SEL-735

Power Quality and Revenue Meter

Instruction Manual

20250228

SCHWEITZER ENGINEERING LABORATORIES

PM735-01

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Preface

Manual Overview

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 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**. 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 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: Touchscreen and Custom Screen Settings.** This section describes the touchscreen options and available custom screens.

- **Section 10: 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 and FTP Communications Protocols.** This appendix describes Modbus RTU communications features supported by the SEL-735 Meter communications port.
- **Appendix F: MIRRORED BITS Communications.** This appendix contains a summary of MIRRORED BITS settings and describes how MIRRORED 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.
- **Appendix H: IEC 61850 Communications.**
- **Appendix I: Synchrophasors.**
- **Appendix J: Continuous Waveform Streaming.**
- **Appendix K: Cybersecurity Features.** This appendix describes the cybersecurity features of the SEL-735.
- **SEL-735 Meter Command Summary.**

Safety Information

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

Dangers, Warnings, and Cautions

This manual uses three kinds of hazard statements, defined as follows:

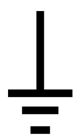
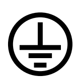
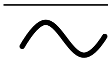
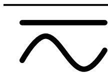
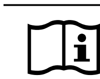
DANGER
Indicates a potentially hazardous situation that, if not avoided, **will** result in death or serious injury.

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

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

Safety Symbols

The following symbols are often marked on SEL products.

	**CAUTION** Refer to accompanying documents.	**ATTENTION** Se reporter à la documentation.
	Earth (ground)	Terre
	Protective earth (ground)	Terre de protection
	Direct current	Courant continu
	Alternating current	Courant alternatif
	Both direct and alternating current	Courant continu et alternatif
	Instruction manual	Manuel d’instructions

Safety Marks

The following statements apply to this device. Install according to the National Electrical Code (NEC) or local code requirements.

Table 1 General Safety Marks

For use in Pollution Degree 2 environment.	Pour l'utilisation dans un environnement de Degré de Pollution 2.
Ambient air temperature is –40°C to 40°C (–40°F to 104°F), per UL 61010-1	La température de l'air ambiant est entre –40 °C et 40 °C (–40 °F et 104 °F) selon UL 61010-1

Terminal Ratings Wire Material Copper Wire Size CT connections: 12–26 AWG Tightening Torque CT terminal blocks: 1.0–1.4 Nm (9.0–12.0 in-lb) Other terminal blocks: 0.79 Nm (7.0 in-lb)	Spécifications des bornes Type de filage Cuivre Calibre de fil Connexions du TC : 12–26 AWG Couple de Serrage CT borniers : 1,0–1,4 Nm (9,0–12,0 livres-pouce) Autres borniers : 0,79 Nm (7,0 livres-pouce)
⚠CAUTION There is danger of explosion if the battery is incorrectly replaced. Replace only with Rayovac no. BR2335 or equivalent recommended by manufacturer. See Owner's Manual for safety instructions. The battery used in this device may present a fire or chemical burn hazard if mistreated. Do not recharge, disassemble, heat above 100°C or incinerate. Dispose of used batteries according to the manufacturer's instructions. Keep battery out of reach of children.	⚠ATTENTION Une pile remplacée incorrectement pose des risques d'explosion. Remplacez seulement avec un Rayovac no BR2335 ou un produit équivalent recommandé par le fabricant. Voir le guide d'utilisateur pour les instructions de sécurité. La pile utilisée dans cet appareil peut présenter un risque d'incendie ou de brûlure chimique si vous en faites mauvais usage. Ne pas recharger, démonter, chauffer à plus de 100°C ou incinérer. Éliminez les vieilles piles suivant les instructions du fabricant. Gardez la pile hors de la portée des enfants.

Table 2 Hazardous Locations Safety Marks

⚠WARNING – EXPLOSION HAZARD Open circuit before removing cover.	⚠AVERTISSEMENT – DANGER D'EXPLOSION Ouvrir le circuit avant de déposer le couvercle.
⚠WARNING – EXPLOSION HAZARD Substitution of components may impair suitability for Class I, Division 2.	⚠AVERTISSEMENT – DANGER D'EXPLOSION La substitution de composants peut détériorer la conformité à Classe I, Division 2.
⚠WARNING – EXPLOSION HAZARD Do not disconnect equipment unless power has been removed or the area is known to be non-hazardous.	⚠AVERTISSEMENT – DANGER D'EXPLOSION Ne pas déconnecter l'équipement à moins qu'il ne soit hors tension ou que la zone ne soit pas dangereuse.
⚠WARNING – EXPLOSION HAZARD Exposure to some chemicals may degrade the sealing properties of materials used in the relays within this device.	⚠AVERTISSEMENT – DANGER D'EXPLOSION L'exposition à certains produits chimiques peut dégrader les propriétés d'étanchéité des matériaux utilisés dans les relais de cet appareil.
Hazardous Locations operating temperature range: –20°C to +40°C (–4°F to +104°F), as evaluated by UL.	Plage de température de fonctionnement dans les zones dangereuses : –20°C à +40°C (–4°F à +104°F), évaluée par UL.

Hazardous Locations Approval

The SEL-735 is UL certified for hazardous locations to Canadian and U.S. standards. In North America, the meter is approved for Hazardous Locations Class I, Division 2, Groups A, B, C, D, and temperature class T3C in the maximum surrounding air temperature of +40°C (+104°F).

Table 3 Other Safety Marks

⚠ **DANGER** Contact with instrument terminals can cause electrical shock that can result in injury or death.	⚠ **DANGER** Tout contact avec les bornes de l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.
⚠ **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.	⚠ **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.
⚠ **WARNING** SEL-735 models with 24/48 Vdc power supply are limited to overvoltage Category II when digital inputs, contact outputs, or other I/O include hazardous voltage.	⚠ **AVERTISSEMENT** Les modèles SEL-735 avec alimentation 24/48 Vcc sont limités à la catégorie de surtension II lorsque les entrées numériques, les sorties de contact ou d'autres E / S incluent une tension dangereuse.
⚠ **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.	⚠ **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.
⚠ **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.	⚠ **AVERTISSEMENT** Cet appareil est expédié avec des mots de passe par défaut. A 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 á l'équipement peut être possible. SEL décline toute responsabilité pour tout dommage résultant de cet accès non-autorisé.
⚠ **WARNING** Use of this equipment in a manner other than specified in this manual can impair operator safety safeguards provided by this equipment.	⚠ **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.
⚠ **WARNING** Operation of this equipment in a residential environment could cause radio interference.	⚠ **AVERTISSEMENT** L'utilisation de cet équipement dans un environnement résidentiel peut causer des interférences radio.
⚠ **CAUTION** Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.	⚠ **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'usager à actionner l'équipement.
⚠ **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 services.	⚠ **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.
⚠ **CAUTION** Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.	⚠ **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.

⚠ CAUTION
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.

These devices are open-type devices that are to be installed in an enclosure that is only accessible with the use of a tool and suitable for the environment.

Port F, located on the front of the unit, is for maintenance use only in hazardous locations. Power must be disconnected prior to connection/disconnecting, or the area must be known to be free of ignitable concentrations of flammable gases or vapors.

Telecom Warnings

Analog Telecom Safety Warnings	Avertissements de sécurité pour les télécommunications analogiques
Never install telephone wiring during a lightning storm.	Ne jamais installer le câblage téléphonique pendant un orage.
Never install a telephone jack in wet locations unless the jack is specifically designed for wet locations.	Ne jamais installer une prise téléphonique dans un lieu humide, sauf si la prise est spécialement conçu pour un endroit humide.
Never touch uninsulated telephone wires or terminals unless the telephone line has been disconnected at the network interface.	Ne jamais toucher les fils ou les borniers non isolés à moins que la ligne téléphonique ne soit déconnectée de l'interface réseau.
Use caution when installing or modifying telephone lines.	Faire attention lors de l'installation ou la modification des lignes téléphoniques.
To reduce the risk of fire, use only 26 AWG or larger telecommunication line cord.	Pour réduire le risque d'incendie, utiliser uniquement un câble de ligne de télécommunication de 26 AWG ou plus grand.
This product must be disconnected from its power source and telephone network interface when servicing.	Lors de l'entretien, ce produit doit être hors tension et déconnecté de l'interface du réseau téléphonique.
This product meets the applicable Innovation, Science and Economic Development Canada technical specifications.	Ce produit est conforme aux spécifications techniques applicables de la ministère de l'Innovation, des Sciences et du Développement économique du Canada.

Analog Telecom Safety Warnings	Avertissements de sécurité pour les télécommunications analogiques
The Ringer Equivalence Number (REN) indicates the maximum number of devices allowed to be connected to a telephone interface. The termination of an interface may consist of any combination of devices subject only to the requirement that the sum of the RENs of all the devices not exceed five.	Le numéro d'équivalence de sonnerie (REN) indique le nombre maximal d'appareils pouvant être connectés à une interface téléphonique. Les connexions terminales d'une interface peut consister en n'importe quelle combinaison de dispositifs pourvu que la somme des REN de tous les dispositifs ne dépasse pas cinq.
Ringer Equivalence (REN): 0.1	Équivalence de la sonnerie (REN): 0,1

New Zealand Telecom Warning Notice

1. The grant of a Telepermit for any item of terminal equipment indicates only that Telecom has accepted that the item complies with minimum conditions for connection to its network. It indicates no endorsement of the product by Telecom, nor does it provide any sort of warranty. Above all, it provides no assurance that any item will work correctly in all respects with another item of Telepermitted equipment of a different make or model, nor does it imply that any product is compatible with all of Telecom's network services.

   This equipment is not capable under all operating conditions of correct operating conditions of correct operation at the higher speed which it is designated. 33.6 kbps and 56 kbps connections are likely to be restricted to lower bit rates when connected to some PSTN implementations. Telecom will accept no responsibility should difficulties arise in such circumstances.

2. Immediately disconnect this equipment should it become physically damaged, and arrange for its disposal or repair.
3. This modem shall not be used in any manner which could constitute a nuisance to other Telecom customers.
4. This device is equipped with pulse dialing, while the Telecom standard is DTMF tone dialing. There is no guarantee that Telecom lines will always continue to support pulse dialing.

   Use of pulse dialing, when this equipment is connected to the same line as other equipment, may give rise to "bell tinkle" or noise and may also cause a false answer condition. Should such problems occur, the user should NOT contact the Telecom Faults Service.

   The preferred method of dialing is to use DTMF tones, as this is faster than pulse (decadic) dialing and is readily available on almost all New Zealand telephone exchanges.

5. Warning Notice: No "111" or other calls can be made from this device during a mains power failure.
6. This equipment may not provide for the effective hand-over of a call to another device connected to the same line.

7. Some parameters required for compliance with Telecom's Telepermit requirements are dependent on the equipment (PC) associated with this device. The associated equipment shall be set to operate within the following limits for compliance with Telecom's Specifications:
   - For repeat calls to the same number:
     - There shall be no more than 10 call attempts to the same number within any 30 minute period for any single manual call initiation, and
     - The equipment shall go on-hook for a period of not less than 30 seconds between the end of one attempt and the beginning of the next attempt.
   - For automatic calls to different numbers:
     - The equipment shall be set to ensure that automatic calls to different numbers are spaced such that there is no less than 5 seconds between the end of one call attempt and the beginning of another.
8. For correct operation, total of the RNs of all devices connected to a single line at any time should not exceed 5.

General Information

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

Trademarks

All brand or product names appearing in this document are the trademark or registered trademark of their respective holders. No SEL trademarks may be used without written permission.

SEL trademarks appearing in this manual are shown in the following table.

ACSELERATOR Analytic Assistant®	Compass®
ACSELERATOR TEAM®	SEL-2407®
ACSELERATOR QuickSet®	MIRRORED BITS®
ACSELERATOR Architect®	SELOGIC®
Connectorized®	

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.

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 Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com/support
Email: info@selinc.com

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SECTION 1

Introduction and Specifications

Overview

NOTE
For quick setup of your meter and software, start with the SEL-735 Power Quality and Revenue Meter Quick-Start Guide.

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

- *Meter Forms and Current Cards on page 2*
- *Applications on page 5*
- *Hardware Connection Features on page 6*
- *Communications Connections on page 7*
- *Specifications on page 8*

Front-Panel Layout

The front-panel interface consists of programmable pushbuttons and LEDs, an LCD or an 800 x 480 pixel color touchscreen, a keypad, a test mode LED, and a front communications port.

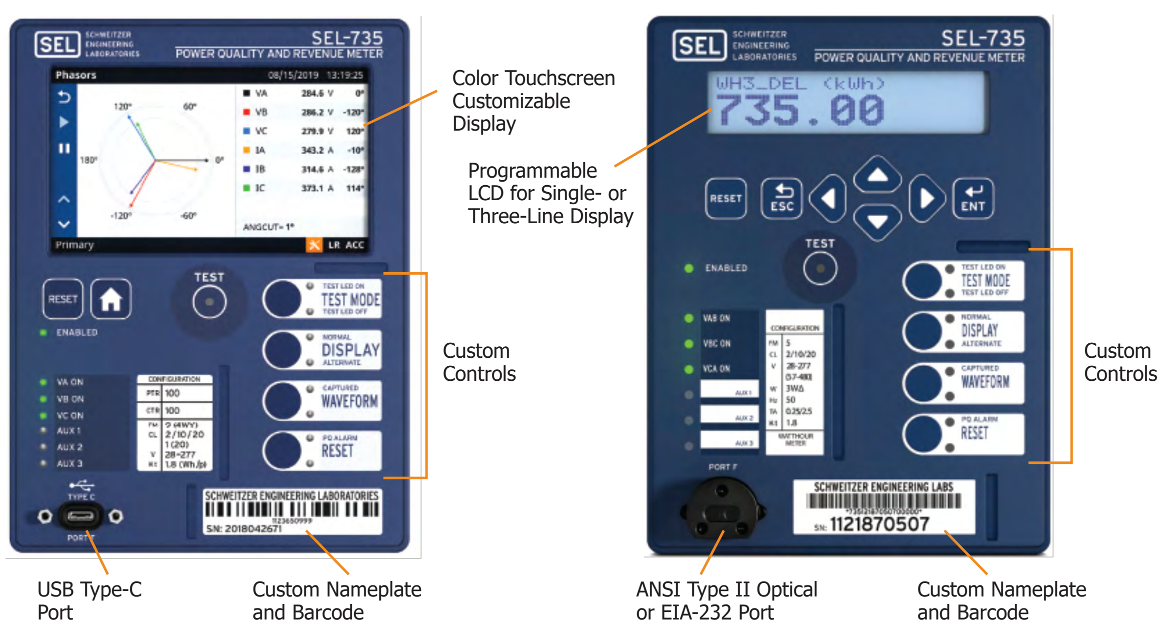

Figure 1.1 Front-Panel Layout

Rear-Panel Layout

Removable connectors allow easy wiring for PT circuits, I/O, communications, and the auxiliary power supply. The CT circuits require ring terminals for safety. SEL offers a self-shorting connector as an accessory for easy removal, part number 915900264.

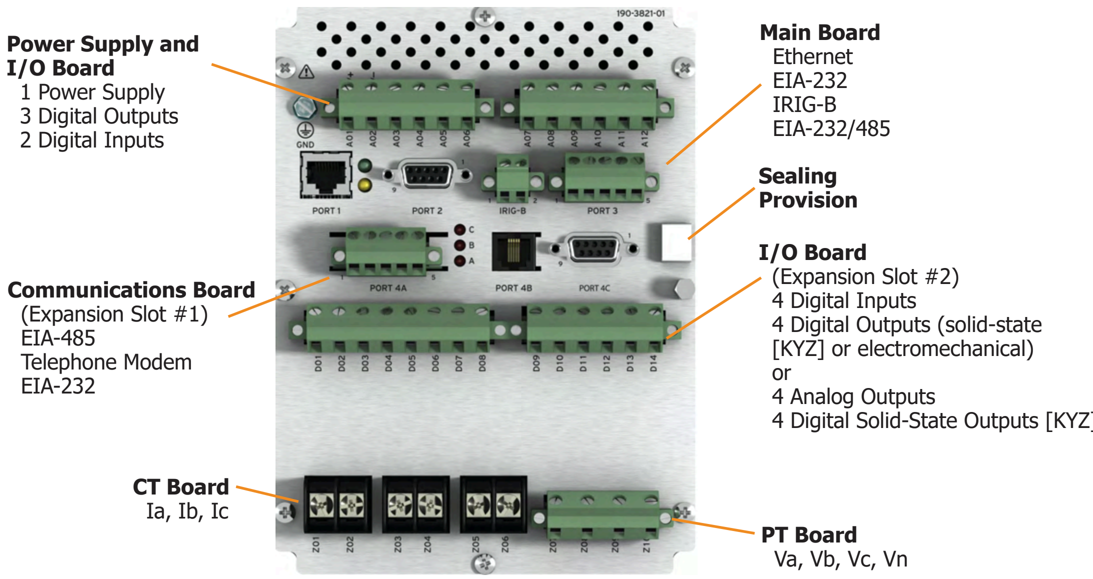

Figure 1.2 Rear-Panel Layout

Front-Panel Options

The SEL-735 offers two front-panel HMI layouts that are model- and option-dependent. *Table 1.1* lists the options for the front-panel type.

Table 1.1 Front-Panel Options

Model/Display Description	Front Port Type
LCD with three-line display (3 x 20 characters)	EIA-232 port ANSI Type II optical
Color touchscreen display (800 x 480 pixels)	USB Type-C

Meter Forms and Current Cards

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

Table 1.2 SEL-735 Form Numbers

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

You can order the SEL-735 as a Form 5, Form 36, or Form 9 meter, but you can change the form by using the **FOR** command from a terminal session at Access Level 2. To change the meter's form number from the terminal, issue the **FOR** *x* (*x* = 5 [Form 5], 9 [Form 9], or 36 [Form 36]) command from Access Level 2.

For more information on changing form, see *Section 5: Metering*.

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, and covers all Classes 2 through 20.

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 1.3* and *Table 1.4* list the options.

For more information about IEC 61000-4-30 testing and measurement, see *IEC 61000-4-30 Testing and Measurement Techniques—Power Quality Measurement Methods on page 152*.

Table 1.3 SEL-735 Power Quality and Recording Options

PQ and Recording	SEL-735 Basic	SEL-735 Intermediate	SEL-735 Advanced
Memory	128 MB	256 MB	1 GB
Max Harmonic Order	15th	63rd	63rd
Interharmonic Quantities	No	No	Yes
Harmonic Angles	No	No	Yes
Power Harmonics	No	No	Yes
Waveform Capture Event Reports			
Samples Per Cycle	16	16, 128	16, 128, 512
Duration (cycles)	15	15–600	15–600
Number of Events	256	33–6,200	101–10,000
COMTRADE Reports	Y	Y	Y
Load Profile Recorder			
Recorders x channels	1 x 16	12 x 16	32 x 16
Acquisition rates	1–120 minutes	3–59 s, 1–120 minutes	3–59 s, 1–120 minutes

PQ and Recording	SEL-735 Basic	SEL-735 Intermediate	SEL-735 Advanced
Storage duration for 10 minute interval data			
16 channels	10 years	20 years	20 years
192 channels	N/A	1.5 years	9.5 years
512 channels	N/A	N/A	3.5 years
Voltage Sag, Swell, Interruption (VSSI) Recorder			
Typical number of summary events	260	260	600
Number of detailed rows	60,000	60,000	130,000
Minimum disturbance duration	1/4 cycle	1/4 cycle	1/4 cycle
Sampling rate	4 samples/cycle–1 sample/day, adaptive	4 samples/cycle–1 sample/day, adaptive	4 samples/cycle–1 sample/day, adaptive
Sequential Events Recorder			
Number of events	>80,000	>80,000	>80,000
Number of channels monitored	≤72	≤72	≤72
Protocols			
Continuous Waveform Streaming Protocol[a]	N	Y	Y
Other Features			
Wave View Oscillography	N[b]	N[b]	Y

[a] Available with the purchase of a device software bundle or as a standalone meter upgrade.
[b] Color touchscreen app available on all models from the front panel. QuickSet HMI screen only available on advanced power quality models.

Table 1.4 SEL-735 Compliance With IEC 61000-4-30 Power Quality Standard[a]

IEC 61000-4-30 Requirement	SEL-735 Basic PQ	SEL-735 Intermediate PQ	SEL-735 Advanced PQ
General			
150/180-cycle, 10-min. aggregation	—	A	A
2-hour aggregation	—	A	A
Real-time clock uncertainty	A	A	A
Power Quality Parameters			
Power frequency	A	A	A
Magnitude of the supply voltage	A	A	A
Flicker	—	A (10 min, 2 hr updates)	A (1 min, 10 min, 2 hr updates)
Supply voltage interruptions, dips, and swells	A	A	A
Supply voltage unbalance	A	A	A
Voltage harmonics	A	A	A
Voltage interharmonics	—	—	A
Magnitude of current	A	A	A
Harmonic currents	A	A	A

IEC 61000-4-30 Requirement	SEL-735 Basic PQ	SEL-735 Intermediate PQ	SEL-735 Advanced PQ
Interharmonic currents	—	—	A
Current unbalance	A	A	A

[a] "A" in the table refers to IEC 61000-4-30:2015 Class A Compliance.

Applications

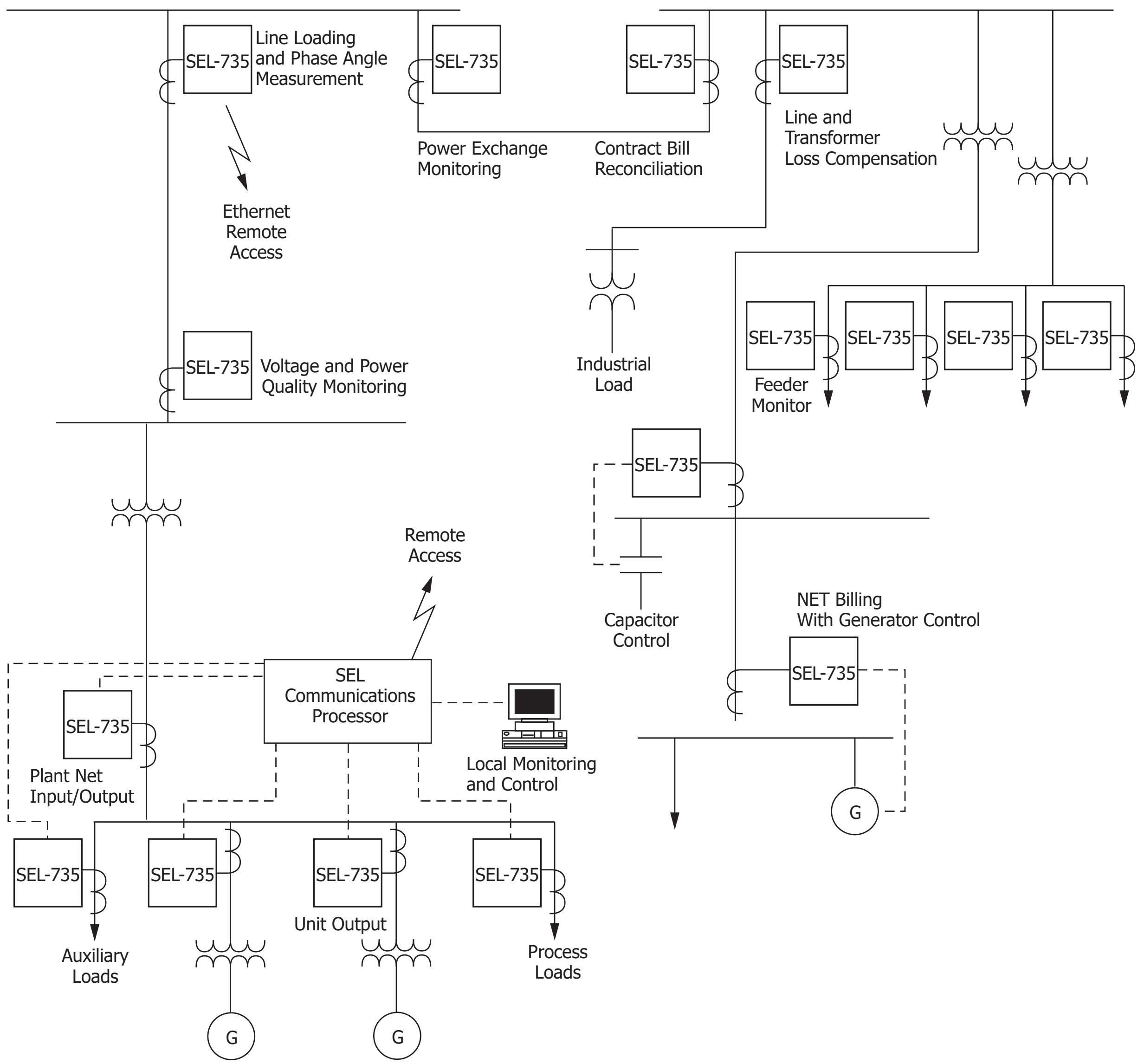

Figure 1.3 SEL-735 Applied at Billing Points Throughout the Power System

Hardware Connection Features

See *Specifications on page 8* and *Section 2: Installation* for more information on hardware and connections.

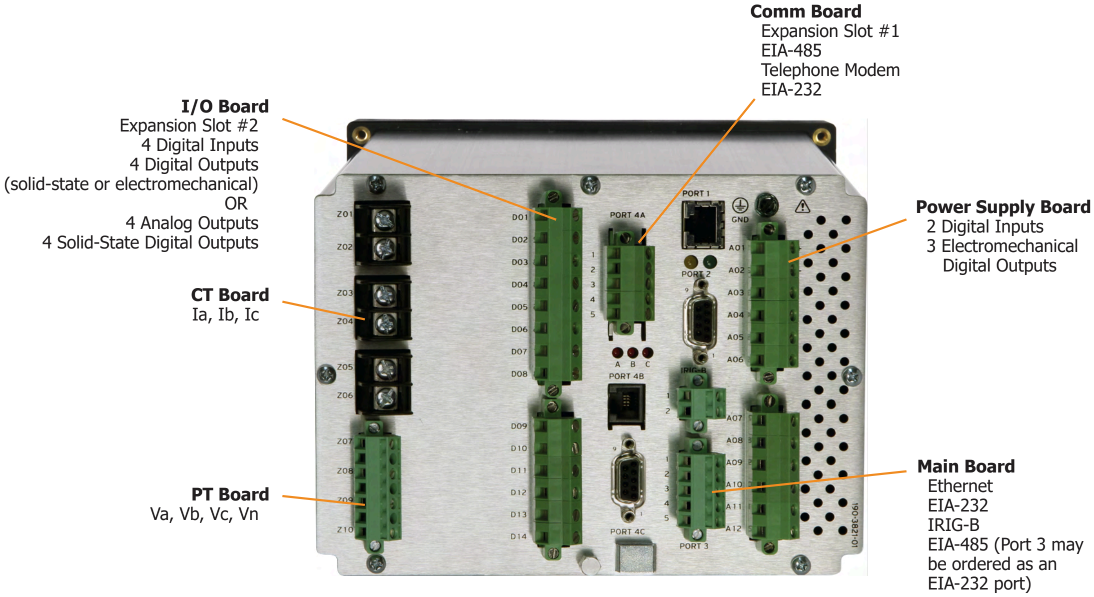

Figure 1.4 SEL-735 Inputs, Outputs, and Communications Ports

Communications Connections

See *Port Connector and Communications Cables on page 280* for more communications connection information.

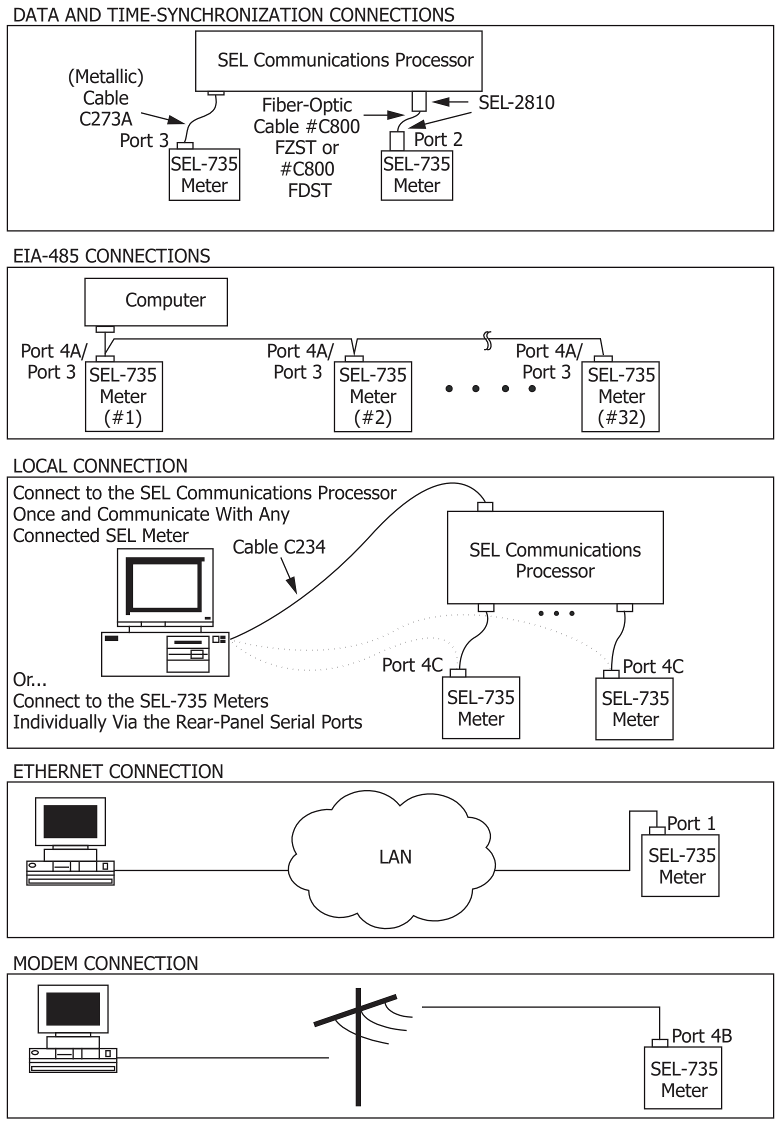

Figure 1.5 SEL-735 Communications Connection Examples

SEL recommends using fiber-optic Ethernet for cables routed in parallel with power system wiring or that penetrate an enclosure. For copper cabling, use shielded twisted-pair (STP) cable with shielded connectors or provide external shielding for unshielded twisted pair (UTP) cable using methods such as grounded ferrous raceways or similar. Copper Ethernet cables should be separated or routed at right angles from power system conductors and should not be installed within or adjacent to trenches, raceways, or wireways that contain such conductors. Within panels, route copper Ethernet cables perpendicular to power system conductors rather than in parallel.

SEL provides model CA605 STP Category 5e Ethernet cables in customized lengths for both indoor and outdoor applications. In addition, SEL can provide Model 915900518 6 kV Ethernet Surge Suppressors for additional electrical isolation and surge protection.

Specifications

⚠CAUTION
Observe ratings prior to commissioning.

Compliance

American National Standards Institute (ANSI)	ANSI C12.1-2014 for Electric Meters, Code for Electricity Metering and ANSI C12.20-2015 for Electricity Meters—0.1, 0.2, and 0.5 Accuracy Classes verified compliant by an accredited third-party test laboratory
Australian National Measurement Institute	NMI M6-1 Electricity Meters: Part 1: Metrological and Technical Requirements verified by an accredited third-party test laboratory
Australia and New Zealand	RCM Mark
California ISO (CAISO)	CAISO Compliant (applies to Blondel-compliant Form 5 and Form 9 only)
Canada	ICES-001(A) / NMB-001(A)
Comisión Federal de Electricidad (CFE)	G0000-48-2010 verified compliant by Laboratorio de Pruebas de Equipos y Materiales (LAPEM)
Electric Reliability Council of Texas (ERCOT)	ERCOT Compliant (applies to Blondel-compliant Form 5 and Form 9 only)
European Union (EU)	CE: Mark—EMC Directive (2014/30/EU), Low Voltage Directive (2014/35/EU)
Federal Institute of Metrology (METAS)	Certified to IEC 61000-4-30 Ed. 3.0 (2015) Class A, Testing according to IEC 62586-1 Ed. 2.0 (2017) and IEC 62586-2 Ed. 2.0 (2017) Certified to IEC 62052-11:2020, IEC 62053-22:2020, IEC 62053-24:2020, AS 62052.11:2018, AS 62053.22:2018, and AS 62052.31:2017
International Electrotechnical Commission	IEC 62052-11:2020, Electricity metering equipment (AC) - General requirements, tests and test conditions
ISO 9001	Designed and manufactured under an ISO 9001 certified quality management system
New York	New York State Department of Public Service Commission (applies to Blondel-compliant Form 5 and Form 9 only)
Underwriter's Laboratories, Inc. (Normal Locations)	UL Listed to U.S. and Canadian safety standards (File E220228, FTRZ, FTRZ7, NRAQ, NRAQ7, PICQ, PICQ7)
Underwriter's Laboratories, Inc. (Hazardous Locations)	ANSI/ISA 12.12.01-2015 and CSA C22.2 No. 213-15 Class I Division 2 Hazardous Locations (File E475839, NRAG, NRAG7).
United Kingdom	UKCA Mark

General

AC Voltage Inputs

Measurement Category:	III
Maximum Rating:	300 $V_{L–N}$, 520 $V_{L–L}$ continuous 600 $V_{L–N}$, 1039 $V_{L–L}$ for 10 seconds

PT input has only been evaluated for a maximum of 300 L-N Vac input rating by UL.

