is reached for the Total Digits number.	9	5-12
Rollover Value	When RolloverType is set to VALUE, then the meter rolls over the value when it reaches the RolloverValue setting value. To disable rollover, set RolloverValue to zero and RolloverType to VALUE.	0	0-1x10 <sup>15</sup>

## Configuration

ACSELERATOR QuickSet settings software simplifies setup of configurable registers. The Configurable Registers setup window, as shown in *Figure 5.35*, contains the following four sections: Map, Options, Interfaces, and Operations. The Map section shows configurable registers already configured and their associated attributes. Use the Options section to enter all attributes explained in *Table 5.19*. View the different result outputs on the Interfaces section. Execute the configurations from the Operations section.

Follow the guidelines and steps that follow to set up a configurable register.

- Step 1. Navigate to settings **Metering > Configurable Registers** in ACSELERATOR QuickSet.

The Configurable Registers setting window displays, similar to *Figure 5.35*.

- Step 2. Enter in the Options section the attributes you want, as explained in *Table 5.19*.
- Step 3. Use the Interfaces section to view how the meter will pass the configurable register result to interfaces.
  - a. Enter a number in the Interfaces section.
  - b. Click the **Preview** button in the Options section.

The different results display in the Interfaces section.

- Step 4. Click the **Add** button in the Operations section to save the configurable register to the map.

Map

Register	Name	Alias	Units	Scale User	Scale Value	Offset	Units Type	Scale Type	Rollover	Ro
CFG0001	3PWFE	XFMR 3P FE	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9
CFG0002	3PWFE	XFMR 3P FE	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9
CFG0003	LWFECB	XFMR PhA FE	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9
CFG0004	LWFECB	XFMR PhB FE	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9
CFG0005	LWFECB	XFMR PhC FE	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9
CFG0006	LWFECB	XFMR PhA FE	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9
CFG0007	LWFECB	XFMR PhB FE	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9
CFG0008	LWFECB	XFMR PhC FE	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9
CFG0009	3PWCU	XFMR 3P CU	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9
CFG0010	3PWCU	XFMR 3P CU	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9

Options

Configured Register Options

Configured Register: CFG0001 Preview

Analog Quantity: 3PWFE Scale

Alias: XFMR 3P FE  Scale: 1.000  Unity  Kilo  Mega

Units: kW Offset: 0.00  Primary  Secondary

Decimal Places: 3 Large Font: N

Leading Zeros: N

Interfaces

Configured Register on Interfaces

Enter a Number (secondary): 0

Display Point

**XFMR 3P FE=0.001 kW**

SEL-ASCII

XFMR 3P FE 0.001 kW

DNP

AI 16 bit: 1      AI 32 bit: 1

CO 16 bit: 1      CO 32 bit: 1

MODBUS

1

Options

Add
Replace
Delete
Delete All
Import
Export

Figure 5.35 Configurable Registers Settings Window

### Calculation and Update Rate

The meter calculates the configurable register results as follows.

$$\text{Result} = \text{AnalogQuantity} \cdot \text{Scale} + \text{Offset}$$

where:

Result is the value of the configurable register.

Analog Quantity is the present value of the analog quantity identified by the Name attribute. The value is in secondary units with unity scaling.

The configurable register result updates every 10/12 cycles.

### LDP Use

When you use configurable registers in LDP recorders, the meter stores the alias as the LDP channel name. The meter stores the configurable register value, with scaling and offset, in the LDP recorder. Because LDP configurable register channels do not contain conversion data, ACSELERATOR QuickSet does not apply conversions to the LDP configurable register retrieved data.

## Display Points

Configurable registers can display on the front-panel LCD in either large or small font.

Display points with large font appear similar to the following text.

E1\_OUT (MWH) =  
  
000058493

Display points with small font appear similar to the following text.

E1\_OUT =000058493 (MWH)

Figure 5.36 shows an example of a configurable register on the front-panel LCD in large font.



Figure 5.36 Front-Panel LCD Display Point Example

## Modbus/DNP

The meter additionally scales the configurable register results by the Decimals attribute set in the Configurable Register. For example, if the configurable register result is 5849.3, and the Decimals attribute is 2, the meter scales the result by 100 and passes the value 584930 over the communications channel.

### EXAMPLE 5.2 Add Transformer and Line Losses to Configurable Registers

You could add the quantities you want to the configurable register list one by one as this manual described previously, but it may be easier to use the following procedure when adding a large number of quantities to the map. Perform the following steps to add transformer and line losses to the configurable registers map.

- Step 1. Create a Microsoft® Excel spreadsheet with CSV format.
- Step 2. Add the Attribute names from Table 5.20 to the first row of the spreadsheet.
- Step 3. Enter the transformer line and losses analog quantity names and other necessary information in the spreadsheet rows. You do not have to enter the CONFIGREG numbers in chronological order.

See the example of the spreadsheet, shown in Table 5.20, for which 3PWFE and 3PVFE provided configuration in kilowatt and kilovar units.

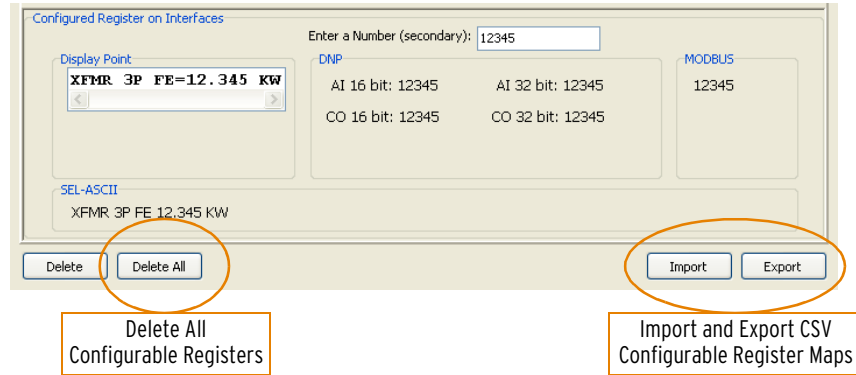
Table 5.20 Configurable Register Spreadsheet Example

CONFIGREG	Name	Alias	Units	Decimals	LeadingZeros	LargeFont	ScaleUser	ScaleValue	Offset	ScaleType	UnitsType	RolloverType	RolloverDials	RolloverValue
1	3PWFE	XFMR 3P FE	kW	3	N	N	B	1	0	PRIMARY	KILO	DIALS	9	1000
2	3PVFE	XFMR 3P FE	kVAR	3	N	N	B	1	0	PRIMARY	KILO	DIALS	9	1000

- Step 4. Save and close the spreadsheet as a CSV file.
- Step 5. Open ACSELERATOR QuickSet, and either open or create a new settings file.
- Step 6. Navigate to the **Metering > Configurable Registers** settings.
- Step 7. Click the Import button, as shown in Figure 5.37.
- Step 8. Open the spreadsheet you just created.

**NOTE:** The meter erases old configurable registers when you import a new map.

The imported configurable registers display in the ACSELERATOR QuickSet Configurable Registers setting map, as shown previously in Figure 5.34. You can also export the configurable registers map to a CSV file, as shown in Figure 5.37.



**Figure 5.37 Configurable Registers Configuration Tool**

## Voltage, Current, and Power Calculations

The following information details meter data calculations. The SEL-735 samples analog values at 128 times per cycle and performs a numerical approximation of the integral mathematical equations for voltage, current, and power. These calculations reference the equivalent mathematical equations in IEC 61000-4-30: Edition 2.0 2008-10.

### Starting Current

The SEL-735 allows you to adjust the starting current threshold of the meter. When the RMS current magnitude is less than the Starting Current Threshold (IST), the meter zeroes current registration. Analog quantities derived from the current quantities will also be impacted. The Starting Current Type setting configures the meter to zero either the RMS derived analog quantities or to zero all current registration. *Table 5.21* summarizes the behavior of the Starting Current Type setting.

**Table 5.21 Starting Current Type Setting Behavior**

Starting Current Type Setting	Behavior
RMS_ONLY (default value)	When the RMS current magnitude on any phase is less than the Starting Current Threshold value, the meter zeroes the RMS current analog quantities and quantities derived from them of the associated phase. The meter continues to register the fundamental current while the RMS current magnitude is greater than the Starting Current Threshold.
ALL	When the RMS current magnitude on any phase is less than the Starting Current Threshold value, the meter zeroes all current registration of the associated phase.

## Neutral Current

For Form 9 and Form 36 meters, the SEL-735 calculates the vector sum of the three-phase currents to calculate the neutral current, IN. The following equation shows this calculation.

$$I_N = I_A + I_B + I_C$$

For Form 5 meters, the SEL-735 assumes that the neutral current is zero. The meter calculates the vector sum of phase currents IA and IC to determine IB, as the following equation shows.

$$I_B = -(I_A + I_C)$$

## Form 5 Metering

Form 5 meters use terminals E07 (VA) and E09 (VC) voltages as the VAB and VCB quantities, respectively. The Form 5 meter calculates VBC as follows.

$$V_{BC} = -V_{CB}$$

The meter uses VAB and VCB to calculate VCA, as follows.

$$V_{CA} = V_{CB} - V_{AB}$$

The meter also reports all line-to-neutral measurements and calculations as zero.

## Form 36 Metering

Form 36 meters use terminals E07 (VA) and E09 (VC) voltages as the VAN and VCN quantities, respectively. The Form 36 meter calculates VBN as follows.

$$V_{BN} = -(V_{AN} + V_{CN})$$

This calculated VBN is used in all subsequent calculations for active power, reactive power, etc.

## Voltage and Current RMS Magnitudes

The SEL-735 calculates voltage and current magnitudes in accordance with IEC 61000-4-30, Section 4.4, Class A. The time intervals for each measurement are 10 cycles for 50 Hz meters and 12 cycles for 60 Hz meters, commonly known as 10/12 cycle intervals. The sample rate is 128 samples/cycle.

The meter calculates rms voltage and current in accordance with the following equation.

$$X_x = \sqrt{\frac{\sum_0^{N-1} [s(n)]^2}{N}}$$

where:

$N$  = Total number of samples

$n$  = Index number

$s(n)$  = Array of periodic  $v$  or  $i$  samples corresponding to  $X$

$X_x$  = Form 5: IA, IB, IC, VAB, VBC, or VCA

Form 9 and Form 36: IA, IB, IC, VA, VB, VC, VAB, VBC, or VCA

## Half-Cycle RMS Calculation

The meter calculates half-cycle voltage and current rms quantities for sag, swell, and interruption (SSI) detection. Sixteen samples/cycle data provide the source for the calculation, and the half-cycle rms calculation updates every 1/16 cycles.

Half-cycle rms calculations are for SSI detection only and are not available as analog quantities.

## Fundamental Only Magnitudes and Angles

The meter calculates fundamental-only quantities and provides these data to analog quantities. Fundamental-only calculations use 16 samples/cycle fundamental measurements. Calculated values update every half-cycle.

The meter references all angles to VA when VA is greater than 13 volts. Otherwise, angles reference IA.

The current and voltage magnitude and angle calculations are as follows.

$$\text{MAG} = \sqrt{x^2 + y^2}$$

$$\text{ANG} = \tan^{-1}\left(2 \cdot \frac{y}{x}\right)$$

where  $x$  and  $y$  are discrete samples taken 90° apart.

## Analog Quantities

The SEL-735 provides the analog quantities (shown in *Figure 5.21*) based on the meter form.

**Table 5.22 Fundamental-Only Power**

Meter Form	Analog Quantities
Form 9 and Form 36	V <sub>x</sub> _MAG and V <sub>x</sub> _ANG where $x$ is A, B, C, AB, BC, or CA  I <sub>x</sub> _MAG and I <sub>x</sub> _ANG where $x$ is A, B, C
Form 5	V <sub>x</sub> _MAG and V <sub>x</sub> _ANG where $x$ is AB, BC, or CA  I <sub>x</sub> _MAG and I <sub>x</sub> _ANG where $x$ is A, B, C

## P, Q, and S

Per-phase fundamental active power (W<sub>x</sub>\_FUND), reactive power (Q<sub>x</sub>\_FUND), and apparent power (S<sub>x</sub>\_FUND) calculations use the following equations.

$$\text{W}_x\text{\_FUND} = \text{V}_x\text{\_MAG} \cdot \text{I}_x\text{\_MAG} \cdot \cos(\text{V}_x\text{\_ANG} - \text{I}_x\text{\_ANG})$$

$$\text{Q}_x\text{\_FUND} = \text{V}_x\text{\_MAG} \cdot \text{I}_x\text{\_MAG} \cdot \sin(\text{V}_x\text{\_ANG} - \text{I}_x\text{\_ANG})$$

$$\text{S}_x\text{\_FUND} = \text{V}_x\text{\_MAG} \cdot \text{I}_x\text{\_MAG}$$

where:

$$x = \text{A, B, or C}$$

Three-phase fundamental active (W3\_FUND) and reactive power (Q3\_FUND) calculations use the following equations.

$$W3\_FUND = WA\_FUND + WB\_FUND + WC\_FUND$$

$$Q3\_FUND = QA\_FUND + QB\_FUND + QC\_FUND$$

Form 9 and Form 36 three-phase fundamental apparent power (S3\_FUND) calculations use the following equation.

$$S3\_FUND = SA\_FUND + SB\_FUND + SC\_FUND$$

Form 5 three-phase fundamental apparent power (S3\_FUND) calculations use the following equation.

$$S3\_FUND = \sqrt{W3\_FUND^2 + Q3\_FUND^2}$$

These values are available from the fundamental-only power analog quantities.

Fundamental reactive power for each quadrant uses the following nomenclature.

$$Qx\_yyy\_zz$$

where:

- $x = A, B, C, \text{ or } 3$
- $yyy = \text{REC (received) or DEL (delivered)}$
- $zz = \text{LD (leading) or LG (lagging)}$

## 10/12 Cycle Power (P, Q, and S)

Active power (P), reactive power (Q), and apparent power (S) calculations use 128 samples/cycle unfiltered voltage and current rms magnitudes as source data.

### Active Power

Active power rms calculations use the following equations.

Per-phase quantities:

$$W_x = \frac{1}{N} \sum_{n=0}^{N-1} (V_n \cdot I_n)$$

where:

- $x = A, B, C$
- $V_n, I_n = \text{discrete measurements of } N \text{ samples}$
- $N = \text{the total number of samples}$

Three-phase quantity:

$$W3 = WA + WB + WC$$

## Apparent Power

Apparent power rms calculations use the following equations.

Per-phase quantities:

$$U_x = I_x \cdot V_x$$

where:

$I_x, V_x$  = the respective phase rms quantities

Three-phase quantity:

$$3U = U_A + U_B + U_C$$

## Reactive Power

Reactive power rms calculations use the following equations. The sign of the fundamental reactive power applies to the calculation results.

Per-phase quantities:

$$Q_x = \sqrt{U_x^2 - W_x^2}$$

where:

$x = A, B, \text{ or } C$

Three-phase quantity:

$$3Q = Q_A + Q_B + Q_C$$

## Power Factor

Per-phase and three-phase power factor calculations use fundamental-only quantities and 10/12-cycle quantities. The 10/12-cycle data define the true power factor, while the fundamental-only data define the displacement power factor.

The 10/12-cycle quantities define the true power factor, as in the following equation.

$$PFT_x = \frac{W_x}{U_x}$$

where:

$x = A, B, C, \text{ or } 3$

The fundamental-only quantities define the displacement power factor, as in the follow equation.

$$PFD_x = \frac{W_{x\_FUND}}{U_{x\_FUND}}$$

where:

$x = A, B, C, \text{ or } 3$

## Average and Imbalance Calculations

Average and imbalance quantities update each processing cycle.

Voltage and current imbalance calculations use the following equation.

$$X\_IMB = \frac{X2\_MAG}{X1\_MAG} \cdot 100$$

where:

$X$  = I or V (current or voltage)

$X1$  and  $X2$  = the positive-sequence and negative-sequence components, respectively.

If  $V1$  is less than 13 V, the meter reports  $V1\_IMB$  as zero. If  $I1$  is less than 10 mA, the meter reports  $I1\_IMB$  as zero.

Average value calculations use the following equation.

$$X\_AVG = \frac{XA + XB + XC}{3}$$

where:

$X$  = I or V (current or voltage rms value)

## Voltage and Frequency Deviation Calculations

Voltage and frequency deviation quantities update each processing cycle.

Voltage and frequency deviation calculations use the following equation.

$$DEV\_Vx = \frac{Vx}{V_{Nominal}} \cdot 100$$

where:

$x$  = A, B, or C

$V_{Nominal}$  = is 120 V

The meter uses the following equation to calculate the percent frequency deviation.

$$DEV\_F = \frac{FREQ}{f_{Nominal}} \cdot 100$$

where:

FREQ = the frequency of the analog quantity

# Section 6

## Logging

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### Introduction

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The SEL-735 stores all logged values into nonvolatile memory. If a power loss occurs, the meter retains all previously logged values throughout the power loss duration. Flexible settings control how much memory the meter uses to maximize logging capabilities. The meter provides LDP data to all external interfaces, providing important historical data to the power system.

The meter LDP recorders allow you to log Analog Quantities and Configurable Registers values, control the log rate, and control the logging function. Using Configurable Registers, you can scale the logged values into primary or secondary units; into mega, kilo, or unity scaling; or apply a user-defined scale factor. The ACSELERATOR QuickSet® SEL-5030 Software interface simplifies scaling and previewing of the values. You can configure the LDP recorders to log the instantaneous value, the quantity's change-over interval, the average value, the maximum value, or the minimum value. The meter has a separate billing LDP recorder that provides the data to common automatic meter reading tools.

### Load Profile Report

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The SEL-735 provides as many as 12 independent load profile recorders. Each load profile recorder has its own settings as shown in *Table 6.1*. Advanced and Intermediate PQ and Recording options have 12 LDP recorders, while the Basic model has one LDP recorder, which is the billing recorder.

*Table 6.1* lists the settings associated with each LDP recorder.

**Table 6.1 Load Profile Recorder Settings**

Name	Range	Description
LDFUNC $n$	EOI, COI, AVG, MAX, MIN	Recorder Function, see <i>Table 6.2</i> for a description of each available recorder function.
LDLIST $n$	Analog Quantity (16 MAX)	Logged quantity list. You can list as many as 16 quantities. Enter 0 or NA to nullify the recorder.
LDAR $n$	3–59 s <sup>a</sup> ; 1, 2, 3, 5, 10, 15, 30, 60, or 120 minutes	Logging Acquisition Rate Setting. The meter logs values after each acquisition period, defined by LDAR, elapses.
LMDUR $n$	0.05 to 5000 days	Logged Values Maximum Duration. The meter starts to overwrite logged values after the period set by LMDUR.

<sup>a</sup> Only available for Advanced and Intermediate PQ and Recording options.

Change LDFUNC<sub>n</sub> according to the LDP recorder function you want. The meter logs values according to the LDP recorder function, as described in *Table 6.2*.

**Table 6.2 LDP LDFUNC Recorder Function Description**

LDFUNC Setting Function (SETTING, Name)	Function Description
AVG, Average	Records the average value during the LDAR period.
EOI, End of Interval	Records the value at the end of the interval.
COI, Change-Over-Interval	Records the difference in values between the beginning and end of the LDAR period
MAX, Maximum	Records the maximum value during the LDAR period
MIN, Minimum	Records the minimum value during the LDAR period

Each LDP record contains the time stamp and value of the selected analog quantities resulting in the LDLIST setting.

## Billing Recorder

We refer to LDP recorder number one as the billing recorder, because it has a functionality slightly different from all other recorders. The meter logs all energy quantities in the billing recorder as the change-over-interval (COI), despite the recorder LDFUNC setting. The meter logs all nonenergy quantities in the billing recorder according to the recorder LDFUNC setting. Additionally, the meter fixes the scaling and units of the quantities (including the source analog quantity of configurable registers) in the billing recorder defined by *Table 6.3*.

**Table 6.3 Billing Recorder (LDP Recorder One) Scaling**

Quantity Type	Scaling
Current (amps)	Primary, Unity
Voltage, Power, Energy	Primary, Kilo

Itron® MV-90® meter reading software reads the billing recorder when it interrogates the meter for energy data. The fixed scaling of the billing recorder ensures MV-90 reads the data correctly.

## PQ Recorders

All other LDP recorders, known as PQ recorders, scale quantities according to the global scale settings PRI\_SCA, VOLT\_SCA, POWR\_SCA, and ENRG\_SCA. The other LDP recorders also log the quantity value according to the LDFUNC setting.

## Settings Changes

Settings changes you apply to the LDP recorder cause erasure of record values. ACSELERATOR QuickSet® SEL-5030 Software prompts you before sending the settings and erasing LDP data.

**HINT:** Click the ellipse button shown in Figure 6.1 to open the LDP Builder. This interface provides names and descriptions of each analog quantity and allows for dragging and dropping quantities to create the LDP list.

ACSELERATOR QuickSet software automatically calculates available LDP storage space depending on the meter configuration. *Figure 6.1* shows a screenshot from the LDP settings editor in ACSELERATOR QuickSet, with display of the available recorder memory.

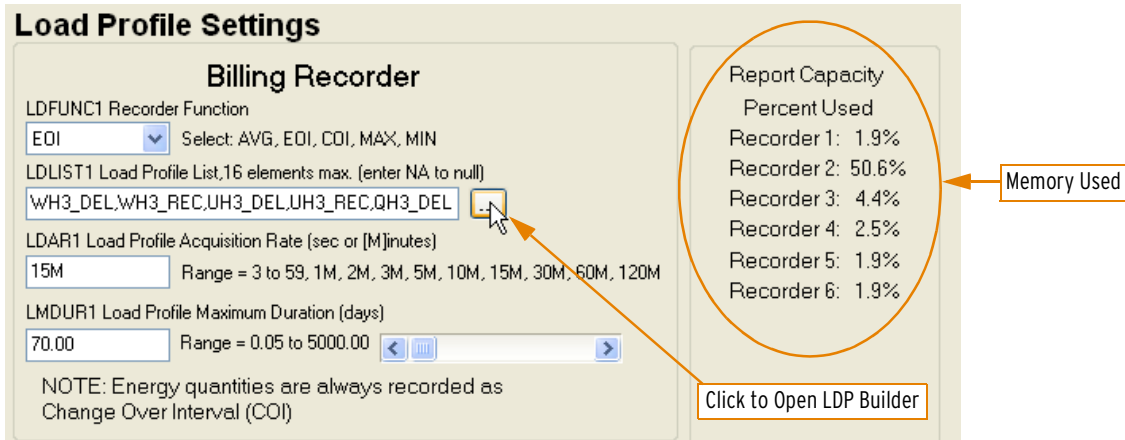


Figure 6.1 LDP Settings Interface

## LDP Retrieval

Use the ACSELERATOR QuickSet HMI to retrieve LDP recorder data. Figure 6.2 shows a screenshot of the LDP HMI window. Refer to Figure 6.2 to retrieve the LDP data.

```
FEEDER 1                               Date: 06/22/11 Time: 13:35:46
STATION A                               Time Source: Internal

SEL-735-R001-V0-Z001001-D20110504      Function: BOI Recorder: 1
```

#	DATE	TIME	IA_MAG	IA_ANG	VA_MAG	VA_ANG
17	06/20/11	09:59:12	1.07	0.63	119.93	0.00
16	06/20/11	09:59:15	1.07	0.59	119.94	0.00
15	06/20/11	09:59:18	1.08	0.63	119.94	0.00
14	06/20/11	09:59:21	1.09	0.60	119.94	0.00
13	06/20/11	09:59:24	1.10	0.63	119.94	0.00
12	06/20/11	09:59:27	1.10	0.60	119.94	0.00
11	06/20/11	09:59:30	1.11	0.63	119.93	0.00
10	06/20/11	09:59:33	1.12	0.62	119.93	0.00
9	06/20/11	09:59:36	1.13	0.59	119.93	0.00
8	06/20/11	09:59:39	1.13	0.61	119.94	0.00
7	06/20/11	09:59:42	1.14	0.61	119.94	0.00
6	06/20/11	09:59:45	1.15	0.62	119.94	0.00
5	06/20/11	09:59:48	1.16	0.62	119.94	0.00
4	06/20/11	09:59:51	1.16	0.61	119.93	0.00
3	06/20/11	09:59:54	1.17	0.59	119.92	0.00
2	06/20/11	09:59:57	1.18	0.62	119.94	0.00
1	06/20/11	10:00:00	1.19	0.59	119.94	0.00

```
Units: Secondary (Unity)
STATUS CODES:
1 - Daylight savings time is in effect during or at start of interval
2 - Power fail within interval (missing data)
3 - Clock reset forward during interval
4 - Clock reset backwards during interval
5 - Skipped interval
6 - TEST mode data
7 - Data overwrite
```

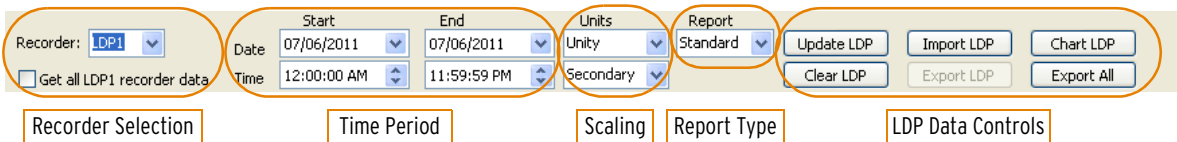


Figure 6.2 LDP HMI Window

Use the following guidelines to retrieve LDP data.

- Select the LDP recorder.
  - *Figure 6.2* annotates the options for recorder selection. Select the desired LDP recorder. Optionally, check the Get all LDP $n$  recorder data checkbox.
- Select the time period of data you want to retrieve.
  - *Figure 6.2* shows the Start and End dates and times in the Time Period section. Set the date and Start and End times you want.
- Select the necessary scaling output.
  - *Figure 6.2* shows the Scaling section. Choose your desired scaling options. ACSELERATOR QuickSet exports the LDP data according to the scale factors you have chosen.
- Select the Report Type as Standard or MV-90.
  - ACSELERATOR QuickSet formats the Standard report to SEL standards.
  - ACSELERATOR QuickSet formats the MV-90 report to replicate an MV-90 Energy report.
- Activate an LDP Control:
  - Click Update LDP to retrieve the LDP recorder data you selected from the meter. The data populate the HMI window.
  - Click Clear LDP to clear the selected recorder. ACSELERATOR QuickSet prompts you before clearing the LDP recorder.
  - Click Import LDP to import LDP files and display them in the HMI. The meter can import the following file types.
    - CSV (Comma-separated Values file)
    - LDP (SEL-formatted LDP file)
    - BIN (Binary file)
    - TXT (SEL-Formatted Text file)
    - HHF (MV-90 Meter-Reading file)
  - Click Export LDP to export the displayed LDP data to a file. The meter supports exports to the following file types.
    - CSV (Comma-separated Values file)
    - BIN (Binary file)
    - TXT (SEL-Formatted Text file)
    - HHF (MV-90 Meter-Reading file)
  - Click Chart LDP to chart the displayed LDP data.
  - Click Export All to export all LDP data on the meter. ACSELERATOR QuickSet reads all of the LDP data before the export.

Table 6.4 defines the format and fields of LDP records.

**Table 6.4 LDP Field Format**

Offset	Name	Length (bytes)	Binary Equivalent
0 to 1	Record Type	2	16 bit unsigned
2 to 3	Record Size	2	16 bit unsigned
4 to (4 + N - 1)	Data Block	N (0-65533)	8 bit unsigned
4 + N	Record checksum	2	16 bit unsigned

## Event Reports Overview

The SEL-735 offers three styles of event reports.

- Waveform Capture Event Reports
- Sequential Events Recorder (SER) Report
- Voltage Sag/Swell/Interruption (VSSI) Report

### Waveform Capture Event Reports

Waveform capture, also known as oscillography, allows the SEL-735 to record the voltage and current waveforms associated with programmable trigger conditions, such as a voltage interruption. You can set the sample rate and duration of the waveform capture using the SRATE and LER settings. The supported sample rates are 16, 128, and 512 samples per cycle. The duration of the waveform capture can be set from 15 to 600 cycles. Each waveform capture can contain 1 to 595 cycles of pretrigger data. Adjust the pretrigger data amount with the PRE setting.

The sample rate and duration determines the number of waveform captures that the meter can store in memory. The meter stores the waveform capture in nonvolatile memory. If more waveform captures are triggered than the meter can store, the latest waveform capture overwrites the oldest waveform capture.

The SEL-735 provides an option to generate a filtered 15-cycle event with 16 samples per cycle. The meter filters these reports to provide fundamental-only waveforms-the report does not contain any harmonics or interharmonics. The event reports contain date, time, currents, voltages, frequency, and Device Word bits.

### Automated Event Report Retrieval

ACSELERATOR Team® SEL-5045 Software automatically retrieves, databases, and displays SEL-735 event reports. ACSELERATOR Team integrates with the SEL-735, which automatically sends new event reports to the ACSELERATOR Team software allowing near instantaneous display of event waveforms. For additional information on ACSELERATOR Team, please contact your SEL Sales Representative.

### Sequential Events Recorder (SER) Report

The meter adds lines in the sequential events recorder (SER) report for a change of state of a programmable condition. The SER lists date and time-stamped lines of information each time a programmed condition changes state.

## Voltage Sag/Swell/ Interruption (VSSI) Report

The VSSI report captures voltage disturbances and displays summary or detailed information per IEC 61000-4-30 and CBEMA/ITIC. The SEL-735 reports VSSI disturbances through the SER, SEL ASCII, ACSELERATOR QuickSet, and DNP3 interfaces. The ACSELERATOR QuickSet interface includes graphical representation of disturbances with additional analysis options.

# Waveform Capture Event Reports

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## Standard Waveform Event Report Triggering

The meter triggers (generates) a standard event report when any of the following occur.

- Programmable SELOGIC® control equation settings  $ER_n$  ( $n = 1-3$ ) asserts to logical 1
- Operator manually triggers an event through ACSELERATOR QuickSet HMI

### Programmable SELOGIC Control Equation Settings $ER_n$

The programmable SELOGIC control equation event report trigger settings  $ER_1$ ,  $ER_2$ , and  $ER_3$  are set to trigger standard event reports. When setting  $ER_n$  detects a rising edge, it generates an event report (if the SEL-735 is not already generating a report that encompasses the new transition). The factory setting for SEL-735 meters is listed below.

$ER_1 :=$  SSI\_EVE OR FAULT

$ER_2 :=$  0

$ER_3 :=$  0

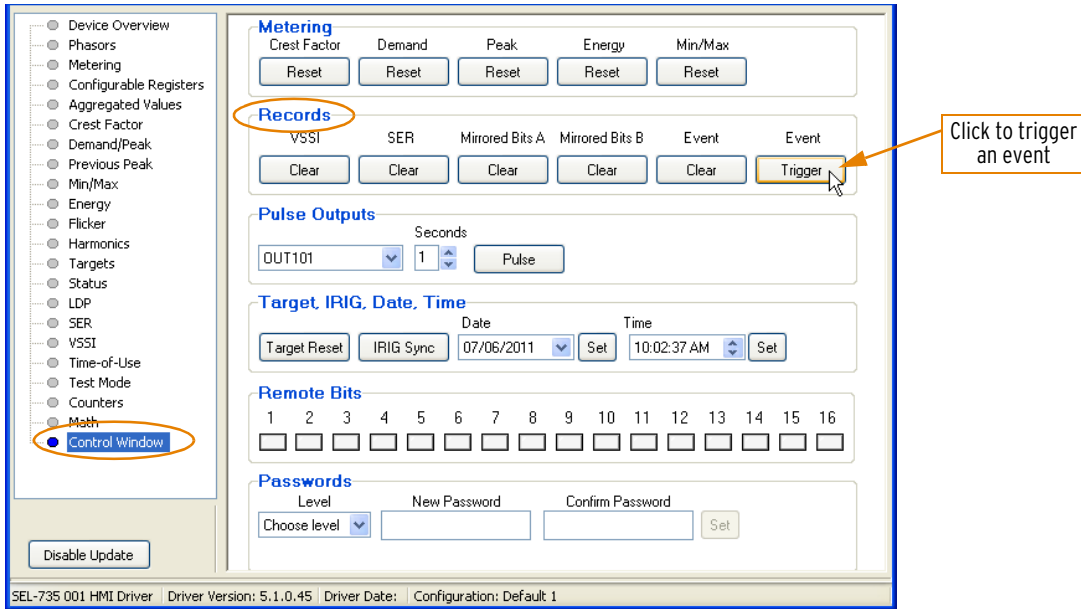
### Trigger Event Report

Follow the steps below to manually trigger an event.

- Step 1. Open ACSELERATOR Quickset HMI Control window and ensure communications with the meter are successful.
- Step 2. In the **Records** section, left-click on the **Trigger** button, as shown in *Figure 6.3*.  
  
ACSELERATOR QuickSet prompts you with `Trigger an event?`
- Step 3. Click **Yes**.

ACSELERATOR QuickSet triggers an event. You may view the event by clicking **Tools > Events > View Event Files**. See *Section 4: ACSELERATOR QuickSet* for more information on viewing and retrieving events.

*Figure 6.3* shows how to trigger events using the ACSELERATOR QuickSet HMI Control Window.



**Figure 6.3 Trigger an Event Via ACSELERATOR QuickSet HMI Control Window**

## Auto Messages

The SEL-735 can automatically send unsolicited text messages called Auto Messages over the serial ports to other devices. These messages include device power-on or reset, event triggers, and self-test warnings or failures. To enable Auto Messages on a specific, set AUTO = Y for the serial port desired.

## Standard Event Report Summary

Each time the meter generates a standard event report, it also generates a corresponding event summary. Event summaries contain the following information.

- Date and time when the event was triggered
- System frequency at the front of the event report
- Cause of event (e.g., TRI, ER)
- Front-panel LED status (targets)

The meter includes the event summary in the standard event report. The identifier, date, and time information is at the top of the standard event report, and the other information follows at the end.

The meter sends event summaries each time an event triggers to any serial ports with setting AUTO = Y.

## Retrieving Event Reports

See *Section 4: ACSELERATOR QuickSet* for instruction to retrieve full-length event reports.

## Clearing Event Report Buffer

Follow the steps below to erase all events stored on the meter.

- Step 1. Open the ACSELERATOR Quickset HMI Control window and ensure communications with the meter are successful.
- Step 2. In the **Records** section, left-click on the **Event Clear** button as shown in *Figure 6.4*.

ACSELERATOR QuickSet prompts you with `Clear History Buffer?`

Step 3. Click **Yes**.

ACSELERATOR QuickSet clears all events stored on the meter.

Figure 6.4 shows how to clear events from the meter using the ACSELERATOR QuickSet HMI Control Window.

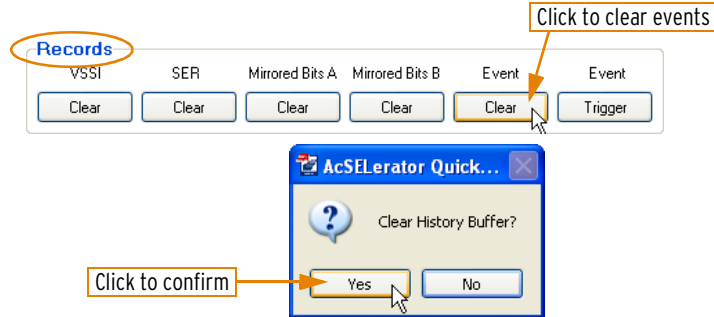


Figure 6.4 Clear Events From Meter

## Sequential Events Recorder (SER) Report

### SER Triggering

The meter triggers (generates) an entry in the SER report for a change of state of any one of the Device Word bits listed in the SER1, SER2, and SER3 trigger settings. The factory default settings are.

SER1 := HALARM,SALARM,RSTDEM,RSTENGY,RSTPKDM,TEST,DSTCH

SER2 := SSI\_EVE,FAULT,HARM02,HARM03,HARM04,HARM05,HARM06,HARM07,  
HARM08,HARM09,HARM10,HARM11,HARM12,HARM13,HARM14,HARM15

SER3 := NA

The meter monitors each Device Word bit in the SER lists every processing interval. If an element changes state, the meter time-tags the change in the SER.

The meter adds a message to the SER to indicate power up, daylight-saving time or other time changes, or settings change conditions.

Each entry in the SER includes the SER row number, date, time, Device Word bit name, and the bit state.

### Making SER Trigger Settings

Enter as many as 24 Device Word bit names in each of the SER settings via ACSELERATOR QuickSet. The meter monitors as many as 72 elements in the SER list (24 in each of the SER equations).

The meter triggers a row in the Sequential Events Recorder (SER) event report for any change of state in any one of the elements listed in the SER1, SER2, or SER3 trigger settings. The meter retains a minimum of 21,000 of the most recent SER entries in nonvolatile memory.

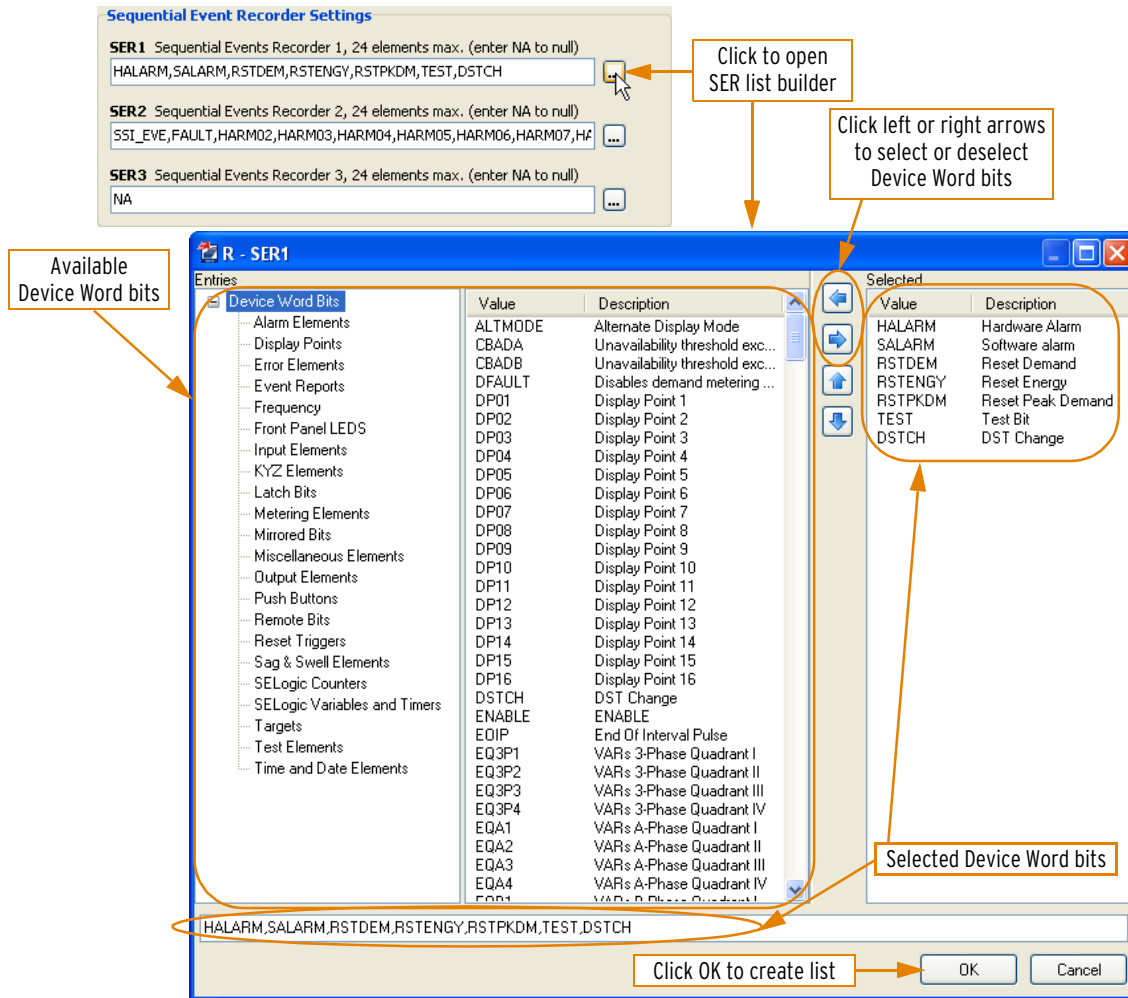
Follow the steps below to create an SER list.

- Step 1. Open an ACSELERATOR Quickset settings instance.
- Step 2. Navigate to the **Events and Logging > Sequential Events Recorder** window.
- Step 3. Click the **SER $n$**  ellipse button.

ACSELERATOR QuickSet opens the SER list builder shown in Figure 6.5.

- Step 4. Select the desired Device Word bits to add to the list.
- Step 5. Click the right arrow.  
 ACSELERATOR QuickSet moves the selected Device Word bits to the Selected section.
- Step 6. Repeat *Step 4* and *Step 5* to add all of the desired elements.
- Step 7. Click **OK**.

Figure 6.5 shows how to open the SER list builder and how to create an SER list.



**Figure 6.5 SER List Builder**

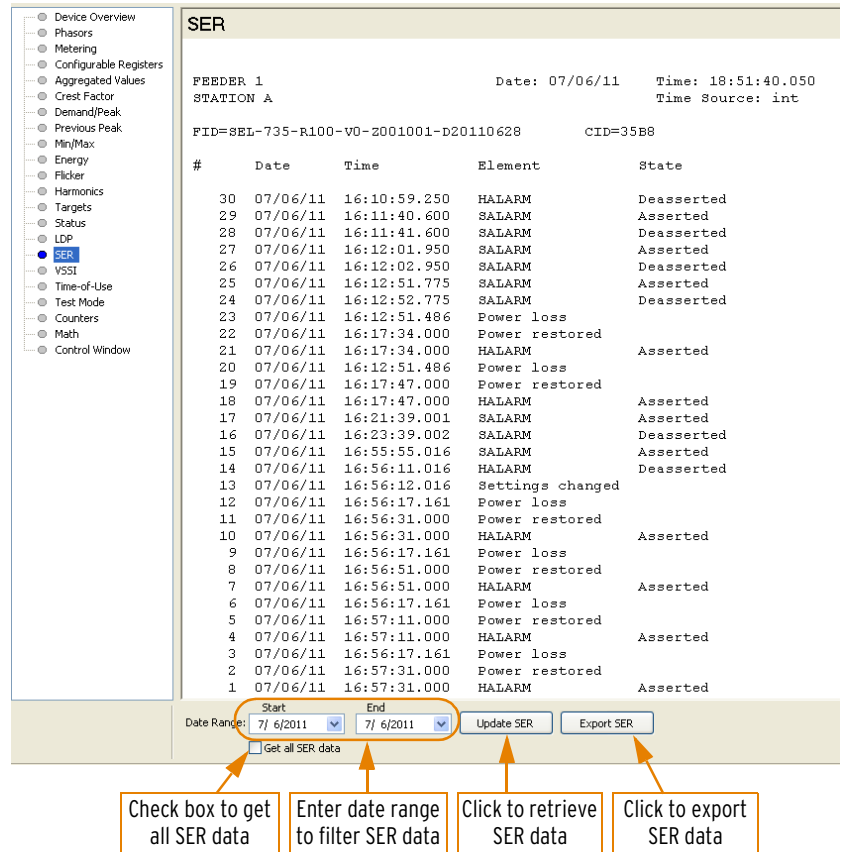
## Retrieve SER Reports

Follow the steps below to retrieve SER data stored on the meter.

- Step 1. Open the ACSELERATOR Quickset HMI SER window and ensure communications with the meter are successful.
- Step 2. Enter the date range you would like to retrieve SER records for or check **Get all SER** to retrieve all SER data.
- Step 3. Click **Update SER**.

If the requested SER event report rows do not exist, the meter reports No SER Data.

Figure 6.6 shows the ACSELERATOR QuickSet HMI SER Window where you can retrieve and export SER reports.



**Figure 6.6 SER HMI Window**

## Export the SER Report

You may export the SER data to comma separated (.csv) files or text (.txt) files. Both file formats contain the same information.

Follow the steps below to export SER data.

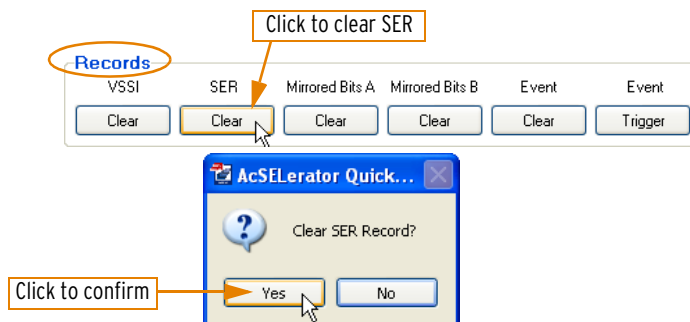
- Step 1. Open the ACSELERATOR Quickset HMI Control window and ensure communications with the meter are successful.
- Step 2. Retrieve the desired SER data as explained previously.  
 ACSELERATOR QuickSet exports the SER data displayed in the SER HMI window.
- Step 3. Click **Export SER**.  
 ACSELERATOR QuickSet opens up the **Save As** window.
- Step 4. Set the file format to export a .csv or .txt file.
- Step 5. Click **Save**.

ACSELERATOR QuickSet saves the present SER data in a similar format to the HMI display.

## Clear the SER Report

Follow the steps below to clear all SER data from the meter.

- Step 1. Open the ACSELERATOR QuickSet HMI Control window and ensure communications with the meter are successful.
- Step 2. In the **Records** section, click **Clear** under SER as shown in *Figure 6.7*.
- Step 3. ACSELERATOR QuickSet prompts you Clear SER Record?
- Step 4. Click **Yes**.



**Figure 6.7** Clear SER Report from Meter

# Voltage Sag/Swell/Interruption (VSSI) Report

The VSSI report captures voltage disturbances and displays summary or detailed information per IEC 61000-4-30 and CBEMA/ITIC. The ACSELERATOR QuickSet software interface includes graphical representation of disturbances with additional analysis options as shown in *Figure 6.8*.

The SEL-735 records VSSI data using an adaptive sampling rate algorithm that maximizes the number of disturbances that the meter can store. Given an average three-second disturbance, the SEL-735 will capture at least 60 independent disturbances and a minimum of 11,000 detailed entries. Sampling rates include fast recording at 4 samples per cycle, medium recording at 1 sample per cycle, slow recording at 1 sample per 64 cycles, and daily at 1 sample per day.

## VSSI Settings

The group setting `ESSI := Y` enables the voltage sag/swell/interruption reporting. The `VBASE` setting defines the initial phase-to-neutral voltage applied to Form 9 and Form 36 connections, and phase-to-phase voltage applied to Form 5 connections. Set `AVG_TIME` to a time between 1 and 10 minutes to calculate a dynamic `VBASE` as the average rms phase voltage over the time period defined by `AVG_TIME`. After VSSI initialization, `VBASE` for each phase is set to the `VBASE` setting. When the `AVG_TIME` period elapses, `VBASE` for each phase is calculated as the 1-second average rms voltage over the period.

Set `AVG_TIME` to `OFF` to disable the dynamic `VBASE` feature. The `VINT`, `VSAG`, and `VSWELL` trigger thresholds define the percentage of `VBASE` at which the meter records a disturbance. Hysteresis settings, `VINTHYS`, `VSAGHYS`, and `VSWELHYS` define the percentage above the trigger thresholds at which the VSSI report stops recording.

## VSSI Initialization

The following conditions must be met before the VSSI function will capture voltage disturbances.

- The phase voltage is greater than 25 V.
- The FAULT Device Word bit is deasserted.
- Ten seconds have elapsed meeting these conditions.

## VSSI Summary Report

The VSSI report in the ACSELERATOR QuickSet HMI displays the summary VSSI reports as shown in *Figure 6.8*. Upon a voltage disturbance, the VSSI reports the event type, date, time, duration, voltages as a percentage of  $V_{BASE}$ , and  $V_{BASE}$  in compliance with IEC 61000-4-30.

*Figure 6.8* shows an example VSSI summary in the ACSELERATOR QuickSet HMI VSSI Window.

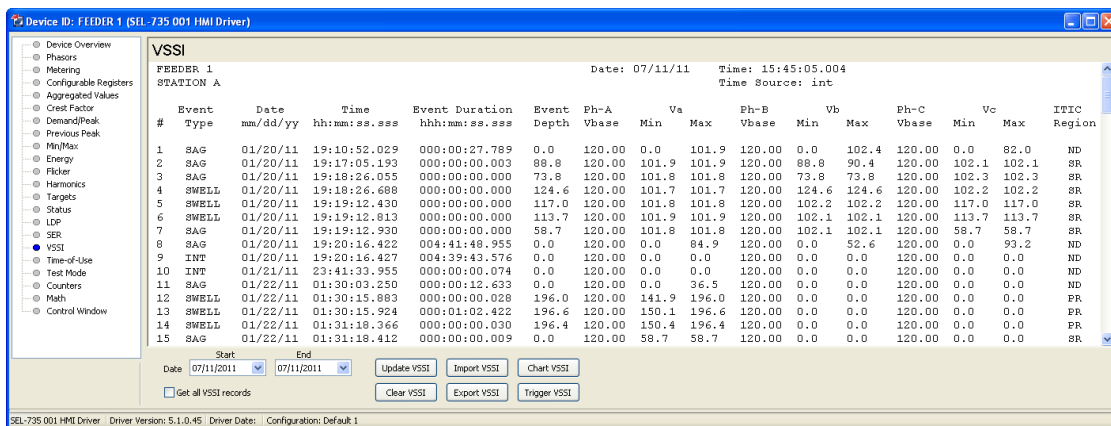


Figure 6.8 Example VSSI Response in ACSELERATOR QuickSet

At the end of each disturbance, the VSSI summary reports the following information.

- List of events in chronological order.
- Event type
  - SAG
  - SWELL
  - INT
  - TRIG
- Date and time the event started.
- Event duration in hhh:mm:ss.sss
- Minimum and maximum voltage magnitude per IEC 61000-4-30
- One of the three CBEMA/ITIC event regions
  - Prohibited region (PR)
  - No damage region (ND)
  - Safe function region (SR)

## VSSI Detailed Report

The detailed VSSI report includes a point by point record of each VSSI value that is useful for graphing data post-disturbance. *Table 6.5* and *Table 6.6* describe the meaning of the detailed VSSI status columns.

The VSSI recorder archives the following information.

- Currents Ia, Ib, Ic, Ig, and In as a percentage of the nominal current rating (shown in the report heading)
- Voltages VA, VB, and VC (VAB, VBC, and VCA for Form 5 meters) as a percentage of the VBASE quantity
- State of the voltage sag/swell/interruption Device Word bits, by phase
- Trigger status
- Recorder status

Table 6.5 shows the enumerations of the sag/swell/interruption Device Word bits that the meter gives in the detailed SSI report. Form 9 meters report the SSI Device Word bits SAGA, SAGB, SAGC, etc. Form 5 meters report the SSI Device Word bits SAGAB, SAGBC, SAGCA, etc. Form 36 meters report the SSI Device Word bits SAGA, SAGC, etc., (excludes B-Phase voltage).

**Table 6.5 State of the Voltage Sag/Swell/Interruption Device Word Bits**

Symbol	Meaning <sup>a</sup>
	Meter Form 9 and Form 36                      Meter Form 5 Column A represents A-phase              Column A represents VAB Column B represents B-phase              Column B represents VBC Column C represents C-phase              Column C represents VCA
.	No VSSI bits asserted for phase
O	Overvoltage (SW <sub>p</sub> asserted)
U	Undervoltage (SAG <sub>p</sub> asserted)
I	Interruption (INT <sub>p</sub> asserted; SAG <sub>p</sub> asserted, unless setting VSAG := OFF)

<sup>a</sup> Replace p with A-, B-, or C-Phase.

**Table 6.6 Status VSSI Column**

Symbol	Meaning (Action)	Duration
R	Ready	Single entry
P	Predisturbance (4 samples per cycle). Always signifies a new disturbance.	12 samples (3 cycles)
F	Fast recording mode (4 samples per cycle)	Varies. At least one VSSI element must be asserted.
E	End (postdisturbance at 4 samples per cycle)	Up to 16 samples (4 cycles). No VSSI elements asserted.
M	Medium recording mode (one sample per cycle)	Maximum of 176 cycles
S	Slow recording mode (one sample per 64 cycles)	Maximum of 4096 cycles
D	Daily recording mode (one sample per day, just after midnight)	Indefinite
X	Data overflow (single entry that indicates that data were lost prior to the present entry)	Single entry

See Figure 6.9 for a partial voltage sag/swell/interruption (VSSI) report. The VSSI report example shows a 3-phase voltage interruption lasting about 2.80 seconds with the meter entering daily sampling mode.

Voltage Sag/Swell/Interruption (VSSI) Report

FEEDER 2		Date: 05/30/00	Time: 14:58:58.620												
STATION A		Time Source: int													
FID=SEL-735-X042-V0-Z001001-D20110516		CID=310D													
I nom. A B C G = 5 Amp N = 5 Amp															
				Ph-AB	Ph-BC	Ph-CA									
#	Date	Time	Current(%I nom.)				In	Vbase	Volt	Vbase	Volt	Vbase	Volt	Ph	ST
			Ia	Ib	Ic	Ig		(Vsec)	%Vbase	(Vsec)	%Vbase	(Vsec)	%Vbase		
863	04/30/00	22:42:13.500	100.3	100.4	100.1	0.3	0.0	120.00	100.3	120.00	100.1	120.00	100.0	...	R
862	05/01/00	00:11:31.944	100.6	100.6	99.6	1.5	1.0	120.00	100.3	120.00	100.1	120.00	100.0	...	P
861	05/01/00	00:11:31.949	100.7	100.5	99.5	1.5	1.0	120.00	100.3	120.00	100.1	120.00	100.0	...	P
860	05/01/00	00:11:31.953	100.7	100.6	99.6	1.6	1.4	120.00	100.3	120.00	100.1	120.00	100.0	...	P
859	05/01/00	00:11:31.957	100.7	100.6	99.6	1.4	1.4	120.00	100.3	120.00	100.1	120.00	100.0	...	P
858	05/01/00	00:11:31.961	100.6	100.6	99.6	1.5	1.4	120.00	100.3	120.00	100.1	120.00	100.0	...	P
857	05/01/00	00:11:31.965	100.6	100.5	99.6	1.5	1.4	120.00	100.3	120.00	100.1	120.00	100.0	...	P
856	05/01/00	00:11:31.969	100.6	100.5	99.6	1.5	1.4	120.00	100.3	120.00	100.1	120.00	100.0	...	P
855	05/01/00	00:11:31.974	100.7	100.6	99.6	1.4	1.0	120.00	100.3	120.00	100.1	120.00	100.0	...	P
854	05/01/00	00:11:31.978	100.6	100.6	99.6	1.4	1.0	120.00	100.3	120.00	100.1	120.00	100.0	...	P
853	05/01/00	00:11:31.982	100.6	100.5	99.6	1.5	1.0	120.00	100.3	120.00	100.1	120.00	100.0	...	P
852	05/01/00	00:11:31.986	100.6	100.5	99.6	1.5	1.4	120.00	100.3	120.00	100.1	120.00	100.0	...	P
851	05/01/00	00:11:31.990	100.6	100.6	99.6	1.4	1.0	120.00	100.3	120.00	100.1	120.00	100.0	...	P
850	05/01/00	00:11:31.993	98.1	93.3	81.4	1.4	1.0	120.00	97.8	120.00	92.9	120.00	81.8	..U	F
849	05/01/00	00:11:31.996	71.4	23.6	64.7	1.3	1.0	120.00	71.1	120.00	23.6	120.00	65.0	UUU	F
848	05/01/00	00:11:31.996	0.0	0.0	0.0	1.3	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
847	05/01/00	00:11:32.007	0.0	0.0	0.0	1.0	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
846	05/01/00	00:11:32.011	0.0	0.0	0.0	1.0	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
845	05/01/00	00:11:32.015	0.0	0.0	0.0	1.0	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
844	05/01/00	00:11:32.019	0.0	0.0	0.0	1.0	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
843	05/01/00	00:11:32.024	0.0	0.0	0.0	1.0	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
842	05/01/00	00:11:32.028	0.0	0.0	0.0	0.9	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
841	05/01/00	00:11:32.032	0.0	0.0	0.0	1.0	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
840	05/01/00	00:11:32.036	0.0	0.0	0.0	1.0	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
839	05/01/00	00:11:32.040	0.0	0.0	0.0	0.9	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
838	05/01/00	00:11:32.044	0.0	0.0	0.0	0.9	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
837	05/01/00	00:11:32.049	0.0	0.0	0.0	1.0	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
836	05/01/00	00:11:32.053	0.0	0.0	0.0	1.0	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
835	05/01/00	00:11:32.057	0.0	0.0	0.0	0.9	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
834	05/01/00	00:11:32.061	0.0	0.0	0.0	0.9	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
833	05/01/00	00:11:32.065	0.0	0.0	0.0	1.0	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
832	05/01/00	00:11:32.069	0.0	0.0	0.0	1.0	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	D
831	05/01/00	00:11:34.753	0.0	0.0	0.0	1.2	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
830	05/01/00	00:11:34.757	0.0	0.0	0.0	1.1	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
829	05/01/00	00:11:34.761	0.0	0.0	0.0	1.1	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
828	05/01/00	00:11:34.765	0.0	0.0	0.0	1.1	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
827	05/01/00	00:11:34.769	0.0	0.0	0.0	1.1	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
826	05/01/00	00:11:34.774	0.0	0.0	0.0	1.1	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
825	05/01/00	00:11:34.778	0.0	0.0	0.0	1.1	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
824	05/01/00	00:11:34.782	0.0	0.0	0.0	1.1	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
823	05/01/00	00:11:34.786	0.0	0.0	0.0	1.2	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
822	05/01/00	00:11:34.790	0.0	0.0	0.0	1.1	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
821	05/01/00	00:11:34.794	0.0	0.0	0.0	1.1	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
820	05/01/00	00:11:34.799	0.0	0.0	0.0	1.3	1.0	120.00	0.0	120.00	0.0	120.00	0.0	III	F
819	05/01/00	00:11:34.802	46.0	80.8	44.4	1.3	1.4	120.00	46.2	120.00	80.1	120.00	44.8	UUU	F
818	05/01/00	00:11:34.807	99.1	92.7	85.1	1.4	1.4	120.00	99.2	120.00	92.0	120.00	85.4	..U	F
817	05/01/00	00:11:34.807	100.2	101.0	99.7	1.4	1.4	120.00	100.3	120.00	100.1	120.00	100.0	...	E
816	05/01/00	00:11:34.815	100.3	101.0	99.6	1.7	1.4	120.00	100.3	120.00	100.1	120.00	100.0	...	E

Figure 6.9 Example Voltage Sag/Swell/Interruption (VSSI) Report (Meter Form 9)

### VSSI Report Memory Details

The meter retains a minimum of 11,000 of the most recent VSSI entries in nonvolatile memory. If the VSSI recorder memory clears while an VSSI report is being displayed, the VSSI report will stop and display this message.

Command Aborted, Data overwrite occurred

### VSSI Device Word Bits

Upon a voltage disturbance, the VSSI recorder asserts Device Word Bits that offer a binary disturbance summary. Mapping these VSSI Device Word Bits to the Sequential Events Recorder (SER) allows rapid analysis of a disturbance and its corresponding CBEMA/ITIC region.

# Section 7

## Inputs/Outputs and SELOGIC Control Equations

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### Overview

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This section explains the settings and operation of the logic inputs/outputs and SELOGIC® control equations for the SEL-735.

*Inputs/Outputs on page 7.2*

- KYZ Outputs
- Output Contacts
- DC Analog Outputs
- Optoisolated Inputs
- Remote Control Bits

*SELOGIC Control Equations on page 7.10*

- Latch Control Bits
- SELOGIC® Control Equation Variables/Timers
- Math Variables
- Virtual Bits
- MIRRORRED BITS® Communications
- Reset Trigger Equations
- Graphic Logic Editor

# Inputs/Outputs

Table 7.1 describes the inputs or settings and outputs of the meter function.

**Table 7.1 SEL-735 Logic Inputs and Output Model Reference**

Description	Input/Setting	Model Reference
KYZ Outputs	KE <sub>n</sub> _SCALE, KE <sub>n</sub> , KET, KE <sub>n</sub> _UNIT, KYZD <sub>n</sub> , KYZPW <sub>n</sub> , KE <sub>n</sub> _OUT	KYZD <sub>n</sub> , KYZDT
Output Contacts	OUT <sub>n</sub>	Word bits OUT <sub>n</sub>
Analog Outputs	AOnAQ, AOnAQL, AOnAQH, AOnL, AOnH	Current Output
Optoisolated Inputs	IN <sub>n</sub> D	IN <sub>n</sub> Word bits
Remote Control Bits	Communications Channels: SEL, DNP, and Modbus®	RB01–RB16 Word bits
Local Control Bits	Front-Panel Pushbuttons	PB01–PB04 and RESET Word bits

## KYZ Pulse Outputs

KYZ pulse outputs are digital pulses that represent a specific amount of energy. The SEL-735 measures energy data and converts it to KYZ output pulses. You can then map the KYZ output pulses to output contacts to communicate the energy data to remote devices.

The SEL-735 KYZ pulses can produce any energy analog quantity. The meter provides as many as four energy quantities for Form A contacts. Solid-state output contacts are vital for KYZ operation to prevent contact wear and premature failure.

Table 7.2 describes the settings associated with the KYZ pulses. Replace *n* with the KYZ pulse number of 1 to 4.

**Table 7.2 KYZ Output Settings and Ranges**

Setting	Definition	Default	Range
KE <sub>n</sub> _SCALE	KE <sub>n</sub> Scale. Sets the scale of KE <sub>n</sub> .	SEC	PRI, SEC
KE <sub>n</sub>	Wathour constant. Sets the KYZ pulse energy constant.	1.8000	0.0001–9999
KE <sub>n</sub> _UNIT	KE <sub>n</sub> Units. Sets the units of KE <sub>n</sub> .	UNITY	UNITY, KILO, MEGA
KYZD <sub>n</sub> <sup>a</sup>	Demand Type to Output <i>n</i> . Sets the energy analog quantity for output.	WH3_DEL	Energy Quantities
KYZPW <sub>n</sub>	KYZ Minimum Pulse Width <i>n</i> . Sets the minimum pulse width.	25 ms	25, 50, 75, 100 ms
KE <sub>n</sub> _OUT	KYZ Output. Maps the KYZ pulses to an output contact.	OFF	OFF, OUT401–OUT404

<sup>a</sup> *n* represents the element number. Replace *n* with the KYZ pulse number 1 to 4.

The SEL-735 also provides a test pulse, KYZDT, while the meter is in TEST mode. The normal KYZ pulses, KYZD1–KYZD4, deassert and stop pulsing while the meter is in TEST mode. See *Section 9: Testing and Troubleshooting* for more details of the meter while it is in TEST mode.

The settings  $KE_n$ ,  $KE_n\_SCALE$ ,  $KE_n\_UNITS$  determine the number of KYZ triggers or KYZ state transitions. The meter calculates the number of KYZ triggers using *Equation 7.1*.

$$\text{Number of KYZ triggers} = \frac{\text{Total Energy (in time } t) + R_{\text{previous}}}{K_e}$$

**Equation 7.1**

where:

$$K_e = KE_n \cdot KE_n\_UNITS / \text{trigger}$$

where:

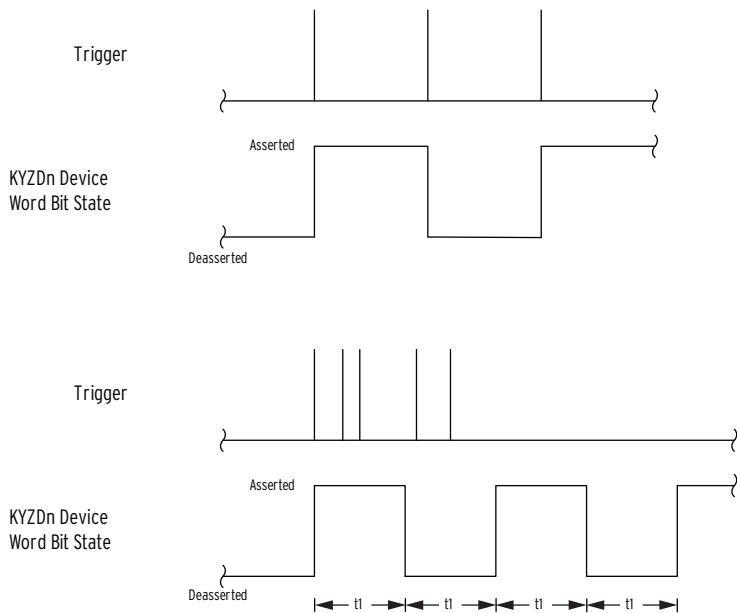
$$\begin{aligned} KE_n\_UNITS &= 1 && \text{if } KE_n\_UNITS = \text{UNITY} \\ &= 1000 && \text{if } KE_n\_UNITS = \text{KILO} \\ &= 1000000 && \text{if } KE_n\_UNITS = \text{MEGA} \end{aligned}$$

$t$  = time in hours

$R_{\text{previous}}$  = Energy remaining from the previous calculation of the number of KYZ triggers

Any remainder left over from the previous calculation carries over to the next calculation. Any remainder resets to zero if a meter loses power for any reason. This means that any nonzero remainder prior to loss of meter power disappears during the power loss.

You can use two methods to collect KYZ energy data. The first uses a pickup that records the rising edge of a pulse; the second records the rising and falling edges. You may configure the KYZ outputs of the SEL-735 using ACSELERATOR QuickSet® SEL-5030 Software without having to enter any logic expressions.



$t_1$  = KYZPwN KYZ Minimum Pulse Width (ms)

**Figure 7.1 KYZ Pulse Pickup**

In *Figure 7.1*, each trigger occurs when the SEL-735 meters the  $KE_n$  amount of energy. The first diagram in *Figure 7.1* shows energy triggers asserting after each KYZ Minimum Pulse Width time period elapses. The second diagram in

Figure 7.1 shows energy triggers asserting prior to the KYZ Pulse Width time period. If a trigger occurs before the Minimum Pulse Width period elapses (as shown in the second diagram in Figure 7.1), then the meter adds these pulses to the remainder of Equation 7.1. The meter applies the remainder to the KYZ Device Word Bit after each Minimum Pulse Width period expires.

To produce outputs of three-phase watt-hours delivered (WH3\_DEL) from KYZ1 to OUT401, set the KYZ set follows.

```
EKYZ := 1
KE1_SCALE := PRI
KE1 := 1.8
KE1_UNIT := KILO
KYZD1 := WH3_DEL
KYZPW1 := 25
KE1_OUT := OUT401
```

For every 1.8 kWh primary the SEL-735 measures, Device Word bit KYZD1 changes state and maintains the new state for at least the time KYZPW1 defines (25 ms in this case). The state of OUT401 follows the Device Word bit KYZD1 state. KYZD1 changes state again after another accumulation of 1.8 kWh.

You can use Equation 7.2 to calculate total energy at the receiving end of these triggers.

If  $KE_n\_SCALE$  is set to SEC:

$$\text{Total Energy (Pri)} = \text{Number of triggers} \cdot \text{CTR} \cdot \text{PTR} \cdot KE_n \cdot \text{UNITS}$$

$$\text{Total Energy (Sec)} = \text{Number of triggers} \cdot KE_n \cdot \text{UNITS}$$

If  $KE_n\_SCALE$  is set to PRI:

$$\text{Total Energy (Pri)} = \text{Number of triggers} \cdot KE_n \cdot \text{UNITS}$$

$$\text{Total Energy (Sec)} = \text{Number of triggers} \cdot KE_n \cdot \text{UNITS} \cdot (\text{CTR} \cdot \text{PTR})$$

**Equation 7.2**

Where:

$$KE_n\_UNITS = \text{UNITS}$$

$$\text{UNIT} = 1$$

$$\text{KILO} = 1000$$

$$\text{MEGA} = 1000000$$

## Output Contacts

Three output contacts (two Form A contacts and one Form C contact) come standard with the SEL-735. Each output contact follows the state of the associated Device Word bit. You can add four additional output contacts. The output contacts update every half power system cycle.

**Table 7.3 Output Contact Settings and Default Settings**

Setting	Definition	Device Word Bit	Default Setting	Range
OUT101	Output Contact 101 SELOGIC control equation that controls OUT101.	OUT101	0	SELOGIC control equation
OUT102	Output Contact 102 SELOGIC control equation that controls OUT102.	OUT102	0	SELOGIC control equation
OUT103	Output Contact 103 SELOGIC control equation that controls OUT103.	OUT103	NOT (SALARM OR HALARM)	SELOGIC control equation
OUT401–OUT404	Output Contact 401–404 SELOGIC control equations that control OUT401–OUT404.	OUT401–OUT404	0	SELOGIC control equation

### Pulse Output Contacts

You can pulse the output contacts from the ACSELERATOR QuickSet HMI as the following steps explain.

- Step 1. From an ACSELERATOR QuickSet HMI, navigate to the control window.
- Step 2. In the Pulse Outputs section, shown in *Figure 7.2*, select the output contact you want to pulse. This example uses OUT101.
- Step 3. Set the amount of time to pulse the output contact from 1 to 30 seconds. This example uses one second.
- Step 4. From the Pulse Outputs window, click the **Pulse** button. A window opens to prompt you to pulse the output contact.
- Step 5. Click **Yes** to assert the command.



**Figure 7.2 Pulse Output Contact Example**

### Contact Output as an Alarm Output

By default, the SEL-735 maps the Device Word bits SALARM (software alarm) and HALARM (hardware alarm) to output contact OUT103, as follows.

$$\text{OUT103} = \text{NOT (SALARM OR HALARM)}$$

The Device Word bits SALARM and HALARM are normally deasserted. When the meter enters Access Level 2, the SALARM Device Word bit momentarily asserts. The HALARM Device Word bit asserts momentarily for hardware warnings and asserts permanently for hardware failures.

Output contact OUT103 is normally closed when SALARM and HALARM are deasserted. If SALARM or HALARM assert then OUT103 opens, indicating a software or hardware warning or alarm. You can change the default settings of output contact OUT103.

## DC Analog Output

The optional analog output/digital output card for the SEL-735 provides as many as four dc analog outputs.

Each analog output acts as a programmable transducer. The SEL-735 measures a user-selectable analog quantity and produces a dc current of  $\pm 1.2$  mA or  $\pm 24.0$  mA that is proportional to the value it measures. The meter updates analog outputs every 100 milliseconds or faster.

You can output all basic analog quantities to dc analog outputs.

Table 7.4 describes each analog output setting. When AOxxAQ is set to OFF the meter hides the associated settings.

**Table 7.4 Analog Output Settings and Default Settings**

Setting <sup>a</sup>	Definition	Default	Range
AOxxAQ	Analog Quantity. Sets the analog quantity for the output.	OFF	OFF, Valid Analog Quantities
AOxxAQL	Analog Quantity Low. Sets the measured value that creates the minimum current output for the selected analog quantity in primary units. Enter voltage, power, and energy quantities in primary kilo units; enter current and all other quantities in unity primary units.	-1.000	-2147483647.000 to 2147483647
AOxxAQH	Analog Quantity High. Input limit. Sets the measured value that creates the maximum current output for the selected analog quantity in primary units. Enter voltage, power, and energy quantities in primary kilo units; enter current and all other quantities in unity primary units.	1.000	-2147483647.000 to 2147483647
AOxxL	Low Analog Output Value (mA). Sets the minimum output current value when the analog quantity equals the analog quantity low value.	-1.000 or 4.000	-1.200 to 1.200 mA or -24.000 to +24.000 mA
AOxxH	High Analog Output Value (mA). Sets the maximum output current value when the analog quantity equals the analog quantity high value.	1.000 or 20.000	-1.200 to 1.200 mA or -24.000 to +24.000 mA

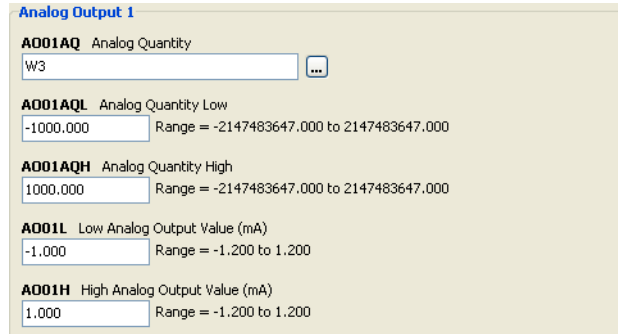
<sup>a</sup> Replace xx with Analog Output numbers 01-04.

### Example

Suppose that our load has a three-phase maximum delivered power of 1 MW (positive) and maximum received power of 1 MW (negative). We want an analog current output that is proportional to the three-phase power, with a conversion factor of 1 mA/MW.

- Step 1. Set Analog Quantity AO01AQ to **W3**.
- Step 2. Set Analog Quantity Low AO01AQL to **-1000.000**.
- Step 3. Set Analog Quantity High AO01AQH to **1000.000**.
- Step 4. Set Low Analog Output Value AO01L to **-1.000**.
- Step 5. Set High Analog Output Value AO01H to **1.000**.

Figure 7.3 shows the Analog Output settings configured for this example.

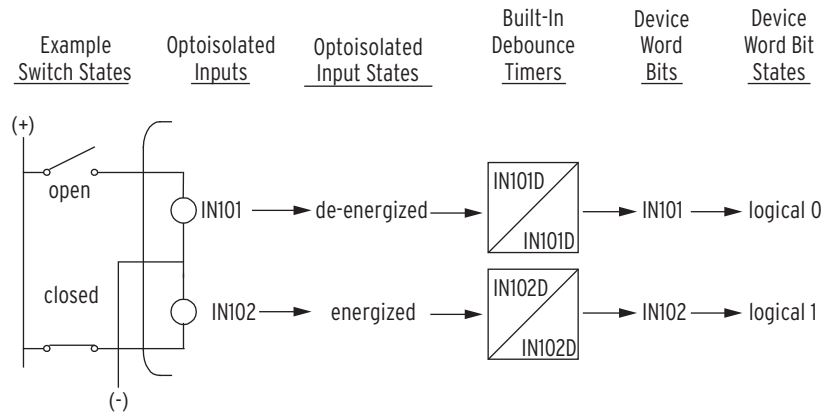


**Figure 7.3 Analog Output Settings Example**

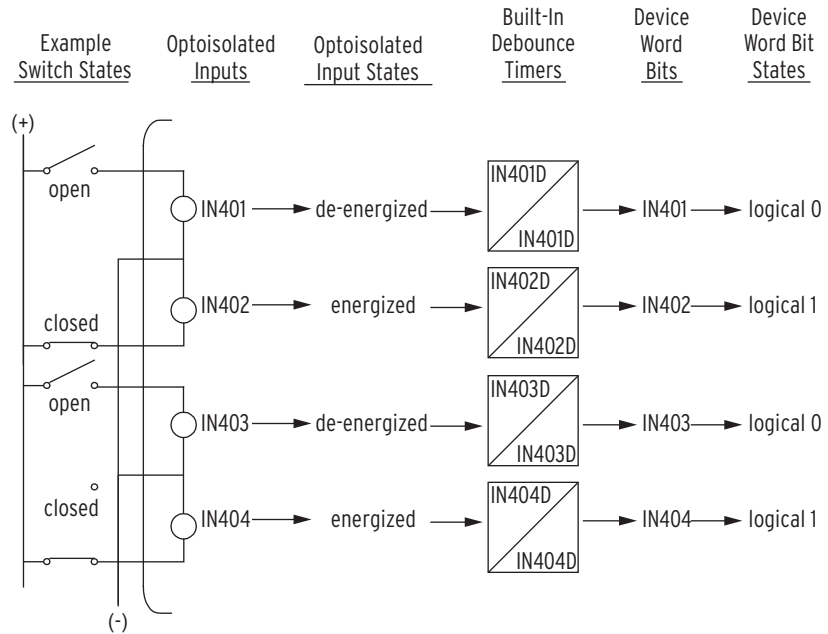
## Optoisolated Inputs

Figure 7.4 and Figure 7.5 show the resultant Device Word bits that follow the SEL-735 input contacts.

The figures show examples of energized and de-energized optoisolated inputs and corresponding Device Word bit states. To assert an input, apply rated control voltage to the appropriate terminal pair.



**Figure 7.4 Example Operation of Optoisolated Inputs IN101–IN102**



**Figure 7.5** Example Operation of Optoisolated Inputs IN401–IN404, Extra I/O Board

## Input Debounce Timers

**Table 7.5** Input Debounce Default Settings and Valid Ranges

Setting	Definition	Default	Range
IN101D–IN102D (standard)	Input <i>n</i> Debounce Time. Sets the debounce time of the input.	5 ms	0–8, AC
IN401D–IN404D (optional)	Where <i>n</i> is 101, 102, 401, 402, 403, or 404.		

Each input has settable pickup/dropout timers (IN101D and IN102D) for input energization/de-energization debounce or may be set to AC. The meter samples each input at least 16 times per power system cycle and updates the Device Word bit every 4 ms.

You can set the input delay times, IN101D–IN102D and IN401D–IN404D from 0 to 8 ms, in 1 ms increments. Use this range for a dc signal input. When you enter this setting, each input voltage sample must exceed the minimum necessary voltage threshold throughout the entire debounce time delay. The associated Device Word bit asserts after the input voltage signal exceeds the minimum threshold throughout the entire debounce time delay.

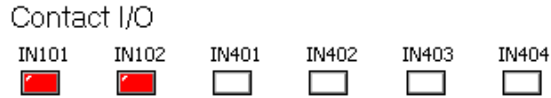
The AC setting allows the input to sense alternating control signals. The input has a maximum pickup time of 25 ms and a maximum dropout time of 25 ms. With the Debounce Time set to AC, the device measures two successive 1 ms samples, compares the measurement to the input voltage threshold, then asserts the corresponding Device Word bit. The input deasserts in the same fashion, but measures 12 successive samples instead of two.

## HMI Status

Perform the following steps to view the input status from ACSELERATOR QuickSet HMI.

- Step 1. Open the ACSELERATOR QuickSet HMI
- Step 2. Navigate to the Device Overview window.

The input contact status that displays will be similar to *Figure 7.6*. For more information on the ACSELERATOR QuickSet HMI, please refer to *Using the Human Machine Interface (HMI)* on page 4.10.

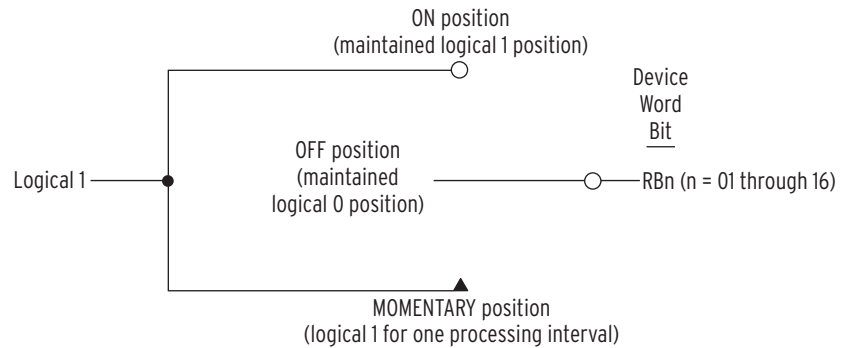


**Figure 7.6 Contact I/O Status Shown in ACSELERATOR QuickSet HMI Device Overview Window**

## Remote Control Bits

You may use remote bits in SELOGIC expressions as binary inputs, allowing for implementation of advanced control schemes. Remote communications channels such as SEL, DNP, and Modbus provide control of remote bits. Each bit has independent control.

*Figure 7.7* shows the resultant Device Word bits (e.g., Device Word bits RB01–RB16) that follow the corresponding logical input state.



The switch representation in this figure is derived from the standard:

Graphic Symbols for Electrical and Electronics Diagrams  
 IEEE Standard 315-1975, CSA Z99-1975, ANSI Y32.2-1975  
 4.11 Combination Locking and Nonlocking Switch, Item 4.11.1

**Figure 7.7 Remote Control Switches Drive Remote Bits RB01–RB16**

You may put remote bits in any of the states given in *Table 7.6*.

**Table 7.6 Remote Bit States**

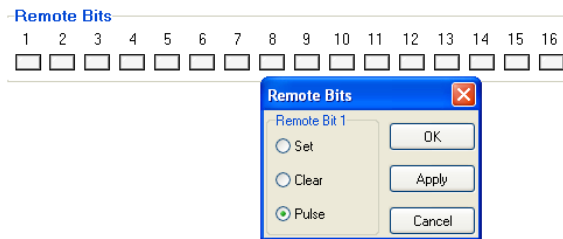
Switch State	Command	Logical State
ON	Set	(logical 1)
OFF	Clear	(logical 0)
MOMENTARY	Pulse	(logical 1 for one processing interval)

## HMI Control

Control remote bits through the ACSELERATOR QuickSet HMI, as the following text explains.

- Step 1. From the ACSELERATOR QuickSet HMI, navigate to the control window.
- Step 2. In the Remote Bits section, shown in *Figure 7.8*, left-click one of the virtual LEDs. The Remote Bits window opens, as shown in *Figure 7.8*.
- Step 3. From the Remote Bits window, select the **Set**, **Clear**, or **Pulse** command.
  - **Set** command asserts the remote bit indefinitely.
  - **Clear** command deasserts the remote bit indefinitely.
  - **Pulse** command asserts the remote bit for one processing cycle and then deasserts the remote bit.
- Step 4. Press **OK** or **Apply** to assert the command.

**NOTE:** If the remote bit is initially asserted before the **Pulse** command, the remote bit deasserts after completion of the command.



**Figure 7.8 Control Remote Bits Through ACSELERATOR QuickSet HMI**

You can also control remote control bits through other communications channels. Please see the DNP or Modbus section for details on remote bit control via those protocols.

## States When Power Is Lost to Device or Settings Are Changed

When the device loses power, remote bit states always return to OFF.

If a remote bit is ON before a setting change, it returns to ON after the change. If a remote bit is OFF before a settings change, it returns to the OFF position after the change.

# SELoGIC Control Equations

*Table 7.7* describes all SEL-735 SELoGIC control equations and shows the inputs or settings and outputs corresponding to each control equation. The inputs or settings and outputs of each category are shown.

**Table 7.7 SELoGIC Control Equation Inputs/Settings and Outputs (Sheet 1 of 2)**

Description	Input/Setting	Output
Latch Bits	SET $n$ , RST $n$	LT $n$
Control Equation Variables/Timers	SV $n$ , SV $n$ PU, SV $n$ DO	SV $n$ , SV $n$ T
Math Variables	MV $n$	MV $n$

**Table 7.7 SELOGIC Control Equation Inputs/Settings and Outputs (Sheet 2 of 2)**

Description	Input/Setting	Output
Counter Variables	SCnCV, SCnPV, SCnR, SCnLD, SCnCU, SCnCD	SCn, SCnR, SCnLD, SCnCU, SCnCD, SCnQU, SCnQD
MIRRORED BIT Equations	TMBnA, TMBnBT, RMBnA, RMBnB	TMBnA, TMBnB
Reset Trigger Equations	RSTDEM, RSTPKDM, RSTENGY	None

## Overview

Boolean expressions in the SEL-735 are called SELOGIC control equations. Create SELOGIC control equations as you would any other Boolean expression. The following section describes the tools available to create Boolean expressions.

## Operator Precedence

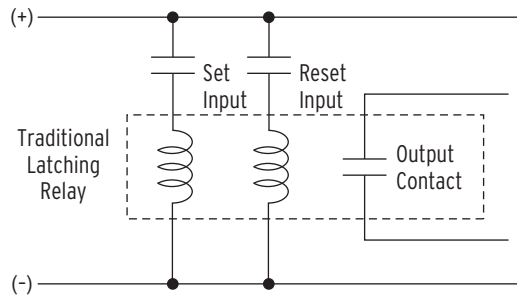
When you combine several operators and operands within a single expression, the SEL-735 evaluates the operators from left to right, starting with the highest precedence operators and proceeding to the lowest precedence. This means that if you write an equation with three AND operators, for example SV01 AND SV02 AND SV03, the SEL-735 evaluates each AND from left to right. If the control equation is SV01 AND SV02 AND NOT SV04, the meter evaluates the NOT operation of SV04 first and uses the result in subsequent evaluation of the expression. *Table 7.8* shows operator precedence, listing the highest precedence first.

**Table 7.8 Operator Precedence**

Operator	Function	Function type
() (Highest precedence)	Parenthesis	Boolean and Mathematical
-	Negation	Mathematical
NOT	Boolean Complement	Boolean
R_TRIG	Rising Edge Trigger	Boolean
F_TRIG	Falling Edge Trigger	Boolean
*, /	Multiply, Divide	Mathematical
+, -	Add, Subtract	Mathematical
<, >, <=, >=	Analog Comparison	Boolean
=	Analog Equality Check	Boolean
◇	Analog Inequality Check	Boolean
AND	Boolean AND	Boolean
OR (Lowest precedence)	Boolean OR	Boolean

## Latch Bits

The SEL-735 comes with 16 latch control switches. The device realizes the switch position using latch bits, which replace traditional latching relays. Traditional latching relays maintain their output contact state. The SEL-735 latch control switches retain their state even when the device loses power. If you map a latch bit to an output contact and the device loses power, the output contact goes to its de-energized state. When the device regains power, the output contact will go back to the state of the latch bit after device initialization.



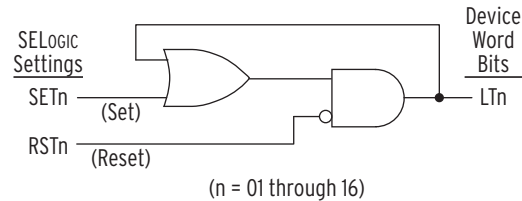
**Figure 7.9 Traditional Latching Relay**

Pulse the SET input to close (assert) the latching relay output contact. Pulse the RESET input to open (deassert) the latching relay output contact. Often, the external contacts wired to the latching relay inputs are from remote control equipment (e.g., SCADA, RTU, remote bits).

Table 7.9 shows the default settings and range for the latch bits.

**Table 7.9 Latch Bit Settings and Default Settings**

Setting	Definition	Default	Range
SETn	SELOGIC control equation that, when evaluates as TRUE, sets the Latch Bit. Enter NA to disable.	NA	SELOGIC control equation
RSTn	SELOGIC control equation that, when evaluates as TRUE, resets the Latch Bit. Enter NA to disable.	NA	SELOGIC control equation



**Figure 7.10 Latch Control Switches Drive Latch Bits LT01–LT16**

Figure 7.10 shows the logical diagram of the latch bit. Device Word bits LT01–LT16 are the outputs of the logic scheme. Use these latch bits in SELOGIC control equations.

Table 7.10 shows the logic states of the latch bits. If RESET equals a logical one, the latch bit deasserts. If SET equals a logical one, the latch bit asserts. RESET always takes priority over SET.

**Table 7.10 Latch Bit Logic Table**

Latch State	SETn	RSTn	LTn
SET OR RESET	0	0	No change
SET	1	0	1
RESET	0	1	0
RESET	1	1	0

## Latch Bits: Application Ideas

You can use latch control switches for such applications as the following.

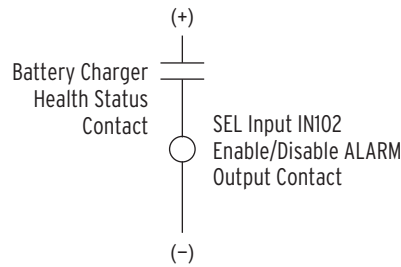
- Battery charger health status alarm latching
- Predictive demand alarm enable/disable

You can apply latch control switches to almost any control scheme. The following is an example of using a latch control switch to add the battery charger health status to the meter **ALARM** contact (output contact **OUT103** by default).

### Example: Adding Battery Charger Health Status to ALARM Contact

Use a latch control switch to add battery charger health status alarm latching to the SEL-735. In this example, an external SCADA contact connects to optoisolated input **IN102**, as shown in *Figure 7.11*. The Device Word bit **IN102** state either sets or resets the latch bit **LT01**. Use a remote bit instead of an optoisolated input, if your application warrants it.

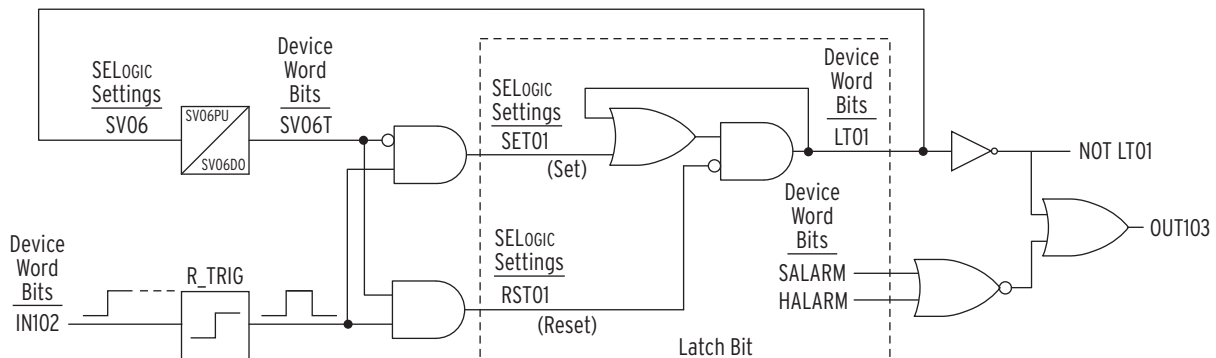
If you pulse the battery charger health status contact while the **ALARM** output contact is closed, the **ALARM** output contact disables. If you pulse the battery charger health status contact again, the **ALARM** output contact enables again. Each pulse of the battery charger health status contact changes the state of the **ALARM** output contact. The control operates in a cyclic manner.



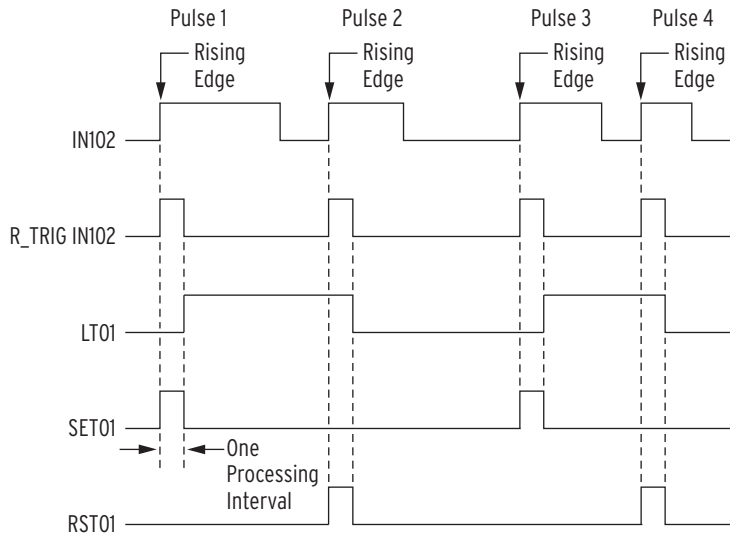
**Figure 7.11 Battery Charger Health Status Contact Pulses Input IN102 to Enable/Disable ALARM Output Contact**

You may implement this **ALARM** output contact logic using the SELOGIC control equation settings as displayed in *Figure 7.12*. Note that the figure includes an extra timer not included in the settings. The next example shows the use of this timer. *Figure 7.13* shows the timing for this example.

$$\begin{aligned} \text{SET01} &:= (\text{R\_TRIG IN102}) \text{ AND } (\text{NOT LT01}) \\ \text{RST01} &:= (\text{R\_TRIG IN102}) \text{ AND } \text{LT01} \\ \text{OUT103} &:= \text{NOT } (\text{SALARM OR HALARM}) \text{ OR } (\text{NOT LT01}) \end{aligned}$$



**Figure 7.12 Single Input to Control ALARM**

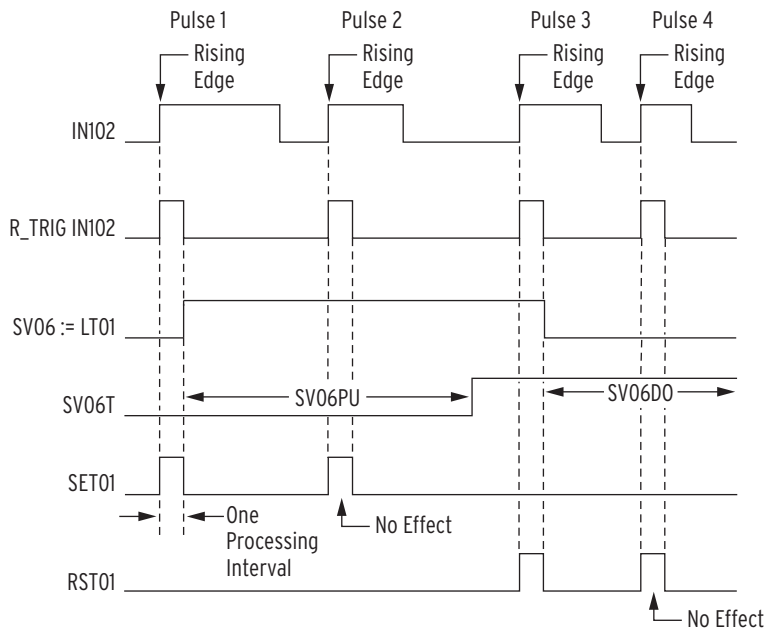


**Figure 7.13 Latch Control Switch Operation Time Line**

A variation of the previous example adds more security by adding a timer with equal pickup/dropout times, as shown in *Figure 7.12*. Suppose that you set both SV06PU and SV06DO to 5 seconds. The SV06T timer prevents the state of latch bit LT01 from switching/changing at a rate faster than once every 5 seconds. *Figure 7.14* shows the timing for this example.

```
SV06 := LT01
SET01 := (R_TRIG IN102) AND (NOT SV06T)
RST01 := (R_TRIG IN102) AND SV06T
OUT103 := NOT (SALARM OR HALARM) OR (NOT LT01)
```

Note in *Figure 7.12* that Latch Bit LT01 uses feedback from the SELOGIC settings SET01 and RST01. The feedback to LT01 determines whether input IN102 operates the SET01 or RST01 input. If LT01 = logical 0, input IN102 operates SET01. If Latch Bit LT01 = logical 1, input IN102 operates RST01.



**Figure 7.14 Latch Control Switch (With Time-Delay Feedback) Operation Time Line**

## Latch Bits: Nonvolatile State

### Power Loss

**NOTE:** If a latch bit is set to a programmable output contact, such as  $OUT103 := LT02$ , and the meter loses power, the meter stores the state of the latch bit in nonvolatile memory, but the output contact goes to its de-energized state. When power returns to the meter, the programmable output contact returns to the state of the latch bit after meter initialization.

The device retains the states of latch bits if it loses, then regains power. This feature makes the latch bit feature behave the same as traditional latching relays. In a traditional installation, if the panel loses power, the latching relay output contact position remains unchanged.

### Settings Change

If you change individual settings, the device retains the state of latch bits, much like in the preceding *Power Loss* explanation.

If the individual settings change causes a change in SELOGIC control equation settings  $SETn$  or  $RSTn$  ( $n = 01-16$ ), it is possible for the retained states of the latch bits to change, subject to the newly enabled settings  $SETn$  or  $RSTn$ .

### Make Latch Control Switch Settings With Care

The SEL-735 stores latch bit states in nonvolatile memory, so the device can retain these states during power losses or setting changes. The device can write to nonvolatile memory for a finite number of times for all cumulative Latch Bit state changes. Exceeding the limit can result in a NONVOL self-test failure. *An average of 70 cumulative latch bit state changes per day can occur for a 25-year meter service life.*

*Due to the finite number of writes to nonvolatile memory, you should make changes to latch bit settings with care.* Settings  $SETn$  and  $RSTn$  cannot result in continuous cyclical operation of Latch Bit  $LTn$ . Use timers to qualify conditions set in settings  $SETn$  and  $RSTn$ . If you use any optoisolated inputs in settings  $SETn$  and  $RSTn$ , the inputs have their own debounce timer that can help in providing the necessary time qualification.

In the preceding example application of adding a battery charger health status to the **ALARM** contact, you should not configure the device to assert/deassert the battery charger health status contact continuously. This situation would cause Latch Bit  $LT01$  to change state continuously. Note that the rising edge operators in the  $SET01$  and  $RST01$  settings keep Latch Bit  $LT01$  from cyclical operation for any single assertion of the battery charger health status contact.

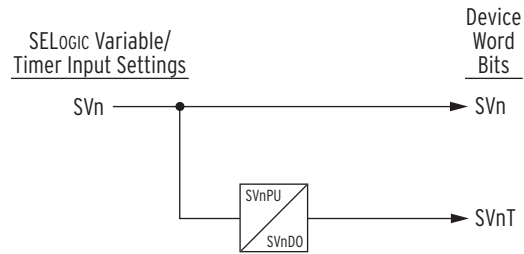
## SELOGIC Control Variables/Timers

The SEL-735 has 16 SELOGIC control variables and timers. Each SELOGIC control variable contains an associated pickup and dropout timer. The pickup and dropout timers have a range from zero to several days, with millisecond resolution.

Table 7.11 shows the associated SELOGIC control equation, pickup timer, and dropout timer settings and ranges.

**Table 7.11 SELOGIC Control Equation Settings and Default Settings**

Setting	Definition	Default	Range
$SVn$	SELOGIC control equation that, when evaluated as TRUE, asserts the variable input.	NA	SELOGIC control equation
$SVnPU$	Time required for the variable input to remain asserted before the variable output ( $SVnT$ ) asserts.	0.000 seconds	0.000 to 1000000.000
$SVnDO$	Time required for the variable input to remain deasserted before the variable output ( $SVnT$ ) deasserts.	0.000 seconds	0.000 to 1000000.000



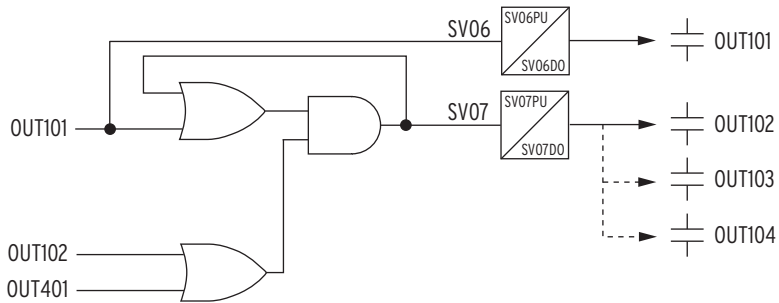
**Figure 7.15 SELogic Control Equation Variables and Timers**

### Timers Reset When Power Is Lost or Settings Are Changed

If the device loses power or if settings change, the SELOGIC control equation variables/timers reset. Device Word bits  $SVn$  and  $SVnT$  ( $n = 01-16$ ) reset to logical 0 after power restoration or a settings change.

Figure 7.16 shows an effective seal-in logic circuit, created by use of Device Word bit SV07 (SELOGIC control equation variable SV07) in SELOGIC control equation SV07.

$$SV07 := (SV07 \text{ OR } OUT101) \text{ AND } (OUT102 \text{ OR } OUT401)$$



**Figure 7.16 Example Use of SELogic Variables/Timers**

## Math Variables

The SEL-735 comes with 16 SELOGIC control equation Math Variables. SELOGIC control equation Math Variables are math calculation storage results.

Use math variables in fixed-form programming to store the results of math calculations as arguments in SELOGIC control equations. Example 7.1 illustrates SELOGIC Math Variable usage.

#### EXAMPLE 7.1 SELogic Control Equation Math Variables

The equations that follow show fixed-form SELOGIC control equation programming examples that use SELOGIC control equation math variables. Each line has a comment after the # that provides additional description.

MV01 := 378.62 # Store 387.62 in MV01

MV09 := 5 + VA\_MAG # Store sum of 5 and A-phase secondary voltage in MV09

### Input Scaling

The device passes Analog Quantity results to Math Variables in secondary units. Additionally, the meter passes Power and Energy Analog Quantity results to Math Variables in UNITY scaling. The meter passes Configurable Registers results to Math Variables without any adjustments to the scaling.

## Math Error Detection

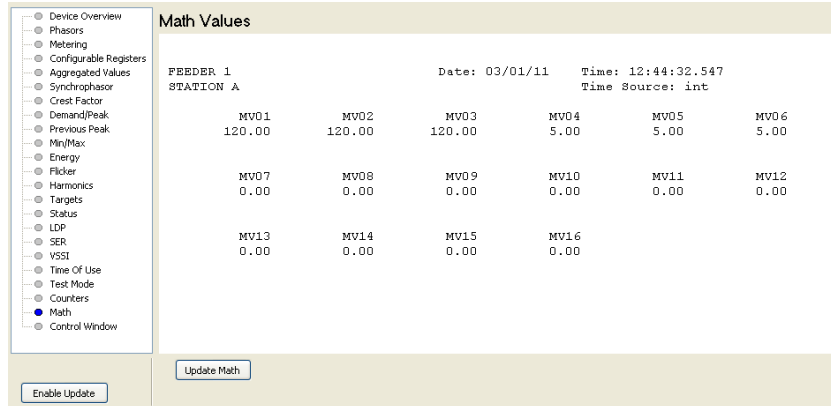
If a math operation results in an error, the SEL-735 turns on the math error Device Word bit MATHERR. A settings change or a status clear resets this bit. For example, if you attempt to divide a value by zero, the math error bit will assert until you clear the bit with a status clear or a settings change.

## HMI View

To view the Math Variables from the ACSELERATOR QuickSet HMI, perform the following steps.

- Step 1. From a ACSELERATOR QuickSet HMI, navigate to the Math window.
- Step 2. Click the **Update Math** button.
  - Click the **Enable Update** button to disable updates.
  - Click the **Disable Update** to enable updates.

ACSELERATOR QuickSet displays the present SELOGIC control equation math variable values, as *Figure 7.17* shows.



**Figure 7.17 Math Variables Shown in HMI Math Window**

## Counter Variables

SELOGIC control equation counter variables are up or down counters with reset functionality. You can load the counters with a specific number based on a SELOGIC control equation.

These counter elements conform to the standard counter function block #3 in *IEC 1131-3 First Edition 1993-03 International Standard for Programmable Controllers - Part 3: Programming Languages*.

Table 7.12 describes the Boolean input settings for the SELOGIC control equation counters.

**Table 7.12 SELOGIC Control Equation Counter Inputs (Sheet 1 of 2)**

Setting	Description	Default	Range
SCnCV	Current value of counter SCn. Use this setting to preload a value into the counter when sending settings to the device. ACSELERATOR QuickSet prompts you to send the current value.	0	0–999999
SCnPV	Maximum value that the counter reaches before freezing; the value loaded into the counter when the Load Preset result evaluates as TRUE.	1	0–999999

**Table 7.12 SELogic Control Equation Counter Inputs (Sheet 2 of 2)**

Setting	Description	Default	Range
SCnR	Logic equation that when TRUE resets the counter to zero.	NA	SELOGIC control equation
SCnLD	Logic equation that when TRUE loads the counter with the preset value.	NA	SELOGIC Expression
SCnCU	Logic equation that when TRUE increments the value of the counter by one.	NA	SELOGIC Expression
SCnCD	Logic equation that when TRUE decrements the value of the counter by one.	NA	SELOGIC Expression

Each time you read the counter settings from the device, it loads the instantaneous counter value into the current value setting (SCnCV) of the active settings editor. When you send the settings back to the meter, ACSELERATOR QuickSet prompts you to send the SCnCV settings. If you choose not to send the SCnCV settings, then the device loads zero into the SCnCV setting.

**Table 7.13 SELogic Control Equation Counter Outputs**

Name	Type	Description
SCnQU	Output, Word Bit	Word bit asserts when the counter current value equals the preset value.
SCnQD	Output, Word Bit	Word bit asserts when the counter current value equals zero.
SCn	Output, Analog Value	Instantaneous counter value. Use with any analog comparison in SELOGIC, and use the COU command to view this value.

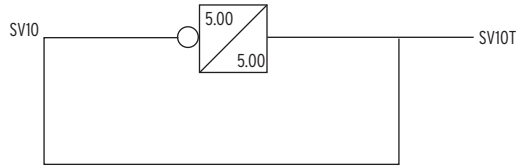
*Example 7.2* illustrates how to use the SELOGIC control equation counters to limit the demand by starting an on-site diesel generator.

**EXAMPLE 7.2 Using Counters to Control Generator Starting via Load Monitoring**

When the three-phase demand is greater than 100 kW for longer than 10 minutes, the diesel generator should start to pick up demand. The generator should start in 5 minutes when demand is greater than 125 kW. If the demand is greater than 150 kW, the diesel generator should start immediately. To achieve this function, make the following settings.

```

SC01PV := 60
SC01R := IN401 # disable the starting of the generator if desired
SC01LD := IN402 OR (WD3_DEL > 150) # start the generator immediately
SV10 := NOT(SV10T) # 10 second period
SC01CU := R_TRIG SV10 AND (WD3_DEL > 100) OR
          F_TRIG SV10 AND (WD3_DEL > 125) # increment counter SC01,
          faster when the demand is higher than 125.00
SC01CD := R_TRIG SV10 AND (WD3_DEL < 100) # decrement counter
          SC01 when the demand is below 100.00
OUT402 := (SC01 > 48) # warning that diesel generator is about to
          start
OUT401 := SC01QU # start generator signal
    
```

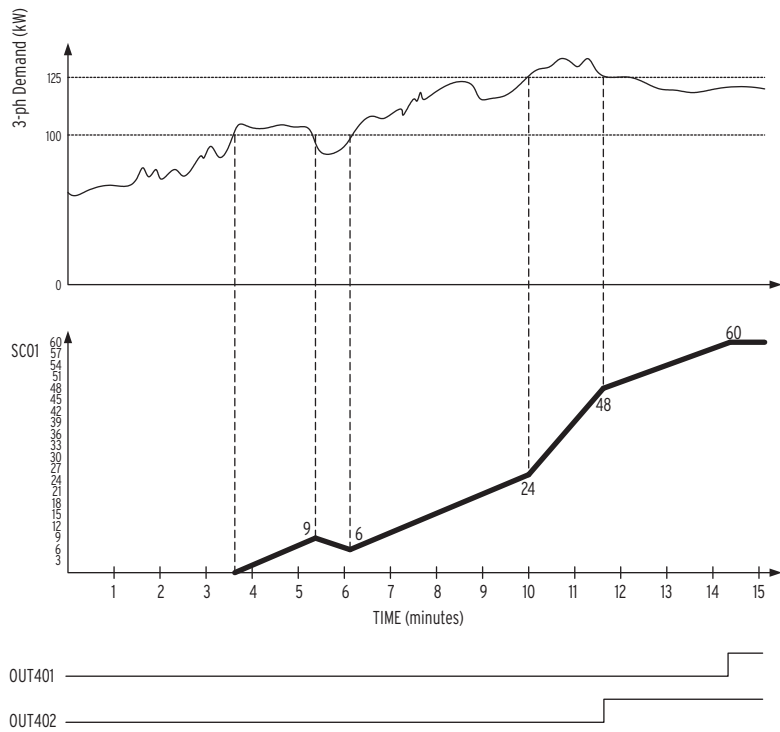


**Figure 7.18 SELogic Variable SV10 Timing Logic**

Because demand are slow-changing values, it makes little sense to check them continuously. The 10 second period on SV10T simplifies determination of the preset value.

$$\text{Preset Value} = \frac{10 \text{ minutes} \cdot 60 \text{ s/minute}}{10 \text{ x/count}} = 60 \text{ s/count}$$

Figure 7.19 is provided as a reference to this example.



**Figure 7.19 SELogic Control Equation Counter Example**

## Virtual Bits

The SEL-735 supports 128 virtual bits, VB001–VB128 for the IEC 61850 protocol.

These Device Word bits can only be set in meters ordered with IEC 61850. When IEC 61850 is enabled, the meter uses the externally created CID file to define the behavior of these virtual bits (received GOOSE messages can be mapped to these bits).

Once defined, the virtual bits can be used in SELOGIC control equations like any other Device Word bit.

The CID file also defines what information gets transmitted in GOOSE messages. See *Appendix H: IEC 61850 Communications* for details on the IEC 61850 protocol.

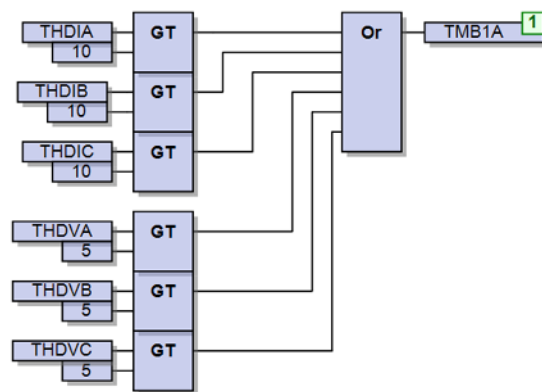
## MIRRORED BITS Communications

MIRRORED BITS communications is a direct device-to-device communications protocol that allows the SEL-735 to exchange binary information quickly and securely, and with minimal expense.

The SEL-735 supports two MIRRORED BITS communications channels, differentiated by the channel specifiers A and B. The device labels Transmitted MIRRORED BITS as TMB1x–TMB8x, where x is the channel specifier (e.g., A or B). The device controls Transmitted MIRRORED BITS through the corresponding SELOGIC control equations. The device labels Received MIRRORED BITS as RMB1x–RMB8x. Control the state of Transmitted MIRRORED BITS by using a separate SELOGIC control equation for each bit. Use Received MIRRORED BITS in any SELOGIC control equation.

Figure 7.20 shows an example of Channel A MIRRORED BIT number one configured to assert when the current or voltage THD exceeds 10 or 5 percent, respectively. Other SEL devices can use this information to make informed control decisions. For example, send this information to a capacitor bank controller to prevent capacitor bank energization when the harmonic distortion is too great.

For more detailed information on MIRRORED BITS communications, please see Appendix F: MIRRORED BITS Communications.



$$TMB1A := THDIA > 10 \text{ OR } THDIB > 10 \text{ OR } THDIC > 10 \text{ OR } THDVA > 5 \text{ OR } THDVB > 5 \text{ OR } THDVC > 5$$

Figure 7.20 MIRRORED BITS Channel A

### View MIRRORED BITS via ACSELERATOR QuickSet HMI

View transmitted and received MIRRORED BITS status through ACSELERATOR QuickSet by performing the following steps.

- Step 1. Open the ACSELERATOR QuickSet HMI.
- Step 2. Navigate to the **Targets** window.

Figure 7.21 shows the Transmitted and Received MIRRORED BITS targets, viewed from ACSELERATOR QuickSet HMI. The Targets HMI also shows the MIRRORED BITS communication status. Please see Appendix F: MIRRORED BITS Communications for detailed information on MIRRORED BITS communications.

RMB8A=0	RMB7A=0	RMB6A=0	RMB5A=0	RMB4A=0	RMB3A=0	RMB2A=0	RMB1A=0
TMB8A=0	TMB7A=0	TMB6A=0	TMB5A=0	TMB4A=0	TMB3A=0	TMB2A=0	TMB1A=0
RMB8B=0	RMB7B=0	RMB6B=0	RMB5B=0	RMB4B=0	RMB3B=0	RMB2B=0	RMB1B=0
TMB8B=0	TMB7B=0	TMB6B=0	TMB5B=0	TMB4B=0	TMB3B=0	TMB2B=0	TMB1B=0
LBOKB=0	CBADB=0	RBADB=0	ROKB=0	LBOKA=0	CBADA=0	RBADA=0	ROKA=0

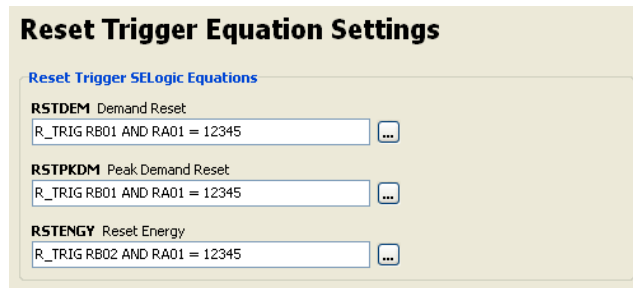
**Figure 7.21 MIRRORRED BITS Targets Shown in ACSELERATOR QuickSet HMI**

## Reset Trigger Equations

The Reset Trigger Equations are SELOGIC control equations that reset demand and energy data.

### Example

Figure 7.22 shows the demand and peak demand configured to reset from a remote device. When RA01 equals 12345 and the device detects the rising edge of RB01, both the demand and peak demand reset to zero. When RA01 equals 12345 and the device detects the rising edge of RB02, the energy resets to zero. The remote analog input requirement in each of the equations provides additional security to the logic scheme. Create a unique PIN by substituting 12345 with any number from the valid range of numbers.



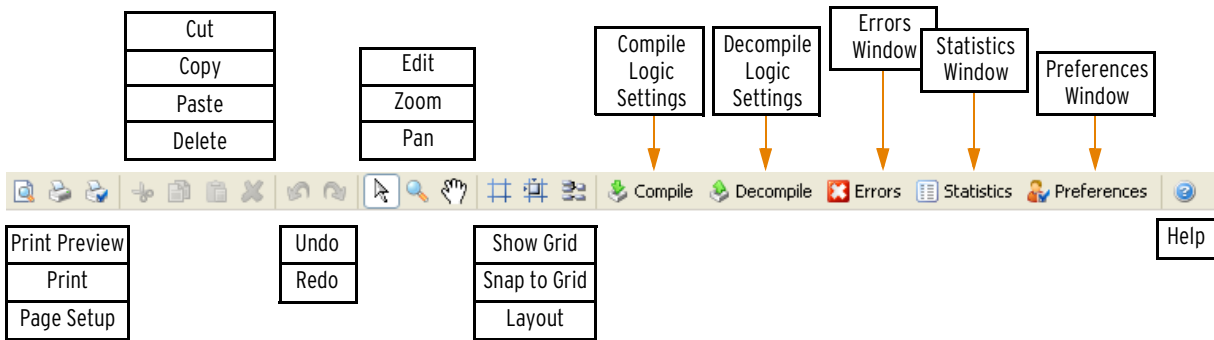
**Figure 7.22 Reset Trigger Equation Settings Example**

## Graphical Logic Editor

### Overview

ACSELERATOR QuickSet contains a powerful graphical logic editor that allows you to create complicated logic algorithms easily. This graphical logic editor also allows you to deconstruct logic expressions into a visual display.

Figure 7.23 shows the toolbar options available in the Graphical Logic Editor.



**Figure 7.23 Graphical Logic Editor Toolbar**

This instruction manual does not detail the basic toolbar options, such as Cut, Copy, Paste, and Delete. Please see the on-demand help menu for further information about the Graphical Logic Editor toolbar. The following text provides explanations of the logic editor toolbar functions.

### Compile Logic Settings

**To Text:** Use this function to convert the active logic diagram into a text string that you can then use in SELOGIC control equations.

**To Settings:** Use this function to convert the active logic diagram into the appropriate SELOGIC control equations and automatically configure the settings.

### Decompile Logic Settings

**From Text:** Use this function to convert a SELOGIC control equation represented as a text string into a diagram in the active logic diagram builder.

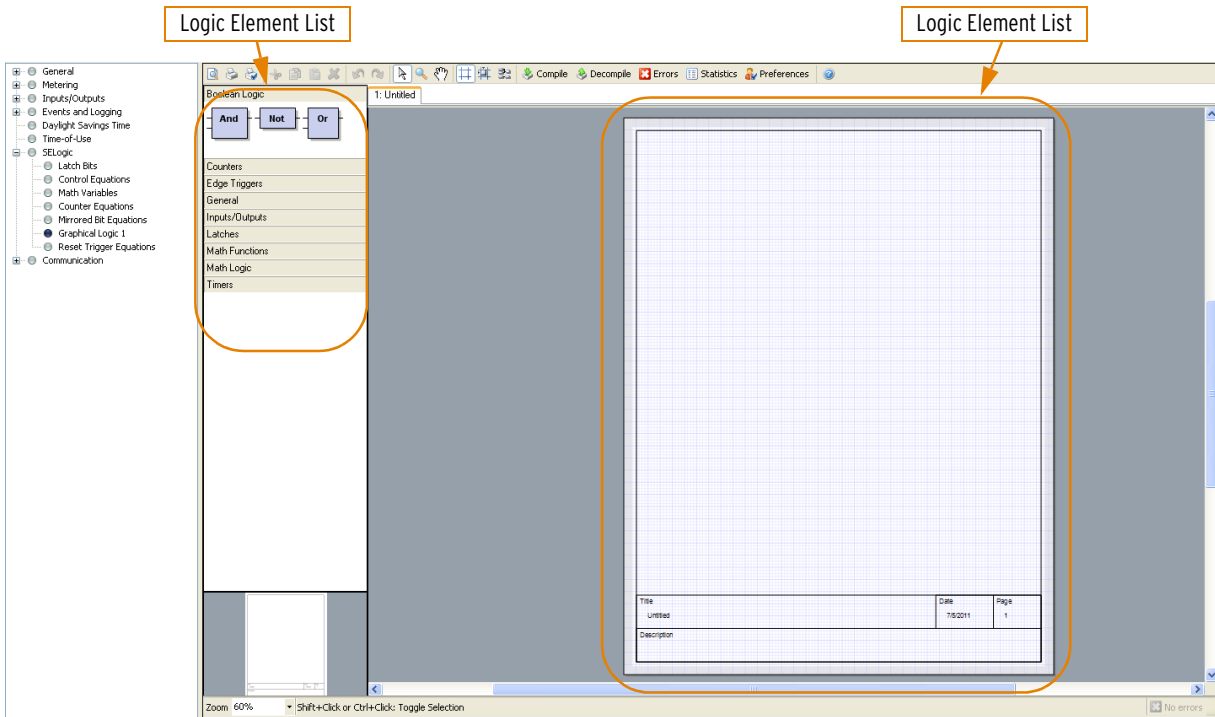
**From Settings:** Use this function to convert the existing SELOGIC control equation into a diagram in the active logic diagram builder.

**Errors Window:** Press this button to toggle the Errors window near the bottom of the screen on and off.

**Statistics Window:** Press this button to toggle the Statistics Window, which shows the number of each logic element you use, open or closed.

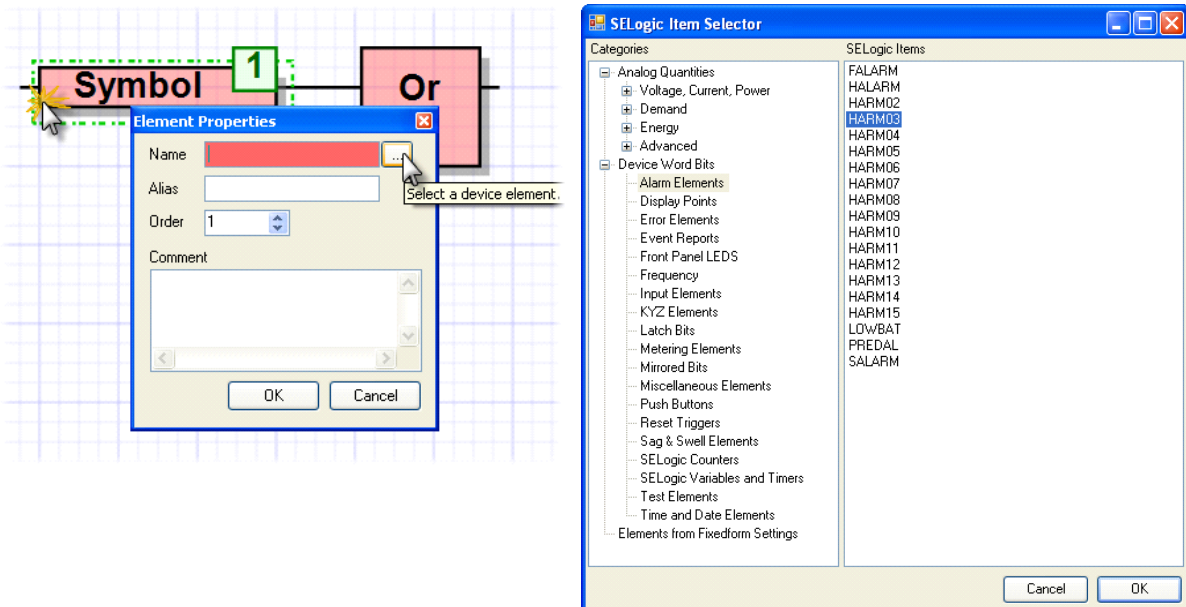
**Preferences Window:** Press this button to toggle the Preferences Window, which allows you to set the style and layout, open or closed.

Drag logic elements from the Logic Element List onto the Logic Diagram Page. Click and drag the appropriate pins together (the pins turn green when they can be connected together) to connect inputs to outputs. Compile the logic to settings, to convert the logic diagram to settings. For the Graphical Logic Editor help program, click on the Help button at the far right on the toolbar.



**Figure 7.24** Graphic Logic Editor Window

When you first drag an in input/output element, it is labeled Symbol, as in *Figure 7.25*. Double-click on the element box to open the Element Properties window. Click on the ellipse button next to the Element Name to open the SELOGIC Item Selector window.



**Figure 7.25** Graphical Logic Editor Element Control

Create your custom logic scheme by dragging and dropping more elements into the Logic Diagram Page and connecting them together. The Logic Diagram Builder shows any errors in the Errors window and highlights the element in red in the Logic Diagram Page. Additionally, you can create multiple pages of logic and connect them together.

Save each Logic Diagram Page you created for later retrieval. ACSELERATOR QuickSet saves the pages to the active settings database with the active settings editor. You can also configure and print the pages to file or a printer.

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# Section 8

## Communications

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### Overview

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There are various options for communicating with the SEL-735. The meter communications ports consist of the following:

- EIA-232
- EIA-485
- Internal Telephone Modem
- 10/100BASE-T Ethernet RJ45 Port
- 100BASE-FX or 100BASE-LX10 Fiber-Optic Ethernet LC Port
- Type 2 Optical Port

This section explains how to connect serial communications cables and how the SEL-735 uses communications protocols.

This section also includes a command summary and command explanations.

### Communications Options

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#### Port Options

You can add communications ports to the main board or communications boards in Slot C. *Table 8.1* shows the various options available on the SEL-735 main board.

**Table 8.1 SEL-735 Meter Models and Available Main Board Communications Options**

Slot B, Main Board Communications Options	Ethernet Port 1	Serial Port 2	Serial Port 3
B	None	EIA-232	EIA-232
C	10/100BASE-T Copper RJ45 Port	EIA-232	EIA-232
D	None	EIA-232	EIA-485
E	10/100BASE-T Copper RJ45 Port	EIA-232	EIA-485
F	100BASE-FX (Multimode) Fiber-Optic LC Port	EIA-232	EIA-232
G	100BASE-FX (Multimode) Fiber-Optic LC Port	EIA-232	EIA-485
H	100BASE-LX10 (Single-Mode) Fiber-Optic LC Port	EIA-232	EIA-232
J	100BASE-LX10 (Single-Mode) Fiber-Optic LC Port	EIA-232	EIA-485

Table 8.2 shows the various communications options available on the SEL-735 Slot C SELECT board. Be aware that you can use only one Port 4 channel at a time. Port 4A, Port 4B, and Port 4C are mutually exclusive. Set the port communications interface with the Communications Interface Selection (COMMINF) setting.

**Table 8.2 SEL-735 Meter Models and Available Slot C SELECT Board Communications Options**

Slot C Options	Port 4A	Port 4B	Port 4C
X	None	None	None
F	EIA-485	None	EIA-232
G	EIA-485	Modem	EIA-232

## Internal Modem

An optional communications card is available for the SEL-735, allowing selection of an internal telephone modem. Port 4B is the internal telephone modem port. Connect to the modem using a standard telephone cable and RJ-11 jack.

For a list of modem-related settings and definitions, see Table 8.3. Certain modem settings are necessary for user-specific applications. For protocols where the meter dials out for unsolicited reporting, such as DNP, a phone number (PH\_NUM), time to attempt dialing (MDTIME), and time between dial-out attempts (MDRET) settings are necessary.

The SEL-735 internal modem is globally compliant and allows direct connection to the Public Switched Telephone Network (PSTN). The modem includes support for CCITT V.92, V.90, V.34, V.32bis, V.32, V.22bis, V.22, V.23, V.21 Bell 212A, and Bell 103 protocols.

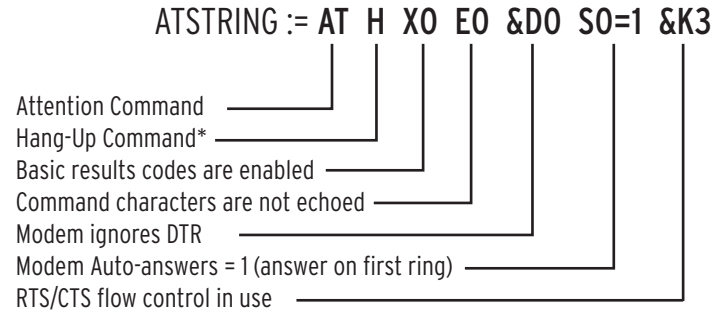
**Table 8.3 Modem Settings**

Setting Name	Setting Value	Description
COMMINF	Modem	Communications Interface Selection (232, 485, MODEM)
ATSTRING	ATHX0E0&D0S0=1&K3 <sup>a</sup>	Modem Initialization AT String: initialization string used by the internal modem (as many as 30 characters)
PH_NUM	15093321890 <sup>b</sup>	Phone Number for Dial-Out: can contain modem dial control characters (as many as 30 characters)
MDTIME	60 <sup>a</sup>	Time to Attempt Dial: time, in seconds, from initiating dial-out to termination because of no connection
MDRET	120 <sup>a</sup>	Time Between Dial-Out Attempts: time from termination on dial-out attempt until retry dial-out

<sup>a</sup> Default SW setting

<sup>b</sup> The default SW setting is blank and requires user-specific setting.

The Modem Initialization AT String comes preset from the factory with the default string `ATSTRING := ATHX0E0&D0S0 = 1&K3`. You can change the modem configuration by changing the AT String setting. Figure 8.1 shows the AT String, expanded to better demonstrate the individual commands that comprise the factory-default string.



\*SEL recommends that you include the Hang-up Command (H) in all AT strings you enter.

**Figure 8.1 Factory-Default AT String**

### Modem Command Set

In general, the SEL-735 modem accepts all Hayes-compatible AT commands configured by the ATSTRING setting. The following are useful AT command settings for the internal SEL-735 modem. For a full set of supported AT commands, please refer to the Multi-Tech® SocketModem® MT5600SMI Reference Guide (available from the SEL web site at <http://www.selinc.com/SEL-735/>).

**Table 8.4 Useful AT Commands**

Command	Description
EO	Disables command echo
L1	Low speaker volume (Default)
L2	Medium speaker volume
L3	High speaker volume
M0	Speaker always off
M1	Speaker on during call establishment
M2	Speaker on during answer
Sr = n	Write to an S register
S0 = n	Number of rings to auto-answer. By default, n = 0.
S6 = n	Wait Time Before Blind Dialing or for Dial Tone. By default, n = 2.
S7 = n	Wait Time for Carrier, Silence, or Dial Tone. By default, n = 50.
S8 = n	Pause Time for Dial Delay. By default, n = 2.
S9 = n	Carrier Detect Response Time. By default, n = 6.
S10 = n	Lost Carrier to Hang Up Delay. By default, n = 14.
S11 = n	DTMF Tone Duration. By default, n = 95.
S30 = n	Disconnect Inactivity Timer. By default, n = 0.
X0	Basic response set
&D0	Ignore DTR signal
&K3	RST/CTS flow control
&P0	Pulse dial make/break ratio of 39/61 @ 10 PPS
&P1	Pulse dial make/break ratio of 33/67 @ 10 PPS
&P2	Pulse dial make/break ratio of 39/61 @ 20 PPS
&P3	Pulse dial make/break ratio of 33/67 @ 20 PPS

**Table 8.5 Useful Dialing Modifiers**

Dial Modifiers	Description
P	Select Pulse dial
T	Select Tone dial
W	Wait for dial tone
,	Pause for duration specified in S8
!	Hook flash
@	Wait for silence

## FCC Compliance

The SEL-735 optional internal modem complies with Part 68 of the FCC Rules and Regulations. The SEL-735 has a label that contains the FCC Registration Number and Ringer Equivalence Number (REN) of the modem. You must, upon request, provide this information to your telephone company. The REN is useful for determining the quantity of devices you can connect to a telephone line and still have all of these devices ring for a call to that number called. In most areas, the sum of the RENs of all devices connected to one line should not exceed five. To determine the number of devices you can connect to the line, contact your local telephone company to find the maximum REN for your calling area.

If your system causes harm to the telephone network, the telephone company can discontinue your service temporarily. If possible, they will notify you in advance. If advance notification is not practical, you will be notified as soon as possible.

Your telephone company can make changes in its facilities, equipment, operations, or procedures that could affect proper functioning of your equipment. If they do, they should notify you in advance to provide you an opportunity to maintain uninterrupted telephone service.

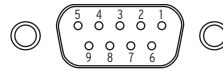
You must not, under any circumstances, attempt any service, adjustments, or repairs on the modem. Return the modem to the factory for any such work.

## Communications Devices

Other devices useful for communications include the SEL Communications Processors, SEL-2505 Remote I/O Module, SEL-2100 Logic Processor, and SEL-3530 RTACs.

# Port Connector and Communications Cables

Figure 8.2 shows the DB-9 connector pinouts for the SEL-735 serial ports.



**Figure 8.2 DB-9 Connector Pinout for EIA-232 and EIA-485 Serial Ports**

## Ethernet

The SEL-735 can be ordered with an optional 10/100BASE-T or 100BASE-FX fiber-optic Ethernet port. Connect to the port using a standard RJ45 connector with the copper Ethernet option or a standard LC connector with the fiber-optic Ethernet option. The default settings for the Ethernet port are the following:

- Primary Telnet Port: 23
- Primary Telnet Port Time-out: 15
- IP Address: 192.168.0.2
- Submask: 255.255.255.0
- Default: 192.168.0.1

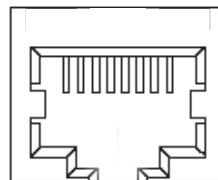
The Ethernet port accommodates six simultaneous sessions that can include any combination of Telnet, Modbus®, or DNP3, but which support a maximum of five DNP3 LAN/WAN and Modbus sessions.

Selection of the protocol for the Ethernet port occurs according to the port number on which requests arrive. The protocols the Ethernet port supports are SEL-ASCII, MODBUS/TCP, and DNP3 LAN/WAN.

The copper Ethernet port has two LEDs, which indicate the status of the port. Table 8.6 describes each LED. Figure 8.3 shows the location of status LEDs.

**Table 8.6 Ethernet Port LED Description**

LED	Description
Green	Tx or Rx Activity
Yellow	Link



- Green
- Yellow

**Figure 8.3 Ethernet Port Status LEDs**

## IRIG-B

While the SEL-735 provides two options for the IRIG-B signal input, only one should be in use at a time. You can use IRIG-B inputs or an SEL communications processor via Serial Port 3 or Port 2. The SEL-735 automatically switches to the IRIG-B time source when it is present and no software settings prevent the meter switching to the IRIG-B time source. If you want to connect to a device that produces an IRIG-B signal output, but you do not want the meter to use this time source, then use a serial cable that does not send the IRIG-B signal to the meter. Table 8.8 lists SEL communications cables.

## Serial Port Pinouts

**Table 8.7 Port Pinout Functions**

Pin	EIA-232 Port 2, Port 3	EIA-232 Port F, 4C	EIA-485 Port 3, Port 4A
1	+5 Vdc	+5 Vdc	+TX
2	RXD	RXD	-TX
3	TXD	TXD	+RX
4	+IRIG-B	N/C	-RX
5	GND	GND	SHIELD
6	-IRIG-B	N/C	N/C
7	RTS	RTS	N/C
8	CTS	CTS	N/C
9	GND	GND	N/C

## SEL-735 Communications Cables

Table 8.8 shows several types of SEL serial communications cables that connect the SEL-735 to other devices. Cables marked with 'R' indicate that the cable may be ruggedized. These and other cables are available from SEL. Please use the SEL-5801 SEL Cable Selector program for more information on SEL cables, including the pinouts of cables.

**Table 8.8 SEL-735 Communications Cables**

Communications Type	Function	SEL Cable Designation	IRIG-B Support?
Serial	SEL-735 to PC, DB-9 Serial	C234A [R]	No
		C235	No
		C287 [R]	No
	SEL-735 to PC, Optical Probe	C660 (DB-9)	No
		C661 (USB)	No
SEL-735 to other IED	C273A [R]	Yes	
Ethernet	SEL-735 to PC or other IED	C627 [R]	No

For long-distance communications as many as 80 kilometers and for electrical isolation of communications ports, use the SEL-2800 family of fiber-optic transceivers. Contact SEL for more details on these devices.

# Communications Protocols

## Software Protocols

SEL-735 communications protocols:

- SEL ASCII
- SEL Distributed Port Switch Protocol (LMD)
- SEL Fast Meter
- SEL Compressed ASCII
- IEC 61850 (Optional)
- MV-90 Translation
- Modbus® RTU
- Modbus® TCP

- MIRRORED BITS® Communications
- Distributed Network Protocol (DNP3) (Optional)
- Telnet
- File Transfer Protocol (FTP)
- Simple Network Time Protocol (SNTP)

SEL Fast Meter and SEL Compressed ASCII commands are active when you set PROTO to either SEL or LMD. The commands are inactive when you set PROTO to DNP, Modbus, or MIRRORED BITS.

## SEL ASCII Protocol

SEL ASCII protocol is designed for manual and automatic communications.

All commands the meter receives must be of the following form:

**<command> <Enter>** or **<command> <CRLF>**

A command you transmit to the meter should consist of the command followed by either a carriage return (**<Enter>**) or a carriage return and line feed (CRLF).

You can truncate commands to the first three characters. For example, **EVENT 1 <Enter>** would become **EVE 1 <Enter>**. You can use upper- and lowercase characters without distinction, except in passwords.

The meter transmits all messages in the following format:

```
<STX><MESSAGE LINE 1><CRLF>
<MESSAGE LINE 2><CRLF>
•
•
•
<LAST MESSAGE LINE><CRLF>< ETX>
```

Each message begins with the start-of-transmission character (ASCII 02) and ends with the end-of-transmission character (ASCII 03). Each line of the message ends with a carriage return and line feed.

The meter implements XON/XOFF flow control.

The meter transmits XON (ASCII hex 11) and asserts the RTS output (if hardware handshaking is enabled) when the meter input buffer drops below 25 percent.

The meter transmits XOFF (ASCII hex 13) when the buffer is over 75 percent. If hardware handshaking is enabled, the meter deasserts the RTS output when the buffer is approximately 95 percent.

Automatic transmission sources should monitor for the XOFF character to avoid overwriting the buffer. Transmission should terminate at the end of the message in progress when the meter receives an XOFF character and can resume when the meter sends XON.

You can use the XON/XOFF protocol to control the meter during data transmission. When the meter receives XOFF during transmission, it pauses until it receives an XON character. If there is no message in progress when the

---

**NOTE:** The **<Enter>** key on most keyboards is configured to send the ASCII character 13 (^M) for a carriage return. This manual instructs you to press the **<Enter>** key after commands, which should send the proper ASCII code to the meter.

meter receives XOFF, it blocks transmission of any message arriving at its buffer. The meter will again accept messages after it receives an XON character.

The CAN character (ASCII hex 18) aborts a pending transmission. This is useful in terminating an unwanted transmission.

You can send control characters from most keyboards with the following keystrokes:

XON: <Ctrl+Q>  
XOFF: <Ctrl+S>  
CAN: <Ctrl+X>

## IEC 61850 Protocol

The meter optionally supports IEC 61850 protocol, including GOOSE and MMS, as described in *Appendix H: IEC 61850 Communications*. The IEC 61850 protocol is only available on meters with an Ethernet port.

## SEL Distributed Port Switch Protocol (LMD)

The SEL Distributed Port Switch Protocol (LMD) permits multiple SEL meters to share a common communications channel. Select the protocol by setting the port setting PROTO = LMD.

## SEL Fast Meter Protocol

SEL Fast Meter protocol supports binary messages to transfer metering and control messages. *Appendix C: SEL Communications Processors* describes this protocol.

## SEL Compressed ASCII Protocol

SEL Compressed ASCII protocol provides compressed versions of some of the meter ASCII commands. *Appendix C: SEL Communications Processors* describes this protocol.

## MV-90 Translation

The meter provides MV-90 support via SEL ASCII protocol.

## Modbus RTU

The meter provides Modbus RTU support. *Appendix E: Modbus Communications Protocol* describes the Modbus protocol.

## MIRRORED BITS Communications

The SEL-735 supports MIRRORED BITS meter-to-meter communications on two ports simultaneously. See *Appendix F: MIRRORED BITS Communications*.

## Distributed Network Protocol (DNP3)

The meter provides Distributed Network Protocol (DNP3) Level 2 Slave support. *Appendix D: Distributed Network Protocol* describes the optional DNP protocol.

## Telnet

The SEL-735 provides Telnet support via the Ethernet port (PORT 1). The meter supports a total of six simultaneous sessions on this port (see *Ethernet on page 8.5*).

## FTP

The SEL-735 provides FTP support via the Ethernet port (PORT 1). The meter supports one FTP session. See *File Transfer Protocol (FTP) and MMS File Transfer*.

## Hardware Protocol, RTS/CTS Handshaking

The EIA-232 serial port supports request to send/clear to send (RTS/CTS) hardware handshaking. EIA-485 Serial Port 4A provides no support for RTS/CTS handshaking.

To enable hardware handshaking, set RTSCTS for the port to Yes. Set RTSCTS = N to disable hardware handshaking.

If RTSCTS = N, the meter permanently asserts the RTS line.

If RTSCTS = Y, the meter deasserts RTS when it is unable to receive characters.

If RTSCTS = Y, the meter does not send characters until the CTS input is asserted.

## Port Automatic Messages

When the serial port AUTO setting is Y, the meter sends automatic messages to indicate specific conditions. *Table 8.9* describes the automatic messages.

**Table 8.9 Serial Port Automatic Messages**

Condition	Description
Power Up	The meter sends a message containing the present date and time, meter and terminal identifiers, and the Access Level 0 prompt when you turn on the meter.
Event Trigger	The meter sends an event summary for each triggering of an event report. See <i>Waveform Capture Event Reports on page 6.6</i> .
Self-Test Warning or Failure	The meter sends a status report each time it detects a self-test warning or failure condition. See <i>Meter Self-Tests on page 9.16</i> .

## Port Access Levels

You can issue commands to the meter via the serial port or via a Telnet connection on the Ethernet port to view metering values, change meter settings, etc. As *Table 8.10* shows, you can access a listing of available port commands only from the corresponding access level. The access levels are as follows:

- Access Level 0 (the lowest access level)
- Access Level 1
- Access Level E
- Access Level 2 (the highest access level)
- Access Level C (use only when directed by SEL)

Again, a higher access level can access the port commands in a lower access level. The manual shows the commands in uppercase letters, but you can also enter these commands with lowercase letters.

## Access Level 0

Once you have established port communications with the meter, you can enter Access Level 0. The meter sends the following prompt at Access Level 0:

---

---

=

---

---

Enter the **ACC** command at the Access Level 0 prompt to move to Access Level 1. The following text shows an example of the **ACC** command.

=**ACC** <Enter>

## Access Level 1

When the meter is in Access Level 1, the meter sends the following prompt:

---

---

=>

---

---

Enter the **2AC** command at Access Level 1 to move to Access Level 2. The following text shows an example of the **2AC** command.

=>**2AC** <Enter>

Enter the **EAC** command at Access Level 1 to move to Access Level E. The following text shows an example of the **EAC** command.

=>**EAC** <Enter>

## Access Level E

When the meter is in Access Level E, the meter sends the following prompt:

---

---

E=>

---

---

## Access Level 2

When the meter is in Access Level 2, the meter sends the following prompt:

---

---

=>>

---

---

Any of the Access Level 1 and Access Level E commands are also available in Access Level 2.

## Access Level C

The CAL access level is intended for use by the SEL factory and by SEL field service personnel to help diagnose troublesome installations. A list of commands available at the CAL level is available from SEL upon request. Do not enter the CAL access level, except as directed by SEL.

## File Transfer Protocol (FTP) and MMS File Transfer

File Transfer Protocol (FTP) is a standard protocol for exchanging files between computers over a TCP/IP network. The SEL-735 operates as an FTP server, presenting files to FTP clients. The meter supports one FTP session at a time. Requests to establish additional FTP sessions are denied.

Manufacturing Messaging Specification (MMS) is used in IEC 61850 applications and provides services for the transfer of real-time data, including files, within a substation LAN.

## File Structure

The file structure is organized as a directory and subdirectory tree similar to that used by Windows and other common operating systems. The files and folder structure available over the FTP and MMS File Transfer interface is different from the files and folder structure available to the **FIL** command. The file structure described here applies to the FTP and MMS interfaces. The SEL-735 root directory contains the CFG.TXT file and an ERR.TXT file, the SET\_61850.CID file (see *Appendix H: IEC 61850 Communications*), a CFG.XML file, a SETTINGS directory, an EVENTS/COMTRADE directory, and a REPORTS directory.

The SETTINGS directory contains the same settings files available using the **FIL** command.

The EVENTS/COMTRADE directory contains event files. On the FTP interface, it is named EVENTS. On the MMS interface, it is named COMTRADE.

The REPORTS directory contains an LDP file for each of the LDP recorders, for each of the following time frames:

- Last 24 Hours
- Last 7 Days
- Last 30 Days
- Last 6 Months
- All

The SET\_61850.CID file defines the 61850 data sets for the meter. Read and write access is available over FTP only; the file is not available to the MMS interface.

## Access Control

To log on to the server, enter the value of the Port 1 setting FTPUSER as the user name in your FTP application. Enter the Level 2 password as the password in your FTP application. Note that FTP does not encrypt passwords before sending them to the server.

MMS is enabled when Port 1 setting E61850 is set to 1 or higher. MMS authentication is supported, see *MMS on page H.4*

## Using FTP and MMS

A free FTP application is included with most web browser software and PC operating systems. Once you have retrieved the necessary files, be sure to close the FTP connection by using the disconnect function of your FTP application or by completely closing the application. Failure to do so can cause the FTP connection to remain open, which blocks subsequent connection attempts until FTPIDLE time expires.

See *Appendix H: IEC 61850 Communications* for information about using MMS.

# Command Summary

The *Command Summary on page 8.12* lists the serial port commands alphabetically in the associated required access level.