Range	
Revenue:	28–300 $V_{L–N}$, 48–520 $V_{L–L}$
Measurement:	11–300 $V_{L–N}$, 19–520 $V_{L–L}$
Burden:	10 MΩ

AC Current Inputs

Measurement Category:	III
Maximum Rating:	20 A continuous, per UL 61010 500 A for 1 second (thermal) 100 A for 25 seconds (thermal)
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 (with saturation)
Burden:	≤0.5 VA

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_A or V_C.

Power Supply

UL Ratings	
120/240 Vac:	50/60 Hz, 60 VA
125/250 Vdc:	25 W
24/48 Vdc:	22 W
12/24 Vdc:	22 W
Typical Power Consumption:	
<20 VA/7 W typical <30 VA/9 W typical (color touchscreen model)	
Startup Time to Begin Energy Metering:	<5 seconds
Continuous Operating Limits	
110–240 Vac/Vdc:	85–264 Vac (50/60 Hz) 85–275 Vdc
24/48 Vdc:	19–58 Vdc
12/24 Vdc:	9.6–30 Vdc
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 60664-1:2020):	300 Vac

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
Fiber Size:	62.5/125 µm or 50/125 µm
Approximate Range:	2 km
TX Power (Max):	–14 dBm average
TX Power (Min):	–20 dBm average (62/125)
TX Power (Min):	–23.5 dBm average (50/125)
RX Sensitivity:	–31 dBm average
RX Power Input (Max):	–14 dBm average

Communications Protocols

SEL ASCII/Compressed ASCII, SEL Fast Operate/Fast Meter, MIRRORED BITS, SEL Distributed Port Switch (LMD), Modbus RTU/TCP, DNP3 serial and LAN/WAN, FTP, TCP/IP, Y-Modem, SNTP, IEC 61850, Telnet, MV-90, IEEE C37.118-2014 (Synchrophasor measurements), and Continuous Waveform Streaming (CWS)

Output Contacts

Ratings determined by IEC 60255-23:1994

Standard (Electromechanical)
250 Vac, 30 Vdc, 3 A resistive

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 V	0.50 A	L/R = 40 ms
125 V	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 (Ue):	250 V
Current (Ie):	3 A
Rated Insulation Voltage (Ui) (Excluding EN 61010):	300 V

Optional (Solid State)

Voltage:	250 Vdc/Vac
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

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

±1 mA Output

Range:	±1.2 mA
Minimum Output Impedance:	100 MΩ
Maximum Load:	10 kΩ, 100 µH
Accuracy:	±0.15% ± 2.0 µA at 25°C

4–20 mA Output

Range:	±24 mA
Minimum Output Impedance:	100 MΩ
Maximum Load:	500 Ω, 100 µH
Accuracy:	±0.20% ± 10 µA at 25°C

Optoisolated Input Ratings (Digital Input Ratings)

DC Control Signal 250 Vac/Vdc (Signal Level)

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 9.6–16.7 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 dedicated IRIG-B port (2-pin Phoenix connector).

IRIG Port Electrical Characteristics

Nominal Voltage:	5 Vdc
Maximum Voltage:	8 Vdc
Input Resistance:	>2 kΩ

Dedicated IRIG Port

On (1) State:	Vih ≥ 3.5 V
Off (0) State:	Vil ≤ 1.5 V

IRIG Pins on Port 2 and Port 3

On (1) State:	Vih ≥ 2.0 V
Off (0) State:	Vil ≤ 0.8 V

Time Accuracy

Clock Drift With No Time Input:	4 minutes per year, typical
IRIG Accuracy:	±2 µs

Simple Network Time Protocol (SNTP) Accuracy

Manycast or Unicast:	±5 ms (when directly connected to SNTP server)
Broadcast:	No specified accuracy

Operating Temperature

IEC 60068-2-1&2:1993:	–40° to +85°C (–40° to +185°F)

Note: Not applicable to UL applications.

LCD/Color Touchscreen

Operating Temperature:	–20° to +70°C (–4° to +158°F)
Dimensions:	3.86" x 0.902"

Operating Environment

Insulation/ Protective Class:	1
Pollution Degree:	2
Overvoltage Category:	CAT III: Color touchscreen model Power supply input, output contact, and digital input voltages must all be HLV or must all be SELV (no mixing of HLV and SELV). No option cards installed. CAT II: All other vertical and horizontal configurations. SELV = non-hazardous low voltage. HLV = hazardous voltage, >60 Vdc, >30 Vac (specified for dry environments)

Indoor Use (Atmospheric Pressure: 80–110 kPa)

Maximum Humidity:	95% RH non-condensing

Maximum Altitude:

Altitude	Working Voltage
0–2000 M	300 Vac
2000–4000 M	150 Vac

Weight

2.3 kg (5.0 lb)

Dimensions

Refer to *Mount Meter on page 19*.

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)

Compression Plug Mounting Ear

Minimum:	0.18 Nm (1.6 in-lb)
Maximum:	0.25 Nm (2.2 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).

Synchrophasor Measurements

Compliance:	P Class Synchrophasor data compliant with IEEE C37.118.1-2011 as amended by IEEE C37.118.1a-2014.
Data Transfer:	IEEE C37.118.2-2011 (Backward compatible with IEEE C37.118-2005)
Message Rates:	60 Hz: 1, 2, 4, 5, 10, 12, 15, 20, 30, 60 messages per second 50 Hz: 1, 2, 5, 10, 25, 50 messages per second

Measurement Category

Nominal Voltage:

120 V when VBASE < 180

240 V when 180 < VBASE < 250

250 V when VBASE ≥ 250

Voltage Range:

80%–120% of Nominal Voltage

Nominal Current:

ANSI CL2/20 and IEC 1 A/2 A/5 A nominal configurations. (1 A, 2 A, and 5 A are the preferred nominal current ratings for transformer-connected IEC meters in IEC 62052-11.)

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:	±1/2 cycle
Analog Values:	±3%

Metering/Monitoring

Voltage, Current, and Power Accuracy

Unity Power Factor:	±0.06%
0.5 Power Factor:	±0.16%

Energy Accuracy (Form 5 and Form 9 Only)

Unity Power Factor:	±0.06% guaranteed ±0.02% typical
0.5 Power Factor:	±0.16% guaranteed ±0.06% typical

ANSI C12.20-2015 Accuracy Class 0.1

IEC 62053-22 Accuracy Class 0.1 S

IEC 62053-24 Accuracy Class 0.5 S

IEEE 519 PQ Compliance with pre-programmed settings

Frequency Accuracy

FREQ_PQ:	±0.001 Hz
FREQ:	±0.01 Hz
FREQ_PMU:	±0.005 Hz at stable frequency ±0.001 Hz at stable frequency between 59–61 Hz or 49–51 Hz

Power Quality

IEC 61000-4-30:2015 Class A

Flicker

PST:	±5% over the range 0.5–25 P_{ST} (10-min interval)
PLT:	±5% over the range 0.5–25 P_{LT} (2-hour interval)

Type Tests

Electromagnetic Compatibility Immunity

Product Standards:	ANSI C12.20-2015 IEC 62052-11:2020 IEC 61000-6-2:2005 + AC:2005 IEC 61000-6-4:2006 + A1:2010 IEEE C37.90-2005
Conducted Radio Frequency Immunity:	IEC 61000-4-6, 150 kHz to 80 MHz, 1 kHz 80% AM 10 Vrms Spot Frequencies: 27 MHz and 68 MHz
Damped Oscillatory Wave Immunity:	ANSI C12.1 IEC 61000-4-18 IEEE C37.90.1
Current:	±2.5 kV common
Voltage:	±2.5 kV common, ±2.5 kV differential
Power:	±2.5 kV common, ±2.5 kV differential
Input:	±2.5 kV common, ±2.5 kV differential
Output:	±2.5 kV common, ±2.5 kV differential
Communication:	±2.5 kV common
Signal:	±2.5 kV common

Electrical Fast Transient Burst:	ANSI C12.1 IEC 61000-4-4 IEEE C37.90.1
Power, Input/Output, Voltage/Current Circuits:	±4 kV @ 5 kHz
Communication:	±2 kV @ 5 kHz
Electrostatic Discharge:	ANSI C12.1 IEC 61000-4-2 IEEE C37.90.3 Contact Discharge: ±8 kV Air Discharge: ±15 kV
Emissions:	ANSI C63.4 CISPR 11/22/32 EN 55011/22/32 Class A or B (configuration-dependent) Canada ICES-001(A) / NMB-001(A)
Power Frequency Magnetic Field Immunity:	ANSI C12.1 ANSI C12.20 IEC 61000-4-8 100 A/m for 60 seconds 1000 A/m for 3 seconds Maximum deviation as specified in ANSI C12.20
Radiated RF Immunity:	ANSI C12.1 IEC 61000-4-3 IEEE C37.90.2

Frequency (MHz)	Field Strength	Modulation
0.2–80	15 V/m	AM 90% 1 kHz sine
80–2000	20 V/m	AM 80% 1 kHz sine AM 90% 1 kHz sine
80–2000	30 V/m	Continuous wave
2000–10000	15 V/m	Continuous wave
80–2000	20 V/m	Keyed 0.5 s on 0.5 s off
80/160/380/450/900/1850/1890/2150/2600/3500/3800/5000	20 V/m	AM 80% 1 kHz sine
900/1732/1800/1890/2310/2450/5800	20 V/m	Pulse Mod. 50%

Ring Wave (100 kHz):	ANSI C12.1 IEC 61000-4-12 IEEE C62.41.2 (Location Category B, Table 2) Power, Voltage/Current Circuits: ±6 kV (12 Ω) LL ±6 kV (12 Ω) LE ±4 kV with barrier-style Euro plugs installed
Startup and Shutdown:	IEC 60255-26 60 s ramp/5 min power off
Surge Immunity:	ANSI C12.1 IEC 61000-4-5 IEEE C62.41.2 (Location Category B, Table 3)
Power, Voltage/Current Circuits:	±6 kV (2 Ω) LL ±6 kV (2 Ω) LE ±4 kV with barrier-style Euro plugs installed
Ethernet:	±6 kV

EIA-232, EIA-485, IRIG-B:	±2 kV
Input/Output:	±2 kV LL ±4 kV LE

Environmental

Product Standards:	ANSI C12.20-2015 IEC 62052-11:2020 IEC 60255-27:2014
Environmental:	ANSI C12.1 IEC 60068-2-1 IEC 60068-2-2 IEC 60068-2-30 –40° to +85°C 5% to 95% relative humidity (37°C dew point)
Object Penetration:	IEC 60529
Enclosed in Panel With Available Gasket (P/N: 915900097) (Monochrome Model):	IP65
Enclosed in Panel With Available Gasket (P/N 915900097) and Cover for Front USB-C Port (Touchscreen Models):	IP54
Without Gasket:	IP41
Back (Terminals):	IP20
Portable Power Quality Enclosure (When Door Closed):	IP67
NEMA Enclosure:	4X
Seismic:	IEC 60255-21-3 Class 2 Quake Response
Shock/Bump:	ANSI C12.1 IEC 60068-2-27 IEC 60255-21-2 Class 1 Shock Withstand Class 2 Shock Response Class 1 Bump
Vibration:	ANSI C12.1 IEC 60068-2-6 IEC 60255-21-1 Class 2 Endurance Class 2 Response

Accuracy

ANSI C12.20-2015	Accuracy Class 0.1; CL2/10/20, and CL10/20 (applies to Blondel-compliant Form 5 and Form 9 only)
IEC 62053-22:2020	Class 0.1 S
IEC 62053-24:2020	Class 0.5 S
IEC 61000-4-30:2015 IEC 62586-2:2017	Class A

Safety

Product Standards:	ANSI/ISA 12.12.01-2015 and CSA C22.2 No. 213-15 Class I Division 2 Hazardous Locations CAN/CSA-C22.2 No. 61010-1-12:2018 IEC/UL 61010-1:2010 IEC/UL 61010-2-030:2010 (300 V, Measurement Category III) IEC/UL 61010-2-201:2013 IEC 62052-11:2020 IEEE C37.90-2005
Dielectric Strength/Impulse:	IEC 61010-1 IEC 62052-11 IEC 60255-27 IEC 60664-1 IEEE C37.90

Routine Dielectric Test Levels

Current Inputs:	2.2 kVdc
Voltage Inputs:	2.2 kVac
Inputs and Outputs:	2.2 kVac
Analog Outputs:	3.11 kVdc
Power Supply:	3.11 kVdc
EIA-485 Port:	1.50 kVdc
Insulation Resistance:	IEC 61010-1 IEC 60255-27 Meets applicable levels
Flammability of Insulating Materials:	IEC 61010-1 IEC 62052-11 IEC 60255-27 Meets applicable levels
Max Temperature of Parts and Materials:	IEC 61010-1 IEC 62052-11 IEC 60255-27 Meets applicable levels, normal use
Protective Bonding/Continuity:	IEC 61010-1 IEC 60255-27 Meets applicable levels

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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 on page 19*

➤ *Make Rear-Panel Connections on page 27*

➤ *Configure and Check Meter Status on page 33*

Device Placement

Physical Location

In North America, the SEL-735 is approved for Hazardous Locations Class I, Division 2, Groups A, B, C, and D, and temperature class T3C in the maximum surrounding air temperature of +40°C (+104°F). 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. These devices can be flush-mounted as part of a certified fire/electrical enclosure. When mounted in these locations, the front of the device will be evaluated as part of the overall fire/electrical enclosure in the end-use installation. For voltage and current inputs, the SEL-735 is rated for Measurement Category III, 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° to +85°C (–40° to +185°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 ±10 percent of the rated voltage. For IEC 61010 certification, the SEL-735 rating is 4,000 meters (13,123 feet) above mean sea level.

Mount Meter

Figure 2.1, *Figure 2.2*, and *Figure 2.4* give the SEL-735 dimensions for the panel-mount applications.

This section explains how to mount the device in a panel or bracket. Torque the mounting screws to at least 12 in-lb, but no more than 15 in-lb.

The SEL-735 meets ingress protection (IP) 41 when installed directly into a panel cutout. In this configuration, the installation protects against ingress of solid objects greater than 1 mm and provides protection against falling drops of water. When greater IP ratings are required, SEL can provide a mounting gasket, PN 915900097. Because only a small fraction of applications require IP greater than IP41, the SEL-735 does not ship standard with this gasket. See *Environmental* in *Specifications on page 8* for full IP ratings.

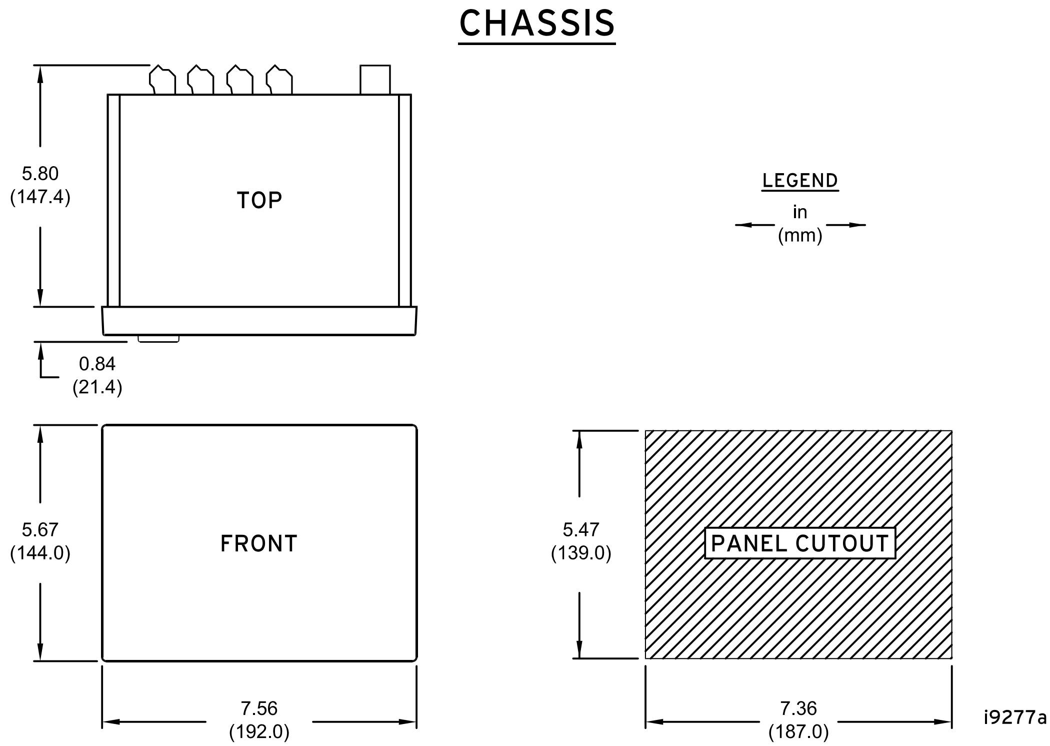


Figure 2.1 SEL-735 Horizontal Panel-Mount Dimensions

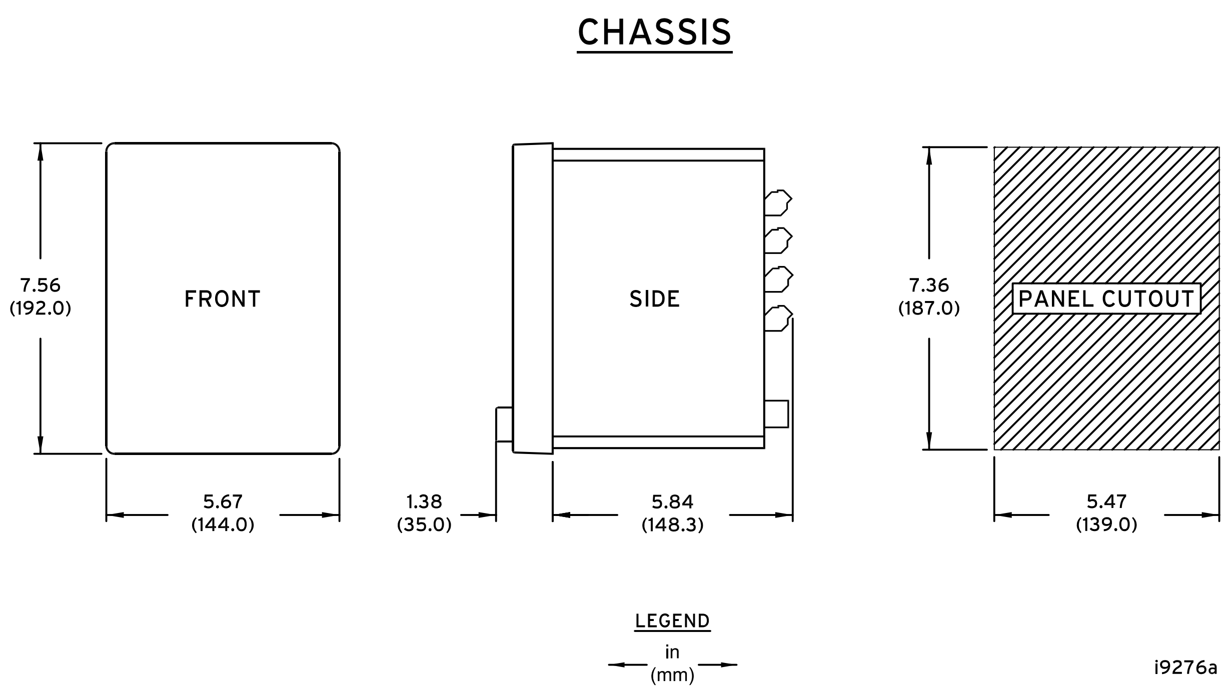


Figure 2.2 SEL-735 Vertical Panel-Mount Dimensions

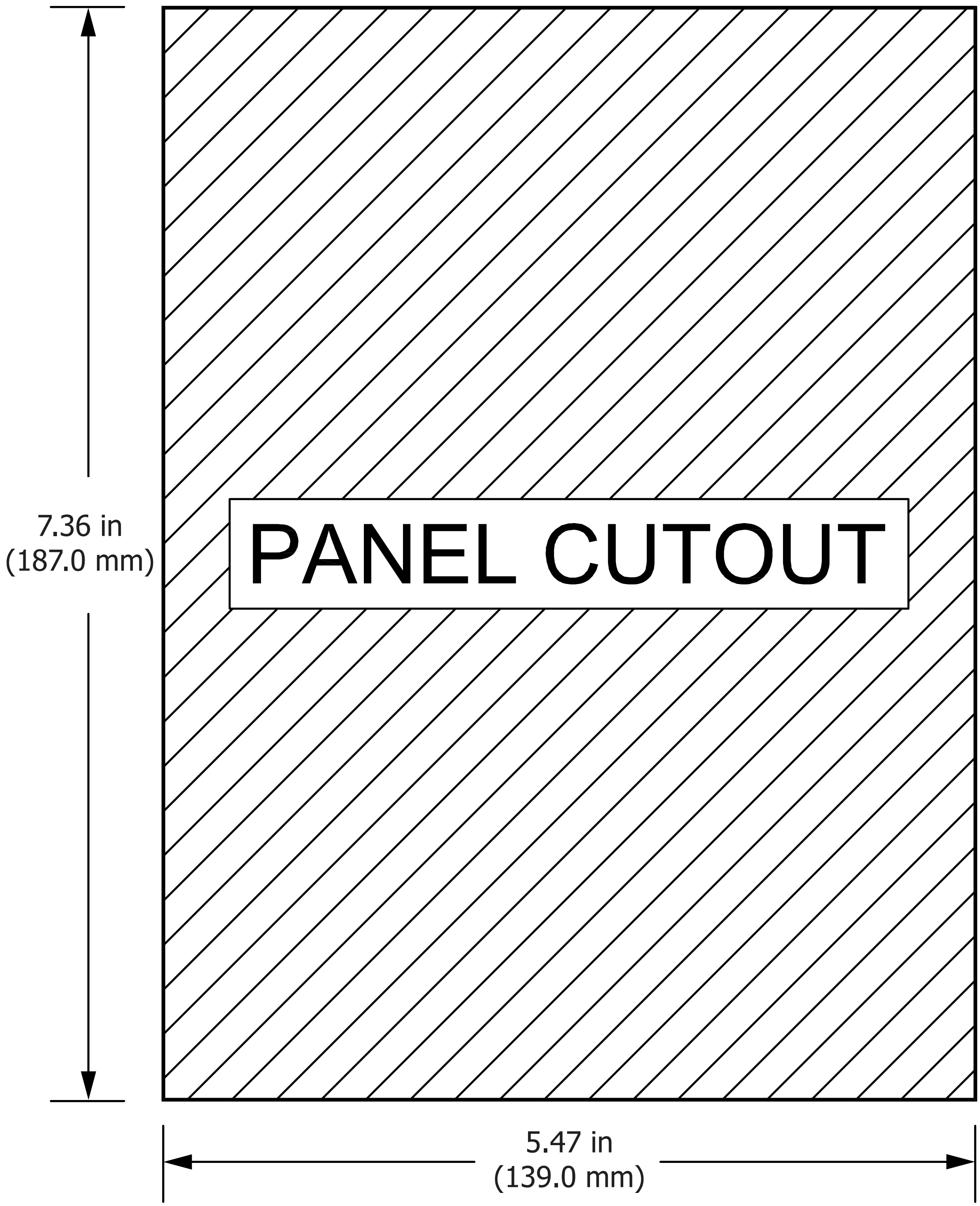


Figure 2.3 Panel Cutout Sheet

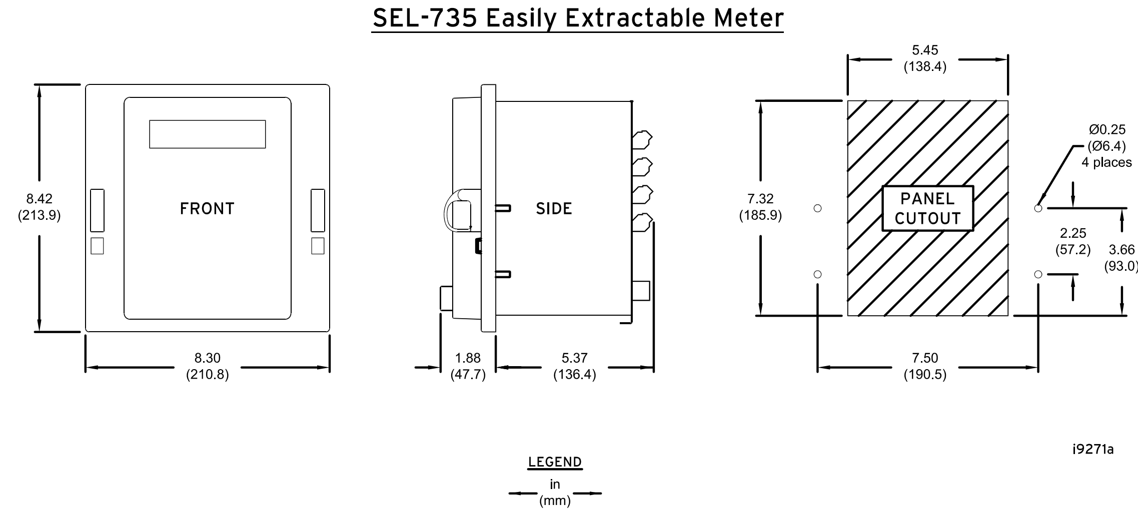


Figure 2.4 SEL-735 Easily Extractable Meter Panel-Mount Dimensions

Installation and Wiring Bracket Mounting

This section outlines how to mount the SEL-735 and wire the power supply, PT, and CT connections.

Required Installation Tools

- 5/32-inch x 1/32-inch slotted-tip screwdriver (240-1104) for Connectorized terminal blocks
- #2 or #3 Phillips screwdriver for current inputs and panel mounting screws
- #6 ring terminals for CT connections
- One of the following serial cables:
  - USB-to-serial cable SEL-C662
  - Front USB-C cable SEL-C497 (color touchscreen model only)
  - SEL-C234 or SEL-C287 cables
  - ANSI optical probe (for more information, see *Table 2.5*)
- ACSELERATOR QuickSet SEL-5030 Software, available for download at *selinc.com*

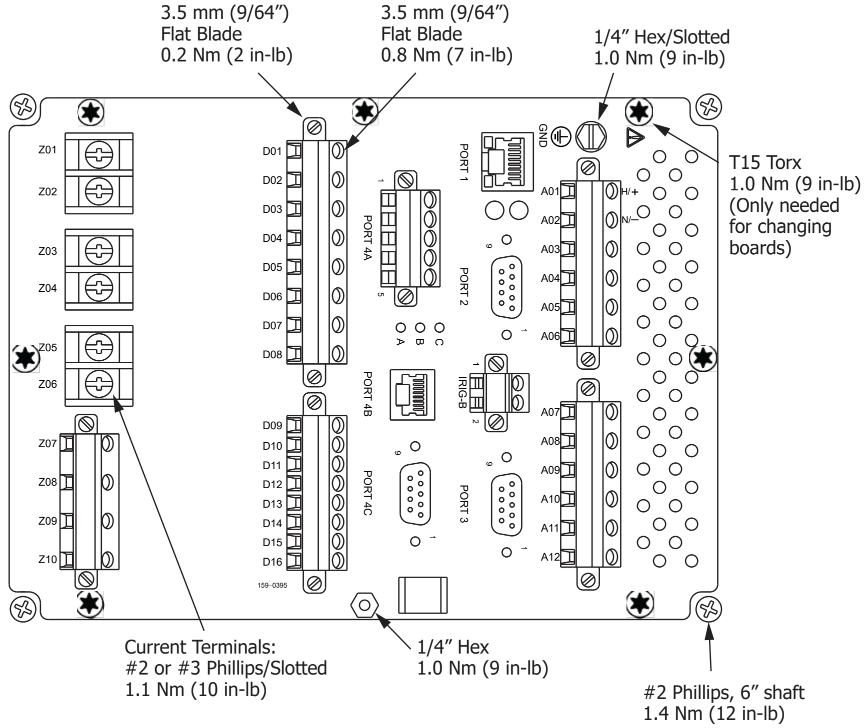


Figure 2.5 Backplate With Screw Sizes and Torques

PC System Requirements for QuickSet

- Serial port, Ethernet connection, or USB for optical, serial, and USB-C to allow communication to SEL devices
- Microsoft Windows 10 (32- and 64-bit)
  Microsoft Windows Server 2008
  Microsoft Windows Server 2012
  Microsoft Windows Server 2016
- 2 GB hard disk space
- Microsoft Windows administrative level privileges (required for installation)

Recommended Torque Values

- Current terminals: 12 in-lb
- Connectorized terminals (accept wire size 12–24 AWG):
  - 7 in-lb for wire connections
  - 2 in-lb for retaining screws
- Mounting screws: 12 in-lb

Mounting Options

SEL supplies each SEL-735 with four #8 screws for mounting the meter in a rectangular panel cutout shown in *Figure 2.5*. For detailed information on mounting options, communications cables, and other accessories, refer to the *SEL-735 Metering Accessories* catalog, found at *selinc.com*.

Mount the SEL-735 by using one of the following options:

- Panel mount (standard)
- Retrofit bezel
- Indoor enclosure
- 19-inch rack-mount bracket
- Wall-mount bracket
- Outdoor enclosure

Power Supply Connections

Before powering the SEL-735, connect the ground terminal ⏚ (**GND**-to-earth ground). See *Figure 1.2* for the location of the chassis ground.

Choose one of the following methods to power the SEL-735.

Auxiliary Power Supply

Connect auxiliary power supply input voltages to terminals **A01** and **A02**.

The SEL-735 supports three power supply options:

- High-voltage ac/dc supply (85–275 Vdc, 85–264 Vac)
- Medium-voltage dc-only supply (19–58 Vdc) (orange connector)
- Low-voltage dc-only supply (9.6–30 Vdc) (orange connector, not available on color touchscreen models)

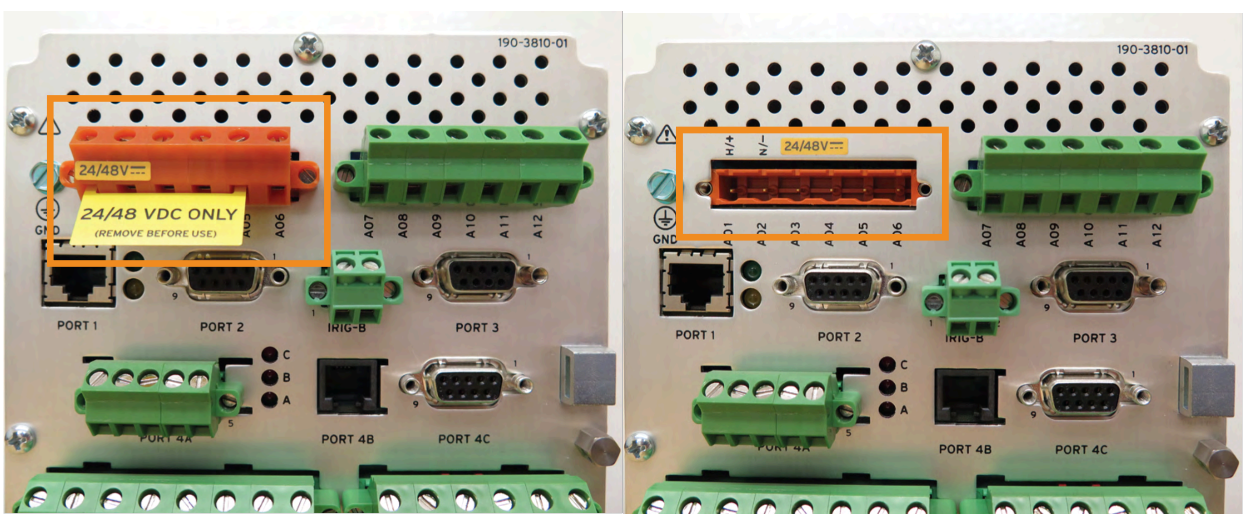


Figure 2.6 Orange Euro Connectors Indicate DC Power Supply Rating

PT Power

To power the SEL-735 from the PT circuit, connect terminals **Z07** to **A01** and **Z10** to **A02** by using 12–24 AWG wire.