Much of the information available from the serial port commands is also available via the front-panel pushbuttons. See *Section 3: Front-Panel Operation* for more information on the front-panel pushbuttons.

The commands at the different access levels offer varying levels of control.

- The Access Level 1 commands allow you to look at information only (settings, metering, etc.), but not to change it.
- The Access Level E commands allow you to reset meter registers, including peak demand.
- The Access Level 2 commands allow you to change meter settings.

The meter responds with `Invalid Access Level` if you enter a command from an access level lower than the specified access level for the command. The following example shows how the meter responds to commands not in the previous listing or which you have entered incorrectly.

---

```
Invalid Command
```

---

Many of the command responses display the following header:

---

```
FEEDER 1          Date: 01/01/02  Time: 00:01:07.175
STATION A        Time Source: int
```

---

- **FEEDER 1:** This is the MID setting (the meter ships with the default setting MID = FEEDER 1).
- **STATION A:** This is the TID setting (the meter ships with the default setting TID = STATION A).
- **Date:** This is the date the meter provided the command response (except for meter response to the **EVE** [Event] command, where it is the date the event occurred). You can modify the date display format by changing the `DATE_F` meter global setting.
- **Time:** This is the time the meter responded to the command (except for meter response to the **EVE** command, where it is the time the event occurred).
- **Time Source:** This is the time source status at the time of the command response (except for the meter response to **EVE** command, where it is the time source status at the time the event occurred).

*Table 8.10* lists all of the available commands from a terminal prompt with the required access level. *Table 8.10* only shows the command summaries; for more details on each command, please contact the SEL factory.

Table 8.10 Command Summary (Sheet 1 of 3)

Access Level	Command	Description
0	<b>ACC</b>	Move to Access Level 1
0	<b>BNA</b>	Binary names
0	<b>CAS</b>	Compressed ASCII data configuration
0	<b>DNA</b>	Compressed names
0	<b>EXI</b>	Terminate a Telnet session. Only available when connected via Telnet.
0	<b>ID</b>	Compressed ASCII Fast Meter ID
0	<b>QUI</b>	Quit to Access Level 0
0	<b>SNS</b>	Compressed SER settings
1	<b>2AC</b>	Move to Access Level 2
1	<b>CEV</b>	Compressed event report, 16 samples per cycle
1	<b>COM</b>	Display MIRRORRED BITS channel statistics
1	<b>COM C</b>	Reset MIRRORRED BITS channel statistics
1	<b>COU</b>	Display SELOGIC counters
1	<b>CHI</b>	Compressed history
1	<b>CCR</b>	Compressed calibration error report
1	<b>CST</b>	Compressed status
1	<b>CTR C [A]</b>	Comtrade format event report, config
1	<b>CTR D [A]</b>	Comtrade format event report, data
1	<b>DAT</b>	Show date
1	<b>DNP[n]</b>	Show DNP map
1	<b>EAC</b>	Move to Energy Access Level
1	<b>EVE</b>	Latest event report, 16 samples per cycle
1	<b>EVE C</b>	Compressed event report
1	<b>EVE D</b>	1/16-cycle resolution Device Word bit data
1	<b>EVE L, EVE R</b>	Raw, unfiltered event report
1	<b>EVE M</b>	1/16-cycle resolution MIRRORRED BITS data
1	<b>FIL DIR</b>	List all device files and directories
1	<b>FIL READ</b>	Transfer settings and other files from meter
1	<b>FIL SHOW</b>	Display file contents
1	<b>GOO</b>	Display GOOSE transmit and receive information
1	<b>HIS</b>	Summary event reports
1	<b>IRI</b>	Force synchronization to IRIG
1	<b>LDP[n]</b>	Display report for load profile recorder, where <i>n</i> is the LDP recorder number
1	<b>MAT</b>	Displays results of SELOGIC math variable equations
1	<b>MET</b>	Display instantaneous metering data
1	<b>MET A</b>	Display aggregated values
1	<b>MET AI</b>	Display analog input voltage
1	<b>MET CF</b>	Display crest factor quantities
1	<b>MET CFG</b>	Display configurable registers values
1	<b>MET D</b>	Display compensated demand data

**Table 8.10 Command Summary (Sheet 2 of 3)**

Access Level	Command	Description
1	<b>MET D P</b>	Display compensated peak demand data
1	<b>MET D P U</b>	Display uncompensated peak demand data
1	<b>MET D T</b>	Display the timestamps of the peak demands
1	<b>MET D T U</b>	Display the timestamps of the uncompensated peak demands
1	<b>MET D U</b>	Display uncompensated demand data
1	<b>MET E</b>	Display energy data
1	<b>MET FL</b>	Display flicker data
1	<b>MET H</b>	Display harmonic data
1	<b>MET L</b>	Display losses
1	<b>MET M</b>	Display maximum and minimum values
1	<b>MET RMS</b>	Display rms metering data
1	<b>QUI</b>	Quit to Access Level 0
1	<b>SER</b>	Display Sequential Events Recorder records
1	<b>SHO</b>	Display settings
1	<b>SSI</b>	Display voltage sag/swell/interruption (VSSI) report
1	<b>STA</b>	Display self-test status
1	<b>STA E</b>	Display EEPROM messages
1	<b>TAR</b>	Display Device Word bits
1	<b>TIM</b>	Show time
1	<b>TOG</b>	Resets NEWEVNT Device Word bit
1	<b>TRI</b>	Trigger an event
1	<b>VER</b>	Display version and configuration information
E	<b>DAT <i>date</i></b>	Set date
E	<b>LDP[n] C</b>	Reset load profile recorder, where <i>n</i> is the LDP recorder number
E	<b>MET CF R</b>	Clear crest factor metering
E	<b>MET M R</b>	Clear max/min metering
E	<b>MET P R</b>	Clear peak demand metering
E	<b>QUI</b>	Quit to Access Level 0
E	<b>TIM <i>time</i></b>	Set time
2	<b>CAL</b>	Go to Access Level C
2	<b>CON <i>x</i></b>	Control remote bits <i>x</i>
2	<b>DNP[n]</b>	Show DNP map
2	<b>FIL WRITE</b>	Write setting files to the meter
2	<b>FOR</b>	Change meter form
2	<b>HIS C</b>	Clear event and history records
2	<b>L_D</b>	Load new firmware
2	<b>LOO</b>	Initiate/clear MIRRORED BITS loopback
2	<b>MET D R</b>	Clear demand metering
2	<b>MET E R</b>	Reset energy metering
2	<b>MET FL R</b>	Reset flicker metering quantities

Table 8.10 Command Summary (Sheet 3 of 3)

Access Level	Command	Description
2	<b>MET P R</b>	Clear peak demand metering
2	<b>MEM</b>	Display memory
2	<b>PAR</b>	Display or modify the part number
2	<b>PAS</b>	Set/show passwords
2	<b>PUL</b>	Pulse output contact
2	<b>QUI</b>	Quit to Access Level 0
2	<b>R_S</b>	Restore factory settings
2	<b>SER [R]</b>	Display or clear SER
2	<b>SET</b>	Change settings
2	<b>SSI C</b>	Clear SSI data (including SSI summary) from the meter
2	<b>SSI R</b>	Reset SSI processing
2	<b>SSI S</b>	Display SSI summary report
2	<b>SSI T</b>	Trigger an event and store SSI data
2	<b>TES AGG</b>	Capture and display 10/12-cycle data
2	<b>TEST DB A</b> <i>name value</i>	Override analog label <i>name</i> with <i>value</i> in communications interface
2	<b>TEST DB D</b> <i>name value</i>	Override Device Word bit <i>name</i> with <i>value</i> in communications interface, where <i>value</i> = 0 or 1
2	<b>TEST MODE</b>	Display Test Mode parameters
2	<b>VER</b>	Display version and configuration information
C	<b>AUT</b>	Autocalibrate the analog acquisition system
C	<b>PAR H</b>	Access part number help
C	<b>R_S F</b>	Force settings restore (including calibration settings), part number, and MAC address
C	<b>TEST AE</b>	Display analog quantities with names and attributes
C	<b>TEST DP</b>	Test display points by listing the quantities that show as errors on the front panel
C	<b>TEST JMP</b>	Test jumpers
C	<b>TEST PS</b>	Show the last, maximum, and minimum values of the power supply
C	<b>TEST SNTP</b>	Test SNTP accuracy
C	<b>SET C</b>	Set calibration settings
C	<b>STA Z</b>	Clear EEPROM messages
C	<b>STA SC/SR</b>	Clear detailed SELOGIC control equation information
C	<b>STA C/R</b>	Clear meter status and reboot
SB	<b>BAU rate</b>	Set baud rate to 300, 1200, 2400, 4800, 9600, 19200, 38400 (57600 or 115200 if Port 2 or Port 3) bps.
SB	<b>BFI</b>	Display the SELBOOT version.
SB	<b>ERA</b>	Erase the existing firmware.
SB	<b>EXI</b>	Exit this program and restart the device.
SB	<b>FID</b>	Display the firmware identification (FID).
SB	<b>HEL</b>	Print a help list of commands.
SB	<b>REC</b>	Receive new firmware for the device using Xmodem.

# Command Explanations

## FIL Command

The **FILE** command uses Y-modem transfer protocol to provide an efficient means of transferring files between the meter and a PC. Software applications, such as ACSELERATOR QuickSet® SEL-5030 Software, use the **FILE** commands to transfer settings files to and from the meter.

Command	Description	Access Level
<b>FILE DIR</b>	Return a list of files.	1
<b>FILE READ</b> <i>filename</i>	Transfer settings file <i>filename</i> from the meter to the PC.	1
<b>FILE WRITE</b> <i>filename</i>	Transfer settings file <i>filename</i> from the PC to the meter.	2
<b>FILE SHOW</b> <i>filename</i>	Displays contents of the file <i>filename</i> .	1

Below is a sample of the **FILE DIR** command response.

```

->>FILE DIR <Enter>

EVENTS                R D
ASCII                 R
ZASCII                R
DIAGNOSTICS.TXT       R
DIAGNOSTICS.ZTXT      R
SET_ALL.TXT           R
CFG.TXT               R
ERR.TXT               R
SET_PF.TXT            RW
SET_P2.TXT            RW
SET_P3.TXT            RW
SET_P1.TXT            RW
SET_1.TXT             RW
SET_F.TXT             RW
SET_L.TXT             RW
SET_R.TXT             RW
SET_E.TXT             RW
SET_CFG.TXT           RW
SET_D.TXT             RW
SET_TOU.TXT           RW
LDP1_DATA.BIN         R
LDP1_DATA.TXT         R
LDP1_DATA.ZBIN        R
LDP2_DATA.BIN         R
LDP2_DATA.TXT         R
LDP2_DATA.ZBIN        R
LDP3_DATA.BIN         R
LDP3_DATA.TXT         R
LDP3_DATA.ZBIN        R
LDP4_DATA.BIN         R
LDP4_DATA.TXT         R
LDP4_DATA.ZBIN        R
LDP5_DATA.BIN         R
LDP5_DATA.TXT         R
LDP5_DATA.ZBIN        R
LDP6_DATA.BIN         R
LDP6_DATA.TXT         R
LDP6_DATA.ZBIN        R
LDP7_DATA.BIN         R
LDP7_DATA.TXT         R
LDP7_DATA.ZBIN        R
LDP8_DATA.BIN         R
LDP8_DATA.TXT         R
LDP8_DATA.ZBIN        R
LDP9_DATA.BIN         R
LDP9_DATA.TXT         R
LDP9_DATA.ZBIN        R
LDP10_DATA.BIN        R
LDP10_DATA.TXT        R
LDP10_DATA.ZBIN       R
LDP11_DATA.BIN        R
  
```

```
LDP11_DATA.TXT           R
LDP11_DATA.ZBIN         R
LDP12_DATA.BIN          R
LDP12_DATA.TXT           R
LDP12_DATA.ZBIN         R
```

## GOO Command

Use the **GOOSE** command to display transmit and receive GOOSE messaging and statistics information, which can be used for troubleshooting. The **GOOSE** command variants and options are shown below.

Command Variant	Description	Access Level
<b>GOO</b>	Display GOOSE information.	1
<b>GOO <i>k</i></b>	Display GOOSE information <i>k</i> times.	1
<b>GOO S</b>	Display a list of GOOSE subscriptions with their ID.	1
<b>GOO S <i>n</i></b>	Display GOOSE statistics for subscription ID <i>n</i> .	1
<b>GOO S ALL</b>	Display GOOSE statistics for all subscriptions.	1
<b>GOO S <i>n</i> L</b>	Display GOOSE statistics for subscription ID <i>n</i> including error history.	1
<b>GOO S ALL L</b>	Display GOOSE statistics for all subscriptions including error history.	1
<b>GOO S <i>n</i> C</b>	Clear GOOSE statistics for subscription ID <i>n</i> .	1
<b>GOO S ALL C</b>	Clear GOOSE statistics for all subscriptions.	1

The information displayed for each GOOSE IED is described in the following table.

Information Field	Description
Transmit GOOSE Control Reference	This field represents the GOOSE control reference information that includes the IED name, IdInst (Logical Device Instance), LN0 InClass (Logical Node Class), and GSEControl name (GSE Control Block Name) (e.g., SEL_735CFG/LLN0\$GO\$GooseDSet13).
Receive GOOSE Control Reference	This field represents the goCbRef (GOOSE Control Block Reference) information that includes the iedName (IED name), IdInst (Logical Device Instance), LN0 InClass (Logical Node Class), and cbName (GSE Control Block Name) (e.g., SEL_735CFG/LLN0\$GO\$GooseDSet13).
MultiCastAddr (Multicast Address)	This hexadecimal field represents the GOOSE multicast address.
Ptag	This three-bit decimal field represents the priority tag value, where spaces are used if the priority tag is unknown.
Vlan	This 12-bit decimal field represents the virtual LAN (Local Area Network) value, where spaces are used if the virtual LAN is unknown.
StNum (State Number)	This hexadecimal field represents the state number that increments with each state change.
SqNum (Sequence Number)	This hexadecimal field represents the sequence number that increments with each retransmitted GOOSE message sent.
TTL (Time to Live)	This field contains the time (in ms) before the next message is expected.

Information Field	Description														
Code	<p>When appropriate, this text field contains warning or error condition text that is abbreviated as follows:</p> <table border="1"> <thead> <tr> <th>Code Abbreviation</th> <th>Explanation</th> </tr> </thead> <tbody> <tr> <td>OUT OF SEQUENC</td> <td>Out of sequence error</td> </tr> <tr> <td>CONF REV MISMA</td> <td>Configuration Revision mismatch</td> </tr> <tr> <td>NEED COMMISSIO</td> <td>Needs Commissioning</td> </tr> <tr> <td>TEST MODE</td> <td>Test Mode</td> </tr> <tr> <td>MSG CORRUPTED</td> <td>Message Corrupted</td> </tr> <tr> <td>TTL EXPIRED</td> <td>Time to live expired</td> </tr> </tbody> </table>	Code Abbreviation	Explanation	OUT OF SEQUENC	Out of sequence error	CONF REV MISMA	Configuration Revision mismatch	NEED COMMISSIO	Needs Commissioning	TEST MODE	Test Mode	MSG CORRUPTED	Message Corrupted	TTL EXPIRED	Time to live expired
Code Abbreviation	Explanation														
OUT OF SEQUENC	Out of sequence error														
CONF REV MISMA	Configuration Revision mismatch														
NEED COMMISSIO	Needs Commissioning														
TEST MODE	Test Mode														
MSG CORRUPTED	Message Corrupted														
TTL EXPIRED	Time to live expired														
Transmit Data Set Reference	<p>This field represents the DataSetReference (Data Set Reference) that includes the IED name, LLN0 InClass (Logical Node Class), and GSEControl datSet (Data Set Name) (e.g., SEL_735/LLN0\$DSet13).</p>														
Receive Data Set Reference	<p>This field represents the datSetRef (Data Set Reference) that includes the iedName (IED name), IdInst (Logical Device Instance), LLN0 InClass (Logical Node Class), and datSet (Data Set Name) (e.g., SEL_735/LLN0\$DSet13).</p>														
Ctrl Ref/ ControlBlockReference	<p>This is the GOOSE control block reference. It is a concatenation of the logical device name, LLN0 (logical node containing the control block), GO (functional constraint), and the GSEControl name. (e.g. SEL_753_1CFG/LLN0\$GO\$GooseDSet13)</p>														
AppID	<p>This is the application identifier as a decimal number.</p>														
From	<p>This is the date and time the current statistics collection started.</p>														
To	<p>This is the date and time the GOOSE statistics command was executed.</p>														
Accumulated downtime duration	<p>This represents the total amount of time a subscription was in an error state. The duration is displayed in the format: hhhh:mm:ss.zzz.</p>														
Maximum downtime duration	<p>This represents the maximum amount of time a subscription was continuously in error state. The duration is displayed in the format: hhhh:mm:ss.zzz.</p>														
Date & time maximum downtime began	<p>This is the date and time the recorded maximum downtime started.</p>														
Number of messages received out-of-sequence (OOS)	<p>This represents the total number of messages received with either the state number and/or sequence number out-of-sequence. This includes cases where more than one instance of a message is received within a single meter processing interval. In this case, the most recent message is processed and the others are discarded.</p>														
Number of time-to-live (TTL) violations detected	<p>This represents the total number of times a message was not received within the expected period/interval.</p>														
Number of messages incorrectly encoded or corrupted	<p>This represents the total number of messages that were identified with this subscription but were either incorrectly encoded or encoded with an incorrect dataset.</p>														
Number of messages lost due to receive overflow	<p>This represents the total number of messages that were not processed because memory resources were exhausted. This includes cases where more than one instance of a message is received within a single meter processing interval. In this case, the most recent message is processed and the others are discarded.</p>														
Calculated max. sequential messages lost due to OOS	<p>This represents the maximum estimated number of messages that were missed after receiving a message with a higher state or sequence number than expected.</p>														
Calculated number of messages lost due to OOS	<p>This represents the total of all estimated number of messages lost as a result of state or sequence number skip in received messages.</p>														

An example response to the **GOOSE** commands is shown in *Figure 8.4*.

```
#>GOOSE <Enter>

GOOSE Transmit Status
MultiCastAddr  Ptag:Vlan AppID  StNum      SqNum      TTL      Code
-----
SEL_735_DevCFG/LLN0$G0$goose_1
01-0C-CD-01-00-07 4:3    7      1          16          792
Data Set: SEL_735_DevCFG/LLN0$GOOSE_out_1

SEL_735_DevCFG/LLN0$G0$goose_2
01-0C-CD-01-00-0A 4:3    10     1          16          632
Data Set: SEL_735_DevCFG/LLN0$GOOSE_out_2

GOOSE Receive Status
MultiCastAddr  Ptag:Vlan AppID  StNum      SqNum      TTL      Code
-----
SEL_735_MonCFG/LLN0$G0$GOOSE_msg_1
01-0C-CD-01-00-05 :    5      101       0          0          2000
Data Set: SEL_735_MonCFG/LLN0$goose_1_1

==>GOOSE S 1 L
SubsID 1
-----
Ctrl Ref: SEL_735_MonCFG/LLN0$G0$GOOSE_msg_1
AppID : 5
From : 05/30/2013 12:06:38.734 To: 05/30/2013 12:07:47.434

Accumulated downtime duration : 0000:01:08.690
Maximum downtime duration : 0000:01:08.690
Date & time maximum downtime began : 05/30/2013 12:06:38.742
Number of messages received out-of-sequence(OOS) : 0
Number of time-to-live(TTL) violations detected : 1
Number of messages incorrectly encoded or corrupted: 0
Number of messages lost due to receive overflow : 0
Calculated max. sequential messages lost due to OOS: 0
Calculated number of messages lost due to OOS : 0

# Date Time Duration Failure
1 05/30/2013 12:06:38.742 0000:01:08.690 TTL EXPIRED

=>
```

**Figure 8.4 GOOSE Command Response**

## TEST DB Command

Use the **TEST DB** command to temporarily force the meter to send fixed analog and/or digital values over IEC 61850 (GOOSE and MMS) for protocol testing.

Command	Description	Access Level
<b>TEST DB</b>	Display the present status of digital and analog overrides.	2
<b>TEST DB A</b> <i>name value</i>	Force protocol analog element <i>name</i> to override <i>value</i> .	2
<b>TEST DB D</b> <i>name value</i>	Force protocol digital element <i>name</i> to override <i>value</i> .	2
<b>TEST DB</b> <i>name OFF</i>	Clear (analog or digital) override for element <i>name</i> .	2
<b>TEST DB OFF</b>	Clear all analog and digital overrides.	2

The **TEST DB** command provides a method to override Device Word bits or analog values to aid testing of communications interfaces. The command overrides values in the IEC 61850 communications interface only. The actual values used by the meter for metering and control are not changed. However, remote devices may use these analog and digital signals to make control decisions. Ensure that remote devices are properly configured to receive the overridden data before using the **TEST DB** command.

### **⚠WARNING**

To reduce the chance of a false operating decision when using the **TEST DB** command, ensure that protocol master device(s) flag the data as "forced or test data." One possible method is to monitor the TESTDB Device Word bit.

To override analog data in a communications interface, enter the following from Access Level 2 or higher.

---

```
=>>TEST DB A name value <Enter>
```

---

where *value* is a numerical value and *name* is an analog label from *Table H.13–Table H.15* (IEC 61850).

For example, the **TEST DB** command can be used to force the value of Phase A current magnitude transmitted to a remote device to 100 amperes.

---

```
=>>TEST DB A IA 100 <Enter>
```

---

**NOTE:** When using the **TEST DB** command to generate values for Fast Meter testing, you may need to override all current and voltage angles (IAFA, VAFA, etc.) to ensure the expected phase relationship.

**NOTE:** When using the **TEST DB** command, specifying a negative value may yield an unexpected display in some instances.

To override digital data in an IEC 61850 communications interface, enter the following from Access Level 2 or higher.

---

```
=>>TEST DB D name value <Enter>
```

---

where *name* is a Device Word bit (see *Table G.24*) and *value* is 1 or 0.

For example, if Device Word bit SAGA = logical 0, the **TEST DB** command can be used to effectively force the communicated status of this Device Word bit to logical 1 to test the communications interface.

---

```
=>>TEST DB D SAGA 1 <Enter>
```

---

When the meter is not in Test DB Mode, the meter responds to either the digital or analog override request with the following message.

---

```
WARNING: TEST MODE is not a regular operation.  
Communication outputs of the device will be overridden by simulated values.  
  
Are you sure (Y/N)? Y <Enter>
```

---

The meter responds as follows.

---

```
Test Mode Active. Use Test DB OFF command to exit Test Mode.  
Override Added
```

---

Device Word bit TESTDB will also assert to indicate that Test DB Mode is active. If the meter is already in Test DB Mode (overrides are already active), the meter responds as follows.

---

```
Override Added
```

---

The **TEST DB** command alone displays the present status of digital and analog overrides. An example **TEST DB** response after two analogs follows.

---

```

==>TEST DB <Enter>

SEL-735                               Date: 10/15/10   Time: 16:24:38.764
STATION A

NAME          OVERRIDE VALUE
IA            100.0000
FREQ         60.0000

==>

```

---

Individual overrides are cleared using the **TEST DB** command with the OFF parameter.

---

```

==>TEST DB D or A name OFF <Enter>

```

---

Entering **TEST DB OFF** without name will clear all overrides. The meter will automatically exit Test DB Mode and clear all overrides if there are no **TEST DB** commands entered for 30 minutes.

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# Section 9

## Testing and Troubleshooting

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### Overview

---

This section provides guidelines for determining and establishing test routines for the SEL-735. Included are discussions on testing philosophies, methods, and tools. Meter self-tests and troubleshooting procedures are shown at the end of the section.

You can test the SEL-735 as you would test any digital revenue meter. The meter and test standard measure and report the same voltage, current, demand, and energy, provided you connect the meter and standard voltage elements in parallel and the current elements in series. *Figure 9.7* shows an example setup of the SEL-735, test standard, and single-phase test source. *Figure 9.1* shows an example setup of the SEL-735, test standard, and three-phase test source.

### TEST Mode Characteristics

---

During TEST mode, the meter uses the optical port and TEST LED to transmit test pulses representative of the energy register under test.

The meter performs the following actions when placed in TEST mode.

- Stops recording billing data, including energy and demand
- Stores present demand values
- Disables all KYZ outputs except for KYZDT
- Stops storing LDP data
- Asserts the TEST Device Word bit

#### Optical Test Pulse

The optical test pulses represent energy consumption and output at a rate according to the TEST Mode configuration and the electrical parameters in which the meter operates. The optical port's left-hand LED emits 850 nm infrared test pulses.

#### TEST LED

The TEST LED operates identically to the optical test pulse, except that the wavelength is slightly different. The TEST LED emits 875 nm infrared test pulses.

# Testing Philosophy

---

Revenue and power quality meter testing may be divided into three categories: acceptance, commissioning, and maintenance testing. Differentiation of the categories is according to when they take place in the life cycle of the meter as well as the test complexity.

The following subsections describe when to perform each type of test, the goals of testing at that time, and the meter functions to test at each point. This information is intended as a guideline for testing SEL meters.

## Acceptance Testing

When: Qualifying a new meter model.

Goals:

1. Ensure the meter meets published critical performance specifications, including metering accuracy.
2. Ensure that the meter meets the requirements of the intended application.
3. Gain familiarity with meter settings and capabilities.

What to Test: All elements and logic functions critical to the intended application.

SEL performs detailed acceptance testing on all meter models and versions. The meters we ship meet their published specifications. It is important for you to perform acceptance testing on a meter if you are unfamiliar with its operating theory or settings. This helps ensure the accuracy and correctness of the meter settings when you issue them.

## Commissioning Testing

When: Installing a new meter.

Goals:

1. Verify ac and dc connections.
2. Test meter functions against the settings.
3. Ensure that all auxiliary equipment operates as intended.

What to Test: All connected or monitored inputs and outputs, polarity and phase rotation of ac connections.

SEL performs a complete functional check and calibration of each meter before it ships. This helps ensure that you receive a meter that operates correctly and accurately. Commissioning tests should verify that the meter is properly connected to the power system and all auxiliary equipment.

At commissioning time, use the ACSELERATOR QuickSet HMI to perform the following functions.

- Verify proper current, voltage magnitudes, and phase rotation.
- Verify proper meter output contact operation.
- Verify proper optoisolated input operation.

## Accuracy Testing

**When:** At regularly scheduled intervals or when there is an indication of a problem with the meter or system.

**Goals:**

1. Ensure that the meter is measuring ac quantities accurately.
2. Ensure that scheme logic is functioning correctly.
3. Ensure that auxiliary equipment is functioning correctly.

**What to Test:** Anything not shown to have operated correctly within the past maintenance interval.

SEL guarantees that the SEL-735 will remain within ANSI and IEC class 0.2 accuracy limits for at least ten years.

SEL meters use extensive self-testing capabilities and feature detailed metering and event reporting functions to decrease dependence on routine maintenance testing.

Use the SEL meter reporting functions as maintenance tools. Periodically verify that the meter is making correct and accurate current and voltage measurements by comparing the meter output to other meter readings on that line. Using the event report current, voltage, and meter element data, you can determine that the meter elements are operating properly. Using the event report input and output data, you can determine that the meter is asserting outputs at the correct instants and that auxiliary equipment is operating properly. At the end of your maintenance interval, the only items that need testing are those that have not operated during the maintenance interval.

## Meter Calibration

The SEL-735 is factory-calibrated. If you suspect that the meter is out of calibration, please contact the factory.

# Testing Methods and Tools

## Test Features

The following features shown in *Table 9.1* assist in meter testing. Please see the appropriate section for further details of each test feature.

**Table 9.1 Meter Testing Features (Sheet 1 of 2)**

Feature	Function
INSTANTANEOUS Measurements	The <b>INSTANTANEOUS</b> window in the ACSELERATOR QuickSet HMI shows the ac currents and voltages (magnitude and phase angle) presented to the meter in primary values. In addition, the window shows power system frequency (FREQ). Compare these quantities against other devices of known accuracy.
EVENT Waveforms	The meter generates event reports in response to disturbances. Each report contains current and voltage information, meter element states, and input/output contact information. If you question the meter response or your test method, use the event report for more information. To retrieve event reports from ACSELERATOR QuickSet, click <b>Tools &gt; Events &gt; Get Event Files</b> . To view event reports from ACSELERATOR QuickSet, click <b>Tools &gt; Events &gt; View Event Files</b> .
SER Elements	The SER window in the ACSELERATOR QuickSet HMI shows all of the SER entries stored in the meter. The meter provides an SER entry with a time tag for changes in the meter elements and configured input/output contact states. The SER provides a convenient means to verify the pickup/dropout of any element in the meter.
TARGETS States	The <b>TARGETS</b> window in the ACSELERATOR QuickSet HMI shows all Device Word bits and their present state. Use this feature to view optoisolated input states, contact output states, and meter element states individually during a test.

**Table 9.1 Meter Testing Features (Sheet 2 of 2)**

Feature	Function
PULSE OUTPUT Contact	The Pulse Outputs section of the <b>CONTROL</b> window in the ACSELERATOR QuickSet HMI allows you to pulse output contacts for a specific time to test the contact output circuits.
KYZDT Device Word Bit	Use the KYZDT Device Word bit to assert an output or front-panel LED to visualize the infrared test pulse from the front optical port.

## Test Quantities

Table 9.2 lists the available Test Mode quantities and gives a description of each quantity. The meter tests only one of these quantities at a time. You can change the test quantity during TEST Mode; the present test resets after the change.

**Table 9.2 TEST Mode Quantities**

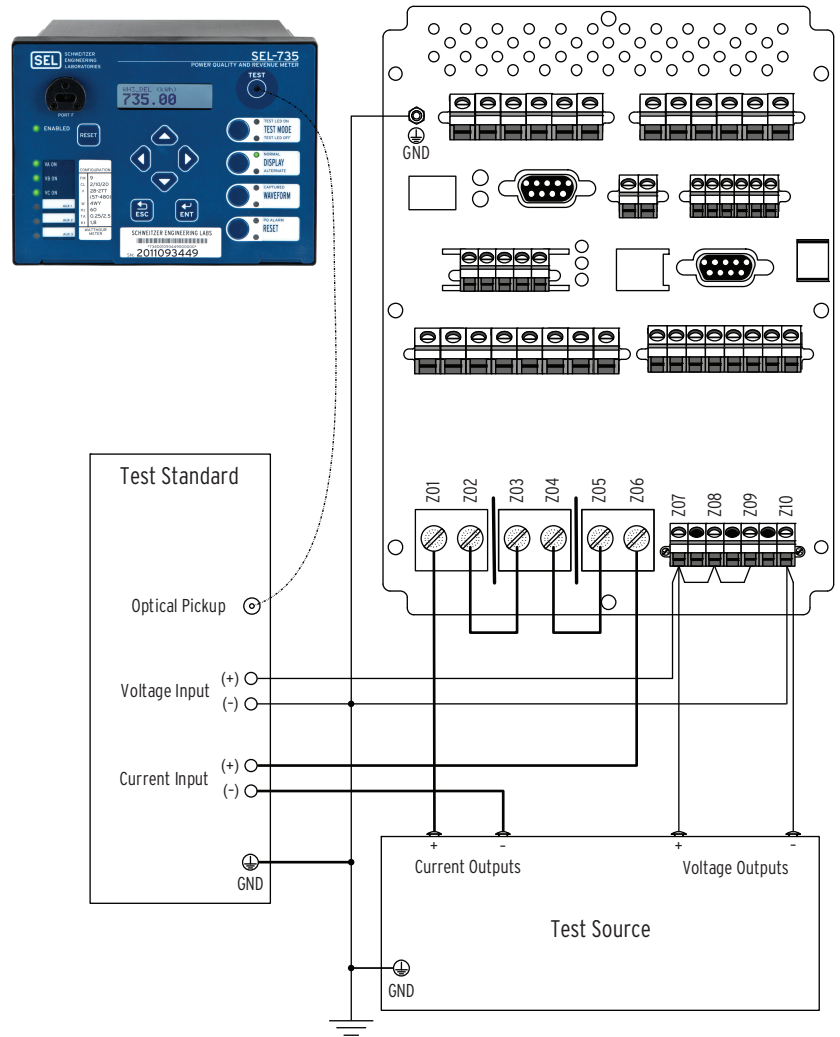
Test Mode Quantities	Analog Quantity Name	Analog Quantity Description
Three-Phase Quantities	WH3_y <sup>a</sup>	Watt-hours delivered or received
	WH3x <sup>b</sup> _NET	Watt-hours, NET
	UH3_y <sup>a</sup>	VA-hours delivered -hours delivered or received
	QH3_y <sup>a</sup>	VAR-hours delivered or received
	QH3_y <sup>a</sup> _z <sup>c</sup>	VAR-hours delivered or received and leading or lagging
	VH3	Volt-hours
	IH3	Ampere-hours
Single-Phase Quantities	WHx <sup>b</sup> _y <sup>a</sup>	Watt-hours delivered or received
	WHx <sup>b</sup> _NET	Watt-hours NET
	UHx <sup>b</sup> _y <sup>a</sup>	VA-hours delivered-hours delivered or received
	QHx <sup>b</sup> _y <sup>a</sup>	Watt-hours delivered or received
	QHx <sup>b</sup> _y <sup>a</sup> _z <sup>c</sup>	VAR-hours delivered or received and leading or lagging
	VHx <sup>b</sup>	Volt-hours
	IHx <sup>b</sup>	Ampere-hours
IHN	Neutral-phase ampere-hours	

<sup>a</sup> Replace y with DEL or REC to indicate power flow delivered or received.  
<sup>b</sup> Replace x with A, B, or C to indicate the phase.  
<sup>c</sup> Replace z with LD or LG to indicate leading or lagging power.

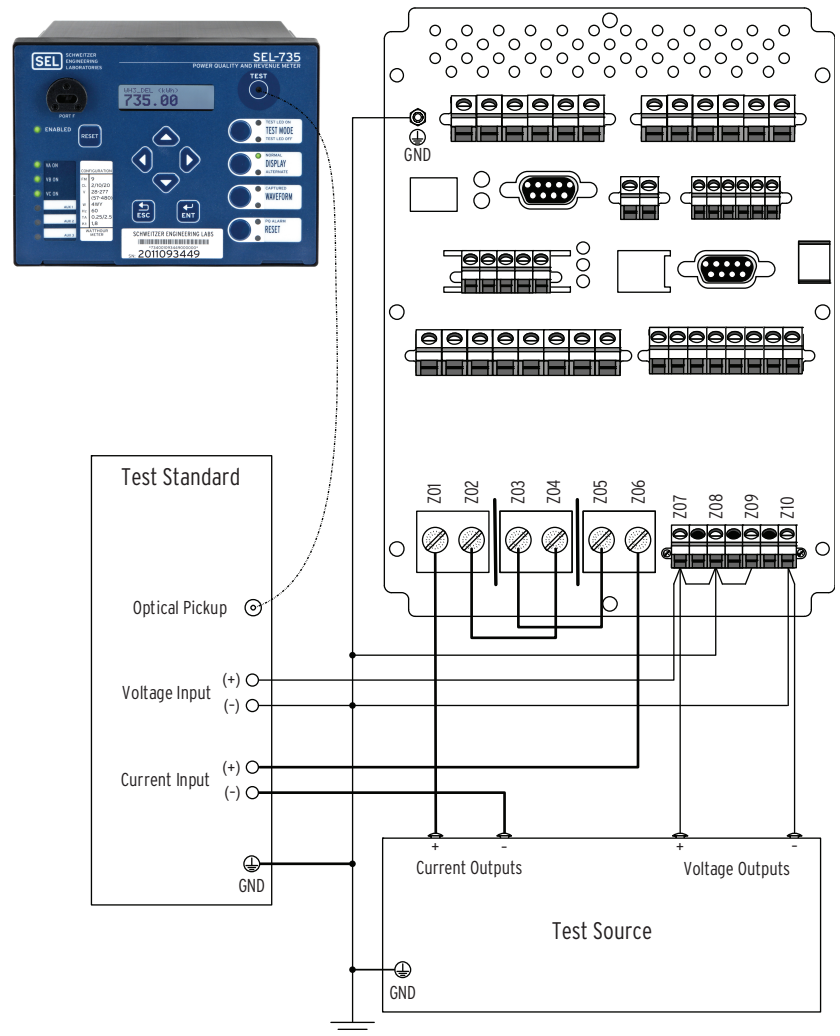
## TEST Mode Connections

Figure 9.1 shows the typical wiring diagram for Form 9 single-phase tests. Figure 9.3 shows the typical wiring diagram for Form 9 three-phase tests. To test Form 5 or Form 36 meters, connect the Z08 terminal (VB) to ground.

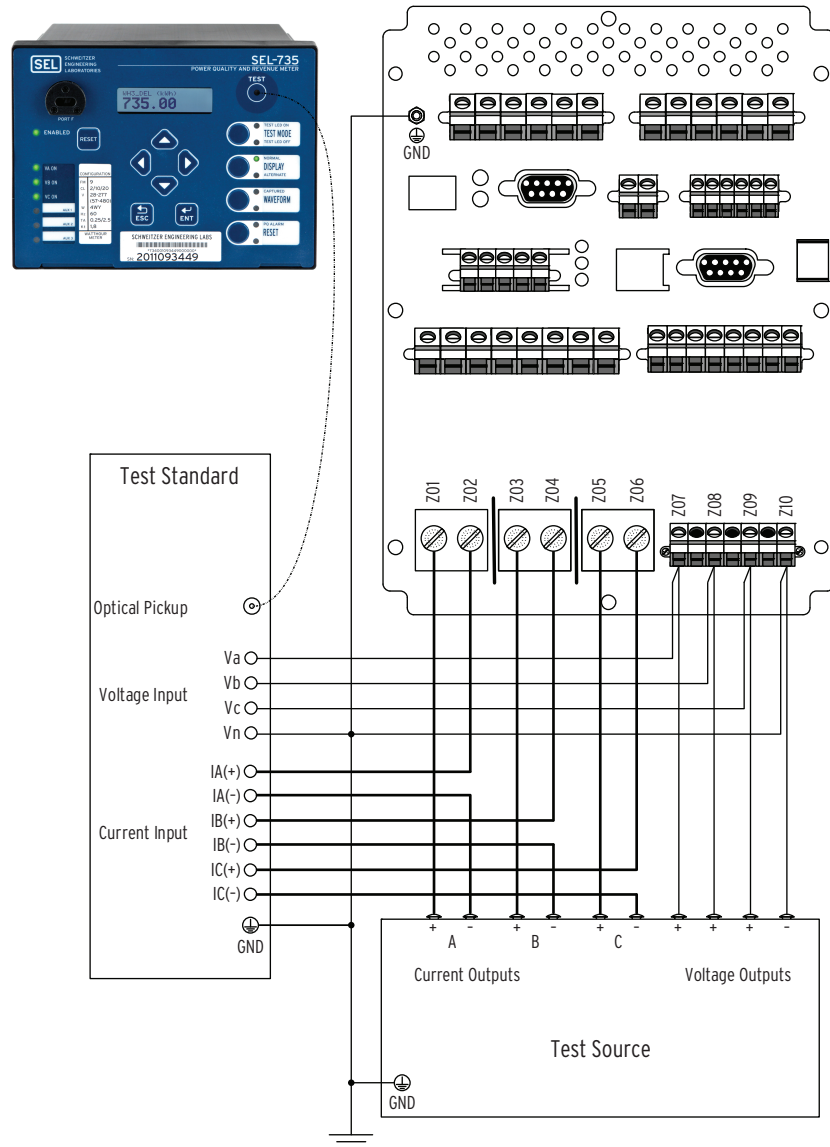
Figure 9.2 shows the typical wiring diagram for Form 36 single-phase tests. To perform single-phase testing on Form 36 meters, the test set must be setup for a 2-1/2 element meter, and the current through IB must be reversed polarity.



**Figure 9.1 Typical TEST Mode Connections for a Form 9 SEL-735 Using a Single-Phase Test Source**



**Figure 9.2 Typical TEST Mode Connections for a Form 36 SEL-735 Using a Single-Phase Test Source**



**Figure 9.3 Typical TEST Mode Connections for a Form 9 SEL-735 Using a Three-Phase Test Source**

## TEST Mode Options

After the meter is in TEST mode you can change the following TEST mode options.

- **Reset the test**

You can reset the test at any time to perform the following actions:

- Test energy accumulation resets to zero
- Front-panel time-out resets

Please see *Reset the Present Test on page 9.11* for more details.

- **Test Mode Quantity**

The active Test Mode Quantity displays on the LCD during TEST Mode. A change to this quantity resets the test but does not cause the meter to exit TEST Mode.

► **Watt-hour Constant**

The watt-hour constant KET setting determines the amount of energy each KYZ pulse represents. Enter this value in secondary units. A change to this quantity resets the test but does not cause the meter to exit TEST mode.

► **Compensation Settings**

You can turn transformer line loss compensation (TLLC) on or off while in TEST Mode. The meter uses the TLLC settings you configured previously in performing compensation calculations. The meter restores the original TLLC settings when you exit TEST mode. Please see the *Transformer/Line Loss Compensation on page 5.45* for more details. A change to this quantity resets the test but does not cause the meter to exit TEST mode.

► **Gain Settings (not available in the ACSELERATOR QuickSet HMI)**

You can adjust the watt and VAR Gain settings while in TEST mode. The meter saves the new watt and VAR gain settings permanently, even after the meter exits TEST Mode. A change to this quantity resets the test but does not cause the meter to exit TEST Mode.

Table 9.3 summarizes the TEST Mode options available during TEST Mode.

**Table 9.3 TEST Mode Options**

TEST Mode Option	Option Description
Select Test Quantity	Select the energy analog quantity you want to test
Watt-hour Constant	Adjust the pulse constant
Compensation Setting	Toggle transformer and line loss compensation on or off
Gain Settings	Adjust watt and VAR gain

## TEST Mode Operations

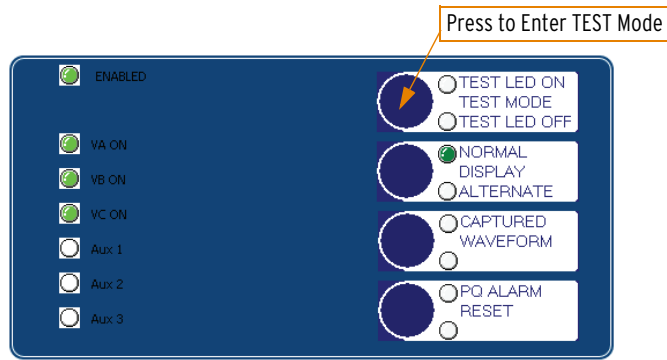
This section explains how to control the various TEST mode options.

### Enter TEST Mode

Use the control pushbuttons, ACSELERATOR QuickSet HMI, the front-panel pushbuttons, or a terminal prompt to enter TEST Mode. Use one of the following three communications methods to enter TEST Mode.

#### Control Pushbuttons

1. If the default pushbutton controls are set (PBDFLT = Y), then press the TEST Mode control pushbutton **PB01** shown in *Figure 9.4*.
2. If prompted, enter a valid 2AC level password.



**Figure 9.4 TEST Mode Control Pushbutton**

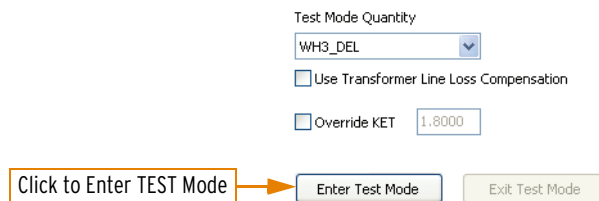
If the default pushbutton controls are set then the **TEST LED OFF** illuminates when the meter first enters **TEST** mode. The **TEST LED ON** and **TEST LED OFF** indications alternate states as the **TEST** pulse turns on and off.

### ACSELERATOR QuickSet HMI

1. Open the ACSELERATOR QuickSet HMI and ensure successful communications to the device.
2. Navigate to the Test Mode window.
3. Select the Test Mode Quantity you want to test.
4. Depending on your preference, either check or uncheck the **Use Transformer Line Loss Compensation** box.
5. Depending on your preference, either check or uncheck the **Override KET** box.

If you check this, then enter in the HMI the KET value you want. The device uses the KET value you entered from the HMI and enters **TEST** Mode. The meter does not save the KET value the next time you enter **TEST** Mode.

6. Click the **Enter Test Mode** button.



SEL-735 is in normal operation

**Figure 9.5 TEST Mode HMI**

*Figure 9.6* shows the HMI display from the Test Mode window. The HMI displays a representation of the front-panel optical port, which illuminates the left-hand infrared LED for the **TEST** pulse.

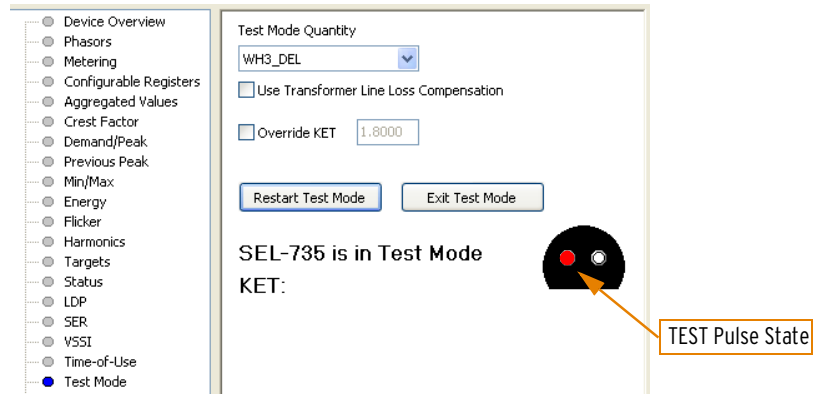


Figure 9.6 ACSELERATOR QuickSet HMI TEST Mode Display

### Front-Panel Menu Buttons

**NOTE:** You must first exit any serial port TEST Mode session in progress before you can access the SEL-735 front panel.

1. Press the ENT button.
2. Activate the TEST Mode option.
3. Press the ENT button.
4. If prompted, enter a valid 2AC password.

If the front-panel control pushbuttons are set to default values, then the TEST LED OFF illuminates. The TEST LED ON and TEST LED OFF indications will alternate states as the TEST pulse turns on and off.

### Terminal Prompt

You can access and control TEST Mode on any rear-panel serial port via a terminal prompt (i.e., HyperTerminal®) that uses ASCII commands to communicate with the meter.

Perform the following steps below to enter Test Mode via a terminal prompt.

1. Open a terminal prompt and connect to any rear-panel serial port.
2. Log on to the 2AC access level.
3. Enter the **TEST MODE** command according to the following syntax:

```
=>>TEST MODE<name>[TLLC]
```

where:

<name> is any valid Test Mode Quantity from Table 9.2.

If you include [TLLC] then the meter uses transformer/line loss compensation while in TEST mode.

### Exit TEST Mode

Use the ACSELERATOR QuickSet HMI, the Esc key, or a terminal prompt to exit TEST Mode. The meter restores all normal metering functions when it exits TEST Mode. Use one of the following three communications methods to exit TEST Mode.

#### ACSELERATOR HMI

Click the Exit TEST Mode button.

**NOTE:** This option is only available if you entered TEST mode via the ACSELERATOR QuickSet HMI.

## Front-Panel Menu Buttons

Press the **ESC** button twice.

**NOTE:** This option is only available if you entered TEST Mode via the ACSELERATOR QuickSet HMI.

## Terminal Prompt

Enter the **TEST MODE OFF** command at the terminal prompt.

In addition to the above options for exiting TEST Mode, the meter automatically exits TEST Mode if any of the following occur:

- The front-panel time-out expires.
- The meter loses power.
- The communications port you use to enter TEST Mode settings changes.
- The communications port you use to enter TEST Mode times out.

## Reset the Present Test

You can reset the test at any time, which resets the present test energy. Use this feature to synchronize the timing of the meter and standard. For example, press and release **RESET** and start the standard at approximately the same time. Use one of the following three communications methods to reset the present test.

## ACSELERATOR QuickSet HMI

Click the **Restart TEST Mode** button.

**NOTE:** This option is only available if you entered TEST mode via the ACSELERATOR QuickSet HMI.

## Front-Panel Menu Buttons

Press the **RESET** button.

## Terminal Prompt

Enter the **TEST MODE** command from the communications port on which you entered TEST Mode as *Enter TEST Mode on page 9.8* explains.

## Device Word Bits

You can view the state of each Device Word bit to facilitate meter testing. Device Word bit information is available through the front panel, a terminal prompt, and the ACSELERATOR QuickSet HMI. Please apply the following guidelines to use Device Word bits in your testing.

## Via Front Panel

Display the state of Device Word bits by using the front-panel LCD Targets. Use the following steps to access the front-panel targets.

1. Press **ENT**.
2. Highlight **Targets** and press **ENT**.

The LCD displays the Device Word bits status by row number. See *Appendix G: Analog Quantities and Device Word Bits* for a list of Device Word bits.

## Via Terminal Prompt

Display the state of all Device Word bits via a terminal prompt command. The command shows the state of one row of Device Word bits. Use the following steps to view the Device Word bit states.

- Step 1. Open a terminal window and establish an SEL protocol connection to the meter.
- Step 2. Log on to the ACC access level or higher.
- Step 3. Enter the command **TAR [name]**.

**NOTE:** You can also enter the command as **TAR [row number]**, where [row number] is the Device Word bit row number.

Where [name] is the Device Word bit name. If you omit the name, the meter displays Device Word bit row number zero. See *Appendix G: Analog Quantities and Device Word Bits* for a list of Device Word names bits and their row numbers.

As an example, to view the KYZD1 Device Word bit, issue the **TAR KYZD1** command. The meter displays the state of all Device Word bits in the same row as KYZD1.

## Via ACSELERATOR QuickSet HMI

The ACSELERATOR QuickSet HMI continuously polls the meter for the most recent Device Word bit states. Perform the following steps to view Device Word bits from the ACSELERATOR QuickSet HMI.

- Step 1. Connect the ACSELERATOR QuickSet HMI to the meter.
- Step 2. Click on **Targets**.
- Step 3. View the desired Device Word bit state.

## Output Contacts

You can use the meter solid-state output contacts for meter testing. You must use solid-state contacts for meter testing to ensure fulfillment of the required timing and accuracy requirements.

Figure 9.7 shows the solid-state outputs contacts OUT401–OUT404, each with configured for different applications. See below for explanations of the different applications.

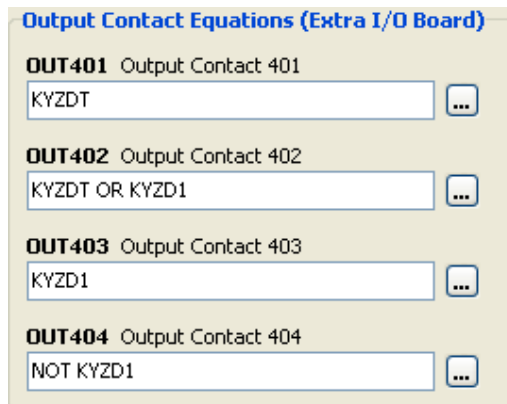


Figure 9.7 Solid-State Output Contact KYZ Options

## Form A Test Pulse Output

Figure 9.7 shows OUT401 configured as a Form A test pulse output contact. With the meter in TEST Mode, the output contact pulses according to the state of the KYZDT Device Word bit.

## Form A Test Pulse or KYZ Pulse Output

**NOTE:** If you use this configuration for calibration testing, you can only configure the test pulse with one other KYZ pulse. For example, the setting OUT402 := KYZT OR KYZD1 OR KYZD2 is invalid for calibration testing.

Figure 9.7 shows OUT402 configured as a Form A test pulse or KYZ pulse output contact. With the meter in TEST Mode, the output contact pulses according to the state of the KYZDT Device Word bit. With the meter not in TEST mode, the output contact pulses according to the state of the KYZD1 Device Word bit.

## Form A KYZ Pulse Output and Form C KYZ Pulse Output

Figure 9.7 shows OUT403 configured as a Form A KYZ pulse output contact. With the meter in TEST Mode, the output contact pulses according to the state of the KYZD1 Device Word bit.

Figure 9.7 shows OUT404 configured as a Form A KYZ pulse output contact in the state opposite to that of as OUT403. Use OUT403 and OUT404 together to create a Form C pulse output contact. With the meter not in TEST mode, OUT403 and OUT404 pulse according to the state of the KYZD1 Device Word bit, but the state of OUT403 is always opposite to the state of OUT404.

## Sequential Events Recorder

You can set the meter to generate an entry in the SER for testing meter elements. You can then compare the time stamps of the SER elements to other meter elements to verify timing between elements. See *Section 6: Logging* for more details on the SER.

For example, to test the first KYZ element, make the following setting.

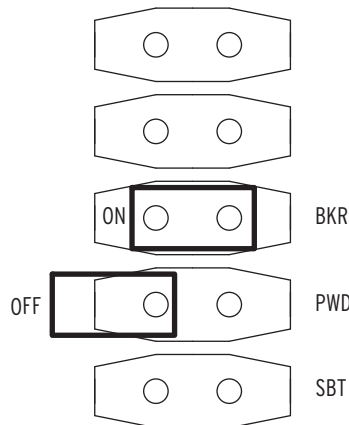
SER1 = **KYZD1**

The Device Word bit KYZD1 pulses when there is load on the meter (assuming you have setup KYZD1). The meter adds an SER record each time KYZD1 asserts and deasserts.

## Main Board Jumpers

The main CPU board located in Slot B of the meter contains jumpers that affect the meter passwords, the output contact operation, and the SELBOOT mode.

Figure 9.8 shows a graphic of the jumpers located on the CPU board:



**Figure 9.8 Jumper Header—Password and Breaker Jumpers**

Table 9.4 lists each of the jumpers and the default position of each.

**Table 9.4 Main Board Jumpers**

Jumper	Default Jumper Position	Function
N/A	OFF	N/A
N/A	OFF	N/A
BKR	ON	Breaker jumper
PWD	OFF	Password override
SBT	OFF	SELBOOT

### Breaker Jumper, BKR (installed by default)

This jumper is installed by default. The jumper enables or disables all of the output contacts. Install the jumper to enable the output contacts and remove the jumper to disable all of the output contacts.

### Password Jumper, PWD (not installed by default)

If you wish to disable password protection for all access levels, you can install the PWD jumper. When the jumper is installed, the meter grants users access to all access levels (ACC, EAC, 2AC, and CAL) without having to enter a password.

### SELBoot Jumper, SBT (not installed by default)

This jumper forces the meter into SELBOOT mode. SELBOOT mode is used mainly for troubleshooting and when loading new firmware to the device; it should not be required for normal operations. When the meter is in SELBOOT, all metering functions stop operating. From SELBOOT, you may erase and send firmware, change the baud rate of the port, display the Firmware Identifier version and the SELBOOT version. Please see the *Command Summary on page 8.12* for a list of commands available from SELBOOT.

## Gain Adjustment

To ensure that the SEL-735 meets ANSI Accuracy Class 0.2, SEL precisely calibrates each meter before it ships. A calibration report accompanying each meter details the measured error throughout a variety of operating conditions. Some customers require the ability to adjust or compensate for any error their test standard measures. The SEL-735 supports this requirement through the gain adjustment feature that scales power and energy values.

Use the WGAIN and VARGAIN settings to adjust watts and VARs. Through these adjustments, you can compensate for any measured error during an accuracy test. *Equation 9.1* shows the calculation the SEL-735 performs with the gain adjustment settings.

$$X_{\text{Adjusted}} = X_{\text{Measured}} \cdot \left( 1 + \frac{\text{Adjustment}}{100} \right) \quad \text{Equation 9.1}$$

where:

X = either watts or VARs

Adjustment = the WGAIN or VARGAIN setting value

To determine the necessary gain adjustment settings, perform a watt-hour and VAR-hour accuracy test (see *Testing Methods and Tools on page 9.3*). Record the results from the accuracy test, and modify the WGAIN and VARGAIN settings to compensate for any error.

**EXAMPLE 9.1 Set WGAIN to Compensate for a Known Accuracy Error**

Step 1. TEST Mode

Follow the TEST mode instructions and your test standards instruction manual. Connect the ac test source, test standard, and meter as shown in Figure 9.1 or Figure 9.3.

Program the Ke into the test standard to match the KET setting of the meter. For this example, we will use 1.8 Wh/pulse. Set the number of test pulses for the test standard to accumulate to 10.

$$10 \text{ pulses} \cdot 1.8 \text{ Wh/pulse} = 18 \text{ Wh}$$

Run the test at 2.5 A.

Step 2. Calculate the error.

Some test standards calculate and display the percent error for the user. If your test standard does not calculate and display the error, it will use the Wh/pulse setting and number of pulses to determine how much energy the meter registered during the test period. It then compares value to the energy that the standard registered during the same period. These values help determine the percent registration of the meter.

$$\text{Watt-hours registered by the meter} = 18.0000 \text{ Wh}$$

$$\text{Watt-hours registered by the standard} = 18.0108 \text{ Wh}$$

We assume the test standard is accurate. The meter communicates that it has registered 18.0000 Wh when sending the tenth pulse to the standard. The standard has recorded 18.0108 Wh during this same period. Therefore, the meter is running slowly because the meter accumulated less energy than the standard. Use Equation 9.2 to calculate the percent error between the meter and the standard:

$$\begin{aligned} \% \text{ERROR} &= \left( \frac{\text{Wh}_{\text{meter}}}{\text{Wh}_{\text{standard}}} \right) \cdot 100 \\ &= \left( \frac{18.0000}{18.0108} \right) \cdot 100 \\ &= 99.94\% \end{aligned} \tag{Equation 9.2}$$

Step 3. Set the gain adjustment as necessary.

To calculate the WGAIN setting and “zero-out” the meter to this test standard, subtract the percent error from 100 to determine the setting.

$$100 - \% \text{ ERROR} = 100 - 99.94 = +0.06\%$$

Enter this value into the WGAIN setting. This will accelerate the accumulation of real energy by 0.06%.

---

Watt Gain %(-10.00-10)	WGAIN := 0.00	? .06
------------------------	---------------	-------

---

**NOTE:** The gain adjustment is not intended to calibrate the meter. It is intended to supplement the factory calibration for specific purpose(s) as the end user deems appropriate. If you suspect your meter is out of calibration, please contact the factory.

Step 4. Verify the new gain adjustment setting by testing the meter at the following points:

- a. 5 A or greater
- b. 0.25 to 0.5 A

The readings at these points should be consistent with the gain values settings. For example, if you perform the test at 2.5 A, resulting in a +0.06% error, test at 0.5 A and 5.0 A to verify consistency of the watt-hour error at these points.

Determination of the VARGAIN setting is by the same method as the WGAIN setting.

The end user takes responsibility for applying these settings for appropriate reasons. Users should verify that any changes to WGAIN and VARGAIN return results they would expect under actual metering conditions.

## Meter Self-Tests

The meter runs a variety of self-tests and reports the following notices for out-of-tolerance conditions (see *Table 9.5*):

- HALARM Assertion: The meter asserts the HALARM bit, which you can map to an output contact. Alarm condition signaling can be a single five-second pulse (Pulsed) or permanent (Latched).
- Automatic status reports at the ACSELERATOR QuickSet HMI.
- Failure messages on the meter LCD display for failures.

Use the ACSELERATOR QuickSet HMI Status window or front-panel STATUS menu to view meter self-test status.

**Table 9.5 Meter Self-Tests** (Sheet 1 of 2)

Self-Test	Condition	Limits	Meter Disabled	Alarm Output	Description
IA, IB, IC, IN, VA, VB, VC Offset	Warning	±50 mV	No	Pulsed	Measures the dc offset at each of the input channels every 10 seconds
-5 V PS	Failure	-3.5 V -6.5 V	Yes	Latched	-5 V power supply
+0.9 V PS	Failure	+1.01 V +0.79 V	Yes	Latched	+0.9 V power supply
+1.2 V PS	Failure	+1.32 V +1.08 V	Yes	Latched	+1.2 V power supply
+1.5 V PS	Failure	+1.65 V +1.35 V	Yes	Latched	+1.5 V power supply
+1.8 V PS	Failure	+1.98 V +1.62 V	Yes	Latched	+1.8 V power supply
+2.5 V PS	Failure	+2.75 V +2.25 V	Yes	Latched	+2.5 V power supply
+3.3 V PS	Failure	+3.63 V +2.97 V	Yes	Latched	+3.3 V power supply
+5 V PS	Failure	+5.75 V +4.25 V	Yes	Latched	+5 V power supply
BATT	Warning	+2.3 V	No	Pulse	Measures the clock battery voltage
TEMP	None	-40°C +85°C	No		Main board temperature for display only. No warnings or alarms are associated.
External RAM	Failure	—	Yes	Latched	Read/write test on external RAM

**Table 9.5 Meter Self-Tests (Sheet 2 of 2)**

Self-Test	Condition	Limits	Meter Disabled	Alarm Output	Description
Critical RAM SELOGIC® Executable	Failure	Checksum	Yes	Latched	Read/write test on SELOGIC executable RAM
Critical RAM Setting	Failure	Checksum	Yes	Latched	Read/write test on settings RAM
Critical RAM Code	Failure	Checksum	Yes <sup>a</sup>	Latched	Read/write test on code RAM
ROM	Failure	Checksum	Yes	Latched	Checksum test on the meter program
NONVOL	Failure	Checksum	Yes	Latched	Checksum test on the nonvolatile memory
Dedicated circuitry in the microprocessor and the SEL-735 main board perform the following self-tests. Failures in these tests shut down the microprocessor and do not appear in the status report.					
Microprocessor	Failure		Yes	Latched	The microprocessor examines each program instruction, memory access, and interrupt. The meter displays VECTOR nn on the LCD upon detection of an invalid instruction, memory access, or spurious interrupt. The test runs continuously.

<sup>a</sup> The meter stores program RAM failures into nonvolatile memory. A fourth program RAM failure occurring in the last 24 hours disables the device. If the device cycles power or resets, then the device erases the RAM failures recorded in nonvolatile memory.

## Meter Troubleshooting

### Inspection Procedure

Complete the following procedure before disturbing the meter. After you finish the inspection, proceed to *Troubleshooting*.

- Step 1. Measure and record the power supply voltage at the power input terminals.
- Step 2. Check to see that the power is on. Do not turn the meter off.
- Step 3. Measure and record the voltage at all control inputs.
- Step 4. Measure and record the state of all outputs.

### Troubleshooting

#### All Front-Panel LEDs Dark

The following conditions cause the meter front-panel LEDs to turn off.

- Input power not present or power supply fuse is blown.
- Self-test failure asserted.
- Meter is in SELBOOT.

#### Cannot See Characters on LCD

The following conditions cause LCD characters to not display.

- Meter is de-energized. Check to see if the HALARM contact is closed.
- LCD contrast is out of adjustment. Use the steps below to adjust the contrast.
  - a. Press the ESC pushbutton for 5 seconds.
  - b. The meter should turn on LCD contrast display bar.

- c. Use the **LEFT ARROW** and **RIGHT ARROW** pushbuttons to adjust the contrast.
- d. Press the **ESC** pushbutton twice to return to normal operation.

## Meter Does Not Respond to Serial Commands

The following conditions cause serial communications to stop.

- Communications device not connected to meter.
- Meter or communications device at incorrect baud rate or other communications parameter incompatibility, including cabling error.
- Meter serial port has received an XOFF, halting communications. Type **<Ctrl+Q>** to send meter an XON and restart communications.

## Information Lost During Power Cycle

The meter stores some data in volatile memory instead of nonvolatile memory. Loss of meter power erases volatile memory, causing certain meter elements to change. The following actions occur when meter power turns on and off.

- SELOGIC values, including timers and math variables, are lost. All values reset to zero when power returns.
- Remote bits deassert. Remote bits return to the OFF position when power returns.
- Contact outputs default to their nonenergized state. Outputs return to their energized state upon restoration of power.
- The meter loses as much as one minute of energy register data.
- The present peak-demand data value restart at zero.

# Factory Assistance

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We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

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Fax: +1.509.332.7990  
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E-mail: [info@selinc.com](mailto:info@selinc.com)

# Appendix A

## Firmware and Manual Versions

### Firmware

#### Determining the Firmware Version in Your Meter

To find the firmware version number in your SEL-735, view the status report through use of the serial port **STAT** command or the front-panel **STATUS** pushbutton.

The firmware revision number is after the R, and the release date is after the D. For example, the following is firmware revision number 100, release date June 28, 2011.

FID=SEL-735-R100-V0-Z001001-D20110628

*Table A.1* lists the firmware, a description of modifications, and the instruction manual date code that corresponds to firmware versions. The most recent firmware version is listed first.

**Table A.1 Firmware Revision History (Sheet 1 of 3)**

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-735-R111-V0-Z006004-D20141107	<ul style="list-style-type: none"> <li>➤ In Firmware revisions R107 to R110, the current and power measurements fluctuate when the Enable ITC for Current (EITCI) setting is enabled and 0.5 A is applied to the CL2/20/20 meter or 2.5 A is applied to the CL10/20 meter. Now, current and power measurements do not fluctuate under those conditions.</li> <li>➤ In Firmware revisions R107 to R110, Instrument Transformer Compensation settings were not applied to real power and real energy quantities when currents below 0.5 A were applied to the CL2/CL10/CL20 meter or currents below 2.5 A were applied to the CL10/CL20 meter. Firmware now applies Instrumentation Transformer Compensation settings to rms quantities across the published current range.</li> </ul>	20141107
SEL-735-R110-V0-Z006004-D20140507	<ul style="list-style-type: none"> <li>➤ Modified the starting current behavior and added the Starting Current Threshold (IST) and Starting Current Type (IST_TYPE) settings. Previously, the meter zeroed the current registration when the RMS current magnitude was less than a fixed threshold.</li> <li>➤ Modified the fiber Ethernet link LED behavior to be consistent with copper Ethernet ports. Previously, the green link LED located next to the fiber Ethernet ports did not flash to indicate Rx/Tx activity. The LED remained on.</li> <li>➤ Modified the port power behavior and added the Enable Port Power setting. Previously, EIA-232 ports always supplied +5 V power from Pin 1.</li> </ul>	20140507
SEL-735-R109-V0-Z005004-D20131015	<ul style="list-style-type: none"> <li>➤ Manual update only (see <i>Table A.2</i>).</li> </ul>	20140313

**Table A.1 Firmware Revision History (Sheet 2 of 3)**

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-735-R109-V0-Z005004-D20131015	<ul style="list-style-type: none"> <li>➤ Corrected an issue where a serial port that was in an XOFF state would not time out.</li> <li>➤ Increased the accuracy of energy data reported over DNP when configured to report more than two decimal places.</li> <li>➤ Increased the accuracy of the energy and demand data stored in Load Profile Recorders (LDP) 2–12.</li> <li>➤ Added functionality to ensure that the meter operates properly when users connect a serial cable that short circuits Pin 1 of the EIA-232 ports to ground.</li> <li>➤ Added Form 36 (2-1/2 element) metrology.</li> <li>➤ Corrected the Voltage Sag/Swell/Interruption (VSSI) initialization voltage threshold.</li> <li>➤ Corrected a potential issue where issuing the <b>MET A</b> command might cause the meter communications port to stop responding to some commands.</li> <li>➤ Corrected an issue that caused the KYZ pulses to use compensated energy quantities when uncompensated quantities were selected.</li> <li>➤ Corrected an issue that caused the meter to reject some valid display point settings.</li> <li>➤ Corrected an issue where the meter diagnostics reported <code>OFFSET WARN</code> on VA, VB, VC, and VN when the meter was starting up.</li> <li>➤ Improved the ease of use of the TPORT setting on the meter HMI.</li> <li>➤ Corrected an issue that could cause the energy data stored in Load Profile Recorders (LDP) 2–12 to truncate the most significant digit when the recorder is set to Change Over Interval (COI).</li> <li>➤ Corrected an issue where the last row of a Voltage Sag/Swell/Interruption (VSSI) event was not written to nonvolatile memory in a timely manner. This last row did not affect the VSSI summary, since it contains data from after the VSSI event concludes.</li> </ul>	20131015
SEL-735-R108-V0-Z004003-D20130906	<ul style="list-style-type: none"> <li>➤ Corrected an issue that prevented the meter from accepting FTP file writes. This only occurs after the user cancels an FTP read of the SET_ALL.TXT file.</li> </ul>	20130906

**Table A.1 Firmware Revision History (Sheet 3 of 3)**

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-735-R107-V0-Z004003-D20130701 <b>Note:</b> Firmware revision R106 did not production release.	<ul style="list-style-type: none"> <li>➤ Added gratuitous Address Resolution Protocol (ARP) messages to network communications.</li> <li>➤ Corrected a DNP LAN/WAN issue which caused the meter to transmit values of zero in response to a single poll from the DNP server.</li> <li>➤ Added IEC 61850 protocol with MMS Reporting and GOOSE.</li> <li>➤ Added File Transfer Protocol (FTP).</li> <li>➤ Added TCP Keep-Alive settings.</li> <li>➤ Added Simple Network Time Protocol (SNTP).</li> <li>➤ Added Instrument Transformer Compensation (ITC).</li> <li>➤ Added active and reactive uncompensated analog quantities.</li> <li>➤ Corrected an issue where the meter reported zero fundamental-only reactive power when the power angle was less than 1 degree.</li> <li>➤ Corrected the dynamic base voltage feature where the meter reported incorrect Voltage Sag/Swell/Interruption data.</li> <li>➤ Changed the factory-default display point formatting.</li> <li>➤ Corrected an issue where sending design templates to the device at 9600 baud would fail.</li> <li>➤ Corrected an issue where the meter disabled and reported NONVOL FAIL because of temporary nonvolatile memory issues.</li> <li>➤ Added virtual bits VB001–VB128.</li> <li>➤ Corrected an issue where the SER Power Loss entries were not in chronological order with other SER entries.</li> <li>➤ Corrected an issue where upgrading from firmware version R100 or R104 could cause the user-defined Configurable Registers to report zero on all external interfaces.</li> <li>➤ Corrected an issue that could be encountered while sending a file via YMODEM.</li> </ul>	20130701
SEL-735-R105-V0-Z003002-D20130228	➤ Manual update only (see <i>Table A.2</i> ).	20130515
SEL-735-R105-V0-Z003002-D20130228	<ul style="list-style-type: none"> <li>➤ Corrected issues with time-of-use and Daylight Saving Time functions.</li> <li>➤ Added fundamental-only power values updated every 1/2 cycle.</li> <li>➤ Added support for single-mode fiber-optic port.</li> </ul>	20130228
SEL-735-R104-V0-Z002002-D20121005	➤ Corrected behavior of KYZ settings with respect to forcing output contact settings.	20121005
SEL-735-R103-V0-Z002002-D20120608	<ul style="list-style-type: none"> <li>➤ The length of unfiltered event reports is now two cycles more than the LER setting.</li> <li>➤ The maximum pre-fault duration in unfiltered event reports is now two cycles more than the PRE setting.</li> <li>➤ Improved VSSI logic to detect immediate transitions between Interrupts and Swells.</li> <li>➤ Corrected power calculations for Form 5 single-phase testing.</li> <li>➤ Corrected filtered event report scaling for Form 5 meters.</li> <li>➤ Corrected SELOGIC Variable Timer accuracy.</li> <li>➤ Modified COMTRADE CFG files to represent variable sampling rate.</li> </ul>	20120608
SEL-735-R102-V0-Z002002-D20111111	➤ Manual update only (see <i>Table A.2</i> ).	20120319
SEL-735-R102-V0-Z002002-D20111111	➤ Changed three-phase energy calculation. Addresses three-phase energy accumulation when power flows in opposite directions on different phases.	20111111
SEL-735-R101-V0-Z002002-D20110818	<ul style="list-style-type: none"> <li>➤ Added option for front-panel EIA-232 serial port.</li> <li>➤ Added option for 100 A fault recording.</li> </ul>	20110818
SEL-735-R100-V0-Z001001-D20110628	➤ Initial version.	20110628

# Instruction Manual

The date code at the bottom of each page of this manual reflects the creation or revision date.