Voltage and Current Connections

The SEL-735 supports Form 9 (4-wire wye), Form 5 (3-wire delta), and Form 36 (4-wire wye) connections.

Outdoor Enclosure Mounting

Use *Figure 2.7* as a guide to installing mounting hardware.

NOTE
The outdoor enclosure weighs approximately 14 kg (30 lb).

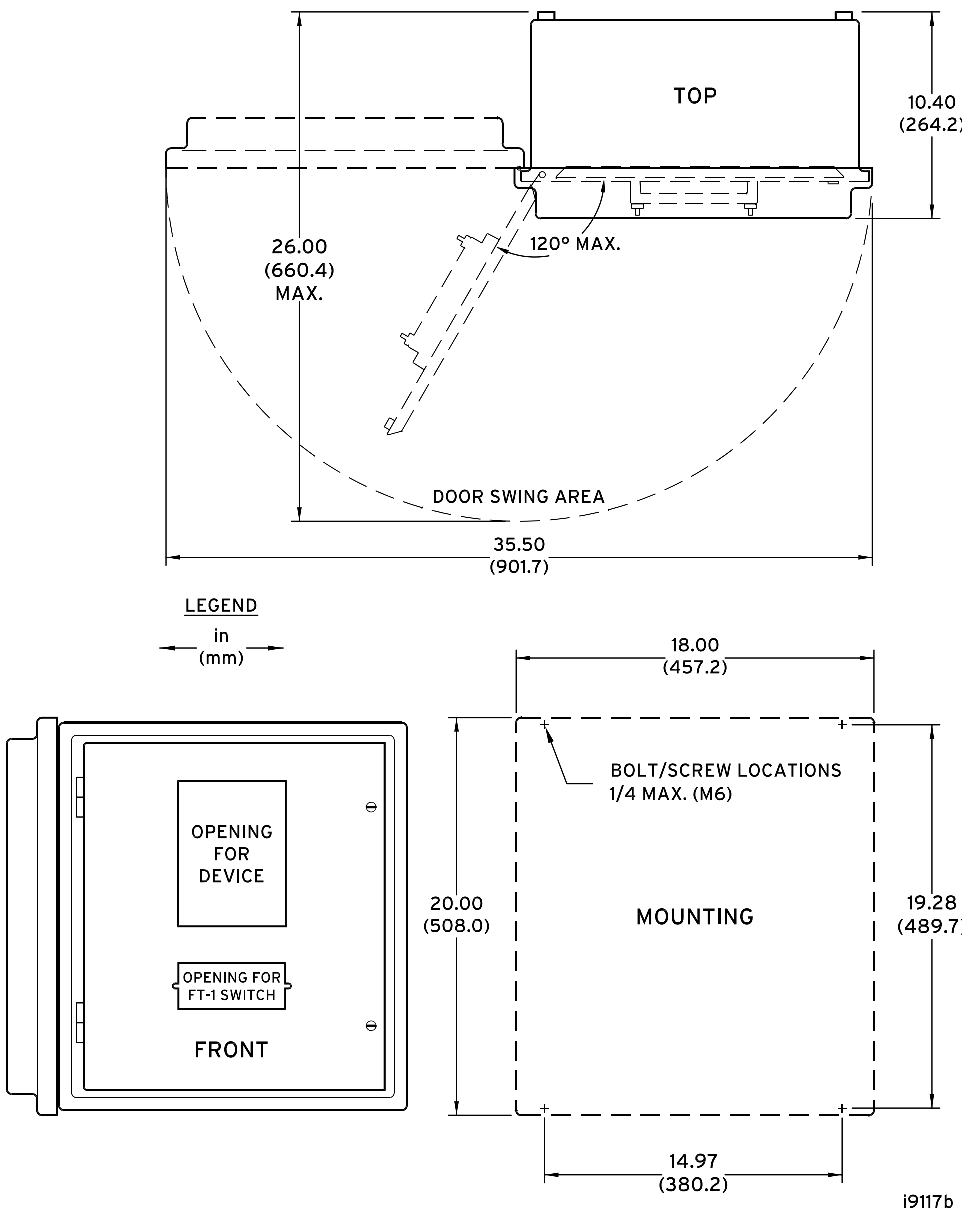


Figure 2.7 Outdoor Enclosure Dimensions

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

Chassis Ground (Protective 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^2) to 12 AWG (4 mm^2) less than 2 m (6.6 ft) in length for the ground connection.

Figure 2.8 Grounding Terminal Symbol

Connection Diagrams

SEL terminals accelerate and simplify connection and disconnection of wiring from the back of the SEL-735. *Figure 2.9* shows typical labels for the rear-panel terminals. This label is on the top for a horizontal version and on the side for a vertical version. Your meter configuration might be different. Please refer to *selinc.com* for a drawing specific to your configuration.

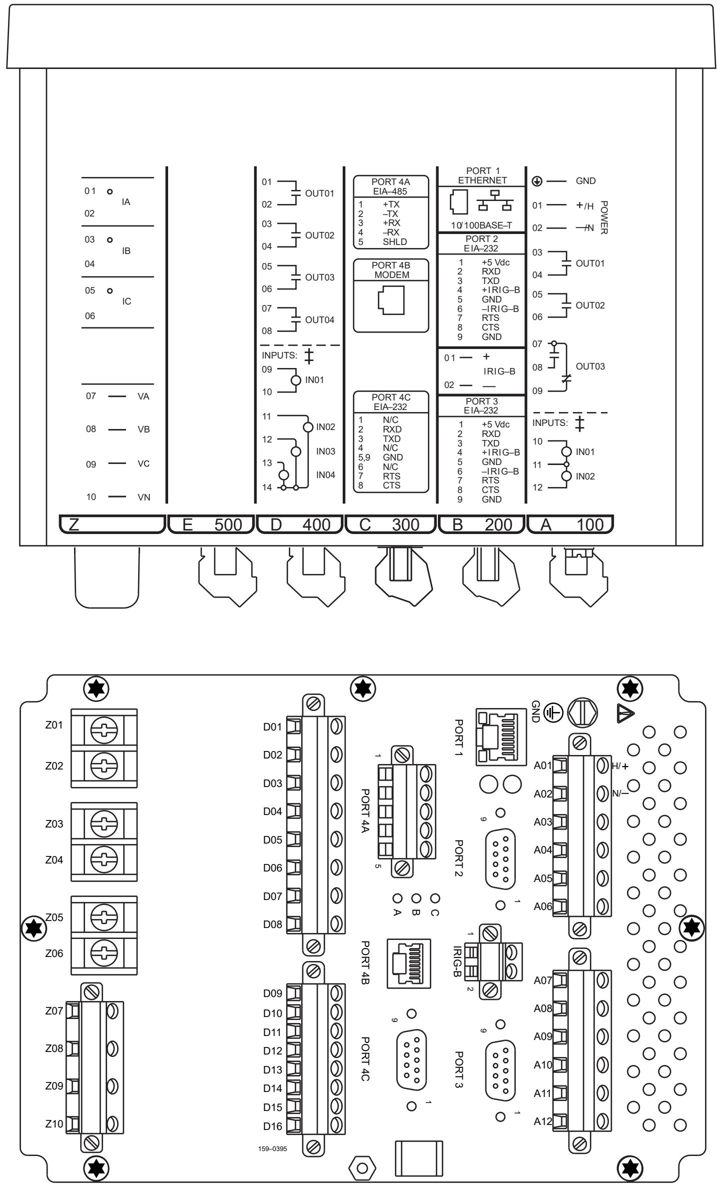


Figure 2.9 Label and Rear-Panel Drawing for a Typical Meter Configuration

Make Rear-Panel Connections

The SEL-735 supports Form 9 (4-wire wye), Form 5 (3-wire delta), and Form 36 (4-wire wye) connections.

Form 5, 3-Wire Delta Connection

Voltages

Wire the phase-to-phase voltages to terminals Z07 and Z09. Connect the neutral wire to terminals Z08 and Z10.

Currents

Wire the currents to terminals Z01–Z02 and Z05–Z06.

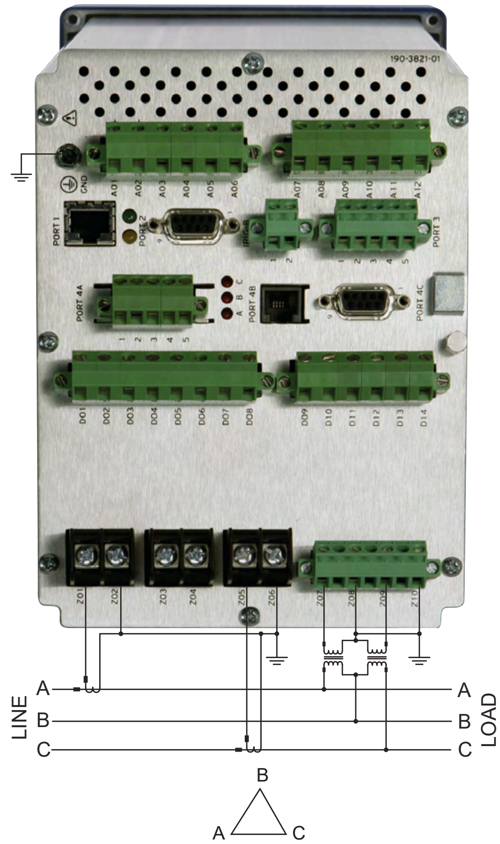


Figure 2.10 Form 5, 2-Element, Three-Wire Delta Wiring Diagram

Form 9, 4-Wire Wye Connection

Voltages

Wire the phase-to-neutral voltages to terminals Z07, Z08, and Z09. Connect the neutral wire to terminal Z10.

Currents

Wire the currents to terminals Z01–Z02, Z03–Z04, and Z05–Z06.

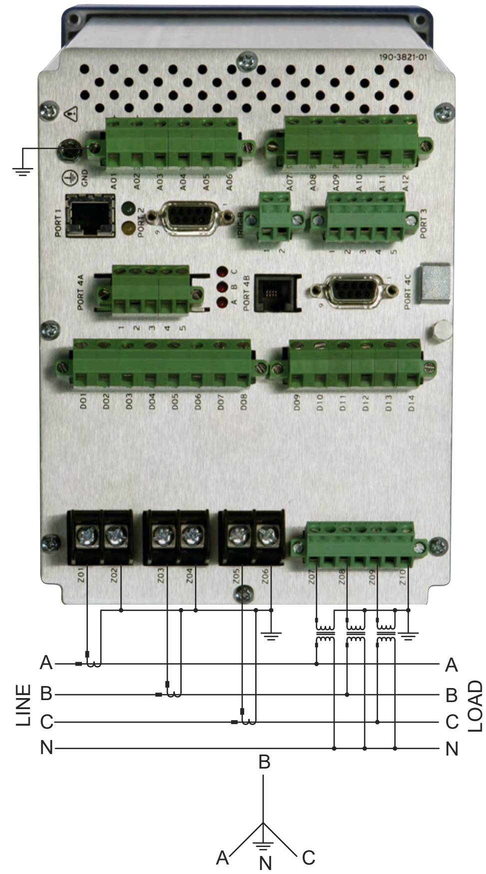


Figure 2.11 Form 9, 3-Element, Four-Wire Wye Wiring Diagram

Form 36, 4-Wire Wye Connection

Voltages

Wire the phase-to-neutral voltages to terminals Z07 and Z09. Connect the neutral wire to terminals Z08 and Z10.

Currents

Wire the currents to terminals Z01–Z02, Z03–Z04, and Z05–Z06.

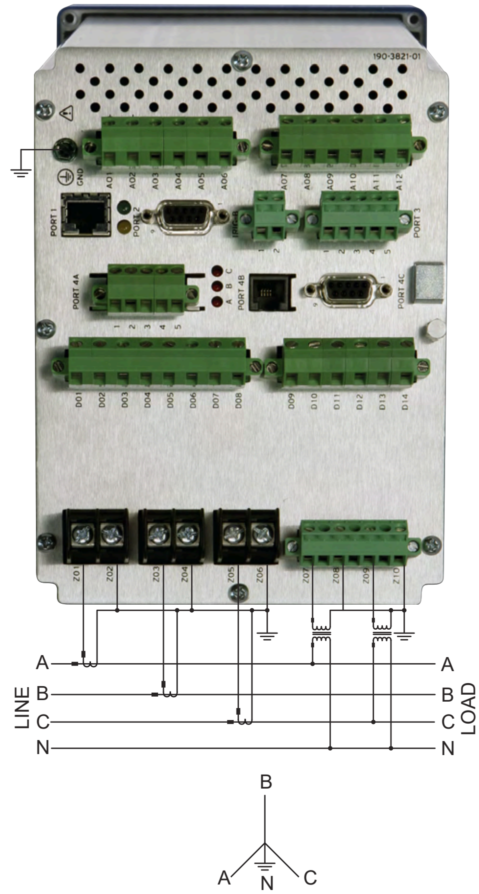


Figure 2.12 Form 36, 2 1/2-Element, Four-Wire Wye Wiring Diagram

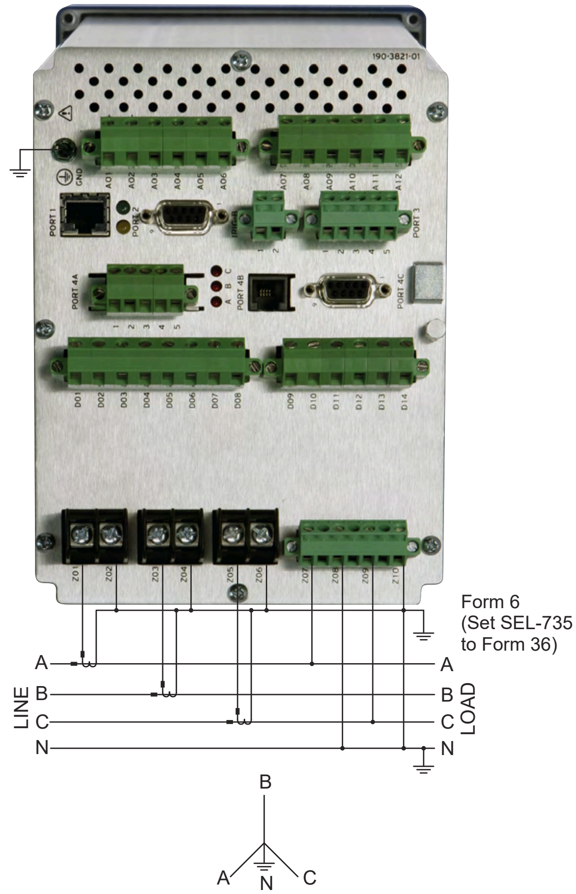


Figure 2.13 Form 6, 2 1/2-Element, Four-Wire Wye Wiring Diagram

Connectorized Terminals

Follow these steps to connect Connectorized terminals.

Step 1. Ensure that the conductor size is between 0.25 mm^2 (24 AWG) and 4 mm^2 (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-lb) 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.

Three-Phase Voltage and Metering

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

Table 2.1 Required Rear-Panel Connections

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
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[a] (IB) IN
		Z04	IB–	Phase B Current[a] (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[a,b] (VB)
		Z09	VC	Phase C Voltage (VC)
		Z10	VN	VA, VB, VC Neutral

[a] 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.
[b] 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. Ground the meter chassis at the ground terminal located on the rear of the meter as described in *Chassis Ground (Protective Earthing) on page 26*.

Step 2. Ensure that power supply and metering instrument wiring is safe. The meter comes with an orange Euro connector on the Slot A card for all low-voltage power supply options. *Figure 2.14* shows the orange Euro connector on the meter with 24/48 Vdc power supply rating.

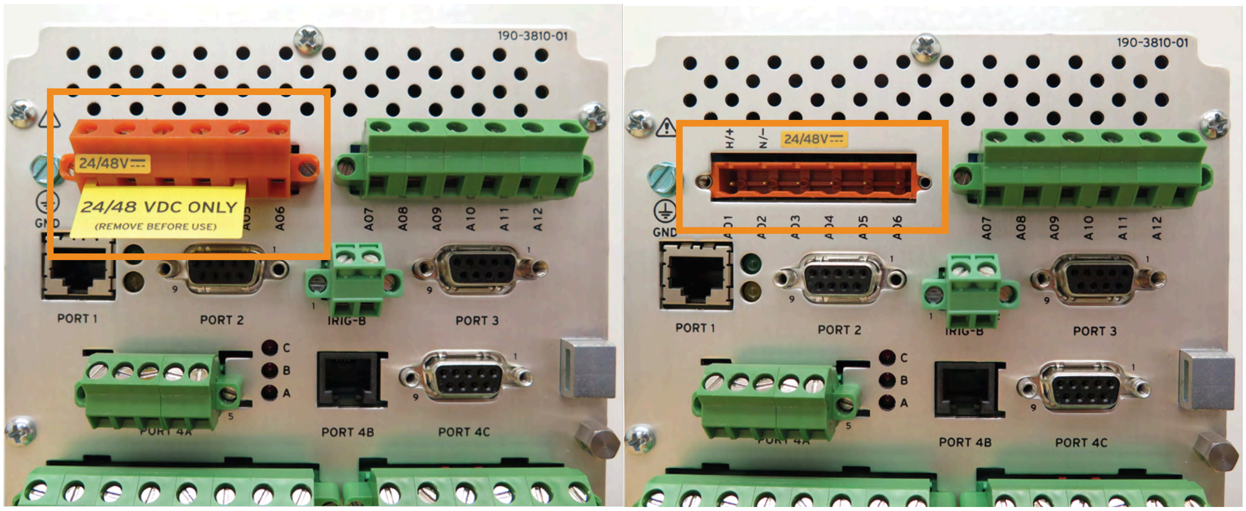


Figure 2.14 Orange Euro Connectors Indicate DC Power Supply Rating

Step 3. Route the power supply and metering instrument wiring to the rear of the device.

Step 4. 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 **A01** and **A02**, respectively.

The power supply input range is printed on the side-panel.

Step 5. Refer to *Table 2.1* and *Figure 2.11* and connect all necessary rear-panel connections. Ensure that connected circuits conform to the SEL-735 specifications, given in *Specifications on page 8*.

Step 6. Refer to the panel label to connect other necessary rear-panel connections.

Step 7. Ensure that conductors are properly supported, free from hazards, and installed in accordance with local electrical codes.

Step 8. Provide power to the power supply connections you wired in *Step 4*.

Step 9. View the front panel of the device. Verify that the front panel illuminates.

Step 10. Continue to *Configure and Check Meter Status on page 33*.

Configure and Check Meter Status

This step describes how to check the status and make the necessary initial configuration settings through the front panel and menu pushbuttons, or any communications port. 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 color touchscreen or three-line display pushbutton menu. A PC is not required to perform this step.

➤ Front 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. Follow these guidelines when navigating the front panel.

Use the following instructions to configure the meter identifier, the terminal identifier, and the potential and current transformer ratios.

Configure and Check Meter Status Through the Touchscreen Display

Step 1. Configure the initial device settings.

a. Press the HOME button to go to the screen displaying applications.

b. Press **Settings > General > Identifier and Scaling**.

The meter displays general settings. *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	1.0000–10000.0000
PTR	Potential Transformer Ratio	1.0000	1.0000–10000.0000
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

c. Select MID or any other settings name to update it.

d. Enter the Access Level 2 password following the prompts. The default Access Level 2 password is TAIL.

e. Enter the new MID to replace the default MID of FEEDER 1 and select **Submit**.

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.

f. Repeat the steps to update all other initial settings.

g. Select **Back** to go to the previous screen and select the **Save** icon to save the new settings.

h. Select **Yes** to confirm saving of settings.

i. Press the **Back** or **Home** button to exit the menu.

Step 2. Check the measured voltage quantities.

a. Select the Meter application and RMS.

b. Scroll through the voltage and current quantities to verify that the scaling and measurement is as expected.

c. Select the **Device Info** application and navigate to Status.

d. 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.

Three-Line Display Models

Use the following instructions 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 the **DOWN ARROW** 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. *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.

e. Press **ENT**.

f. Enter the Access Level 2 password by following the text entry prompts on the LCD. The default Access Level E password is BLONDEL, and the default Access Level 2 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 1.g*, except scroll down further to enter new terminal identifier, potential and current transformer ratios, and any other necessary settings.

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

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 activate **MAIN > Meter > Voltage**.

The meter displays the rms voltage quantities and their scaling.

b. Ensure the measured quantities are correct.

c. Optionally, repeat *Step 2.a* and *Step 2.b*, but check the rms current quantities from the menu item **MAIN > Meter > Current**.

d. Press **ENT**, and then activate **MAIN > Status**.

e. Press the **DOWN ARROW** to scroll down and view the following diagnostic points:

- Device status (Status)
- Firmware identifier (FID)
- Part number (PARTNO)
- Power supply status (Batt, Temp)

f. Record the FID string of the device for use in subsequent steps.

Communications and Cable Management

Cable Management

Using an improper cable can cause numerous problems or failure to operate, so you must specify the proper cable for application with your meter. Several standard SEL communications cables are available for use with the meter.

The following list provides additional rules and practices you should follow for successful communication through use of EIA-232 serial communications devices and cables:

- Route communications cables well away from power and control circuits. Switching spikes and surges in power and control circuits can cause noise in the communications circuits if power and control circuits are not adequately separated from communications cables.
- Keep the length of the communications cables as short as possible to minimize communications circuit interference and also to minimize the magnitude of hazardous ground potential differences that can develop during abnormal power system conditions.
- Ensure that EIA-232 communications cable lengths never exceed 30 feet, and always use shielded cables at both ends for communications circuit lengths greater than 10 feet. When powering devices from the EIA-232 ports, ensure the device is never connected with a cable longer than 3 feet.
- Fiber-optic transceivers provide communication over long distances and give isolation from ground potential differences that are present between device locations (examples are the SEL-2800-series transceivers).
- Lower data speed communication is less susceptible to interference and will transmit greater distances over the same medium than higher data speeds. Use the lowest data speed that provides an adequate data transfer rate.

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

The front port, serial ports, 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 QuickSet to configure the meter. Refer to *Section 4: ACSELERATOR QuickSet* for complete details of the features of the software.

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

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

a. For front port communications, connect the cable from your PC to the SEL-735 front port.

Ensure that you have installed drivers properly for the type of cable you will be using.

The following list shows the known compatible optical probes of the SEL-735. Note that some of these are no longer manufactured.

- Abacus Electrics A9U, USB (Requires additional software drivers)
- Abacus Electrics A7Z
- Abacus Electrics A6Z
- ABB Unicom III
- GE SmartCoupler SC-1A
- Intelliprobe IP503-330, USB (Requires additional software drivers)
- Microtex Electronics FR3 (Requires additional software drivers)
- Probe-Tec 392010, USB (Requires additional software drivers)
- P+E Technik K01-USB (Requires additional software drivers)
- uData Net PM500-300

b. For serial communications, connect USB cables SEL-C497 or SEL-C662. Other serial cables available are the SEL-C234, SEL-C272, SEL-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

EIA-232 Port Pin Number	Pin Function
1	+5 VDC[a]
2	RXD
3	TXD
4	+IRIG-B[a]
5	GND
6	–IRIG-B[a]
7	RTS
8	CTS
9	GND

[a] Available only on Port 2 and Port 3, which have a combined current draw of 400 mA.

c. For Ethernet communications, connect an SEL-CA605 or equivalent Ethernet cable from your PC Ethernet port to the SEL-735 Ethernet port (Port 1).

Step 2. Open QuickSet on the PC.

Step 3. Activate the Communication Parameters window through the menu, toolbar, or by pressing **<Ctrl+R>**. *Figure 2.15* shows the QuickSet Communication Parameters window.

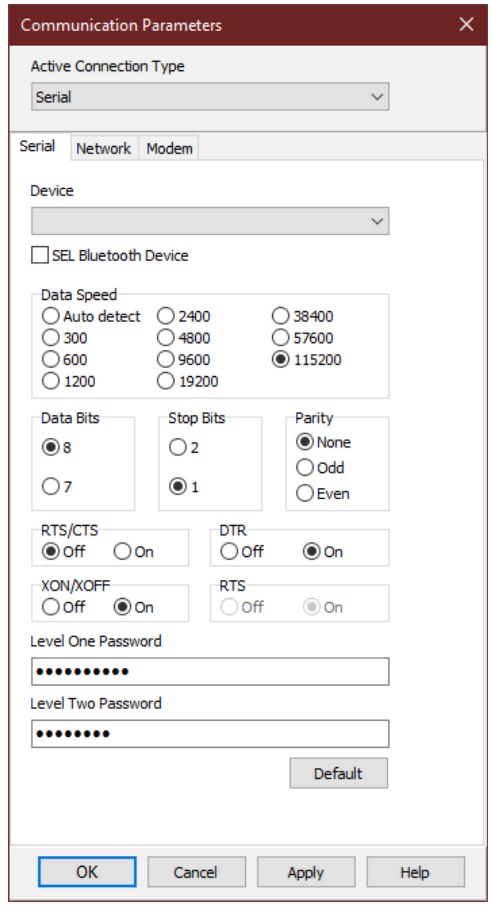


Figure 2.15 QuickSet Communication Parameters

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

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

Communications Connection Type	SEL-735 Setting Name	SEL-735 Default Setting
All Communications Protocols and Channels	PAS 1 (ACC)	"OTTER"
	PAS E (EAC)	"BLONDEL"
	PAS 2 (2AC)	"TAIL”
	PAS C (CAL)	"PAPOULIS"
All Ports, Port Specific	EPORT	Y
	MAXACC	2
Front Optical Port (Port F)	PROTO	SEL
	SPEED	9600

Communications Connection Type	SEL-735 Setting Name	SEL-735 Default Setting
	BITS	8
	PARITY	N
	STOP	1
Serial Ports (EIA-232 Ports 2, 4, or F; Port 3)	COMMINF	232
	PROTO	SEL
	SPEED	9600
	BITS	8
	STOP	1
	PARITY	N
Ethernet Communications (Port 1)	ETELNET	Y
	IPADDR	192.168.0.2
	TPORT	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 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	QuickSet Communications Setting Name	QuickSet Communications Required Setting
Abacus Electrics A9U, USB	RTS/CTS	Off
	DTR	Off
	RTS	On
Abacus Electrics A7Z, ABB Unicom III, GE SmartCoupler SC-1A	DTR	Off
Probe-Tec 392010, USB	DTR	Off
	Data Speed	38400 or slower
Intelliprobe IP503-330, USB	DTR	Off
	Data Speed	19200 or slower
Microtex Electronics FR3	Data Speed	19200 or slower

Step 4. Enter the proper 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 QuickSet, as shown in *Figure 2.16*.

Step 7. Verify that the connection status indicates Connected, also shown in *Figure 2.16*.

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.

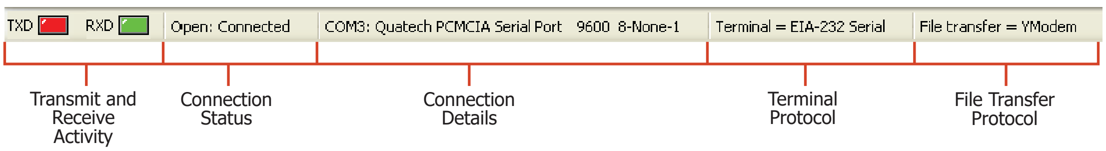


Figure 2.16 QuickSet Communications Activity and Status

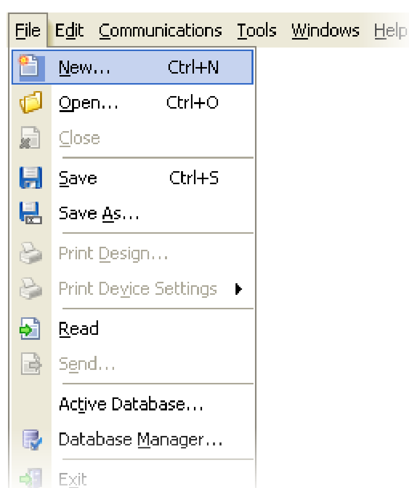
If the communications fail to connect, please verify operation of the applicable port communications through the front-panel pushbuttons.

Step 8. Click **OK**.

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

a. Create New Settings.



When you create new settings from QuickSet, all default settings load into the new device Settings Editor instance. 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, 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 2.17 shows the default options for the SEL-735.

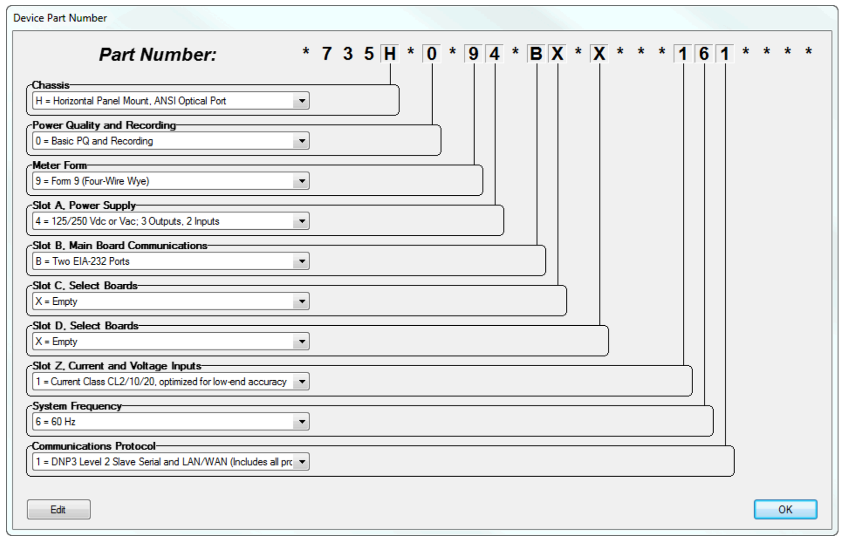
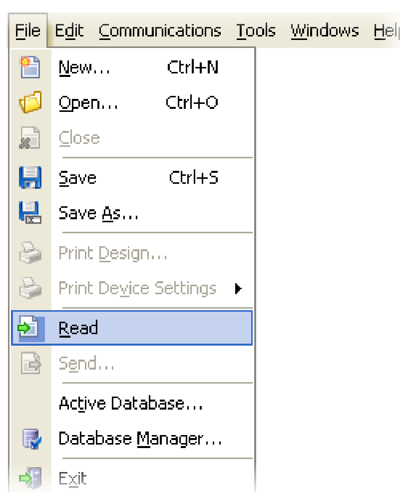


Figure 2.17 SEL-735 Model Option Table

b. Read Settings.



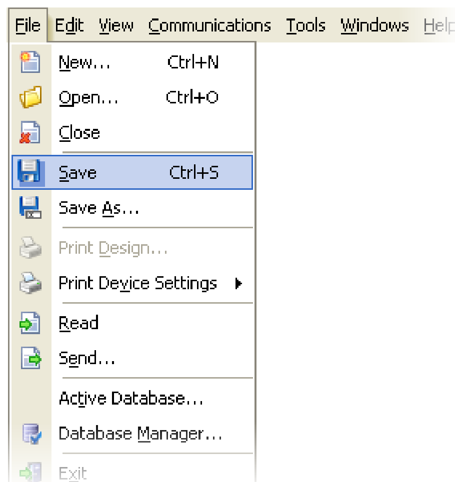
The following steps and QuickSet menu/toolbar diagrams show how to read device settings from the SEL-735 and the reading process behavior. SEL recommends you read and save settings before and after each settings change.

i. Click **File > Read** (or **<Alt+F+R>**).

ii. Click **OK**.

QuickSet reads the settings from the SEL-735, and populates the settings into a new Settings Editor instance. Any settings groups that 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 QuickSet produce a settings change report. To compare settings, select **Edit > Compare**.