*Table A.2* lists the instruction manual release dates and a description of modifications. The most recent instruction manual revisions are listed at the top.

**Table A.2 Instruction Manual Revision History (Sheet 1 of 3)**

Revision Date	Summary of Revisions
20141107	<b>Appendix A</b> ► Updated for firmware version R111.
20140507	<b>Section 1</b> ► Updated <i>SEL-735 Meter Forms and Models</i> section. ► Updated <i>Specifications</i> section. <b>Section 3</b> ► Added explanation of number of characters per line displayed by the LCD. <b>Settings Sheets</b> ► Added settings IST and IST_TYPE to <i>Advanced Global Settings</i> . ► Added setting EPP to <i>Communications Settings</i> . <b>Section 5</b> ► Added command syntax of <b>FORM</b> command in <i>Form Factor Support</i> . ► Added <i>Starting Current</i> section. <b>Section 8</b> ► Changed description of green LED in <i>Table 8.6: Ethernet Port LED Description</i> . <b>Appendix A</b> ► Updated for firmware version R110. <b>Command Summary</b> ► Added <b>MET D</b> , <b>MET D P</b> , <b>MET D P U</b> , <b>MET D T</b> , <b>MET D T U</b> , and <b>MET D U</b> commands.
20140313	<b>Section 1</b> ► Updated <i>Specifications</i> section.
20131015	<b>Section 1</b> ► Updated for Form 36 Metering. <b>Section 5</b> ► Added Form 36 Metering. <b>Appendix A</b> ► Updated for firmware version R109.
20130906	<b>Appendix A</b> ► Updated for firmware version R108.
20130701	<b>Section 5</b> ► Added <i>Instrument Transformer Compensation</i> . ► Updated <i>Transformer/Line Loss Compensation</i> . <b>Section 8</b> ► Added <i>FTP</i> and <i>MMS</i> . ► Added <i>Command Explanations</i> . <b>Appendix A</b> ► Updated for firmware version R107.

**Table A.2 Instruction Manual Revision History (Sheet 2 of 3)**

Revision Date	Summary of Revisions
	<p><b>Appendix G</b></p> <ul style="list-style-type: none"> <li>➤ Added new Uncompensated Analog Quantities.</li> </ul> <p><b>Appendix H</b></p> <ul style="list-style-type: none"> <li>➤ Added <i>Appendix H: 61850 Communications</i>.</li> </ul>
20130515	<p><b>Section 1</b></p> <ul style="list-style-type: none"> <li>➤ Updated <i>Specifications</i> for single-mode fiber-optic support.</li> </ul> <p><b>Section 5</b></p> <ul style="list-style-type: none"> <li>➤ Corrected transformer line-loss compensation equations.</li> </ul> <p><b>Section 8</b></p> <ul style="list-style-type: none"> <li>➤ Updated <i>Table 8.1: Meter Models and Available Main Board Communications Options</i> for single-mode fiber-optic support.</li> </ul>
20130228	<p><b>Section 5</b></p> <ul style="list-style-type: none"> <li>➤ Corrected <i>Demand Metering</i> explanation.</li> </ul> <p><b>Section 8</b></p> <ul style="list-style-type: none"> <li>➤ Corrected <i>SEL-735 Command Summary</i>.</li> </ul> <p><b>Appendix A</b></p> <ul style="list-style-type: none"> <li>➤ Updated for firmware version R105.</li> </ul> <p><b>Appendix G</b></p> <ul style="list-style-type: none"> <li>➤ Revised <i>Table G.1: Analog Quantities Available to Internal Interface Types</i> and analog quantities.</li> </ul>
20121005	<p><b>Section 1</b></p> <ul style="list-style-type: none"> <li>➤ Updated <i>Output Contacts Pickup/Dropout Time</i> in <i>Specifications</i>.</li> </ul> <p><b>Section 5</b></p> <ul style="list-style-type: none"> <li>➤ Added <i>Neutral Current</i>.</li> </ul> <p><b>Appendix A</b></p> <ul style="list-style-type: none"> <li>➤ Updated for firmware version R104.</li> </ul>
20120608	<p><b>Appendix A</b></p> <ul style="list-style-type: none"> <li>➤ Updated for firmware version R103.</li> </ul>
20120319	<p><b>Section 1</b></p> <ul style="list-style-type: none"> <li>➤ Updated <i>Table 1.2: SEL-735 Feature Availability</i>.</li> <li>➤ Updated <i>Figure 1.2: SEL-735 Inputs, Outputs, and Communications Ports</i>.</li> <li>➤ Added <i>Fiber-Optic Ethernet Port</i> in <i>Specifications</i>.</li> </ul> <p><b>Section 2</b></p> <ul style="list-style-type: none"> <li>➤ Updated <i>Figure 2.6: Four-Wire Wye and Three-Wire Delta Wiring Diagrams</i>.</li> <li>➤ Updated <i>Table 2.4: Default SEL-735 Settings and Required ACSELEATOR QuickSet Communications Parameters</i>.</li> </ul> <p><b>Section 3</b></p> <ul style="list-style-type: none"> <li>➤ Use of Configurable Registers in Display Points added in <i>Display Points</i>.</li> </ul> <p><b>Settings</b></p> <ul style="list-style-type: none"> <li>➤ Added <i>Table SET.2</i> and introductory text in <i>Communications Settings</i>.</li> </ul> <p><b>Section 5</b></p> <ul style="list-style-type: none"> <li>➤ Updated thermal demand algorithm in <i>Comparison of Thermal, Rolling, and Block Demand Meters</i>.</li> <li>➤ Updated <i>Figure 5.28: FAULT and DFAULT Device Word Bit Logic</i>.</li> <li>➤ Changed amount for maximum positive-sequence current in <i>Fault Detection</i>.</li> <li>➤ Removed basic underpower quality and recording option in <i>Table 5.14: Flicker Quantities Available</i>.</li> <li>➤ Updated <i>Table 5.17: Configurable Register Attributes</i>.</li> <li>➤ Updated <i>Table 5.18: Configurable Register Spreadsheet Example</i>.</li> <li>➤ Updated <i>Figure 5.33: Meter and Billing Positions</i> and <i>Table 5.15: Transformer and Line Loss Adjustments</i>.</li> </ul>

**Table A.2 Instruction Manual Revision History (Sheet 3 of 3)**

Revision Date	Summary of Revisions
	<p><b>Section 7</b></p> <ul style="list-style-type: none"> <li>➤ Removed reference to logic updates in processing cycle in <i>Output Contacts</i>.</li> <li>➤ Updated <i>Example</i> and <i>Figure 7.3: Analog Output Settings Example</i> in <i>DC Analog Output</i>.</li> </ul> <p><b>Section 8</b></p> <ul style="list-style-type: none"> <li>➤ Updated <i>Ethernet</i> section in <i>Port Connector and Communications Cables</i>.</li> <li>➤ Updated <i>Table 8.7: Port Pinout Functions</i>.</li> <li>➤ Updated <i>Table 8.10: Command Summary</i>.</li> </ul> <p><b>Appendix D</b></p> <ul style="list-style-type: none"> <li>➤ Updated <i>VSSI Summary Records</i>.</li> <li>➤ Removed <i>Event Summary Records</i>.</li> </ul> <p><b>Appendix G</b></p> <ul style="list-style-type: none"> <li>➤ Updated <i>Table G.1: Analog Quantities Available to Internal Interface Types</i>.</li> </ul> <p><b>Command Summary</b></p> <ul style="list-style-type: none"> <li>➤ Updated with additional commands.</li> </ul>
20111216	<p><b>Appendix A</b></p> <ul style="list-style-type: none"> <li>➤ Updated for firmware version R102.</li> </ul>
20111111	<p><b>Section 1</b></p> <ul style="list-style-type: none"> <li>➤ Updated Waveform Capture duration values in <i>Table 1.2: SEL-735 Feature Availability</i>.</li> <li>➤ Added Fiber-Optic Ethernet Port specifications to <i>Specifications</i> section.</li> </ul> <p><b>Appendix A</b></p> <ul style="list-style-type: none"> <li>➤ Updated for firmware version R102.</li> </ul>
20110818	<p><b>Section 1</b></p> <ul style="list-style-type: none"> <li>➤ Modified for 100 A fault recording addition.</li> </ul> <p><b>Appendix A</b></p> <ul style="list-style-type: none"> <li>➤ Updated for firmware version R101.</li> </ul>
20110628	<ul style="list-style-type: none"> <li>➤ Initial version.</li> </ul>

# Appendix B

## SEL-735 Upgrade Instructions

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### Overview

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These instructions describe how to install various SEL-735 upgrades including firmware, meter form changes and intermediate/advanced power quality.

### Equipment Needed

Obtain the following equipment prior to performing this procedure:

- ▶ Personal Computer (PC) with serial port capable of 115.2 kbps (with Microsoft® Windows® 98, 2000, XP, or Vista®)
- ▶ Communications cable:
  - 38.4 kbps compatible for Port F (C660 or C661)
  - 115.2 kbps compatible for Port 2 or Port 3 (C234 or C287)
- ▶ SEL-735 Access Level 1 and Access Level 2 passwords

### Installation

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Step 1. Place the Meter Upgrade Software CD in the PC CD-ROM drive. The software should run automatically.

If the software fails to run automatically, use Windows Explorer to browse the CD-ROM contents, and run the Setup.exe file.

Step 2. The software will prompt for a shortcut location. Select one or both of the locations and click **Install**.

Step 3. Click **Close** to complete the installation and launch the software.

Clear the check box to run the software at a later time.

### Upgrade Procedure

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Step 1. Use an optical or serial cable to connect a PC to the SEL-735 Port 2, Port F, or EIA-232 Port 3. For faster upgrades, connect to the SEL-735 Port 2 or EIA-232 Port 3 instead of Port F.

Step 2. Double-click the Meter Upgrade Software shortcut saved on the desktop or from the Start menu to run the software.

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**IMPORTANT:** SEL charges for intermediate/advanced power quality and password protects these options. If you purchased an intermediate/advanced power quality, please refer to the Meter Upgrade Software Kit for the passwords. Please contact SEL if you would like to purchase an upgrade.

- Step 3. A **PC Port** dialog box displays on the PC screen. Select the PC port that is connected to the SEL-735, and click **OK** to view a list of available upgrades.
- Step 4. Select from the list of available upgrades and click **Upgrade**.  
The software will automatically install the selected upgrades and prompt when completed.
- Step 5. Click **OK** to acknowledge completion of the upgrade process and close the software.

# Appendix C

## SEL Communications Processors

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### SEL Communications Protocols

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The SEL-735 supports the protocols and command sets shown in *Table C.1*.

**Table C.1 Supported Serial Command Sets**

Command Set	Description
SEL ASCII	Sends ASCII commands and receives ASCII responses that are human readable with an appropriate terminal emulation program.
SEL Compressed ASCII	Sends ASCII commands and receives Compressed ASCII responses that are comma delimited for use with spreadsheet and database programs or for use by intelligent electronic devices.
SEL Fast Meter	Sends binary commands and receives binary meter and target responses.
SEL Fast Operate	Receives binary control commands.
SEL Fast SER	Receives binary Sequential Events Recorder unsolicited responses.

#### SEL ASCII Commands

The SEL ASCII protocol supports commands between the meter and a human operator via a keyboard and monitor or a printing terminal. A computer with a serial port can also use the SEL ASCII protocol to communicate with the meter, collect data, and issue commands.

#### SEL Compressed ASCII Commands

The meter supports a subset of SEL ASCII commands identified as Compressed ASCII commands. Each of these commands results in a comma-delimited message that includes a checksum field. Most spreadsheet and database programs can directly import comma-delimited files. Devices with embedded processors connected to the meter can execute software to parse and interpret comma-delimited messages without expending the customization and maintenance labor necessary to interpret nondelimited messages. The meter calculates a checksum for each line by numerically summing all of the bytes that precede the checksum field in the message. The program that uses the data can detect transmission errors in the message by summing the characters of the received message and comparing this sum to the received checksum.

Most commands are available only in SEL ASCII or Compressed ASCII format. Selected commands have versions in both standard SEL ASCII and Compressed ASCII formats. Compressed ASCII reports generally have fewer characters than conventional SEL ASCII reports, because the compressed reports reduce blanks, tabs, and other “white space” between data fields to a single comma.

Table C.2 lists the Compressed ASCII commands and contents of the responses.

**Table C.2 Compressed ASCII Commands**

Command	Response	Access Level
BNAME	ASCII names of Fast Meter status bits	0
CASCII	Configuration data of all Compressed ASCII commands available at access levels > 0	0
CEVENT	Event report	1
CHISTORY	List of events	1
DNAME	ASCII names of digital I/O reported in Fast Meter	0
ID	Meter identification	0
SNS	ASCII names for SER data reported in Fast Meter	0

## Interleaved ASCII and Binary Messages

SEL meters have two separate data streams that share the same physical serial port. Human data communications with the meter consist of ASCII character commands and reports that you view by using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information; the ASCII data stream continues after the interruption. This mechanism uses a single communications channel for ASCII communication (transmission of an event report, for example) interleaved with short bursts of binary data to support fast acquisition of metering data. The device connected to the other end of the link requires software that uses the separate data streams to exploit this feature. However, you do not need a device to interleave data streams to use the binary or ASCII commands. Note that XON, XOFF, and CAN operations operate on only the ASCII data stream.

An example of using these interleaved data streams is when the SEL-735 communicates with an SEL communications processor. These SEL communications processors perform auto-configuration by using a single data stream and SEL Compressed ASCII and binary messages. In subsequent operations, the SEL communications processor uses the binary data stream for Fast Meter, and Fast Operate messages to populate a local database and to perform SCADA operations. At the same time, you can use the binary data stream to connect transparently to the SEL-735 and use the ASCII data stream for commands and responses.

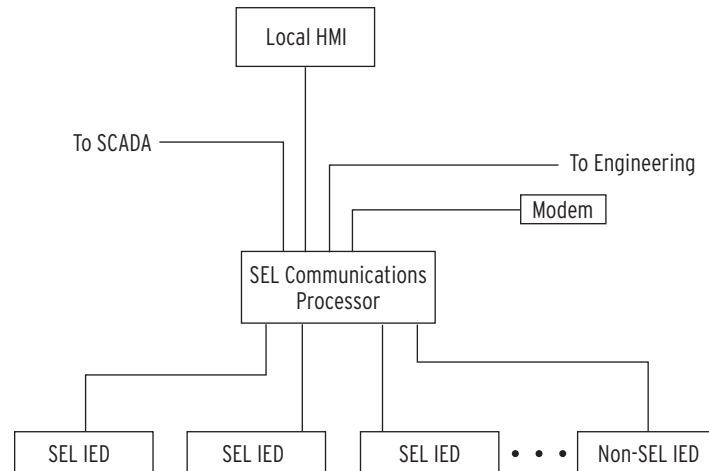
## SEL Fast Meter, Fast Operate, and Fast SER Messages

SEL Fast Meter is a binary message that you solicit with binary commands. Fast Operate is a binary message for control. The meter can also send unsolicited Fast SER messages automatically. If the meter is connected to an SEL communications processor, these messages provide the mechanism that the communications processor uses for SCADA or DCS functions that occur simultaneously with ASCII interaction.

SEL Application Guide *AG95-10, Configuration and Fast Meter Messages*, is a comprehensive description of SEL binary messages.

# SEL Communications Processor

SEL offers communications processors that are powerful tools for system integration and automation. These devices provide a single point of contact for integration networks with a star topology as shown in *Figure C.1*.



**Figure C.1 SEL Communications Processor Star Integration Network**

In the star topology network in *Figure C.1* the SEL communications processor offers the following substation integration functions:

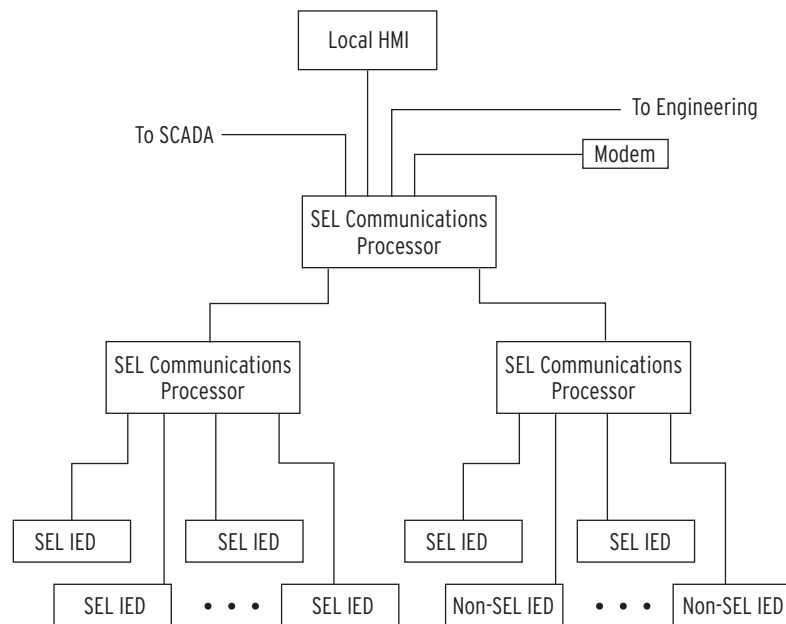
- Collection of real-time data from SEL and non-SEL IEDs
- Calculation, concentration, and aggregation of real-time IED data into databases for SCADA, HMI, and other data consumers
- Access to the IEDs for engineering functions including configuration, report data retrieval, and control through local serial, remote dial-in, and Ethernet network connections
- Simultaneous collection of SCADA data and engineering connection to SEL IEDs over a single cable
- Distribution of IRIG-B time-synchronization signal to IEDs based on external IRIG-B input, internal clock, or protocol interface
- Automated dial out on alarms

The SEL communications processors have as many as 33 serial ports plus a front port. This port configuration does not limit the size of a substation integration project, because you can create a multitiered solution as shown in *Figure C.2*. In this multitiered system, the lower-tier SEL communications processors forward data to the upper-tier SEL communications processor that serves as the central point of access to substation data and station IEDs.

The SEL-735 supports the Fast Meter commands as listed in *Table C.3*.

**Table C.3 SEL-735 Fast Meter Commands**

Command	Description
A5C0	SEL-735 Fast Meter definition message
A5C1	Fast Meter configuration message
A5D1	Fast Meter data message
A5C2	Demand Fast Meter configuration message
A5D2	Demand Fast Meter data message
A5C3	Peak demand Fast Meter configuration message
A5D3	Peak demand Fast Meter data message
A5B9	Status bits clear command



**Figure C.2 Multitiered SEL Communications Processor Architecture**

You can add additional communications processors to provide redundancy and eliminate possible single points of failure. SEL communications processors provide an integration solution with a reliability comparable to that of SEL meters. In terms of mean time between failures (MTBF), SEL communications processors are 100 to 1000 times more reliable than computer-based and industrial technology-based solutions.

Configuration of an SEL communications processor differs from other general-purpose integration platforms. You can configure SEL communications processors with a system of communications-specific keywords and data movement commands rather than programming in C or another general-purpose computer language. SEL communications processors offer the protocol interfaces listed in *Table C.4*.

**Table C.4 SEL Communications Processors Protocol Interfaces**

Protocol	Connect to
DNP3 Level 2 Slave	DNP3 masters
Modbus® RTU	Modbus masters
Modbus® TCP	Modbus masters with Ethernet
SEL ASCII/Fast Message Slave	SEL protocol masters
SEL ASCII/Fast Message Master	SEL protocol slaves including other communications processors and SEL meters
ASCII and Binary auto messaging	SEL and non-SEL IED master and slave devices
Modbus Plus <sup>a</sup>	Modbus Plus peers with global data and Modbus Plus masters
FTP (File Transfer Protocol) <sup>b</sup>	FTP clients
Telnet <sup>b</sup>	Telnet servers and clients
UCA2 GOMSFE <sup>b</sup>	UCA2 protocol masters
UCA2 GOOSE <sup>b</sup>	UCA2 protocol and peers

<sup>a</sup> Requires SEL-2711 Modbus Plus protocol card.

<sup>b</sup> Requires SEL-2701 Ethernet Processor.

# SEL Communications Processor and Meter Architecture

You can apply SEL communications processors and SEL meters in a limitless variety of applications that integrate, automate, and improve station operation. Most system integration architectures using SEL communications processors involve either developing a star network or enhancing a multidrop network.

## Developing Star Networks

*Figure C.1* shows the simplest architecture that uses both the SEL-735 and an SEL communications processors. In this architecture, the SEL communications processor collects data from the SEL-735 and other station IEDs. The SEL communications processor acts as a single point of access for local and remote data consumers (local HMI, SCADA, engineers). The communications processor also provides a single point of access for engineering operations that includes configuration and the collection of report-based information.

By configuring a data set optimized to each data consumer, you can significantly increase the utilization efficiency on each link. A system that uses an SEL communications processor to provide a protocol interface to an RTU will have a shorter lag time (data latency); communications processor overhead is much less for a single data exchange conversation to collect all substation data than for many conversations necessary to collect data directly from each individual IED. You can further reduce data latency by connecting an SEL communications processor directly to the SCADA master and eliminating redundant communications processing in the RTU.

The SEL communications processor is responsible for the protocol interface, so you can install, test, and even upgrade the system in the future without disturbing protective meters and other station IEDs. This insulation of the

meters from the communications interface assists greatly in situations where different departments are responsible for SCADA operation, communication, protection, and metering.

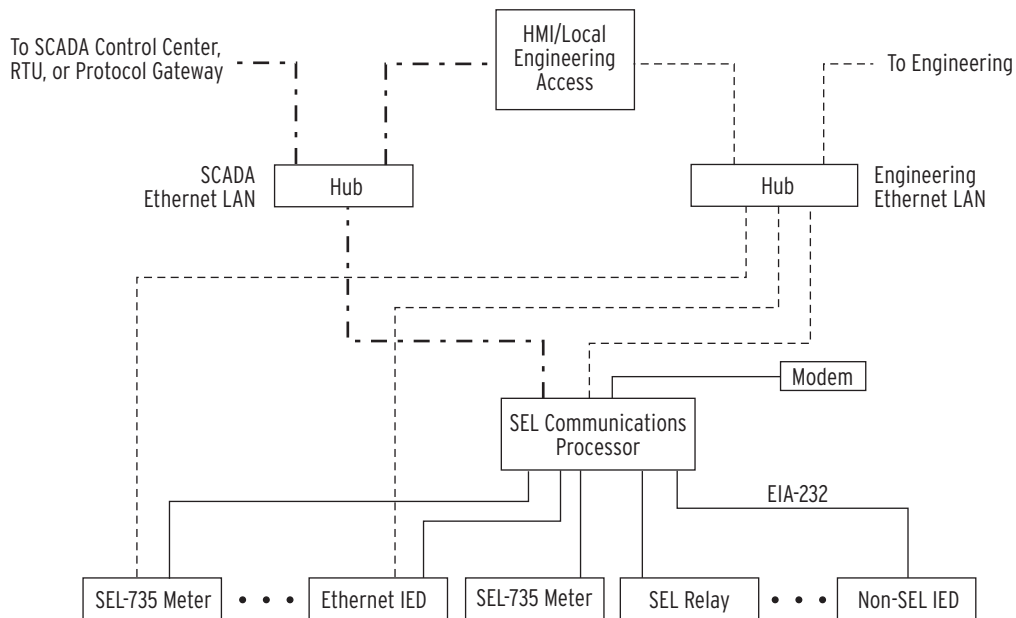
The engineering connection can use either an Ethernet network connection or a serial port connection. This versatility accommodates the channel available between the station and the engineering center. SEL software, including ACCELERATOR QuickSet® SEL-5030 Software, can use either a serial port connection or an Ethernet network connection from an engineering workstation to the meters in the field.

## Enhancing Multidrop Networks

You can also use an SEL communications processor to enhance a multidrop architecture similar to the one shown in *Figure C.3*. In this example, the SEL communications processor enhances a system with an Ethernet HMI multidrop network. In the example, there are two Ethernet networks, the SCADA LAN and the Engineering LAN. The SCADA LAN provides real-time data directly to the SCADA Control Center via a protocol gateway and to the HMI (Human Machine Interface).

In this example, the SEL communications processor provides the following enhancements when compared to a system that employs only the multidrop network:

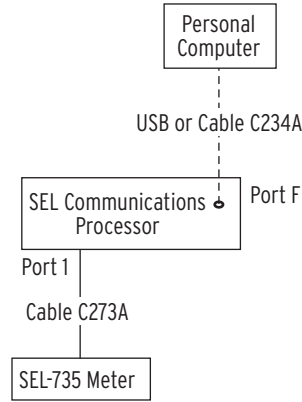
- Ethernet access for IEDs with serial ports
- Backup engineering access through the dial-in modem
- IRIG-B time signal distribution to all station IEDs
- Integration of IEDs without Ethernet
- Single point of access for real-time data for SCADA, HMI, and other uses
- Significant cost savings through use of existing IEDs with serial ports



**Figure C.3 Enhancing Multidrop Networks With SEL Communications Processors**

# SEL Communications Processor Example

This example demonstrates the data and control points available in the SEL communications processor when you connect an SEL-735. *Figure C.4* shows the physical configuration this example uses.



**Figure C.4 Example SEL Meter and SEL Communications Processor Configuration**

*Table C.5* shows the Port 1 settings for the SEL communications processor.

**Table C.5 SEL Communications Processor Port 1 Settings**

Setting Name	Setting	Description
DEVICE	S	Connected device is an SEL device
CONFIG	Y	Allow auto-configuration for this device
PORTID	“Meter 1”	Name of connected meter <sup>a</sup>
BAUD	19200	Channel speed of 19200 bits per second <sup>a</sup>
DATABIT	8	Eight data bits <sup>a</sup>
STOPBIT	1	One stop bit
PARITY	N	No parity
RTS_CTS	Y	Hardware flow control enabled
TIMEOUT	5	Idle time-out that terminates transparent connections of 5 minutes

<sup>a</sup> Automatically collected by the SEL communications processor during auto-configuration.

## Data Collection

The SEL communications processor collects data from the SEL-735 through use of the auto-messages listed in *Table C.6*. Disable auto-messages with the **FMR1–FMR4** settings if eight or more SEL-735 meters are connected to an SEL-2020 or SEL-2030 communications processor, and the communications processor issues the following report:

```

Attempting auto-configuration...
FAILED, auto-configuration error
  
```

This error indicates that the amount of data that the SEL-735 meters are sending during an auto configuration attempt exceeds the memory of the communications processor.

**Table C.6 SEL Communications Processor Data Collection Automessages**

Message	Data Collected
20METER	Power system metering data
20ENERGY	Energy metering data; enable and disable with <b>FMR1</b> .
20DEM4Q	Four-quadrant demand metering data; enable and disable with <b>FMR2</b> .
20PEAK4Q	Four-quadrant peak demand metering data; enable and disable with <b>FMR3</b> .
20MET4Q	Four-quadrant power system metering data; enable and disable with <b>FMR4</b> .

Table C.7 shows the automessage (Set A) settings for the SEL communications processor.

**Table C.7 SEL Communications Processor Port 1 Automatic Messaging Settings**

Setting Name	Setting	Description
AUTOBUF	Y	Save unsolicited messages
STARTUP	“ACC\nOTTER\n”	Automatically log on at Access Level 1
SEND_OPER	Y	Send Fast Operate messages for remote bit and breaker bit control
REC_SER	N	Automatic sequential events recorder data collection disabled
NOCONN	NA	No SELOGIC control equation entered to selectively block connections to this port
MSG_CNT	3	Three automessages
ISSUE1	P00:00:01.0	Issue Message 1 every second
MESG1	20METER	Collect metering data
ISSUE2	P00:00:02.0	Issue Message 2 every second
MESG2	20TARGET	Collect Device Word bit data
ISSUE3	P00:03:00.0	Issue Message 3 every minute
MESG3	20DEMAND	Collect demand metering data
ARCH_EN	N	Archive memory disabled
USER	0	No USER region registers reserved

Table C.8 shows the map of regions in the SEL communications processor for data collected from the SEL-735.

**Table C.8 SEL Communications Processor Port 1 Region Map**

Region	Data Collection Message Type	Region Name	Description
D1	Binary	METER	Meter metering data
D2	Binary	TARGET	Device Word bit data
D3	Binary	DEMAND	Demand metering data
D4–D8	n/a	n/a	Unused
A1–A3	n/a	n/a	Unused
USER	n/a	n/a	Unused

## Control Points

The SEL communications processor can automatically pass control messages, called Fast Operate messages, to the SEL-735. You must enable Fast Operate messages through use of the FASTOP setting in the SEL-735 port settings for the port connected to the SEL communications processor. You must also enable Fast Operate messages in the SEL communications processor by setting the automessage setting SEND\_OPER equal to Y.

When you enable Fast Operate functions, the SEL communications processor automatically sends messages to the meter for changes in remote bits RB01–RB16 on the corresponding SEL communications processor port. In this example, if you set RB01 on Port 1 in the SEL communications processor, it automatically sets RB01 in the SEL-735.

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# Appendix D

## Distributed Network Protocol

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### Overview

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The SEL-735 supports Distributed Network Protocol (DNP3) Level 2 Slave protocol. This includes access to metering data, contact I/O, targets, sequential events recorders, and meter summary event reports. The SEL-735 also supports DNP point remapping.

### Binary Inputs

The SEL-735 can use binary inputs to write Device Word bits to the DNP master. The SEL-735 updates binary inputs 0–399 and 1600–1604 approximately once per second. The time stamps for binary input events can be as long as two seconds behind the time of actual occurrence. The device only has one row of LEDs (fault targets), the upper byte representing targets. This means that 0000001 will read 256.

The SEL-735 derives binary inputs 800–871 from the SER and updates these inputs once per second with a time stamp of actual occurrence. Only points the meter has recorded in the SER1, SER2, or SER3 lists generate events.

### Binary Outputs

The DNP master can assert and deassert SEL-735 remote bits, reset energy, and reset demand by writing binary outputs to the SEL-735.

Binary outputs allow external control of:

- Remote bits
- Remote bit pairs
- Contact outputs
- Next event bit
- Reset energy or demand through a remote bit

### Binary/Frozen Counters

The SEL-735 updates binary counters once per second and reports a time-stamped event when a counter value changes beyond its dead-band setting. The time stamps for binary counter events can be as long as two seconds behind the time of actual occurrence.

Four types of data are available as binary counters:

- Configurable Registers
- Energy
- LDP Most Recent Record/LDP 50 Records
- VSSI Summary Records

## Configurable Registers

The meter scales configurable registers used in DNP binary counters by the configurable register DECIMAL setting. For example, if the setting for number of decimals is 2 for a configurable register, the SEL-735 scales the DNP configurable register by 100.

## Energy

Both per-point scaling and class scaling (DECPLE) applies to energy values. Energy registers roll over at 999,999,999 after application of scaling. If you want a different roll-over point, then you can use configurable registers to communicate energy data.

## LDP Most Recent Record/LDP 50 Records

The SEL-735 reports load profile either as the most recent record or in 50-record groups, when a DNP master uses analog outputs 40–45 to write the time and date of the earliest record. After the DNP master writes to the date and time analog output, the SEL-735 updates the DNP LDP points with the load profile data. This update takes 5–30 seconds. Use one of the following three methods to ensure that the SEL-735 has successfully updated the DNP LDP points before the master reads the load profile data.

- Wait 30 seconds after writing the time and date
- Monitor the LDP Data Ready Binary Input flag and read after the meter sets the bit
- Monitor the LDP Data Ready Counter Input flag and read after the meter sets the bit

The SEL-735 scales the LDP data it communicates over DNP3 protocol in the same manner that it scales LDP.

Meters with intermediate and advanced power quality and recording support 12 independent load profile recorders: LDP1, LDP2, LDP3, ... LDP12. Upon application of power, the SEL-735 defaults to and reports LDP1 recorder data. To retrieve LDP2 data, select and write a value of 2 to Analog Output (Object 40, 41) point 39 before retrieving LDP data. Continue this process for recorders 3–12 by writing a value of 3 for LDP3, 3 for LDP4, and so forth. If the master writes a value outside of the valid range, then the SEL-735 reports a format error by asserting bit 2 from the internal indicators (IIN) 0–11. If the SEL-735 does not support the recorders LDP2–LDP12, it will always report LDP1 regardless of whether the master writes a 1–12 to Analog Output (Object 40, 41) point 39.

## VSSI Summary Records

The SEL-735 contains DNP points with the 10 most recent VSSI event summaries. VSSI event summary 1 always contains the most recent VSSI event. When a new VSSI event occurs, the meter sets the new VSSI summary point (device index 6000) asserts. The new VSSI summary point deasserts when you read the VSSI summary from the SEL-735.

*Table D.1* provides definitions of VSSI record report status.

**Table D.1 VSSI Summary Record Status Report Definitions**

DNP Value	VSSI Definition
0	No Data
1	Dip
2	Swell
3	Interrupt
4	Triggered
5	Power Loss During Event
6	Data Overwrite

Table D.2 shows the DNP values representative of the ITIC regions.

**Table D.2 VSSI Summary ITIC Region Definitions**

DNP Value	ITIC Definition
0	No Data
1	No Damage Region
2	Safe Operation Region
3	Prohibited Region

## Analog Inputs

The SEL-735 scales analog inputs by their per-point scale setting. The settings ANADBA, ANADBM, and ANADBV define the dead bands in counts of analog input values. Analog inputs LDP most recent record points behave similarly to the binary counter LDP most recent record points.

## Analog Outputs

The SEL-735 accepts analog output values from the master for use in SELOGIC control equations and the 4AO/4DO output card. Analog outputs can also write the time and date of load profile records available through binary counters.

## Miscellaneous

- Object 50 (Time and Date): Object 50 function code 1 returns the time and date. To set the SEL-735 time, use function code 2 to write the time and date to Object 50. Adjust the TIMERQ setting to control the frequency with which the meter requests DNP time synchronization. Set the TIMERQ setting to M to disable time synchronization requests but cause the meter to still accept and apply time-synchronizations from the master; set the TIMERQ setting to I to cause the meter to ignore time synchronizations from the master when another time source, such as IRIG-B, takes precedence.
- Object 60 (Class Data): Object 60 returns Class 0, 1, 2, and 3 data assigned to the ECLASSB, ECLASSC, and ECLASSA settings.
- Object 80, (Internal Indications): Object 80 returns the internal indicator (IIN) bits specified by the DNP protocol. The SEL-735 sets the “Device Trouble” bit if the meter disables. Write “0” to bit 7 to clear the “Restart” bit.

## Ethernet Ports

- DNP LAN/WAN conforms to DNP3 Specification, Vol. 7, Networking—Transporting DNP3 Over Local and Wide-Area Networks, Version 2.0 Draft H, 15 December 2004.

- Existing TCP/IP connections with the SEL-735 terminate if the SEL-735 accepts a new connection from the DNP master.
- A Link Layer Status request generates for every open TCP connection that is inactive for an amount of time the DNPINA[n] setting defines, where *n* is 2–5 for DNP sessions 2–5.
- If the settings for a DNP session specify a port number to receive responses, the SEL-735 will send responses to this port only. Otherwise, the meter sends DNP UDP responses to the requesting device port number.

## Configuration

### DNP Operation

To configure a port for DNP, set the port PROTO setting to DNP. Refer to *SEL-735 Settings Sheets* for a list of all DNP settings.

### Default Data Map

Table D.3 shows the SEL-735 default DNP data map. The remapping feature customizes the data map for your application. See *Configurable Data Mapping on page D.4*.

**Table D.3 SEL-735 DNP3 Default Data Map**

DNP Object Type	Description	Default Map
01, 02	Binary Inputs	0, 2–7, 1600–1602
10, 12	Binary Outputs	183
20, 22	Counter Inputs	1–28
30, 32	Analog Inputs	1–22, 150–155, 200, 300–322, 3000
40, 41	Analog Outputs	0

### Default Variations

Table D.4 shows the default response for each object when a DNP master requests variation 0.

**Table D.4 SEL-735 DNP3 Default Variations**

DNP Object Type	Description	Default Variation
01,02	Binary Inputs	2
10	Binary Outputs	2
12	Binary Outputs	1
20, 22	Counter Inputs	5
21,23	Frozen Counters	1
30	Analog Inputs	4
32	Analog Inputs	2
40,41	Analog Outputs	2

### Configurable Data Mapping

One of the most powerful features of the DNP3 implementation is the ability to remap data with per-point scaling and dead bands. Remapping is the process of selecting data from the reference map and organizing it into a smaller data set optimized for each application. The SEL-735 Settings Driver in ACSELERATOR QuickSet can remap, apply per-point scaling, and apply dead bands to DNP points. The map consists of five indices, as *Overview on*

page D.1 describes. The order of points in the DNP map determines the order that the meter reports to the DNP master. If a value is not in the map, it is unavailable to the DNP master.

Follow these instructions to map and re-order DNP Binary Outputs.

Step 1. In the settings tree, navigate to the desired DNP map and object type.

ACSELERATOR QuickSet® SEL-5030 Software displays a DNP map builder similar to *Figure D.1*.

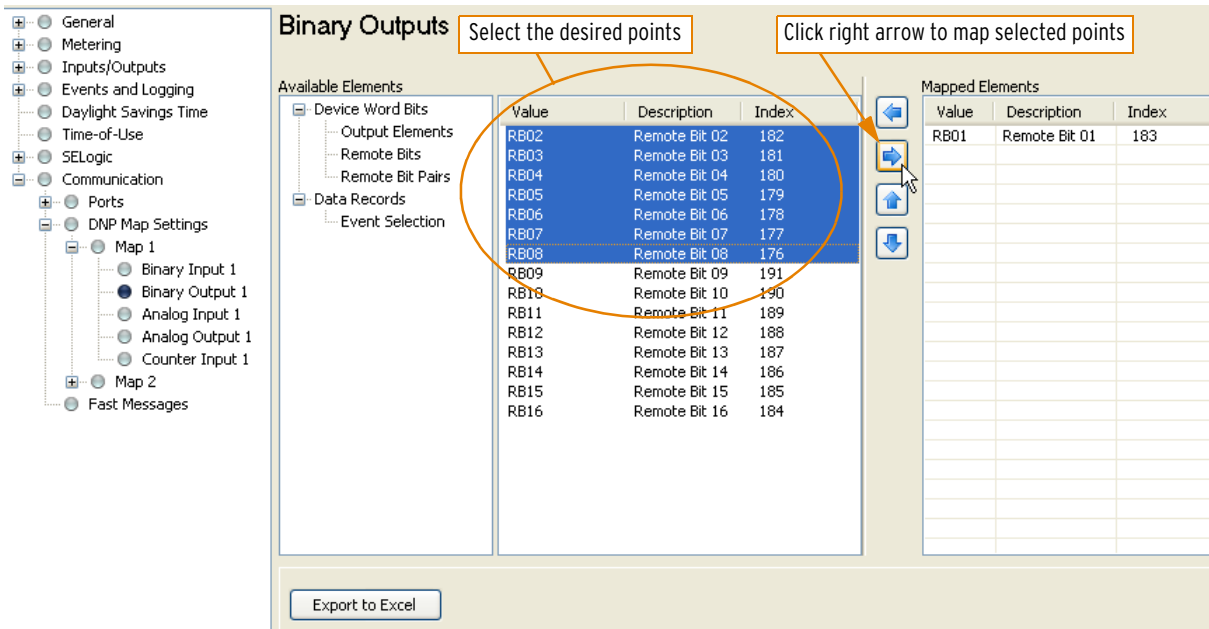
Step 2. Select the desired points from the available elements.

Step 3. Click the right arrow to map the selected points.

The selected points move to the mapped elements list, as shown in *Figure D.2*.

Step 4. To re-order the mapped elements, select the desired point and click the up or down arrow.

*Figure D.1* shows an example of using the DNP Binary Output Map Builder to create custom maps.



**Figure D.1 Mapping DNP Binary Outputs**

*Figure D.2* shows an example of using the DNP map builder to re-order the points of the custom map.

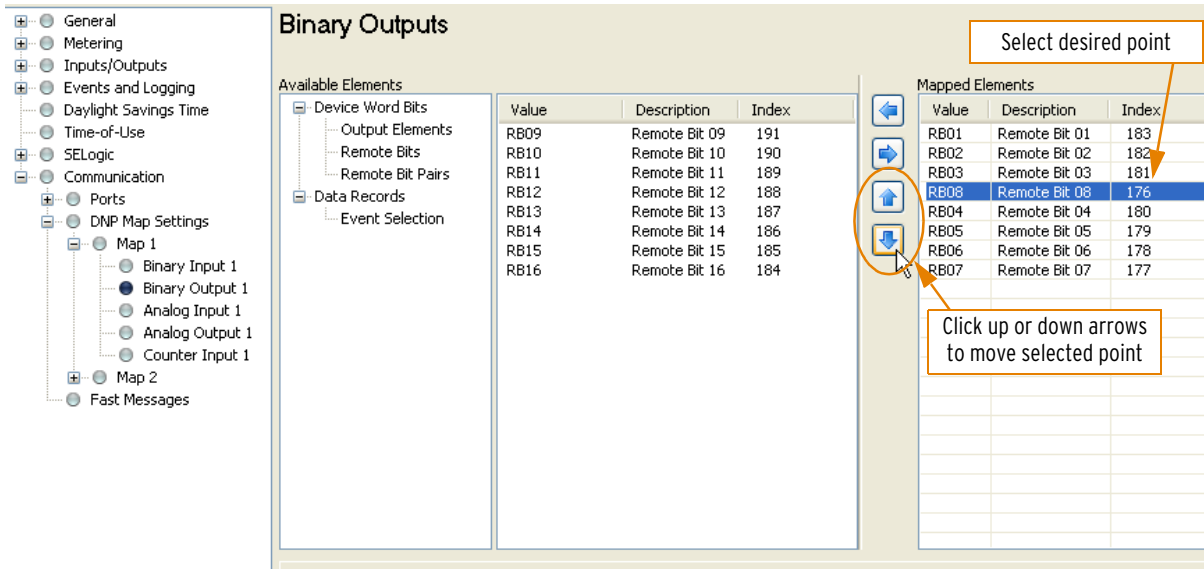


Figure D.2 Reorder DNP Binary Outputs

### Per-Point Scaling and Dead Bands

Scaling factors overcome limitations imposed by the integer nature of Objects 30 and 32. For example, the meter rounds a value of 11.4 A to 11 A. Scaling can add decimal places through multiplication. If you use 10 as a scaling factor, the meter transmits 11.4 A as 114. Divide the value by 10 in the master device to see the original value including one decimal place.

Scaling helps to avoid overflowing the 16-bit maximum integer value of 32767. Unsigned 16-bit integers cannot represent numbers greater than 65535. Use a scaling factor of 0.1 so the meter can report a maximum value of 655350. You then must multiply the received value by 10 in order to get the correct value. You will lose some precision because the scaling process rounds the last digit, but you can use standard DNP Objects 30 and 32 to transmit the scaled value.

Follow these instructions to change the DNP Analog Input map per-point scaling and dead band.

- Step 1. In the ACSELERATOR QuickSet settings tree, navigate to the desired Analog Input DNP map.

ACSELERATOR QuickSet displays the DNP map builder similar to *Figure D.3*.

- Step 2. Double-click the desired mapped element.

The scaling and dead band window opens, as shown in *Figure D.4*.

- Step 3. Enter the Scaling and Dead Band values and click **OK**.

- Step 4. Verify the proper scaling and dead band.

The DNP Map Builder shows the per-point scaling and dead band applied to each point, as shown in *Figure D.5*.

*Figure D.3* shows the DNP Map Builder with default analog inputs.

Value	Description	Index
Q03_DEL	Watt demand, 3-phase, delivered (VAR)	104
Q03_REC	Watt demand, 3-phase, received (VAR)	105
LD03_DEL	VA demand, 3-phase, delivered (VA)	102
LD03_REC	VA demand, 3-phase, received (VA)	103
W03_DEL	Watt demand, 3-phase, delivered (W)	100
W03_REC	Watt demand, 3-phase, received (W)	101
IDA	Current demand, Ia (A)	106
IDB	Current demand, Ib (A)	107
IDC	Current demand, Ic (A)	108
IDN	Current demand, In (A)	109
SID0	Current demand, 3*zero sequence (A)	110
SID2	Current demand, 3*negative sequence (A)	111
WDA_DEL	Watt demand, A-phase, delivered (W)	112
WDB_DEL	Watt demand, B-phase, delivered (W)	113
WDC_DEL	Watt demand, C-phase, delivered (W)	114
WDA_REC	Watt demand, A-phase, delivered (W)	115
WDB_REC	Watt demand, B-phase, delivered (W)	116
WDC_REC	Watt demand, C-phase, delivered (W)	117
UDA_DEL	VA demand, A-phase, delivered (VA)	118
UDB_DEL	VA demand, B-phase, delivered (VA)	119
UDC_DEL	VA demand, C-phase, delivered (VA)	120
UDA_REC	VA demand, A-phase, delivered (VA)	121
UDB_REC	VA demand, B-phase, delivered (VA)	122
UDC_REC	VA demand, C-phase, delivered (VA)	123
Q03_DEL_LG	VAR demand, 3-phase, delivered, lag (Q1) (VAR)	130
Q03_REC_LG	VAR demand, 3-phase, delivered, lead (Q2) (VAR)	131
Q03_REC_LD	VAR demand, 3-phase, received, lead (Q3) (VAR)	132
Q03_REC_LD	VAR demand, 3-phase, received, lead (Q4) (VAR)	133
Q0A_DEL_LG	VAR demand, A-phase, delivered, lag (Q1) (VAR)	134
Q0A_DEL_LD	VAR demand, A-phase, delivered, lag (Q2) (VAR)	135
Q0A_REC_LG	VAR demand, A-phase, received, lag (Q3) (VAR)	136
Q0A_REC_LD	VAR demand, A-phase, received, lead (Q4) (VAR)	137
Q0B_DEL_LG	VAR demand, B-phase, delivered, lag (Q1) (VAR)	138
Q0B_DEL_LD	VAR demand, B-phase, delivered, lead (Q2) (VAR)	139
Q0B_REC_LG	VAR demand, B-phase, received, lag (Q3) (VAR)	140
Q0B_REC_LD	VAR demand, B-phase, received, lead (Q4) (VAR)	141
Q0C_DEL_LG	VAR demand, C-phase, delivered, lag (Q1) (VAR)	142
Q0C_DEL_LD	VAR demand, C-phase, delivered, lead (Q2) (VAR)	143
Q0C_REC_LG	VAR demand, C-phase, received, lag (Q3) (VAR)	144
Q0C_REC_LD	VAR demand, C-phase, received, lead (Q4) (VAR)	145

Value	Description	Index [; Scale : Deadband]
IA	RMS current, Ia (A)	1
IB	RMS current, Ib (A)	2
IC	RMS current, Ic (A)	3
IN	RMS current, In (A)	4
VA	RMS voltage, Van (V)	5
VB	RMS voltage, Vbn (V)	6
VC	RMS voltage, Vcn (V)	7
VAB	RMS voltage, Vab (V)	8
VBC	RMS voltage, Vbc (V)	9
VCA	RMS voltage, Vca (V)	10
W3	Watts, 3-phase (W)	11
LB3	VARs, 3-phase (VAR)	12
Q3	VARs, 3-phase (VAR)	13
WA	Watts, A-phase (W)	14
WB	Watts, B-phase (W)	15
WC	Watts, C-phase (W)	16
UA	VA, A-phase (VA)	17
UB	VA, B-phase (VA)	18
UC	VA, C-phase (VA)	19
QA	VARs, A-phase (VAR)	20
QB	VARs, B-phase (VAR)	21
QC	VARs, C-phase (VAR)	22
W03_DEL	Watt peak demand, 3-phase, delivered (W)	150
W03_REC	Watt peak demand, 3-phase, received (W)	151
LP3_DEL	VA peak demand, 3-phase, delivered (VA)	152
LP3_REC	VA peak demand, 3-phase, received (VA)	153
QP3_DEL	VAR peak demand, 3-phase, delivered (VAR)	154
QP3_REC	VAR peak demand, 3-phase, received (VAR)	155
FREQ	Frequency (Hz)	200
IA_FUND	Fundamental current, Ia (A)	300
IB_FUND	Fundamental current, Ib (A)	301
IC_FUND	Fundamental current, Ic (A)	302
IN_FUND	Fundamental current, In (A)	303
VA_FUND	Fundamental voltage, Va (V)	304
VB_FUND	Fundamental voltage, Vb (V)	305
VC_FUND	Fundamental voltage, Vc (V)	306
VAB_FUND	Fundamental voltage, Vab (V)	307
VBC_FUND	Fundamental voltage, Vbc (V)	308
VCA_FUND	Fundamental voltage, Vca (V)	309

Figure D.3 DNP Map Builder

Double-click to apply per-point scaling and dead band

Figure D.4 shows the window opened when you double-click on a mapped element.

**D - AI\_MAP1**

Scaling (0.001 - 1000.000)    Deadband (0 - 32767)

Figure D.4 Scaling and Dead Band Window

Figure D.5 shows the DNP map builder with per-point scaling and dead band applied to IA.

Value	Description	Index [; Scale : Deadband]
IA	RMS current, Ia (A)	1;100.0000:10
IB	RMS current, Ib (A)	2
IC	RMS current, Ic (A)	3
IN	RMS current, In (A)	4

Per-point scaling and dead band applied

Figure D.5 Per-Point Scaling and Dead Band Applied

### Class Scaling and Dead Bands

The SEL-735 applies class scaling (DECPLA, DECPLV, and DECPLM) and dead band (ANADBA, ANADBV, and ANADBM) settings to all indices without per-point entries. For the class scaling settings, select 0 to multiply by 1, 1 for 10, 2 for 100, or 3 for 1000.

Table D.5 includes the default object map that the SEL-735 supports. Note that single-phase elements are only available with a Form 9 or Form 36 meter.

**Table D.5 DNP3 Device Profile** (Sheet 1 of 7)

DNP Object Type	Index	Description	Scaling/Dead Band
<b>DNP BINARY INPUT POINT MAP</b>			
Status of Word Bits and Word Bits in SER Settings			
01,02	000–399	Device Word Bits	
01,02	800–871	SER Status	
Device Status			
01,02	1600	Device disabled	
01,02	1601	Diagnostic failure	
01,02	1602	Diagnostic warning	
01,02	1603	Settings change or device restart	
01,02	1604	New event is available	
01,02	3000	LDP Data Ready (50 records)	
Power Factor			
01,02	3005	LDPFDA	
01,02	3006	LDPFDB	
01,02	3007	LDPFDC	
01,02	3008	LDPFD3	
01,02	3012	LDPFTA	
01,02	3013	LDPFTB	
01,02	3014	LDPFTC	
01,02	3015	LDPFT3	
Device Status, Continued			
01,02	5000	LDP Data Ready (most recent)	
01,02	6000	New VSSI Summary	
<b>DNP BINARY OUTPUT POINT MAP</b>			
Remote Bit Pairs			
10,12	30–37	Remote Bit Pairs RB01, RB02–RB15, RB16	
Event Selection			
10,12	40	Read Next Event	
<b>DEVICE WORD BIT CONTROLS</b>			
10,12	81–84	OUT404–OUT401	
10,12	85–87	OUT103–OUT101	
10,12	176–183	RB08–RB01	
10,12	184–191	RB16–RB09	
<b>DNP COUNTER POINT MAP</b>			
Energy			
20,22	1, 2	WH3_DEL, WH3_REC	DECPLE
20,22	3, 4	UH3_DEL, UH3_REC	DECPLE
20,22	5, 6	QH3_DEL, QH3_REC	DECPLE
20,22	7, 8, 9	WHA_DEL, WHB_DEL, WHC_DEL	DECPLE
20,22	10, 11, 12	WHA_REC, WHB_REC, WHC_REC	DECPLE

**Table D.5 DNP3 Device Profile (Sheet 2 of 7)**

DNP Object Type	Index	Description	Scaling/Dead Band
20,22	13, 14, 15, 16	WHA_NET, WHB_NET, WHC_NET, WH3_NET	DECPLE
20,22	17, 18, 19	UHA_DEL, UHB_DEL, UHC_DEL	DECPLE
20,22	20, 21, 22	UHA_REC, UHB_REC, UHC_REC	DECPLE
20,22	23, 24, 25	QHA_DEL, QHB_DEL, QHC_DEL	DECPLE
20,22	26, 27, 28	QHA_REC, QHB_REC, QHC_REC	DECPLE
20,22	29	QH3_NET	DECPLE
20,22	30, 31, 32, 33	QH3_DEL_LG, QH3_DEL_LD, QH3_REC_LG, QH3_REC_LD	DECPLE
20,22	34, 35, 36, 37	QHA_DEL_LG, QHA_DEL_LD, QHA_REC_LG, QHA_REC_LD	DECPLE
20,22	38, 39, 40, 41	QHB_DEL_LG, QHB_DEL_LD, QHB_REC_LG, QHB_REC_LD	DECPLE
20,22	42, 43, 44, 45	QHC_DEL_LG, QHC_DEL_LD, QHC_REC_LG, QHC_REC_LD	DECPLE
20,22	46, 47, 48, 49	VHA, VHB, VHC, VH3	DECPLE
20,22	50, 51, 52, 53, 54	IHA, IHB, IHC, IHN, IH3	DECPLE
<b>Configured Registers</b>			
20,22	1001-2000	CFG0001-CFG1000	None
<b>LDP 50 Records</b> Select a recorder by writing a 1-12 to Select LDP Recorder DNP register (Analog Output index 39).			
20,22	3000	LDP Data Ready (50 Records)	None
20,22	3001	Selected Recorder LDAR	None
20,22	3002	Selected Recorder LDFUNC	None
<b>Selected Recorder Record 1:</b>			
20,22	3003	Record Status	None
20,22	3004	Record Seconds	None
20,22	3005	Record Minutes	None
20,22	3006	Record Hours	None
20,22	3007	Record Day	None
20,22	3008	Record Month	None
20,22	3009	Record Year	None
20,22	3010	Channel 1 Data	DECPLM
20,22	3011	Channel 2 Data	DECPLM
20,22	3012	Channel 3 Data	DECPLM
20,22	3013	Channel 4 Data	DECPLM
20,22	3014	Channel 5 Data	DECPLM
20,22	3015	Channel 6 Data	DECPLM
20,22	3016	Channel 7 Data	DECPLM
20,22	3017	Channel 8 Data	DECPLM
20,22	3018	Channel 9 Data	DECPLM
20,22	3019	Channel 10 Data	DECPLM
20,22	3020	Channel 11 Data	DECPLM
20,22	3021	Channel 12 Data	DECPLM
20,22	3022	Channel 13 Data	DECPLM

**Table D.5 DNP3 Device Profile (Sheet 3 of 7)**

DNP Object Type	Index	Description	Scaling/Dead Band
20,22	3023	Channel 14 Data	DECPLM
20,22	3024	Channel 15 Data	DECPLM
20,22	3025	Channel 16 Data	DECPLM
<b>Record 2-50:</b>			
20,22	3026-4152	Record 2-50	
<b>LDP Most Recent Records</b>			
20,22	5000	LDP Data Ready (Most Recent)	None
<b>Recorder 1:</b>			
20,22	5001	LDAR	None
20,22	5002	LDFUNC	None
20,22	5003	Latest Record Status	None
20,22	5004	Latest Record Seconds	None
20,22	5005	Latest Record Minutes	None
20,22	5006	Latest Record Hours	None
20,22	5007	Latest Record Day	None
20,22	5008	Latest Record Month	None
20,22	5009	Latest Record Year	None
20,22	5010-5025	Channel 1-16 Data	DECPLM
<b>Recorder 2-12:</b>			
20,22	5026-5050	Recorder 2	
20,22	5051-5075	Recorder 3	
20,22	5076-5100	Recorder 4	
20,22	5101-5125	Recorder 5	
20,22	5126-5150	Recorder 6	
20,22	5151-5175	Recorder 7	
20,22	5176-5200	Recorder 8	
20,22	5201-5225	Recorder 9	
20,22	5226-5250	Recorder 10	
20,22	5251-5275	Recorder 11	
20,22	5276-5300	Recorder 12	
<b>VSSI Summary Records</b>			
20,22	6000	New VSSI Summary	None
<b>Summary 1:</b>			
20,22	6001-6003	VA, VB, VC VBASE setting in volts	100
20,22	6004	Event Type	None
20,22	6005	Event Milliseconds	None
20,22	6006	Event Minutes	None
20,22	6007	Event Hours	None
20,22	6008	Event Day	None
20,22	6009	Event Month	None

**Table D.5 DNP3 Device Profile (Sheet 4 of 7)**

DNP Object Type	Index	Description	Scaling/Dead Band
20,22	6010	Event Year	None
20,22	6011	Event Duration Milliseconds	None
20,22	6012	Event Duration Minutes	None
20,22	6013	Event Duration Hours	None
20,22	6014	Event Magnitude	100
20,22	6015, 6016	VA Min, Max	100
20,22	6017, 6018	VB Min, Max	100
20,22	6019, 6020	VC Min, Max	100
20,22	6021	ITIC Region	None
<b>Summary 2-10:</b>			
20,22	6022–6210	Summary 2–10	
<b>DNP ANALOG INPUT POINT MAP</b>			
<b>Voltage, Current, and Power</b>			
30,32	1, 2, 3, 4	IA, IB, IC, IN	DECPLA/ANADBA
30,32	5, 6, 7	VA, VB, VC	DECPLV/ANADBV
30,32	8, 9, 10	VAB, VBC, VCA	DECPLV/ANADBV
30,32	11, 12, 13	W3, U3, Q3	DECPLM/ANADBM
30,32	14, 15, 16	WA, WB, WC	DECPLM/ANADBM
30,32	16	WC	DECPLM/ANADBM
30,32	17, 18, 19	UA, UB, UC	DECPLM/ANADBM
30,32	20, 21, 22	QA, QB, QC	DECPLM/ANADBM
<b>Demand, Present Interval</b>			
30,32	100, 101	WD3_DEL, WD3_REC	DECPLM/ANADBM
30,32	102, 103	UD3_DEL, UD3_REC	DECPLM/ANADBM
30,32	104, 105	QD3_DEL, QD3_REC	DECPLM/ANADBM
30,32	106, 107, 108, 109	IDA, IDB, IDC, IDN	DECPLA/ANADBA
30,32	110, 111	3I0D, 3I2D	DECPLA/ANADBA
30,32	112, 113, 114	WDA_DEL, WDB_DEL, WDC_DEL	DECPLM/ANADBM
30,32	115, 116, 117	WDA_REC, WDB_REC, WDC_REC	DECPLM/ANADBM
30,32	118, 119, 120	UDA_DEL, UDB_DEL, UDC_DEL	DECPLM/ANADBM
30,32	121, 122, 123	UDA_REC, UDB_REC, UDC_REC	DECPLM/ANADBM
30,32	124, 125, 126	QDA_DEL, QDB_DEL, QDC_DEL	DECPLM/ANADBM
30,32	127, 128, 129	QDA_REC, QDB_REC, QDC_REC	DECPLM/ANADBM
30,32	130, 131, 132, 133	QD3_DEL_LG, QD3_DEL_LD, QD3_REC_LG, QD3_REC_LD	DECPLM/ANADBM
30,32	134, 135, 136, 137	QDA_DEL_LG, QDA_DEL_LD, QDA_REC_LG, QDA_REC_LD	DECPLM/ANADBM
30,32	138, 139, 140, 141	QDB_DEL_LG, QDB_DEL_LD, QDB_REC_LG, QDB_REC_LD	DECPLM/ANADBM
30,32	142, 143, 144, 145	QDC_DEL_LG, QDC_DEL_LD, QDC_REC_LG, QDC_REC_LD	DECPLM/ANADBM

**Table D.5 DNP3 Device Profile (Sheet 5 of 7)**

DNP Object Type	Index	Description	Scaling/Dead Band
<b>Demand, Peak</b>			
30,32	150, 151	WP3_DEL, WP3_REC	DECPLM/ANADBM
30,32	152, 153	UP3_DEL, UP3_REC	DECPLM/ANADBM
30,32	154, 155	QP3_DEL, QP3_REC	DECPLM/ANADBM
30,32	156, 157, 158, 159	IPA, IPB, IPC, IPN	DECPLA/ANADBA
30,32	160, 161	3I0P, 3I2P	DECPLA/ANADBA
30,32	162, 163, 164	WPA_DEL, WPB_DEL, WPC_DEL	DECPLM/ANADBM
30,32	165, 166, 167	WPA_REC, WPB_REC, WPC_REC	DECPLM/ANADBM
30,32	168, 169, 170	UPA_DEL, UPB_DEL, UPC_DEL	DECPLM/ANADBM
30,32	171, 172, 173	UPA_REC, UPB_REC, UPC_REC	DECPLM/ANADBM
30,32	174, 175, 176	QPA_DEL, QPB_DEL, QPC_DEL	DECPLM/ANADBM
30,32	177, 178, 179	QPA_REC, QPB_REC, QPC_REC	DECPLM/ANADBM
30,32	180, 181, 182, 183	QP3_DEL_LG, QP3_DEL_LD, QP3_REC_LG, QP3_REC_LD	DECPLM/ANADBM
30,32	184, 185, 186, 187	QPA_DEL_LG, QPA_DEL_LD, QPA_REC_LG, QPA_REC_LD	DECPLM/ANADBM
30,32	188, 189, 190, 191	QPB_DEL_LG, QPB_DEL_LD, QPB_REC_LG, QPB_REC_LD	DECPLM/ANADBM
30,32	192, 193, 194, 195	QPC_DEL_LG, QPC_DEL_LD, QPC_REC_LG, QPC_REC_LD	DECPLM/ANADBM
<b>Frequency</b>			
30,32	200	FREQ	100/ANADBM
30,32	201	FREQ_PQ	100/ANADBM
<b>Fundamental-Only Voltage, Current, and Power</b>			
30,32	300, 301, 302, 303	IA_FUND, IB_FUND, IC_FUND, IN_FUND	DECPLA/ANADBA
30,32	304, 305, 306	VA_FUND, VB_FUND, VC_FUND	DECPLV/ANADBV
30,32	307, 308, 309	VAB_FUND, VBC_FUND, VCA_FUND	DECPLV/ANADBV
30,32	310, 311, 312, 313	IA_ANG, IB_ANG, IC_ANG, IN_ANG	100/ANADBM
30,32	314, 315, 316	VA_ANG, VB_ANG, VC_ANG	100/ANADBM
30,32	317, 318, 319	VAB_ANG, VBC_ANG, VCA_ANG	100/ANADBM
30,32	320, 321, 322	W3_FUND, S3_FUND, Q3_FUND	DECPLM/ANADBM
30,32	323, 324, 325	WA_FUND, WB_FUND, WC_FUND	DECPLM/ANADBM
30,32	326, 327, 328	SA_FUND, SB_FUND, SC_FUND	DECPLM/ANADBM
30,32	329, 330, 331	QA_FUND, QB_FUND, QC_FUND	DECPLM/ANADBM
30,32	332, 333, 334, 335	Q3_DEL_LG, Q3_DEL_LD, Q3_REC_LG, Q3_REC_LD	DECPLM/ANADBM
30,32	336, 337, 338, 339	QA_DEL_LG, QA_DEL_LD, QA_REC_LG, QA_REC_LD	DECPLM/ANADBM

**Table D.5 DNP3 Device Profile (Sheet 6 of 7)**

DNP Object Type	Index	Description	Scaling/Dead Band
30,32	340, 341, 342, 343	QB_DEL_LG, QB_DEL_LD, QB_REC_LG, QB_REC_LD	DECPLM/ANADBM
30,32	344, 345, 346, 347	QC_DEL_LG, QC_DEL_LD, QC_REC_LG, QC_REC_LD	DECPLM/ANADBM
<b>Configured Registers</b>			
30,32	1001–2000	CFG001–CFG1000	None/ANADBM
<b>Power Factor</b>			
30,32	3000	PFD3	100/ANADBM
30,32	3001	PFT3	100/ANADBM
30,32	3002, 3003, 3004	PFDA, PFDB, PFDC	100/ANADBM
30,32	3005, 3006, 3007, 3008	LDPFDA, LDPFDB, LDPFDC, LDPFD3	None/ANADBM
30,32	3009, 3010, 3011	PFTA, PFTB, PFTC	100/ANADBM
30,32	3012, 3013, 3014, 3015	LDPFTA, LDPFTB, LDPFTC, LDPFT3	None/ANADBM
<b>LDP Most Recent Record</b>			
30,32	5000	LDP Data Ready (most recent)	None/ANADBM
30,32	5001	Recorder 1 LDAR	None/ANADBM
30,32	5002	Recorder 1 LDFUNC	None/ANADBM
30,32	5003	Recorder 1 Latest Record Status	None/ANADBM
30,32	5004	Recorder 1 Latest Record Seconds	None/ANADBM
30,32	5005	Recorder 1 Latest Record Minutes	None/ANADBM
30,32	5006	Recorder 1 Latest Record Hours	None/ANADBM
30,32	5007	Recorder 1 Latest Record Day	None/ANADBM
30,32	5008	Recorder 1 Latest Record Month	None/ANADBM
30,32	5009	Recorder 1 Latest Record Year	None/ANADBM
30,32	5010	Recorder 1 Channel 1 Data	DECPLM/ANADBM
30,32	5011	Recorder 1 Channel 2 Data	DECPLM/ANADBM
30,32	5012	Recorder 1 Channel 3 Data	DECPLM/ANADBM
30,32	5013	Recorder 1 Channel 4 Data	DECPLM/ANADBM
30,32	5014	Recorder 1 Channel 5 Data	DECPLM/ANADBM
30,32	5015	Recorder 1 Channel 6 Data	DECPLM/ANADBM
30,32	5016	Recorder 1 Channel 7 Data	DECPLM/ANADBM
30,32	5017	Recorder 1 Channel 8 Data	DECPLM/ANADBM
30,32	5018	Recorder 1 Channel 9 Data	DECPLM/ANADBM
30,32	5019	Recorder 1 Channel 10 Data	DECPLM/ANADBM
30,32	5020	Recorder 1 Channel 11 Data	DECPLM/ANADBM
30,32	5021	Recorder 1 Channel 12 Data	DECPLM/ANADBM
30,32	5022	Recorder 1 Channel 13 Data	DECPLM/ANADBM
30,32	5023	Recorder 1 Channel 14 Data	DECPLM/ANADBM

**Table D.5 DNP3 Device Profile (Sheet 7 of 7)**

DNP Object Type	Index	Description	Scaling/Dead Band
30,32	5024	Recorder 1 Channel 15 Data	DECPLM/ANADBM
30,32	5025	Recorder 1 Channel 16 Data	DECPLM/ANADBM
30,32	5026–5050	Recorder 2	
30,32	5051–5075	Recorder 3	
30,32	5076–5100	Recorder 4	
30,32	5101–5125	Recorder 5	
30,32	5126–5150	Recorder 6	
30,32	5151–5175	Recorder 7	
30,32	5176–5200	Recorder 8	
30,32	5201–5225	Recorder 9	
30,32	5226–5250	Recorder 10	
30,32	5251–5275	Recorder 11	
30,32	5276–5300	Recorder 12	
<b>Event Summary Information</b>			
30,32	6000	Event type	None/ANADBM
30,32	6001	Event targets	None/ANADBM
30,32	6002	Event frequency	None/ANADBM
30,32	6003–6005	Event time in DNP format (high, middle, and low 16 bits)	None/ANADBM
<b>DNP ANALOG OUTPUT POINT MAP</b>			
<b>Remote Analog Outputs</b>			
40,41	00–31	RA00–RA31	
<b>LDP Recorder and Start-Time Selection</b>			
40,41	39	Select LDP Recorder	
40,41	40	LDP start record time: Seconds	
40,41	41	LDP start record time: Minutes	
40,41	42	LDP start record time: Hours	
40,41	43	LDP start record time: Day	
40,41	44	LDP start record time: Month	
40,41	45	LDP start record time: Year	

## EIA-232 Physical Layer Operation

The RTS signal can control an external transceiver. The CTS signal can act as a DCD input, indicating when the medium is in use. Transmissions initiate only if DCD is deasserted. When DCD drops and after the idle time is satisfied, the meter can send the next pending outgoing message. This idle time is random, but is between the minimum and maximum allowed idle times (i.e., MINDLY and MAXDLY).

In addition, the SEL-735 monitors received data and treats receipt of data as a DCD indication. In cases where the external transceiver does not support DCD, you can loop the RTS signal back to the CTS line. When the SEL-735

transmits a DNP message, it delays transmitting after asserting RTS by at least the time in the PREDLY setting. After transmitting the last byte of the message, the SEL-735 delays for at least PSTDLY ms before deasserting RTS.

If the PSTDLY time delay is in progress (RTS still high) following a transmission, and another transmission initiates, the SEL-735 transmits the message without completing the PSTDLY delay and without any preceding PREDLY delay. Set PREDLY to OFF to completely disable RTS/CTS handshaking. In this case, the meter forces RTS high and ignores CTS, with only received characters acting as a DCD indication. The timing is the same as previously, but PREDLY functions as if it were set to 0, and RTS does not actually deassert after the PSTDLY time delay expires.

## Ethernet Operation

The SEL-735 DNP LAN/WAN implementation conforms to *DNP3 Specification, Vol. 7, Networking—Transporting DNP3 over Local and Wide Area Networks*, Version 2.0, Draft H, 15 December 2004. DNP sessions act as listening end points as defined by the DNP LAN/WAN specification previously referenced.

The DNP-IP response is identical to the serial response, but it requires the following communications-specific settings.

**Table D.6 DNP-IP Specific Settings**

Setting	Definition	Range	Default Value
EDNP	Enable DNP-IP Sessions. Set this value to 0 to disable DNP-IP in the SEL-735.	0–5	0
DNPNUM	DNP TCP and UDP Port. Identifies the TCP and UDP port between the master and the SEL-735.	1–65534 excluding 20, 21, 502, and the TPORT setting.	2000
DNPIP <sub>n</sub>	Master IP Address. Set DNPIP = 0.0.0.0 to accept requests from any DNP-IP address.	zzz.yyy.xxx.www	192.168.0.3
DNPTR <sub>n</sub>	Transport Protocol. Selects between TCP and UDP protocols.	TCP, UDP	TCP
DNPUDP <sub>n</sub>	UDP Response Port. Selects the port to which the SEL-735 responds. If DNPUDP = REQ, the SEL-735 responds to the port number from the master's UDP request.	REQ, 1–65534	2000

If the UNSOL setting is set to Y, the SEL-735 transmits unsolicited data when either of the following are true.

- Initialization is complete and DNPTR = UDP, or
- The master has established a session, if DNPTR = TCP.

# DNP Channels

DNP channels are logical groupings of sessions that share the same DNP data-link and transport layers. All DNP data-link and transport layer settings sharing the same DNP channel are common between the shared sessions. The following settings are the same between shared DNP sessions: Seconds to Data Link Time-Out (DTIMEO) and Data Link Retries (DRETRY). Other settings, specific to the type of channel, may also need to be common across shared DNP sessions. The SEL-735 routes DNP message traffic it receives on a channel with shared sessions to the appropriate session.

All DNP sessions that communicate over the same serial port are on the same DNP channel. The Data Link Time-Out and Data Link Retries settings are common between the shared DNP sessions. Additionally, all serial port settings are common between the shared DNP sessions.

# Data Access Method

Based on the capabilities of the system, it is necessary to determine which method you want to use for retrieving data on the DNP connection.

Table D.7 summarizes the main options, listed from least to most efficient, and indicates the corresponding key settings.

**Table D.7 Data Access Methods**

Data Retrieval Method	Description	Relevant SEL-735 DNP Settings
Polled Static	The master polls for static (Class 0) data only	Set ECLASS = 0 Set UNSOL = N
Polled Report-by-Exception	The master polls frequently for event data and occasionally for static data	Set ECLASS to a nonzero value, Set UNSOL = N
Unsolicited Report-by-Exception	The slave devices send unsolicited event data to the master, and the master occasionally sends integrity polls for static data	Set ECLASS to a nonzero value Set UNSOL = Y Set NUMEVE and AGEEVE to adjust the response rate
Quiescent	The master never polls, relies on unsolicited reports only	Set ECLASS to a nonzero value Set UNSOL = Y Set NUMEVE and AGEEVE to adjust the response rate

# Device Profile

Table D.8 contains the standard DNP3 device profile information. The example device profile in the DNP3 subset definitions replaces traditional device profile checkboxes with presentation of only relevant selections.

**Table D.8 SEL-735 DNP3 Device Profile**

Parameter	Value
Vendor name	Schweitzer Engineering Laboratories
Device name	SEL-735
Highest DNP request level	Level 2
Highest DNP response level	Level 2
Device function	Slave
Notable objects, functions, and/or qualifiers supported	Supports enabling and disabling of unsolicited reports on a class basis
Maximum data link frame size transmitted/received (octets)	292
Maximum data link retries	Configurable using DRETRY
Requires data link layer confirmation	Configurable using DTIMEO
Maximum application fragment size transmitted/received (octets)	2048
Maximum application layer retries	None
Requires application layer confirmation	When reporting Event Data
Data link confirm time-out	Configurable using DTIMEO
Complete application fragment time-out	None
Application confirm time-out	Configurable using ETIMEO
Complete Application response time-out	None
Executes control WRITE binary outputs	Always
Executes control SELECT/OPERATE	Always
Executes control DIRECT OPERATE	Always
Executes control DIRECT OPERATE-NO ACK	Always
Executes control count greater than 1	Never
Executes control Pulse On	Always
Executes control Pulse Off	Always
Executes control Latch Off	Always
Executes control Latch Off	Always
Executes control Queue	Never
Executes control Clear Queue	Never
Reports binary input change events when no specific variation requested	Only time-tagged
Reports time-tagged binary input change events when no specific variation requested	Binary Input change with time
Sends unsolicited responses	Configurable using UNSOL
Sends static data in unsolicited responses	Never
Default counter object/variation	Object 20, Variation 5
Counter roll-over	32 bits
Sends multifragment responses	No

# Object Table

Table D.9 lists the objects and variations with supported function codes and qualifier codes.

**Table D.9 SEL-735 DNP Object List (Sheet 1 of 2)**

Obj.	Var.	Description	Request (supported)		Response (may generate)	
			Funct. Codes (dec)	Qual. Codes (hex)	Funct. Codes (dec)	Qual. Codes (hex)
1	0	Binary Input—All Variations	1	0, 1, 6, 7, 8		
1	1	Binary Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
1	2 <sup>a</sup>	Binary Input With Status	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
2	0	Binary Input Change—All Variations	1	6, 7, 8		
2	1	Binary Input Change Without Time	1	6, 7, 8	129	17, 28
2	2 <sup>a</sup>	Binary Input Change With Time	1	6, 7, 8	129, 130	17, 28
2	3	Binary Input Change With Relative Time	1	6, 7, 8	129	17, 28
10	0	Binary Output—All Variations	1	0, 1, 6, 7, 8	129	
10	1	Binary Output		0, 1, 6, 7, 8	129	
10	2 <sup>a</sup>	Binary Output Status	1	0, 1, 6, 7, 8	129	0, 1
12	1	Control Meter Output Block	3, 4, 5, 6	17, 28	129	Echo of Request
20	0	Binary Counter—All Variations	1, 7, 8	0, 1, 6, 7, 8, 17, 28		
20	5 <sup>a</sup>	32-Bit Binary Counter Without Flag	1, 7, 8	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
20	6	16-Bit Binary Counter Without Flag	1, 7, 8	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
21	0	Frozen Counter—All Variations	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
21	1 <sup>a</sup>	32-Bit Frozen Counter	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
21	2	16-Bit Frozen Counter	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
21	5	32-Bit Frozen Counter With Time of Freeze	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
21	6	16-Bit Frozen Counter With Time of Freeze	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
22	0	Counter Change Event—All Variations	1	6, 7, 8		
22	1	32-Bit Counter Change Event Without Time	1	6, 7, 8	129	17, 28
22	2	16-Bit Counter Change Event Without Time	1	6, 7, 8	129	17, 28
22	5 <sup>a</sup>	32-Bit Counter Change Event With Time	1	6, 7, 8	129, 130	17, 28
22	6	16-Bit Counter Change Event With Time	1	6, 7, 8	129	17, 28
23	0	Frozen Counter Event—All Variations	1	6, 7, 8	129	17, 28
23	1 <sup>a</sup>	32-Bit Frozen Counter Event Without Time	1	6, 7, 8	129, 130	17, 28
23	2	16-Bit Frozen Counter Event Without Time	1	6, 7, 8	129	17, 28
23	5	32-Bit Frozen Counter Event With Time	1	6, 7, 8	129	17, 28
23	6	16-Bit Frozen Counter Event With Time	1	6, 7, 8	129	17, 28
30	0	Analog Input—All Variations	1	0, 1, 6, 7, 8, 17, 28		
30	1	32-Bit Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30	2	16-Bit Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30	3	32-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30	4 <sup>a</sup>	16-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
32	0	Analog Change Event—All Variations	1	6, 7, 8		

**Table D.9 SEL-735 DNP Object List (Sheet 2 of 2)**

Obj.	Var.	Description	Request (supported)		Response (may generate)	
			Funct. Codes (dec)	Qual. Codes (hex)	Funct. Codes (dec)	Qual. Codes (hex)
32	1	32-Bit Analog Change Event Without Time	1	6, 7, 8	129	17, 28
32	2 <sup>a</sup>	16-Bit Analog Change Event Without Time	1	6, 7, 8	129, 130	17, 28
32	3	32-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
32	4	16-Bit Analog Change Event With Time	1	6, 7, 8	129	17, 28
34	1	16-Bit Analog Reporting Dead Band	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	2	32-Bit Analog Reporting Dead Band	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
40	0	Analog Output Status—All Variations	1	0, 1, 6, 7, 8		
40	1	32-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1
40	2 <sup>a</sup>	16-Bit Analog Output Status	1	0, 1, 6, 7, 8	129	0, 1
41	1	32-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	Echo of Request
41	2 <sup>a</sup>	16-Bit Analog Output Block	3, 4, 5, 6	17, 28	129	Echo of Request
50	1	Time and Date	1, 2	7, 8 index=0	129	07, quantity=1
50	3	Time and Date—Absolute time at last recorded time		7, 8 index=0	129	07, quantity=1
51	1	Synchronized Time and Date CTO				07, quantity=1
52	2	Time Delay, Fine			129	07, quantity=1
60	1	Class 0 Data	1	6, 7, 8		17, 28
60	2	Class 1 Data	1, 20, 21	6, 7, 8		17, 28
60	3	Class 2 Data	1, 20, 21	6, 7, 8		17, 28
60	4	Class 3 Data	1, 20, 21	6, 7, 8		
80	1	Internal Indications	2	0, 1 index=7		
N/A		No object required for the following function codes: 13 cold start 14 warm start 23 delay measurement	13, 14, 23			

<sup>a</sup> Default variation.

The SEL-735 supports control meter output blocks (Object 12, Variation 1). The control meters correspond to the remote bits and other functions, as shown in *Table D.10*.

**Table D.10 Control Field (Sheet 1 of 2)**

Index	Trip/Close Pairs		Code Selection Operation			
	Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
30	Pulse RB02	Pulse RB01	Pulse RB02	Pulse RB01	Pulse RB02	Pulse RB01
31	Pulse RB04	Pulse RB03	Pulse RB04	Pulse RB03	Pulse RB04	Pulse RB03
32	Pulse RB06	Pulse RB05	Pulse RB06	Pulse RB05	Pulse RB06	Pulse RB05
33	Pulse RB08	Pulse RB07	Pulse RB08	Pulse RB07	Pulse RB08	Pulse RB07
34	Pulse RB10	Pulse RB09	Pulse RB10	Pulse RB09	Pulse RB10	Pulse RB09
35	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11	Pulse RB12	Pulse RB11
36	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13	Pulse RB14	Pulse RB13
37	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15	Pulse RB16	Pulse RB15

**Table D.10 Control Field (Sheet 2 of 2)**

Index	Trip/Close Pairs		Code Selection Operation			
	Close (0x4X)	Trip (0x8X)	Latch On (3)	Latch Off (4)	Pulse On (1)	Pulse Off (2)
40	Read next meter event	Read next meter event	Read next meter event	No action	Read next meter event	No action
81–84	Pulse OUT401–OUT404	Pulse OUT401–OUT404	Pulse OUT401–OUT404	Pulse OUT401–OUT404	Pulse OUT401–OUT404	Pulse OUT401–OUT404
85–87	Pulse OUT101–OUT103	Pulse OUT101–OUT103	Pulse OUT101–OUT103	Pulse OUT101–OUT103	Pulse OUT101–OUT103	Pulse OUT101–OUT103
176–183	Set RB08–RB01	Clear RB08–RB01	Set RB08–RB01	Clear RB08–RB01	Pulse RB08–RB01	Clear RB08–RB01
184–191	Set RB16–RB09	Clear RB16–RB09	Set RB16–RB09	Clear RB16–RB09	Pulse RB16–RB09	Clear RB16–RB09

When the TRIP bit asserts, the SEL-735 performs a latch off operation on the corresponding index. When the CLOSE bit asserts, the SEL-735 performs a latch on operation on the corresponding index. Pulse operations asserts the corresponding index for one processing interval. Exercise caution with multiple remote bit pulses in a single message (i.e., point count > 1), because this can result in the meter disregarding some of the pulse commands and returning an already active status.

# Appendix E

## Modbus Communications Protocol

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### Overview

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This appendix describes Modbus® communications features that the SEL-735 supports. For a further details on the Modbus protocol, please see the publication: *Modicon Modbus Protocol Reference Guide* (PI-MBUS-300 Rev. J).

Modbus is a binary protocol that permits communication among a single master device and multiple slave devices. The communication is half duplex; only one device transmits at a time. The master transmits a binary command that includes the address of the desired slave device. All of the slave devices receive the message, but only the slave device with the matching address responds.

The SEL-735 allows a Modbus master device to do the following:

- Acquire metering, monitoring, load profile, and event data.
- Control output contacts and remote bits.
- Read the self-test status and learn the present condition of all the meter protection elements.

### Modbus RTU Communications Protocol

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#### Modbus Queries

Modbus RTU master devices initiate all exchanges by sending a query. The query consists of the fields shown in *Table E.1*.

**Table E.1 Modbus Query Fields**

Field	Number of Bytes	Range
Slave Device Address	1 byte	1–247
Function Code	1 byte	Supported Modbus function codes
Data Region	0–251 bytes	0–255 (each byte)
Cyclical Redundancy Check (CRC)	2 bytes	0–65535

The SLAVEID setting defines the device address. Set this value to a unique number for each device on the Modbus network. For Modbus communication to operate properly, no two slave devices may have the same address.

A cyclical redundancy check detects errors in the received data. If the meter detects an error, it discards the data packet.

## Modbus Responses

The slave device sends a response message after it performs the action the query requests. If the slave cannot execute the command for any reason, it sends an error response. Otherwise, the meter formats the slave device response similarly to the query and includes the slave address, function code, data (if applicable), and a cyclical redundancy check value.

## Supported Modbus Function Codes

The SEL-735 supports the function codes shown in *Table E.2*.

**Table E.2 Modbus Function Codes**

Codes	Description
01h	Read Coil Status
02h	Read Input Status
03h	Read Holding Registers
04h	Read Input Registers
05h	Force Single Coil
06h	Preset Single Register
10h	Preset Multiple Registers

## Modbus Exception Responses

The SEL-735 returns an exception code under the conditions *Table E.3* describes.

**Table E.3 Modbus Exception Codes**

Error Code	Error Type	Description
01	Illegal Function Code	The received function code is either undefined or unsupported.
02	Illegal Data Address	The received command contains an unsupported address in the data field.
03	Illegal Data Value	The received command contains a value that is out of range.
04	Device Error	The SEL-735 is in the wrong state for the requested function.
06	Busy	The SEL-735 is unable to process the command at this time because of a busy resource.
08	Memory Error	Checksum error on stored data.

In the event that any of the errors listed in *Table E.3* occur, the meter assembles a response message that includes the exception code in the data field. The meter sets the most significant bit in the function code field to indicate to the master that the data field contains an exception code, instead of the requested data. *Table E.4* shows the format of the exception codes.

**Table E.4 Modbus Exception Code Format**

Value	Number of Bytes
Slave Device Address	1
Function Code (with MSB set)	1
Error Code	1
CRC	1

## Cyclical Redundancy Check

The SEL-735 uses the device address, function code, and data fields to calculate a 2-byte CRC value. It appends this value to the end of every Modbus response. When the master device receives the response, it recalculates the CRC. If the calculated CRC matches the CRC the SEL-735 sent, the master device uses the data it received. If there is no match, the check fails and the meter ignores the message. The devices use a similar process when the master sends queries.

## 01h Read Coil Status Command

Use function code 01h to read the On/Off status of the selected bits (coils). You can read the status of as many as 2000 bits per query.

Note that the meter coil addresses start at 0 (e.g., Coil 1 is located at address zero). The coil status is packed one coil per bit of the data field. The least significant bit (LSB) of the first data byte contains the starting coil address in the query. The other coils follow toward the high-order end of this byte and from low order to high order in subsequent bytes.

**Table E.5 01h Read Coil Status Commands**

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (01h)
2 bytes	Address of the First Bit
2 bytes	Number of Bits to Read
2 bytes	CRC-16
A successful response from the slave has the following format:	
1 byte	Slave Address
1 byte	Function Code (01h)
1 byte	Bytes of data ( <i>n</i> )
<i>n</i> bytes	Data
2 bytes	CRC-16

To build the response, the meter calculates the number of bytes necessary to contain the number of bits the query requested. If the number of bits the query requested is not evenly divisible by eight, the meter adds one more byte to maintain the balance of bits, padded by zeroes to make an even byte.

Table E.6 shows responses to 01h query errors.

**Table E.6 Device Responses to 01h Read Coil Query Errors**

Error	Error Code Returned	Communication Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

## 02h Read Input Status Command

Use function code 02h to read the On/Off status of the selected bits (inputs). You can read the status of as many as 2000 bits per query. Note that the input addresses start at 0 (e.g., Input 1 is located at address zero).

The input status is packed one input per bit of the data field. The LSB of the first data byte contains the starting input address in the query. The other inputs follow towards the high-order end of this byte, and from low order to high order in subsequent bytes.

**Table E.7 02h Read Input Status Command**

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (02h)
2 bytes	Address of the First Bit
2 bytes	Number of Bits to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (02h)
1 byte	Bytes of data ( <i>n</i> )
<i>n</i> bytes	Data
2 bytes	CRC-16

To build the response, the meter calculates the number of bytes necessary to contain the number of bits the query requested. If the number of bits the query requested is not evenly divisible by eight, the meter adds one more byte to maintain the balance of bits, padded by zeroes to make an even byte.

Table E.8 defines input numbers.

**Table E.8 Device Input Coils**

Input Coil Number	Input Coil Name	Notes
1	IN101	
2	IN102	
3	IN401	Returns 0 if not installed
4	IN402	Returns 0 if not installed
5	IN403	Returns 0 if not installed
6	IN404	Returns 0 if not installed

In each row, the device assigns input numbers from the right-most input to the left-most input (i.e., Input 1 is N and Input 8 is EN). Input addresses start at 0000 (i.e., Input 1 is located at Input Address 0000).

Table E.9 shows responses to 02h query errors.

**Table E.9 Device Responses to 02h Read Input Query Errors**

Error	Error Code Returned	Communication Counter Increments
Invalid bit to read	Illegal Data Address (02h)	Invalid Address
Invalid number of bits to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format

## 03h Read Holding Register Command

Use function code 03h to read directly from the Modbus Register Map shown in *Table E.26*.

You can read a maximum of 125 registers at once with this function code. Most masters use 4X references with this function code. If you are accustomed to 4X references with this function code, for five-digit addressing, add 40001 to the standard database address.

**Table E.10 03h Read Holding Register Command**

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (03h)
1 byte	Bytes of data ( <i>n</i> )
<i>n</i> bytes	Data
2 bytes	CRC-16

*Table E.11* shows responses to 03h query errors.

**Table E.11 Device Responses to 03h Read Holding Register Query Errors**

Error	Error Code Returned	Communication Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format
Busy	Slave is busy with other task (06h)	

## 04h Read Input Registers Command

Use function code 04h to read from the Modbus Register Map shown in *Table E.26*.

You can read a maximum of 125 registers at once with this function code. Most masters use 3X references with this function code. If you are accustomed to 3X references with this function code, for five-digit addressing, add 30001 to the standard database address.

**Table E.12 04h Read Holding Register Command**

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (04h)
2 bytes	Starting Register Address
2 bytes	Number of Registers to Read
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (04h)
1 byte	Bytes of data ( <i>n</i> )
<i>n</i> bytes	Data
2 bytes	CRC-16

Table E.13 shows responses to 04h query errors.

**Table E.13 Device Responses to 04h Read Holding Register Query Errors**

Error	Error Code Returned	Communication Counter Increments
Illegal register to read	Illegal Data Address (02h)	Invalid Address
Illegal number of registers to read	Illegal Data Value (03h)	Illegal Register
Format error	Illegal Data Value (03h)	Bad Packet Format
Busy	Slave is busy with other task (06h)	

## 05h Force Single Coil Command

Use function code 05h to set or clear a coil. In Table E.14, the command response is identical to the command request.

**Table E.14 05h Force Single Coil Command**

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (05h)
2 bytes	Coil Reference
1 byte	Operation Code (FF for bit set, 00 for bit clear)
1 byte	Placeholder (00)
2 bytes	CRC-16

Table E.15 lists available coil numbers. The physical coils (coils 1–7) are self-resetting. Pulsing a set remote bit clears the remote bit.

**Table E.15 SEL-735 Device Output Coils (FC05h)**

Output Coil Number	Output Coil Name	Note
1–3	OUT101–OUT103	Returns 0 if not installed
4–7	OUT401–OUT404	
8–23	RB01–RB16	
24–39	Pulse RB01–Pulse RB16	

Coil addresses start at 0000 (i.e., Coil 1 is located at Coil address 0000). If the meter disables or the breaker jumper is not installed, it responds with Exception Code 4 (Device Error).

Table E.16 shows additional responses to 05h query errors.

**Table E.16 Device Responses to 05h Force Single Coil Query Errors**

Error	Error Code Returned	Communication Counter Increments
Invalid bit (coil) number	Illegal Data Address (02h)	Invalid Address
Illegal bit state requested	Illegal Data Value (03h)	Illegal Function Code/Op Code
Format error	Illegal Data Value (03h)	Bad Packet Format

## 06h Preset Single Register Command

The SEL-735 uses this function to allow a Modbus master to write directly to a database register. Refer to the Modbus Register Map in Table E.26 for a list of registers that remote devices can write to using this function code. If you are accustomed to 4X references with this function code, for six-digit addressing, add 400001 to the standard database addresses.

In Table E.17, the command response is identical to the command request.

**Table E.17 06h Preset Single Register Command**

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (06h)
2 bytes	Register Address
2 bytes	Data
2 bytes	CRC-16

Table E.18 shows responses to 06h query errors.

**Table E.18 Device Responses to 06h Preset Single Register Query Errors**

Error	Error Code Returned	Communication Counter Increments
Illegal register address	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal register value	Illegal Data Value (03h)	Illegal Write
Format error	Illegal Data Value (03h)	Bad Packet Format
Device Error	Invalid Access Level (04h)	None

## 10h Preset Multiple Registers Command

This function code works similarly to code 06h, except that it allows as many as 100 writes (per operation) to registers. Refer to the Modbus Register Map, Control I/O Commands, in *Table E.26* for a list of registers that remote devices can write to using this function code. If you are accustomed to 4X references with the function code, for six-digit addressing, simply add 400001 to the standard database addresses.

**Table E.19 10h Preset Multiple Registers Command**

Bytes	Field
Requests from the master must have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers to Write
1 byte	Bytes of Data ( <i>n</i> )
<i>n</i> bytes	Data
2 bytes	CRC-16
A successful response from the slave will have the following format:	
1 byte	Slave Address
1 byte	Function Code (10h)
2 bytes	Starting Address
2 bytes	Number of Registers
2 bytes	CRC-16

*Table E.20* shows responses to 10h query errors.

**Table E.20 Device Responses to 10h Preset Multiple Registers Query Errors**

Error	Error Code Returned	Communication Counter Increments
Illegal register to set	Illegal Data Address (02h)	Invalid Address Illegal Write
Illegal number of registers to set	Illegal Data Value (03h)	Illegal Register Illegal Write
Incorrect number of bytes in query data region	Illegal Data Value (03h)	Bad Packet Format Illegal Write
Invalid register data value	Illegal Data Value (03h)	Illegal Write

## Modbus Password Control and Parameter Modification

The SEL-735 parameters MID, TID, Password, Device Time, and the User Map Registers are settable via Modbus. Any settable parameter or reset that requires a valid password write will time out 15 minutes after the last valid write to any of these restricted registers.

Writing the password for access level change requires the 10h (preset multiple register) command. Using this command, remote devices can write new passwords one register at a time. The meter returns an error during setting saves if the meter is disabled or when settings are being changed from another port. It also returns a device error for attempts to write to settable values if the access level has not been changed.

To enable modification of the settable parameters, remote devices must write a valid Access Level E (EAC) password to the password registers using function code 10h. Note that changing the password changes the password for all ports.

Once you have written a valid password, change the values by using standard single or multiple register writes (06h or 10h). Until you issue a save or discard settings command, the value the device returns when reading the settable parameter registers is a temporary copy.

To save the modified parameters, write a 0x0001 to the Save Settings register of the Control I/O region. This is the only method by which you can save the changes.

To discard settings, either write a 0x0001 to the Discard Settings Changes register of the Control I/O region, write a 0x0001 to the Drop Access Level register of the Control I/O region, or wait 15 minutes since last write for access level time-out.

## Modbus Sequential Event Recorder Register Operation

You can read the Sequential Event Recorder through Modbus communications channels. The Modbus register Selected Starting Record sets the starting record to read from the device.

Certain SER Modbus registers use enumerations. See *Table E.25* for the definitions.

To obtain SER records from the Modbus register map, perform the following steps.

Step 1. Write to the Selected Starting Record (address 216) register of the SER region of the map the date and time of the first record you want.

Step 2. Read the Number of Records Available register to determine how many SER records are available on or after the selected date and time.

Ten records are available for reading from the SER region of the map.

Step 3. Write to the Selected Starting Record register to select additional records from the number available.

For example, if the number of records available is 25, write 11 to the selected starting record to read records 11 to 20.

## Modbus Load Profile Register Operation

You can read load profile recorders through Modbus communications channels. The Modbus register Select Load Profile Recorder sets the LDP recorder from which the device will read. By default, the register is set to one, which selects LDP recorder 1. You can also read the status of each load profile record.

Certain load profile registers are enumerated and bitmapped. See *Table E.25* and *Table E.26* for the definitions.

To read load profile data from the SEL-735, perform the following steps.

- Step 1. If reading an SEL-735 that supports as many as 12 independent LDP recorders, set the LDP recorder you want to read from. If reading an SEL-735 that supports only one LDP recorder, skip to Step 2.

Write the LDP recorder number to the Select Load Profile Recorder register (address 5000). For example, to read LDP recorder 12, write 12 to the register.

- Step 2. Read the LDP selected recorder channel name registers from the Load Profile section of the Modbus map. These register addresses range from 5020 to 5170.

These names return as a NULL-terminated ASCII string and provides the human-readable label for the profiled data. If the load profile channel is unused, then the associated label is an empty string.

- Step 3. Write to the Starting Record Time/Date registers of the Load Profile region of the map the date and time for the first record you want. The Starting Record register addresses range from 5180 to 5185.

- Step 4. Read Record 1 Channel *n* Data registers to get the value of the first record of the selected LDP recorder, where *n* is your desired channel number selection from 1 through 16. The Record 1 Channel *n* Data register addresses range from 5193 to 5223.

As many as 100 records are available on or after the selected date and time. Channels that are not profiling data return a reserved value when you read them (see *Table E.22*).

- Step 5. Read the remaining records from the selected LDP recorder. The Record 2–100 register addresses range from 5225 to 9085.

## Modbus TCP

Modbus TCP is available over Ethernet, SEL-735 Port 1, TCP Port 502. Determine appropriate Ethernet port settings (i.e., IP, Default Router, and Subnet Mask) for your network. The SEL-735 Ethernet port supports five simultaneous Modbus sessions.

*Table E.21* defines the specific format of Modbus TCP messages.

**Table E.21 Modbus TCP Message Format**

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
TIDU	TIDL	PIDU	PIDL	LENU	LENL	UNITID	FC	DATA

Table E.22 defines the quantities of the Modbus TCP message shown in Table E.21.

**Table E.22 Modbus TCP Message Format Definitions**

Field	Definition	Server Action	Notes
TIDU	Transaction Identifier Upper	Copied into response	
TIDL	Transaction Identifier Lower	Copied into response	
PIDU	Protocol Identifier Upper	Copied into response	Always zero
PIDL	Protocol Identifier Lower	Copied into response	Always zero
LENU	Data Length Upper	Copied into response	Always zero (messages are less than 256 bytes)
LENL	Data Length Lower	Length of response data in bytes	
UNITID	Unit Identifier	Copied into response	
FC	Function Code	Copied into response if no error, high bit set if error condition	Follows Modbus TRU rules
DATA	Response Data	The request data or error code	

## Modbus Data Types

Table E.23 shows the data types that the SEL-735 supports. Each Modbus register is 2 bytes long, 16 bits. Data types that require more than 2 bytes use more than one register. For example, STRING data types use many registers to represent the string value. The Meter Identifier string includes 11 registers.

**Table E.23 Modbus Data Types**

Conversion <sup>a</sup>	Description	Range	Number of Registers Used
INT	Integer, signed	-32767 to 32767	1
INT <sub>x</sub>	Integer, signed with scale factor <i>x</i>	-32767 to 32767	1
UINT	Integer, unsigned	0 to 65535	1
UNIT <sub>x</sub>	Integer, unsigned with scale factor <i>x</i>	0 to 65535	1
LONG	Long, signed	-2147483647 to 2147483647	2
LONG <sub>y</sub>	Long, signed with scale factor <i>y</i>	-2147483647 to 2147483647	2
BITMAP	Bitmapped value. Represents binary data.	0 to 65535	1
ENUM	Enumerated value. See Table E.24 for definitions.	0 to 65535	1
STRING	A null-terminated ASCII string	ASCII characters	Variable

<sup>a</sup> Replace *x* with 10, 100, or 1000. Replace *y* with 10, 100, 1000, or 10000.

## Modbus Enumerated Registers (ENUM)

Some Modbus registers include enumerations that use a value to convey specific data. *Table E.24* shows the enumerated Modbus registers and the definitions of each.

**Table E.24 Modbus Enumeration Definitions**

Enumerated Registers	Register Addresses	Value	Definition
Meter Form	62	0	Meter Form 9
		1	Meter Form 5
		2	Meter Form 36
BATT, TEMP, Diagnostic status	180, 181	0	OK
		1	WARN
		2	FAIL
Time Source	206	0	Internal
		1	External
Selected record: Type	218	0	Device settings changed
		1	Power restored
		2	Power loss
		3	Manual time change occurred
		4	Automatic daylight-saving time change occurred
		0x1yyy	Device Word bit yyy deasserted, yyy is the Device Word bit number
		0x2yyy	Device Word bit yyy asserted, yyy is the Device Word bit number
		0x8000	Invalid record
Selected recorder channel function LDFUNC	5002	0	End of Interval (EOI)
		1	Average (AVG)
		2	Change Over Interval (COI)
		3	Maximum During Interval (MAX)
		4	Minimum During Interval (MIN)

## Modbus Bitmapped Registers (BITMAP)

Some Modbus registers use bitmaps to convey specific data. Bitmapped registers are different from enumerated registers in that each bit has a specific definition, while enumerated register values contain the definition.

**Table E.25 Modbus BITMAP Definitions**

Enumerated Registers	Register Addresses	Bit	Definition
Record <i>n</i> : Status	5186...	0	Daylight-saving time in effect
		1	Power loss during the interval
		2	Time set forward
		3	Time set backward
		4	Skipped interval
		5	Test mode active during interval
Device Word bit status	100–149	N/A	Each register contains one Device Word bit row, located in the most significant byte of the register.

# Modbus Register Map

Table E.26 shows each Modbus register address, the register name, any notes pertaining to the register, the read/write access, and the data type of the register.

**Table E.26 Modbus Register Map (Sheet 1 of 10)**

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
<b>Device Configuration</b>					
0–19	0000–0013	Firmware Identifier	SEL FID String	R	STRING
20–39	0014–0027	Serial Number	Meter ID String	R	STRING
40–50	0028–0032	Meter Identifier		RW	STRING
51–61	0033–003D	Terminal Identifier		RW	STRING
62	003E	Meter Form		R	ENUM
63–64	003F–0040	Current Transformer Ratio		R	LONG10000
65–66	0041–0042	Neutral Current Transformer Ratio		R	LONG10000
67–68	0043–0044	Potential Transformer Ratio		R	LONG 10000
69	0045	Reserved		R	UINT
<b>Control and I/O Commands</b>					
70–74	0046–004A	Password		W	STRING
75	004B	Drop Access Level		W	UINT
76	004C	Save Settings		W	UINT
77	004D	Discard Settings Changes		W	UINT
78	004E	Reset Communication Counters		W	UINT
79	004F	Reset Max/Min Values		W	UINT
80	0050	Reset Peak Demand		W	UINT
81	0051	Reserved		R	UINT
<b>Status</b>					
100–149	0064–0095	Device Word Bit Status		R	BITMAP
150–159	0096–009F	Reserved		R	UINT
<b>Communication Counters</b>					
160	00A0	Num Msgs Rx		R	UINT
161	00A1	Num Msgs Sent to Other Devices		R	UINT
162	00A2	Invalid Address		R	UINT
163	00A3	Bad CRC		R	UINT
164	00A4	UART ERROR		R	UINT
165	00A5	Illegal Function or Op code		R	UINT
166	00A6	Illegal Register		R	UINT
167	00A7	Illegal Write		R	UINT
168	00A8	Bad Packet Format		R	UINT
169	00A9	Bad Packet Length		R	UINT
170–179	00AA–00B3	Reserved		R	UINT

**Table E.26 Modbus Register Map (Sheet 2 of 10)**

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
<b>Diagnostics</b>					
180	00B4	BATT		R	ENUM
181	00B5	TEMP		R	ENUM
182	00B6	Reserved		R	UINT
<b>Time</b>					
200	00C8	Present Device Time: Seconds		RW	UINT
201	00C9	Present Device Time: Minutes		RW	UINT
202	00CA	Present Device Time: Hours		RW	UINT
203	00CB	Present Device Time: Day		RW	UINT
204	00CC	Present Device Time: Month		RW	UINT
205	00CD	Present Device Time: Year		RW	UINT
206	00CE	Time Source		R	ENUM
207–209	00CF–00D1	Reserved		R	UINT
<b>Sequential Events Recorder</b>					
210	00D2	Start Record: Seconds		RW	UINT
211	00D3	Start Record: Minutes		RW	UINT
212	00D4	Start Record: Hours		RW	UINT
213	00D5	Start Record: Day		RW	UINT
214	00D6	Start Record: Month		RW	UINT
215	00D7	Start Record: Year		RW	UINT
216	00D8	Selected Starting Record		RW	UINT
217	00D9	Number of Records Available		R	UINT
218	00DA	Start Record: Type		R	ENUM
219	00DB	Start Record: Milliseconds		R	UINT
220	00DC	Start Record: Minutes		R	UINT
221	00DD	Start Record: Hours		R	UINT
222	00DE	Start Record: Day		R	UINT
223	00DF	Start Record: Month		R	UINT
224	00E0	Start Record: Year		R	UINT
225–231	00FF–00E7	Selected Record + 1			
232–238	00E8–00EE	Selected Record + 2			
239–245	00EF–00F5	Selected Record + 3			
246–252	00F6–00FC	Selected Record + 4			
253–259	00FD–0103	Selected Record + 5			
260–266	0104–010A	Selected Record + 6			
267–273	010B–0111	Selected Record + 7			
274–280	0112–0118	Selected Record + 8			
281–287	0119–011F	Selected Record + 9			
288–349	0120–015D	Reserved		R	UINT

**Table E.26 Modbus Register Map (Sheet 3 of 10)**

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
<b>Voltage, Current, and Power</b>					
350–351	015E–015F	IA		R	LONG100
352–353	0160–0161	IB		R	LONG100
354–355	0162–0163	IC		R	LONG100
356–357	0164–0165	IN		R	LONG100
358–359	0166–0167	VA		R	LONG100
360–361	0168–0169	VC		R	LONG100
362–363	016A–016B	VB		R	LONG100
364–365	016C–016D	VAB		R	LONG100
366–367	016E–016F	VBC		R	LONG100
368–369	0170–0171	VCA		R	LONG100
370–371	0172–0173	W3		R	LONG100
372–373	0174–0175	U3		R	LONG100
374–375	0176–0177	Q3		R	LONG100
376–377	0178–0179	WA		R	LONG100
378–379	017A–017B	WB		R	LONG100
380–381	017C–017D	WC		R	LONG100
382–383	017E–017F	UA		R	LONG100
384–385	0180–0181	UB		R	LONG100
386–387	0182–0183	UC		R	LONG100
388–389	0184–0185	QA		R	LONG100
390–391	0186–0187	QB		R	LONG100
392–393	0188–0189	QC		R	LONG100
394–399	018A–018F	Reserved		R	UINT
<b>Demand–Present Interval</b>					
400–401	0190–0191	WD3_DEL		R	LONG100
402–403	0192–0193	WD3_REC		R	LONG100
404–405	0194–0195	UD3_DEL		R	LONG100
406–407	0196–0197	UD3_REC		R	LONG100
408–409	0198–0199	QD3_DEL		R	LONG100
410–411	019A–019B	QD3_REC		R	LONG100
412–413	019C–019D	IDA		R	LONG100
414–415	019E–019F	IDB		R	LONG100
416–417	01A0–01A1	IDC		R	LONG100
418–419	01A2–01A3	IDN		R	LONG100
420–421	01A4–01A5	3I0D		R	LONG100
422–423	01A6–01A7	3I2D		R	LONG100
424–425	01A8–01A9	WDA_DEL		R	LONG100
426–427	01AA–01AB	WDB_DEL		R	LONG100
428–429	01AC–01AD	WDC_DEL		R	LONG100

**Table E.26 Modbus Register Map (Sheet 4 of 10)**

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
430-431	01AE-01AF	WDA_REC		R	LONG100
432-433	01B0-01B1	WDB_REC		R	LONG100
434-435	01B2-01B3	WDC_REC		R	LONG100
436-437	01B4-01B5	UDA_DEL		R	LONG100
438-489	01B6-01B7	UDB_DEL		R	LONG100
440-441	01B8-01B9	UDC_DEL		R	LONG100
442-443	01BA-01BB	UDA_REC		R	LONG100
444-445	01BC-01BD	UDB_REC		R	LONG100
446-447	01BE-01BF	UCD_REC		R	LONG100
448-449	01C0-01C1	QDA_DEL		R	LONG100
450-451	01C2-01C2	QDB_DEL		R	LONG100
452-453	01C6-01C7	QDC_REC		R	LONG100
454-455	01C8-01C9	QDA_REC		R	LONG100
456-457	01C8-01C9	QDB_REC		R	LONG100
458-459	01CA-01CB	QDC_REC		R	LONG100
460-461	01CC-01CD	QD3_DEL_LG		R	LONG100
462-463	01CD-01CF	QD3_DEL_LD		R	LONG100
464-465	01D0-01D1	QD3_REC_LG		R	LONG100
466-467	01D2-01D3	QD3_REC_LD		R	LONG100
468-469	01D4-01D5	QDA_DEL_LG		R	LONG100
470-471	01D6-01D7	QDA_DEL_LD		R	LONG100
472-473	01D8-01D9	QDA_REC_LG		R	LONG100
474-475	01DA-01DB	QDA_REC_LD		R	LONG100
476-477	01DC-01DD	QDB_DEL_LG		R	LONG100
478-479	01DE-01DF	QDB_DEL_LD		R	LONG100
480-481	01E0-01E1	QDB_REC_LG		R	LONG100
482-483	01E2-01E3	QDB_REC_LD		R	LONG100
484-485	01E4-01E5	QDC_DEL_LG		R	LONG100
486-487	01E6-01E7	QDC_DEL_LD		R	LONG100
488-489	01E8-01E9	QDC_REC_LG		R	LONG100
490-491	01EA-01EB	QDC_REC_LD		R	LONG100
492-499	01EC-01ED	Reserved		R	UINT
<b>Demand-Peak</b>					
500-501	01F4-01F5	WP3_DEL		R	LONG100
502-503	01F6-01F7	WP3_REC		R	LONG100
504-505	01F8-01F9	UP3_DEL		R	LONG100
506-507	01FA-01FB	UP3_REC		R	LONG100
508-509	01FC-01FD	QP3_DEL		R	LONG100
510-511	01FE-01FF	QP3_REC		R	LONG100
512-513	0200-0201	IDA		R	LONG100

**Table E.26 Modbus Register Map (Sheet 5 of 10)**

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
514–515	0202–0203	IDB		R	LONG100
516–517	0204–0205	IDC		R	LONG100
518–519	0206–0207	IDN		R	LONG100
520–521	0208–0209	3I0P		R	LONG100
522–523	020A–200B	3I2P		R	LONG100
524–525	020C–020D	WPA_DEL		R	LONG100
527–527	020E–020F	WPB_DEL		R	LONG100
528–529	0210–0211	WPC_DEL		R	LONG100
530–531	0212–0213	WPA_REC		R	LONG100
532–533	0214–0215	WPB_REC		R	LONG100
534–535	0216–0217	WPC_REC		R	LONG100
536–537	0218–0219	UPA_DEL		R	LONG100
538–539	021A–021B	UPB_DEL		R	LONG100
540–541	021C–021D	UPC_DEL		R	LONG100
542–543	021E–021F	UPA_REC		R	LONG100
544–545	0220–0221	UPB_REC		R	LONG100
546–547	0222–0223	UPC_REC		R	LONG100
548–549	0224–0225	QPA_DEL		R	LONG100
550–551	0226–0227	QPB_DEL		R	LONG100
552–553	0228–0229	QPC_DEL		R	LONG100
554–555	022A–022B	QPA_REC		R	LONG100
556–557	022C–022D	QPB_REC		R	LONG100
558–559	022E–022F	QPC_REC		R	LONG100
560–561	0230–0231	QP3_DEL_LG		R	LONG100
562–563	0232–0233	QP3_DEL_LD		R	LONG100
564–565	0234–0235	QP3_REC_LG		R	LONG100
566–567	0236–0237	QP3_REC_LD		R	LONG100
568–569	0238–0239	QPA_DEL_LG		R	LONG100
570–571	023A–023B	QPA_DEL_LD		R	LONG100
572–573	023C–023D	QPA_REC_LG		R	LONG100
574–575	023E–023F	QPA_REC_LD		R	LONG100
576–577	0240–0241	QPB_DEL_LG		R	LONG100
578–579	0242–0243	QPB_DEL_LD		R	LONG100
580–581	0244–0245	QPB_REC_LG		R	LONG100
582–583	0246–0247	QPB_REC_LD		R	LONG100
584–585	0248–0249	QPC_DEL_LG		R	LONG100
586–587	024A–024B	QPC_DEL_LD		R	LONG100
588–589	024C–024D	QPC_REC_LG		R	LONG100
590–591	024E–024F	QPC_REC_LD		R	LONG100
592–599	0250–0257	Reserved		R	UINT

**Table E.26 Modbus Register Map (Sheet 6 of 10)**

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
<b>Energy</b>					
600–601	0258–0259	WH3_DEL		R	LONG
602–603	025A–025B	WH3_REC		R	LONG
604–605	025C–025D	UH3_DEL		R	LONG
606–607	025E–025F	UH3_REC		R	LONG
608–609	0260–0261	QH3_DEL		R	LONG
610–611	0262–0263	QH3_REC		R	LONG
612–613	0264–0265	WHA_DEL		R	LONG
614–615	0266–0267	WHB_DEL		R	LONG
616–617	0268–0269	WHC_DEL		R	LONG
618–619	026A–026B	WHA_REC		R	LONG
620–621	026C–026D	WHB_REC		R	LONG
622–623	026E–026F	WHC_REC		R	LONG
624–625	0270–0271	WHA_NET		R	LONG
626–627	0272–0273	WHB_NET		R	LONG
628–629	0274–0275	WHC_NET		R	LONG
630–631	0276–0277	WH3_NET		R	LONG
632–633	0278–0279	UHA_DEL		R	LONG
634–635	027A–027B	UHB_DEL		R	LONG
636–637	027C–027D	UHC_DEL		R	LONG
638–639	027E–027F	UHA_REC		R	LONG
640–641	0280–0281	UHB_REC		R	LONG
642–643	0282–0283	UHC_REC		R	LONG
644–645	0284–0285	QHA_DEL		R	LONG
646–647	0286–0287	QHB_DEL		R	LONG
648–649	0288–0289	QHC_DEL		R	LONG
650–651	028A–028B	QHA_REC		R	LONG
652–653	028C–028D	QHB_REC		R	LONG
654–655	028E–028F	QHC_REC		R	LONG
656–657	0290–0291	QH3_DEL_LG		R	LONG
658–659	0292–0293	QH3_DEL_LD		R	LONG
660–661	0294–0295	QH3_REC_LG		R	LONG
662–663	0269–0297	QH3_REC_LD		R	LONG
664–665	0298–0299	QHA_DEL_LG		R	LONG
666–667	029A–029B	QHA_DEL_LD		R	LONG
668–669	029C–029D	QHA_REC_LG		R	LONG
670–671	029E–029F	QHA_REC_LD		R	LONG
672–673	02A0–02A1	QHB_DEL_LG		R	LONG
674–675	02A2–02A3	QHB_DEL_LD		R	LONG
676–677	02A4–02A5	QHB_REC_LG		R	LONG

**Table E.26 Modbus Register Map (Sheet 7 of 10)**

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
678–679	02A6–02A7	QHB_REC_LD		R	LONG
680–681	02A8–02A9	QHC_DEL_LG		R	LONG
682–683	02AA–02AB	QHC_DEL_LD		R	LONG
684–684	02AC–02AD	QHC_REC_LG		R	LONG
686–687	02AE–02AF	QHC_REC_LD		R	LONG
688–689	02B0–02B1	VHA		R	LONG
690–691	02B2–02B3	VHB		R	LONG
692–693	02B4–02B5	VHC		R	LONG
694–695	02B6–02B7	VH3		R	LONG
696–697	02B8–02B9	IHA		R	LONG
698–699	02BA–02BB	IHB		R	LONG
700–701	02BC–02BD	IHC		R	LONG
702–703	02BE–02BF	IHN		R	LONG
704–705	02C0–02C1	IH3		R	LONG
706–899	02C2–0383	Reserved		R	UINT
<b>Frequency</b>					
900	0384	FREQ		R	UINT100
901	0385	FREQ_PQ		R	UINT100
902–909	0386–038D	Reserved		R	UINT
<b>Power Factor</b>					
910	038F	PF3		R	INT100
911	038F	PFT3		R	INT100
912	0390	PFDA		R	INT100
913	0391	PFDB		R	INT100
914	0392	PFDC		R	INT100
915	0393	LDPFDA		R	UINT
916	0394	LDPFDB		R	UINT
917	0395	LDPFDC		R	UINT
918	0396	LDPFD3		R	UINT
919	0397	PFTA		R	INT100
920	0398	PFTB		R	INT100
921	0399	PFTC		R	INT100
922	039A	LDPFTA		R	UINT
923	039B	LDPFTB		R	UNIT
924	039C	LDPFTC		R	UINT
925	039D	LDPFT3		R	UINT
926–999	039E–03E7	Reserved		R	UINT

**Table E.26 Modbus Register Map (Sheet 8 of 10)**

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
<b>Configured Registers</b>					
1000–1001	03E8–03E9	CFG0001		R	LONG
1002–2997	03EA–0BB5	CFG0002–CFG0999		R	LONG
2998–2999	0BB6–0BB7	CFG1000		R	LONG
3000–3999	0BB8–0F9F	Reserved		R	UINT
<b>Fundamental-Only Voltage, Current, and Power</b>					
4000–4001	0FA0–0FA1	IA_MAG		R	LONG100
4002–4003	0FA2–0FA3	IB_MAG		R	LONG100
4004–4005	0FA4–0FA5	IC_MAG		R	LONG100
4006–4007	0FA6–0FA7	IN_MAG		R	LONG100
4008–4009	0FA8–0FA9	VA_MAG		R	LONG100
4010–4011	0FAA–0FAB	VB_MAG		R	LONG100
4012–4013	0FAC–0FAD	VC_MAG		R	LONG100
4014–4015	0FAE–0FAF	VAB_MAG		R	LONG100
4016–4017	0FB0–0FB1	VBC_MAG		R	LONG100
4018–4019	0FB2–0FB3	VCA_MAG		R	LONG100
4020–4021	0FB4–0FB5	IA_ANG		R	LONG100
4022–4023	0FB6–0FB7	IB_ANG		R	LONG100
4024–4025	0FB8–0FB9	IC_ANG		R	LONG100
4026–4027	0FBA–0FBB	IN_ANG		R	LONG100
4028–4029	0FBC–0FBD	VA_ANG		R	LONG100
4030–4031	0FBE–0FBF	VB_ANG		R	LONG100
4032–4033	0FC0–0FC1	VC_ANG		R	LONG100
4034–4035	0FC2–0FC3	VAB_ANG		R	LONG100
4036–4037	0FC4–0FC5	VBC_ANG		R	LONG100
4038–4039	0FC6–0FC7	VCA_ANG		R	LONG100
4040–4041	0FC8–0FC9	W3_FUND		R	LONG100
4042–4043	0FCA–0FCB	S3_FUND		R	LONG100
4044–4045	0FCC–0FCD	Q3_FUND		R	LONG100
4046–4047	0FCE–0FCF	WA_FUND		R	LONG100
4048–4049	0FD0–0FD1	WB_FUND		R	LONG100
4050–4051	0FD2–0FD3	WC_FUND		R	LONG100
4052–4053	0FD4–0FD5	SA_FUND		R	LONG100
4054–4055	0FD6–0FD7	SB_FUND		R	LONG100
4056–4057	0FD8–0FD9	SC_FUND		R	LONG100
4058–4059	0FDA–0FDB	QA_FUND		R	LONG100
4060–4061	0FDC–0FDD	QB_FUND		R	LONG100
4062–4063	0FDE–0FDF	QC_FUND		R	LONG100
4064–4065	0FE0–0FE1	Q3_DEL_LG		R	LONG100
4066–4067	0FE2–0FE3	Q3_DEL_LD		R	LONG100

**Table E.26 Modbus Register Map (Sheet 9 of 10)**

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
4068–4069	0FE4–0FE5	Q3_REC_LG		R	LONG100
4070–4071	0FE6–0FE7	Q3_REC_LD		R	LONG100
4072–4073	0FE8–0FE9	QA_DEL_LG		R	LONG100
4074–4075	0FEA–0FEB	QA_DEL_LD		R	LONG100
4076–4077	0FEC–0FED	QA_REC_LG		R	LONG100
4078–4079	0FEE–0FEF	QA_REC_LD		R	LONG100
4080–4081	0FF0–0FF1	QB_DEL_LG		R	LONG100
4082–4083	0FF2–0FF3	QB_DEL_LD		R	LONG100
4084–4085	0FF4–0FF5	QB_REC_LG		R	LONG100
4086–4087	0FF6–0FF7	QB_REC_LD		R	LONG100
4088–4089	0FF8–0FF9	QC_DEL_LG		R	LONG100
4090–4091	0FFA–0FFB	QC_DEL_LD		R	LONG100
4092–4093	0FFC–0FFD	QC_REC_LG		R	LONG100
4094–4095	0FFE–0FFF	QC_REC_LD		R	LONG100
4096–4999	1000–1387	Reserved		R	UINT
<b>Load Profile</b>					
5000	1388	Select Load Profile Recorder		RW	UINT
5001	1389	Selected Recorder Interval Duration (seconds)		R	UINT
5002	138A	Selected Recorder Channel Function		R	ENUM
5003–5019	138B–0139B	Reserved		R	UINT
5020–5029	139C–13A5	LDP Selected Recorder Channel 1 Name		R	STRING
5030–5039	13A6–13AF	LDP Selected Recorder Channel 2 Name		R	STRING
5040–5049	13B0–13B9	LDP Selected Recorder Channel 3 Name		R	STRING
5050–5059	13BA–13C3	LDP Selected Recorder Channel 4 Name		R	STRING
5060–5069	13C4–13CD	LDP Selected Recorder Channel 5 Name		R	STRING
5070–5079	13CE–13D7	LDP Selected Recorder Channel 6 Name		R	STRING
5080–5089	13D8–13E1	LDP Selected Recorder Channel 7 Name		R	STRING
5090–5099	13E2–13EB	LDP Selected Recorder Channel 8 Name		R	STRING
5100–5109	13EC–13F5	LDP Selected Recorder Channel 9 Name		R	STRING
5110–5119	13F6–13FF	LDP Selected Recorder Channel 10 Name		R	STRING
5120–5129	1400–1409	LDP Selected Recorder Channel 11 Name		R	STRING
5130–5139	140A–1413	LDP Selected Recorder Channel 12 Name		R	STRING
5140–5149	1414–141D	LDP Selected Recorder Channel 13 Name		R	STRING
5150–5159	141E–1427	LDP Selected Recorder Channel 14 Name		R	STRING
5160–5169	1428–1431	LDP Selected Recorder Channel 15 Name		R	STRING
5170–5179	1432–143B	LDP Selected Recorder Channel 16 Name		R	STRING
5180	143C	Starting Record: Seconds		RW	UINT
5181	143D	Starting Record: Minutes		RW	UINT
5182	143E	Starting Record: Hours		RW	UINT
5183	143F	Starting Record: Day		RW	UINT

**Table E.26 Modbus Register Map (Sheet 10 of 10)**

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
5184	1440	Starting Record: Month		RW	UINT
5185	1441	Starting Record: Year		RW	UINT
5186	1442	Record 1: Status		R	BITMAP
5187	1443	Record 1: Seconds		R	UINT
5188	1444	Record 1: Minutes		R	UINT
5189	1445	Record 1: Hours		R	UINT
5190	1446	Record 1: Day		R	UINT
5191	1447	Record 1: Month		R	UINT
5192	1448	Record 1: Year		R	UINT
5193–5194	1449–144A	Record 1: Channel 1 Data		R	LONG100
5195–5196	144B–144C	Record 1: Channel 2 Data		R	LONG100
5197–5198	144D–144E	Record 1: Channel 3 Data		R	LONG100
5199–5200	144F–1450	Record 1: Channel 4 Data		R	LONG100
5201–5202	1451–1452	Record 1: Channel 5 Data		R	LONG100
5203–5204	1453–1454	Record 1: Channel 6 Data		R	LONG100
5205–5206	1455–1456	Record 1: Channel 7 Data		R	LONG100
5207–5208	1457–1458	Record 1: Channel 8 Data		R	LONG100
5209–5210	1459–1460	Record 1: Channel 9 Data		R	LONG100
5211–5212	145B–145C	Record 1: Channel 10 Data		R	LONG100
5213–5214	145D–145E	Record 1: Channel 11 Data		R	LONG100
5215–5216	145F–1460	Record 1: Channel 12 Data		R	LONG100
5217–5218	1461–1462	Record 1: Channel 13 Data		R	LONG100
5219–5220	1463–1464	Record 1: Channel 14 Data		R	LONG100
5221–5222	1465–1466	Record 1: Channel 15 Data		R	LONG100
5223–5224	1467–1468	Record 1: Channel 16 Data		R	LONG100
5225–9085	1469–237D	Record 2–100			
9086–9099	237E–238B	Reserved		R	UINT
<b>User-Mapped Registers</b>					
9100–9224	238C–2408	Mapped Register		RW	UINT
9225–9349	2409–2485	Mapped Register Value		R	UINT
9350–65535	2486–FFFF	Reserved		R	UINT

# Appendix F

## MIRRORED BITS Communications

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### Overview

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MIRRORED BITS<sup>®</sup> communications is a direct meter-to-meter communications protocol that allows meters to exchange information quickly and securely, and with minimal expense.

The SEL-735 supports two MIRRORED BITS channels, differentiated by the channel specifiers A and B. Bits the device transmits are called TMB1 $x$ –TMB8 $x$ , where  $x$  is the channel specifier (e.g., A or B), and control for these bits comes from corresponding SELOGIC<sup>®</sup> control equations. Bits the device receives are called RMB1 $x$ –RMB8 $x$  and are usable as inputs to any SELOGIC control equations. Channel status bits are called ROK $x$ , RBAD $x$ , CBAD $x$  and LBOK $x$  and are also usable as inputs to any SELOGIC control equations. Further channel status information is available via the **COM** command. If both the A and B MIRRORED BITS channels are active, use the **COM A** or **COM B** commands to distinguish which channel the device displays.

### Operation

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#### Port Connections

See *Table 8.7*.

#### Message Formatting

MIRRORED BITS communications protocol options include MBA and MBB for standard MIRRORED BITS communications and MB8A/MB8B for special message formats necessary for radios and some CSU/DSU devices.

MIRRORED BITS communications messages consist of four characters or bytes. Each byte includes a start bit, six data bits, one parity bit, and one or two stop bits. The MBA/MBB settings protocol includes one stop bit, for a total of nine bits per character. The MB8 $n$  protocol setting includes two stop bits, for a total of 10 bits per character. Use the MB8 $n$  setting with communications channel equipment that counts bits and requires a 10-bit character.

#### Message Transmission

The SEL-735 transmits all messages without idle bits between characters. Idle bits may exist between messages.

- At 4800 baud, the device transmits one message each half power system cycle.
- At 9600 baud, the device transmits one message each quarter power system cycle.
- At 19200 and 38400 baud, the device transmits one message each quarter power system cycle.

## Message Decoding and Integrity Checks

The meter will deassert a user-accessible flag per channel (hereafter called ROK<sub>x</sub>) upon failing any of the following received-data checks:

- Parity, framing, or overrun errors
- Receive data redundancy error
- Receive message identification error
- No message received in the time three messages have been sent

While ROK<sub>x</sub> is deasserted, the meter will do the following:

1. Prevent transfer of new data from the pickup/dropout security counters following text describes. Instead, the meter sends one of the following user-selectable values (hereafter called default values) to the security counter inputs:
  - 1
  - 0
  - The last valid value

You can select one of the default values for each RMB.

2. Enter the synchronization process the following text describes.

The meter will assert ROK<sub>x</sub> only after successful synchronization (according to the following description) and two consecutive messages pass all of the data checks described previously. After ROK<sub>x</sub> reasserts, security counters (for which the following text provides descriptions) can delay passage of data the meter receives.

Transfer of received data to RMB<sub>1x</sub>–RMB<sub>8x</sub> receives supervision from eight user-programmable pickup/dropout security counters that you can set from 1 (allow every occurrence to pass) to at least 8 (require eight consecutive occurrences to pass). The pickup and dropout security count settings are separate.

A pickup/dropout security counter operates identically to a pickup/dropout timer, except that its setting occurs in counts of received messages instead of time. An SEL-735 communicating with another SEL-735 sends and receives MIRRORED BITS messages four times per power system cycle. Therefore, a security counter with a setting of two counts will delay by about a half power system cycle.

Things become more complicated when two meters with different processing rates are connected via MIRRORED BITS, as in the case of an SEL-321 communicating with an SEL-735. The SEL-321 processes power system information each eighth power system cycle, but processes the pickup/dropout security counters as it receives messages. Because the SEL-321 is receiving messages from the SEL-735, it will receive a message each quarter-cycle processing interval. Therefore, a counter set to two will again delay by about a half cycle. In that same example, however, a security counter set to two on the SEL-735 will delay by a quarter-cycle, because the SEL-735 is receiving new MIRRORED BITS messages each eighth cycle from the SEL-321.

## Synchronization

When a node detects a communications error, it deasserts ROK<sub>x</sub> and transmits an attention message, which includes the TX\_ID setting for that node.

When a node receives an attention message, it checks whether that message includes its TX\_ID.

If the attention message includes the node's own TX\_ID along with at least one other TX\_ID, the node transmits data.

If the message does not include the node's own TX\_ID, the node deasserts ROK<sub>x</sub>, includes its TX\_ID in the attention message, and transmits the new attention message.

If the node's own TX\_ID is the only TX\_ID the message includes, the meter assumes the message to be corrupt unless the loopback mode has been enabled. If loopback is not enabled, the node deasserts ROK<sub>x</sub> and transmits the attention message including its TX\_ID. If loopback is enabled, the meter transmits data.

In summary, when a node detects an error, it transmits an attention message until it receives an attention message that includes its own TX\_ID. If three or four meters are connected in a ring topology, the attention message will travel around the loop until the originating node receives it. The message then dies, and data transmission resumes.

This method of synchronization allows the meters to reliably determine the first byte of the message. It also forces resynchronization of unsynchronized universal asynchronous receiver/transmitters (UARTs). A disadvantage of this method is that it takes down the entire loop for a receive error at any node in the loop. This decreases availability also makes one-way communications impossible.

## Loopback Testing

Use the **LOOP** command to enable loopback testing.

While in loopback mode, ROK<sub>x</sub> is deasserted, and another user-accessible flag, LBOK<sub>x</sub>, asserts and deasserts according to received data checks.

## Channel Monitoring

Based on the results of data checks described previously, the meter collects information regarding the 255 most recent communications errors. Each record will contain at least the following fields:

- Dropout Time/Date
- Pickup Time/Date
- Time elapsed during dropout
- Reason for dropout (See *Message Decoding and Integrity Checks* on page F.2)

Use the **COM** command to generate a long or summary report of the communications errors.

There is only a single record for each outage, but an outage can evolve. For example, the initial cause could be a data disagreement, but framing errors can perpetuate the outage. If the channel is presently down, the COM record shows only the initial cause, but the COM summary displays the present cause of failure.

When the duration of an outage exceeds a user-settable threshold, the meter asserts a user-accessible flag called RBAD<sub>x</sub>.

You would typically combine RBAD<sub>x</sub> with other alarm conditions through use of SELOGIC control equations.

When channel unavailability exceeds a user-settable threshold, the meter asserts a user-accessible flag called CBAD<sub>x</sub>.

You would typically combine CBAD<sub>x</sub> with other alarm conditions through use of SELOGIC control equations.

# MIRRORED BITS Protocol for Pulsar 9600 Baud Modem

You can indicate that you want the device to use a Pulsar MBT modem by responding with an entry of MBT to the RTS/CTS setting prompt. When you select MBT, the device limits the baud rate setting to 9600 baud.

**NOTE:** The MBT mode will not work with PROTO = MB8A or MB8B.

**NOTE:** An idle processing interval guarantees at least 19 idle bits at 9600 baud in an SEL-735 with the system frequency at 65 Hz.

The MIRRORED BITS protocol compatible with the Pulsar MBT9600 modem is identical to the standard MIRRORED BITS protocol, with the following exceptions:

- The meter injects a delay (idle time) between messages. The length of the delay is one meter processing interval.
- The meter resets RTS (to a negative voltage at the EIA-232 connector) for MIRRORED BITS communications through use of this specification. The meter sets RTS (to a positive voltage at the EIA-232 connector) for MIRRORED BITS communications, using the R6 or original R version of MIRRORED BITS.

## Settings

Protocol (SEL, LMD, DNP, DNPE, MBA, MBB, MB8A, MB8B)      PROTO = MB8A      ?

Set PROTO = MBA or MB8A to enable the MIRRORED BITS protocol channel A on this port. Set PROTO = MBB or MB8B to enable the MIRRORED BITS protocol channel B on this port. The standard MIRRORED BITS protocols MBA and MBB use a 7-data bit format for data encoding. The MB8 protocols MB8A and MB8B use an 8-data bit format, which allows MIRRORED BITS to operate on communications channels for which an 8-data bit format is necessary. For the remainder of this section, We assume PROTO = MBA.

Baud Rate(300-38400)      SPEED = 9600      ?

Use the SPEED setting to control the rate at which the device transmits MIRRORED BITS messages, in power system cycles (~), based on *Table F.1*:

**Table F.1 Using the SPEED Setting to Control MIRRORED BIT Rates**

SPEED	SEL-321	SEL-735
38400	1 message per 1/8 cycle	1 message per 4 ms
19200	1 message per 1/8 cycle	1 message per 4 ms
9600	1 message per 1/4 cycle	1 message per 4 ms
4800	1 message per 1/2 cycle	1 message per 8 ms

Enable Hardware Handshaking(Y,N,MBT)      RTSCTS= N      ?

Use the MBT option if you are using a Pulsar MBT9600 baud modem. With this option set, the meter transmits a message every half power system cycle and deasserts the RTS signal on the EIA-232 connector. The meter also monitors the CTS signal on the EIA-232 connector, which the modem deasserts if the channel has too many errors. The modem uses the meter RTS signal to determine whether the meter is using the new or old MIRRORED BITS protocol.

---

Seconds to Mirrored Bits Rx Bad Pickup(1-10000)    RBADPU= 60    ?

---

Use the RBADPU setting to determine how long a channel error persists before the meter element RBADA asserts. RBADA deasserts upon channel error correction. RBADPU is accurate to  $\pm 1$  second.

---

PPM Mirrored Bits Channel Bad Pickup(1-10000)    CBADPU= 1000    ?

---

Use the CBADPU setting to determine the ratio of channel down-time to the total channel time before the meter element CBADA asserts. The calculation uses times available in the COM records. See the **COM** command in the instruction manual for a description of the COM records.

---

Mirrored Bits Receive Identifier(1-4)                    RXID = 1                    ?  
 Mirrored Bits Transmit Identifier(1-4)                TXID = 2                    ?

---

Set the RX\_ID of the local meter to match the TX\_ID of the remote meter. For example, in the three-terminal case, where Meter X transmits to Meter Y, Meter Y transmits to Meter Z, and Meter Z transmits to Meter X (see *Table F.2*).

**Table F.2 Matching RX\_ID of Local Meter to TX\_ID of Remote Meter**

	TX_ID	RX_ID
Meter X	1	3
Meter Y	2	1
Meter Z	3	2

---

Mirrored Bits Receive Default State(string of 1s, 0s or Xs)  
 87654321  
 RXDFLT=XXXXXXXX  
 ?

---

Use the RXDFLT setting to determine the default state the MIRRORED BITS should use in place of received data if the meter detects an error condition. The setting is a mask of 1s, 0s, and/or Xs (for RMB1A–RMB8A), where X represents the most recently received valid value.

---

Mirrored Bits RMB\_ Pickup Debounce msgs(1-8)                    RMB1PU= 1                    ?  
 Mirrored Bits RMB\_ Dropout Debounce msgs(1-8)                RMB1DO= 1                    ?  
 Mirrored Bits RMB\_ Pickup Debounce msgs(1-8)                    RMB2PU= 1                    ?  
 Mirrored Bits RMB\_ Dropout Debounce msgs(1-8)                RMB2DO= 1                    ?  
 Mirrored Bits RMB\_ Pickup Debounce msgs(1-8)                    RMB3PU= 1                    ?  
 Mirrored Bits RMB\_ Dropout Debounce msgs(1-8)                RMB3DO= 1                    ?  
 Mirrored Bits RMB\_ Pickup Debounce msgs(1-8)                    RMB4PU= 1                    ?  
 Mirrored Bits RMB\_ Dropout Debounce msgs(1-8)                RMB4DO= 1                    ?  
 Mirrored Bits RMB\_ Pickup Debounce msgs(1-8)                    RMB5PU= 1                    ?  
 Mirrored Bits RMB\_ Dropout Debounce msgs(1-8)                RMB5DO= 1                    ?  
 Mirrored Bits RMB\_ Pickup Debounce msgs(1-8)                    RMB6PU= 1                    ?  
 Mirrored Bits RMB\_ Dropout Debounce msgs(1-8)                RMB6DO= 1                    ?  
 Mirrored Bits RMB\_ Pickup Debounce msgs(1-8)                    RMB7PU= 1                    ?  
 Mirrored Bits RMB\_ Dropout Debounce msgs(1-8)                RMB7DO= 1                    ?  
 Mirrored Bits RMB\_ Pickup Debounce msgs(1-8)                    RMB8PU= 1                    ?  
 Mirrored Bits RMB\_ Dropout Debounce msgs(1-8)                RMB8DO= 1                    ?

---

Supervise the transfer of received data (or default data) to RMB1A–RMB8A with the MIRRORED BITS pickup and dropout security counters. Set the pickup and dropout counters individually for each bit.

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# Appendix G

## Analog Quantities and Device Word Bits

### Overview

The analog quantities are separated into several categories having similar quantities. Additionally, analog quantities are further divided into basic and advanced groups. *Table G.2–Table G.23* list all analog quantities available in the SEL-735 by category group.

### Internal Interfaces

*Table G.1* lists the available analog quantities available with each internal interface.

**Table G.1 Analog Quantities Available to Internal Interface Types** (Sheet 1 of 2)

Internal Interface Type	Available Analog Quantities
Configured Registers	All analog quantities except DATE, TIME, and DATE_TIME
Load Profile	Voltage, Current, and Power; Demand; Peak Demand; Previous Peak Demand; Energy; Configured Registers; Half-Cycle Fundamental Powers; Harmonics; Flicker; Measurement Aggregation; Frequency; Power Factor; Diagnostics; DNP Remote Analog Output Objects; Maximum/Minimum, Crest Factor Metering; Monthly Frizen/Consumed Values; SELOGIC; Symmetrical Components; Transformer Settings; Voltage and Current Imbalance and Average; Voltage and Frequency Deviation
Display Points	Voltage, Current, and Power; Demand; Peak Demand; Previous Peak Demand; Energy; Configured Registers; Half-Cycle Fundamental Powers; Harmonics; Flicker; Measurement Aggregation; Frequency; Power Factor; Diagnostics; DNP Remote Analog Output Objects; Maximum/Minimum, Crest Factor Metering; Monthly Frizen/Consumed Values; SELOGIC; Symmetrical Components; Transformer Settings; Voltage and Current Imbalance and Average; Voltage and Frequency Deviation; Date and Time: DATE, TIME, DATE_TIME; Present and Previous Time-of-Use (excludes self-reads)
Analog Outputs	Voltage, Current, and Power; Demand; Peak Demand; Previous Peak Demand; Energy; Configured Registers; Half-Cycle Fundamental Powers; Harmonics; Flicker; Measurement Aggregation; Frequency; Power Factor; Diagnostics; DNP Remote Analog Output Objects; Maximum/Minimum, Crest Factor Metering; Monthly Frizen/Consumed Values; SELOGIC; Symmetrical Components; Transformer Settings; Voltage and Current Imbalance and Average; Voltage and Frequency Deviation

**Table G.1 Analog Quantities Available to Internal Interface Types (Sheet 2 of 2)**

Internal Interface Type	Available Analog Quantities
SELOGIC <sup>a</sup>	Voltage, Current, and Power; Demand; Peak Demand; Previous Peak Demand; Energy; Configured Registers; Half-Cycle Fundamental Powers; Harmonics; Flicker; Measurement Aggregation; Frequency; Power Factor; Diagnostics; DNP Remote Analog Output Objects; Maximum/Minimum, Crest Factor Metering; Monthly Frizen/Consumed Values; SELOGIC; Symmetrical Components; Transformer Settings; Voltage and Current Imbalance and Average; Voltage and Frequency Deviation; Fundamental-Only Voltage, Current, and Power (excludes power); Date/Time (excludes DATE, TIME, and DATE_TIME)
KYZ Pulse Outputs	Energy
Predictive Demand	Demand

<sup>a</sup> We represent analog quantities in SELogic in secondary units. Unity scaling applies to power and energy quantities.

## External Interfaces

Analog quantities are available over the following communications channels.

- SEL-ASCII
- Compressed ASCII
- Fast Message
- Fast Meter Message
- Front-Panel HMI
- Modbus
- DNP3
- IEC 61850

## Analog Quantity Scaling

The SEL-735 supports analog quantity scaling in unity, kilo, or mega scales based the following settings.

- VOLT\_SCA – Voltage Scaling
- POWR\_SCA – Power Scaling
- ENRG\_SCA – Energy Scaling
- PRI\_SCA – Primary/Secondary Scaling

You can set the voltage, power, and energy scale factors to UNITY, KILO, or MEGA scales. For example, if you set VOLT\_SCA to KILO, then a primary value of 14,400 volts reports as 14.40 kV.

The SEL-735 allows you to scale analog quantities in either primary or secondary. The setting PRI\_SCA controls scaling of all analog quantities. Set PRI\_SCA = Y to scale analog quantities in primary units, and set PRI\_SCA = N to scale analog quantities in secondary units.

Analog Quantities used in the IEC 61850 interface are always in primary units, and scaling is as follows:

- Voltage, power (watts, VARs and VA), Vh, Wh, VAh and VARh are scaled in KILO scales
- All other quantities (including current and Ah) are scaled in unity scales

Analog quantities used in SELOGIC control equations are always in secondary units.

## Rollover

By default, energy analog quantities rollover at nine dials with two decimal places: 999999999.99. You can set configured registers with different rollover values, each unique to a particular configurable register.

# Basic Analog Quantity List

Table G.2–Table G.7 list the basic Analog Quantities. Where applicable, replace *x* with 3 to signify a three-phase quantity and A, B, or C to signify a single-phase quantity. You may use basic Analog Quantities in Load Profile Recorders, Display Points, Analog Outputs, and SELOGIC equations.

**Table G.2 Voltage, Current, and Power**

Name	Description	Units
<b>Current</b>		
I <sub>x</sub>	Phase A, B, or C RMS Current	Amps
I <sub>N</sub>	Neutral RMS Current	Amps
<b>Voltage</b>		
V <sub>x</sub>	Phase A, B, or C RMS Line-to-Neutral Voltage	Volts
V <sub>AB</sub> , V <sub>BC</sub> , V <sub>CA</sub>	Phase A-B, B-C, or C-A RMS Line-to-Line Voltage	Volts
<b>Power</b>		
W <sub>3</sub>	Three-phase Watts	Watts
W <sub>3_UC</sub> <sup>a</sup>	Three-phase Watts, uncompensated	Watts
U <sub>3</sub>	Three-phase apparent power	Volt-amps
Q <sub>3</sub>	Three-phase reactive power	Volt-amps reactive
Q <sub>3_UC</sub> <sup>a</sup>	Three-phase reactive power, uncompensated	Volt-amps reactive
<b>Power, More</b>		
W <sub>x</sub>	Phase A, B, or C Watts	Watts
W <sub>x_UC</sub> <sup>a</sup>	Phase A, B, or C Watts, uncompensated	Watts
U <sub>x</sub>	Phase A, B, or C apparent power	Volt-amps
Q <sub>x</sub>	Phase A, B, or C reactive power	Volt-amps reactive
Q <sub>x_UC</sub> <sup>a</sup>	Phase A, B, or C reactive power, uncompensated	Volt-amps reactive

<sup>a</sup> Uncompensated values are not affected by transformer/line loss compensation, regardless of whether ETLCC is set to Y or N.