Step 10. Save Settings.



The following steps and 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>**.

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 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 2.18* 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) and the potential transformer ratio (PTR).

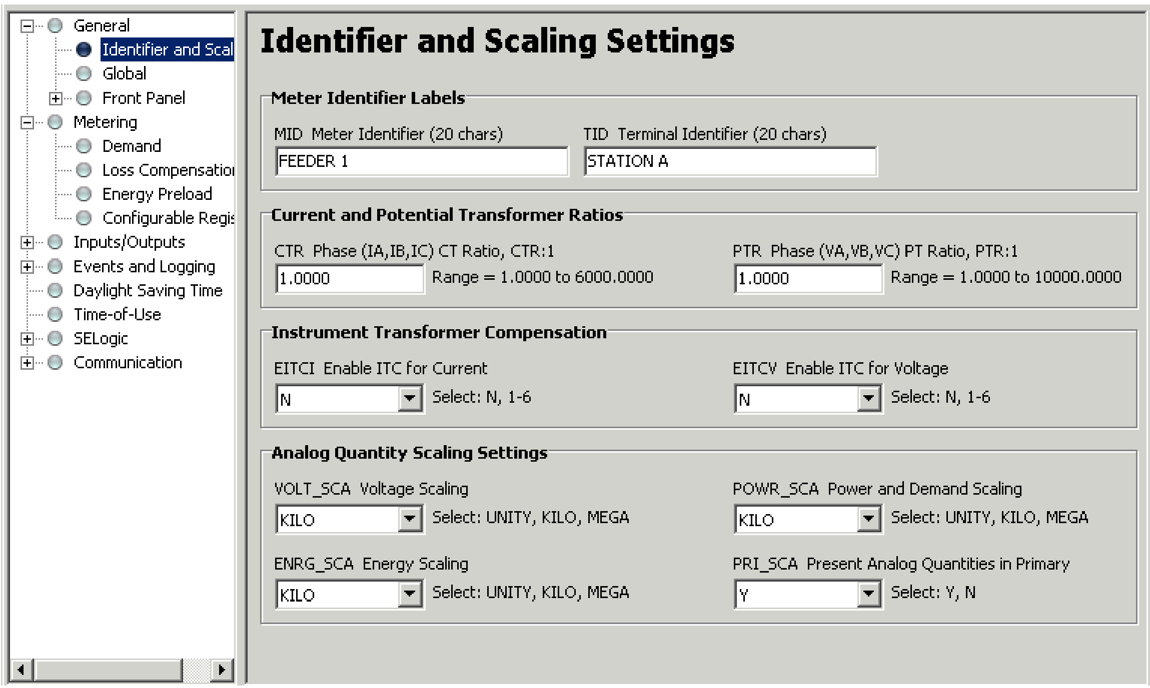


Figure 2.18 Identifier and Scaling Settings

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 (unless called out otherwise in Analog Quantity Scaling). 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 (unless called out otherwise in *Analog Quantity Scaling on page 435*).

Step 12. Send Settings.

The following steps and 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 2.19*. QuickSet automatically selects any setting groups that have changed since the last read.

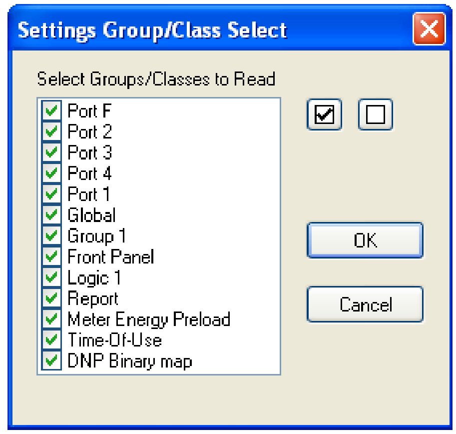


Figure 2.19 Settings Group/Class Select to Send Window

b. Select or deselect the appropriate group settings.

c. Click **OK**.

QuickSet sends the selected groups to the device.

SECTION 3

Front-Panel Operation

Overview

The SEL-735 Power Quality and Revenue Meter front panel presents metering and power quality information in a quick and efficient format. The front panel presents operating information, device settings, and control functions. The SEL-735 includes two front-panel options: a three-line monochromatic 32 x 128 pixel graphical display and a 5-inch 800 x 480 pixel color touchscreen display.

The front-panel supports the following activities:

- View metering values
- Inspect targets
- Access, modify, and save settings
- Control operations
- Perform accuracy verification in test mode

Access Levels

Overview

The SEL-735 has three normal access levels: Access Level 1, Access Level E, and Access Level 2. These levels allow you to view metering data and configure and operate the meter via the front-panel human-machine interface (HMI), ACSELERATOR QuickSet SEL-5030 Software, or a terminal window.

You can also access these levels through certain communications protocols. For example, writing to some registers via Modbus requires that you enter Access Level E through use of the Modbus protocol. The SEL-735 allows you to configure different maximum levels of access for each communications port.

Table 3.1 Access Level Functionality

Access Level	QuickSet Software or Terminal Window Functionality	Front-Panel Functionality
1	**View** data	**View** data
E	**Configure** Date and Time **Reset** load profile recorders, crest factor, maximum/minimum and peak demand metering	**Configure** Date and Time **Reset** peak demand metering
2	**Configure** all settings and control equations	**All of the above** **Change the Access Level E and Access Level 2 password** **Reset** demand, crest factor, energy maximum/minimum metering, and events

Access Level 1 (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.

Access Level E (EAC)

From this level, use ACSELERATOR QuickSet to perform the following: set the date and time, reset load profile recorders, and reset crest factor, maximum/minimum, and peak demand metering. You can also use the front-panel HMI while in Access Level E to reset peak demand metering.

Refer to *Table 3.1* for details about the functionality available at each access level.

Access Level 2 (2AC)

From this level, use ACSELERATOR QuickSet or a terminal emulator to configure all settings and control functions and reset all quantities of the SEL-735. Please see *Section 4: ACSELERATOR QuickSet* for details on configuration settings and control functions.

Access Level 2 allows you to use the front-panel HMI to perform the following actions: set the Access Level E and Access Level 2 passwords, reset the quantities available at Access Level E, reset events, and reset crest factor, demand, energy, and maximum/minimum metering.

Refer to *Table 3.1* for details about the functionality available at each access level.

Access Level C (CAL)

This level is intended for use by the SEL factory, and for use by SEL field service personnel to help diagnose troublesome meters. A list of commands available at Access Level C is available from SEL upon request. Do not enter this 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.

Password Command

Use the **PAS** command to change the passwords from a terminal window. *Table 3.3* lists the factory-default passwords for each access level. For password rules, see *Access Control on page 533*.

Table 3.2 Password Commands

Command	Description	Access Level
PAS	Display PAS command usage	2
PAS *level*	Display password for Access Level *level* (*level* = 1, E, 2, or C)	2

Command	Description	Access Level
PAS *level* [C] *newpassword*[a]	Change password for Access Level *level* to *newpassword* (maximum of eight characters)	2

[a] Parameter C is optional. If included, the user must confirm the new password before it is set.

NOTE
The 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.

Table 3.3 Factory-Default Passwords

Access Level	Terminal Prompt	Password	Capability
0	=	N/A	Entry access level.
1	=>	OTTER	View configuration settings and meter data.
E	E=>	BLONDEL	Reset demands and perform all Access Level 1 commands.
2	=>>	TAIL	Change configuration settings, reset all data, and perform all Access Level 1 and Access Level E commands.
C	==>>	PAPOULIS	Access Level C should only be used at the direction of an SEL engineer. If you are in this level, type **2AC** to return to Access Level 2.

Password Parameters

Passwords can contain as many as eight characters. Upper- and lowercase letters are treated as different characters. Strong passwords consist of eight characters, with at least one special character or digit and mixed-case sensitivity, but do not form a name, date, acronym, or word. Passwords formed in this manner are less susceptible to password guessing and automated attacks.

Examples of valid, distinct, and strong passwords are as follows:

- #0t3579!
- (Ih2dcs)
- $A24.68&
- *4u-Iwg+

Table 3.4 Valid Password Characters

Alpha	A B C D E F G H I J K L M N O P Q R S T U V W X Y Z a b c d e f g h i j k l m n o p q r s t u v w x y z
Numeric	0 1 2 3 4 5 6 7 8 9
Special	! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ` { | } ~

Changing Color Touchscreen Password

To prevent unauthorized access, set strong passwords as described in the following steps. For example, the password **OTTER** is weak because it is a six-character word found in the dictionary. The password **O#h"pVw&** is strong because it is random, undefined, and contains eight characters.

Step 1. On the touchscreen display, navigate to **Settings > Change Password**.

Step 2. Enter the name of the access level for which you want to change the password.

Step 3. Enter the current password for that access level.

Step 4. Type the new password in the **New Password** field and press **Submit**.

The message `Password Successfully Changed` confirms the update.

Figure 3.1 Change Password on Color Touchscreen

Port Security

Each communications port is configurable to allow a maximum access of Access Level 1, E, or 2, or to turn the port completely off to any communications. Please see *Section 4: ACSELERATOR QuickSet* for more details on port security.

Front-Panel Layout

The SEL-735 front-panel interface consists of 14 programmable LEDs, an LCD, a seven-button menu keypad (one button on color touchscreen model), a **TEST** LED, a USB-C, optical, or EIA-232 communications port, and four user-configurable control pushbuttons.

Figure 3.2 shows the front-panel layout of the SEL-735 with a color touchscreen display, and *Figure 3.4* shows the vertical unit with a three-line LCD. The touchscreen model has a USB Type-C front port.

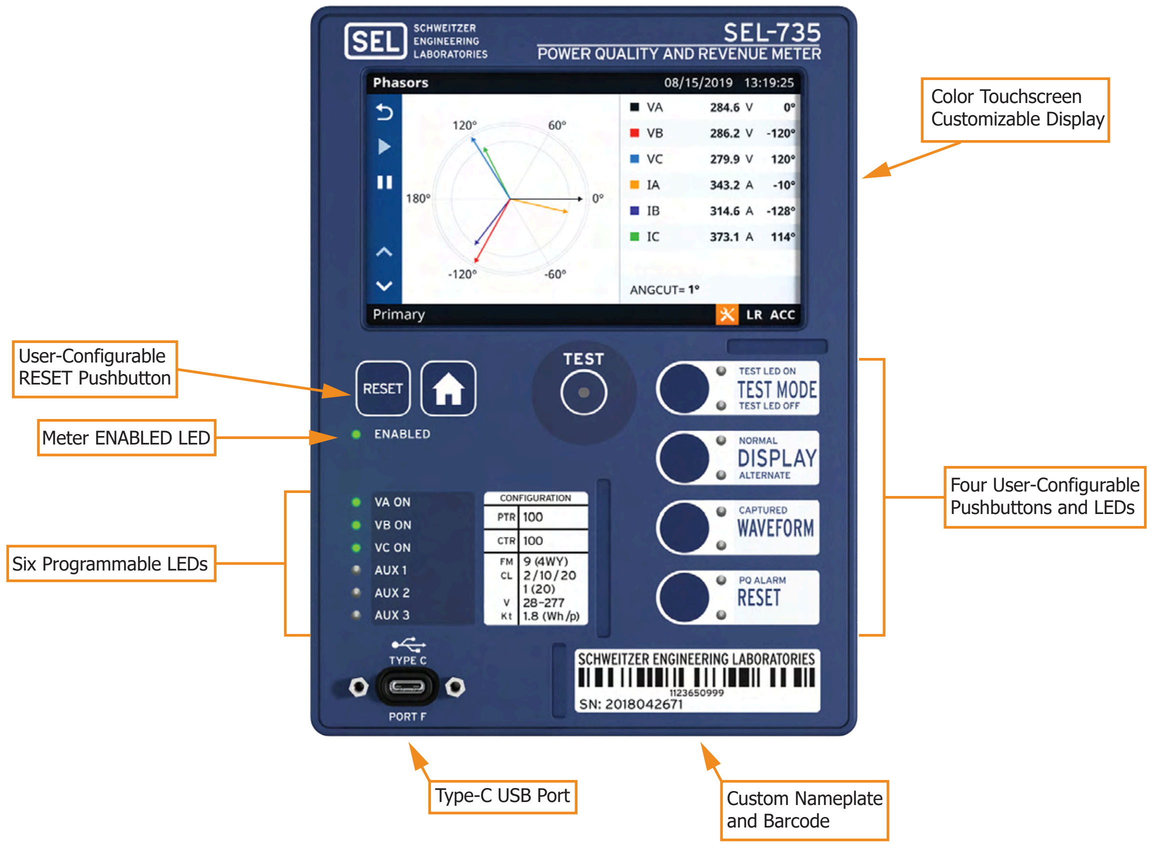


Figure 3.2 SEL-735 Color Touchscreen Unit Front-Panel Layout

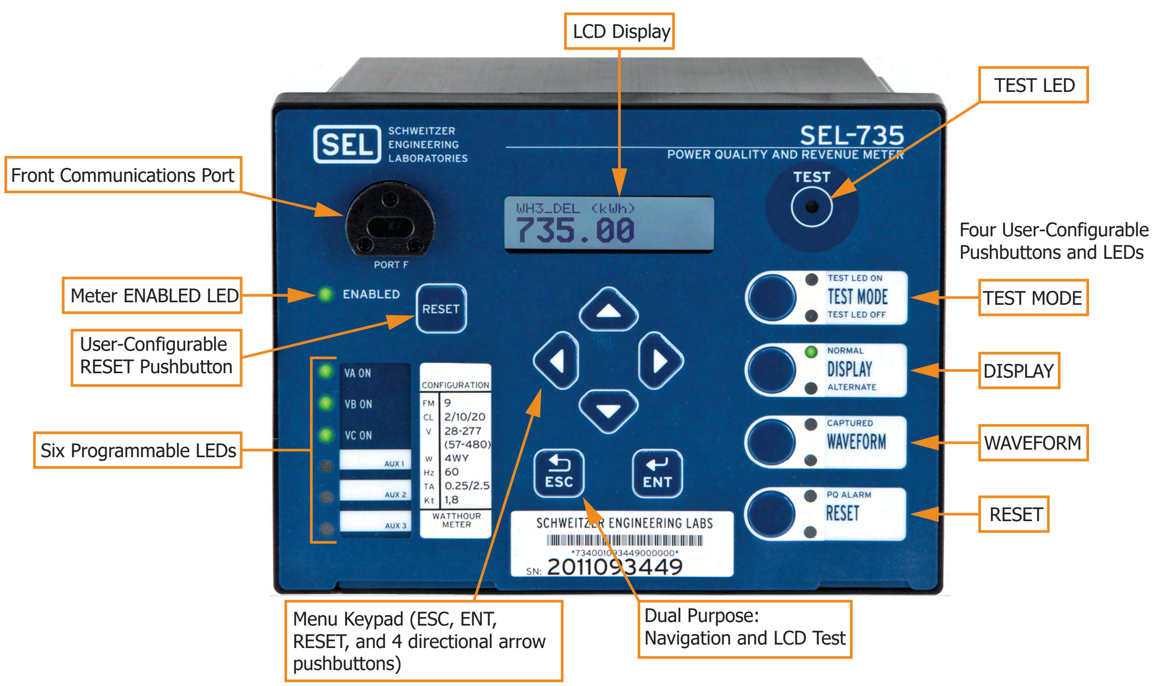


Figure 3.3 SEL-735 Horizontal Unit Front-Panel Layout

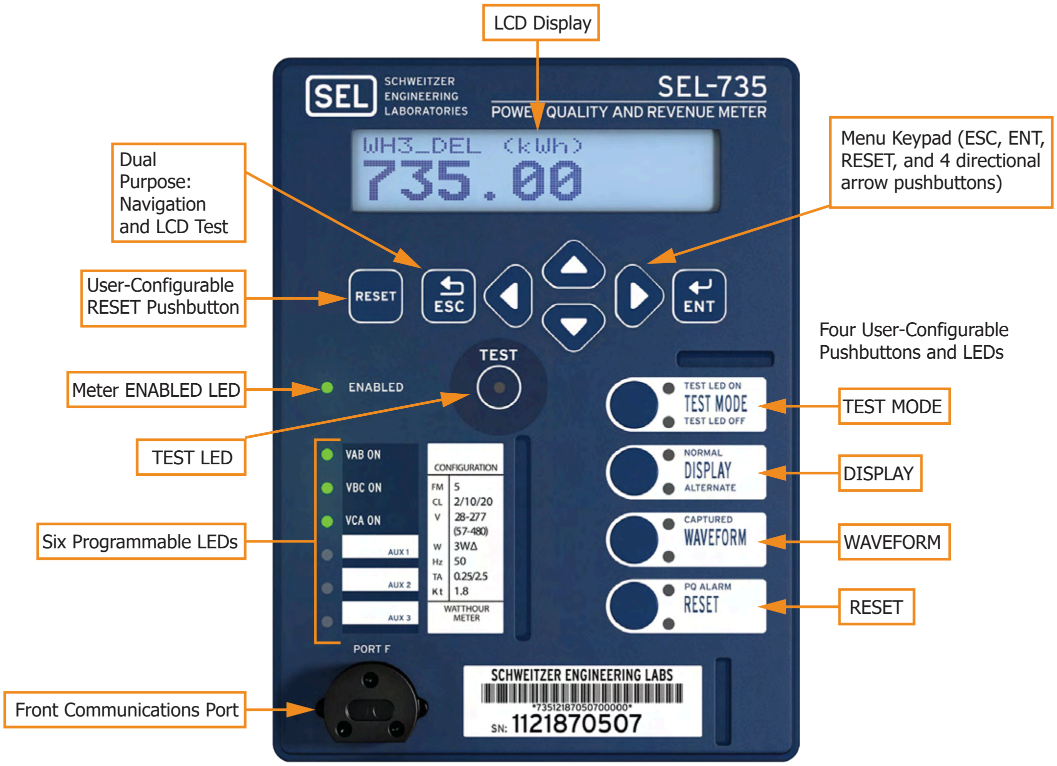


Figure 3.4 SEL-735 Vertical Unit Front-Panel Layout

Front-Panel Operations

Three-Line LCD Display

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

Touchscreen Display

The SEL-735 supports an optional 5-inch 800 x 480 pixel color touchscreen display. The touchscreen display features a straightforward application-driven control structure and includes intuitive and graphical screen designs. The optional touchscreen front-panel includes all of the functionality of the standard three-line panel including target LEDs, operator control pushbuttons, and **RESET** pushbutton. The navigation arrows and **ESC** are replaced by a **HOME** pushbutton.

RESET (User-Configurable)

Configure the **RESET** pushbutton by using the RESETFCN setting. The **RESET** pushbutton can be configured for lamp test, peak demand reset following password rules, or peak demand rest bypassing password rules.

To inhibit peak demand reset, refer to *Peak Demand Reset Inhibit on page 54*. See *Configure and Check Meter Status on page 33* and the *SEL-735 Quick-Start Guide* for more information.

Activating the **RESET** pushbutton asserts the Reset Device Word bit. Refer to *Four User-Configurable Pushbuttons and LEDs on page 54* to reset peak demand by using a configurable pushbutton. Refer to *Reset Trigger Equations on page 271* to reset peak demand through use of logic equations.

LAMPTEST

When RESETFCN is set to LAMPTEST, the SEL-735 performs in the following ways based on whether the meter is in TEST mode or not.

- When the meter *is not* in TEST mode, pressing the **RESET** pushbutton tests (illuminates) all of the front-panel LEDs.
- When the meter *is* in TEST mode, pressing the **RESET** pushbutton resets the TEST mode energy quantities and the testing time. (The maximum testing time is the front-panel time-out setting FP_TO.)

RESETPD

If RESETFCN is set to RESETPD and the meter is not in TEST mode, the meter resets the peak demand data when the **RESET** pushbutton is pressed and held for five seconds, if the peak demand reset function is not inhibited. Refer to *Peak Demand Reset Inhibit on page 54* for details.

RESETPE

When RESETFCN is set to RESETPE and the meter is not in TEST mode, the meter prompts for the Access Level 2 password. The meter resets the peak demand data after receiving the correct password, if the peak demand reset function is not inhibited. Refer to *Peak Demand Reset Inhibit on page 54* for details.

ESC

On models with a three-line LCD, adjust the contrast and perform a pixel test by pressing and holding the **ESC** pushbutton.

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.

Front Communications Port

SEL-735 meters with the touchscreen display are available with a Type-C USB front port. Models with the monochromatic LCD are orderable with either an ANSI Type 2 Optical or an EIA-232 serial front port. Use this port for easy front-panel serial communications. The optical communications port outputs test pulses when the meter is in TEST mode.

Six Programmable LEDs

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

Peak Demand Reset

Reset peak demand data from the front panel by pressing **RESET** or one of the four pushbuttons configured for reset functionality. The SEL-735 applies the peak demand reset inhibit logic before resetting peak demand data.

Peak Demand Reset Inhibit

The SEL-735 uses the Reset Peak Demand Inhibit setting RPDEMINH to qualify all peak demand resets initiated from the front-panel HMI. If the time between two peak demand resets does not meet the time set in RPDEMINH, the SEL-735 displays `Peak Demand reset inhibited. Please wait for timeout`. The SEL-735 display returns to normal operating mode after five seconds or if any of the menu keypad pushbuttons are pressed. See *Front-Panel LED Logic Settings on page 133* for details.

Set RPDEMINH to OFF to disable the peak demand reset inhibit time-out period. All subsequent front-panel peak demand resets will cause the SEL-735 to reset the peak demand and restart the inhibit timer.

Four User-Configurable Pushbuttons and LEDs

The SEL-735 provides four user-configurable pushbuttons, each with two LEDs. Each pushbutton has one function setting and two LED settings, as shown in *Table 3.5*. The LED settings are only available if the pushbutton function setting is set to NA. Refer to *Table 3.6* for available pushbutton functions.

Table 3.5 User-Configurable Pushbutton Settings

Pushbutton	Function Setting	Top LED Setting	Bottom LED Setting
PB01	PB01FCN	T07_LED	T08_LED
PB02	PB02FCN	T09_LED	T10_LED
PB03	PB03FCN	T11_LED	T12_LED
PB04	PB04FCN	T13_LED	T14_LED

Table 3.6 shows the available user-configurable pushbutton functions and their associated LED settings.

Table 3.6 User-Configurable Pushbutton Function Setting Options

Options of Pushbutton Function Setting	Top LED Setting Value	Bottom LED Setting Value
TEST	TEST AND KYZDT	TEST AND NOT KYZDT
ALT	NOT ALTMODE	ALTMODE
WAVCAP	EVNTCPT	0

Options of Pushbutton Function Setting	Top LED Setting Value	Bottom LED Setting Value
RSTPQALRM	PQALRM	0
RESETPE	PB0*n*[a]	0
RESETPD	PB0*n*[a]	0
LAMPTEST	0	0
NA	0	0

[a]n = 1–4, corresponding to the assigned pushbutton.

Below is a detailed explanation of each function.

TEST MODE

Press the assigned pushbutton to quickly enter TEST mode through the front-panel HMI (you must enter a valid Access Level 2 password). The LEDs next to the assigned pushbutton replicate the state of the KYZ test pulses. In addition, the TEST Device Word bit asserts (see *Appendix G: Analog Quantities and Device Word Bits* for details).

DISPLAY

Press the assigned pushbutton to toggle between normal and alternate displays. The LEDs next to the assigned pushbutton show the present display mode state.

Pressing the assigned pushbutton puts the meter in the Alternate Display mode and asserts the ALTMODE Device Word bit (see *Appendix G: Analog Quantities and Device Word Bits* for details).

WAVEFORM

Press the assigned pushbutton to trigger an event and capture a waveform. The LED next to the assigned pushbutton indicates that the meter is actively capturing waveform data. In addition, the EVNTCPT Device Word bit asserts (see *Appendix G: Analog Quantities and Device Word Bits* for details).

RESET (PQ ALARM)

Press the assigned pushbutton to reset the latched power quality alarm.

The SEL-735 asserts and latches the PQALRM Device Word bit when any of the PQ indicator Device Word bits assert (e.g., harmonic alarms, event reports, SELOGIC, or SSI events). The LED next to the assigned pushbutton indicates the PQALRM Device Word bit status.

RESETPE (Reset With Password Enabled)

Press the assigned pushbutton to display the following reset selection menu:

- Reset Peak Demand
- Reset Max/Min

- Reset Energy
- Reset All

If reset is inhibited, the meter returns to the reset selection menu. If the reset is not inhibited, the SEL-735 prompts for the Access Level 2 password and resets the peak demand data after accepting the correct password. The password allows access until the FP_TO (front-panel time-out) period expires, after which the password is required again. The reset inhibit logic only applies to the Reset Peak Demand option. Selecting the Reset All option resets Max/Min and Energy and runs the reset inhibit logic prior to performing peak demand reset.

RESETPD (Reset With Password Disabled)

When you press the assigned pushbutton, the SEL-735 performs as described in *RESETPE (Reset With Password Enabled) on page 55*, but bypasses password rules.

LAMPTEST

Press the assigned pushbutton to test (illuminate) all front-panel LEDs. When you release the pushbutton, the LEDs return to their previous state.

NA

When one of the PB01–PB04 pushbuttons is not mapped to any of the above functions through use of settings PB01FCN–PB04FCN, the SEL-735 allows you the flexibility to customize the pushbuttons and LEDs for a function defined by using the logic equations as shown in *Table 3.7* (also refer to *Front-Panel LED Logic Settings on page 133*).

Table 3.7 LED Setting Names Associated With Pushbuttons

Pushbutton	Top LED Setting Name	Bottom LED Setting Name
PB01	T07_LED	T08_LED
PB02	T09_LED	T10_LED
PB03	T11_LED	T12_LED
PB04	T13_LED	T14_LED

Example: Custom Pushbutton Control Logic

Set the PB0*n*FCN setting (where *n* = 1–4) to NA to program a pushbutton and its associated LEDs with custom control equations to perform different tasks. For example, you can program a pushbutton to reset a remote lockout protection function after you depress the pushbutton for a length of time. *Figure 3.5* 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.

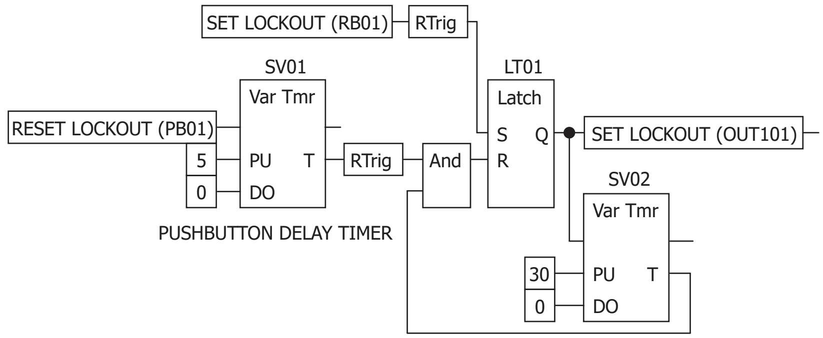


Figure 3.5 Graphical Logic Editor Lockout Latch Control Example

Figure 3.6 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 **Apply to Settings** to apply the new settings shown to the active settings.

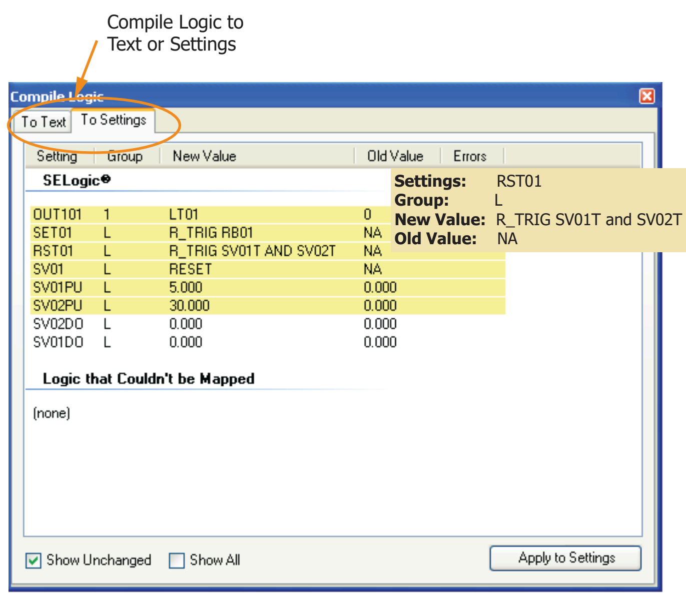


Figure 3.6 Graphical Logic Editor Compile Logic Window

Normal Operation

Models With the Three-Line LCD

In normal operation, the **ENABLED** LED remains illuminated and the LCD screen rotates through the programmed display points. By default, a display point is displayed for 6 seconds before rotating to the next display point. You can customize the update rate by changing the Display Update Rate setting (SCROLD).

The LCD screen is always on but not always illuminated. Once any of the menu keypad buttons or pushbuttons are pushed, the LCD screen illuminates according to the Front Panel LCD Contrast setting (FP_CONT), with the default set to 4. The LCD screen darkens after a time length of inactivity specified by the front-panel time-out setting (FP_TO).

Models With the Touchscreen

In normal operation, the ENABLED LED remains illuminated and the graphical display screen rotates through screens. By default, each screen is displayed for 5 seconds.

You can customize the update rate by changing the Rotating Display Transition Time setting (FPDUR). Pressing the HOME pushbutton stops the rotating display and opens the home screen. The HOME pushbutton can be programmed to default to a different selection by using the FPHOME setting. Similarly, any of the other four pushbuttons can be programmed to open screens by using the FPPB0*n* settings. Adjust the brightness by using the Backlight Active Brightness setting (FPBAB). By default, the setting is 6.

Automatic Messages

If an error occurs, the meter displays a message and turns off the ENABLED LED. For complete details on error messages, see *Section 10: Testing and Troubleshooting*. If this or any abnormality with the device occurs, please contact SEL.

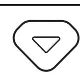
Three-Line LCD Menus and Navigation

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.

On models with the three-line LCD, the seven-button keypad and LCD display allow you 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 3.8* describes the function of each front-panel pushbutton.

Table 3.8 Menu Keypad 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.

Pushbutton		Function
ESC	ESC	Wake up the front-panel display. Escape from the current menu or display. Hold to adjust the contrast and to perform an LCD pixel test.
ENT	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	RESET	User-Configurable: Test front-panel LEDs, reset the timer when in TEST mode, reset peak demand, and assert the RESET bit.

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

- The front-panel pushbuttons **ENT**, **ESC**, **UP ARROW**, **DOWN ARROW**, **LEFT ARROW**, and **RIGHT ARROW** 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 3.7*.
- Hold the **ESC** pushbutton to adjust the contrast of the front-panel LCD. Adjust contrast as desired with the **LEFT ARROW** and **RIGHT ARROW** pushbuttons. Press **ENT** to accept the contrast setting and enter the LCD pixel test.

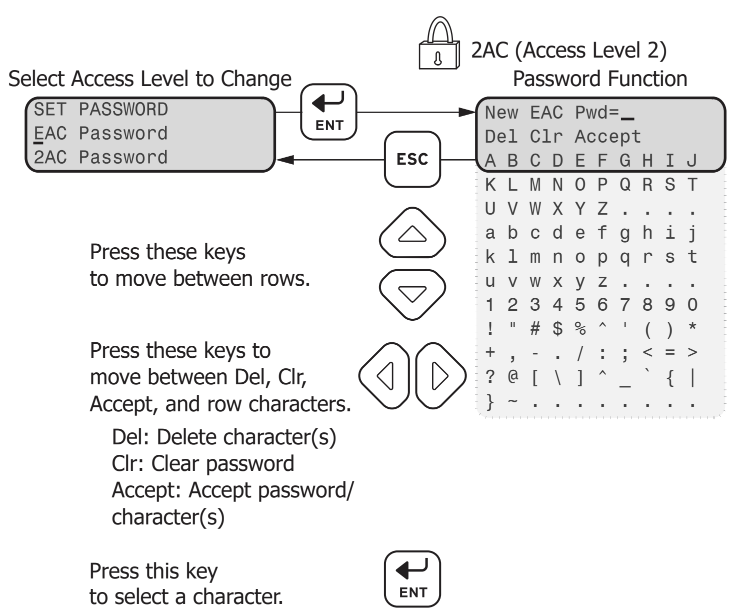


Figure 3.7 Keypad Entry Through Front-Panel LCD

Main Menu

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

Table 3.9 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 3.9 SEL-735 Front-Panel Menu Structure

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[a]	
	Energy	Display Energy	Display Energy Values and the Date/Time of Last Energy Reset, and Reset Energy Values
		Last Energy Reset	
		Reset Energy[a]	
	Demand/Peak	Display Demand	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
		Last Demand Reset	
		Display Peak	
		Last Peak Reset	
		Previous Peak	
		Peak Demand Resets	
		Reset Demand[a]	
		Reset Peak Demand[b,c]	
	Harmonics		Display THD, K-Factor, and Distortion Power
Events	Display Events		Display Events
	Reset Events[a]		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[a]		Set or Show Identifier and Scaling, Global, Demand, Loss Compensation, KYZ Pulse Outputs, and Fast Meter Messages Settings
	Port Settings[a]		Set or Show Front Port, Port 1, Port 2, Port 3, or Port 4 Settings
	Front-Panel Settings[a]		Set or Show Display Points Settings

Menu Option			Function
	Date/Time[b]		Set or Show the Date and Time
	Set Password		Set Access Level E[b] and Access Level 2[a] Passwords
Reset[d]			Reset Device
TEST Mode[a]		Select Test Quantity	Select the Energy Analog Quantity for testing
		Watthour 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

[a] Access Level 2 access required to reset quantity or change setting.
[b] Access Level E access required to reset quantity or change setting.
[c] If the peak demand reset inhibit logic is on, the specified time needs to be elapsed before the meter can perform the peak demand reset.
[d] 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 password or Access Level E 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 as many as 50 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 (SCROLD) to change the length of time each point displays.

SELOGIC display point control equations DP*nn* (*nn* = 01–50) 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. You can configure one of the front-panel pushbuttons to toggle the display between Normal and Alternate modes (see *Four User-Configurable Pushbuttons and LEDs on page 54* for details). The device reverts back to the normal display after the Front-Panel Time-out, FP_TO, expires without any front-panel activity (refer to *Appendix G: Analog Quantities and Device Word Bits* for available analog quantities).

Table 3.10 lists the default display points for the normal and alternate display modes.

Table 3.10 Default Normal and Alternate Display Points

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			

Normal Display Points			Alternate Display Points	
Analog Quantity	**Description**		**Analog Quantity**	**Description**
VA	Phase A RMS Voltage			
VB	Phase B RMS Voltage			
VC	Phase C RMS Voltage			
PFT3	True Power Factor			

See *Display Point Builder on page 113* for information on how to configure display points through a user 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 3.11* shows the elements of display point string settings.

Table 3.11 Display Point Setting Definitions

Term	Definition
Name	Any valid analog quantity or Device Word bit you want to display
Alias	An alternate name (string) displayed, replacing the analog quantity or Device Word bit assigned in *Name*
Set String	A user-defined string displayed when the Device Word bit assigned in *Name* asserts (logical 1)
Clear String	A user-defined string displayed when the Device Word bit assigned in *Name* deasserts (logical 0)
User text {numerical formatting}	A user-defined text string *(Alias)* 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 ({}) for the Set String or Clear String. 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 3.12 Display Point Formatting

Display Point Setting Format	Example Display Point Setting	Example Display
DP*nn_n* := *Name*	IN101	IN101=0
DP*nn_n* := *Name*	IA_MAG	IA MAG (A) 1234.567
DP*nn_n* := *Name*	MVAADI	MVAADI (MVA) 1234.56
DP*nn_n* := *Name,Alias*	MVAADO,"APPARENT DEM. A"	APPARENT DEM. A (MVA) 1234.56
DP*nn_ n* := *Name,Alias*	CFG0001, "First CFG Value"[a]	FIRST CFG VALUE (KWH) 10
DP*nn_ n* := *Name,Alias,Set String,Clear String*	SV01,"CONTROL",ON,OFF	CONTROL=ON CONTROL=OFF
DP *nn_n* := *Name,Alias,Set String*	SV02,BREAKER,TRIPPED,	BREAKER=TRIPPED *Entry is hidden*
DP*nn_n* := *Name,,{},Clear String*	RB03,,{},"OVERCURRENT"	*Empty line displayed* OVERCURRENT
DP*nn_n* := *Name,"User {numerical width} text"*	MVRADI,"VAR DEM {4}MVAR"	VAR DEM 1234MVAR
DP*nn_n* := *Name,"User text ={numerical width.dec}"*	MVR3PO,"REACT P OUT={4.1}"	REACT P OUT= 12.1a
DP*nn_n* := *Name,"User {numerical width} text"*	ICD,"C DEMAND={5}"	C DEMAND= 1234a
DP*nn_n* := *Name,"User text ={width.dec,scale}"*	ICD,"C DEMAND={4.2,0.001}kA"	C DEMAND=1.23 kA
DP*nn_ n* := *Name,"User text = {width,scale}"*	MVRHAO,"KVARH OUT A={4,1000}"	KVARH OUT A=1234

Display Point Setting Format	Example Display Point Setting	Example Display
DP*nn_n* := *Name, {Alias}*	1,"FIXED TEXT"	FIXED TEXT
DP*nn_n* := *1,{}*	1,{}	*Empty line*

[a] If configurable registers are used for display points, the alias name of the display point will overwrite the alias name of the configurable register.

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.

Touchscreen Display Menus and Navigation

The touchscreen front panel is the same as the three-line display in regard to the target LEDs, operator control pushbuttons, and the **TARGET RESET** pushbutton. In addition, the touchscreen front panel features a **HOME** pushbutton.

The touchscreen display allows you to:

- View and control custom screens
- Access metering and monitoring data
- Inspect targets
- View event history, summary data, and SER information
- View device status and configuration
- Control operations
- View and edit settings
- Enable the rotating display
- Program control pushbuttons to jump to a specific screen
  - View real-time oscillography
  - Test meter accuracy

Figure 3.8 shows the meter touchscreen display components and indicators.

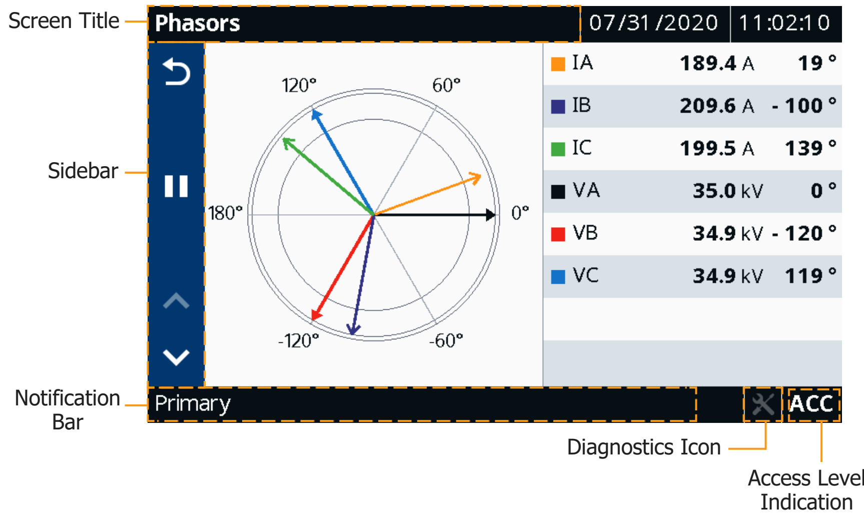
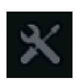
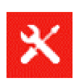


Figure 3.8 Touchscreen Display Components and Indicators

Table 3.13 Touchscreen Display Component and Indicator Descriptions

Display Components and Indicators	Function or Indication
Screen Title	Shows the display name of a screen (see *Figure 3.8*).
Sidebar	Shows the navigation icons (see *Figure 3.8*).
Notification Bar	Shows the notification messages and help text for screens (see *Figure 3.8*).
Diagnostics Icon	ON if there are any warning/diagnostic failures on the unit.
	Normal (no warnings or diagnostic failures present). Icon is OFF.
	Warning. Icon asserts in amber.
	Diagnostic failure. Icon asserts in red.
Access Level Indication	Indicates the access level that the device is on at the time. Shows ACC if the device is on Access Level 1 EAC if the device is on Access Level E, and 2AC if the device is on Access Level 2.

Home Pushbutton

Use the **HOME** pushbutton to return to the Home screen. While the default mapping of the **HOME** pushbutton is the Home screen (see *Figure 3.9*), you can program the **HOME** pushbutton to jump to any screen. Refer to *Table 3.25* for a list of screens available for the **HOME** pushbutton. Use the FPHOME setting in the Touchscreen settings of QuickSet to program a specific screen.

Touchscreen Backlight Adjustment

You can adjust the touchscreen backlight to suit your viewing angle and lighting conditions. To change the backlight settings, tap the **Settings** folder and then tap the **Touchscreen** application. Use the FPBAB setting to adjust the brightness of the display.

Front-Panel Automatic Messages

The meter displays automatic messages that override the present display when there is a diagnostic message. These messages can also be accessed by tapping the Diagnostic Messages application in the Device Info folder.

Front-Panel Security

Use the **Access Level** folder on the Home screen for login/logout operations. The SEL-735 front panel typically operates at Access Level 1 and allows you to view meter measurements and settings. Particular activities, such as editing settings and controlling output contacts, are restricted to those operators who know the Access Level 2 password.

When an activity requires Access Level 2, an authentication screen appears on the display, which requires you to enter the Access Level 2 password to proceed further. After you have correctly entered the password, you can perform other Access Level 2 operations without re-entering the password. You will have to re-enter the password if the front-panel inactivity timer, FPTO, expires.

See *Password Command on page 48* for the list of default passwords and more information on changing the passwords.

Front-Panel Time-Out

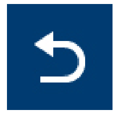
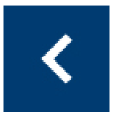
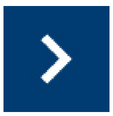
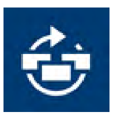
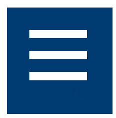
To help prevent unauthorized access to password-protected functions, the SEL-735 provides a front-panel time-out setting, FPTO, in the Touchscreen application in the Settings folder. The time-out resets each time you press a front-panel pushbutton or tap the display. Once the time-out expires, the access level resets to Access Level 1. You can manually reset the access level by tapping **Logout** in the Access Level folder.

Touchscreen

Navigating the Touchscreen Folders and Applications

Use the front-panel touchscreen and pushbuttons to access data measured and stored by the meter and to perform meter operations. All meter information and operations are available through the touchscreen via folders, applications, and the buttons in the sidebar. *Table 3.14* describes the functions of the sidebar buttons.

Table 3.14 Sidebar Buttons

Button	Button Name	Function	Button	Button Name	Function
	Up	Pages up in applications with multiple screens; when on the first screen, this button is disabled.		Back	Returns to the preceding screen, e.g., from applications to folders.
	Down	Pages down in applications with multiple screens; when on the last screen, this button is disabled.		Pause	Stops updating.
	Left	Pages left on the home screen and in folders with multiple screens; this button is hidden if there is no screen to the left.		Play	Updates the phasor values from the meter as the screen refreshes.
	Right	Pages right on the home screen and in folders with multiple screens; this button is hidden if there is no screen to the right.		Refresh	Reloads the data when new data are available.
	Rotating Display	Displays screens on a loop, as designated in settings.		Menu	Flyout menu showing additional selections
	Zoom	Zooms in on the screen graphics		Reset	Resets the accumulating quantities, such as energy, to zero.
	Keyboard	Use to edit meter settings.		Save	Saves the edited settings to the meter.
	Search	Search tool (e.g., search for the status of a Meter Word bit).		Cancel Save	Cancels the setting edits.
	Trash	Deletes the records from the report.			

Navigate the touchscreen by tapping the folders and applications. Tap a folder or an application to view available applications or access an application, respectively. Folders and applications are labeled according to functionality.

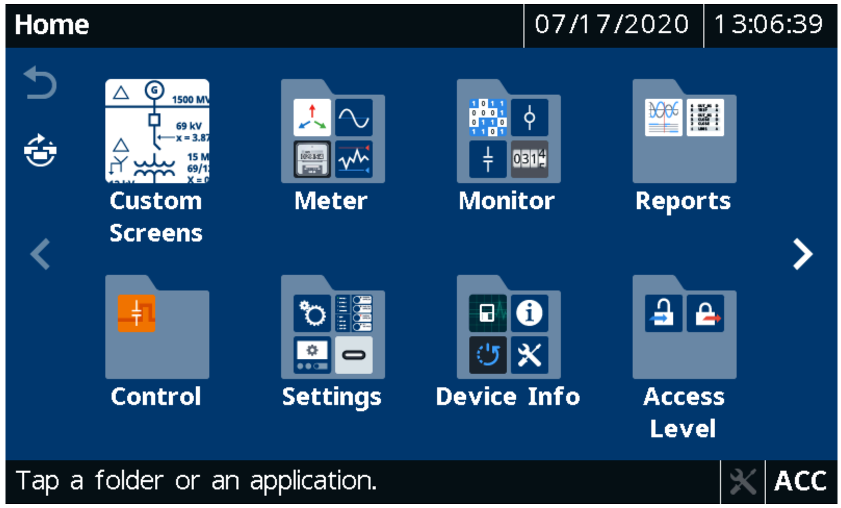


Figure 3.9 Home Screen

From the Home screen you can navigate to all menus in the shown in *Table 3.15*.

Table 3.15 Home Menu

Level 2 Menu	Level 3 Menu	Level 4 Menu
Custom Screens		
Meter	Wave View	
	Phasors	
	Fundamental	
	RMS	
	Energy	
	Max/Min	
	Demand	
	Peak Demand	
	Math Variables	
Monitor	Device Word Bits	
	Digital Outputs	
	Digital Inputs	
	SELOGIC Counters	
Reports	Events	
	SER	
Control	Output Pulsing	
Settings	Port	Port F
		Port 1
		Port 2
		Port 3
		Port 4

Level 2 Menu	Level 3 Menu	Level 4 Menu
	General	
	Energy Preload	
	Front Panel	
	Date and Time	Date
		Time
	Touchscreen	
	Change Password	
Device Info	Status	
	Configuration	
	Reboot	
	Diagnostic Messages	
	Test Mode	
Access Level	Login	
	Logout	
Rotating Display		

Table 3.16 shows a list of folders and applications available on the Home screen.

Table 3.16 Home Folders and Applications

Screen Name	Folder or Application Name
Home	Custom Screens
	Meter
	Monitor
	Reports
	Control
	Device Info
	Access Level
	Settings
	Rotating Display

Custom Screens

Tap this application to navigate to as many as 25 custom-designed screens. For a complete list of default screens and the variables used, see *Table 3.25*. You can design these screens by using ACSELERATOR Bay Screen Builder SEL-5036 Software. Refer to *Section 9: Touchscreen and Custom Screen Settings* for the procedure to create custom screens.

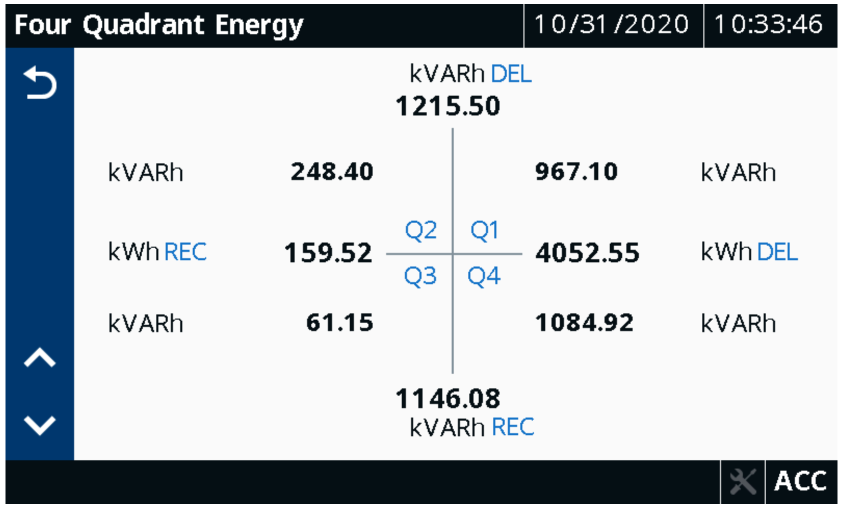


Figure 3.10 Example Default Custom Screen

Meter

Tapping this folder navigates to the Meter screen, as shown in *Figure 3.11*. This screen lists all of the available metering applications. The applications on the Meter screen are part-number dependent. Only those metering applications specific to your part number appear on the Meter screen. Tapping an application on the Meter screen shows you the report for that particular application.

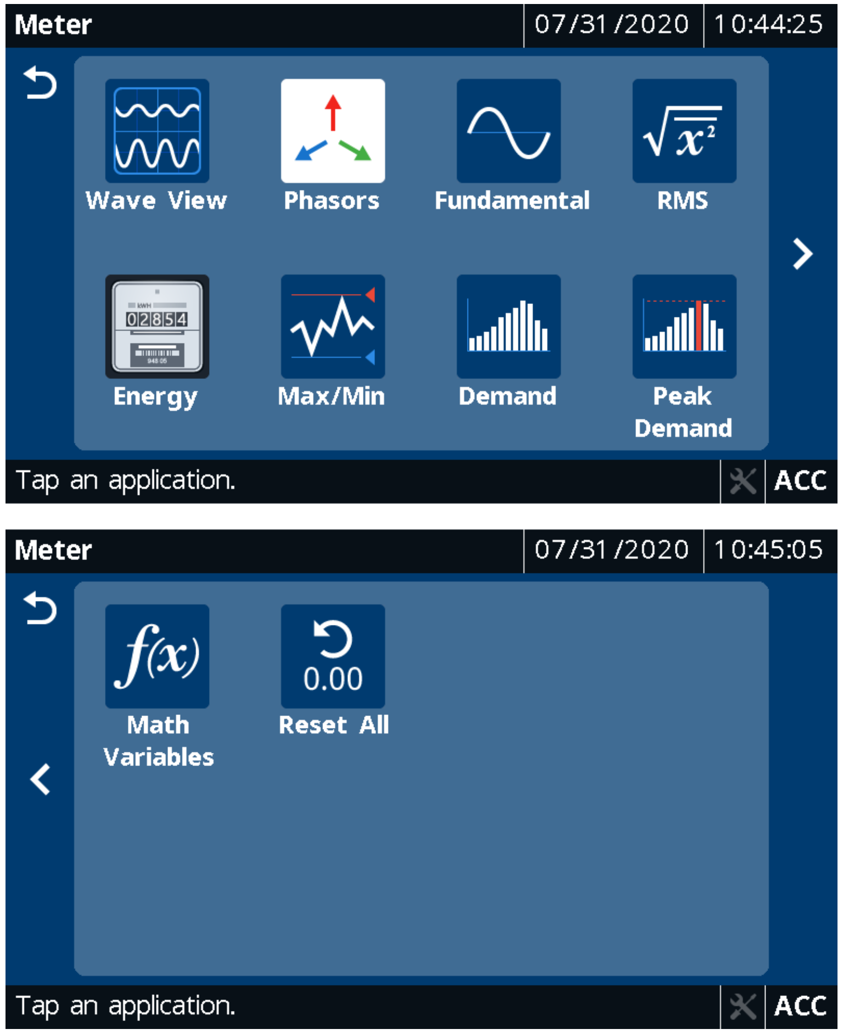


Figure 3.11 Meter Applications

Table 3.17 identifies all the applications available in the Meter folder.

Table 3.17 Meter Application Availability

Folder Name	Application Name
Meter	Wave View
	Phasors
	Fundamental
	RMS
	Energy
	Max/Min
	Demand
	Peak Demand
	Math Variables
	Reset

Wave View provides a graphical view of the waveforms in real time and allows you to freeze the screen if desired. *Figure 3.12* and *Figure 3.13* show typical screens for Wave View.

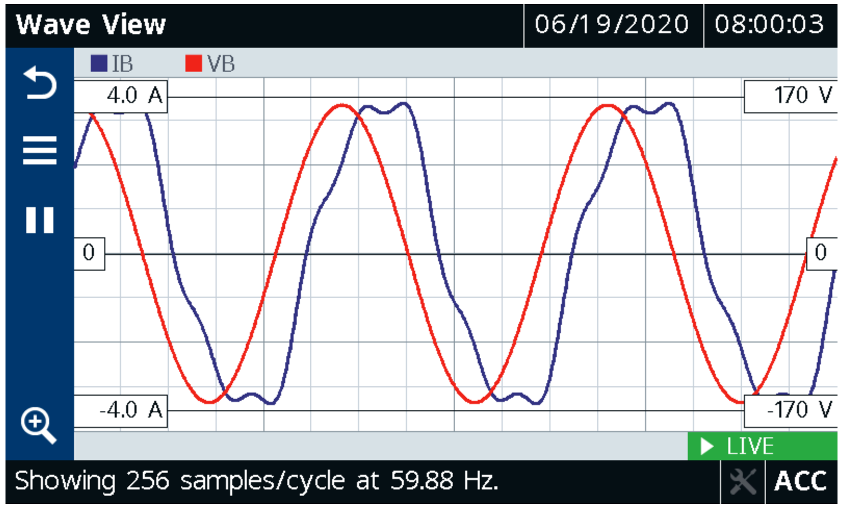


Figure 3.12 Wave View Typical Default

By selecting the flyout menu (icon), you can select the channels you want to display.

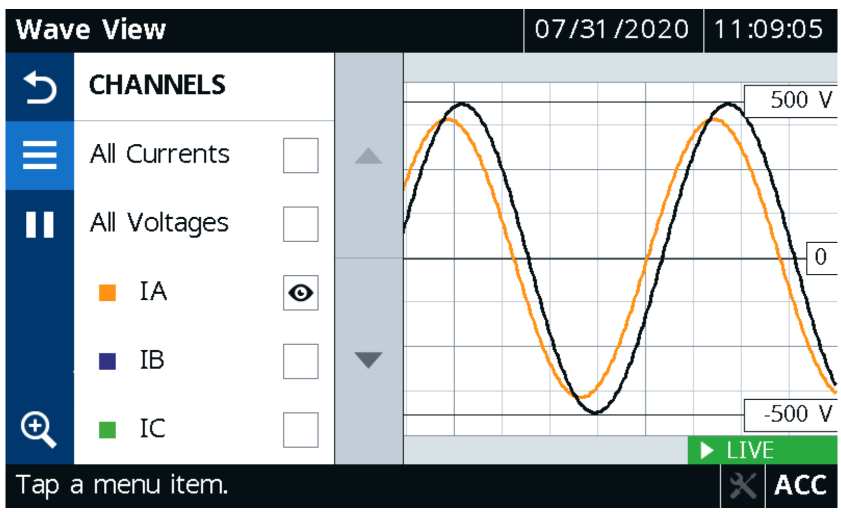


Figure 3.13 Wave View Selecting Display Channels

Figure 3.14 and *Figure 3.15* show typical screens for phasor and fundamental metering.

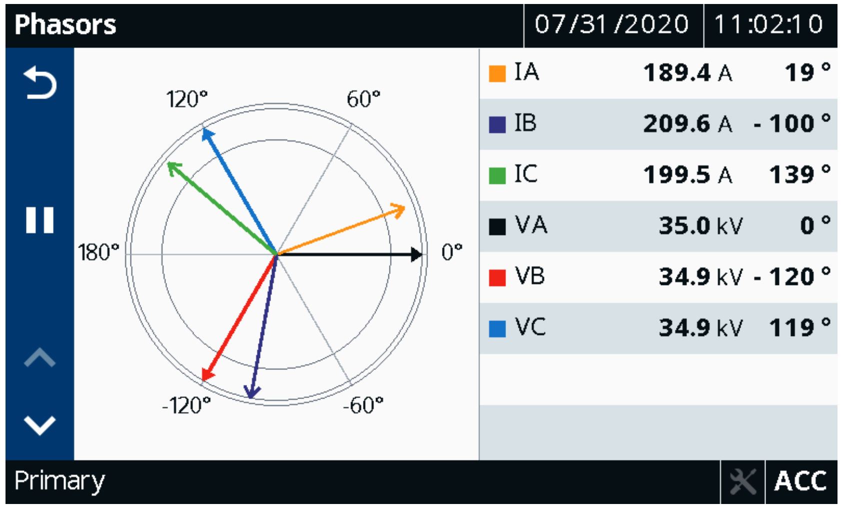


Figure 3.14 Meter Phasors

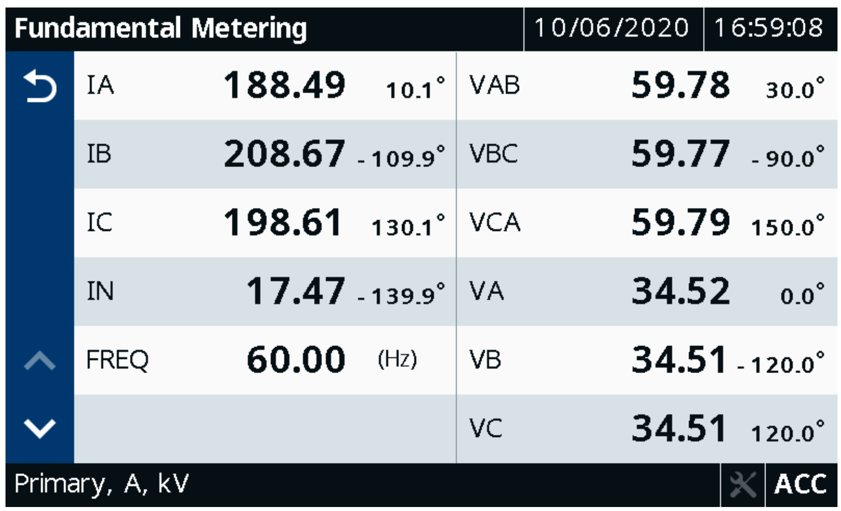


Figure 3.15 Meter Fundamental

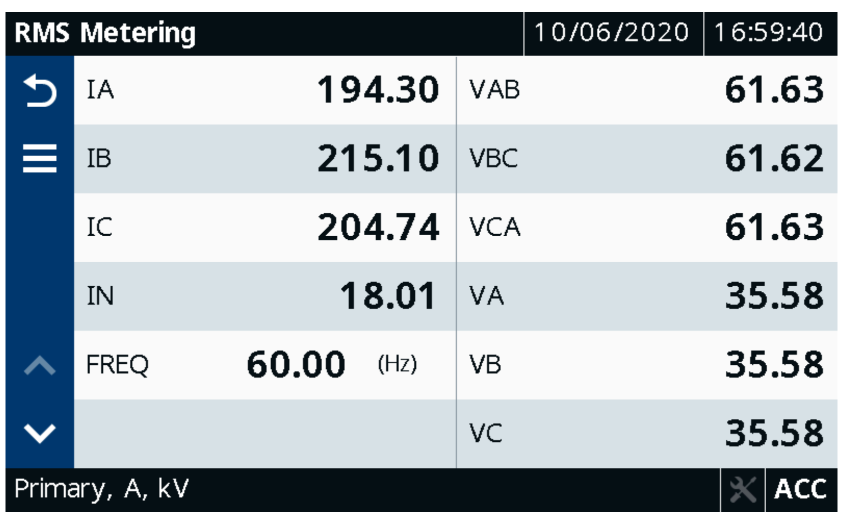


Figure 3.16 Meter RMS

Energy Metering has three screens that provide measures for three-phase and per-phase energy. A reset feature is provided for the Energy, Max/Min, Demand, and Peak Demand applications. Tap the **Reset** button to navigate to the reset confirmation screen. Once you confirm the reset, the data are reset to zero. *Figure 3.17* and *Figure 3.18* show typical screens for energy metering and reset confirmation.

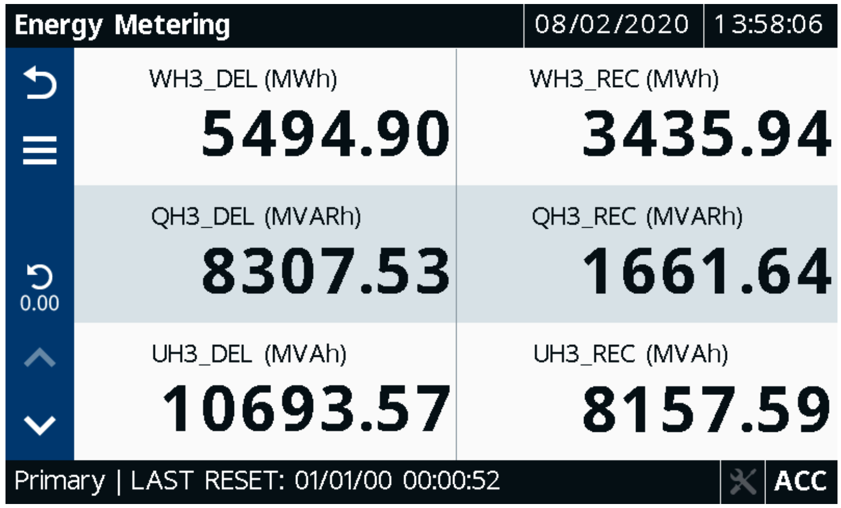


Figure 3.17 Meter Energy

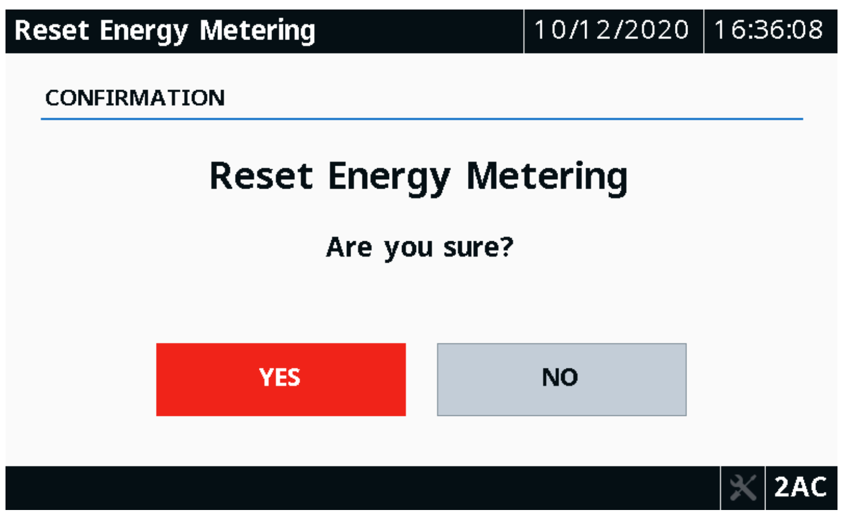


Figure 3.18 Meter Energy Reset

The Peak Demand and Energy applications provide information that can assist in determining billing parameters. These include peak demand and energy consumption values over a day, week, month, year, and a user-configurable period.

Monitor

Tapping this folder navigates you to the Monitor screen, as shown in *Figure 3.19*. Monitor the status of the Device Word bits (targets), digital outputs, digital inputs, SELogic counters, and harmonic alarms.

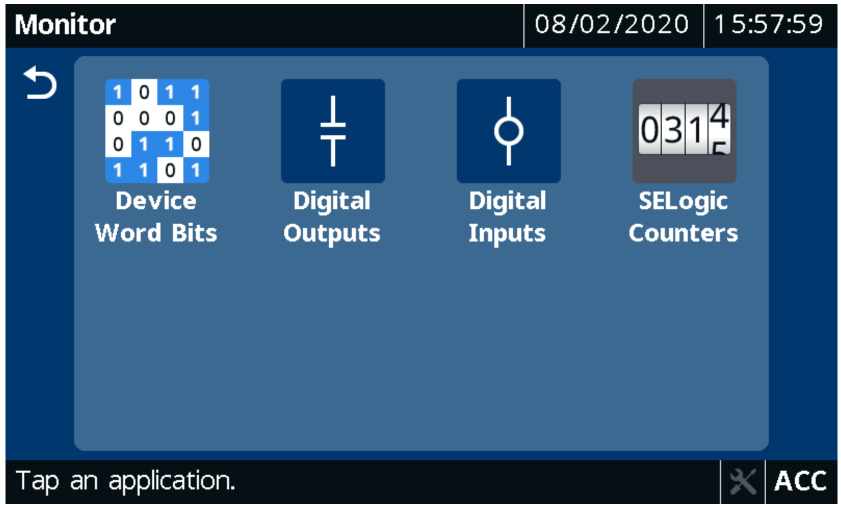


Figure 3.19 Monitor Applications

Table 3.18 identifies all the applications available in the Monitor folder.