**Table G.3 Demand, Peak Demand, Previous Demand (Sheet 1 of 4)**

Demand, Present Interval, Three Phase		
WD3_DEL	Watt demand, 3Φ delivered	Watts
WD3_DEL_UC <sup>a</sup>	Watt demand, 3Φ delivered, uncompensated	Watts
WD3_REC	Watt demand, 3Φ received	Watts
WD3_REC_UC <sup>a</sup>	Watt demand, 3Φ received, uncompensated	Watts
UD3_DEL	Volt-amp demand, 3Φ delivered	Volt-amps
UD3_REC	Volt-amp demand, 3Φ received	Volt-amps
QD3_DEL	Volt-amp reactive demand, 3Φ delivered	Volt-amps reactive

**Table G.3 Demand, Peak Demand, Previous Demand (Sheet 2 of 4)**

QD3_DEL_UC <sup>a</sup>	Volt-amp reactive demand, 3 $\Phi$ delivered, uncompensated	Volt-amperes reactive
QD3_REC	Volt-amp reactive demand, 3 $\Phi$ received	Volt-amperes reactive
QD3_REC_UC <sup>a</sup>	Volt-amp reactive demand, 3 $\Phi$ received, uncompensated	Volt-amperes reactive
<b>Demand, Present Interval, More, Current</b>		
IDx	Phase A, B, or C current demand	Amps
IDN	Neutral current demand	Amps
3I0D	Current demand, 3 $\Phi$ zero sequence	Amps
3I2D	Current demand, 3 $\Phi$ negative sequence	Amps
<b>Demand, Present Interval, More, Real Power</b>		
WDx_DEL	Phase A, B, or C watt demand, delivered	Watts
WDx_DEL_UC <sup>a</sup>	Phase A, B, or C watt demand, delivered, uncompensated	Watts
WDx_REC	Phase A, B, or C watt demand, received	Watts
WDx_REC_UC <sup>a</sup>	Phase A, B, or C watt demand, received, uncompensated	Watts
<b>Demand, Present Interval, More, Apparent Power</b>		
UDx_DEL	Phase A, B, or C apparent power demand, delivered	Volt-amperes
UDx_REC	Phase A, B, or C apparent power demand, received	Volt-amperes
<b>Demand, Present Interval, More, Reactive Power</b>		
QDx_DEL	Phase A, B, or C reactive power demand, delivered	Volt-amperes reactive
QDx_DEL_UC <sup>a</sup>	Phase A, B, or C reactive power demand, delivered, uncompensated	Volt-amperes reactive
QDx_REC	Phase A, B, or C reactive power demand, received	Volt-amperes reactive
QDx_REC_UC <sup>a</sup>	Phase A, B, or C reactive power demand, received, uncompensated	Volt-amperes reactive
<b>Demand, Present Interval, More, Reactive Power, 4-Quadrant</b>		
QDx_DEL_LG	Three-phase, Phase A, B, or C lagging reactive power demand, delivered (Quadrant 1)	Volt-amperes reactive
QDx_DEL_LG_UC <sup>a</sup>	Three-phase, Phase A, B, or C lagging reactive power demand, delivered (Quadrant 1), uncompensated	Volt-amperes reactive
QDx_DEL_LD	Three-phase, Phase A, B, or C leading reactive power demand, delivered (Quadrant 2)	Volt-amperes reactive
QDx_DEL_LD_UC <sup>a</sup>	Three-phase, Phase A, B, or C leading reactive power demand, delivered (Quadrant 2), uncompensated	Volt-amperes reactive
QDx_REC_LG	Three-phase, Phase A, B, or C lagging reactive power demand, received (Quadrant 3)	Volt-amperes reactive
QDx_REC_LG_UC <sup>a</sup>	Three-phase, Phase A, B, or C lagging reactive power demand, received (Quadrant 3), uncompensated	Volt-amperes reactive
QDx_REC_LD	Three-phase, Phase A, B, or C leading reactive power demand, received (Quadrant 4)	Volt-amperes reactive
QDx_REC_LD_UC <sup>a</sup>	Three-phase, Phase A, B, or C leading reactive power demand, received (Quadrant 4), uncompensated	Volt-amperes reactive
<b>Demand, Peak</b>		
WP3_DEL	Active power peak demand, 3 $\Phi$ delivered	Watts
WP3_DEL_UC <sup>a</sup>	Active power peak demand, 3 $\Phi$ delivered, uncompensated	Watts
WP3_REC	Active power peak demand, 3 $\Phi$ received	Watts
WP3_REC_UC <sup>a</sup>	Active power peak demand, 3 $\Phi$ received, uncompensated	Watts
UP3_DEL	Apparent power peak demand, 3 $\Phi$ delivered	Volt-amperes
UP3_REC	Apparent power peak demand, 3 $\Phi$ received	Volt-amperes

**Table G.3 Demand, Peak Demand, Previous Demand (Sheet 3 of 4)**

QP3_DEL	Reactive power peak demand, 3 $\Phi$ delivered	Volt-amps reactive
QP3_DEL_UC <sup>a</sup>	Reactive power peak demand, 3 $\Phi$ delivered, uncompensated	Volt-amps reactive
QP3_REC	Reactive power peak demand, 3 $\Phi$ received	Volt-amps reactive
QP3_REC_UC <sup>a</sup>	Reactive power peak demand, 3 $\Phi$ received, uncompensated	Volt-amps reactive
<b>Demand, Peak, More, Current</b>		
IPx	Phase A, B, or C current peak demand	Amps
IPN	Neutral current peak demand	Amps
3I0P	Current peak demand, 3 $\Phi$ zero sequence	Amps
3I2P	Current peak demand, 3 $\Phi$ negative sequence	Amps
<b>Demand, Peak, More, Real Power</b>		
WPx_DEL	Phase A, B, or C active power peak demand, delivered	Watts
WPx_REC	Phase A, B, or C active power peak demand, received	Watts
<b>Demand, Peak, More, Apparent Power</b>		
UPx_DEL	Phase A, B, or C apparent power peak demand, delivered	Volt-amps
UPx_REC	Phase A, B, or C apparent power peak demand, received	Volt-amps
<b>Demand, Peak, More, Reactive Power</b>		
QPx_DEL	Phase A, B, or C reactive power peak demand, delivered	Volt-amps reactive
QPx_REC	Phase A, B, or C reactive power peak demand, received	Volt-amps reactive
<b>Demand, Peak, More, Reactive Power, 4-Quadrant</b>		
QPx_DEL_LG	Three-phase, Phase A, B, or C lagging reactive power peak demand, delivered (Quadrant 1)	Volt-amps reactive
QPx_DEL_LG_UC <sup>a</sup>	Three-phase, Phase A, B, or C lagging reactive power peak demand, delivered (Quadrant 1), uncompensated	Volt-amps reactive
QPx_DEL_LD	Three-phase, Phase A, B, or C leading reactive power peak demand, delivered (Quadrant 2)	Volt-amps reactive
QPx_DEL_LD_UC <sup>a</sup>	Three-phase, Phase A, B, or C leading reactive power peak demand, delivered (Quadrant 2), uncompensated	Volt-amps reactive
QPx_REC_LG	Three-phase, Phase A, B, or C lagging reactive power peak demand, received (Quadrant 3)	Volt-amps reactive
QPx_REC_LG_UC <sup>a</sup>	Three-phase, Phase A, B, or C lagging reactive power peak demand, received (Quadrant 3), uncompensated	Volt-amps reactive
QPx_REC_LD	Three-phase, Phase A, B, or C leading reactive power peak demand, received (Quadrant 4)	Volt-amps reactive
QPx_REC_LD_UC <sup>a</sup>	Three-phase, Phase A, B, or C leading reactive power peak demand, received (Quadrant 4), uncompensated	Volt-amps reactive
<b>Demand, Previous Peak</b>		
WPP3_DEL	Three-phase active power previous peak demand, delivered	Watts
WPP3_DEL_UC <sup>a</sup>	Three-phase active power previous peak demand, delivered, uncompensated	Watts
WPP3_REC	Three-phase active power previous peak demand, received	Watts
WPP3_REC_UC <sup>a</sup>	Three-phase active power previous peak demand, received, uncompensated	Watts
UPP3_DEL	Three-phase apparent power previous peak demand, delivered	Volt-amps
UPP3_REC	Three-phase apparent power previous peak demand, received	Volt-amps
QPP3_DEL	Three-phase reactive power previous peak demand, delivered	Volt-amps reactive

**Table G.3 Demand, Peak Demand, Previous Demand (Sheet 4 of 4)**

QPP3_DEL_UC <sup>a</sup>	Three-phase reactive power previous peak demand, delivered, uncompensated	Volt-amps reactive
QPP3_REC	Three-phase reactive power previous peak demand, received	Volt-amps reactive
QPP3_REC_UC <sup>a</sup>	Three-phase reactive power previous peak demand, received, uncompensated	Volt-amps reactive
<b>Demand, Previous Peak, More, Current</b>		
IPPx	Phase A, B, or C current previous peak demand	Amps
IPPN	Neutral current previous peak demand	Amps
3I0PP	Current previous peak demand, 3 • zero sequence	Amps
3I2PP	Current previous peak demand, 3 • negative sequence	Amps
<b>Demand, Previous Peak, More, Real Power</b>		
WPPx_DEL	Phase A, B, or C active power previous peak demand, delivered	Watts
WPPx_DEL_UC <sup>a</sup>	Phase A, B, or C active power previous peak demand, delivered, uncompensated	Watts
WPPx_REC	Phase A, B, or C active power previous peak demand, received	Watts
WPPx_REC_UC <sup>a</sup>	Phase A, B, or C active power previous peak demand, received, uncompensated	Watts
<b>Demand, Previous Peak, More, Apparent Power</b>		
UPPx_DEL	Phase A, B, or C apparent power previous peak demand, delivered	Volt-amps
UPPx_REC	Phase A, B, or C apparent power previous peak demand, received	Volt-amps
<b>Demand, Previous Peak, More, Reactive Power</b>		
QPPx_DEL	Phase A, B, or C reactive power previous peak demand, delivered	Volt-amps reactive
QPPx_DEL_UC <sup>a</sup>	Phase A, B, or C reactive power previous peak demand, delivered, uncompensated	Volt-amps reactive
QPPx_REC	Phase A, B, or C reactive power previous peak demand, received	Volt-amps reactive
QPPx_REC_UC <sup>a</sup>	Phase A, B, or C reactive power previous peak demand, received, uncompensated	Volt-amps reactive
<b>Demand, Previous Peak, More, Reactive Power, 4-Quadrant</b>		
QPPx_DEL_LG	Three-phase, Phase A, B, or C lagging reactive power previous peak demand, delivered (Quadrant 1)	Volt-amps reactive
QPPx_DEL_LG_UC <sup>a</sup>	Three-phase, Phase A, B, or C lagging reactive power previous peak demand, delivered (Quadrant 1), uncompensated	Volt-amps reactive
QPPx_DEL_LD	Three-phase, Phase A, B, or C leading reactive power previous peak demand, delivered (Quadrant 2)	Volt-amps reactive
QPPx_DEL_LD_UC <sup>a</sup>	Three-phase, Phase A, B, or C leading reactive power previous peak demand, delivered (Quadrant 2), uncompensated	Volt-amps reactive
QPPx_REC_LG	Three-phase, Phase A, B, or C lagging reactive power previous peak demand, received (Quadrant 3)	Volt-amps reactive
QPPx_REC_LG_UC <sup>a</sup>	Three-phase, Phase A, B, or C lagging reactive power previous peak demand, received (Quadrant 3), uncompensated	Volt-amps reactive
QPPx_REC_LD	Three-phase, Phase A, B, or C leading reactive power previous peak demand, received (Quadrant 4)	Volt-amps reactive
QPPx_REC_LD_UC <sup>a</sup>	Three-phase, Phase A, B, or C leading reactive power previous peak demand, received (Quadrant 4), uncompensated	Volt-amps reactive

<sup>a</sup> Uncompensated values are not affected by transformer/line loss compensation, regardless of whether ETLIC is set to Y or N.

**Table G.4 Energy (Sheet 1 of 3)**

Energy		
WH3_DEL	Three-phase delivered active energy	Watt-hours
WH3_DEL_UC <sup>a</sup>	Three-phase delivered active energy, uncompensated	Watt-hours
WH3_REC	Three-phase received active energy	Watt-hours
WH3_REC_UC <sup>a</sup>	Three-phase received active energy, uncompensated	Watt-hours
UH3_DEL	Three-phase delivered apparent energy	Volt-amps hours
UH3_REC	Three-phase received apparent energy	Volt-amps hours
QH3_DEL	Three-phase delivered reactive energy	Volt-amps-reactive hours
QH3_DEL_UC <sup>a</sup>	Three-phase delivered reactive energy, uncompensated	Volt-amps-reactive hours
QH3_REC	Three-phase received reactive energy	Volt-amps-reactive hours
QH3_REC_UC <sup>a</sup>	Three-phase received reactive energy, uncompensated	Volt-amps-reactive hours
Energy, More, Real Energy		
WHA_DEL	Wh, AΦ delivered	Watt-hours
WHA_DEL_UC <sup>a</sup>	Wh, AΦ delivered, uncompensated	Watt-hours
WHB_DEL	Wh, BΦ delivered	Watt-hours
WHB_DEL_UC <sup>a</sup>	Wh, BΦ delivered, uncompensated	Watt-hours
WHC_DEL	Wh, CΦ delivered	Watt-hours
WHC_DEL_UC <sup>a</sup>	Wh, CΦ delivered, uncompensated	Watt-hours
WHA_REC	Wh, AΦ received	Watt-hours
WHA_REC_UC <sup>a</sup>	Wh, AΦ received, uncompensated	Watt-hours
WHB_REC	Wh, BΦ received	Watt-hours
WHB_REC_UC <sup>a</sup>	Wh, BΦ received, uncompensated	Watt-hours
WHC_REC	Wh, CΦ received	Watt-hours
WHC_REC_UC <sup>a</sup>	Wh, CΦ received, uncompensated	Watt-hours
WHA_NET	Wh, AΦ net (delivered—received)	Watt-hours
WHB_NET	Wh, BΦ net (delivered—received)	Watt-hours
WHC_NET	Wh, CΦ net (delivered—received)	Watt-hours
WH3_NET	Wh, 3Φ net (delivered—received)	Watt-hours
Energy, More, Apparent Energy		
UHA_DEL	VAh, AΦ delivered	Volt-amps hours
UHB_DEL	VAh, BΦ delivered	Volt-amps hours
UHC_DEL	VAh, CΦ delivered	Volt-amps hours
UHA_REC	VAh, AΦ received	Volt-amps hours
UHB_REC	VAh, BΦ received	Volt-amps hours
UHC_REC	VAh, CΦ received	Volt-amps hours
Energy, More, Reactive Energy		
QHA_DEL	VARh, AΦ delivered	Volt-amps-reactive hours
QHA_DEL_UC <sup>a</sup>	VARh, AΦ delivered, uncompensated	Volt-amps-reactive hours
QHB_DEL	VARh, BΦ delivered	Volt-amps-reactive hours
QHB_DEL_UC <sup>a</sup>	VARh, BΦ delivered, uncompensated	Volt-amps-reactive hours
QHC_DEL	VARh, CΦ delivered	Volt-amps-reactive hours
QHC_DEL_UC <sup>a</sup>	VARh, CΦ delivered, uncompensated	Volt-amps-reactive hours

**Table G.4 Energy (Sheet 2 of 3)**

QHA_REC	VARh, A $\Phi$ received	Volt-amps-reactive hours
QHA_REC_UC <sup>a</sup>	VARh, A $\Phi$ received, uncompensated	Volt-amps-reactive hours
QHB_REC	VARh, B $\Phi$ received	Volt-amps-reactive hours
QHB_REC_UC <sup>a</sup>	VARh, B $\Phi$ received, uncompensated	Volt-amps-reactive hours
QHC_REC	VARh, C $\Phi$ received	Volt-amps-reactive hours
QHC_REC_UC <sup>a</sup>	VARh, C $\Phi$ received, uncompensated	Volt-amps-reactive hours
QH3_NET	VARh, 3 $\Phi$ (delivered—received)	Volt-amps-reactive hours
<b>Energy, More, Reactive Energy, 4-Quadrant</b>		
VARH3_DEL_LG	VARh, 3 $\Phi$ delivered, lag (Q1)	Volt-amps-reactive hours
QH3_DEL_LG	VARh, 3 $\Phi$ delivered, lag (Q1)	Volt-amps-reactive hours
QH3_DEL_LG_UC <sup>a</sup>	VARh, 3 $\Phi$ delivered, lag (Q1), uncompensated	Volt-amps-reactive hours
VARH3_DEL_LD	VARh, 3 $\Phi$ delivered, lead (Q2)	Volt-amps-reactive hours
QH3_DEL_LD	VARh, 3 $\Phi$ delivered, lead (Q2)	Volt-amps-reactive hours
QH3_DEL_LD_UC <sup>a</sup>	VARh, 3 $\Phi$ delivered, lead (Q2), uncompensated	Volt-amps-reactive hours
VARH3_REC_LG	VARh, 3 $\Phi$ received, lag (Q3)	Volt-amps-reactive hours
QH3_REC_LG	VARh, 3 $\Phi$ received, lag (Q3)	Volt-amps-reactive hours
QH3_REC_LG_UC <sup>a</sup>	VARh, 3 $\Phi$ received, lag (Q3), uncompensated	Volt-amps-reactive hours
VARH3_REC_LD	VARh, 3 $\Phi$ received, lead (Q4)	Volt-amps-reactive hours
QH3_REC_LD	VARh, 3 $\Phi$ received, lead (Q4)	Volt-amps-reactive hours
QH3_REC_LD_UC <sup>a</sup>	VARh, 3 $\Phi$ received, lead (Q4), uncompensated	Volt-amps-reactive hours
QHA_DEL_LG	VARh, A $\Phi$ delivered, lag (Q1)	Volt-amps-reactive hours
QHA_DEL_LG_UC <sup>a</sup>	VARh, A $\Phi$ delivered, lag (Q1), uncompensated	Volt-amps-reactive hours
QHA_DEL_LD	VARh, A $\Phi$ delivered, lead (Q2)	Volt-amps-reactive hours
QHA_DEL_LD_UC <sup>a</sup>	VARh, A $\Phi$ delivered, lead (Q2), uncompensated	Volt-amps-reactive hours
QHA_REC_LG	VARh, A $\Phi$ received, lag (Q3)	Volt-amps-reactive hours
QHA_REC_LG_UC <sup>a</sup>	VARh, A $\Phi$ received, lag (Q3), uncompensated	Volt-amps-reactive hours
QHA_REC_LD	VARh, A $\Phi$ received, lead (Q4)	Volt-amps-reactive hours
QHA_REC_LD_UC <sup>a</sup>	VARh, A $\Phi$ received, lead (Q4), uncompensated	Volt-amps-reactive hours
QHB_DEL_LG	VARh, B $\Phi$ delivered, lag (Q1)	Volt-amps-reactive hours
QHB_DEL_LG_UC <sup>a</sup>	VARh, B $\Phi$ delivered, lag (Q1), uncompensated	Volt-amps-reactive hours
QHB_DEL_LD	VARh, B $\Phi$ delivered, lead (Q2)	Volt-amps-reactive hours
QHB_DEL_LD_UC <sup>a</sup>	VARh, B $\Phi$ delivered, lead (Q2), uncompensated	Volt-amps-reactive hours
QHB_REC_LG	VARh, B $\Phi$ received, lag (Q3)	Volt-amps-reactive hours
QHB_REC_LG_UC <sup>a</sup>	VARh, B $\Phi$ received, lag (Q3), uncompensated	Volt-amps-reactive hours
QHB_REC_LD	VARh, B $\Phi$ received, lead (Q4)	Volt-amps-reactive hours
QHB_REC_LD_UC <sup>a</sup>	VARh, B $\Phi$ received, lead (Q4), uncompensated	Volt-amps-reactive hours
QHC_DEL_LG	VARh, C $\Phi$ delivered, lag (Q1)	Volt-amps-reactive hours
QHC_DEL_LG_UC <sup>a</sup>	VARh, C $\Phi$ delivered, lag (Q1), uncompensated	Volt-amps-reactive hours
QHC_DEL_LD	VARh, C $\Phi$ delivered, lead (Q2)	Volt-amps-reactive hours
QHC_DEL_LD_UC <sup>a</sup>	VARh, C $\Phi$ delivered, lead (Q2), uncompensated	Volt-amps-reactive hours
QHC_REC_LG	VARh, C $\Phi$ received, lag (Q3)	Volt-amps-reactive hours
QHC_REC_LG_UC <sup>a</sup>	VARh, C $\Phi$ received, lag (Q3), uncompensated	Volt-amps-reactive hours

**Table G.4 Energy (Sheet 3 of 3)**

QHC_REC_LD	VARh, C $\Phi$ received, lead (Q4)	Volt-amps-reactive hours
QHC_REC_LD_UC <sup>a</sup>	VARh, C $\Phi$ received, lead (Q4), uncompensated	Volt-amps-reactive hours
<b>Energy, More, Volt-Hours</b>		
VHA	Vh, Van (Vab if Form 5)	Volt-hours
VHB	Vh, Vbn (Vbc if Form 5)	Volt-hours
VHC	Vh, Vcn (Vca if Form 5)	Volt-hours
VH3	Vh, 3 $\emptyset$	Volt-hours
<b>Energy, More, Amp-Hours</b>		
IHA	Ah, Ia	Amp-hours
IHB	Ah, Ib	Amp-hours
IHC	Ah, Ic	Amp-hours
IHN	Ah, In	Amp-hours
IH3	Ah, 3 $\emptyset$	Amp-hours

<sup>a</sup> Uncompensated values are not affected by transformer/line loss compensation, regardless of whether ETLIC is set to Y or N.

**Table G.5 Frequency**

<b>Frequency</b>		
FREQ	Frequency	Hertz
FREQ_PQ	Frequency, 10-second average	Hertz

**Table G.6 Power Factor**

<b>Power Factor, Three Phase</b>		
PFD3	Displacement PF, 3 $\Phi$	Unitless
PFT3	True PF, 3 $\Phi$	Unitless
<b>Power Factor, More, Displacement Power Factor</b>		
PFDA	Displacement PF, A $\Phi$	Unitless
PFDB	Displacement PF, B $\Phi$	Unitless
PFDC	Displacement PF, C $\Phi$	Unitless
LDPFDA	Lead/Lag indication, A $\Phi$ (1 = Lead, 0 = Lag)	Unitless
LDPFDB	Lead/Lag indication, B $\Phi$ (1 = Lead, 0 = Lag)	Unitless
LDPFDC	Lead/Lag indication, C $\Phi$ (1 = Lead, 0 = Lag)	Unitless
LDPFD3	Lead/Lag indication, 3 $\Phi$ (1 = Lead, 0 = Lag)	Unitless
<b>Power Factor, More, True Power Factor</b>		
PFTA	True PF, A $\Phi$	Unitless
PFTB	True PF, B $\Phi$	Unitless
PFTC	True PF, C $\Phi$	Unitless
LDPFTA	Lead/Lag indication, A $\Phi$ (1 = Lead, 0 = Lag)	Unitless
LDPFTB	Lead/Lag indication, B $\Phi$ (1 = Lead, 0 = Lag)	Unitless
LDPFTC	Lead/Lag indication, C $\Phi$ (1 = Lead, 0 = Lag)	Unitless
LDPFT3	Lead/Lag indication, 3 $\Phi$ (1 = Lead, 0 = Lag)	Unitless

# Advanced Analog Quantity List

Table G.7–Table G.23 list the advanced Analog Quantities.

**Table G.7 Aggregation (Sheet 1 of 2)**

Advanced: Aggregation, Voltage (Replace n with 3SEC, 10MIN, or 2HR)		
VA <sub>n</sub>	Aggregated RMS voltage, Van	Volts
VB <sub>n</sub>	Aggregated RMS voltage, Vbn	Volts
VC <sub>n</sub>	Aggregated RMS voltage, Vcn	Volts
VAB <sub>n</sub>	Aggregated RMS voltage, Vab	Volts
VBC <sub>n</sub>	Aggregated RMS voltage, Vbc	Volts
VCA <sub>n</sub>	Aggregated RMS voltage, Vca	Volts
Advanced: Aggregation, Current (Replace n with 3SEC, 10MIN, or 2HR)		
IA <sub>n</sub>	Aggregated RMS current, Ia	Amps
IB <sub>n</sub>	Aggregated RMS current, Ib	Amps
IC <sub>n</sub>	Aggregated RMS current, Ic	Amps
IN <sub>n</sub>	Aggregated RMS current, In	Amps
Advanced: Aggregation, Imbalance (Replace n with 3SEC, 10MIN, or 2HR)		
V_IMB <sub>n</sub>	Aggregated voltage imbalance	%
I_IMB <sub>n</sub>	Aggregated current imbalance	%
Advanced: Aggregation, Power (Replace n with 3SEC, 10MIN, or 2HR)		
W3 <sub>n</sub>	Aggregated watts, 3Φ	Watts
U3 <sub>n</sub>	Aggregated VAs, 3Φ	Volt-amps
Q3 <sub>n</sub>	Aggregated VARs, 3Φ	Volt-amps reactive
WA <sub>n</sub>	Aggregated watts, AΦ	Watts
WB <sub>n</sub>	Aggregated watts, BΦ	Watts
WC <sub>n</sub>	Aggregated watts, CΦ	Watts
UA <sub>n</sub>	Aggregated VAs, AΦ	Volt-amps
UB <sub>n</sub>	Aggregated VAs, BΦ	Volt-amps
UC <sub>n</sub>	Aggregated VAs, CΦ	Volt-amps
QA <sub>n</sub>	Aggregated VARs, AΦ	Volt-amps reactive
QB <sub>n</sub>	Aggregated VARs, BΦ	Volt-amps reactive
QC <sub>n</sub>	Aggregated VARs, CΦ	Volt-amps reactive
Advanced: Aggregation, 2nd–63rd Harmonic (Replace n with 3SEC, 10MIN, or 2HR; Replace n with 2–63)		
HRMM <sub>n</sub> _IA <sub>n</sub>	<i>n</i> th Harmonic, aggregated current, Ia	Amps
HRMM <sub>n</sub> _IB <sub>n</sub>	<i>n</i> th Harmonic, aggregated current, Ib	Amps
HRMM <sub>n</sub> _IC <sub>n</sub>	<i>n</i> th Harmonic, aggregated current, Ic	Amps
HRMM <sub>n</sub> _IN <sub>n</sub>	<i>n</i> th Harmonic, aggregated current, In	Amps
HRMM <sub>n</sub> _VA <sub>n</sub>	<i>n</i> th Harmonic, aggregated voltage, Van (Vab if Form 5)	Volts
HRMM <sub>n</sub> _VB <sub>n</sub>	<i>n</i> th Harmonic, aggregated voltage, Vbn (Vbc if Form 5)	Volts
HRMM <sub>n</sub> _VC <sub>n</sub>	<i>n</i> th Harmonic, aggregated voltage, Vcn (Vca if Form 5)	Volts

**Table G.7 Aggregation (Sheet 2 of 2)**

Advanced: Aggregation, Total Harmonic Distortion (Replace n with 3SEC, 10MIN, or 2HR)		
THDIA <sub>n</sub>	THD %, aggregated Ia	%
THDIB <sub>n</sub>	THD %, aggregated Ib	%
THDIC <sub>n</sub>	THD %, aggregated Ic	%
THDIN <sub>n</sub>	THD %, aggregated In	%
THDVA <sub>n</sub>	THD %, aggregated Van (Vab if Form 5)	%
THDVB <sub>n</sub>	THD %, aggregated Vbc (Vbc if Form 5)	%
THDVC <sub>n</sub>	THD %, aggregated Vca (Vca if Form 5)	%

**Table G.8 Advanced: Configured Registers**

Advanced: Configurable Registers (Replace nnnn = 0001-1000)		
CFG <sub>nnnn</sub>	User-configured register	User-defined

**Table G.9 Advanced: Date and Time**

Advanced: Date and Time		
DATE	Present date	0-31
TIME	Present time	
DATE_TIME	Present date and time	
YEAR	Year number	0000-9999
DAYY	Day of year number	1-366
WEEK	Week number	1-52
DAYW	Day of week number	1-7
MINSM	Minutes since midnight	0-1440

**Table G.10 Advanced: Diagnostics**

Advanced: Diagnostics		
BATT	Real-time clock battery voltage	V
TEMP	Device temperature	Celsius

**Table G.11 Advanced: DNP Remote Analog Outputs**

Advanced: DNP Remote Analog Outputs (Replace nn with 00-31)		
RA <sub>nn</sub>	DNP analog outputs	

**Table G.12 Advanced: Flicker (Sheet 1 of 2)**

Advanced: Flicker		
PINST_VA	Maximum instantaneous flicker, Van (Vab if Form 5)	Unitless
PINST_VB	Maximum instantaneous flicker, Vbn (Vbc if Form 5)	Unitless
PINST_VC	Maximum instantaneous flicker, Vcn (Vca if Form 5)	Unitless
PST_1MIN_VA	Short-term flicker, 1 minute, Van (Vab if Form 5)	Unitless
PST_1MIN_VB	Short-term flicker, 1 minute, Vbn (Vbc if Form 5)	Unitless
PST_1MIN_VC	Short-term flicker, 1 minute, Vcn (Vca if Form 5)	Unitless
PST_10MIN_VA	Short-term flicker, 10 minute, Van (Vab if Form 5)	Unitless
PST_10MIN_VB	Short-term flicker, 10 minute, Vbn (Vbc if Form 5)	Unitless
PST_10MIN_VC	Short-term flicker, 10 minute, Vcn (Vca if Form 5)	Unitless

**Table G.12 Advanced: Flicker (Sheet 2 of 2)**

PLT_VA	Long-term flicker, 2 hour, Van (Vab if Form 5)	Unitless
PLT_VB	Long-term flicker, 2 hour, Vbn (Vbc if Form 5)	Unitless
PLT_VC	Long-term flicker, 2 hour, Vcn (Vca if Form 5)	Unitless
SEC_PINST	Seconds until PINST and PST_1MIN update	Seconds
SEC_PST	Seconds until PST 10 minute update	Seconds
SEC_PLT	Seconds until PLT 2 hour update	Seconds

**Table G.13 Advanced: Fundamental Only (Sheet 1 of 2)**

Advanced: Fundamental Only		
IA_FUND	Current magnitude, Ia	Amps
IB_FUND	Current magnitude, Ib	Amps
IC_FUND	Current magnitude, Ic	Amps
IN_FUND	Current magnitude, In	Amps
VA_FUND	Voltage magnitude, Van	Volts
VB_FUND	Voltage magnitude, Vbn	Volts
VC_FUND	Voltage magnitude, Vcn	Volts
VAB_FUND	Voltage magnitude, Vab	Volts
VBC_FUND	Voltage magnitude, Vbc	Volts
VCA_FUND	Voltage magnitude, Vca	Volts
IA_ANG	Current, Ia angle	Degrees
IB_ANG	Current, Ib angle	Degrees
IC_ANG	Current, Ic angle	Degrees
IN_ANG	Current, In angle	Degrees
VA_ANG	Voltage, Van angle	Degrees
VB_ANG	Voltage, Vbn angle	Degrees
VC_ANG	Voltage, Vcn angle	Degrees
VAB_ANG	Voltage, Vab, angle	Degrees
VBC_ANG	Voltage, Vbc angle	Degrees
VCA_ANG	Voltage, Vca angle	Degrees
Advanced: Fundamental Only, Power, 3-Phase		
W3_FUND	Fundamental watts, 3Φ	Watts
W3_HALF_CYCLE	Half-cycle fundamental watts	Watts
S3_FUND	Fundamental VAs, 3Φ	Volt-amps
S3_HALF_CYCLE	Half-cycle fundamental VAs	Volt-amps
Q3_FUND	Fundamental VARs, 3Φ	Volt-amps reactive
Q3_HALF_CYCLE	Half-cycle fundamental VARs	Volt-amps reactive
Advanced: Fundamental Only, Power, More		
Wx_FUND	Fundamental watts; Phase A, B, or C	Watts
Wx_HALF_CYCLE	Half-cycle fundamental watts; Phase A, B, or C	Watts
Sx_FUND	Fundamental VAs; Phase A, B, or C	Volt-amps
Sx_HALF_CYCLE	Half-cycle fundamental VAs; Phase A, B, or C	Volt-amps

**Table G.13 Advanced: Fundamental Only (Sheet 2 of 2)**

Qx_FUND	Fundamental VARs; Phase A, B, or C	Volt-amps reactive
Qx_HALF_CYCLE	Half-cycle fundamental VARs; Phase A, B, or C	Volt-amps reactive
<b>Advanced: Fundamental Only, Power, More, 4-Quadrant Reactive Power</b>		
Qx_DEL_LG	Fundamental VARs, delivered, lag (Q1); Phase A, B, or C, or 3-Phase	Volt-amps reactive
Qx_DEL_LD	Fundamental VARs, delivered, lead (Q2); Phase A, B, or C, or 3-Phase	Volt-amps reactive
Qx_REC_LG	Fundamental VARs, received, lag (Q3); Phase A, B, or C, or 3-Phase	Volt-amps reactive
Qx_REC_LD	Fundamental VARs, received, lead (Q4); Phase A, B, or C, or 3-Phase	Volt-amps reactive

**Table G.14 Advanced: Harmonics**

<b>Advanced: Harmonics, Total Harmonic Distortion</b>		
THDIx	Current THD; Phase A, B, or C	%
THDIN	Neutral current THD	%
THDVx	Voltage THD; Phase A, B, or C (Vab, Vbc, or Vca if Form 5)	%
<b>Advanced: Harmonics, Grouped Total Harmonic Distortion</b>		
THDGIx	Grouped current THD; Phase A, B, or C	%
THDGIN	Grouped neutral current THD	%
THDGVx	Grouped voltage THD; Phase A, B, or C (Vab, Vbc, or Vca if Form 5)	%
<b>Advanced: Harmonics, K-Factor</b>		
KFx	K-factor ratio; Phase A, B, or C	Unitless
<b>Advanced: Harmonics, Distortion Power Ratio</b>		
DPx	Distortion power ratio; Phase A, B, or C, or 3-Phase	Unitless
<b>Advanced: Harmonics, Percentage of Fundamental, 2nd–63rd (Replace n with 2–63)</b>		
HRMn_Ix	n <sup>th</sup> Current harmonic %; Phase A, B, or C	%
HRMn_IN	n <sup>th</sup> Neutral current harmonic %	%
HRMn_Vx	n <sup>th</sup> Voltage harmonic %; Phase A, B, or C (Vab, Vbc, or Vca if Form 5)	%
<b>Advanced: Harmonics, Magnitude and Angle, 2nd–63rd (Replace n with 2–63)</b>		
HRMMn_Ix	n <sup>th</sup> Harmonic current magnitude; Phase A, B, or C	Amps
HRMA <sub>n</sub> _Ix	n <sup>th</sup> Harmonic current angle; Phase A, B, or C	Degrees
HRMMn_IN	n <sup>th</sup> Harmonic neutral current magnitude	Amps
HRMA <sub>n</sub> _IN	n <sup>th</sup> Harmonic current magnitude	Degrees
HRMMn_Vx	n <sup>th</sup> Harmonic voltage magnitude; Phase A, B, or C (Vab, Vbc, or Vca if Form 5)	Volts
HRMA <sub>n</sub> _Vx	n <sup>th</sup> Harmonic voltage angle; Phase A, B, or C (Vab, Vbc, or Vca if Form 5)	Degrees
<b>Advanced: Harmonics, Power, 2nd–63rd (Replace n with 2–63)</b>		
HRMPn_x	n <sup>th</sup> Harmonic active power; Phase A, B, C, or three-phase	Watts

**Table G.15 Advanced: Maximum/Minimum, Crest Factor (Sheet 1 of 2)**

<b>Advanced: Maximum/Minimum Current</b>		
IxMX	Maximum phase A, B, or C current	Amps
INMX	Maximum neutral current	Amps
IxMN	Minimum phase A, B, or C current	Amps
INMN	Minimum neutral current	Amps

**Table G.15 Advanced: Maximum/Minimum, Crest Factor (Sheet 2 of 2)**

Advanced: Maximum/Minimum Voltage		
VxMX	Phase A, B, or C maximum voltage (Vab, Vbc, or Vca if Form 5)	Volts
VxMN	Phase A, B, or C minimum voltage (Vab, Vbc, or Vca if Form 5)	Volts
Advanced: Maximum/Minimum Power		
W3MX	Watts, 3 $\Phi$ maximum	Watts
U3MX	VAs, 3 $\Phi$ maximum	Volt-amps
Q3MX	VARs, 3 $\Phi$ maximum	Volt-amps reactive
W3MN	Watts, 3 $\Phi$ minimum	Watts
U3MN	VAs, 3 $\Phi$ minimum	Volt-amps
Q3MN	VARs, 3 $\Phi$ minimum	Volt-amps reactive
Advanced: Maximum/Minimum Crest Factor, Current		
IxCFMX	Phase A, B, or C maximum current crest factor	Unitless
INCFMX	Maximum neutral current crest factor	Unitless
IxCFMN	Phase A, B, or C minimum current crest factor	Unitless
INCFMN	Minimum neutral current crest factor	Unitless
Advanced: Maximum/Minimum Crest Factor, Voltage		
VxCFMX	Phase A, B, or C maximum voltage crest factor (Vab, Vbc, or Vca if Form 5)	Unitless
VxCFMN	Phase A, B, or C minimum voltage crest factor (Vab, Vbc, or Vca if Form 5)	Unitless

**Table G.16 Advanced: Monthly Frozen/Consumed Values (Sheet 1 of 2)**

Advanced: Monthly, DST, and Season Change Energy		
ENGY_STA	Energy set status present month	Unitless
ENGY_STA_1M	Energy set status previous month	Unitless
ENGY_STA_2M	Energy set status two months previous	Unitless
FWH3_DEL	Frozen Wh 3 $\Phi$ delivered, start of present month	Watt-hours
FWH3_DEL_1M	Frozen Wh 3 $\Phi$ delivered, start of previous month	Watt-hours
FWH3_DEL_2M	Frozen Wh 3 $\Phi$ delivered, start of two months previous	Watt-hours
FWH3_REC	Frozen Wh 3 $\Phi$ received, start of present month	Watt-hours
FWH3_REC_1M	Frozen Wh 3 $\Phi$ received, start of previous month	Watt-hours
FWH3_REC_2M	Frozen Wh 3 $\Phi$ received, start of two months previous	Watt-hours
CWH3_DEL	Consumed Wh 3 $\Phi$ delivered, present month	Watt-hours
CWH3_DEL_1M	Consumed Wh 3 $\Phi$ delivered, previous month	Watt-hours
CWH3_DEL_2M	Consumed Wh 3 $\Phi$ delivered, two months previous	Watt-hours
CWH3_REC	Consumed Wh 3 $\Phi$ received, present month	Watt-hours
CWH3_REC_1M	Consumed Wh 3 $\Phi$ received, previous month	Watt-hours
CWH3_REC_2M	Consumed Wh 3 $\Phi$ received, two months previous	Watt-hours
ENGY_STA_DCE	DST change event energy set status	Unitless
FDWH3_DEL	Frozen Wh 3 $\Phi$ delivered, at DST change	Watt-hours
FDQH3_DEL	Frozen VARh 3 $\Phi$ delivered, at DST change	Volt-amps-reactive hours
CDWH3_DEL	Consumed Wh 3 $\Phi$ delivered, between recent two DST changes	Watt-hours
ENGY_STA_SCE	Season change event energy set status	Unitless

**Table G.16 Advanced: Monthly Frozen/Consumed Values (Sheet 2 of 2)**

FSWH3_DEL	Frozen Wh 3Φ delivered, at TOU season change	Watt-hours
FSQH3_DEL	Frozen VARh 3Φ delivered, at TOU season change.	Volt-amps-reactive hours
CSWH3_DEL	Consumed Wh 3Φ delivered, between recent two TOU season changes	Watt-hours

**Table G.17 Advanced: SELogic**

Advanced: SELogic: (Replace n with 01–16)		
SC <sub>n</sub>	SELOGIC counter <i>n</i> present value	
MV <sub>n</sub>	SELOGIC math variable <i>n</i> present value	

**Table G.18 Advanced: Symmetrical Components**

Advanced: Symmetrical Components		
3I0_MAG	Current, 3Φ zero-sequence	Amps
I1_MAG	Current, positive-sequence	Amps
3I2_MAG	Current, 3Φ negative-sequence	Amps
3V0_MAG	Voltage, 3Φ zero-sequence	Volts
V1_MAG	Voltage, positive-sequence	Volts
V2_MAG	Voltage, negative-sequence	Volts
3I0_ANG	Current, 3Φ zero-sequence, angle	Degrees
I1_ANG	Current, positive-sequence, angle	Degrees
3I2_ANG	Current, 3Φ negative-sequence, angle	Degrees
3V0_ANG	Voltage, 3Φ zero-sequence, angle	Degrees
V1_ANG	Voltage, positive-sequence, angle	Degrees
V2_ANG	Voltage, negative-sequence, angle	Degrees

**Table G.19 Advanced: Time-of-Use Metering (Sheet 1 of 2)**

Advanced: Time-of-Use Metering, Energy, Rated Energy (Replace Z with: PRES, PREV, SnPRES, or SnPREV; Replace n with the Self-Read number: 1–15)		
Z_WH_<A-F>_TOT	Wh, 3Φ rate <A-F>, total	Watt-hours
Z_UH_<A-F>_TOT	VAh, 3Φ rate <A-F>, total	Volt-amps hours
Z_QH_<A-F>_TOT	VARh, 3Φ rate <A-F>, total	Volt-amps-reactive hours
Z_WH_<A-F>_REC	Wh, 3Φ rate <A-F>, received	Watt-hours
Z_UH_<A-F>_REC	VAh, 3Φ rate <A-F>, received	Volt-amps hours
Z_QH_<A-F>_REC	VARh, 3Φ rate <A-F>, received	Volt-amps-reactive hours
Advanced: Time-of-Use Metering, Energy, Nonrated Energy		
Z_WH_REC	Wh, 3Φ nonrated, received	Watt-hours
Z_QH_REC	VARh, 3Φ nonrated, received	Volt-amps-reactive hours
Z_WH_TOT_SINCE_RESET	Wh, 3Φ nonrated, total since peak demand reset	Watt-hours
Z_WH_TOT_AT_RESET	Wh, 3Φ nonrated, total at peak demand reset	Watt-hours
Z_UH_TOT_SINCE_RESET	VAh, 3Φ nonrated, total since peak demand reset	Volt-amps hours
Z_UH_TOT_AT_RESET	VAh, 3Φ nonrated, total at peak demand reset	Volt-amps hours
Z_QH_TOT_SINCE_RESET	VARh, 3Φ nonrated, total since peak demand reset	Volt-amps-reactive hours
Z_QH_TOT_AT_RESET	VARh, 3Φ nonrated, total at peak demand reset	Volt-amps-reactive hours

**Table G.19 Advanced: Time-of-Use Metering (Sheet 2 of 2)**

Advanced: Time-of-Use Metering, Demand, Rated Peak Demand		
Z_W_<A-F>_PD	Watts, 3Φ rate <A-F>, total peak demand	Watts
Z_PF_AT_W_<A-F>_PD	PF at watts, 3Φ rate <A-F>, total peak demand	Unitless
Z_U_<A-F>_PD	VAAs, 3Φ rate <A-F>, total peak demand	Volt-amps
Z_PF_AT_U_<A-F>_PD	PF at VAs, 3Φ rate <A-F>, total peak demand	Unitless
Z_Q_<A-F>_PD	VARs, 3Φ rate <A-F>, total peak demand	Volt-amps reactive
Z_PF_AT_Q_<A-F>_PD	PF at VARs, 3Φ rate <A-F>, total peak demand	Unitless
Z_W_<A-F>_REC_PD	Watts, 3Φ rate <A-F>, received peak demand	Watts
Z_PF_AT_W_<A-F>_REC_PD	PF at watts, 3Φ rate <A-F>, received peak demand	Unitless
Z_U_<A-F>_REC_PD	VAAs, 3Φ rate <A-F>, received peak demand	Volt-amps
Z_PF_AT_U_<A-F>_REC_PD	PF at VAs, 3Φ rate <A-F>, received peak demand	Unitless
Z_Q_<A-F>_REC_PD	VARs, 3Φ rate <A-F>, received peak demand	Volt-amps reactive
Z_PF_AT_U_<A-F>_REC_PD	PF at VARs, 3Φ rate <A-F>, received peak demand	Unitless
Advanced: Time-of-Use Metering, Demand, Nonrated Peak Demand		
Z_W_<1-5>_PD	Watts, 3Φ nonrated, <1-5> total peak demand	Watts
Z_PF_AT_W_1_PD	PF at watts, 3Φ nonrated, 1 total peak demand	Unitless
Z_U_<1-5>_PD	VAAs, 3Φ nonrated, <1-5> peak demand	Volt-amps
Z_PF_AT_U_1_PD	PF at VAs, 3Φ nonrated, 1 total peak demand	Unitless
Z_Q_<1-5>_PD	VARs, 3Φ nonrated, <1-5> total peak demand	Volt-amps reactive
Z_PF_AT_Q_1_PD	PF at VARs, 3Φ nonrated, 1 total peak demand	Unitless
Z_W_<1-5>_REC_PD	Watts, 3Φ nonrated, <1-5> received peak demand	Watts
Z_PF_AT_W_1_REC_PD	PF at watts, 3Φ nonrated, 1 received peak demand	Unitless
Z_U_<1-5>_REC_PD	VAAs, 3Φ nonrated, <1-5> received peak demand	Volt-amps
Z_PF_AT_U_1_REC_PD	PF at VAs, 3Φ nonrated, 1 received peak demand	Unitless
Z_Q_<1-5>_REC_PD	VARs, 3Φ nonrated, <1-5> received peak demand	Volt-amps reactive
Z_PF_AT_Q_1_REC_PD	PF at VARs, 3Φ nonrated, 1 received peak demand	Unitless
Advanced: Time-of-Use Metering, Demand, Cumulative Demand, Rated		
Z_W_<A-F>_CD	Watts, 3Φ rate <A-F>, cumulative demand	Watts
Z_U_<A-F>_CD	VAAs, 3Φ rate <A-F>, cumulative demand	Volt-amps
Z_Q_<A-F>_CD	VARs, 3Φ rate <A-F>, cumulative demand	Volt-amps reactive
Advanced: Time-of-Use Metering, Demand, Cumulative Demand, Nonrated		
Z_W_CD	Watts, 3Φ nonrated, cumulative demand	Watts
Z_U_CD	VAAs, 3Φ nonrated, cumulative demand	Volt-amps
Z_Q_CD	VARs, 3Φ nonrated, cumulative demand	Volt-amps reactive
Advanced: Time-of-Use Metering, Demand, Cumulative Demand, Reset Relative		
Z_W_MAX_AT_RESET	Watts, 3Φ peak demand at reset	Watts
Z_Q_MAX_AT_RESET	VARs, 3Φ peak demand at reset	Volt-amps reactive
Z_W_AT_MIN_PF_AT_RESET	Watts, 3Φ demand at minimum PF at reset	Watts
Z_W_AT_MIN_PF_SINCE_RESET	Watts, 3Φ nonrated, demand at minimum PF since reset	Watts
Z_PF_AVG_AT_RESET	Average PF, 3Φ at reset	Unitless
Z_PF_AVG_SINCE_RESET	Average PF, 3Φ since reset	Unitless
Z_NUM_DEMAND_RESETS	Number of peak demand resets	Unitless

**Table G.20 Advanced: Transformer and Line Losses**

Advanced: Transformer and Line Losses, Transformer Iron Losses		
3PWFE	Watts, 3 $\Phi$ iron losses	Watts
3PVFE	VARs, 3 $\Phi$ iron losses	Volt-amps reactive
LWFECA	Watts, A $\Phi$ iron losses	Watts
LWFE CB	Watts, B $\Phi$ iron losses	Watts
LWFECC	Watts, C $\Phi$ iron losses	Watts
LVFECA	VARs, A $\Phi$ iron losses	Volt-amps reactive
LVFE CB	VARs, B $\Phi$ iron losses	Volt-amps reactive
LVFECC	VARs, C $\Phi$ iron losses	Volt-amps reactive
Advanced: Transformer and Line Losses, Transformer Copper Losses		
3PWCU	Watts, 3 $\Phi$ copper losses	Watts
3PVCU	VARs, 3 $\Phi$ copper losses	Volt-amps reactive
LWCUCx	Phase A, B, or C copper watt losses	Watts
LVCUCx	Phase A, B, or C copper VAR losses	Volt-amps reactive
Advanced: Transformer and Line Losses, Total Transformer Losses		
TTL	VA, 3 $\Phi$ total transformer losses	Volt-amps
TVALx	Phase A, B, or C total transformer losses	Volt-amps
Advanced: Transformer and Line Losses, Supply Line Losses		
SPLL	Watts, 3 $\Phi$ supply line losses	Watts
SQLL	VARs, 3 $\Phi$ supply line losses	Volt-amps reactive
SPxL	Phase A, B, or C supply line watt losses	Watts
SQxL	Phase A, B, or C supply line VAR losses	Volt-amps reactive
Advanced: Transformer and Line Losses, Load Line Losses		
LPLL	Watts, 3 $\Phi$ load line losses	Watts
LQLL	VARs, 3 $\Phi$ load line losses	Volt-amps reactive
LPxL	Phase A, B, or C load line watt losses	Watts
LQxL	Phase A, B, or C load line VAR losses	Volt-amps reactive

**Table G.21 Advanced: Transformer Settings**

Advanced: Transformer Settings		
PTR	Potential transformer ratio	Ratio:1
CTR	Phase current transformer ratio	Ratio:1

**Table G.22 Advanced: Voltage and Current Imbalance and Average**

Advanced: Voltage and Current Unbalance and Average		
I_IMB	Current unbalance	%
V_IMB	Voltage unbalance	%
I_AVE	3-phase average current	Amps
V_AVE	3-phase average voltage	Volts

**Table G.23 Advanced: Voltage and Frequency Deviation**

Advanced: Voltage and Frequency Deviation		
DEV_Vx	Voltage deviation from nominal; Phase A, B, or C (Vab, Vbc, or Vca if Form 5)	%
DEV_F	Frequency deviation from nominal	%

## Device Word Bits (Used in SELogic Control Equations)

SELOGIC control equation settings use Device Word bits as binary inputs to the logic. SELOGIC control equation settings can also be set directly to 1 or 0.

The Device Word bit target row numbers correspond to the row numbers shown in ACSELERATOR QuickSet® SEL-5030 Software HMI Targets window.

**Table G.24 SEL-735 Device Word Bits (Sheet 1 of 2)**

Target Row	DNP Index	7	6	5	4	3	2	1	0
0	7–0	LED6	LED5	LED4	LED3	LED2	LED1	*	ENABLE
1	15–8	FALARM	HARM02	HARM03	HARM04	HARM05	HARM06	HARM07	HARM08
2	23–16	HARM09	HARM10	HARM11	HARM12	HARM13	HARM14	HARM15	RESET
3	31–24	SAGA	SAGB	SAGC	SAG3P	SWA	SWB	SWC	SW3P
4	39–32	SAGAB	SAGBC	SAGCA	ITIC_ND	SWAB	SWBC	SWCA	ITIC_PR
5	47–40	INTA	INTB	INTC	INT3P	INTAB	INTBC	INTCA	ITIC_SR
6	55–48	ALTMODE	EVNTCPT	PQALARM	*	RSTDEM	EOIP	RSTPKDM	MATHERR
7	63–56	FLTBLK	FAULT	DFAULT	TEST	IRIGOK	SSI_EVE	MIU	LOWBAT
8	71–64	SESNCH	DSTCH	*	*	*	RATECH	TESTDB	SETCH
9	79–72	*	*	*	*	TSNTPB	TSNTTP	TSOK	PMDOK
10	87–80	OUT101	OUT102	OUT103	OUT401 <sup>a</sup>	OUT402 <sup>a</sup>	OUT403 <sup>a</sup>	OUT404 <sup>a</sup>	SALARM
11	95–88	IN101	IN102	IN401 <sup>a</sup>	IN402 <sup>a</sup>	IN403 <sup>a</sup>	IN404 <sup>a</sup>	*	HALARM
12	103–96	KYZD1	KYZD2	KYZD3	KYZD4	KYZDT	RSTENGY	PREDAL	*
13	111–104	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
14	119–112	TMB8A	TMB7A	TMB6A	TMB5A	TMB4A	TMB3A	TMB2A	TMB 1A
15	127–120	RMB8B	RMB7B	RMB6B	RMB5B	RMB4B	RMB3B	RMB2B	RMB1B
16	135–128	TMB8B	TMB7B	TMB6B	TMB5B	TMB4B	TMB3B	TMB2B	TMB1B
17	143–136	LBOKB	CBADB	RBADB	ROKB	LBOKA	CBADA	RBADA	ROKA
18	151–144	SV01	SV02	SV03	SV04	SV01T	SV02T	SV03T	SV04T
19	159–152	SV05	SV06	SV07	SV08	SV05T	SV06T	SV07T	SV08T
20	167–160	SV09	SV10	SV11	SV12	SV09T	SV10T	SV11T	SV12T
21	175–168	SV13	SV14	SV15	SV16	SV13T	SV14T	SV15T	SV16T
22	183–176	RB01	RB02	RB03	RB04	RB05	RB06	RB07	RB08
23	191–184	RB09	RB10	RB11	RB12	RB13	RB14	RB15	RB16
24	199–192	LT01	LT02	LT03	LT04	LT05	LT06	LT07	LT08
25	207–200	LT09	LT10	LT11	LT12	LT13	LT14	LT15	LT16
26	215–208	SET01	SET02	SET03	SET04	SET05	SET06	SET07	SET08
27	223–216	RST01	RST02	RST03	RST04	RST05	RST06	RST07	RST08

**Table G.24 SEL-735 Device Word Bits (Sheet 2 of 2)**

Target Row	DNP Index	7	6	5	4	3	2	1	0
28	231–224	SET09	SET10	SET11	SET12	SET13	SET14	SET15	SET16
29	239–232	RST09	RST10	RST11	RST12	RST13	RST14	RST15	RST16
30	247–240	SC01QU	SC02QU	SC03QU	SC04QU	SC05QU	SC06QU	SC07QU	SC08QU
31	255–248	SC01QD	SC02QD	SC03QD	SC04QD	SC05QD	SC06QD	SC07QD	SC08QD
32	263–256	SC09QU	SC10QU	SC11QU	SC12QU	SC13QU	SC14QU	SC15QU	SC16QU
33	271–264	SC09QD	SC10QD	SC11QD	SC12QD	SC13QD	SC14QD	SC15QD	SC16QD
34	279–272	T06_LED	T05_LED	T04_LED	T03_LED	T02_LED	T01_LED	*	*
35	287–280	T14_LED	T13_LED	T12_LED	T11_LED	T10_LED	T09_LED	T08_LED	T07_LED
36	295–288	ER1	ER2	ER3	NEWEVNT	FREQY	PFREQY	*	*
37	303–296	DP01	DP02	DP03	DP04	DP05	DP06	DP07	DP08
38	311–304	DP09	DP10	DP11	DP12	DP13	DP14	DP15	DP16
39	319–312	SC01R	SC02R	SC03R	SC04R	SC05R	SC06R	SC07R	SC08R
40	327–320	SC01LD	SC02LD	SC03LD	SC04LD	SC05LD	SC06LD	SC07LD	SC08LD
41	335–328	SC01CU	SC02CU	SC03CU	SC04CU	SC05CU	SC06CU	SC07CU	SC08CU
42	343–329	SC01CD	SC02CD	SC03CD	SC04CD	SC05CD	SC06CD	SC07CD	SC08CD
43	351–344	SC09R	SC10R	SC11R	SC12R	SC13R	SC14R	SC15R	SC16R
44	359–352	SC09LD	SC10LD	SC11LD	SC12LD	SC13LD	SC14LD	SC15LD	SC16LD
45	367–360	SC09CU	SC10CU	SC11CU	SC12CU	SC13CU	SC14CU	SC15CU	SC16CU
46	375–368	SC09CD	SC10CD	SC11CD	SC12CD	SC13CD	SC14CD	SC15CD	SC16CD
47	383–376	EQA1	EQA2	EQA3	EQA4	EQB1	EQB2	EQB3	EQB4
48	391–384	EQC1	EQC2	EQC3	EQC4	EQ3P1	EQ3P2	EQ3P3	EQ3P4
49	399–392	PB01	PB02	PB03	PB04	*	*	*	*
50	407–400	VB001	VB002	VB003	VB004	VB005	VB006	VB007	VB008
51	415–408	VB009	VB010	VB011	VB012	VB013	VB014	VB015	VB016
52	423–416	VB017	VB018	VB019	VB020	VB021	VB022	VB023	VB024
53	431–424	VB025	VB026	VB027	VB028	VB029	VB030	VB031	VB032
54	439–432	VB033	VB034	VB035	VB036	VB037	VB038	VB039	VB040
55	447–440	VB041	VB042	VB043	VB044	VB045	VB046	VB047	VB048
56	455–448	VB049	VB050	VB051	VB052	VB053	VB054	VB055	VB056
57	463–456	VB057	VB058	VB059	VB060	VB061	VB062	VB063	VB064
58	471–464	VB065	VB066	VB067	VB068	VB069	VB070	VB071	VB072
59	479–472	VB073	VB074	VB075	VB076	VB077	VB078	VB079	VB080
60	487–480	VB081	VB082	VB083	VB084	VB085	VB086	VB087	VB088
61	495–488	VB089	VB090	VB091	VB092	VB093	VB094	VB095	VB096
62	503–496	VB097	VB098	VB099	VB100	VB101	VB102	VB103	VB104
63	511–504	VB105	VB106	VB107	VB108	VB109	VB110	VB111	VB112
64	519–512	VB113	VB114	VB115	VB116	VB117	VB118	VB119	VB120
65	527–520	VB121	VB122	VB123	VB124	VB10925	VB126	VB127	VB128

<sup>a</sup> Optional feature.

**Table G.25 SEL-735 Device Word Bit Definitions**  
 (Sheet 1 of 14)

Row	Bit	Definition
0 <sup>a</sup>	7	LED6 LED6 asserted
	6	LED5 LED5 asserted
	5	LED4 LED4 asserted
	4	LED3 LED3 asserted
	3	LED2 LED2 asserted
	2	LED1 LED1 asserted
	1	* Not used
	0	ENABLE Meter enabled
1	7	FALARM Harmonic threshold alarm
	6	HARM02 Second harmonic threshold
	5	HARM03 Third harmonic threshold
	4	HARM04 Fourth harmonic threshold
	3	HARM05 Fifth harmonic threshold
	2	HARM06 Sixth harmonic threshold
	1	HARM07 Seventh harmonic threshold
	0	HARM08 Eighth harmonic threshold
2	7	HARM09 Ninth harmonic threshold
	6	HARM10 Tenth harmonic threshold
	5	HARM11 Eleventh harmonic threshold
	4	HARM12 Twelfth harmonic threshold
	3	HARM13 Thirteenth harmonic threshold
	2	HARM14 Fourteenth harmonic threshold
	1	HARM15 Fifteenth harmonic threshold
	0	RESET RESET bit asserted
3	7	SAGA A-phase voltage sag element
	6	SAGB B-phase voltage sag element
	5	SAGC C-phase voltage sag element
	4	SAG3P Three-phase voltage sag element
	3	SWA A-phase voltage swell element
	2	SWB B-phase voltage swell element
	1	SWC C-phase voltage sag element
	0	SW3P Three-phase voltage swell element
4	7	SAGAB Phase-to-phase AB voltage sag element
	6	SAGBC Phase-to-phase BC voltage sag element
	5	SAGCA Phase-to-phase CA voltage sag element
	4	ITIC_ND CBEMA/ITIC no damage region
	3	SWAB Phase-to-phase AB voltage swell element
	2	SWBC Phase-to-phase BC voltage swell element
	1	SWCA Phase-to-phase CA voltage swell element
	0	ITIC_PR CBEMA/ITIC prohibited region

**Table G.25 SEL-735 Device Word Bit Definitions**  
 (Sheet 2 of 14)

Row	Bit	Definition
5	7	INTA A-phase voltage interrupt element
	6	INTB B-phase voltage interrupt element
	5	INTC C-phase voltage interrupt element
	4	INT3P Three-phase voltage interrupt element
	3	INTAB Phase-to-phase AB voltage interrupt element
	2	INTBC Phase-to-phase BC voltage interrupt element
	1	INTCA Phase-to-phase CA voltage interrupt element
	0	ITIC_SR CBEMA/ITIC safe region
6	7	ALTMODE Alternate display mode
	6	EVNTCPT Event capture
	5	PQALARM Power quality alarm
	4	* Not used
	3	RSTDEM Present demand value reset
	2	EOIP End of Interval Pulse asserted (demand)
	1	RSTPKDM Peak demand value reset
	0	MATHERR Math error asserted for error in math variables
7	7	FLTBLK Fault block asserted
	6	FAULT Fault bit asserted
	5	DFAULT Delayed fault asserted
	4	TEST Test mode bit asserted
	3	IRIGOK IRIG-B input OK
	2	SSI_EVE Detect SSI event within processing interval
	1	MIU Modem in use
	0	LOWBAT Low real-time clock battery warning
8	7	SESNCH TOU season change bit asserted
	6	DSTCH DST change bit asserted
	5	* Not used
	4	* Not used
	3	* Not used
	2	RATECH Rate change bit asserted
	1	TESTDB Test database command active
	0	SETCH Settings change bit asserted
9	7	* Not used
	6	* Not used
	5	* Not used
	4	* Not used
	3	* Not used
	2	* Not used

**Table G.25 SEL-735 Device Word Bit Definitions**  
 (Sheet 3 of 14)

Row	Bit	Definition
	1	TSOK Time stamp OK
	0	PMDOK Measurement data OK
10	7	OUT101 Output contact <b>OUT101</b> asserted
	6	OUT102 Output contact <b>OUT102</b> asserted
	5	OUT103 Output contact <b>OUT103</b> asserted
	4	OUT401 <sup>b</sup> Output contact <b>OUT401</b> asserted
	3	OUT402 <sup>b</sup> Output contact <b>OUT402</b> asserted
	2	OUT403 <sup>b</sup> Output contact <b>OUT403</b> asserted
	1	OUT404 <sup>b</sup> Output contact <b>OUT404</b> asserted
	0	SALARM Software alarm asserted
11	7	IN101 Optoisolated input <b>IN101</b> asserted
	6	IN102 Optoisolated input <b>IN102</b> asserted
	5	IN401 <sup>b</sup> Optoisolated input <b>IN401</b> asserted
	4	IN402 <sup>b</sup> Optoisolated input <b>IN402</b> asserted
	3	IN403 <sup>b</sup> Optoisolated input <b>IN403</b> asserted
	2	IN404 <sup>b</sup> Optoisolated input <b>IN404</b> asserted
	1	* Not used
	0	HALARM Hardware alarm
12	7	KYZD1 KYZ pulse number 1
	6	KYZD2 KYZ pulse number 2
	5	KYZD3 KYZ pulse number 3
	4	KYZD4 KYZ pulse number 4
	3	KYZDT KYZ pulse test
	2	RSTENGY Energy registers reset
	1	PREDAL Predictive demand alarm
	0	* Not used
13	7	RMB8A Channel A, received bit 8
	6	RMB7A Channel A, received bit 7
	5	RMB6A Channel A, received bit 6
	4	RMB5A Channel A, received bit 5
	3	RMB4A Channel A, received bit 4
	2	RMB3A Channel A, received bit 3
	1	RMB2A Channel A, received bit 2
	0	RMB1A Channel A, received bit 1
14	7	TMB8A Channel A, transmit bit 8
	6	TMB7A Channel A, transmit bit 7
	5	TMB6A Channel A, transmit bit 6
	4	TMB5A Channel A, transmit bit 5
	3	TMB4A Channel A, transmit bit 4
	2	TMB3A Channel A, transmit bit 3

**Table G.25 SEL-735 Device Word Bit Definitions**  
 (Sheet 4 of 14)

Row	Bit	Definition
	1	TMB2A Channel A, transmit bit 2
	0	TMB1A Channel A, transmit bit 1
15	7	RMB8B Channel B, received bit 8
	6	RMB7B Channel B, received bit 7
	5	RMB6B Channel B, received bit 6
	4	RMB5B Channel B, received bit 5
	3	RMB4B Channel B, received bit 4
	2	RMB3B Channel B, received bit 3
	1	RMB2B Channel B, received bit 2
	0	RMB1B Channel B, received bit 1
16	7	TMB8B Channel B, transmit bit 8
	6	TMB7B Channel B, transmit bit 7
	5	TMB6B Channel B, transmit bit 6
	4	TMB5B Channel B, transmit bit 5
	3	TMB4B Channel B, transmit bit 4
	2	TMB3B Channel B, transmit bit 3
	1	TMB2B Channel B, transmit bit 2
	0	TMB1B Channel B, transmit bit 1
17	7	LBOKB Channel B, looped back ok
	6	CBADB Channel B, channel unavailability over threshold
	5	RBADB Channel B, outage duration over threshold
	4	ROKB Channel B, received data ok
	3	LBOKA Channel A, looped back ok
	2	CBADA Channel A, channel unavailability over threshold
	1	RBADA Channel A, outage duration over threshold
	0	ROKA Channel A, received data ok
18	7	SV01 SELOGIC control equation variable timer input SV1 asserted
	6	SV02 SELOGIC control equation variable timer input SV2 asserted
	5	SV03 SELOGIC control equation variable timer input SV3 asserted
	4	SV04 SELOGIC control equation variable timer input SV4 asserted
	3	SV01T SELOGIC control equation variable timer output SV1T asserted
	2	SV02T SELOGIC control equation variable timer output SV2T asserted
	1	SV03T SELOGIC control equation variable timer output SV3T asserted

**Table G.25 SEL-735 Device Word Bit Definitions**  
 (Sheet 5 of 14)

Row	Bit	Definition
	0 SV04T	SELOGIC control equation variable timer output SV4T asserted
19	7 SV05	SELOGIC control equation variable timer input SV5 asserted
	6 SV06	SELOGIC control equation variable timer input SV6 asserted
	5 SV07	SELOGIC control equation variable timer input SV7 asserted
	4 SV08	SELOGIC control equation variable timer input SV8 asserted
	3 SV05T	SELOGIC control equation variable timer output SV5T asserted
	2 SV06T	SELOGIC control equation variable timer output SV6T asserted
	1 SV07T	SELOGIC control equation variable timer output SV7T asserted
	0 SV08T	SELOGIC control equation variable timer output SV8T asserted
20	7 SV09	SELOGIC control equation variable timer input SV9 asserted
	6 SV10	SELOGIC control equation variable timer input SV10 asserted
	5 SV11	SELOGIC control equation variable timer input SV11 asserted
	4 SV12	SELOGIC control equation variable timer input SV12 asserted
	3 SV09T	SELOGIC control equation variable timer output SV9T asserted
	2 SV10T	SELOGIC control equation variable timer output SV10T asserted
	1 SV11T	SELOGIC control equation variable timer output SV11T asserted
	0 SV12T	SELOGIC control equation variable timer output SV12T asserted
21	7 SV13	SELOGIC control equation variable timer input SV13 asserted
	6 SV14	SELOGIC control equation variable timer input SV14 asserted
	5 SV15	SELOGIC control equation variable timer input SV15 asserted
	4 SV16	SELOGIC control equation variable timer input SV16 asserted
	3 SV13T	SELOGIC control equation variable timer output SV13T asserted
	2 SV14T	SELOGIC control equation variable timer output SV14T asserted
	1 SV15T	SELOGIC control equation variable timer output SV15T asserted

**Table G.25 SEL-735 Device Word Bit Definitions**  
 (Sheet 6 of 14)

Row	Bit	Definition
	0 SV16T	SELOGIC control equation variable timer output SV16T asserted
22	7 RB01	Remote bit 1 asserted
	6 RB02	Remote bit 2 asserted
	5 RB03	Remote bit 3 asserted
	4 RB04	Remote bit 4 asserted
	3 RB05	Remote bit 5 asserted
	2 RB06	Remote bit 6 asserted
	1 RB07	Remote bit 7 asserted
	0 RB08	Remote bit 8 asserted
23	7 RB09	Remote bit 9 asserted
	6 RB10	Remote bit 10 asserted
	5 RB11	Remote bit 11 asserted
	4 RB12	Remote bit 12 asserted
	3 RB13	Remote bit 13 asserted
	2 RB14	Remote bit 14 asserted
	1 RB15	Remote bit 15 asserted
	0 RB16	Remote bit 16 asserted
24	7 LT01	Latch bit 1 asserted
	6 LT02	Latch bit 2 asserted
	5 LT03	Latch bit 3 asserted
	4 LT04	Latch bit 4 asserted
	3 LT05	Latch bit 5 asserted
	2 LT06	Latch bit 6 asserted
	1 LT07	Latch bit 7 asserted
	0 LT08	Latch bit 8 asserted
25	7 LT09	Latch bit 9 asserted
	6 LT10	Latch bit 10 asserted
	5 LT11	Latch bit 11 asserted
	4 LT12	Latch bit 12 asserted
	3 LT13	Latch bit 13 asserted
	2 LT14	Latch bit 14 asserted
	1 LT15	Latch bit 15 asserted
	0 LT16	Latch bit 16 asserted
26	7 SET01	Latch bit 1 set asserted
	6 SET02	Latch bit 2 set asserted
	5 SET03	Latch bit 3 set asserted
	4 SET04	Latch bit 4 set asserted
	3 SET05	Latch bit 5 set asserted
	2 SET06	Latch bit 6 set asserted