Table 3.18 Monitor Application Availability

Folder Name	Application Name	Comments
Monitor	Device Word Bits	See *Appendix G: Analog Quantities and Device Word Bits* for more information.
	Digital Outputs	See *Section 7: Inputs/ Outputs and SELogic Control Equations* for more information.
	Digital Inputs	
	SELogic Counters	

Monitor the status of the Device Word bits by using the Device Word Bits screen. Note that asserted Device Word bits are highlighted in blue. You can use the **Search** button in the Device Word Bits application to view the status of a bit. To search for a Device Word bit, you must enter the full name of the bit in the search field. *Figure 3.20* and *Figure 3.21* show typical Device Word bits monitoring screens.

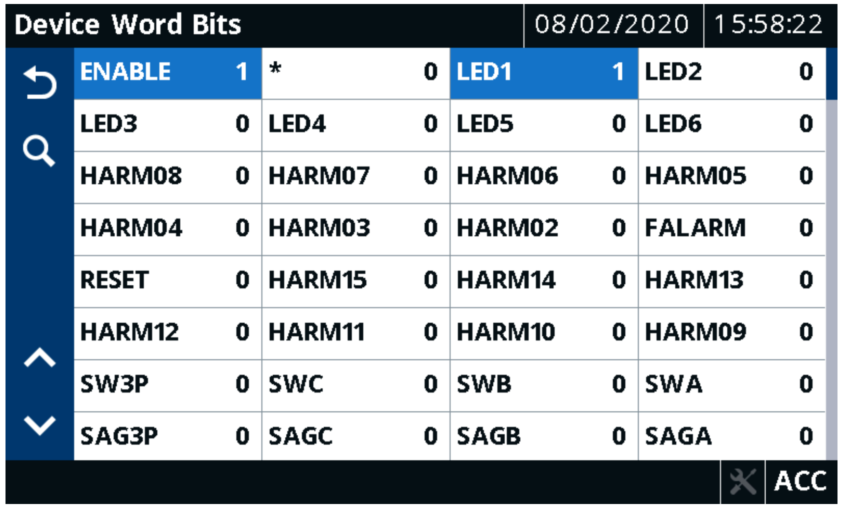


Figure 3.20 Monitor Device Word Bits

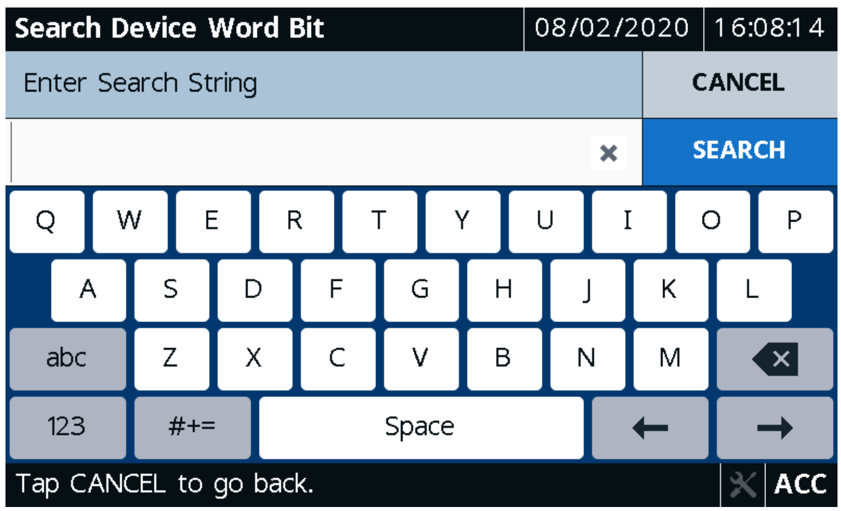


Figure 3.21 Search Device Word Bits

Reports

Tapping this folder navigates you to the Reports screen where you can access the Events and SER applications. Use these applications to view event SERs.

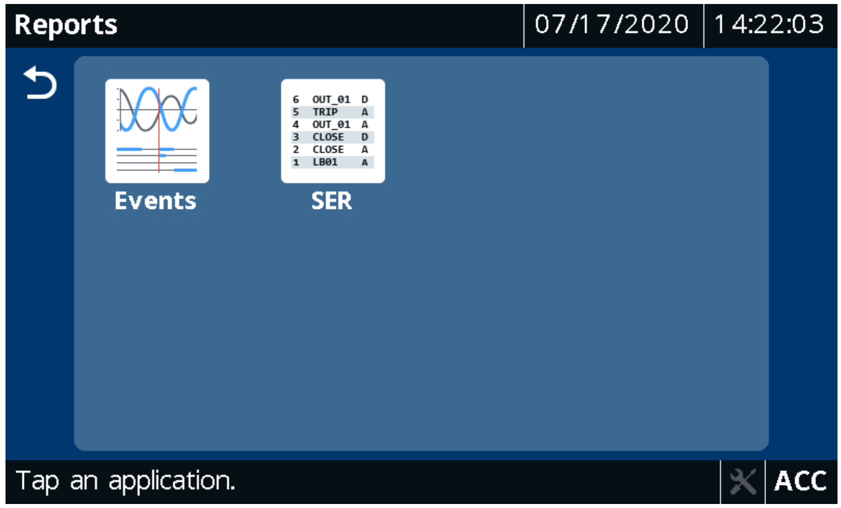


Figure 3.22 Reports Applications

Table 3.19 identifies all the applications available in the Reports folder.

Table 3.19 Reports Application Availability

Folder Name	Application Name
Reports	Events
	SER

To view the summary of a particular event record, tap the event record on the Event History screen. When new records become available while viewing any of the Reports screens (Events, HIF Events, and SER), the up and down buttons are disabled and the footer displays a message to refresh the screen. Update the screen by using the **Refresh** button. Tapping the **Trash** button on the Event History, HIF Event History, and Sequential Events Recorder screens and confirming the delete action removes the records from the device. *Figure 3.23* through *Figure 3.24* show typical Event History, Event Summary, and Sequential Events Recorder screens.

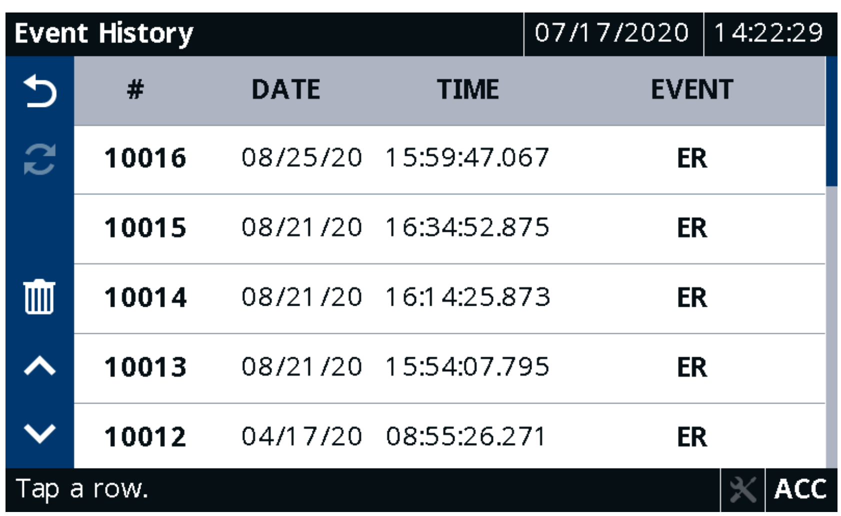


Figure 3.23 Event History

Figure 3.24 Sequential Events Recorder

Control

The Control folder includes an application that pulses the output contacts. Tapping this folder navigates you to the Control screen, as shown in *Figure 3.26*. Use the Output Pulsing application to pulse output contacts. The Output Pulsing applications require that the jumper be installed on the main board. Refer to *Table 10.4* for information on the jumper.

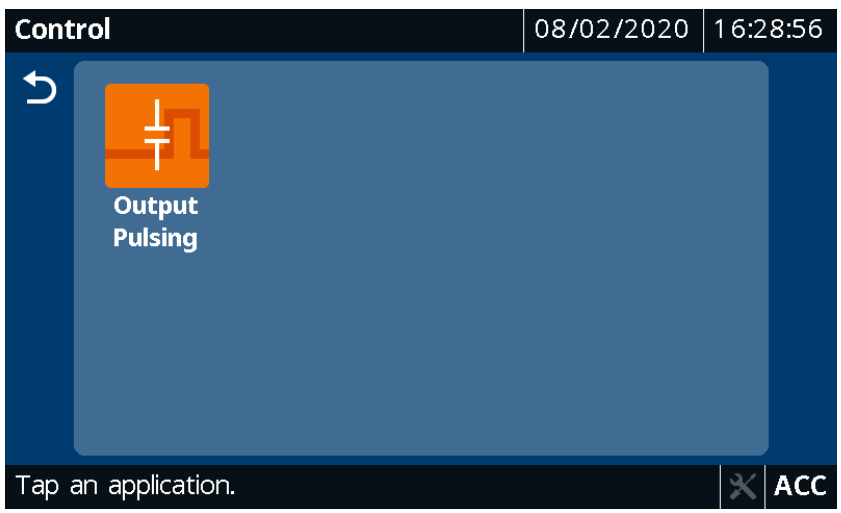


Figure 3.25 Control Applications

Table 3.20 identifies all the applications available in the Control folder.

Table 3.20 Control Application Availability

Folder Name	Application Name
Control	Output Pulsing

To pulse a digital output contact, tap the Output Pulsing application. Navigate to the desired output contact screen, tap the desired output, and confirm the control action. The output tile will be highlighted in blue on assertion, as shown in *Figure 3.26*. An output contact will not pulse if it is already asserted. Pulsing the output contact requires that the jumper be installed and that you have Level 2 access.

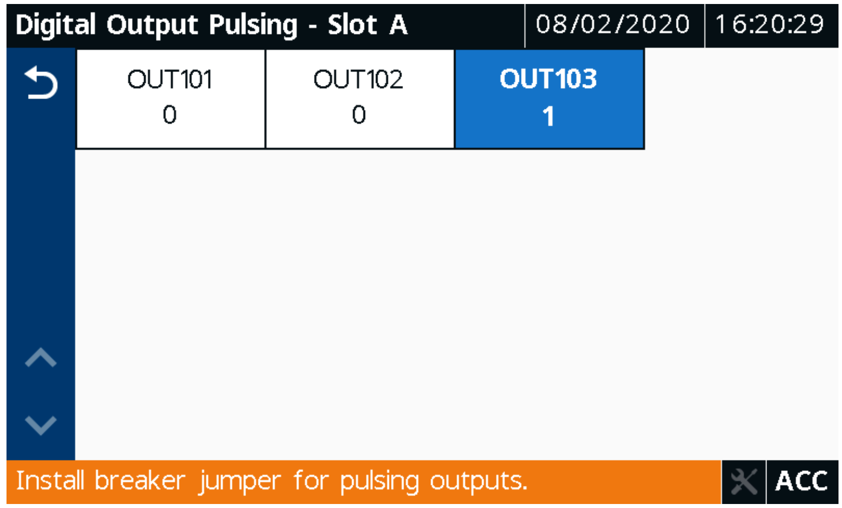


Figure 3.26 Digital Output Pulsing—Slot A

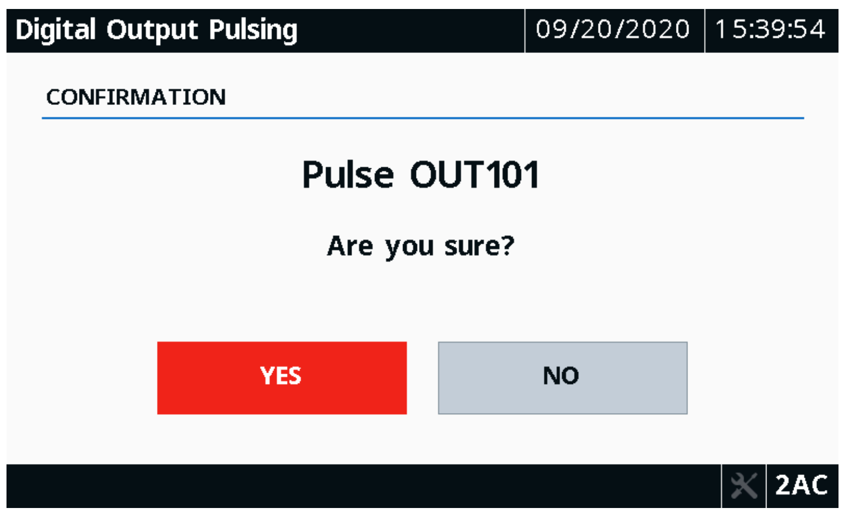


Figure 3.27 Digital Output Pulsing Confirmation

Device Info

Tapping this folder navigates to the Device Info screen to access specific device information applications, including Status, Configuration, Reboot, Diagnostics, and Test Mode.

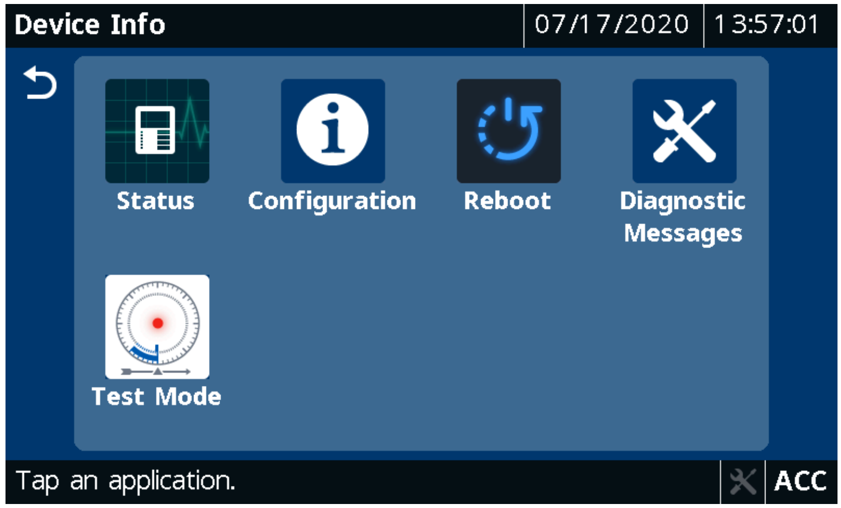


Figure 3.28 Device Info Applications

Table 3.21 identifies all the applications available in the Device Info folder.

Table 3.21 Device Info Application Availability

Folder Name	Application Name
Device Info	Status
	Configuration
	Reboot
	Diagnostic Messages
	Test Mode

Status

Tap **Status** to view the device status, firmware version, part number, etc., as shown in *Figure 3.29*.

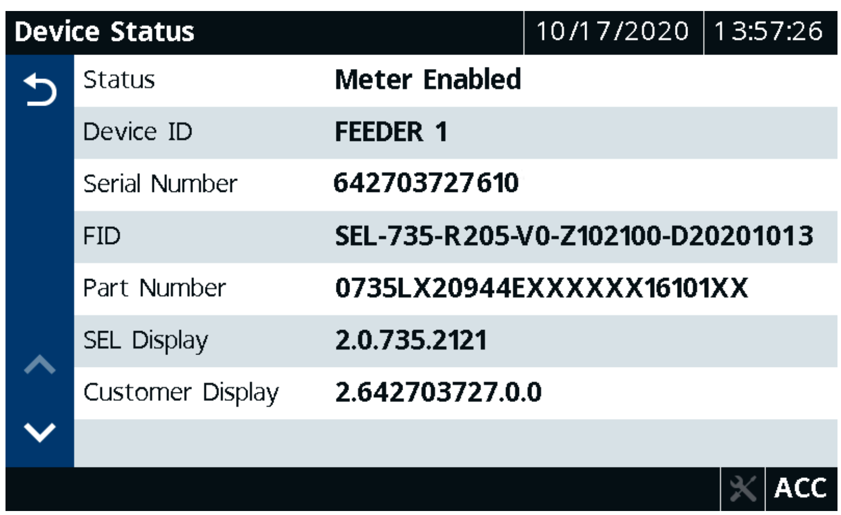


Figure 3.29 Device Status

Configuration

Use **Configuration** to view port information such as the jumper positions for the output. *Figure 3.30* through *Figure 3.31* show typical screens for device configuration, device status, and trip and diagnostic messages. Most boards are self-identifying. For more information, refer to the *SEL Meter Circuit Card Upgrade Instructions*. For more on communication settings, see *Section 8: Communications*.

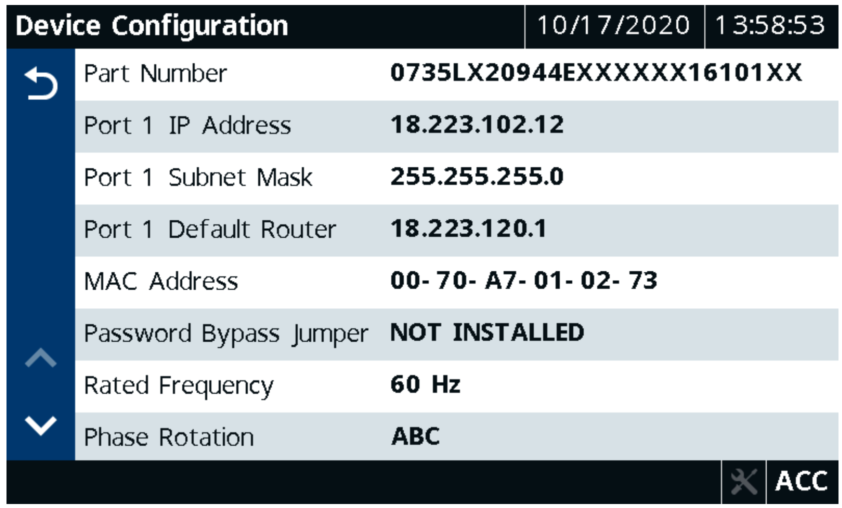


Figure 3.30 Device Configuration

If the meter detects any new card in one of the slots, it disables and directs you to accept the change in configuration, as shown in *Figure 3.31*.

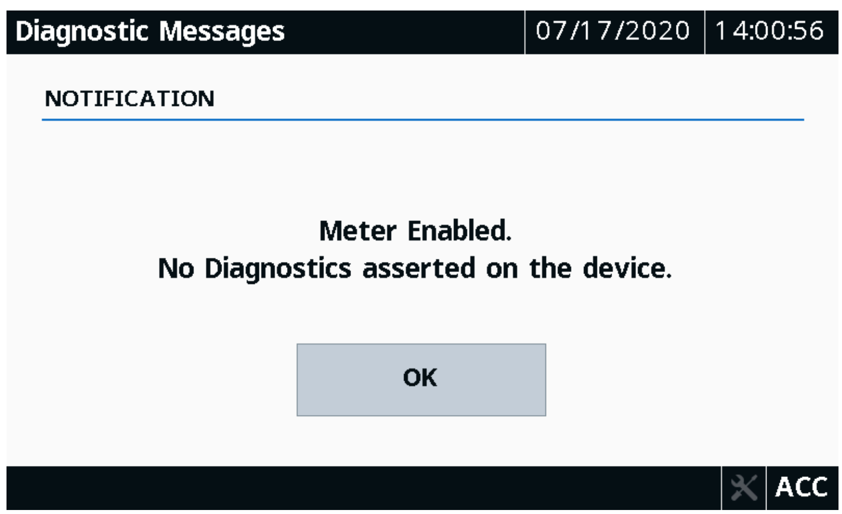


Figure 3.31 Diagnostic Messages

If you see the message `Meter Disabled`, check that you have entered the new meter part number in QuickSet. For more information, see the SEL instruction sheet *SEL-735 Meter Circuit Card Upgrade Instructions*.

For more information on Test Mode, see *TEST Mode Characteristics on page 311*.

Access Level

Tapping this folder navigates to the Access Level screen where you can either log in to or log out of Access Level 2.

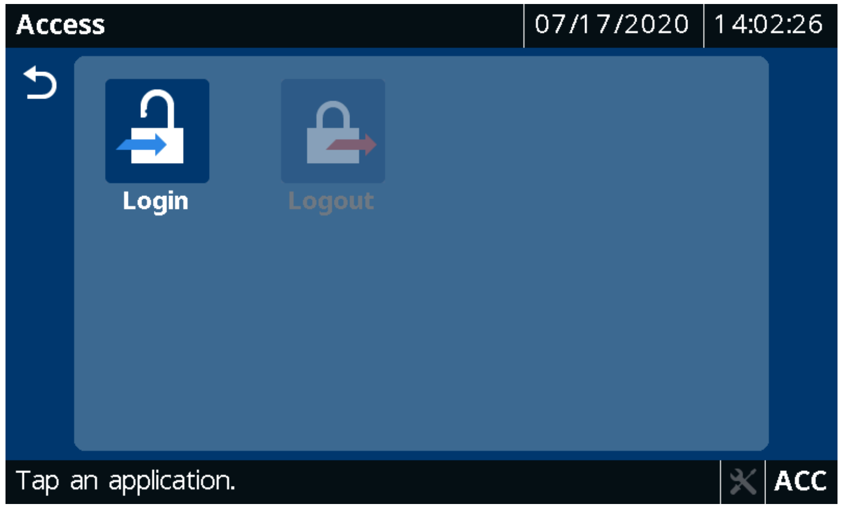


Figure 3.32 Access Level Applications

Table 3.22 identifies all of the applications available in the Access Level folder.

Table 3.22 Access Level Application

Folder Name	Application Name
Access Level	Login
	Logout

Note that when a folder requires Access Level 2 and the meter is at Access Level 1, the meter automatically opens the authentication screen requiring you to enter the password before performing a control operation, editing setting, etc.

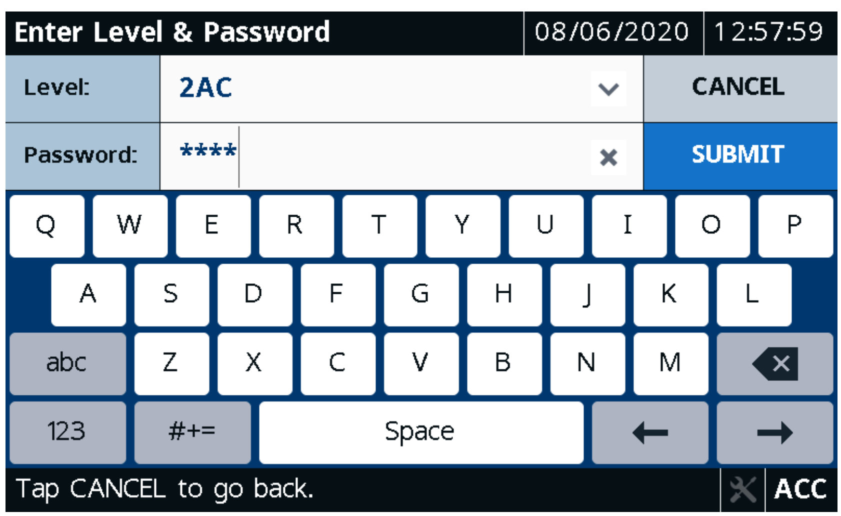


Figure 3.33 Authentication Screen

Settings

Tapping this folder navigates you to the Settings screen where you can access settings applications or settings folders (Port, Group, Date, Time, and Touchscreen) through which you can set or show settings.

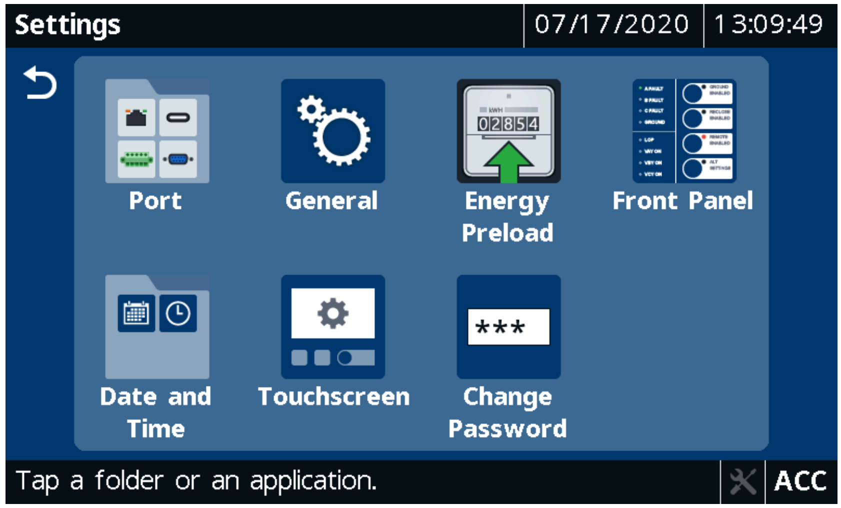


Figure 3.34 Settings Folders and Applications

Table 3.23 identifies all of the folders and applications available in the Settings folder.

Table 3.23 Settings Folder and Applications

Folder Name	Folder or Application Name
Settings	Port
	General
	Energy Preload
	Front Panel
	Date and Time
	Touchscreen
	Change Password

Table 3.24 identifies all the applications available in each folder in the Settings folder.

Table 3.24 Settings Folders Port, Group, and Date and Time Application Availability

Folder Name	Application Name
Port (For setting details, see *Section 8: Communications*)	Port F
	Port 1
	Port 2
	Port 3
	Port 4

Folder Name	Application Name
General (For setting details, see *Section 5: Metering*)	Identifier and Scaling
	Instrument Transformer Compensation
	Demand Metering
	Transformer/Line-Loss Compensation
	KYZ Pulse Outputs
	Output Contacts
	Fast Messages
Energy Preload (For setting details, see *Section 5: Metering*)	Compensated
	Uncompensated
Front Panel	Pushbutton Functionality
	LED Logic Equations
Date and Time	Date
	Time
Touchscreen	–
Change Password	–

Figure 3.35 shows typical port settings.

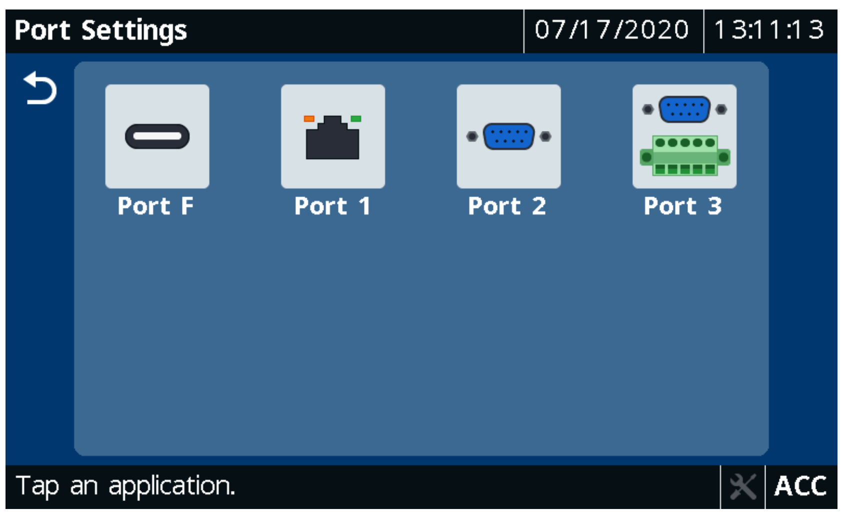


Figure 3.35 Port Settings

To edit a setting, tap on a setting row and enter the Access Level 2 password. If the access level is already at Access Level 2, the meter does not prompt for password authentication. After entering the value, tap the **Save** button to save the edit, or select the **Cancel Save** button to cancel the edit (see *Table 3.14*). Before moving to a new folder, save your changes to prevent loss of the new settings.

Port F

Tap any of the items to change the configuration in Access Level 2.

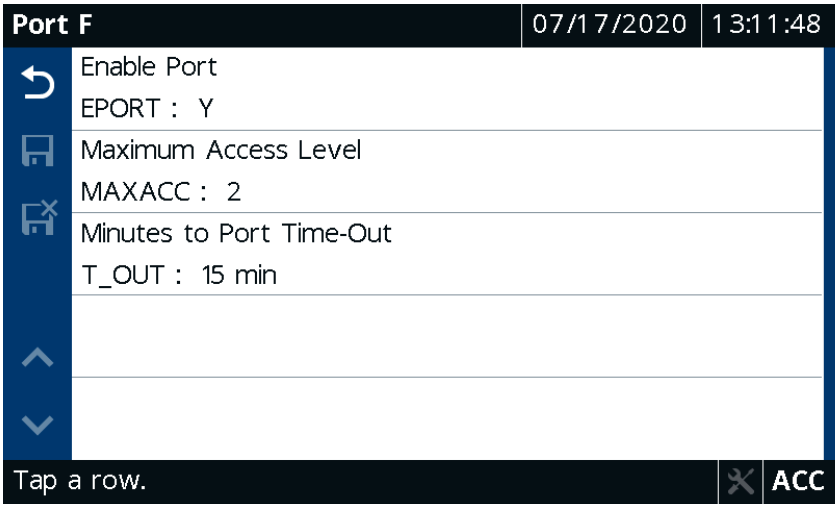


Figure 3.36 Port F

Port 1

Tap any of the items to change the configuration in Access Level 2.

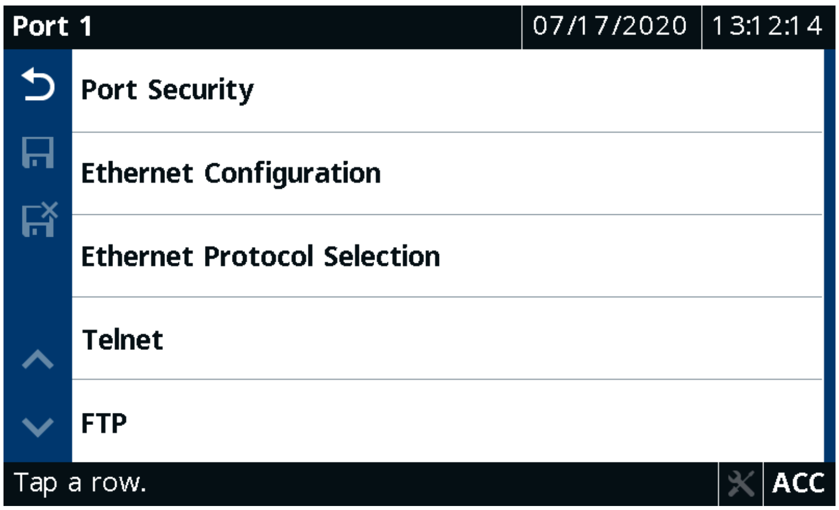


Figure 3.37 Port 1

Tap any Port 1 item to view or change settings. For an example of using selections within a menu, see *Menu Navigation Examples on page 98*.

Port 2

Tap any of the items to change the settings in Access Level 2.

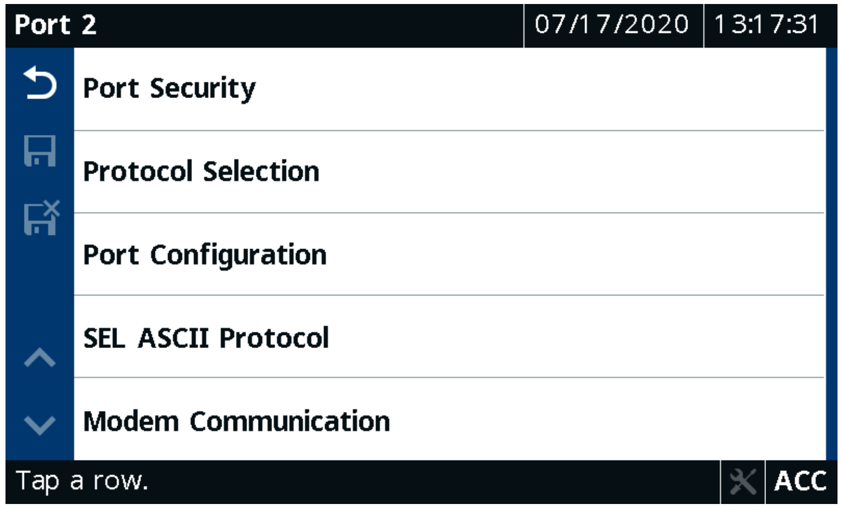


Figure 3.38 Port 2

Port 2 Port Security

Tap any of the items to change the settings in Access Level 2.

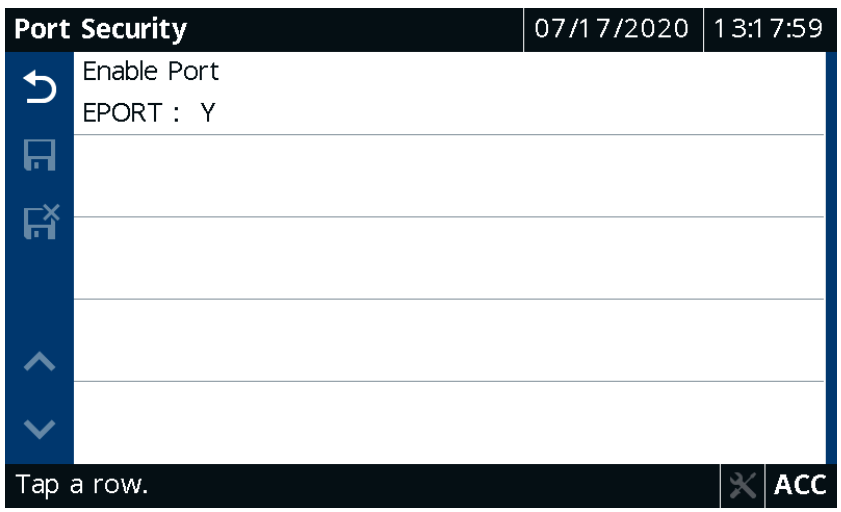


Figure 3.39 Port 2 Port Security

Port 2 Protocol Selection

Tap any of the items to change the settings in Access Level 2.

Figure 3.40 Port 2 Protocol Selection

Port 2 Port Configuration

Tap any of the items to change the settings in Access Level 2.

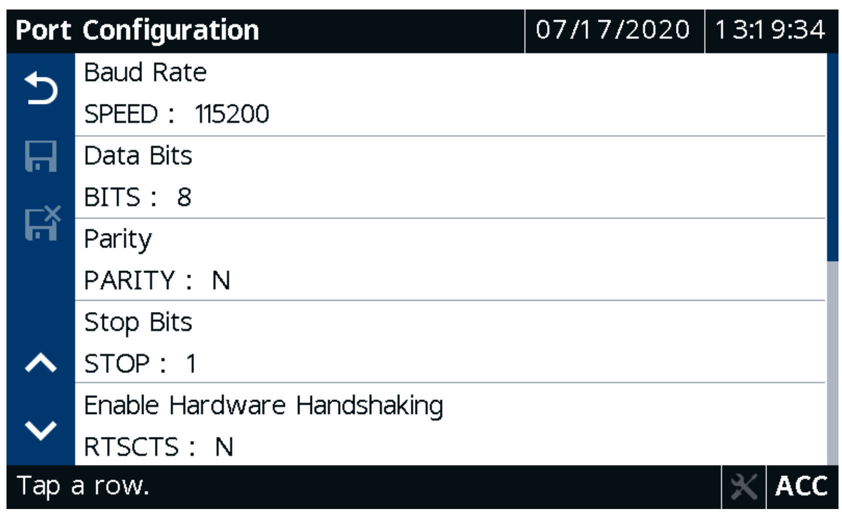


Figure 3.41 Port 2 Port Configuration

Port 2 SEL ASCII Protocol

Tap any of the items to change the settings in Access Level 2.

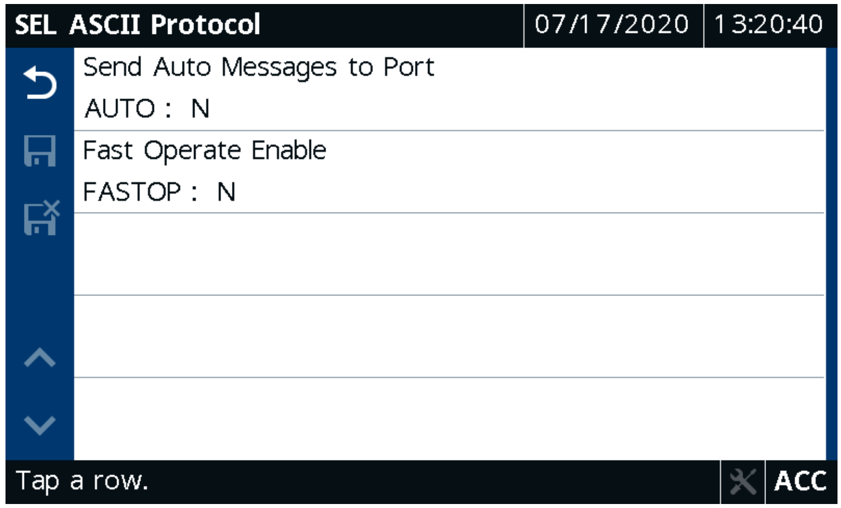


Figure 3.42 Port 2 SEL ASCII Protocol

Port 2 Modem Communication

Tap any of the items to change the settings in Access Level 2.

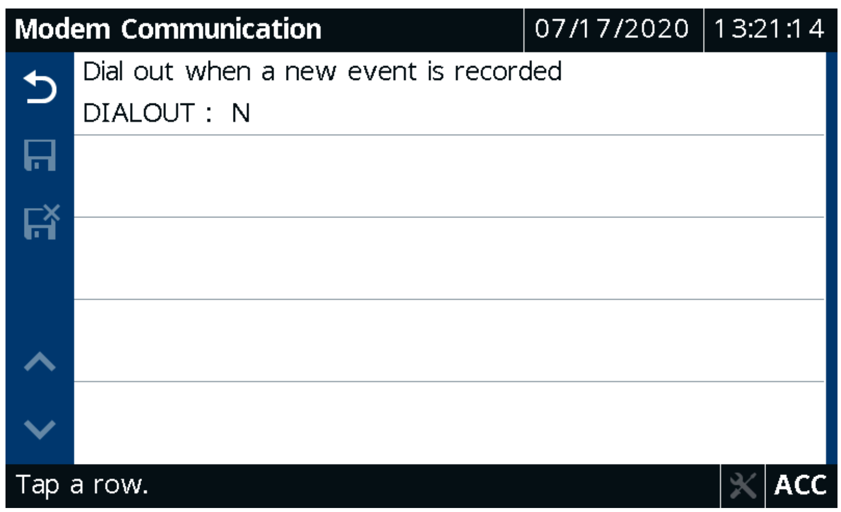


Figure 3.43 Port 2 Modem Communication

Port 3

Tap any of the items to change the settings in Access Level 2.

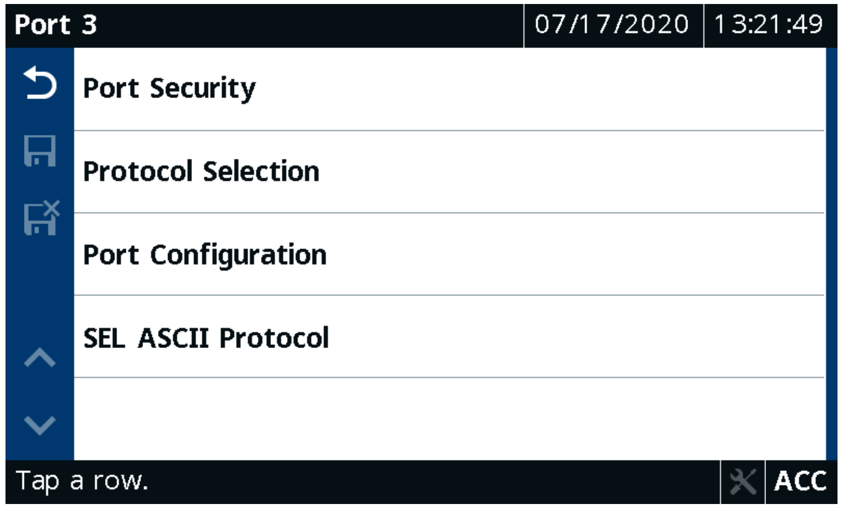


Figure 3.44 Port 3

Port 3 Port Security

Tap any of the items to change the settings in Access Level 2.

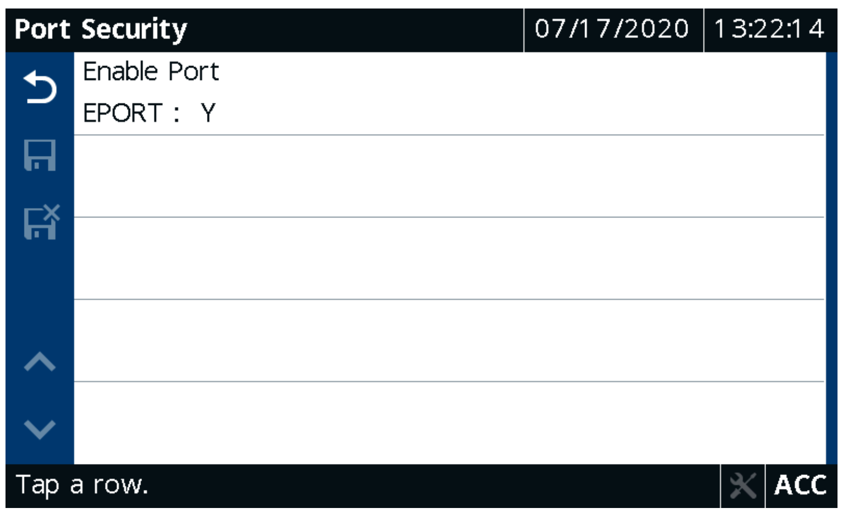


Figure 3.45 Port 3 Port Security

Port 3 Protocol Selection

Tap any of the items to change the settings in Access Level 2.

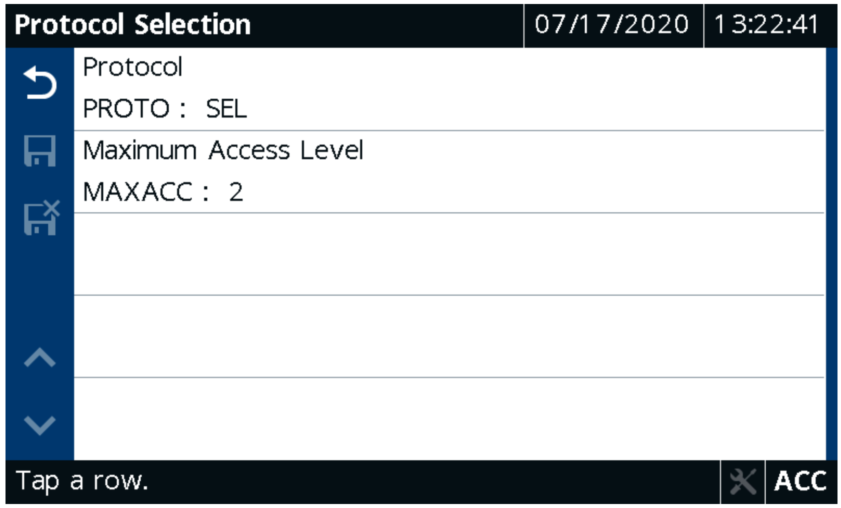


Figure 3.46 Port 3 Protocol Selection

Port 3 Port Configuration

Tap any of the items to change the settings in Access Level 2.

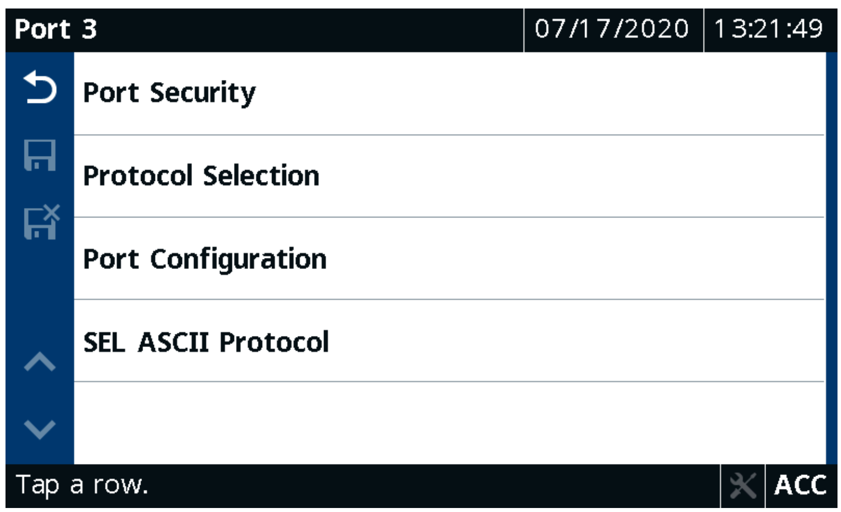


Figure 3.47 Port 3 Port Configuration

Port 3 SEL ASCII Protocol

Tap any of the items to change the settings in Access Level 2.

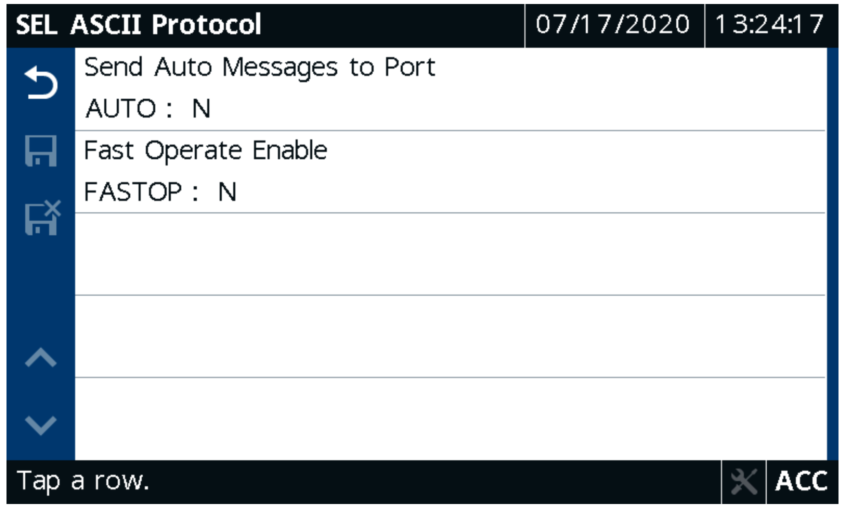


Figure 3.48 Port 3 SEL ASCII Protocol

Rotating Display

Tapping this application or icon allows you to start the rotating display. You can pick as many as 25 screens through which the display can rotate after the inactivity timer expires. Refer to *Table 3.25* for all the default screens and available quantities on each.

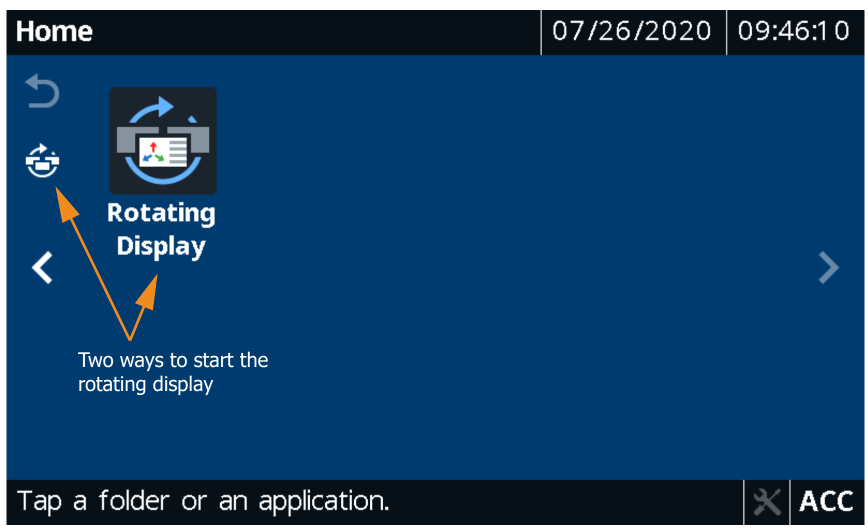


Figure 3.49 Start Rotating Display

Tapping any screen while the display is rotating takes you to that particular screen. You can perform the needed operation and use the **Back** button to return to the Home screen.

If the Display Home Screen (FPHOME) is configured for Rotating Display (ROTATE), the display will automatically scroll through the various displays after the meter is turned on or after you refresh a timed-out display.

Table 3.25 Screens Available for the Rotating Display, HOME Pushbutton, and Programmable Pushbuttons

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
Custom Screens				
		Month Energy and Peak Demand	CWH3_DEL, CWH3_DEL_1M, CWH3_REC, CWH3_REC_1M, PRES_W_1_PD, PREV_W_1_PD	
		Accumulated Energy	WH3_DEL, CWH3_REC, QH3_DEL, QH3_REC	
		Peak Demand	WP3_DEL, WP3_REC, QP3_DEL, QP3_REC	
		Line-to-Line Voltage and Current	VAB, IA, VBC, IB, VCA, IC	
		Line-to-Neutral Voltage and Current	VA, IA, VB, IB, VC, IC	
		Power Factor and Unbalance	PFD3 LDPFD3, PFT3 LDPFT3, V_IMB, I_IMB	
		Four Quadrant Demand	QD3_DEL_LD, WD3_REC, QD3_DEL, QD3_DEL_LG, WD3_DEL, QD3_REC_LG, QD3_REC, QD3_REC_LD	
		Four Quadrant Energy	QH3_DEL_LD, WH3_DEL, QH3_DEL_LG, QH3_DEL, QH3_REC_LG, WH3_REC, QH3_REC_LD, QH3_REC	
		Line-to-Line Voltage	VAB, VBC, VCA	
		Line-to-Neutral Voltage	VA, VB, VC	
		Line Current	IA, IB, IC	
		ANSI Configuration Label	NA	
		IEC Configuration Label	NA	
		2nd–8th Voltage Harmonics	HRM2_VA, HRM2_VB, HRM2_VC, HRM3_VA, HRM3_VB, HRM3_VC, HRM4_VA, HRM4_VB, HRM4_VC, HRM5_VA, HRM5_VB, HRM5_VC, HRM6_VA, HRM6_VB, HRM6_VC, HRM7_VA, HRM7_VB, HRM7_VC, HRM8_VA, HRM8_VB, HRM8_VC, FREQ_PQ	

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
		9th–15th Voltage Harmonics	HRM9_VA, HRM9_VB, HRM9_VC, HRM10_VA, HRM10_VB, HRM10_VC, HRM11_VA, HRM11_VB, HRM11_VC, HRM12_VA, HRM12_VB, HRM12_VC, HRM13_VA, HRM13_VB, HRM13_VC, HRM14_VA, HRM14_VB, HRM14_VC, HRM15_VA, HRM15_VB, HRM15_VC, FREQ_PQ	
		16th–22nd Voltage Harmonics	HRM16_VA, HRM16_VB, HRM16_VC, HRM17_VA, HRM17_VB, HRM17_VC, HRM18_VA, HRM18_VB, HRM18_VC, HRM19_VA, HRM19_VB, HRM19_VC, HRM20_VA, HRM20_VB, HRM20_VC, HRM21_VA, HRM21_VB, HRM21_VC, HRM22_VA, HRM22_VB, HRM22_VC, FREQ_PQ	
		2nd–8th Current Harmonics	HRM2_IA, HRM2_IB, HRM2_IC, HRM3_IA, HRM3_IB, HRM3_IC, HRM4_IA, HRM4_IB, HRM4_IC, HRM5_IA, HRM5_IB, HRM5_IC, HRM6_IA, HRM6_IB, HRM6_IC, HRM7_IA, HRM7_IB, HRM7_IC, HRM8_IA, HRM8_IB, HRM8_IC, FREQ_PQ	
		9th–15th Current Harmonics	HRM9_IA, HRM9_IB, HRM9_IC, HRM10_IA, HRM10_IB, HRM10_IC, HRM11_IA, HRM11_IB, HRM11_IC, HRM12_IA, HRM12_IB, HRM12_IC, HRM13_IA, HRM13_IB, HRM13_IC, HRM14_IA, HRM14_IB, HRM14_IC, HRM15_IA, HRM15_IB, HRM15_IC, FREQ_PQ	
		16th–22nd Current Harmonics	HRM16_IA, HRM16_IB, HRM16_IC, HRM17_IA, HRM17_IB, HRM17_IC, HRM18_IA, HRM18_IB, HRM18_IC, HRM19_IA, HRM19_IB, HRM19_IC, HRM20_IA, HRM20_IB, HRM20_IC, HRM21_IA, HRM21_IB, HRM21_IC, HRM22_IA, HRM22_IB, HRM22_IC, FREQ_PQ	

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
Meter				
	Phasors			
		Phasor Screen 1	IA_FUND, IA_ANG, IB_FUND, IB_ANG, IC_FUND, IC_ANG, VAB_FUND, VAB_ANG, VBC_FUND, VBC_ANG, VCA_FUND, VCA_ANG	
		Phasor Screen 2	I1_MAG, I1_ANG, 3I2_MAG, 3I2_ANG, 3I0_MAG, 3I0_ANG, V1_MAG, V1_ANG, V2_MAG, V2_ANG, 3V0_MAG, 3V0_ANG	
	Fundamental			
		Fundamental Screen 1	IA_FUND IA_ANG, VAB_FUND VAB_ANG, IB_FUND IB_ANG, VBC_FUND VBC_ANG, IC_FUND IC_ANG, VCA_FUND VCA_ANG, IN_FUND IN_ANG, VA_FUND VA_ANG, FREQ, VB_FUND VB_ANG	
		Fundamental Screen 2	W3_FUND, Q3_FUND, S3_FUND, PFD3, LDPFD3	
		Fundamental Screen 3	WA_FUND, WB_FUND, WC_FUND, QA_FUND, QB_FUND, QC_FUND, SA_FUND, SB_FUND, SC_FUND, PFDA LDPFDA, PFDB LDPFDB, PFDC LDPFDC	
	RMS			
		RMS Screen 1	IA, VAB, IB, VBC, IC, VCA, IN, VA, FREQ, VB, VC	
		RMS Screen 2	W3/W3_UC, Q3/Q3_UC, U3, PFT3, LDPFT3	
		RMS Screen 3	WA/WA_UC, WB/WB_UC, WC/WC_UC, QA/QA_UC, QB/QB_UC, QC/QB_UC, UA, UB, UC, PFTA LDPFTA, PFTB LDPFTB, PFTC LDPFTC	
	Energy			
		Energy Screen 1	WH3_DEL, WH3_REC, QH3_DEL, QH3_DEL, UH3_DEL, UH3_DEL	

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
		Energy Screen 2	WHA_DEL, WHB_DEL, WHC_DEL WHA_REC, WHB_REC, WHC_REC, WHA_NET, WHB_NET, WHC_NET	Note that in some older SEL devices, WHA_NET, WHB_NET, WHC_NET , and WH3_NET are named EA_NET, EB_NET, EC_NET, and E3_NET, respectively
		Energy Screen 3	QHA_DEL, QHB_DEL, QHC_DEL, QHA_REC, QHB_REC, QHC_REC, UHA_DEL, UHB_DEL, UHC_DEL, UHA_REC, UHB_REC, UHC_REC	
	Max/Min			
		Max/Min Screen 1	IAMX, IAMX_D, IAMX_T, IAMN, IAMN_D, IAMN_T, IBMX, IBMX_D, IBMX_T, IBMN, IBMN_D, IBMN_T, ICMX, ICMX_D, ICMX_T, ICMN, ICMN_D, ICMN_T	
		Max/Min Screen 2	INMX, INMX_D, INMX_T, INMN, INMN_D, INMN_T	
		Max/Min Screen 3	VAMX, VAMX_D, VAMX_T, VAMN, VAMN_D, VAMN_T, VBMX, VBMX_D, VBMX_T, VBMN, VBMN_D, VBMN_T, VCMX, VCMX_D, VCMX_T, VCMN, VCMN_D, VCMN_T	
		Max/Min Screen 4	W3MX, W3MX_D, W3MX_T, W3MN, W3MN_D, W3MN_T, U3MX, U3MX_D, U3MX_T, U3MN, U3MN_D, U3MN_T, Q3MX, Q3MX_D, Q3MX_T, Q3MN, Q3MN_D, Q3MN_T	
	Demand			
		Demand Screen 1	IDA, IDN, IDB, 3I0D, IDC,3I2D	
		Demand Screen 2	WD3_DEL, WD3_REC, QD3_DEL, QD3_REC, UD3_DEL, UD3_REC	
		Demand Screen 3	WDA_DEL, WDA_REC, WDB_DEL, WDB_REC, WDC_DEL, WDC_REC	
		Demand Screen 4	QDA_DEL, QDA_REC, QDB_DEL, QDB_REC, QDC_DEL, QDC_REC	
	Peak Demand			
		Peak Demand Screen 1	WP3_DEL, WP3_REC, QP3_DEL, QP3_REC, UP3_DEL, UP3_REC	

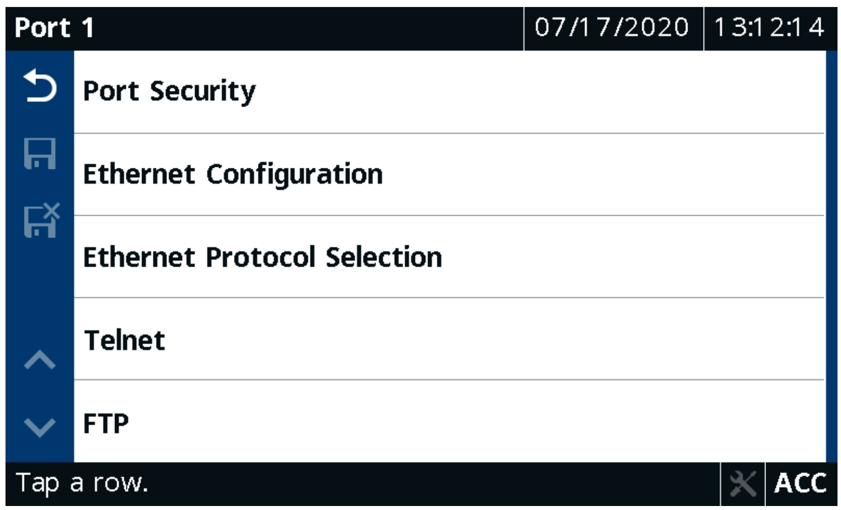
Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
		Peak Demand Screen 2	IPA	
		Peak Demand Screen 3	WP3_DEL, WP3_DEL_D, WP3_DEL_T, WP3_REC, WP3_REC_D, WP3_REC_T, WPA_DEL, WPA_DEL_D, WPA_DEL_T, WPA_REC, WPA_REC_D, WPA_REC_T, WPB_DEL, WPB_DEL_D, WPB_DEL_T, WPB_REC, WPB_REC_D, WPB_REC_T, WPC_DEL, WPC_DEL_D, WPC_DEL_T, WPC_REC, WPC_REC_D, WPC_REC_T	
		Peak Demand Screen 4	QP3_DEL, QP3_DEL_D, QP3_DEL_T, QP3_REC, QP3_REC_D, QP3_REC_T, QPA_DEL, QPA_DEL_D, QPA_DEL_T, QPA_REC, QPA_REC_D, QPA_REC_T, QPB_DEL, QPB_DEL_D, QPB_DEL_T, QPB_REC, QPB_REC_D, QPB_REC_T, QPC_DEL, QPC_DEL_D, QPC_DEL_T, QP3_REC, QPC_REC_D, QPC_REC_T	
		Peak Demand Reset Screen	UP3_DEL, UP3_DEL_D, UP3_DEL_T, UP3_REC, UP3_REC_D, UP3_REC_T, UPA_DEL, UPA_DEL_D, UPA_DEL_T, UPA_REC, UPA_REC_D, UPA_REC_T, UPB_DEL, UPB_DEL_D, UPB_DEL_T, UPB_REC, UPB_REC_D, UPB_REC_T, UPC_DEL, UPC_DEL_D, UPC_DEL_T, UP3_REC, UPC_REC_D, UPC_REC_T	
		Peak Demand Reset Screen	IPA, IPA_D, IPA_T, IPB, IPB_D, IPB_T, IPC, IPC_D, IPC_T, IPN, IPN_D, IPN_T	
Monitor				
	Device Word Bits	Device Word Bits Screen 1	Shows status of all the Device Word bits	Shows 32 Device Word bits per page
	Digital Inputs	Digital Inputs Screen 1	IN101, IN102	
	Digital Outputs	Digital Outputs Screen 1	OUT101, OUT102, OUT103	
	SELOGIC Counters	SELOGIC Counters Screens	SC01–SC32	

Home Screen Folders and Applications	Folder and Application Names	Display Name	Quantities	Comments
Reports				
	Events	Event History Screen 1		Shows the event records in the device
	SER	SER Screen 1		Shows the Sequential Events Records (SERs) in the device

Menu Navigation Examples

Port 1

Tap any of the items to change the configuration in Access Level 2.



Port Security

Tap Port Security to view or change the port security settings.

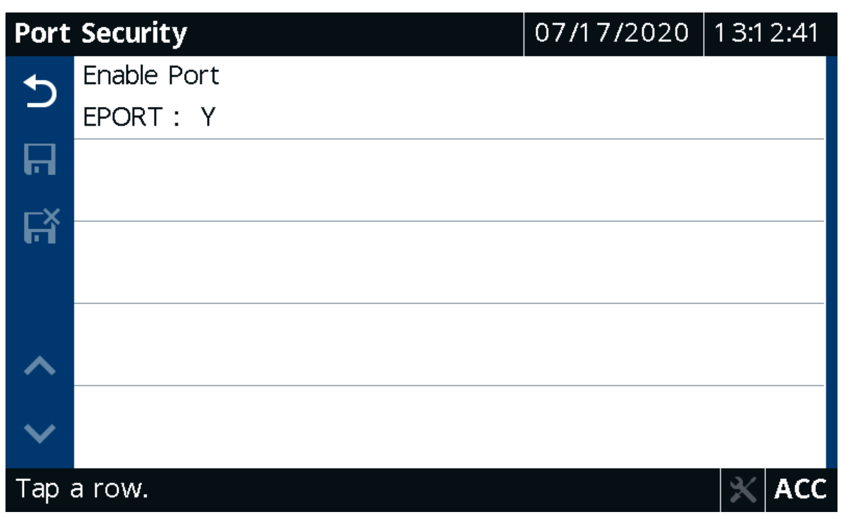


Figure 3.50 Port 1 Port Security

Ethernet Configuration

To change the IP address, tap **IP Address**. You will be prompted for the Access Level 2 password.

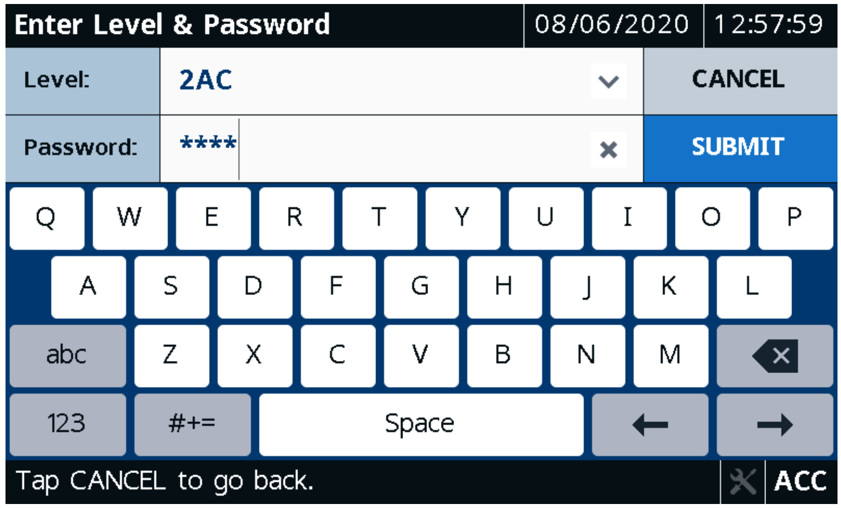


Figure 3.51 Enter Password

After submitting the password, the IP address appears. Make the change as necessary.