**Table G.25 SEL-735 Device Word Bit Definitions**  
 (Sheet 7 of 14)

Row	Bit	Definition
	1	SET07 Latch bit 7 set asserted
	0	SET08 Latch bit 8 set asserted
27	7	RST01 Latch bit 1 reset asserted
	6	RST02 Latch bit 2 reset asserted
	5	RST03 Latch bit 3 reset asserted
	4	RST04 Latch bit 4 reset asserted
	3	RST05 Latch bit 5 reset asserted
	2	RST06 Latch bit 6 reset asserted
	1	RST07 Latch bit 7 reset asserted
	0	RST08 Latch bit 8 reset asserted
28	7	SET09 Latch bit 9 set asserted
	6	SET10 Latch bit 10 set asserted
	5	SET11 Latch bit 11 set asserted
	4	SET12 Latch bit 12 set asserted
	3	SET13 Latch bit 13 set asserted
	2	SET14 Latch bit 14 set asserted
	1	SET15 Latch bit 15 set asserted
0	SET16 Latch bit 16 set asserted	
29	7	RST09 Latch bit 9 reset asserted
	6	RST10 Latch bit 10 reset asserted
	5	RST11 Latch bit 11 reset asserted
	4	RST12 Latch bit 12 reset asserted
	3	RST13 Latch bit 13 reset asserted
	2	RST14 Latch bit 14 reset asserted
	1	RST15 Latch bit 15 reset asserted
0	RST16 Latch bit 16 reset asserted	
30	7	SC01QU SELOGIC counter 1 up asserted
	6	SC02QU SELOGIC counter 2 up asserted
	5	SC03QU SELOGIC counter 3 up asserted
	4	SC04QU SELOGIC counter 4 up asserted
	3	SC05QU SELOGIC counter 5 up asserted
	2	SC06QU SELOGIC counter 6 up asserted
	1	SC07QU SELOGIC counter 7 up asserted
	0	SC08QU SELOGIC counter 8 up asserted
31	7	SC01QD SELOGIC counter 1 down asserted
	6	SC02QD SELOGIC counter 2 down asserted
	5	SC03QD SELOGIC counter 3 down asserted
	4	SC04QD SELOGIC counter 4 down asserted
	3	SC05QD SELOGIC counter 5 down asserted
	2	SC06QD SELOGIC counter 6 down asserted

**Table G.25 SEL-735 Device Word Bit Definitions**  
 (Sheet 8 of 14)

Row	Bit	Definition
	1	SC07QD SELOGIC counter 7 down asserted
	0	SC08QD SELOGIC counter 8 down asserted
32	7	SC09QU SELOGIC counter 9 up asserted
	6	SC10QU SELOGIC counter 10 up asserted
	5	SC11QU SELOGIC counter 11 up asserted
	4	SC12QU SELOGIC counter 12 up asserted
	3	SC13QU SELOGIC counter 13 up asserted
	2	SC14QU SELOGIC counter 14 up asserted
	1	SC15QU SELOGIC counter 15 up asserted
	0	SC16QU SELOGIC counter 16 up asserted
33	7	SC09QD SELOGIC counter 9 down asserted
	6	SC10QD SELOGIC counter 10 down asserted
	5	SC11QD SELOGIC counter 11 down asserted
	4	SC12QD SELOGIC counter 12 down asserted
	3	SC13QD SELOGIC counter 13 down asserted
	2	SC14QD SELOGIC counter 14 down asserted
	1	SC15QD SELOGIC counter 15 down asserted
0	SC16QD SELOGIC counter 16 down asserted	
34	7	T06_LED LED 06 asserted
	6	T05_LED LED 05 asserted
	5	T04_LED LED 04 asserted
	4	T03_LED LED 03 asserted
	3	T02_LED LED 02 asserted
	2	T01_LED LED 01 asserted
	1	*
0	*	Not used
35	7	T14_LED LED 14 asserted
	6	T13_LED LED 13 asserted
	5	T12_LED LED 12 asserted
	4	T11_LED LED 11 asserted
	3	T10_LED LED 10 asserted
	2	T09_LED LED 09 asserted
	1	T08_LED LED 08 asserted
	0	T07_LED LED 07 asserted
36	7	ER1 Event report equation 1 asserted
	6	ER2 Event report equation 2 asserted
	5	ER3 Event report equation 3 asserted
	4	NEWEVNT Asserts when a new event is triggered
	3	FREQY FREQ is valid
	2	PFREQY FREQ_PQ is valid

**Table G.25 SEL-735 Device Word Bit Definitions**  
 (Sheet 9 of 14)

Row	Bit	Definition
	1 *	Not used
	0 *	Not used
37	7 DP01	Display point 01 asserted
	6 DP02	Display point 02 asserted
	5 DP03	Display point 03 asserted
	4 DP04	Display point 04 asserted
	3 DP05	Display point 05 asserted
	2 DP06	Display point 06 asserted
	1 DP07	Display point 07 asserted
	0 DP08	Display point 08 asserted
38	7 DP09	Display point 09 asserted
	6 DP10	Display point 10 asserted
	5 DP11	Display point 11 asserted
	4 DP12	Display point 12 asserted
	3 DP13	Display point 13 asserted
	2 DP14	Display point 14 asserted
	1 DP15	Display point 15 asserted
	0 DP16	Display point 16 asserted
39	7 SC01R	SELOGIC Counter 01, counter reset
	6 SC02R	SELOGIC Counter 02, counter reset
	5 SC03R	SELOGIC Counter 03, counter reset
	4 SC04R	SELOGIC Counter 04, counter reset
	3 SC05R	SELOGIC Counter 05, counter reset
	2 SC06R	SELOGIC Counter 06, counter reset
	1 SC07R	SELOGIC Counter 07, counter reset
	0 SC08R	SELOGIC Counter 08, counter reset
40	7 SC01LD	SELOGIC Counter 01, load preset value
	6 SC02LD	SELOGIC Counter 02, load preset value
	5 SC03LD	SELOGIC Counter 03, load preset value
	4 SC04LD	SELOGIC Counter 04, load preset value
	3 SC05LD	SELOGIC Counter 05, load preset value
	2 SC06LD	SELOGIC Counter 06, load preset value
	1 SC07LD	SELOGIC Counter 07, load preset value
	0 SC08LD	SELOGIC Counter 08, load preset value
41	7 SC01CU	SELOGIC Counter 01, count up
	6 SC02CU	SELOGIC Counter 02, count up
	5 SC03CU	SELOGIC Counter 03, count up
	4 SC04CU	SELOGIC Counter 04, count up
	3 SC05CU	SELOGIC Counter 05, count up
	2 SC06CU	SELOGIC Counter 06, count up

**Table G.25 SEL-735 Device Word Bit Definitions**  
 (Sheet 10 of 14)

Row	Bit	Definition
	1 SC07CU	SELOGIC Counter 07, count up
	0 SC08CU	SELOGIC Counter 08, count up
42	7 SC01CD	SELOGIC Counter 01, count down
	6 SC02CD	SELOGIC Counter 02, count down
	5 SC03CD	SELOGIC Counter 03, count down
	4 SC04CD	SELOGIC Counter 04, count down
	3 SC05CD	SELOGIC Counter 05, count down
	2 SC06CD	SELOGIC Counter 06, count down
	1 SC07CD	SELOGIC Counter 07, count down
	0 SC08CD	SELOGIC Counter 08, count down
43	7 SC09R	SELOGIC Counter 09, counter reset
	6 SC10R	SELOGIC Counter 10, counter reset
	5 SC11R	SELOGIC Counter 11, counter reset
	4 SC12R	SELOGIC Counter 12, counter reset
	3 SC13R	SELOGIC Counter 13, counter reset
	2 SC14R	SELOGIC Counter 14, counter reset
	1 SC15R	SELOGIC Counter 15, counter reset
	0 SC16R	SELOGIC Counter 16, counter reset
44	7 SC09LD	SELOGIC Counter 09, load preset value
	6 SC10LD	SELOGIC Counter 10, load preset value
	5 SC11LD	SELOGIC Counter 11, load preset value
	4 SC12LD	SELOGIC Counter 12, load preset value
	3 SC13LD	SELOGIC Counter 13, load preset value
	2 SC14LD	SELOGIC Counter 14, load preset value
	1 SC15LD	SELOGIC Counter 15, load preset value
	0 SC16LD	SELOGIC Counter 16, load preset value
45	7 SC09CU	SELOGIC Counter 09, count up
	6 SC10CU	SELOGIC Counter 10, count up
	5 SC11CU	SELOGIC Counter 11, count up
	4 SC12CU	SELOGIC Counter 12, count up
	3 SC13CU	SELOGIC Counter 13, count up
	2 SC14CU	SELOGIC Counter 14, count up
	1 SC15CU	SELOGIC Counter 15, count up
	0 SC16CU	SELOGIC Counter 16, count up
46	7 SC09CD	SELOGIC Counter 09, count down
	6 SC10CD	SELOGIC Counter 10, count down
	5 SC11CD	SELOGIC Counter 11, count down
	4 SC12CD	SELOGIC Counter 12, count down
	3 SC13CD	SELOGIC Counter 13, count down
	2 SC14CD	SELOGIC Counter 14, count down

**Table G.25 SEL-735 Device Word Bit Definitions**  
 (Sheet 11 of 14)

Row	Bit	Definition	
	1	SC15CD SELOGIC Counter 15, count down	
	0	SC16CD SELOGIC Counter 16, count down	
47	7	EQA1 VARs, A-phase, Quadrant I	
	6	EQA2 VARs, A-phase, Quadrant II	
	5	EQA3 VARs, A-phase, Quadrant III	
	4	EQA4 VARs, A-phase, Quadrant IV	
	3	EQB1 VARs, B-phase, Quadrant I	
	2	EQB2 VARs, B-phase, Quadrant II	
	1	EQB3 VARs, B-phase, Quadrant III	
	0	EQB4 VARs, B-phase, Quadrant IV	
48	7	EQC1 VARs, C-phase, Quadrant I	
	6	EQC2 VARs, C-phase, Quadrant II	
	5	EQC3 VARs, C-phase, Quadrant III	
	4	EQC4 VARs, C-phase, Quadrant IV	
	3	EQ3P1 VARs, 3-phase, Quadrant I	
	2	EQ3P2 VARs, 3-phase, Quadrant II	
	1	EQ3P3 VARs, 3-phase, Quadrant III	
	0	EQ3P4 VARs, 3-phase, Quadrant IV	
49	7	PB01 Pushbutton 1 bit asserted	
	6	PB02 Pushbutton 2 bit asserted	
	5	PB03 Pushbutton 3 bit asserted	
	4	PB04 Pushbutton 4 bit asserted	
	3	*	Not used
	2	*	Not used
	1	*	Not used
	0	*	Not used
50	7	VB001 Virtual Bit	
	6	VB002 Virtual Bit	
	5	VB003 Virtual Bit	
	4	VB004 Virtual Bit	
	3	VB005 Virtual Bit	
	2	VB006 Virtual Bit	
	1	VB007 Virtual Bit	
	0	VB008 Virtual Bit	
	51	7	VB009 Virtual Bit
6		VB010 Virtual Bit	
5		VB011 Virtual Bit	
4		VB012 Virtual Bit	
3		VB013 Virtual Bit	
2		VB014 Virtual Bit	

**Table G.25 SEL-735 Device Word Bit Definitions**  
 (Sheet 12 of 14)

Row	Bit	Definition
	1	VB015 Virtual Bit
	0	VB016 Virtual Bit
52	7	VB017 Virtual Bit
	6	VB018 Virtual Bit
	5	VB019 Virtual Bit
	4	VB020 Virtual Bit
	3	VB021 Virtual Bit
	2	VB022 Virtual Bit
	1	VB023 Virtual Bit
	0	VB024 Virtual Bit
53	7	VB025 Virtual Bit
	6	VB026 Virtual Bit
	5	VB027 Virtual Bit
	4	VB028 Virtual Bit
	3	VB029 Virtual Bit
	2	VB030 Virtual Bit
	1	VB031 Virtual Bit
	0	VB032 Virtual Bit
54	7	VB033 Virtual Bit
	6	VB034 Virtual Bit
	5	VB035 Virtual Bit
	4	VB036 Virtual Bit
	3	VB037 Virtual Bit
	2	VB038 Virtual Bit
	1	VB039 Virtual Bit
	0	VB040 Virtual Bit
55	7	VB041 Virtual Bit
	6	VB042 Virtual Bit
	5	VB043 Virtual Bit
	4	VB044 Virtual Bit
	3	VB045 Virtual Bit
	2	VB046 Virtual Bit
	1	VB047 Virtual Bit
	0	VB048 Virtual Bit
	56	7
6		VB050 Virtual Bit
5		VB051 Virtual Bit
4		VB052 Virtual Bit
3		VB053 Virtual Bit
2		VB054 Virtual Bit

**Table G.25 SEL-735 Device Word Bit Definitions**  
 (Sheet 13 of 14)

Row	Bit	Definition
	1 VB055	Virtual Bit
	0 VB056	Virtual Bit
57	7 VB057	Virtual Bit
	6 VB058	Virtual Bit
	5 VB059	Virtual Bit
	4 VB060	Virtual Bit
	3 VB061	Virtual Bit
	2 VB062	Virtual Bit
	1 VB063	Virtual Bit
	0 VB064	Virtual Bit
58	7 VB065	Virtual Bit
	6 VB066	Virtual Bit
	5 VB067	Virtual Bit
	4 VB068	Virtual Bit
	3 VB069	Virtual Bit
	2 VB070	Virtual Bit
	1 VB071	Virtual Bit
	0 VB072	Virtual Bit
59	7 VB073	Virtual Bit
	6 VB074	Virtual Bit
	5 VB075	Virtual Bit
	4 VB076	Virtual Bit
	3 VB077	Virtual Bit
	2 VB078	Virtual Bit
	1 VB079	Virtual Bit
	0 VB080	Virtual Bit
60	7 VB081	Virtual Bit
	6 VB082	Virtual Bit
	5 VB083	Virtual Bit
	4 VB084	Virtual Bit
	3 VB085	Virtual Bit
	2 VB086	Virtual Bit
	1 VB087	Virtual Bit
	0 VB088	Virtual Bit
61	7 VB089	Virtual Bit
	6 VB090	Virtual Bit
	5 VB091	Virtual Bit
	4 VB092	Virtual Bit
	3 VB093	Virtual Bit
	2 VB094	Virtual Bit

**Table G.25 SEL-735 Device Word Bit Definitions**  
 (Sheet 14 of 14)

Row	Bit	Definition
	1 VB095	Virtual Bit
	0 VB096	Virtual Bit
62	7 VB097	Virtual Bit
	6 VB098	Virtual Bit
	5 VB099	Virtual Bit
	4 VB100	Virtual Bit
	3 VB101	Virtual Bit
	2 VB102	Virtual Bit
	1 VB103	Virtual Bit
	0 VB104	Virtual Bit
63	7 VB105	Virtual Bit
	6 VB106	Virtual Bit
	5 VB107	Virtual Bit
	4 VB108	Virtual Bit
	3 VB109	Virtual Bit
	2 VB110	Virtual Bit
	1 VB111	Virtual Bit
	0 VB112	Virtual Bit
64	7 VB113	Virtual Bit
	6 VB114	Virtual Bit
	5 VB115	Virtual Bit
	4 VB116	Virtual Bit
	3 VB117	Virtual Bit
	2 VB118	Virtual Bit
	1 VB119	Virtual Bit
	0 VB120	Virtual Bit
65	7 VB121	Virtual Bit
	6 VB122	Virtual Bit
	5 VB123	Virtual Bit
	4 VB124	Virtual Bit
	3 VB125	Virtual Bit
	2 VB126	Virtual Bit
	1 VB127	Virtual Bit
	0 VB128	Virtual Bit

<sup>a</sup> Row 0 Device Word Bits are not available via the Front-Panel HMI Targets menu.  
<sup>b</sup> Optional feature.

# Appendix H

## IEC 61850 Communications

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### Features

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The SEL-735 Power Quality and Revenue Meter supports the following features using Ethernet and IEC 61850:

**NOTE:** The SEL-735 supports one CID file, which should be transferred only if a change in the meter configuration is required. If an invalid CID file is transferred, the meter will no longer have a valid IEC 61850 configuration, and the protocol will stop operating. To restart protocol operation, a valid CID must be transferred to the meter.

- **SCADA**—Connect as many as six simultaneous IEC 61850 MMS client sessions. The SEL-735 also supports as many as six buffered and six unbuffered report control blocks. See *Table H.14* for Logical Node mapping that enables SCADA control via a Manufacturing Messaging Specification (MMS) browser. Controls support the direct control with normal security, direct control with enhanced security, and select-before-operate (SBO) with enhanced security control models.
- **Peer-to-Peer Real-Time Status and Control**—Use GOOSE with as many as 24 incoming (receive) and 8 outgoing (transmit) messages. Virtual bits (VB001–VB128) and Remote Analogs (RA00–RA31) can be mapped from incoming GOOSE messages.
- **Configuration**—Use FTP client software or ACSELERATOR Architect® SEL-5032 Software to transfer the Substation Configuration Language (SCL) Configured IED Description (CID) file to the meter.
- **Commissioning and Troubleshooting**—Use software such as MMS Object Explorer and AX-S4 MMS from Cisco, Inc., to browse the meter logical nodes and verify functionality.
- **IEC 61850 Standard**—IEC 61850 Standard, Edition 1 is supported.

This section presents the information you need to use the IEC 61850 features of the SEL-735:

- *Introduction to IEC 61850*
- *IEC 61850 Operation on page H.3*
- *IEC 61850 Configuration on page H.13*
- *Logical Nodes on page H.17*

# Introduction to IEC 61850

In the early 1990s, the Electric Power Research Institute (EPRI) and the Institute of Electrical and Electronics Engineers, Inc. (IEEE) began to define a Utility Communications Architecture (UCA). They initially focused on inter-control center and substation-to-control center communications and produced the Inter-Control Center Communications Protocol (ICCP) specification. This specification, later adopted by the IEC as 60870-6 TASE.2, became the standard protocol for real-time exchange of data between databases.

In 1994, EPRI and IEEE began work on UCA 2.0 for Field Devices (simply referred to as UCA2). In 1997, they combined efforts with Technical Committee 57 of the IEC to create a common international standard. Their joint efforts created the current IEC 61850 standard.

The IEC 61850 standard, a superset of UCA2, contains most of the UCA2 specification, plus additional functionality. The standard describes client/server and peer-to-peer communications, substation design and configuration, testing, and project standards.

The IEC 61850 standard consists of the parts listed in *Table H.1*.

**Table H.1 IEC 61850 Document Set**

IEC 61850 Sections	Definitions
IEC 61850-1	Introduction and overview
IEC 61850-2	Glossary
IEC 61850-3	General requirements
IEC 61850-4	System and project management
IEC 61850-5	Communication requirements
IEC 61850-6	Configuration description language for substation IEDs
IEC 61850-7-1	Basic communication structure for substations and feeder equipment—Principles and models
IEC 61850-7-2	Basic communication structure for substations and feeder equipment—Abstract communication service interface (ACSI)
IEC 61850-7-3	Basic communication structure for substations and feeder equipment—Common data classes
IEC 61850-7-4	Basic communication structure for substations and feeder equipment—Compatible logical node (LN) classes and data classes
IEC 61850-8-1	SCSM—Mapping to Manufacturing Messaging Specification (MMS) (ISO/IEC 9506-1 and ISO/IEC 9506-2 over ISO/IEC 8802-3)
IEC 61850-9-1	SCSM—Sampled values over serial multidrop point-to-point link
IEC 61850-9-2	SCSM—Sampled values over ISO/IEC 8802-3
IEC 61850-10	Conformance testing

The IEC 61850 document set, available directly from the IEC at [www.iec.ch](http://www.iec.ch), contains information necessary for successful implementation of this protocol. SEL strongly recommends that anyone involved with the design, installation, configuration, or maintenance of IEC 61850 systems be familiar with the appropriate sections of this standard.

# IEC 61850 Operation

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## Ethernet Networking

IEC 61850 and Ethernet networking model options are available when ordering a new SEL-735 and may also be available as field upgrades to meters equipped with copper or fiber-optic Ethernet. In addition to IEC 61850, the meter provides support protocols and data exchange, including FTP and Telnet. Access the SEL-735 Port 1 settings to configure all of the Ethernet settings, including IEC 61850 enable settings.

The SEL-735 supports IEC 61850 services, including transport of Logical Node objects, over TCP/IP. The meter can coordinate a maximum of six concurrent IEC 61850 sessions.

## Object Models

The IEC 61850 standard relies heavily on the Abstract Communication Service Interface (ACSI) models to define a set of services and the responses to those services. In terms of network behavior, abstract modeling enables all IEDs to act identically. These abstract models are used to create objects (data items) and services that exist independently of any underlying protocols. These objects are in conformance with the common data class (CDC) specification IEC 61850-7-3, which describes the type and structure of each element within a logical node. CDCs for status, measurements, controllable analogs and statuses, and settings all have unique CDC attributes. Each CDC attribute belongs to a set of functional constraints that groups the attributes into specific categories such as status (ST), description (DC), and substituted value (SV). Functional constraints, CDCs, and CDC attributes are used as building blocks for defining Logical Nodes.

UCA2 used GOMSFE (Generic Object Models for Substation and Feeder Equipment) to present data from station IEDs as a series of objects called models or bricks. The IEC working group has incorporated GOMSFE concepts into the standard, with some modifications to terminology; one change was the renaming of bricks to logical nodes. Each logical node represents a group of data (controls, status, measurements, etc.) associated with a particular function. For example, the MMXU logical node (polyphase measurement unit) contains non-revenue grade measurement data and other points associated with three-phase fundamental quantity metering including voltages and currents. Each IED may contain many functions such as protection, metering, and control. Multiple logical nodes represent the functions in multifunction devices.

Logical nodes can be organized into logical devices that are similar to directories on a computer disk. As represented in the IEC 61850 network, each physical device can contain many logical devices and each logical device can contain many logical nodes. Many relays, meters, and other IEC 61850 devices contain one primary logical device where all models are organized.

IEC 61850 devices are capable of self-description. You do not need to refer to the specifications for the logical nodes, measurements, and other components to request data from another IEC 61850 device. IEC 61850 clients can request and display a list and description of the data available in an IEC 61850 server device. This process is similar to the autoconfiguration process used within SEL communications processors (SEL-2032 and SEL-2030). Simply run an MMS browser to query devices on an IEC 61850 network and discover what data are available. Self-description also permits extensions to both standard and custom data models. Instead of having to look up data in a profile stored in its database, an IEC 61850 client can simply query an IEC 61850 device and receive a description of all logical devices, logical nodes, and available data.

Unlike other Supervisory Control and Data Acquisition (SCADA) protocols that present data as a list of addresses or indices, IEC 61850 presents data with descriptors in a composite notation made up of components. *Table H.2* shows how the A-phase current expressed as MET\$FUNDMMXU1\$A\$phsA\$cVal\$mag\$f is broken down into its component parts. The Data Attribute is characterized (filtered) by a functional constraint (FC) property. The supported FCs are listed in *Table H.3*. The FC for the given example above is MX.

**Table H.2 Example IEC 61850 Descriptor Components**

Component	Description
FUNDMMXU1	Logical Node
A	Data Object
phsA	Sub-Data Object
.cVal	Data Attribute
mag	Sub-Data Object
f	Data Type

**Table H.3 Functional Constraints**

FC	Description
ST	Status information
MX	Measurements (analog values)
CO	Control
CF	Configuration
DC	Description
EX	Extended definition

## Data Mapping

Device data are mapped to IEC 61850 Logical Nodes (LN) according to rules defined by SEL. Refer to IEC 61850-5:2003(E) and IEC 61850-7-4:2003(E) for the mandatory content and usage of these LNs. The SEL-735 logical nodes are grouped under Logical Devices for organization based on function. See *Table H.4* for descriptions of the Logical Devices in an SEL-735. See *Logical Nodes on page H.17* for a description of the LNs that make up these Logical Devices.

**Table H.4 SEL-735 Logical Devices**

Logical Device	Description
ANN	Annunciator elements—alarms, status values, and logic elements
CFG	Configuration elements—datasets and report control blocks
CON	Control elements—remote bits
MET	Metering or Measurement elements—currents, voltages, power, etc.

## MMS

Manufacturing Messaging Specification (MMS) provides services for the application-layer transfer of real-time data within a substation LAN. MMS was developed as a network independent data exchange protocol for industrial networks in the 1980s and standardized as ISO 9506.

In theory, you can map IEC 61850 to any protocol. However, it can become unwieldy and quite complicated to map objects and services to a protocol that only provides access to simple data points via registers or index numbers.

MMS supports complex named objects and flexible services that enable mapping to IEC 61850 in a straightforward manner. This was why the UCA users group used MMS for UCA from the start, and why the IEC chose to keep it for IEC 61850.

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**NOTE:** After sending settings to the SEL-735 via MMS, read the err.txt file to see if any errors were encountered while applying the settings.

In the SEL-735, event files and reports can be read through MMS and settings can be written using MMS. See *File Transfer Protocol (FTP) and MMS File Transfer on page 8.10*.

If MMS authentication is enabled, the device will authenticate each MMS association by requiring the client to provide the password authentication parameter with a value that is equal to the 2AC password of the SEL-735.

- If the correct password authentication parameter value is not received, the device will return a not authenticated error code.
- If the correct password authentication parameter value is received, the device will give a successful association response. The device will allow access to all supported MMS services for that association.

## GOOSE

The Generic Object Oriented Substation Event (GOOSE) object within IEC 61850 is for high-speed control messaging. IEC 61850 GOOSE automatically broadcasts messages containing status, controls, and measured values onto the network for use by other devices. IEC 61850 GOOSE sends the message several times, increasing the likelihood that other devices receive the messages. GOOSE message publication is a persistent function. Once GOOSE is enabled, the IED will continuously publish GOOSE messages until they are disabled regardless of the contents. The publication process description indicates when and why the publication rate changes.

IEC 61850 GOOSE objects can quickly and conveniently transfer status, controls, and measured values between peers on an IEC 61850 network. Configure SEL devices to respond to GOOSE messages from other network devices with ACSELERATOR Architect. Also, configure outgoing GOOSE messages for SEL devices in ACSELERATOR Architect. See the ACSELERATOR Architect instruction manual or online help for more information.

Each IEC 61850 GOOSE sender includes a text identification string (GOOSE Control Block Reference), APP ID field, and an Ethernet multicast group address, in each outgoing message. Some devices that receive GOOSE messages use the text identification and multicast group to identify and filter incoming GOOSE messages. The parameters used to identify incoming GOOSE messages are configurable with ACSELERATOR Architect and multicast group to identify and filter incoming GOOSE messages.

Virtual bits (VB001–VB128) are control inputs that you can map to GOOSE receive messages using the ACSELERATOR Architect software. If you intend to use any SEL-735 virtual bits for controls, you must create SELOGIC® control equations to define these operations. The SEL-735 is capable of receiving and sending analog values via peer-to-peer GOOSE messages. Remote Analogs (RA001–RA128) are analog inputs that you can map to values from incoming GOOSE messages.

## File Services

The File System supports FTP and MMS file transfer. The File System provides:

- A means for the device to transfer data as files.
- A hierarchal file structure for the device data.

See *File Transfer Protocol (FTP) and MMS File Transfer* on page 8.10 for more information about file services.

## SCL Files

Substation Configuration Language (SCL) is an XML-based configuration language used to support the exchange of database configuration data between different tools, which may come from different manufacturers. There are four types of SCL files:

- Intelligent Electronic Device (IED) Capability Description file (.ICD)
- System Specification Description (.SSD) file
- Substation Configuration Description file (.SCD)
- Configured IED Description file (.CID)

The ICD file describes the capabilities of an IED, including information on LN and GOOSE support. The SSD file describes the single-line diagram of the substation and the required LNs. The SCD file contains information on all IEDs, communications configuration data, and a substation description. The CID file, of which there may be several, describes a single instantiated IED within the project, and includes address information.

## Datasets

Datasets are configured using ACSELERATOR Architect® SEL-5032 Software and contain data attributes that represent real data values within the SEL-735 device. See *Logical Nodes* for the logical node tables that list the available data attributes for each logical node and the Device Word bit mapping for these data attributes. The list of datasets in *Figure H.1* are the defaults for a SEL-735 device. Datasets 1 through 12 are preconfigured with common FCDAs to be used for reporting. These datasets can be configured to represent the desired data to be monitored.

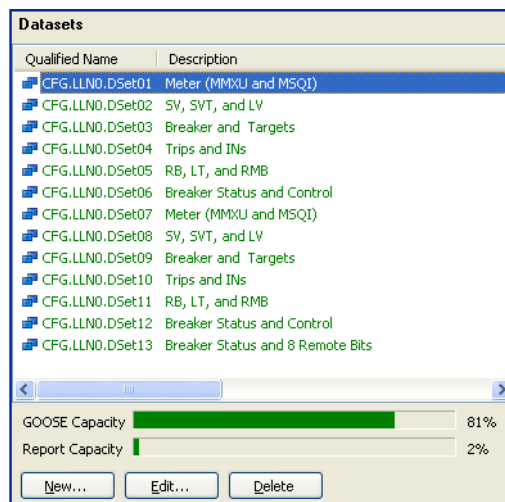


Figure H.1 SEL-735 Datasets

Within ACSELERATOR Architect, IEC 61850 datasets have the following purposes:

- **GOOSE:** You can use predefined or edited datasets, or create new datasets for outgoing GOOSE transmission.
- **Reports:** Twelve predefined datasets (DSet01 to DSet12) correspond to the default six buffered and six unbuffered reports. Note that you cannot change the number (12) or type of reports (buffered or unbuffered) within ACSELERATOR Architect. However, you can alter the data attributes that a dataset contains and so define what data an IEC 61850 client receives with a report.
- **MMS:** You can use predefined or edited datasets, or you can create new datasets to be monitored by MMS clients.

**NOTE:** Do not edit the dataset names used in reports. Changing or deleting any of those dataset names will cause a failure in generating the corresponding report.

## Reports

The SEL-735 implements the IEC 61850 reporting service as part of its server functionality. The reporting service includes the functionality necessary to configure, manage, and send IEC 61850 buffered and unbuffered reports as unsolicited data change reports, periodic integrity reports, or as the result of a general interrogation. See the IEC 61850 Standard, Part 7-1, Section 6.4.3.3, Part 7-2, Section 14, and Part 8-1, Section 17 for more details on the IEC 61850 reporting service.

A total of 12 predefined reports (6 buffered and 6 unbuffered) are supported. The predefined reports and the datasets assigned to each report are shown in *Figure H.2* and are available by default via IEC 61850. The number of reports (12), the dataset assigned to each report, and the type of reports (buffered or unbuffered) cannot be changed. However, by using ACSELERATOR Architect software, you can reallocate data within each report dataset to present different data attributes for each report beyond the predefined datasets.

Reports			
ID	Name	Description	Data Set
DSet01	BRep01	Predefined Buffered Report 01	DSet01
DSet02	BRep02	Predefined Buffered Report 02	DSet02
DSet03	BRep03	Predefined Buffered Report 03	DSet03
DSet04	BRep04	Predefined Buffered Report 04	DSet04
DSet05	BRep05	Predefined Buffered Report 05	DSet05
DSet06	BRep06	Predefined Buffered Report 06	DSet06
DSet07	URep01	Predefined Unbuffered Report 01	DSet07
DSet08	URep02	Predefined Unbuffered Report 02	DSet08
DSet09	URep03	Predefined Unbuffered Report 03	DSet09
DSet10	URep04	Predefined Unbuffered Report 04	DSet10
DSet11	URep05	Predefined Unbuffered Report 05	DSet11
DSet12	URep06	Predefined Unbuffered Report 06	DSet12

Properties | GOOSE Receive | GOOSE Transmit | **Reports** | Datasets

**Figure H.2 SEL-735 Predefined Reports**

Buffered and unbuffered report control blocks are supported in the report model as defined in IEC 61850-8-1:2004(E). There are 12 report control blocks (6 buffered and 6 unbuffered).

For each buffered report control block (BRCB), there can be just one client association (i.e., only one client can be associated to a BRCB at any given time). The client association occurs when the client enables the RptEna attribute of the BRCB. Once enabled, the associated client has exclusive

access to the BRCB until the connection is closed or the client disables the RptEna attribute. Once enabled, all unassociated clients have read only access to the BRCB and the associated client will be the only client that receives buffered report data. The BRCB parameters are shown in *Table H.5*.

**Table H.5 Buffered Report Control Block Client Access**

RCB Attribute	User Changeable (Report Disabled)	User Changeable (Report Enabled)	Default Values
RptId	YES		DSet01–DSet06
RptEna	YES	YES	FALSE
OptFlds	YES		seqNum timeStamp dataSet reasonCode confRev
BufTm	YES		500
TrgOps	YES		dchg qchg
IntgPd	YES		0
GI	YES <sup>a b</sup>	YES <sup>a</sup>	FALSE
PurgeBuf	YES <sup>a</sup>		FALSE
EntryId	YES		0

<sup>a</sup> Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted will return to zero. Always read as zero.

<sup>b</sup> When disabled, a GI will be processed and the report buffered if a buffer has been previously established. A buffer is established when the report is enabled for the first time.

Once a BRCB has been enabled, a report buffer is established. The buffer is sized to contain 10 complete reports with a size hard coded in the SEL-735 ICD file. However, in cases where the report dataset is smaller than the allowed maximum size, or when the encoded report does not include the entire dataset, as many as 200 reports may appear in the buffer. Reports are maintained in the buffer regardless of having been sent. This allows the client to retrieve reports that have already been sent by writing an EntryID prior to the current EntryID.

When a client sets the RptEna attribute of a BRCB to true, all new reports contained in the report buffer, starting from the buffer entry following the EntryID attribute specified in the BRCB until the most current buffered report, are sent. At this time, new reports will be sent as required by normal report processing. This behavior allows the client to write the last received EntryID to the BRCB before enabling the report in an attempt to retrieve all report entries that were lost during a lapse in the client association.

When insertion of a new report into a report buffer would cause the buffer size to be exceeded, the oldest entries in the buffer are discarded until the buffer size has been reduced sufficiently to allow the new report to be added to the buffer. If the reports removed from the buffer have not yet been sent to the client, a buffer overflow indication is set in the next report queued for transmission to indicate that reports have been lost. The buffer overflow indication is reported in the BufOvfl field of the report if the buffer overflow OptFld has been enabled in the BRCB.

The contents of a report buffer are deleted when a PurgeBuf is commanded by a client. As noted in the requirements for the BRCB, the PurgeBuf can only be commanded when the report is disabled. The buffer overflow indication shall be cleared when the client commands a PurgeBuf. Additionally, the buffered reports will be purged if any of the BRCB attributes RptID, DatSet, BufTm, TrgOps, or IntgPd are modified by the client while the report is disabled.

For each unbuffered control block (URCB), there can be as many as six client associations. The client association occurs when the client enables the RptEna attribute of the URCB. Once enabled, each client has independent access to its instance of the URCB and all associated clients receive unbuffered report data. The URCB parameters are shown in *Table H.6*.

The URCB Resv attribute is writable, however, the SEL-735 does not support reservations. Writing any field of the URCB causes the client to obtain their own instance of the URCB—in essence, acquiring a reservation.

**Table H.6 Unbuffered Report Control Block Client Access**

RCB Attribute	User Changeable (Report Disabled)	User Changeable (Report Enabled)	Default Values
RptId	YES		DSet07–DSet12
RptEna	YES	YES	FALSE
Resv	YES		FALSE
OptFlds	YES		seqNum timeStamp dataSet reasonCode confRev
BufTm	YES		250
TrgOps	YES		dchg qchg
IntgPd	YES		0
GI		YES <sup>a</sup>	FALSE

<sup>a</sup> Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted will return to zero. Always read as zero.

**NOTE:** The TrgOp data update is not supported by the SEL-735 device.

The IEC 61850 standard defines the trigger options (TrgOps) of data change, quality change, and data update. These TrgOps allow reports to be filtered to report only changes associated with the selected TrgOps. Additionally, each of these TrgOps is only associated with or valid for certain data attributes. The valid TrgOps for any given data attribute is described in the Common Data Class (CDC) Descriptions contained within the IEC standard, Part 7-3.

When a client has enabled the RptEna attribute of a BRCB or an URCB, and any of the data change or quality change TrgOps are enabled within the same BRCB or URCB, the SEL-735 sends an unsolicited report to that client upon detecting a change on an FCDA with a reason corresponding to one of the enabled TrgOps. The unsolicited report contains only those FCDAs that have been detected to have changed for a reason corresponding to one of the enabled TrgOps.

When a client has enabled the RptEna attribute of a BRCB or an URCB, and that same client writes a nonzero value to the GI attribute of the BRCB or URCB, a report is sent to that client containing the current data for all FCDA within the report dataset.

When a client has enabled the RptEna attribute and the IntgPd TrgOp of a BRCB or an URCB, and the IntgPd attribute of the BRCB or URCB is set to a nonzero value, a report is sent to that client containing the current data for all FCDA's within the report dataset upon detecting an expiration of the IntgPd.

FCDA updates are serviced every 500 ms. The client can set the report control block (BRCB or URCB) IntgPd to any value greater than 500 ms with a resolution of 1 ms. However, the integrity report is only sent when the period has been detected as having expired. The new IntgPd will begin at the time that the current report is serviced.

BufTm timers are part of the report control block (BRCB and URCB). The purpose of the BufTm timers is to buffer mutually exclusive data change events over a period of time and send these changes out as one report. Each client that enables an unbuffered report may have a BufTm value independent of other clients that enable the same unbuffered report. This does not apply to buffered reports because only one client can enable a buffered report.

Report data are updated every 500 ms. Setting BufTm less than 500 ms does not result in data changes from multiple scans being buffered into a single report. For a BRCB with a nonzero BufTm attribute, a BufTm timer is started upon receiving notification of the change of a member of a dataset, and all changes received during BufTm are combined into a single report to be buffered and sent at the expiration of BufTm. If a second internal notification of the same member of a dataset has occurred prior to the expiration of BufTm, a report is immediately buffered and sent.

Reports are formatted as specified in the IEC 61850 standard, Part 7-2, Table 24. The report EntryID attribute is incremented each time a report is built.

## Supplemental Software

Examine the data structure and values of the supported IEC 61850 LNs with an MMS browser such as MMS Object Explorer and AX-S4 MMS from Cisco, Inc.

The settings needed to browse an SEL-735 with an MMS browser are shown below.

OSI-PSEL (Presentation Selector)	00000001
OSI-SSEL (Session Selector)	0001
OSI-TSEL (Transport Selector)	0001

## Time Stamps and Quality

In addition to the various data values, the two attributes quality (q) and time stamp (t) are available at any time. The timestamp is determined when data or quality change is detected and is UTC reported as the Second of Century since January 1, 1970, plus fractional seconds.

The timestamp is applied to all data and quality attributes (Boolean, Bstrings, Analogs, etc.) in the same fashion when a data or quality change is detected.

Functionally Constrained Data Attributes (FCDA) mapped to points assigned to the SER report have SER-accuracy timestamps for data change events. To ensure that you will get SER-quality timestamps for changes to certain points, you must include those points in the SER report. All other FCDA's are scanned for data changes on a 1/2-second interval and have 1/2-second timestamp accuracy.

The SEL-735 uses GOOSE quality attributes to indicate the quality of the data in its transmitted GOOSE messages. Under normal conditions, all attributes are zero, indicating good quality data. Internal status indicators provide the

**NOTE:** The Leap Second bit field is always set to TRUE for the time data object.

information necessary for the device to set these attributes. If the device becomes disabled, as shown via status indications (e.g., an internal self-test failure), the SEL-735 will stop transmitting GOOSE messages.

## GOOSE Processing

SEL devices support GOOSE processing as defined by IEC 61850-7-1:2003(E), IEC 61850-7-2:2003(E), and IEC 61850-8-1:2004(E) via the installed Ethernet card.

Outgoing GOOSE messages are processed in accordance with the following constraints.

- The user can define up to eight outgoing GOOSE messages consisting of any Data Attribute (DA) from any Logical Node. A single DA can be mapped to one or more outgoing GOOSE, or one or more times within the same outgoing GOOSE. A user can also map a single GOOSE dataset to multiple GOOSE control blocks.
- The SEL-735 will transmit all configured GOOSE immediately upon successful initialization. If a GOOSE is not retriggered, then the following initial transmission shall retransmit that GOOSE based on the configured esel:MinTime and esel:MaxTime from the CID file. The first transmission shall occur immediately upon the GOOSE triggering. The second shall occur esel:MinTime later. The third shall occur esel:MinTime after the second. The fourth shall occur twice esel:MinTime after the third. All subsequent transmissions shall occur at the esel:MaxTime interval. For example, if esel:MinTime is 4 ms and esel:MaxTime is 100 ms, the intervals between transmissions will be 4 ms, 4 ms, 8 ms, and then 100 ms. The time-to-live reported in the first two messages shall be three times esel:MinTime. The time-to-live in all subsequent messages shall be two times esel:MaxTime (see IEC 61850-8-1, sec. 18.1).
- Each outgoing GOOSE includes communication parameters (VLAN, Priority, and Multicast Address) and is transmitted entirely in a single network frame.
- The SEL-735 will maintain the configuration of outgoing GOOSE through a power cycle and device reset.

Incoming GOOSE messages are processed in accordance with the following constraints.

- The user can configure the SEL-735 to subscribe to as many as 24 incoming GOOSE messages.
- Control bits in the SEL-735 get data from incoming GOOSE messages which are mapped to Virtual Bits (VB001–VB128).
- The SEL-735 will recognize incoming GOOSE messages as valid based on the following content:
  - Source broadcast MAC address
  - Dataset Reference
  - Application ID
  - GOOSE Control Reference

Any GOOSE message that fails these checks shall be rejected.

- Every received and validated GOOSE message that indicates a data change, by an incremented status number, is evaluated as follows.
  - Data within the received GOOSE dataset that are mapped to host data bits are identified.
  - Mapped bits are compared against a local version of the available host data bits.
  - If the state of the received bits is different than the local version,
    - Update the local version with the new state for that bit.
    - Pass the new state for the bit to the SEL-735.
- Reject all DA contained in an incoming GOOSE based on the accumulation of the following error indications created by inspection of the received GOOSE.
  - **Configuration Mismatch.** The configuration number of the incoming GOOSE changes.
  - **Needs Commissioning.** This Boolean parameter of the incoming GOOSE is true.
  - **Test Mode.** This Boolean parameter of the incoming GOOSE is true.
  - **Decode Error.** The format of the incoming GOOSE is not as configured.
- The SEL-735 will discard incoming GOOSE under the following conditions.
  - after a permanent (latching) self-test failure
  - when EGSE is set to No

## GOOSE Performance

The GOOSE performance in the SEL-735 has two components: response time and throughput.

### Response Time

Outbound transmission of a GOOSE data point begins within 6 ms ( $\pm 6$  ms) of transition of data within the SEL-735. Outbound transmission of a GOOSE analog data point typically occurs within 0.5 seconds of data change within the SEL-735.

Control commands from incoming GOOSE messages are issued to the SEL-735 within 6 ms ( $\pm 6$  ms) of a GOOSE reception.

### Throughput

The SEL-735 will process at most 24 outgoing and 24 incoming messages every 200 ms. If there is a significant amount of other Ethernet traffic for the SEL-735 to process, then it may process messages at a slightly slower rate.

## GOOSE Construction Tips

- Quality bit strings published from SEL relays are not generally useful in determining the quality of associated data because the SEL IEDs suspend publication of GOOSE messages if any quality attribute fails. Therefore receipt of the message indicates that all quality attributes are normal. Do not include quality bit strings in published GOOSE messages unless required by some other type of IED.

- Make GOOSE publications as small as possible. Include in the GOOSE publication only the information required by subscribing relays.
- Give higher VLAN priority tags to more important GOOSE. This allows the network to preferentially forward those GOOSE to the subscribers.

# IEC 61850 Configuration

## Settings

**NOTE:** Virtual bits retain state until overwritten or the device is restarted. When loading a new CID file, make sure to issue the **STA C** command or cycle power on the device to clear the virtual bits if the configuration has changed.

Table H.7 lists IEC 61850 settings. These settings are only available if your device includes the optional IEC 61850 protocol.

**Table H.7 IEC 61850 Settings**

Label	Description	Range	Default
E61850	IEC 61850 MMS client sessions enable	0–6	0
EGSE	IEC 61850 GSE message enable	Y <sup>a</sup> , N	N

<sup>a</sup> Requires E61850 set to 1 or higher to send IEC 61850 GSE messages.

Devices ordered with the optional IEC 61850 protocol are delivered with a default CID file loaded on the device. The file is named “SET\_61850.CID.” To make the device communicate with other devices over IEC 61850, the device must be configured. Configure all other IEC 61850 settings, including subscriptions to incoming GOOSE messages, with ACSELERATOR Architect software.

When IEC 61850 is enabled (E61850 > 0), the device parses the CID file to determine the device IEC 61850 configuration. When EGSE = Y, the device begins transmitting GOOSE messages and receiving GOOSE subscriptions configured in the CID file. Issuing the ASCII **GOO** command provides GOOSE status information. See *GOO Command on page 8.17* for a detailed description of the **GOO** command.

If the device does not have a valid IEC 61850 configuration, it will not send or receive any IEC 61850 communications. Issuing the ASCII **ID** command provides information on the status of the CID file. If there is a problem with the CID file, the `iedName`, `type`, and `configVersion` fields of the **ID** command response will display `PARSE FAILURE` as shown below.

```

=>>ID <Enter>

"FID=SEL-735-R107-V0-Z004003-D20130701", "08A8"
"BFID=B00TLDR-R203-V0-Z000000-D20100324", "0943"
"CID=2B96", "0260"
"DEVID=FEEDER 2", "0416"
"DEVCODE=57", "0313"
"PARTNO=0735VX20944GXXB4XX26201XX", "08C9"
"CONFIG=11112200", "03EB"
"SPECIAL=0000000Y", "0457"
"iedName=PARSE FAILURE", "0703"
"type=PARSE FAILURE", "0612"
"configVersion=PARSE FAILURE", "09AC"

=>>

```

Load a valid CID file into the device by using FTP or ACSELERATOR Architect. Once a valid CID file is loaded, the `iedName`, `type`, and `configVersion` fields in the **ID** command response show the properly configured information (see following example). The `iedName` displays the configured IED name, which can be modified

using ACSELERATOR Architect. The type and configVersion fields cannot be modified and represent the meter type and the ICD file version used for the configured CID file.

```
=>>ID <Enter>

"FID=SEL-735-R107-V0-Z004003-D20130701", "08A8"
"BFID=B00TLDR-R203-V0-Z000000-D20100324", "0943"
"CID=2B96", "0260"
"DEVID=FEEDER 2", "0416"
"DEVCODE=57", "0313"
"PARTNO=0735VX20944GXXB4XX26201XX", "08C9"
"CONFIG=11112200", "03EB"
"SPECIAL=0000000Y", "0457"
"iedName=SEL735_005_ICD_1", "1898"
"type=SEL_735", "1061"
"configVersion=ICD-735-R100-V0-Z000000-D20130214", "3297"

=>>
```

## ACSELERATOR Architect

The ACSELERATOR Architect software enables users to design and commission IEC 61850 substations containing SEL IEDs.

Users can use ACSELERATOR Architect to do the following:

- Organize and configure all SEL IEDs in a substation project.
- Configure incoming and outgoing GOOSE messages.
- Edit and create GOOSE datasets.
- Read non-SEL IED Capability Description (ICD) and Configured IED Description (CID) files and determine the available IEC 61850 messaging options.
- Use or edit preconfigured datasets for reports.
- Load IEC 61850 CID files into SEL IEDs.
- Generate ICD and CID files that will provide SEL IED descriptions to other manufacturers' tools so they can use SEL GOOSE messages and reporting features.
- Edit dead-band settings for measured values.

ACSELERATOR Architect provides a Graphical User Interface (GUI) for users to select, edit, and create IEC 61850 GOOSE messages important for substation protection, coordination, and control schemes. Typically, the user first places icons representing IEDs in a substation container, then edits the outgoing GOOSE messages or creates new ones for each IED. The user can also select incoming GOOSE messages for each IED to receive from any other IEDs in the domain.

Some measured values are reported to IEC 61850 only when the value changes beyond a defined dead-band value. ACSELERATOR Architect allows a dead band to be changed during the CID file configuration. Check and set the dead-band values for your particular application when configuring the CID file for a device.

ACSELERATOR Architect has the capability to read other manufacturers' ICD and CID files, enabling the user to map the data seamlessly into SEL IED logic. See the ACSELERATOR Architect online help for more information.

## SEL ICD File Versions

ACSELERATOR Architect version R.1.1.69.0 and later support multiple ICD file versions for each type of IED in a project. Because meters with different firmware versions may require different CID file versions, users can manage the CID files of all IEDs within a single project.

Please ensure that you work with the appropriate version of ACSELERATOR Architect relative to your current configuration, existing project files, and ultimate goals. If you want the best available IEC 61850 functionality for your SEL meter, obtain the latest version of ACSELERATOR Architect and select the appropriate ICD version(s) for your needs.

## Logical Node Extensions

The following Logical Nodes and Data Classes were created in this device as extensions to the IEC 61850 standard, in accordance with IEC 61850 guidelines.

**Table H.8 New Logical Node Extensions**

Logical Node	IEC 61850	Description or Comments
Flicker measurement	MFLK	Power quality flicker data
Voltage variation	QVVR	Voltage Sag Swell Interrupt measurements

**Table H.9 Flicker Measurement Logical Node Class Definition**

IEC 61850 Logical Node Class: MFLK				
Attribute Name	Attribute Type	Explanation	T <sup>a</sup>	M/O/C/E <sup>b</sup>
LNNName		The name shall be composed of the class name, LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
<b>Data</b>				
Common Logical Node Information				
		LN shall inherit all mandatory data from Common Logical Node Class		M
Measured Values				
PhPiMax	WYE	Maximum instantaneous flicker		E
PhPst	WYE	Short-term flicker severity of last complete interval		E
PhPlt	WYE	Long-term flicker severity of last complete interval		E
PhPiMaxTms	MV	Seconds until PINST and PST_1MIN update		E
PhPstTms	MV	Seconds until PST 10 minute update		E
PhPltTms	MV	Seconds until PLT 2 hour update		E

<sup>a</sup> Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.

<sup>b</sup> M: Mandatory; O: Optional; C: Conditional; E: Extension

**Table H.10 Voltage Variation Logical Node Class Definition**

IEC 61850 Logical Node Class: QVVR				
Attribute Name	Attribute Type	Explanation	T <sup>a</sup>	M/O/C/E <sup>b</sup>
LNNName		The name shall be composed of the class name, LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
<b>Data</b>				
Common Logical Node Information				
		LN shall inherit all mandatory data from Common Logical Node Class		M
Measured Values				
Vva	MV	Voltage variation magnitude of the last completed event		
VVaTm	MV	Voltage variation duration of the last completed event		
VVaRcd	SSR	SSI summary record		

<sup>a</sup> Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.

<sup>b</sup> M: Mandatory; O: Optional; C: Conditional; E: Extension

**Table H.11 Energy Quantities Logical Node Class Definition**

IEC 61850 Logical Node Class: MMTR				
Attribute Name	Attribute Type	Explanation	T <sup>a</sup>	M/O/C/E <sup>b</sup>
LNNName		The name shall be composed of the class name, LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
<b>Data</b>				
Common Logical Node Information				
		LN shall inherit all mandatory data from Common Logical Node Class		M
Measured Values				
TotWh	BCR	Net real energy since last reset		O
TotVARh	BCR	Net reactive energy since last reset		O
SupWh	BCR	Real energy supply (energy received)		O
SupVARh	BCR	Reactive energy supply (energy received)		O
DmdWh	BCR	Real energy demand (energy delivered)		O
DmdVARh	BCR	Reactive energy demand (energy delivered)		O
SupVAh	BCR	Apparent energy supply (energy received)		E
DmdVAh	BCR	Apparent energy demand (energy delivered)		E
Vh	BCR	Volt-hours		E
Ah	BCR	Amp-hours		E

<sup>a</sup> Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.

<sup>b</sup> M: Mandatory; O: Optional; C: Conditional; E: Extension

**Table H.12 Metering Statistics Logical Node Class Definition**

IEC 61850 Logical Node Class: MSTA				
Attribute Name	Attribute Type	Explanation	T <sup>a</sup>	M/O/C/E <sup>b</sup>
LNName		The name shall be composed of the class name, LN-Prefix and LN-Instance-ID according to IEC 61850-7-2.		
<b>Data</b>				
Common Logical Node Information				
		LN shall inherit all mandatory data from Common Logical Node Class		M
Measured Values				
SupTotW	MV	Peak watts received		E
SupTotVAr	MV	Peak VARs received		E
SupTotVA	MV	Apparent power, three-phase, received		E
DmdTotW	MV	Active power peak demand, three-phase, delivered		E
DmdTotVAr	MV	Reactive power peak demand, three-phase, delivered		E
DmdTotVA	MV	Apparent power peak demand, three-phase, delivered		E
SupW	WYE	Active power peak demand, received		E
SupVAr	WYE	Reactive power peak demand, received		E
DmdW	WYE	Active power peak demand, delivered		E
DmdVAr	WYE	Reactive power peak demand, delivered		E
DmdVA	WYE	Apparent power peak demand, delivered		E

<sup>a</sup> Transient data objects—the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state.  
<sup>b</sup> M: Mandatory; O: Optional; C: Conditional; E: Extension

## Logical Nodes

Table H.13 through Table H.15 show the logical nodes (LNs) supported in the SEL-735 and the Device Word bits or Analog Quantities mapped to those LNs.

Table H.13 shows the LNs associated with the annunciation element, defined as Logical Device ANN.

**Table H.13 Logical Device: ANN (Annunciation) (Sheet 1 of 4)**

Logical Node	Attribute	Data Source	Comment
<b>Functional Constraint = ST</b>			
ALMGGIO1	Ind01.stVal	ENABLE	Indication that Enabled LED is asserted  Pulses for one second whenever settings are changed
ALMGGIO1	Ind02.stVal	HALARM	
ALMGGIO1	Ind03.stVal	SALARM	
ALMGGIO1	Ind04.stVal	SETCHG	
ALMGGIO1	Ind05.stVal	RSTDEM	
ALMGGIO1	Ind06.stVal	RSTENGY	
ALMGGIO1	Ind07.stVal	RSTPKDM	
ALMGGIO1	Ind08.stVal	TEST	

**Table H.13 Logical Device: ANN (Annunciation) (Sheet 2 of 4)**

Logical Node	Attribute	Data Source	Comment
ALMGGIO1	Ind09.stVal	SESNCH	
ALMGGIO1	Ind10.stVal	DSTCH	
ALMGGIO1	Ind11.stVal	MATHERR	
<b>Power Quality Indicators</b>			
PQGGIO2	Ind01.stVal	PQALARM	
PQGGIO2	Ind02.stVal	PREDAL	
PQGGIO2	Ind03.stVal	*	Reserved for future use
PQGGIO2	Ind04.stVal	*	Reserved for future use
PQGGIO2	Ind05.stVal	FLTBLK	
PQGGIO2	Ind06.stVal	FAULT	
PQGGIO2	Ind07.stVal	DFAULT	
PQGGIO2	Ind08.stVal	*	Reserved for future use
PQGGIO2	Ind09.stVal	SSI_EVE	
PQGGIO2	Ind10.stVal	EVNTCPT	
PQGGIO2	Ind11.stVal	NEWEVNT	
PQGGIO2	Ind12.stVal	ER1	
PQGGIO2	Ind13.stVal	ER2	
PQGGIO2	Ind14.stVal	ER3	
PQGGIO2	Ind15.stVal	FREQY	
PQGGIO2	Ind16.stVal	PFREQY	
PQGGIO2	Ind17.stVal	EQA1	
PQGGIO2	Ind18.stVal	EQA2	
PQGGIO2	Ind19.stVal	EQA3	
PQGGIO2	Ind20.stVal	EQA4	
PQGGIO2	Ind21.stVal	EQB1	
PQGGIO2	Ind22.stVal	EQB2	
PQGGIO2	Ind23.stVal	EQB3	
PQGGIO2	Ind24.stVal	EQB4	
PQGGIO2	Ind25.stVal	EQC1	
PQGGIO2	Ind26.stVal	EQC2	
PQGGIO2	Ind27.stVal	EQC3	
PQGGIO2	Ind28.stVal	EQC4	
PQGGIO2	Ind29.stVal	EQ3P1	
PQGGIO2	Ind30.stVal	EQ3P2	
PQGGIO2	Ind31.stVal	EQ3P3	
PQGGIO2	Ind32.stVal	EQ3P4	
SSIGGIO3	Ind01.stVal	SAGA	
SSIGGIO3	Ind02.stVal	SAGB	
SSIGGIO3	Ind03.stVal	SAGC	
SSIGGIO3	Ind04.stVal	SAG3P	
SSIGGIO3	Ind05.stVal	SWA	

**Table H.13 Logical Device: ANN (Annunciation)** (Sheet 3 of 4)

Logical Node	Attribute	Data Source	Comment
SSIGGIO3	Ind06.stVal	SWB	
SSIGGIO3	Ind07.stVal	SWC	
SSIGGIO3	Ind08.stVal	SW3P	
SSIGGIO3	Ind09.stVal	INTA	
SSIGGIO3	Ind10.stVal	INTB	
SSIGGIO3	Ind11.stVal	INTC	
SSIGGIO3	Ind12.stVal	INT3P	
SSIGGIO3	Ind13.stVal	SAGAB	
SSIGGIO3	Ind14.stVal	SAGBC	
SSIGGIO3	Ind15.stVal	SAGCA	
SSIGGIO3	Ind16.stVal	SWAB	
SSIGGIO3	Ind17.stVal	SWBC	
SSIGGIO3	Ind18.stVal	SWCA	
SSIGGIO3	Ind19.stVal	INTAB	
SSIGGIO3	Ind20.stVal	INTBC	
SSIGGIO3	Ind21.stVal	INTCA	
SSIGGIO3	Ind22.stVal	ITIC_ND	
SSIGGIO3	Ind23.stVal	ITIC_PR	
SSIGGIO3	Ind24.stVal	ITIC_SR	
KYZGGIO4	Ind01.stVal	KYZDT	
KYZGGIO4	Ind02.stVal	KYZD1	
KYZGGIO4	Ind03.stVal	KYZD2	
KYZGGIO4	Ind04.stVal	KYZD3	
KYZGGIO4	Ind05.stVal	KYZD4	
TLEDGGIO5	Ind01.stVal–Ind14.stVal	T01_LED–T14_LED	
HARMGGIO6	Ind01.stVal	FALARM	
HARMGGIO6	Ind02.stVal–Ind15.stVal	HARM02–HARM15	
OUT1GGIO7	Ind01.stVal–Ind03.stVal	OUT101–OUT103	
OUT4GGIO8	Ind01.stVal–Ind04.stVal	OUT401–OUT404	
IN1GGIO9	Ind01.stVal–Ind02.stVal	IN101–IN102	
IN4GGIO10	Ind01.stVal–Ind04.stVal	IN401–IN404	
RMBAGGIO11	Ind01.stVal–Ind08.stVal	RMB1A–RMB8A	
TMBAGGIO12	Ind01.stVal–Ind08.stVal	TMB1A–TMB8A	
RMBBGGIO13	Ind01.stVal–Ind08.stVal	RMB1B–RMB8B	
TMBBGGIO14	Ind01.stVal–Ind08.stVal	TMB1B–TMB8B	
MBOKGGIO15	Ind01.stVal	LBOKB	
MBOKGGIO15	Ind02.stVal	CBADB	
MBOKGGIO15	Ind03.stVal	RBADB	
MBOKGGIO15	Ind04.stVal	ROKB	
MBOKGGIO15	Ind05.stVal	LBOKA	
MBOKGGIO15	Ind06.stVal	CBADA	

**Table H.13 Logical Device: ANN (Annunciation) (Sheet 4 of 4)**

Logical Node	Attribute	Data Source	Comment
MBOKGGIO15	Ind07.stVal	RBADA	
MBOKGGIO15	Ind08.stVal	ROKA	
SVGGIO16	Ind01.stVal–Ind16.stVal	SV01–SV16	
SVTGGIO17	Ind01.stVal–Ind16.stVal	SVT01–SVT16	
LTGGIO18	Ind01.stVal–Ind16.stVal	LT01–LT16	
VBGGIO19	Ind001.stVal–Ind128.stVal	VB001–VB128	
SCGGIO21	IntIn01.stVal–IntIn16.stVal	SC01–SC16	
<b>Functional Constraint = MX</b>			
MVGGIO22	AnIn01.Mag.f–AnIn16.Mag.f	MV01–MV16	
RAGGIO23	AnIn001.Mag.f–AnIn032.Mag.f	RA00–RA31	
CRGGIO24	AnIn01.Mag.f–AnIn50.Mag.f	CFG0001–CFG0050	
CRGGIO25	AnIn01.Mag.f–AnIn50.Mag.f	CFG0051–CFG0100	
PFLIGGIO20	AnIn1.Mag.f	LDPFDA	
PFLIGGIO20	AnIn2.Mag.f	LDPFDB	
PFLIGGIO20	AnIn3.Mag.f	LDPFDC	
PFLIGGIO20	AnIn4.Mag.f	LDPFD3	
PFLIGGIO20	AnIn5.Mag.f	LDPFTA	
PFLIGGIO20	AnIn6.Mag.f	LDPFTB	
PFLIGGIO20	AnIn7.Mag.f	LDPFTC	
PFLIGGIO20	AnIn8.Mag.f	LDPFT3	

Table H.14 shows the LNs associated with control elements, defined as Logical Device CON.

**Table H.14 Logical Device: CON (Remote Control)**

Logical Node	Attribute	Data Source	Comment
<b>Functional Constraint = ST</b>			
RBGGIO1	SPCSO01.stVal– SPCSO08.stVal	RB01–RB08	
RBGGIO2	SPCSO09.stVal– SPCSO16.stVal	RB09–RB16	

Table H.15 shows the LNs associated with metering elements, defined as Logical Device MET.

**Table H.15 Logical Device: MET (Metering) (Sheet 1 of 13)**

Logical Node	Attribute	Data Source	Comment
<b>Functional Constraint = ST</b>			
<b>Three-Phase Energy Quantities</b>			
TPMMTR1	TotWh.actVal	WH3_NET	
TPMMTR1	TotVArh.actVal	QH3_NET	
TPMMTR1	SupWh.actVal	WH3_REC	
TPMMTR1	SupVArh.actVal	QH3_REC	
TPMMTR1	DmdWh.actVal	WH3_DEL	
TPMMTR1	DmdVArh.actVal	QH3_DEL	

**Table H.15 Logical Device: MET (Metering) (Sheet 2 of 13)**

Logical Node	Attribute	Data Source	Comment
TPMMTR1	DmdVArh1.actVal	QH3_DEL_LG	
TPMMTR1	DmdVArh2.actVal	QH3_DEL_LD	
TPMMTR1	SupVArh1.actVal	QH3_REC_LG	
TPMMTR1	SupVArh2.actVal	QH3_REC_LD	
TPMMTR1	SupVAh.actVal	UH3_REC	
TPMMTR1	DmdVAh.actVal	UH3_DEL	
TPMMTR1	Vh.actVal	VH3	
TPMMTR1	Ah.actVal	IH3	
TPMMTR1	Ah1.actVal	IHN	
<b>A-Phase Energy Quantities</b>			
APMMTR2	TotWh.actVal	WHA_NET	
APMMTR2	SupWh.actVal	WHA_REC	
APMMTR2	SupVArh.actVal	QHA_REC	
APMMTR2	DmdWh.actVal	WHA_DEL	
APMMTR2	DmdVArh.actVal	QHA_DEL	
APMMTR2	DmdVArh1.actVal	QHA_DEL_LG	
APMMTR2	DmdVArh2.actVal	QHA_DEL_LD	
APMMTR2	SupVArh1.actVal	QHA_REC_LG	
APMMTR2	SupVArh2.actVal	QHA_REC_LD	
APMMTR2	SupVAh.actVal	UHA_REC	
APMMTR2	DmdVAh.actVal	UHA_DEL	
APMMTR2	Vh.actVal	VHA	
APMMTR2	Ah.actVal	IHA	
<b>B-Phase Energy Quantities</b>			
BPMTR3	TotWh.actVal	WHB_NET	
BPMTR3	SupWh.actVal	WHB_REC	
BPMTR3	SupVArh.actVal	QHB_REC	
BPMTR3	DmdWh.actVal	WHB_DEL	
BPMTR3	DmdVArh.actVal	QHB_DEL	
BPMTR3	DmdVArh1.actVal	QHB_DEL_LG	
BPMTR3	DmdVArh2.actVal	QHB_DEL_LD	
BPMTR3	SupVArh1.actVal	QHB_REC_LG	
BPMTR3	SupVArh2.actVal	QHB_REC_LD	
BPMTR3	SupVAh.actVal	UHB_REC	
BPMTR3	DmdVAh.actVal	UHB_DEL	
BPMTR3	Vh.actVal	VHB	
BPMTR3	Ah.actVal	IHB	
<b>C-Phase Energy Quantities</b>			
CPMMTR4	TotWh.actVal	WHC_NET	
CPMMTR4	SupWh.actVal	WHC_REC	
CPMMTR4	SupVArh.actVal	QHC_REC	

**Table H.15 Logical Device: MET (Metering) (Sheet 3 of 13)**

Logical Node	Attribute	Data Source	Comment
CPMMTR4	DmdWh.actVal	WHC_DEL	
CPMMTR4	DmdVArh.actVal	QHC_DEL	
CPMMTR4	DmdVArh1.actVal	QHC_DEL_LG	
CPMMTR4	DmdVArh2.actVal	QHC_DEL_LD	
CPMMTR4	SupVArh1.actVal	QHC_REC_LG	
CPMMTR4	SupVArh2.actVal	QHC_REC_LD	
CPMMTR4	SupVAh.actVal	UHC_REC	
CPMMTR4	DmdVAh.actVal	UHC_DEL	
CPMMTR4	Vh.actVal	VHC	
CPMMTR4	Ah.actVal	IHC	
<b>Uncompensated Three Phase Energy Quantities</b>			
UCTPMMTR5	TotWh.actVal	WH3_NET_UC	
UCTPMMTR5	TotVArh.actVal	QH3_NET_UC	
UCTPMMTR5	SupWh.actVal	WH3_REC_UC	
UCTPMMTR5	SupVArh.actVal	QH3_REC_UC	
UCTPMMTR5	DmdWh.actVal	WH3_DEL_UC	
UCTPMMTR5	DmdVArh.actVal	QH3_DEL_UC	
UCTPMMTR5	DmdVArh1.actVal	QH3_DEL_LG_UC	
UCTPMMTR5	DmdVArh2.actVal	QH3_DEL_LD_UC	
UCTPMMTR5	SupVArh1.actVal	QH3_REC_LG_UC	
UCTPMMTR5	SupVArh2.actVal	QH3_REC_LD_UC	
<b>Uncompensated A Phase Energy Quantities</b>			
UCAPMMTR6	TotWh.actVal	WHA_NET_UC	
UCAPMMTR6	SupWh.actVal	WHA_REC_UC	
UCAPMMTR6	SupVArh.actVal	QHA_REC_UC	
UCAPMMTR6	DmdWh.actVal	WHA_DEL_UC	
UCAPMMTR6	DmdVArh.actVal	QHA_DEL_UC	
UCAPMMTR6	DmdVArh1.actVal	QHA_DEL_LG_UC	
UCAPMMTR6	DmdVArh2.actVal	QHA_DEL_LD_UC	
UCAPMMTR6	SupVArh1.actVal	QHA_REC_LG_UC	
UCAPMMTR6	SupVArh2.actVal	QHA_REC_LD_UC	
<b>Uncompensated B Phase Energy Quantities</b>			
UCBPMTR7	TotWh.actVal	WHB_NET_UC	
UCBPMTR7	SupWh.actVal	WHB_REC_UC	
UCBPMTR7	SupVArh.actVal	QHB_REC_UC	
UCBPMTR7	DmdWh.actVal	WHB_DEL_UC	
UCBPMTR7	DmdVArh.actVal	QHB_DEL_UC	
UCBPMTR7	DmdVArh1.actVal	QHB_DEL_LG_UC	
UCBPMTR7	DmdVArh2.actVal	QHB_DEL_LD_UC	
UCBPMTR7	SupVArh1.actVal	QHB_REC_LG_UC	
UCBPMTR7	SupVArh2.actVal	QHB_REC_LD_UC	

**Table H.15 Logical Device: MET (Metering)** (Sheet 4 of 13)

Logical Node	Attribute	Data Source	Comment
<b>Uncompensated C Phase Energy Quantities</b>			
UCCPMTR8	TotWh.actVal	WHC_NET_UC	
UCCPMTR8	SupWh.actVal	WHC_REC_UC	
UCCPMTR8	SupVArh.actVal	QHC_REC_UC	
UCCPMTR8	DmdWh.actVal	WHC_DEL_UC	
UCCPMTR8	DmdVArh.actVal	QHC_DEL_UC	
UCCPMTR8	DmdVArh1.actVal	QHC_DEL_LG_UC	
UCCPMTR8	DmdVArh2.actVal	QHC_DEL_LD_UC	
UCCPMTR8	SupVArh1.actVal	QHC_REC_LG_UC	
UCCPMTR8	SupVArh2.actVal	QHC_REC_LD_UC	
<b>VSSI</b>			
PQQVVR1	VVaRcd.vvaTyp	SSIR1_TYPE	
PQQVVR1	VVaRcd.vvaTsta	SSIR1_TS	
PQQVVR1	VarStr.stVal	SSI_EVE	
<b>Functional Constraint = MX</b>			
<b>Device Demand, Peak Demand, and Previous Peak Demand Quantities</b>			
PIDMSTA1	A.phsA.Mag.f	IDA	
PIDMSTA1	A.phsB.Mag.f	IDB	
PIDMSTA1	A.phsC.Mag.f	IDC	
PIDMSTA1	A.neut.Mag.f	IDN	
PIDMSTA1	A.zseq.Mag.f	3I0D	
PIDMSTA1	A.nseq.Mag.f	3I2D	
PIDMSTA1	SupTotW.Mag.f	WD3_REC	
PIDMSTA1	SupTotVAr.Mag.f	QD3_REC	
PIDMSTA1	SupTotVA.Mag.f	UD3_REC	
PIDMSTA1	DmdTotW.Mag.f	WD3_DEL	
PIDMSTA1	DmdTotVAr.Mag.f	QD3_DEL	
PIDMSTA1	DmdTotVA.Mag.f	UD3_DEL	
PIDMSTA1	DmdTotVAr1.Mag.f	QD3_DEL_LG	
PIDMSTA1	DmdTotVAr2.Mag.f	QD3_DEL_LD	
PIDMSTA1	SupTotVAr1.Mag.f	QD3_REC_LG	
PIDMSTA1	SupTotVAr2.Mag.f	QD3_REC_LD	
PIDMSTA1	SupW.phsA.Mag.f	WDA_REC	
PIDMSTA1	SupW.phsB.Mag.f	WDB_REC	
PIDMSTA1	SupW.phsC.Mag.f	WDC_REC	
PIDMSTA1	SupVAr.phsA.Mag.f	QDA_REC	
PIDMSTA1	SupVAr.phsB.Mag.f	QDB_REC	
PIDMSTA1	SupVAr.phsC.Mag.f	QDC_REC	
PIDMSTA1	SupVA.phsA.Mag.f	UDA_REC	
PIDMSTA1	SupVA.phsB.Mag.f	UDB_REC	
PIDMSTA1	SupVA.phsC.Mag.f	UDC_REC	

**Table H.15 Logical Device: MET (Metering) (Sheet 5 of 13)**

Logical Node	Attribute	Data Source	Comment
PIDMSTA1	DmdW.phsA.Mag.f	WDA_DEL	
PIDMSTA1	DmdW.phsB.Mag.f	WDB_DEL	
PIDMSTA1	DmdW.phsC.Mag.f	WDC_DEL	
PIDMSTA1	DmdVAr.phsA.Mag.f	QDA_DEL	
PIDMSTA1	DmdVAr.phsB.Mag.f	QDB_DEL	
PIDMSTA1	DmdVAr.phsC.Mag.f	QDC_DEL	
PIDMSTA1	DmdVA.phsA.Mag.f	UDA_DEL	
PIDMSTA1	DmdVA.phsB.Mag.f	UDB_DEL	
PIDMSTA1	DmdVA.phsC.Mag.f	UDC_DEL	
PIDMSTA1	DmdVAr1.phsA.Mag.f	QDA_DEL_LG	
PIDMSTA1	DmdVAr1.phsB.Mag.f	QDB_DEL_LG	
PIDMSTA1	DmdVAr1.phsC.Mag.f	QDC_DEL_LG	
PIDMSTA1	DmdVAr2.phsA.Mag.f	QDA_DEL_LD	
PIDMSTA1	DmdVAr2.phsB.Mag.f	QDB_DEL_LD	
PIDMSTA1	DmdVAr2.phsC.Mag.f	QDC_DEL_LD	
PIDMSTA1	SupVAr1.phsA.Mag.f	QDA_REC_LG	
PIDMSTA1	SupVAr1.phsB.Mag.f	QDB_REC_LG	
PIDMSTA1	SupVAr1.phsC.Mag.f	QDC_REC_LG	
PIDMSTA1	SupVAr2.phsA.Mag.f	QDA_REC_LD	
PIDMSTA1	SupVAr2.phsB.Mag.f	QDB_REC_LD	
PIDMSTA1	SupVAr2.phsC.Mag.f	QDC_REC_LD	
<b>Device Peak Demand</b>			
PKDMSTA2	A.phsA.Mag.f	IPA	
PKDMSTA2	A.phsB.Mag.f	IPB	
PKDMSTA2	A.phsC.Mag.f	IPC	
PKDMSTA2	A.neut.Mag.f	IPN	
PKDMSTA2	A.zseq.Mag.f	3I0P	
PKDMSTA2	A.nseq.Mag.f	3I2P	
PKDMSTA2	SupTotW.Mag.f	WP3_REC	
PKDMSTA2	SupTotVAr.Mag.f	QP3_REC	
PKDMSTA2	SupTotVA.Mag.f	UP3_REC	
PKDMSTA2	DmdTotW.Mag.f	WP3_DEL	
PKDMSTA2	DmdTotVAr.Mag.f	QP3_DEL	
PKDMSTA2	DmdTotVA.Mag.f	UP3_DEL	
PKDMSTA2	DmdTotVAr1.Mag.f	QP3_DEL_LG	
PKDMSTA2	DmdTotVAr2.Mag.f	QP3_DEL_LD	
PKDMSTA2	SupTotVAr1.Mag.f	QP3_REC_LG	
PKDMSTA2	SupTotVAr2.Mag.f	QP3_REC_LD	
PKDMSTA2	SupW.phsA.Mag.f	WPA_REC	
PKDMSTA2	SupW.phsB.Mag.f	WPB_REC	
PKDMSTA2	SupW.phsC.Mag.f	WPC_REC	

Table H.15 Logical Device: MET (Metering) (Sheet 6 of 13)

Logical Node	Attribute	Data Source	Comment
PKDMSTA2	SupVAr.phsA.Mag.f	QPA_REC	
PKDMSTA2	SupVAr.phsB.Mag.f	QPB_REC	
PKDMSTA2	SupVAr.phsC.Mag.f	QPC_REC	
PKDMSTA2	SupVA.phsA.Mag.f	UPA_REC	
PKDMSTA2	SupVA.phsB.Mag.f	UPB_REC	
PKDMSTA2	SupVA.phsC.Mag.f	UPC_REC	
PKDMSTA2	DmdW.phsA.Mag.f	WPA_DEL	
PKDMSTA2	DmdW.phsB.Mag.f	WPB_DEL	
PKDMSTA2	DmdW.phsC.Mag.f	WPC_DEL	
PKDMSTA2	DmdVAr.phsA.Mag.f	QPA_DEL	
PKDMSTA2	DmdVAr.phsB.Mag.f	QPB_DEL	
PKDMSTA2	DmdVAr.phsC.Mag.f	QPC_DEL	
PKDMSTA2	DmdVA.phsA.Mag.f	UPA_DEL	
PKDMSTA2	DmdVA.phsB.Mag.f	UPB_DEL	
PKDMSTA2	DmdVA.phsC.Mag.f	UPC_DEL	
PKDMSTA2	DmdVAr1.phsA.Mag.f	QPA_DEL_LG	
PKDMSTA2	DmdVAr1.phsB.Mag.f	QPB_DEL_LG	
PKDMSTA2	DmdVAr1.phsC.Mag.f	QPC_DEL_LG	
PKDMSTA2	DmdVAr2.phsA.Mag.f	QPA_DEL_LD	
PKDMSTA2	DmdVAr2.phsB.Mag.f	QPB_DEL_LD	
PKDMSTA2	DmdVAr2.phsC.Mag.f	QPC_DEL_LD	
PKDMSTA2	SupVAr1.phsA.Mag.f	QPA_REC_LG	
PKDMSTA2	SupVAr1.phsB.Mag.f	QPB_REC_LG	
PKDMSTA2	SupVAr1.phsC.Mag.f	QPC_REC_LG	
PKDMSTA2	SupVAr2.phsA.Mag.f	QPA_REC_LD	
PKDMSTA2	SupVAr2.phsB.Mag.f	QPB_REC_LD	
PKDMSTA2	SupVAr2.phsC.Mag.f	QPC_REC_LD	
<b>Device Previous Peak Demand</b>			
PPDMSTA3	A.phsA.Mag.f	IPPA	
PPDMSTA3	A.phsB.Mag.f	IPPB	
PPDMSTA3	A.phsC.Mag.f	IPPC	
PPDMSTA3	A.neut.Mag.f	IPPN	
PPDMSTA3	A.zseq.Mag.f	3I0PP	
PPDMSTA3	A.nseq.Mag.f	3I2PP	
PPDMSTA3	SupTotW.Mag.f	WPP3_REC	
PPDMSTA3	SupTotVAr.Mag.f	QPP3_REC	
PPDMSTA3	SupTotVA.Mag.f	UPP3_REC	
PPDMSTA3	DmdTotW.Mag.f	WPP3_DEL	
PPDMSTA3	DmdTotVAr.Mag.f	QPP3_DEL	
PPDMSTA3	DmdTotVA.Mag.f	UPP3_DEL	
PPDMSTA3	DmdTotVAr1.Mag.f	QPP3_DEL_LG	

**Table H.15 Logical Device: MET (Metering) (Sheet 7 of 13)**

Logical Node	Attribute	Data Source	Comment
PPDMSTA3	DmdTotVAr2.Mag.f	QPP3_DEL_LD	
PPDMSTA3	SupTotVAr1.Mag.f	QPP3_REC_LG	
PPDMSTA3	SupTotVAr2.Mag.f	QPP3_REC_LD	
PPDMSTA3	SupW.phsA.Mag.f	WPPA_REC	
PPDMSTA3	SupW.phsB.Mag.f	WPPB_REC	
PPDMSTA3	SupW.phsC.Mag.f	WPPC_REC	
PPDMSTA3	SupVAr.phsA.Mag.f	QPPA_REC	
PPDMSTA3	SupVAr.phsB.Mag.f	QPPB_REC	
PPDMSTA3	SupVAr.phsC.Mag.f	QPPC_REC	
PPDMSTA3	SupVA.phsA.Mag.f	UPPA_REC	
PPDMSTA3	SupVA.phsB.Mag.f	UPPB_REC	
PPDMSTA3	SupVA.phsC.Mag.f	UPPC_REC	
PPDMSTA3	DmdW.phsA.Mag.f	WPPA_DEL	
PPDMSTA3	DmdW.phsB.Mag.f	WPPB_DEL	
PPDMSTA3	DmdW.phsC.Mag.f	WPPC_DEL	
PPDMSTA3	DmdVAr.phsA.Mag.f	QPPA_DEL	
PPDMSTA3	DmdVAr.phsB.Mag.f	QPPB_DEL	
PPDMSTA3	DmdVAr.phsC.Mag.f	QPPC_DEL	
PPDMSTA3	DmdVA.phsA.Mag.f	UPPA_DEL	
PPDMSTA3	DmdVA.phsB.Mag.f	UPPB_DEL	
PPDMSTA3	DmdVA.phsC.Mag.f	UPPC_DEL	
PPDMSTA3	DmdVAr1.phsA.Mag.f	QPPA_DEL_LG	
PPDMSTA3	DmdVAr1.phsB.Mag.f	QPPB_DEL_LG	
PPDMSTA3	DmdVAr1.phsC.Mag.f	QPPC_DEL_LG	
PPDMSTA3	DmdVAr2.phsA.Mag.f	QPPA_DEL_LD	
PPDMSTA3	DmdVAr2.phsB.Mag.f	QPPB_DEL_LD	
PPDMSTA3	DmdVAr2.phsC.Mag.f	QPPC_DEL_LD	
PPDMSTA3	SupVAr1.phsA.Mag.f	QPPA_REC_LG	
PPDMSTA3	SupVAr1.phsB.Mag.f	QPPB_REC_LG	
PPDMSTA3	SupVAr1.phsC.Mag.f	QPPC_REC_LG	
PPDMSTA3	SupVAr2.phsA.Mag.f	QPPA_REC_LD	
PPDMSTA3	SupVAr2.phsB.Mag.f	QPPB_REC_LD	
PPDMSTA3	SupVAr2.phsC.Mag.f	QPPC_REC_LD	
<b>Uncompensated Device Present Interval Demand</b>			
UCPIDMSTA4	SupTotW.Mag.f	WD3_REC_UC	
UCPIDMSTA4	SupTotVAr.Mag.f	QD3_REC_UC	
UCPIDMSTA4	DmdTotW.Mag.f	WD3_DEL_UC	
UCPIDMSTA4	DmdTotVAr.Mag.f	QD3_DEL_UC	
UCPIDMSTA4	DmdTotVAr1.Mag.f	QD3_DEL_LG_UC	
UCPIDMSTA4	DmdTotVAr2.Mag.f	QD3_DEL_LD_UC	
UCPIDMSTA4	SupTotVAr1.Mag.f	QD3_REC_LG_UC	

**Table H.15 Logical Device: MET (Metering) (Sheet 8 of 13)**

Logical Node	Attribute	Data Source	Comment
UCPIDMSTA4	SupTotVAr2.Mag.f	QD3_REC_LD_UC	
UCPIDMSTA4	SupW.phsA.Mag.f	WDA_REC_UC	
UCPIDMSTA4	SupW.phsB.Mag.f	WDB_REC_UC	
UCPIDMSTA4	SupW.phsC.Mag.f	WDC_REC_UC	
UCPIDMSTA4	SupVAr.phsA.Mag.f	QDA_REC_UC	
UCPIDMSTA4	SupVAr.phsB.Mag.f	QDB_REC_UC	
UCPIDMSTA4	SupVAr.phsC.Mag.f	QDC_REC_UC	
UCPIDMSTA4	DmdW.phsA.Mag.f	WDA_DEL_UC	
UCPIDMSTA4	DmdW.phsB.Mag.f	WDB_DEL_UC	
UCPIDMSTA4	DmdW.phsC.Mag.f	WDC_DEL_UC	
UCPIDMSTA4	DmdVAr.phsA.Mag.f	QDA_DEL_UC	
UCPIDMSTA4	DmdVAr.phsB.Mag.f	QDB_DEL_UC	
UCPIDMSTA4	DmdVAr.phsC.Mag.f	QDC_DEL_UC	
UCPIDMSTA4	DmdVAr1.phsA.Mag.f	QDA_DEL_LG_UC	
UCPIDMSTA4	DmdVAr1.phsB.Mag.f	QDB_DEL_LG_UC	
UCPIDMSTA4	DmdVAr1.phsC.Mag.f	QDC_DEL_LG_UC	
UCPIDMSTA4	DmdVAr2.phsA.Mag.f	QDA_DEL_LD_UC	
UCPIDMSTA4	DmdVAr2.phsB.Mag.f	QDB_DEL_LD_UC	
UCPIDMSTA4	DmdVAr2.phsC.Mag.f	QDC_DEL_LD_UC	
UCPIDMSTA4	SupVAr1.phsA.Mag.f	QDA_REC_LG_UC	
UCPIDMSTA4	SupVAr1.phsB.Mag.f	QDB_REC_LG_UC	
UCPIDMSTA4	SupVAr1.phsC.Mag.f	QDC_REC_LG_UC	
UCPIDMSTA4	SupVAr2.phsA.Mag.f	QDA_REC_LD_UC	
UCPIDMSTA4	SupVAr2.phsB.Mag.f	QDB_REC_LD_UC	
UCPIDMSTA4	SupVAr2.phsC.Mag.f	QDC_REC_LD_UC	
<b>Uncompensated Device Peak Demand</b>			
UCPKDMSTA5	SupTotW.Mag.f	WP3_REC_UC	
UCPKDMSTA5	SupTotVAr.Mag.f	QP3_REC_UC	
UCPKDMSTA5	DmdTotW.Mag.f	WP3_DEL_UC	
UCPKDMSTA5	DmdTotVAr.Mag.f	QP3_DEL_UC	
UCPKDMSTA5	DmdTotVAr1.Mag.f	QP3_DEL_LG_UC	
UCPKDMSTA5	DmdTotVAr2.Mag.f	QP3_DEL_LD_UC	
UCPKDMSTA5	SupTotVAr1.Mag.f	QP3_REC_LG_UC	
UCPKDMSTA5	SupTotVAr2.Mag.f	QP3_REC_LD_UC	
UCPKDMSTA5	SupW.phsA.Mag.f	WPA_REC_UC	
UCPKDMSTA5	SupW.phsB.Mag.f	WPB_REC_UC	
UCPKDMSTA5	SupW.phsC.Mag.f	WPC_REC_UC	
UCPKDMSTA5	SupVAr.phsA.Mag.f	QPA_REC_UC	
UCPKDMSTA5	SupVAr.phsB.Mag.f	QPB_REC_UC	
UCPKDMSTA5	SupVAr.phsC.Mag.f	QPC_REC_UC	
UCPKDMSTA5	DmdW.phsA.Mag.f	WPA_DEL_UC	

**Table H.15 Logical Device: MET (Metering) (Sheet 9 of 13)**

Logical Node	Attribute	Data Source	Comment
UCPKDMSTA5	DmdW.phsB.Mag.f	WPB_DEL_UC	
UCPKDMSTA5	DmdW.phsC.Mag.f	WPC_DEL_UC	
UCPKDMSTA5	DmdVAr.phsA.Mag.f	QPA_DEL_UC	
UCPKDMSTA5	DmdVAr.phsB.Mag.f	QPB_DEL_UC	
UCPKDMSTA5	DmdVAr.phsC.Mag.f	QPC_DEL_UC	
UCPKDMSTA5	DmdVAr1.phsA.Mag.f	QPA_DEL_LG_UC	
UCPKDMSTA5	DmdVAr1.phsB.Mag.f	QPB_DEL_LG_UC	
UCPKDMSTA5	DmdVAr1.phsC.Mag.f	QPC_DEL_LG_UC	
UCPKDMSTA5	DmdVAr2.phsA.Mag.f	QPA_DEL_LD_UC	
UCPKDMSTA5	DmdVAr2.phsB.Mag.f	QPB_DEL_LD_UC	
UCPKDMSTA5	DmdVAr2.phsC.Mag.f	QPC_DEL_LD_UC	
UCPKDMSTA5	SupVAr1.phsA.Mag.f	QPA_REC_LG_UC	
UCPKDMSTA5	SupVAr1.phsB.Mag.f	QPB_REC_LG_UC	
UCPKDMSTA5	SupVAr1.phsC.Mag.f	QPC_REC_LG_UC	
UCPKDMSTA5	SupVAr2.phsA.Mag.f	QPA_REC_LD_UC	
UCPKDMSTA5	SupVAr2.phsB.Mag.f	QPB_REC_LD_UC	
UCPKDMSTA5	SupVAr2.phsC.Mag.f	QPC_REC_LD_UC	

**Uncompensated Device Previous Peak Demand**

UCPPDMSTA6	SupTotW.Mag.f	WPP3_REC_UC	
UCPPDMSTA6	SupTotVAr.Mag.f	QPP3_REC_UC	
UCPPDMSTA6	DmdTotW.Mag.f	WPP3_DEL_UC	
UCPPDMSTA6	DmdTotVAr.Mag.f	QPP3_DEL_UC	
UCPPDMSTA6	DmdTotVAr1.Mag.f	QPP3_DEL_LG_UC	
UCPPDMSTA6	DmdTotVAr2.Mag.f	QPP3_DEL_LD_UC	
UCPPDMSTA6	SupTotVAr1.Mag.f	QPP3_REC_LG_UC	
UCPPDMSTA6	SupTotVAr2.Mag.f	QPP3_REC_LD_UC	
UCPPDMSTA6	SupW.phsA.Mag.f	WPPA_REC_UC	
UCPPDMSTA6	SupW.phsB.Mag.f	WPPB_REC_UC	
UCPPDMSTA6	SupW.phsC.Mag.f	WPPC_REC_UC	
UCPPDMSTA6	SupVAr.phsA.Mag.f	QPPA_REC_UC	
UCPPDMSTA6	SupVAr.phsB.Mag.f	QPPB_REC_UC	
UCPPDMSTA6	SupVAr.phsC.Mag.f	QPPC_REC_UC	
UCPPDMSTA6	DmdW.phsA.Mag.f	WPPA_DEL_UC	
UCPPDMSTA6	DmdW.phsB.Mag.f	WPPB_DEL_UC	
UCPPDMSTA6	DmdW.phsC.Mag.f	WPPC_DEL_UC	
UCPPDMSTA6	DmdVAr.phsA.Mag.f	QPPA_DEL_UC	
UCPPDMSTA6	DmdVAr.phsB.Mag.f	QPPB_DEL_UC	
UCPPDMSTA6	DmdVAr.phsC.Mag.f	QPPC_DEL_UC	
UCPPDMSTA6	DmdVAr1.phsA.Mag.f	QPPA_DEL_LG_UC	
UCPPDMSTA6	DmdVAr1.phsB.Mag.f	QPPB_DEL_LG_UC	
UCPPDMSTA6	DmdVAr1.phsC.Mag.f	QPPC_DEL_LG_UC	

Table H.15 Logical Device: MET (Metering) (Sheet 10 of 13)

Logical Node	Attribute	Data Source	Comment
UCPPDMSTA6	DmdVAr2.phsA.Mag.f	QPPA_DEL_LD_UC	
UCPPDMSTA6	DmdVAr2.phsB.Mag.f	QPPB_DEL_LD_UC	
UCPPDMSTA6	DmdVAr2.phsC.Mag.f	QPPC_DEL_LD_UC	
UCPPDMSTA6	SupVAr1.phsA.Mag.f	QPPA_REC_LG_UC	
UCPPDMSTA6	SupVAr1.phsB.Mag.f	QPPB_REC_LG_UC	
UCPPDMSTA6	SupVAr1.phsC.Mag.f	QPPC_REC_LG_UC	
UCPPDMSTA6	SupVAr2.phsA.Mag.f	QPPA_REC_LD_UC	
UCPPDMSTA6	SupVAr2.phsB.Mag.f	QPPB_REC_LD_UC	
UCPPDMSTA6	SupVAr2.phsC.Mag.f	QPPC_REC_LD_UC	
<b>Device Flicker Quantities</b>			
METMFLK1	PhPiMax.phsA.cVal.mag.f	PINST_VA	
METMFLK1	PhPiMax.phsB.cVal.mag.f	PINTS_VB	
METMFLK1	PhPiMax.phsC.cVal.mag.f	PINTS_VC	
METMFLK1	PhPst.phsA.cVal.mag.f	PST_1MIN_VA	
METMFLK1	PhPst.phsB.cVal.mag.f	PST_1MIN_VB	
METMFLK1	PhPst.phsC.cVal.mag.f	PST_1MIN_VC	
METMFLK1	PhPst1.phsA.cVal.mag.f	PST_10MIN_VA	
METMFLK1	PhPst1.phsB.cVal.mag.f	PST_10MIN_VB	
METMFLK1	PhPst1.phsC.cVal.mag.f	PST_10MIN_VC	
METMFLK1	PhPlt.phsA.cVal.mag.f	PLT_VA	
METMFLK1	PhPlt.phsB.cVal.mag.f	PLT_VB	
METMFLK1	PhPlt.phsC.cVal.mag.f	PLT_VC	
METMFLK1	PhiMaxTms.cVal.mag.f	SEC_PINST	
METMFLK1	PhPstTms.cVal.mag.f	SEC_PST	
METMFLK1	TmsPhPltTms.cVal.mag.f	SEC_PLT	
<b>Device Fundamental Quantities</b>			
FUNDMMXU1	TotW.Mag.f	W3_FUND	
FUNDMMXU1	TotVAr.Mag.f	Q3_FUND	
FUNDMMXU1	TotVA.Mag.f	S3_FUND	
FUNDMMXU1	TotVAr1.Mag.f	Q3_DEL_LG	
FUNDMMXU1	TotVAr2.Mag.f	Q3_DEL_LD	
FUNDMMXU1	TotVAr3.Mag.f	Q3_REC_LG	
FUNDMMXU1	TotVAr4.Mag.f	Q3_REC_LD	
FUNDMMXU1	TotPF.Mag.f	PFD3	
FUNDMMXU1	Hz.Mag.f	FREQ	
FUNDMMXU1	PPV.phsAB.cVal.mag.f	VAB_FUND	
FUNDMMXU1	PPV.phsAB.cVal.ang.f	VAB_ANG	
FUNDMMXU1	PPV.phsBC.cVal.mag.f	VBC_FUND	
FUNDMMXU1	PPV.phsBC.cVal.ang.f	VBC_ANG	
FUNDMMXU1	PPV.phsCA.cVal.mag.f	VCA_FUND	
FUNDMMXU1	PPV.phsCA.cVal.ang.f	VCA_ANG	

**Table H.15 Logical Device: MET (Metering) (Sheet 11 of 13)**

Logical Node	Attribute	Data Source	Comment
FUNDMMXU1	PhV.phsA.cVal.mag.f	VA_FUND	
FUNDMMXU1	PhV.phsA.cVal.ang.f	VA_ANG	
FUNDMMXU1	PhV.phsB.cVal.mag.f	VB_FUND	
FUNDMMXU1	PhV.phsB.cVal.ang.f	VB_ANG	
FUNDMMXU1	PhV.phsC.cVal.mag.f	VC_FUND	
FUNDMMXU1	PhV.phsC.cVal.ang.f	VC_ANG	
FUNDMMXU1	A.phsA.cVal.mag.f	IA_FUND	
FUNDMMXU1	A.phsA.cVal.ang.f	IA_ANG	
FUNDMMXU1	A.phsB.cVal.mag.f	IB_FUND	
FUNDMMXU1	A.phsB.cVal.ang.f	IB_ANG	
FUNDMMXU1	A.phsC.cVal.mag.f	IC_FUND	
FUNDMMXU1	A.phsC.cVal.ang.f	IC_ANG	
FUNDMMXU1	A.neut.cVal.mag.f	IN_FUND	
FUNDMMXU1	A.neut.cVal.ang.f	IN_ANG	
FUNDMMXU1	W.phsA.cVal.mag.f	WA_FUND	
FUNDMMXU1	W.phsB.cVal.mag.f	WB_FUND	
FUNDMMXU1	W.phsC.cVal.mag.f	WC_FUND	
FUNDMMXU1	VAr.phsA.cVal.mag.f	QA_FUND	
FUNDMMXU1	VAr.phsB.cVal.mag.f	QB_FUND	
FUNDMMXU1	VAr.phsC.cVal.mag.f	QC_FUND	
FUNDMMXU1	VA.phsA.cVal.mag.f	SA_FUND	
FUNDMMXU1	VA.phsB.cVal.mag.f	SB_FUND	
FUNDMMXU1	VA.phsC.cVal.mag.f	SC_FUND	
FUNDMMXU1	VAr1.phsA.cVal.mag.f	QA_DEL_LG	
FUNDMMXU1	VAr1.phsB.cVal.mag.f	QB_DEL_LG	
FUNDMMXU1	VAr1.phsC.cVal.mag.f	QC_DEL_LG	
FUNDMMXU1	VAr2.phsA.cVal.mag.f	QA_DEL_LD	
FUNDMMXU1	VAr2.phsB.cVal.mag.f	QB_DEL_LD	
FUNDMMXU1	VAr2.phsC.cVal.mag.f	QC_DEL_LD	
FUNDMMXU1	VAr3.phsA.cVal.mag.f	QA_REC_LG	
FUNDMMXU1	VAr3.phsB.cVal.mag.f	QB_REC_LG	
FUNDMMXU1	VAr3.phsC.cVal.mag.f	QC_REC_LG	
FUNDMMXU1	VAr4.phsA.cVal.mag.f	QA_REC_LD	
FUNDMMXU1	VAr4.phsB.cVal.mag.f	QB_REC_LD	
FUNDMMXU1	VAr4.phsC.cVal.mag.f	QC_REC_LD	
FUNDMMXU1	PF.phsA.cVal.mag.f	PFDA	
FUNDMMXU1	PF.phsB.cVal.mag.f	PFDB	
FUNDMMXU1	PF.phsC.cVal.mag.f	PFDC	
<b>Device RMS Quantities</b>			
RMSMMXU2	TotW.Mag.f	W3	
RMSMMXU2	TotVAr.Mag.f	Q3	

**Table H.15 Logical Device: MET (Metering) (Sheet 12 of 13)**

Logical Node	Attribute	Data Source	Comment
RMSMMXU2	TotVA.Mag.f	U3	
RMSMMXU2	TotPF.Mag.f	PFT3	
RMSMMXU2	Hz.Mag.f	FREQ	
RMSMMXU2	PPV.phsAB.cVal.mag.f	VAB	
RMSMMXU2	PPV.phsBC.cVal.mag.f	VBC	
RMSMMXU2	PPV.phsCA.cVal.mag.f	VCA	
RMSMMXU2	PhV.phsA.cVal.mag.f	VA	
RMSMMXU2	PhV.phsB.cVal.mag.f	VB	
RMSMMXU2	PhV.phsC.cVal.mag.f	VC	
RMSMMXU2	A.phsA.cVal.mag.f	IA	
RMSMMXU2	A.phsB.cVal.mag.f	IB	
RMSMMXU2	A.phsC.cVal.mag.f	IC	
RMSMMXU2	A.neut.cVal.mag.f	IN	
RMSMMXU2	W.phsA.cVal.mag.f	WA	
RMSMMXU2	W.phsB.cVal.mag.f	WB	
RMSMMXU2	W.phsC.cVal.mag.f	WC	
RMSMMXU2	Var.phsA.cVal.mag.f	QA	
RMSMMXU2	Var.phsB.cVal.mag.f	QB	
RMSMMXU2	Var.phsC.cVal.mag.f	QC	
RMSMMXU2	VA.phsA.cVal.mag.f	UA	
RMSMMXU2	VA.phsB.cVal.mag.f	UB	
RMSMMXU2	VA.phsC.cVal.mag.f	UC	
RMSMMXU2	PF.phsA.cVal.mag.f	PFTA	
RMSMMXU2	PF.phsB.cVal.mag.f	PFTB	
RMSMMXU2	PF.phsC.cVal.mag.f	PFTC	
<b>Uncompensated Device RMS Quantities</b>			
UCRMSMMXU3	TotW..Mag.f	W3_UC	
UCRMSMMXU3	TotVAr..Mag.f	Q3_UC	
UCRMSMMXU3	W.phsA.cVal.	WA_UC	
UCRMSMMXU3	W.phsB.cVal.	WB_UC	
UCRMSMMXU3	W.phsC.cVal.	WC_UC	
UCRMSMMXU3	Var.phsA.cVal.	QA_UC	
UCRMSMMXU3	Var.phsB.cVal.	QB_UC	
UCRMSMMXU3	Var.phsC.cVal.	QC_UC	
<b>Device Sequence/Imbalance Quantities</b>			
SEQIMSQI1	SeqA.c1.cVal.mag.f	I1_MAG	
SEQIMSQI1	SeqA.c1.cVal.ang.f	I1_ANG	
SEQIMSQI1	SeqA.c2.cVal.mag.f	3I2_MAG	
SEQIMSQI1	SeqA.c2.cVal.ang.f	3I2_ANG	
SEQIMSQI1	SeqA.c3.cVal.mag.f	3I0_MAG	
SEQIMSQI1	SeqA.c3.cVal.ang.f	3I0_ANG	

**Table H.15 Logical Device: MET (Metering) (Sheet 13 of 13)**

Logical Node	Attribute	Data Source	Comment
SEQIMSQI1	SeqV.c1.cVal.mag.f	V1_MAG	
SEQIMSQI1	SeqV.c1.cVal.ang.f	V1_ANG	
SEQIMSQI1	SeqV.c2.cVal.mag.f	V2_MAG	
SEQIMSQI1	SeqV.c2.cVal.ang.f	V2_ANG	
SEQIMSQI1	SeqV.c3.cVal.mag.f	3V0_MAG	
SEQIMSQI1	SeqV.c3.cVal.ang.f	3V0_ANG	
SEQIMSQI1	ImbNgA.Mag.f.	I_IMB	
SEQIMSQI1	ImbNgV.Mag.f.	V_IMB	
<b>Device Power Quality Quantities</b>			
PQMHA11	Hz.Mag.f.	FREQ_PQ	
PQMHA11	HKf.phsA.cVal.mag.f	KFA	
PQMHA11	HKf.phsB.cVal.mag.f	KFB	
PQMHA11	HKf.phsC.cVal.mag.f	KFC	
PQMHA11	ThdA.phsA.cVal.mag.f	THDIA	
PQMHA11	ThdA.phsB.cVal.mag.f	THDIB	
PQMHA11	ThdA.phsC.cVal.mag.f	THDIC	
PQMHA11	ThdA.neut.cVal.mag.f	THDIN	
PQMHA11	ThdPhV.phsA.cVal.mag.f	THDVA	
PQMHA11	ThdPhV.phsB.cVal.mag.f	THDVB	
PQMHA11	ThdPhV.phsC.cVal.mag.f	THDVC	
PQMHA11	ThdPPV.phsA.cVal.mag.f	THDVA	
PQMHA11	ThdPPV.phsB.cVal.mag.f	THDVB	
PQMHA11	ThdPPV.phsC.cVal.mag.f	THDVC	
<b>Max Crest Factor</b>			
PQMHA11	HCfPhV.phsA.cVal.mag.f	VACFMX	
PQMHA11	HCfPhV.phsB.cVal.mag.f	VBCFMX	
PQMHA11	HCfPhV.phsC.cVal.mag.f	VCCFMX	
PQMHA11	HCfPPV.phsAB.cVal.mag.f	VACFMX	
PQMHA11	HCfPPV.phsBC.cVal.mag.f	VBCFMX	
PQMHA11	HCfPPV.phsCA.cVal.mag.f	VCCFMX	
PQMHA11	HCfA.phsA.cVal.mag.f	IACFMX	
PQMHA11	HCfA.phsB.cVal.mag.f	IBCFMX	
PQMHA11	HCfA.phsC.cVal.mag.f	ICCFMX	
PQMHA11	HCfA.neut.cVal.mag.f	INCFMX	
<b>VSSI</b>			
PQQVVR1	VVa.Mag.f.	SSIR1_DEPTH	
PQQVVR1	VVaTm.Mag.f.	SSIR1_DUR	

# Glossary

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<b>a Output</b>	A meter control output that closes when the output meter asserts.
<b>b Output</b>	A meter control output that opens when the output meter asserts.
<b>c Contact</b>	A breaker auxiliary contact that you can set to serve either as an a contact or as a b contact.
<b>A</b>	Abbreviation for Amps or Amperes; unit of electrical current flow.
<b>Acceptance Testing</b>	Testing that confirms that the meter meets published critical performance specifications and requirements of the intended application. Such testing involves accuracy testing and logic functions when qualifying a meter model for use on the utility system.
<b>Access Level</b>	A meter command level with a specified set of meter information and commands. Except for Access Level 0, you must have the correct password to enter an access level.
<b>Access Level 0</b>	The least secure and most limited access level. No password protects this level. From this level, you must enter a password to go to a higher level.
<b>Access Level 1</b>	A meter command level you use to monitor (view) meter information. The default access level for the meter front panel.
<b>Access Level E</b>	A meter command level you use for Access Level 1 functions and resetting of peak demand, maximum/minimum, crest factors, and load profile. This access level is for the meter reader.
<b>Access Level 2</b>	The most secure access level, from which you have total meter functionality and control of all settings types.
<b>ACSELERATOR QuickSet<sup>®</sup> SEL-5030 Software</b>	A Windows <sup>®</sup> -based program that simplifies settings and provides analysis support.
<b>Analog Quantities</b>	Variables represented by such fluctuating measurable quantities as frequency, current, and voltage.
<b>AND Operator</b>	Logical AND. An operator in Boolean SELOGIC <sup>®</sup> control equations that requires fulfillment of conditions on both sides of the operator before the equation is true.
<b>Anti-Aliasing Filter</b>	A low-pass filter that blocks frequencies too high for the given sampling rate to accurately reproduce.
<b>Apparent Power (S)</b>	Complex power expressed in units of volt-amperes (VA). Accounts for both real (P) and reactive (Q) power dissipated in a circuit: $S = P + jQ$ . This is power at the fundamental frequency only; this quantity includes no harmonics.
<b>ASCII</b>	Abbreviation for American Standard Code for Information Interchange. Defines a standard set of text characters. The SEL-735 uses ASCII text characters to communicate through the use of front-panel and rear-panel EIA-232 serial ports on the meter and through virtual serial ports.

<b>ASCII Terminal</b>	A terminal without built-in logic or local processing capability that can only send and receive information.
<b>Assert</b>	To activate. To fulfill the logic or electrical requirements necessary to operate a device. To set a logic condition to the true state (logical 1) of that condition. To apply a closed contact to an SEL-735 input. To close a normally open output contact. To open a normally closed output contact.
<b>AT Modem Command Set Dialing String Standard</b>	The command language standard that Hayes Microcomputer Products, Inc. developed to control auto-dial modems from an ASCII terminal (usually EIA-232 connected) or a PC (personal computer) containing software allowing emulation of such a terminal.
<b>Automatic Messages</b>	Messages including status failure and status warning messages that the meter generates at the serial ports and displays automatically on the front-panel LCD.
<b>Bandpass Filter</b>	A filter that passes frequencies within a certain range and blocks all frequencies outside this range.
<b>Bit Label</b>	The identifier for a particular bit.
<b>Bit Value</b>	Logical 0 or logical 1.
<b>Blondel's Theorem</b>	This theorem states that in a system of N conductors, N-1 meter elements, properly connected, will measure the power or energy taken. The connection must be such that all voltage coils have a common tie to the conductor in which there is no current coil.
<b>Boolean Logic Statements</b>	Statements consisting of variables that behave according to Boolean logic operators such as AND, NOT, and OR.
<b>Checksum</b>	A method for checking the accuracy of data transmission involving summation of a group of digits and comparison of this sum to a previously calculated value.
<b>CID</b>	Checksum identification of the firmware.
<b>Class Designation</b>	The maximum of the watt-hour meter load range in amperes. This value is indicated on the faceplate after the abbreviation CL. Typical class designations for transformer-rated meters are CL 10 or CL 20. A typical class designation for a residential type meter is CL 200.
<b>Cold Start</b>	Beginning a system from application of power without carryover of previous system activities.
<b>Commissioning Testing</b>	Testing that serves to validate all system ac and dc connections and confirm that the meter, auxiliary equipment, and SCADA interface all function as intended with your settings. Perform such testing when installing a new metering system.
<b>Common Inputs</b>	Meter control inputs that share a common terminal.
<b>Communications Protocol</b>	A language for communication among devices.
<b>Comparison</b>	Boolean SELOGIC control equation operation that compares two numerical values. Compares floating-point values such as currents, total counts, and other measured and calculated quantities.

<b>Conditioning Timers</b>	Timers for conditioning Boolean values. Conditioning timers either stretch incoming pulses or allow you to require that an input take a state for a certain period before reacting to the new state.
<b>Contact Input</b>	See Control Input.
<b>Contact Output</b>	See Control Output.
<b>Control Input</b>	Meter inputs for monitoring the state of external circuits. Connect auxiliary meter and circuit breaker contacts to the control inputs.
<b>Control Output</b>	Meter outputs that affect the state of other equipment. Connect control outputs and SCADA systems.
<b>Counter</b>	Variable or device such as a register or storage location that either records or represents the number of times an event occurs.
<b>CT</b>	Current transformer.
<b>CTR</b>	Current transformer ratio.
<b>Data Bit</b>	A single unit of information that can assume a value of either logical 0 or logical 1 and can convey control, address, information, or frame check sequence data.
<b>Data Label</b>	The identifier for a particular data item.
<b>Data Objects</b>	Individual pieces of UCA data created from instances of common class components or data items that are instances of standard data types.
<b>DCE Devices</b>	Data communication equipment devices (modems).
<b>Dead Band</b>	The range of variation an analog quantity can traverse before causing a response.
<b>Deassert</b>	To deactivate. To remove the logic or electrical requirements necessary to operate a device. To clear a logic condition to its false state (logical 0). To open the circuit or open the contacts across an SEL-735 input. To open a normally open output contact. To close a normally closed output contact.
<b>Debounce Time</b>	The time that masks the period when meter contacts continue to move after closing; debounce time covers this indeterminate state.
<b>Default Data Map</b>	The default map of objects and indices that the SEL-735 uses in DNP protocol.
<b>Delta</b>	A phase-to-phase series connection of circuit elements, particularly voltage transformers or loads.
<b>Demand Meter</b>	A measuring function that calculates a rolling average, block, or thermal average, block, of instantaneous measurements over time.
<b>Dial</b>	The clock-type hands on an electromechanical register. The billing system must be aware of the “number of dials” on the meter to properly detect a rollover condition. Use of four- and five-dial registers is common.

<b>Dial Multiplier</b>	The value the meter register displays multiplied by the dial multiplier to obtain kilowatt-hours. The nameplate shows the dial multiplier. For self-contained meters, a dial multiplier of one or ten is most common. Determination of the dial multiplier for transformer-rated meters occurs at installation time, depending on the transformer ratios. This multiplier applies to both the kilowatt-hour and demand (kW) readings.
<b>Distortion Power Ratio (Dx)</b>	The meter calculates distortion power as the ratio of average power to fundamental power and reported the result as a percentage. Calculation occurs on a per-phase or three-phase basis as follows:  $Dx = \left( \frac{Px_{avg}}{Px} - 1 \right) 100$ <p>where:</p> <ul style="list-style-type: none"> <li>Dx is the distortion power ratio for the respective phase</li> <li>Px_avg is the average power for the respective phase</li> <li>Px is the fundamental power for the respective phase</li> </ul>
<b>DMSI Period</b>	The subinterval time of the demand meter time constant in demand metering.
<b>DMTC Period</b>	The time of the demand meter time constant in demand metering.
<b>DNP (Distributed Network Protocol)</b>	Manufacturer-developed, hardware-independent communications protocol.
<b>Dropout Time</b>	The time measured from the removal of an input signal until the output signal deasserts. You can set the time, in the case of a logic variable timer, or the dropout time can be a result of the characteristics of an element algorithm.
<b>DTE Devices</b>	Data terminal equipment (computers, terminals, printers, meters, etc.).
<b>Dumb Terminal</b>	See ASCII terminal.
<b>EIA-232</b>	Electrical definition for point-to-point serial data communications interfaces, based on the standard EIA/TIA-232. Formerly known as RS-232.
<b>EIA-485</b>	Electrical standard for multidrop serial data communications interfaces, based on the standard EIA/TIA-485. Formerly known as RS-485.
<b>Element</b>	A combination of a voltage-sensing unit and a current-sensing unit that provides an output proportional to the quantities measured. For example, a Form 9 meter is a three-element meter. See also Stator.
<b>Energy Metering</b>	Energy metering provides a look at imported power, exported power, and net usage over time.
<b>ESD (Electrostatic Discharge)</b>	The sudden transfer of charge between objects at different potentials caused either by direct contact or induction by an electrostatic field.
<b>Ethernet</b>	A network physical and data link layer defined by IEEE 802.2 and IEEE 802.3.
<b>Event History</b>	A quick look at recent meter activity that includes a standard report header, event number, date, time, type, and targets.
<b>Event Report</b>	A text-based collection of data the meter stores in response to a triggering condition, such as an ASCII <b>TRI</b> command. The data show meter

measurements before and after the trigger, in addition to the states of elements each processing interval.

<b>Event Summary</b>	A shortened version of stored event reports. An event summary includes items such as event date, event time, and event type.  The meter sends an event report summary (if auto messaging is enabled) to the meter serial port a few seconds after an event.
<b>F_TRIG</b>	Falling-edge trigger. Boolean SELOGIC control equation operator that triggers an operation upon logic detection of a falling edge.
<b>Fail-Safe</b>	Refers to an output that is open during normal meter operation and closed when meter power is removed or if the meter fails. Configure alarm outputs for fail-safe operation.
<b>Falling Edge</b>	Transition from logical 1 to logical 0.
<b>Fast Meter</b>	SEL binary serial port command used to collect metering data with SEL devices.
<b>Fast Operate</b>	SEL binary serial port command used to perform control with SEL devices.
<b>Firmware</b>	The nonvolatile program stored in the meter that defines meter operation.
<b>Flash Memory</b>	A type of nonvolatile meter memory used for storing large blocks of nonvolatile data.
<b>Flicker</b>	The visible, periodic change in light intensity of an incandescent bulb caused by the fluctuation of input voltage. IEC 61000-4-15 specifies the requirements for the measurement of flicker.
<b>Function Code</b>	A code that defines how you manipulate an object in DNP3 protocol.
<b>Fundamental Frequency</b>	The component of the measured electrical signal with a frequency equal to the normal electrical system frequency, usually 50 Hz or 60 Hz. Generally used to differentiate between the normal system frequency and any harmonic frequencies present.
<b>Global Settings</b>	General settings including those for date format, phase rotation, control inputs, ASCII report scaling, and time and date management.
<b>GPS</b>	Global Positioning System. Source of position and high-accuracy time information.
<b>Group Total Harmonic Distortion</b>	The ratio of the sum of the power of all harmonic frequencies including interharmonics above the fundamental frequency to the power of the fundamental frequency. Usually expressed as a percentage. Large numbers indicate increased distortion.
<b>GUI</b>	Graphical user interface.
<b>Hexadecimal Address</b>	A register address consisting of a numeral with an “h” suffix or a “0x” prefix.
<b>HMI</b>	Human machine interface.
<b>IA, IB, IC</b>	Measured A-phase, B-phase, and C-phase currents.
<b>IED</b>	Intelligent electronic device.

<b>IG</b>	Residual current, calculated from the sum of the phase currents. In normal, balanced operation, this current is very small or zero.
<b>Input Conditioning</b>	The establishment of debounce time and assertion level.
<b>Instantaneous Meter</b>	Type of meter data presented by the SEL-735 that includes the present values measured at the meter ac inputs. The word “Instantaneous” provides differentiation of these values from the measurements presented by the demand, energy, and other meter types.
<b>IRIG-B</b>	A time code input that the meter can use to set the internal meter clock.
<b>Jitter</b>	Time, amplitude, frequency, or phase-related abrupt, spurious variations in duration, magnitude, or frequency.
<b>K<sub>e</sub> or KYZ Output Constant</b>	A pulse constant for the KYZ outputs of a solid-state meter, programmable in unit-hours per pulse.
<b>K<sub>h</sub> or Watt-hour Constant</b>	The number of watt-hours represented by one revolution of the disk in electromechanical meters—also called the Disk Constant. For a solid-state meter, K <sub>h</sub> is essentially meaningless because there is no disk. However, ANSI C12.10 requires that K <sub>h</sub> be displayed on the faceplate.
<b>K<sub>t</sub> or Test Constant</b>	The number of watt-hours represented by one test pulse in a solid-state meter. An IR LED or a contact output usually provides the test pulse.
<b>K-factor</b>	A measure of the effect of harmonic load currents used for derating equipment (transformers), as described in ANSI/IEEE C57.110. The larger the K-factor, the greater the harmonic heating effects. A K-factor of 1.0 indicates a linear load (no harmonics). K-factor is the summation of the square of a particular harmonic current multiplied by the square of the harmonic number. K-factor transformers have additional thermal capacity, design features that minimize harmonic current losses, and oversized thermal connections.
<b>KYZ Output</b>	A three-wire (Form C contact) output from a metering device to drive external control or recording equipment. Each pulse or transition represents a predetermined increment of energy or other quantity.
<b>L/R</b>	Circuit inductive/resistive ratio.
<b>Latch Bits</b>	Nonvolatile storage locations for binary information.
<b>LED</b>	Light-emitting diode. Used as indicators on the meter front panel.
<b>LMD</b>	SEL Distributed Port Switch protocol.
<b>Logical 0</b>	A false logic condition, dropped-out element, or deasserted control input or control output.
<b>Logical 1</b>	A true logic condition, picked-up element, or asserted control input or control output.
<b>Low-Level Test Interface</b>	An interface that provides a means for interrupting the connection between the meter input transformers and the input processing module and allows inserting reduced-scale test quantities for meter testing.
<b>Maintenance Testing</b>	Testing that confirms that the meter is measuring ac quantities accurately and verifies correct functioning of auxiliary equipment and scheme logic.

<b>Math Operators</b>	Operators that you use in the construction of math SELOGIC control equations to manipulate numerical values and provide a numerical base-10 result.
<b>Maximum Dropout Time</b>	The maximum time interval following a change of input conditions between the deassertion of the input and the deassertion of the output.
<b>Maximum/Minimum Meter</b>	Type of meter data presented by the SEL-735 that includes a record of the maximum and minimum of each value, along with the date and time that each maximum and minimum occurred.
<b>Meter Form</b>	The design of the measuring portion of the electric meter so that the meter can correctly measure the electric service supplied by the utility. There are many different forms because of the different types of electric service and the size of the service. ANSI C12.10 defines the meter forms. Socket-based meters use an “S” suffix in the form number, e.g., “2S.” Bottom-connected meters, also known as “A-base” meters, use an “A” suffix, e.g., “9A.” A Form 2S meter, a three-wire, self-contained device, is the most common residential meter for a 120/240 V service. The Form 9 meter is common for substation metering. A Form 9 meter is a three-stator, transformer-rated, three-phase, four-wire wye.
<b>Device Word Bit</b>	A single meter element or logic result. A Device Word bit can equal either logical 1 or logical 0. Logical 1 represents a true logic condition, picked-up element, or asserted control input or control output. Logical 0 represents a false logic condition, dropped-out element, or deasserted control input or control output. Use Device Word bits in SELOGIC control equations.
<b>MID</b>	Meter firmware identification string. Lists the meter model, firmware version and date code, and other information that uniquely identifies the firmware installed in a particular meter.
<b>MIRRORED BITS® Communications</b>	Patented meter-to-meter communications technique that sends internal logic status, encoded in a digital message, from one meter to the other. Eliminates the need for some communications hardware.
<b>MMS</b>	Manufacturing Messaging Specification. A data exchange protocol used by UCA.
<b>Model</b>	Model of device (or component of a device) including the data, control access, and other features in UCA protocol.
<b>Negation Operator</b>	A SELOGIC control equation math operator that changes the sign of the argument. The argument of the negation operation is multiplied by $-1$ .
<b>Negative-Sequence</b>	A configuration of three-phase currents and voltages. The currents and voltages have equal magnitude, a phase displacement of $120^\circ$ , and clockwise phase rotation with current and voltage maxima that occur differently from that for positive-sequence configuration. If positive-sequence maxima occur as ABC, negative-sequence maxima occur as ACB.
<b>NEMA</b>	National Electrical Manufacturers’ Association.
<b>NONVOL</b>	Nonvolatile memory where the meter stores meter settings, event reports, SER records, and other nonvolatile data.
<b>Nonvolatile Memory</b>	Meter memory that persists over time to maintain the contained data even when the meter is de-energized.
<b>NOT Operator</b>	A logical operator that produces the inverse value.

<b>Optical Port</b>	A communications interface on a metering product that allows the transfer of information while providing electrical isolation and metering security. The communications medium is typically infrared light transmitted and received through the meter cover.
<b>OR Operator</b>	Logical OR. A Boolean SELOGIC control equation operator that compares two Boolean values and yields either a logical 1 if either compared Boolean value is logical 1 or a logical 0 if both compared Boolean values are logical 0.
<b>Parentheses Operator</b>	Math operator. Use paired parentheses to control the execution of operations in a SELOGIC control equation.
<b>PC</b>	Personal computer.
<b>Peak Demand Metering</b>	Maximum demand and a time stamp for phase currents, negative-sequence and zero-sequence currents, and powers. The SEL-735 stores peak demand values and the date and time these occurred to nonvolatile storage, overwriting a previously stored value if the new value is larger. Should the meter lose control power, the meter restores the peak demand information the meter last stored.
<b>Phase Rotation</b>	The sequence of voltage or current phasors in a multiphase electrical system. In an ABC phase rotation system, the B-phase voltage lags the A-phase voltage by 120°, and the C-phase voltage lags B-phase voltage by 120°. In an ACB phase rotation system, the C-phase voltage lags the A-phase voltage by 120°, and the B-phase voltage lags the C-phase voltage by 120°.
<b>Pickup Time</b>	The time measured from the application of an input signal until the output signal asserts. You can set the time, as in the case of a logic variable timer, or the pickup time can be a result of the characteristics of an element algorithm.
<b>Pinout</b>	The definition or assignment of each electrical connection at an interface. Typically refers to a cable, connector, or jumper.
<b>Port Settings</b>	Communications port settings such as Data Bits, Speed, and Stop Bits.
<b>Positive-Sequence</b>	A configuration of three-phase currents and voltages. The currents and voltages have equal magnitude and a phase displacement of 120°. With conventional rotation in the counter-clockwise direction, the positive-sequence current and voltage maxima occur in ABC order.
<b>Power Factor</b>	The cosine of the angle by which phase current lags or leads phase voltage in an ac electrical circuit. Power factor equals 1.0 for power flowing to a pure resistive load.
<b>PT</b>	Potential transformer. Also referred to as a voltage transformer or VT.
<b>PTR</b>	Potential transformer ratio.
<b>Qualifier Code</b>	Specifies type of range for DNP3 objects. With the help of qualifier codes, DNP master devices can compose the shortest, most concise messages.
<b>R_TRIG</b>	Rising-edge trigger. Boolean SELOGIC control equation operator that triggers an operation upon logic detection of a rising edge.
<b>RAM</b>	Random Access Memory. Volatile memory where the meter stores intermediate calculation results, Device Word bits, and other data.

<b>Real Power (P)</b>	Power that produces actual work. The portion of apparent power that is real, not imaginary.
<b>Real Power Average (P<sub>AVE</sub>)</b>	Real power averaged over a one-second interval.
<b>Real Power Three Phase (P3P)</b>	Three-phase real power measured in watts.
<b>Reactive Power (Q)</b>	Reactive power measured in volt-amperes reactive (VAR). The product of the voltage and current multiplied by the sine of the angle between the two.
<b>Reactive Power Average (Q<sub>AVE</sub>)</b>	Reactive power (Q) average over a one-second interval. Q <sub>AVE</sub> is forced to zero when the apparent power (S) is less than or equal to real power (P) • 0.001.
<b>Reactive Power Three Phase (Q3P)</b>	Three-phase instantaneous reactive power measured in volt-amperes reactive (VAR).
<b>Register</b>	An electromechanical or electronic device that stores and displays metering quantities, e.g., kWh, kW demand. In solid-state meters, meter data quantities are often referred to as “registers.”
<b>Remapping</b>	The process of selecting data from the default map and configuring new indices to form a smaller data set optimized to your application.
<b>Remote Bit</b>	A Device Word bit with a state that is controlled by serial port commands, including the <b>CONTROL</b> command, a binary Fast Operate command, DNP binary output operation, or a UCA control operation.
<b>Report Settings</b>	Event report and Sequential Events Recorder settings.
<b>Residual Current</b>	The sum of the measured phase currents. In normal, balanced operation, this current is very small or zero.
<b>Rising Edge</b>	Transition from logical 0 to logical 1, or the beginning of an operation.
<b>RMS</b>	Root-mean-square. This is the effective value of the current and voltage measured by the meter, accounting for the fundamental frequency and higher-order harmonics in the signal.
<b>Rolling Demand</b>	A sliding time-window arithmetic average in demand metering.
<b>RTU</b>	Remote terminal unit.
<b>RXD</b>	Received data.
<b>SCADA</b>	Supervisory control and data acquisition.
<b>Self-Contained Meter</b>	A watt-hour meter that is connected directly to the supply voltage and is in series with the customer loads. Residential meters are almost always self-contained meters.
<b>Self-Test</b>	A function that verifies the correct operation of a critical device subsystem and indicates detection of an out-of-tolerance condition. The SEL-735 has self-tests that validate the meter power supply, microprocessor, memory, and other critical systems.
<b>SELOGIC Expression Builder</b>	A rules-based editor within the ACSELERATOR QuickSet software program for programming SELOGIC control equations.

<b>SELOGIC Math Variables</b>	Math calculation result storage locations.
<b>SELOGIC Control Equation</b>	A meter setting that allows you to control a meter function (such as a control output) through the use of a logical combination of meter element outputs and fixed logic outputs.
<b>Sequencing Timers</b>	Timers designed for sequencing automated operations.
<b>Sequential Events Recorder</b>	A meter function that stores a record of the date and time of each assertion and deassertion of every Device Word bit in a list that you set in the meter. SER provides a useful way to determine the order and timing of events of a meter operation.
<b>SER</b>	Sequential Events Recorder or the meter serial port command to request a report of the latest sequential events.
<b>Settle/Settling Time</b>	Time required for an input signal to result in an unvarying output signal within a specified range.
<b>Stator</b>	The unit that provides the driving torque in a watt-hour meter. It contains a voltage coil, one or more current coils, and the necessary steel to provide the required magnetic paths. Other names used for stator are element or driving element.
<b>Status Failure</b>	A severe out-of-tolerance internal operating condition. The meter issues a status failure message and enters a disabled state.
<b>Status Warning</b>	Out-of-tolerance internal operating conditions that do not compromise meter protection, yet are beyond expected limits. The meter issues a status warning message and continues to operate.
<b>Strong Password</b>	A mix of valid password characters in an eight-character combination that does not spell common words in any portion of the password. Valid password characters are numbers, upper- and lower-case alphabetic characters, “.” (period), and “-” (hyphen).
<b>Telnet</b>	An Internet protocol for exchanging terminal data that connects a computer to a network server and allows control of that server and communication with other servers on the network.
<b>Terminal Emulation Software</b>	Software that can be used to send and receive ASCII text messages and files via a computer serial port.
<b>Thermal Demand</b>	Thermal demand is a continuous exponentially increasing or decreasing accumulation of metered quantities; used in demand metering.
<b>Thermal Withstand Capability</b>	The capability of equipment to withstand a predetermined temperature value for a specified time.
<b>Time Delay on Pickup</b>	The time interval between initiation of a signal at one point and detection of the same signal at another point.
<b>Time-of-Use Metering</b>	A metering method that records demand during selected periods of time so consumption during different time periods can be billed at different rates.
<b>Total Harmonic Distortion (THD)</b>	The ratio of the sum of the power of all harmonic frequencies above the fundamental frequency to the power of the fundamental frequency. Usually expressed as a percentage, large numbers indicate increased distortion.

**Transformer Impedance**

The resistive and reactive parameters of a transformer looking in to the transformer primary or secondary windings. Use industry accepted open-circuit and short-circuit tests to determine these transformer equivalent circuit parameters.

**Transformer-Rated Meter**

A watt-hour meter that requires external instrument transformer(s) to isolate or step down the current or voltage. Transformer-rated meters are usually located on high-current or high-voltage services. The meter reading on a transformer-rated meter is usually in secondary units. To convert to primary units, the reading must be multiplied by the dial multiplier, which should be shown on the meter faceplate.

**TXD**

Transmitted data.

**VA, VB, VC**

Measured A-phase-to-neutral, B-phase-to-neutral, and C-phase-to-neutral voltages.

**VAB, VBC, VCA**

Measured or calculated phase-to-phase voltages.

**Vector Power (U)**

Apparent power with the addition of distortion power representing the third dimension (k) in the power triangle. Measured in volt-amperes (VA), U equals  $iP + jQ + kD$ , where kD is distortion power that is the result of harmonics and noise.

**Virtual Terminal Connection**

A mechanism that uses a virtual serial port to provide the equivalent functions of a dedicated serial port and a terminal.

**Volatile Storage**

A storage device that cannot retain data following removal of meter power.

**VT**

Voltage transformer. Also referred to as a potential transformer or PT.

**Warm Start**

The reset of a running system without removing and restoring power.

**Wye**

A phase-to-neutral connection of circuit elements, particularly voltage transformers or loads. To form a wye connection using transformers, connect the nonpolarity side of each of three voltage transformer secondaries in common (the neutral), and take phase-to-neutral voltages from each of the remaining three leads. When properly phased, these leads represent the A-phase-, B-phase-, and C-phase-to-neutral voltages. This connection is frequently called “four-wire wye,” alluding to the three-phase leads plus the neutral lead.

**Z-Number**

That portion of the meter MID string that identifies the proper ACSELERATOR QuickSet software meter driver version and HMI driver version when creating or editing meter settings files.

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# SEL-735 Meter Command Summary

Access Level	Command	Description
0	<b>ACC</b>	Move to Access Level 1
0	<b>BNA</b>	Binary names
0	<b>CAS</b>	Compressed ASCII data configuration
0	<b>DNA</b>	Compressed names
0	<b>EXI</b>	Terminate a Telnet session. Only available when connected via Telnet.
0	<b>ID</b>	Compressed ASCII Fast Meter ID
0	<b>QUI</b>	Quit to Access Level 0
0	<b>SNS</b>	Compressed SER settings
1	<b>2AC</b>	Move to Access Level 2
1	<b>CEV</b>	Compressed event report, 16 samples per cycle
1	<b>COM</b>	Display MIRRORRED BITS channel statistics
1	<b>COM C</b>	Reset MIRRORRED BITS channel statistics
1	<b>COU</b>	Display SELOGIC counters
1	<b>CHI</b>	Compressed history
1	<b>CCR</b>	Compressed calibration error report
1	<b>CST</b>	Compressed status
1	<b>CTR C [A]</b>	Comtrade format event report, config
1	<b>CTR D [A]</b>	Comtrade format event report, data
1	<b>DAT</b>	Show date
1	<b>DNP[n]</b>	Show DNP map
1	<b>EAC</b>	Move to Energy Access Level
1	<b>EVE</b>	Latest event report, 16 samples per cycle
1	<b>EVE C</b>	Compressed event report
1	<b>EVE D</b>	1/16-cycle resolution Device Word bit data
1	<b>EVE L, EVE R</b>	Raw, unfiltered event report
1	<b>EVE M</b>	1/16-cycle resolution MIRRORRED BITS data
1	<b>FIL DIR</b>	List all device files and directories
1	<b>FIL READ</b>	Transfer settings and other files from meter
1	<b>FIL SHOW</b>	Display file contents
1	<b>GOO</b>	Display GOOSE transmit and receive information
1	<b>HIS</b>	Summary event reports
1	<b>IRI</b>	Force synchronization to IRIG
1	<b>LDP[n]</b>	Display report for load profile recorder, where <i>n</i> is the LDP recorder number
1	<b>MAT</b>	Displays results of SELOGIC math variable equations
1	<b>MET</b>	Display instantaneous metering data
1	<b>MET A</b>	Display aggregated values
1	<b>MET AI</b>	Display analog input voltage

Access Level	Command	Description
1	<b>MET CF</b>	Display crest factor quantities
1	<b>MET CFG</b>	Display configurable registers values
1	<b>MET D</b>	Display compensated demand data
1	<b>MET D P</b>	Display compensated peak demand data
1	<b>MET D P U</b>	Display uncompensated peak demand data
1	<b>MET D T</b>	Display the timestamps of the peak demands
1	<b>MET D T U</b>	Display the timestamps of the uncompensated peak demands
1	<b>MET D U</b>	Display uncompensated demand data
1	<b>MET E</b>	Display energy data
1	<b>MET FL</b>	Display flicker data
1	<b>MET H</b>	Display harmonic data
1	<b>MET L</b>	Display losses
1	<b>MET M</b>	Display maximum and minimum values
1	<b>MET RMS</b>	Display rms metering data
1	<b>QUI</b>	Quit to Access Level 0
1	<b>SER</b>	Display Sequential Events Recorder records
1	<b>SHO</b>	Display settings
1	<b>SSI</b>	Display voltage sag/swell/interruption (VSSI) report
1	<b>STA</b>	Display self-test status
1	<b>STA E</b>	Display EEPROM messages
1	<b>TAR</b>	Display Device Word bits
1	<b>TIM</b>	Show time
1	<b>TOG</b>	Resets NEWEVNT Device Word bit
1	<b>TRI</b>	Trigger an event
1	<b>VER</b>	Display version and configuration information
E	<b>DAT <i>date</i></b>	Set date
E	<b>LDP[n] C</b>	Reset load profile recorder, where <i>n</i> is the LDP recorder number
E	<b>MET CF R</b>	Clear crest factor metering
E	<b>MET M R</b>	Clear max/min metering
E	<b>MET P R</b>	Clear peak demand metering
E	<b>QUI</b>	Quit to Access Level 0
E	<b>TIM <i>time</i></b>	Set time
2	<b>CAL</b>	Go to Access Level C
2	<b>CON <i>x</i></b>	Control remote bits <i>x</i>
2	<b>DNP[n]</b>	Show DNP map
2	<b>FIL WRITE</b>	Write setting files to the meter
2	<b>FOR</b>	Change meter form
2	<b>HIS C</b>	Clear event and history records
2	<b>L_D</b>	Load new firmware
2	<b>LOO</b>	Initiate/clear MIRRORED BITS loopback
2	<b>MET D R</b>	Clear demand metering

Access Level	Command	Description
2	<b>MET E R</b>	Reset energy metering
2	<b>MET FL R</b>	Reset flicker metering quantities
2	<b>MET P R</b>	Clear peak demand metering
2	<b>MEM</b>	Display memory
2	<b>PAR</b>	Display or modify the part number
2	<b>PAS</b>	Set/show passwords
2	<b>PUL</b>	Pulse output contact
2	<b>QUI</b>	Quit to Access Level 0
2	<b>R_S</b>	Restore factory settings
2	<b>SER [R]</b>	Display or clear SER
2	<b>SET</b>	Change settings
2	<b>SSI C</b>	Clear SSI data (including SSI summary) from the meter
2	<b>SSI R</b>	Reset SSI processing
2	<b>SSI S</b>	Display SSI summary report
2	<b>SSI T</b>	Trigger an event and store SSI data.
2	<b>TES AGG</b>	Capture and display 10/12-cycle data
2	<b>TEST DB A</b> <i>name value</i>	Override analog label <i>name</i> with <i>value</i> in communications interface
2	<b>TEST DB D</b> <i>name value</i>	Override Device Word bit <i>name</i> with <i>value</i> in communications interface, where <i>value</i> = 0 or 1
2	<b>TEST MODE</b>	Display Test Mode parameters
2	<b>VER</b>	Display version and configuration information
C	<b>AUT</b>	Autocalibrate the analog acquisition system
C	<b>PAR H</b>	Access part number help
C	<b>R_S F</b>	Force settings restore (including calibration settings), part number, and MAC address
C	<b>TEST AE</b>	Display analog quantities with names and attributes
C	<b>TEST DP</b>	Test display points by listing the quantities that show as errors on the front panel
C	<b>TEST JMP</b>	Test jumpers
C	<b>TEST PS</b>	Show the last, maximum, and minimum values of the power supply
C	<b>TEST SNTP</b>	Test SNTP accuracy
C	<b>SET C</b>	Set calibration settings
C	<b>STA Z</b>	Clear EEPROM messages
C	<b>STA SC/SR</b>	Clear detailed SELOGIC control equation information
C	<b>STA C/R</b>	Clear meter status and reboot
SB	<b>BAU rate</b>	Set baud rate to 300, 1200, 2400, 4800, 9600, 19200, 38400 (57600 or 115200 if Port 2 or Port 3) bps.
SB	<b>BFI</b>	Display the SELBOOT version.
SB	<b>ERA</b>	Erase the existing firmware.
SB	<b>EXI</b>	Exit this program and restart the device.
SB	<b>FID</b>	Display the firmware identification (FID).
SB	<b>HEL</b>	Print a help list of commands.
SB	<b>REC</b>	Receive new firmware for the device using Xmodem.

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# SEL-735 Meter Command Summary

Access Level	Command	Description
0	<b>ACC</b>	Move to Access Level 1
0	<b>BNA</b>	Binary names
0	<b>CAS</b>	Compressed ASCII data configuration
0	<b>DNA</b>	Compressed names
0	<b>EXI</b>	Terminate a Telnet session. Only available when connected via Telnet.
0	<b>ID</b>	Compressed ASCII Fast Meter ID
0	<b>QUI</b>	Quit to Access Level 0
0	<b>SNS</b>	Compressed SER settings
1	<b>2AC</b>	Move to Access Level 2
1	<b>CEV</b>	Compressed event report, 16 samples per cycle
1	<b>COM</b>	Display MIRRORED BITS channel statistics
1	<b>COM C</b>	Reset MIRRORED BITS channel statistics
1	<b>COU</b>	Display SELOGIC counters
1	<b>CHI</b>	Compressed history
1	<b>CCR</b>	Compressed calibration error report
1	<b>CST</b>	Compressed status
1	<b>CTR C [A]</b>	Comtrade format event report, config
1	<b>CTR D [A]</b>	Comtrade format event report, data
1	<b>DAT</b>	Show date
1	<b>DNP[n]</b>	Show DNP map
1	<b>EAC</b>	Move to Energy Access Level
1	<b>EVE</b>	Latest event report, 16 samples per cycle
1	<b>EVE C</b>	Compressed event report
1	<b>EVE D</b>	1/16-cycle resolution Device Word bit data
1	<b>EVE L, EVE R</b>	Raw, unfiltered event report
1	<b>EVE M</b>	1/16-cycle resolution MIRRORED BITS data
1	<b>FIL DIR</b>	List all device files and directories
1	<b>FIL READ</b>	Transfer settings and other files from meter
1	<b>FIL SHOW</b>	Display file contents
1	<b>GOO</b>	Display GOOSE transmit and receive information
1	<b>HIS</b>	Summary event reports
1	<b>IRI</b>	Force synchronization to IRIG
1	<b>LDP[n]</b>	Display report for load profile recorder, where <i>n</i> is the LDP recorder number
1	<b>MAT</b>	Displays results of SELOGIC math variable equations
1	<b>MET</b>	Display instantaneous metering data
1	<b>MET A</b>	Display aggregated values
1	<b>MET AI</b>	Display analog input voltage

Access Level	Command	Description
1	<b>MET CF</b>	Display crest factor quantities
1	<b>MET CFG</b>	Display configurable registers values
1	<b>MET D</b>	Display compensated demand data
1	<b>MET D P</b>	Display compensated peak demand data
1	<b>MET D P U</b>	Display uncompensated peak demand data
1	<b>MET D T</b>	Display the timestamps of the peak demands
1	<b>MET D T U</b>	Display the timestamps of the uncompensated peak demands
1	<b>MET D U</b>	Display uncompensated demand data
1	<b>MET E</b>	Display energy data
1	<b>MET FL</b>	Display flicker data
1	<b>MET H</b>	Display harmonic data
1	<b>MET L</b>	Display losses
1	<b>MET M</b>	Display maximum and minimum values
1	<b>MET RMS</b>	Display rms metering data
1	<b>QUI</b>	Quit to Access Level 0
1	<b>SER</b>	Display Sequential Events Recorder records
1	<b>SHO</b>	Display settings
1	<b>SSI</b>	Display voltage sag/swell/interruption (VSSI) report
1	<b>STA</b>	Display self-test status
1	<b>STA E</b>	Display EEPROM messages
1	<b>TAR</b>	Display Device Word bits
1	<b>TIM</b>	Show time
1	<b>TOG</b>	Resets NEWEVNT Device Word bit
1	<b>TRI</b>	Trigger an event
1	<b>VER</b>	Display version and configuration information
E	<b>DAT <i>date</i></b>	Set date
E	<b>LDP[n] C</b>	Reset load profile recorder, where <i>n</i> is the LDP recorder number
E	<b>MET CF R</b>	Clear crest factor metering
E	<b>MET M R</b>	Clear max/min metering
E	<b>MET P R</b>	Clear peak demand metering
E	<b>QUI</b>	Quit to Access Level 0
E	<b>TIM <i>time</i></b>	Set time
2	<b>CAL</b>	Go to Access Level C
2	<b>CON <i>x</i></b>	Control remote bits <i>x</i>
2	<b>DNP[n]</b>	Show DNP map
2	<b>FIL WRITE</b>	Write setting files to the meter
2	<b>FOR</b>	Change meter form
2	<b>HIS C</b>	Clear event and history records
2	<b>L_D</b>	Load new firmware
2	<b>LOO</b>	Initiate/clear MIRRORED BITS loopback
2	<b>MET D R</b>	Clear demand metering

Access Level	Command	Description
2	<b>MET E R</b>	Reset energy metering
2	<b>MET FL R</b>	Reset flicker metering quantities
2	<b>MET P R</b>	Clear peak demand metering
2	<b>MEM</b>	Display memory
2	<b>PAR</b>	Display or modify the part number
2	<b>PAS</b>	Set/show passwords
2	<b>PUL</b>	Pulse output contact
2	<b>QUI</b>	Quit to Access Level 0
2	<b>R_S</b>	Restore factory settings
2	<b>SER [R]</b>	Display or clear SER
2	<b>SET</b>	Change settings
2	<b>SSI C</b>	Clear SSI data (including SSI summary) from the meter
2	<b>SSI R</b>	Reset SSI processing
2	<b>SSI S</b>	Display SSI summary report
2	<b>SSI T</b>	Trigger an event and store SSI data.
2	<b>TES AGG</b>	Capture and display 10/12-cycle data
2	<b>TEST DB A</b> <i>name value</i>	Override analog label <i>name</i> with <i>value</i> in communications interface
2	<b>TEST DB D</b> <i>name value</i>	Override Device Word bit <i>name</i> with <i>value</i> in communications interface, where <i>value</i> = 0 or 1
2	<b>TEST MODE</b>	Display Test Mode parameters
2	<b>VER</b>	Display version and configuration information
C	<b>AUT</b>	Autocalibrate the analog acquisition system
C	<b>PAR H</b>	Access part number help
C	<b>R_S F</b>	Force settings restore (including calibration settings), part number, and MAC address
C	<b>TEST AE</b>	Display analog quantities with names and attributes
C	<b>TEST DP</b>	Test display points by listing the quantities that show as errors on the front panel
C	<b>TEST JMP</b>	Test jumpers
C	<b>TEST PS</b>	Show the last, maximum, and minimum values of the power supply
C	<b>TEST SNTP</b>	Test SNTP accuracy
C	<b>SET C</b>	Set calibration settings
C	<b>STA Z</b>	Clear EEPROM messages
C	<b>STA SC/SR</b>	Clear detailed SELOGIC control equation information
C	<b>STA C/R</b>	Clear meter status and reboot
SB	<b>BAU rate</b>	Set baud rate to 300, 1200, 2400, 4800, 9600, 19200, 38400 (57600 or 115200 if Port 2 or Port 3) bps.
SB	<b>BFI</b>	Display the SELBOOT version.
SB	<b>ERA</b>	Erase the existing firmware.
SB	<b>EXI</b>	Exit this program and restart the device.
SB	<b>FID</b>	Display the firmware identification (FID).
SB	<b>HEL</b>	Print a help list of commands.
SB	<b>REC</b>	Receive new firmware for the device using Xmodem.

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