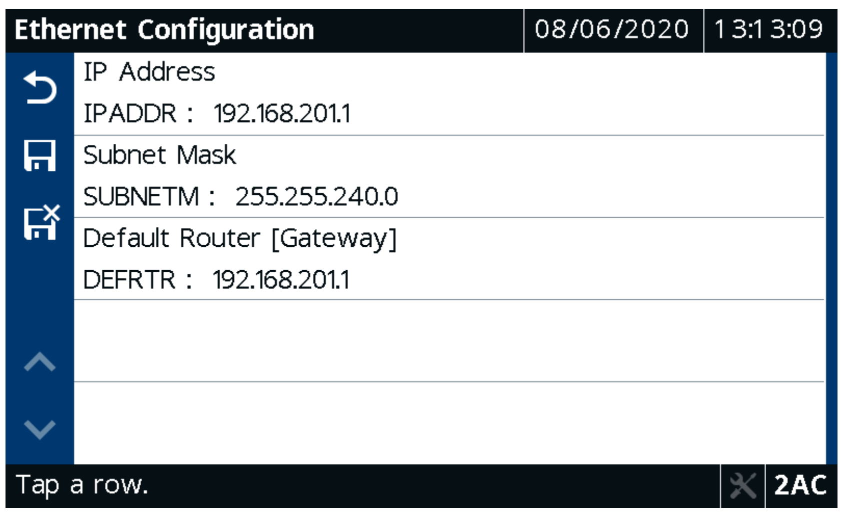


Figure 3.52 Ethernet Configuration Screen

Figure 3.53 Change IP Address

After you tap **Submit**, the configuration screen appears again. If the settings look good, tap the save icon. No changes are applied to the meter until you save the settings.

Ethernet Protocol

Tap any item under Ethernet Protocol Selection to change the configuration. Saving new port settings will cause the SEL-735 to restart.

Telnet

Tap any item on the Telnet screen to change the configuration.

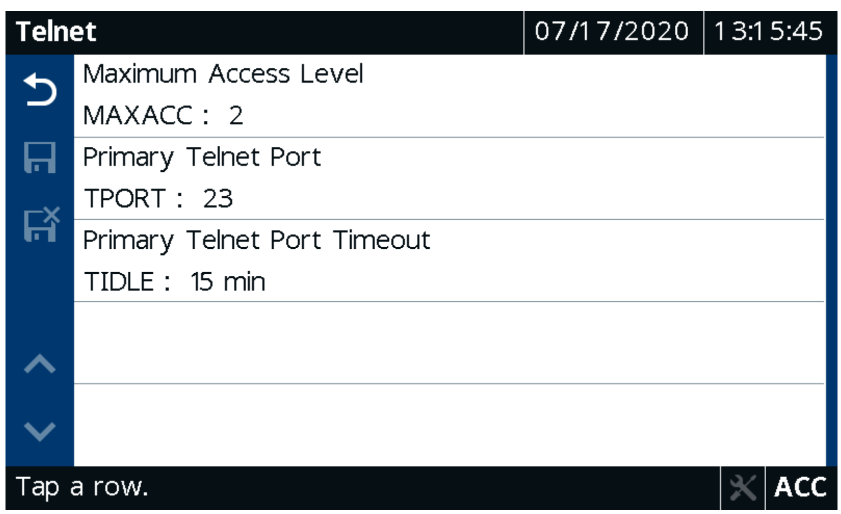


Figure 3.54 Telnet

FTP

Tap any item on the FTP screen to change the configuration.

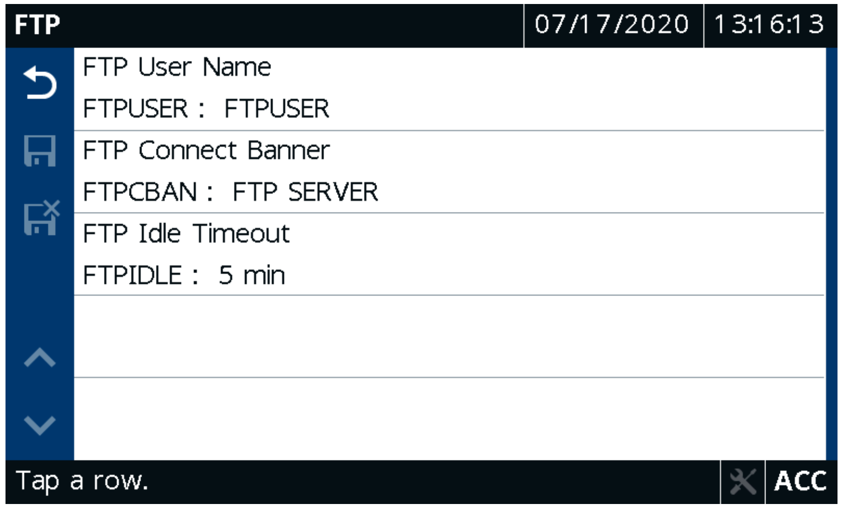


Figure 3.55 FTP

Ethernet Protocol Selection

Tap any item on the Ethernet Protocol Selection screen to change the configuration.

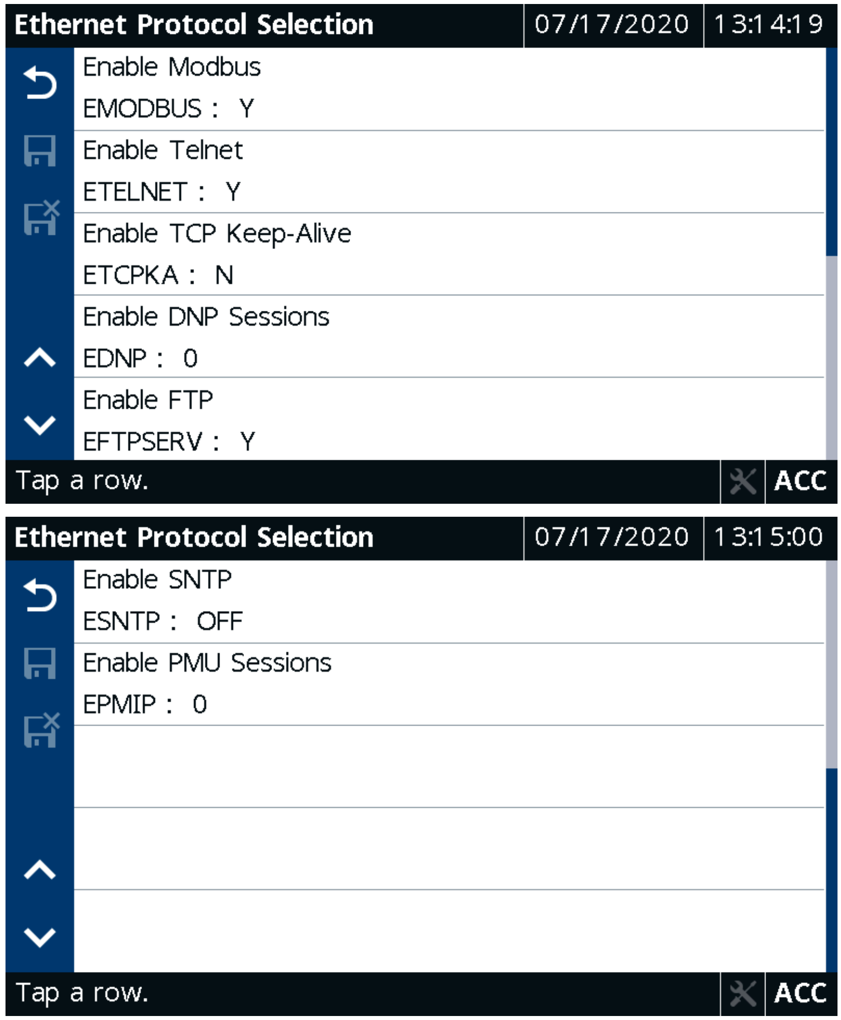


Figure 3.56 Ethernet Protocol Selection

Front-Panel Operator Control Pushbuttons

The SEL-735 touchscreen display features four operator-controlled pushbuttons, PB01–PB04, each with two programmable tricolor pushbutton LEDs. Refer to *Front-Panel Operations on page 52* for details on operator control pushbuttons and LEDs and their programming.

You can program the selectable operator pushbutton screen settings under the Touchscreen settings category in QuickSet and map the button to a specific screen. For example, PB03, which is used to capture a waveform by default, can be programmed to jump to a custom screen by mapping the pushbutton touchscreen setting FPPB03 to Custom Screen 1.

In addition to the listed screens, the Home screen is available for the **HOME** pushbutton. By default, the **HOME** pushbutton is programmed to the Home screen.

SECTION 4

ACSELERATOR QuickSet

Overview

Each SEL-735 ships with the ACSELERATOR QuickSet SEL-5030 Software. Use QuickSet to perform the following tasks.

- Read and send configuration settings with an SEL-735.
- Save and open configuration settings on a PC.
- Monitor real-time power system data.
- Control the meter remotely.
- Configure the communications ports.
- Retrieve the LDP, SER, and VSSI reports.
- Display real-time and recorded waveforms from event reports.

Install QuickSet

Install QuickSet by downloading it from selinc.com/products/5030/, or, on the SEL website, select **Products > All Software Downloads**, check the **Configuration** checkbox, and select **ACSELERATOR QuickSet SEL-5030 Software**. Select **Download**, save, and then run Setup.exe. A wizard will guide an installation or an upgrade of QuickSet.

Configure QuickSet Communications

From a Windows PC, open QuickSet by selecting **Start > SEL Applications >** ACSELERATOR **QuickSet** or by double-clicking the QuickSet icon. For initial communications, connect any available serial or optical port on the meter to the PC through use of an ANSI optical probe, an SEL-C234 or SEL-C287 serial cable, an SEL-C662 serial-to-USB cable, or an SEL-497 Type-A-to-Type-C USB cable.

The SEL-735 supports various optical probes. *Table 4.1* lists compatible probes and any special requirements.

Table 4.1 Optical Probes[a]

SEL-735 Compatible Optical Probes	Connector	Special Instructions
ABACUS ELECTRICS A6Z	DB-9	None
ABACUS ELECTRICS A7Z	DB-9	DTR Off
ABACUS ELECTRICS A9U	USB	DTR Off; requires software driver
ELSTER/ABB UNICOM III	DB-9	DTR Off

SEL-735 Compatible Optical Probes	Connector	Special Instructions
GE SmartCoupler SC-1A	DB-9	DTR Off
Intelliprobe IP503-330	USB	DTR Off; Maximum 19200 bps rate
Microtex Electronics FR3	USB	Maximum 19200 bps rate; requires software driver
P+E Tecnik K01-USB	USB	Requires software driver; cannot use to upgrade firmware
Probe-Tec 392010	USB	DTR Off; Maximum 38400 bps rate
uData Net PM500-300	DB-9	DTR Off; requires power from ac adapter or connector for mouse or keyboard

[a] Not available on color touchscreen model.

To access the communications parameters in QuickSet, select **Communications > Parameters**. *Figure 4.1* shows the default serial port parameters for the SEL-735.

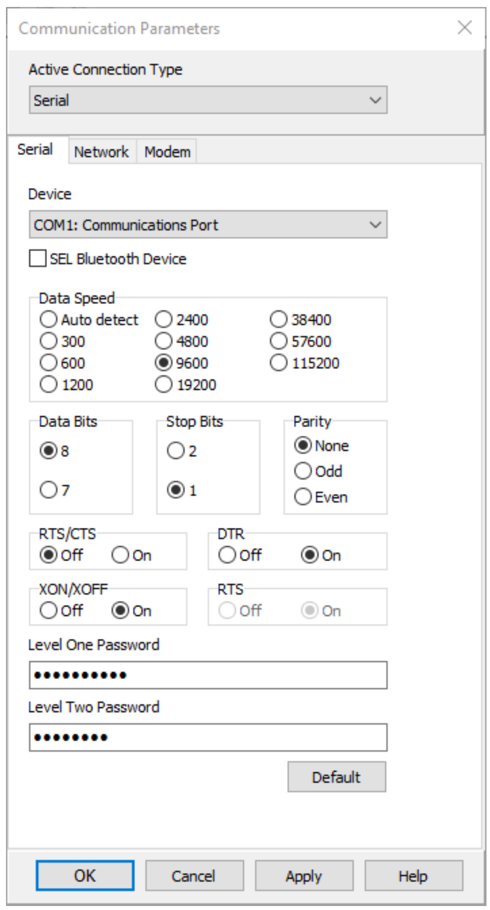


Figure 4.1 Default Communications Parameters

The USB-C cable is a nonproprietary plug-and-play cable. The Device dropdown menu displays **SEL CP210x USB to UART Bridge** for an SEL-C662 cable and **SEL Fast CDC USB Device** for an SEL-C497 USB-A to USB-C cable when plugged into the SEL-735 front port.

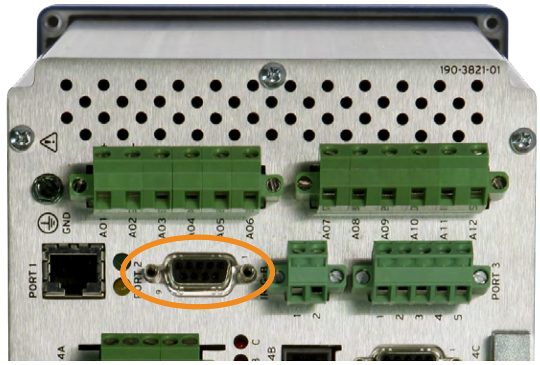


Figure 4.2 SEL-735 Serial Port 2

Figure 4.3 Cables for the SEL-735

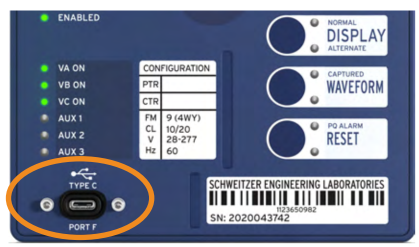


Figure 4.4 SEL-735 Serial Port F

Settings Editor

This section discusses how to read, modify, save, and send configuration settings within QuickSet.

Toolbar and Icon Functions

QuickSet allows access to features through both menus and icons. This document describes how to access features using the menu structure. *Figure 4.5* illustrates the icon functions in the QuickSet toolbar.

NOTE
Hover over icons to view the title and function.

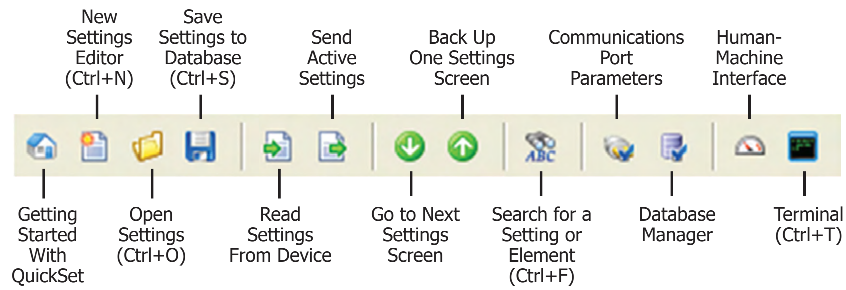


Figure 4.5 Icon Functions

Read Configuration Settings From the Meter Into QuickSet

Before editing configuration settings, QuickSet must read them from the SEL-735.

Select **File > Read** to read meter configuration settings.

Modify Configuration Settings

A settings tree view appears when QuickSet successfully reads meter configuration settings from the SEL-735.

Select the plus sign (+) to expand a setting group, or select a group name to see all associated configuration settings as shown in *Figure 4.6*.

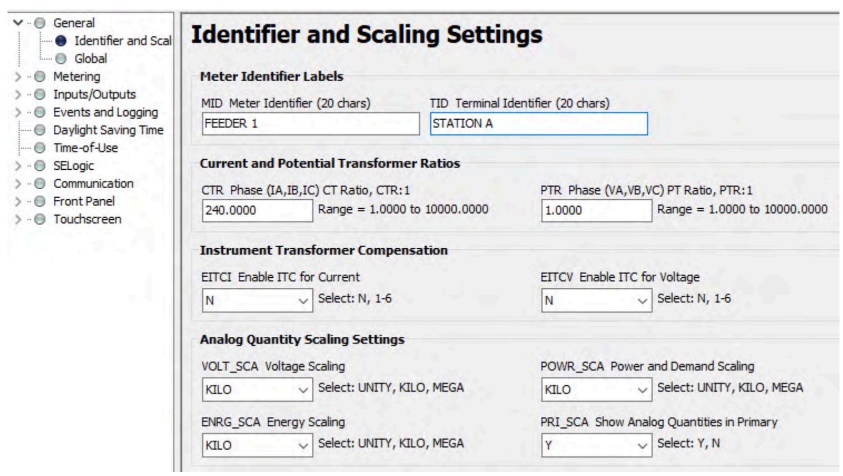


Figure 4.6 Meter Configuration Settings

QuickSet automatically hides unavailable configuration settings and flags invalid configuration settings at the bottom of the screen.

Right-click any setting for the previous or default value.

Save Configuration Settings to the PC Hard Drive

Select **File > Save** to save changes made within QuickSet to the PC hard drive. Replace **New Settings 1** in the **Settings Name** text box with a unique name. Select **OK** to save the configuration settings to the QuickSet settings database on the PC hard drive.

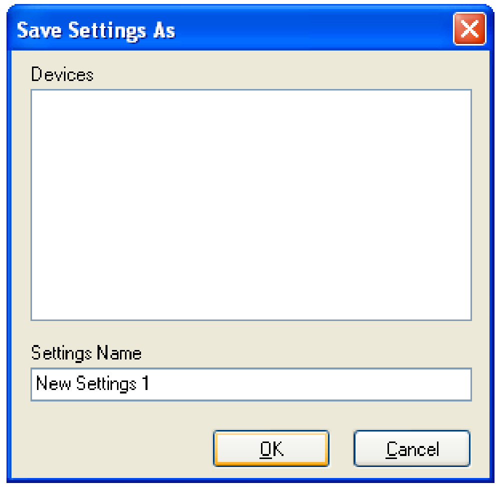


Figure 4.7 Save Settings

Send Configuration Settings to the Meter to Update All Modified Configuration Settings

The **File > Send** command sends any changes made within QuickSet to the meter. QuickSet automatically selects modified configuration settings groups and warns if these settings will overwrite existing data or change active communications parameters.

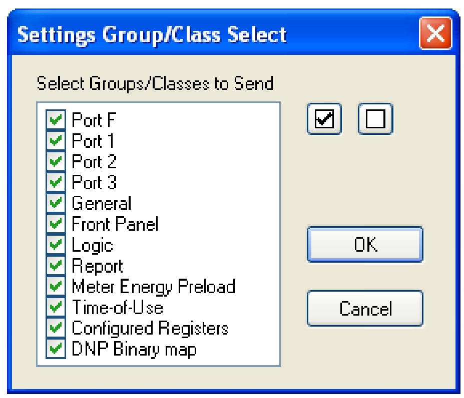


Figure 4.8 Settings Group/Class Select

Settings

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

Store and Retrieve Settings

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.

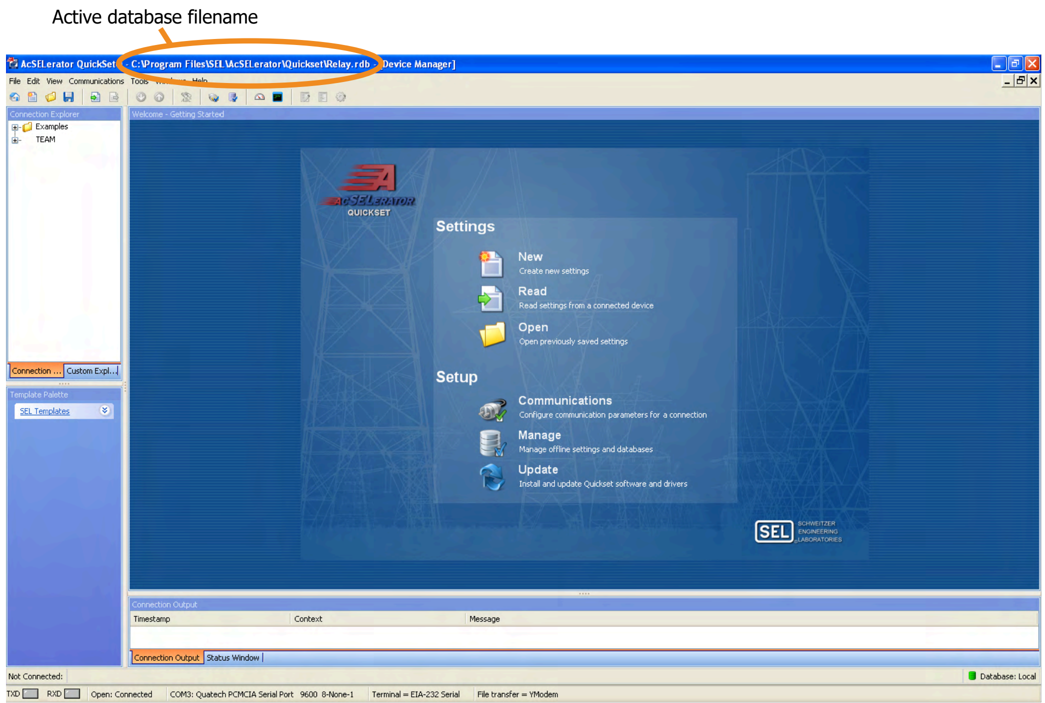


Figure 4.9 QuickSet Initial View

You can save multiple setting configurations to a single settings database, and you can save multiple setting databases to your computer. 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 QuickSet, perform the following steps to create new database files.

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

The Database Manager window opens similar to *Figure 4.10*, with the Database text box displaying the active database name.

Step 2. Click **New**.

The **Create New Settings Database** window opens, shown in *Figure 4.11*.

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**.

QuickSet creates the new database and prompts you the result of the operation.

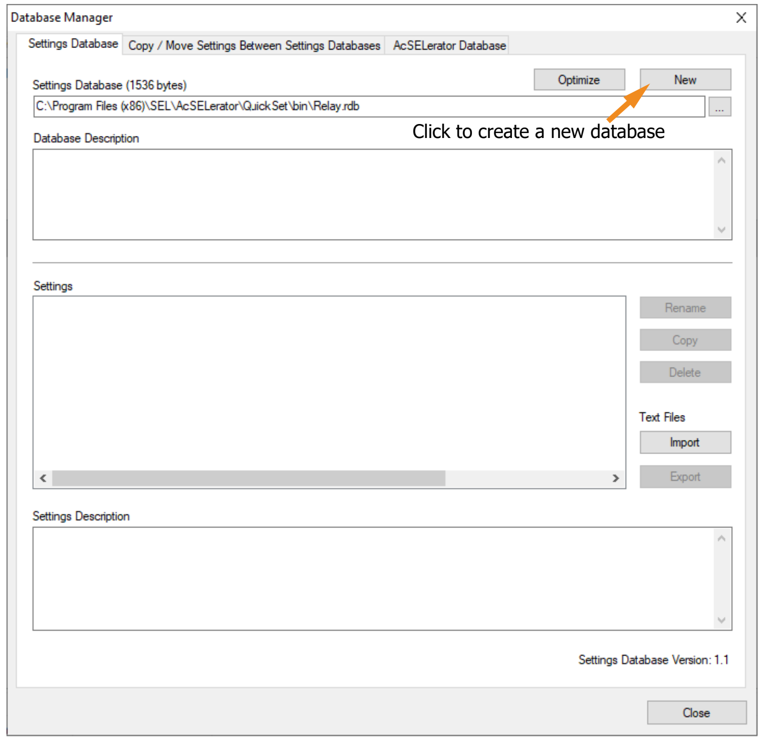


Figure 4.10 Database Manager, Create New Database

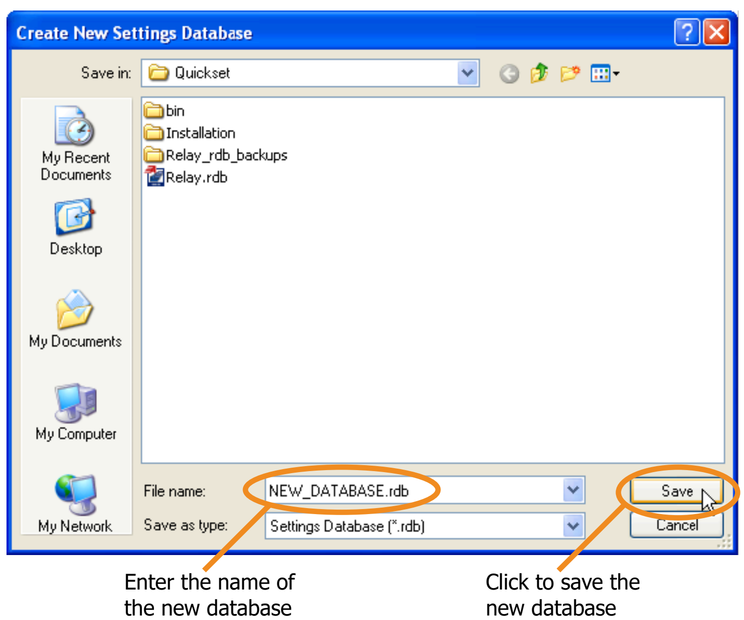


Figure 4.11 Create New Settings Database Window

Create New Settings Configuration Editor

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 4.12*, 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**.

QuickSet opens the **Device Part Number** window shown in *Figure 4.13*.

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. QuickSet prompts you for the mismatched part number digits.

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**.

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 4.14*. Click on any settings tree category to view and configure the associated settings.

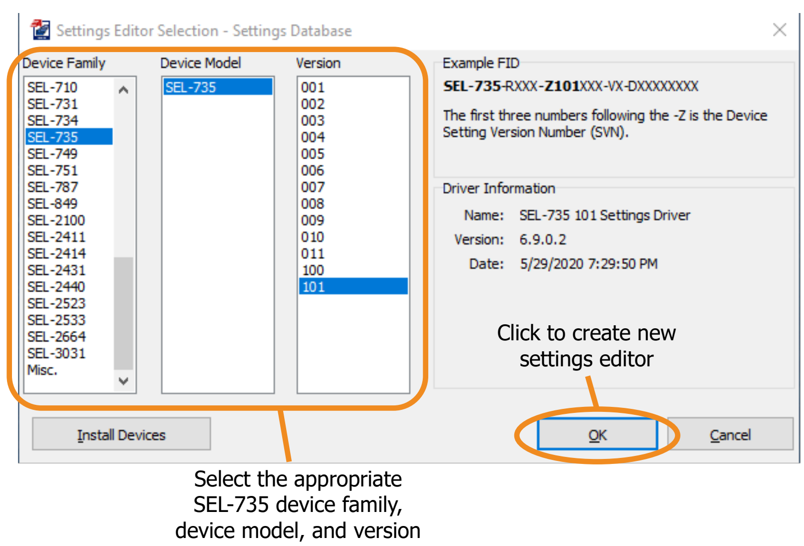


Figure 4.12 Settings Editor Selection Window

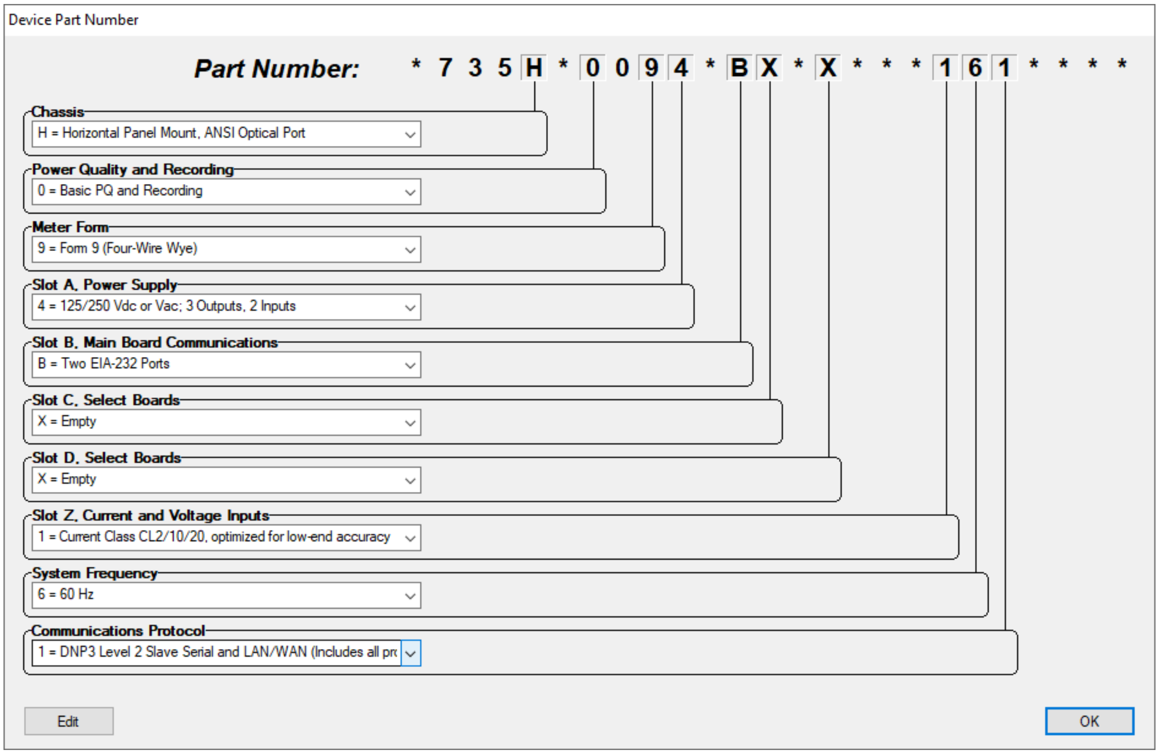


Figure 4.13 Device Part Number Window

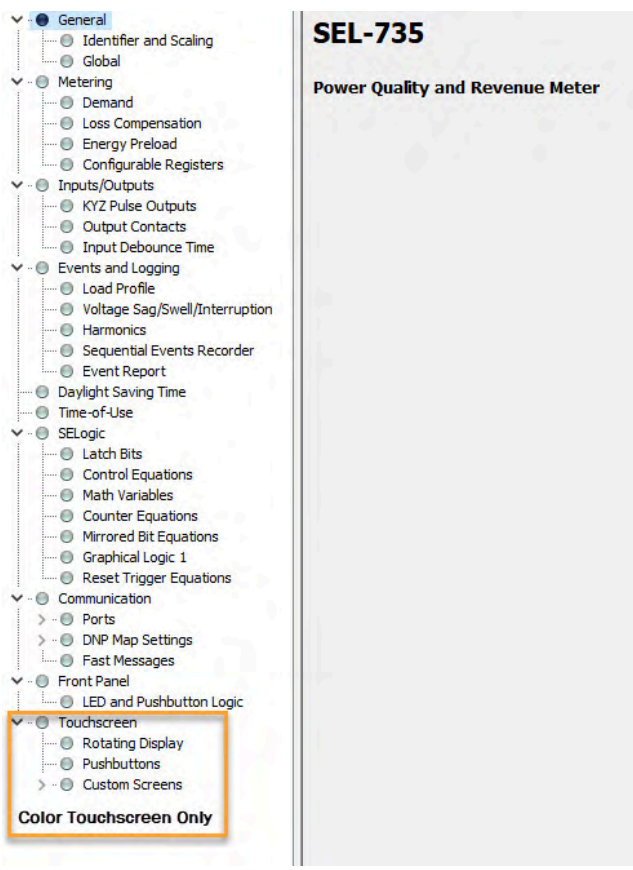


Figure 4.14 SEL-735 Settings Editor Window and Settings Tree

Read Settings From Meter

QuickSet reads the settings from the meter and populates a new editor with the read settings.

Connect to the meter. See *Section 2: Installation* for further information on this process.

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. See the *SEL-735 Quick-Start Guide* for further information on this step.

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

QuickSet sends settings from the active settings editor window.

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

QuickSet opens the **Settings Group/Class Select** window (*Figure 4.15*), but QuickSet may automatically select certain settings groups.

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

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

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

NOTE
Changes of Port 1 settings forces the meter to restart.

Step 5. Click **OK**.

QuickSet sends only the selected settings groups to the meter.

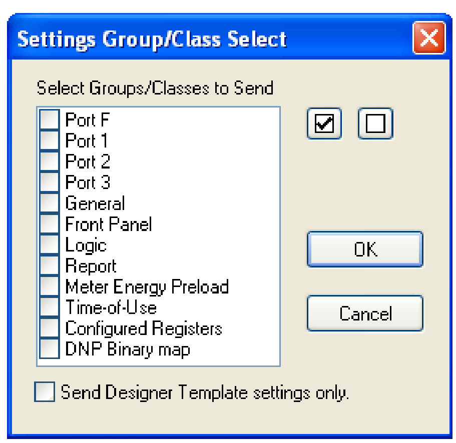


Figure 4.15 Settings Group/Class Select Window

Display Point Builder

QuickSet has a monochromatic LCD 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. For the color touchscreen model, see *Section 9: Touchscreen and Custom Screen Settings*.

Each display point displays two different quantities based on the display point control equation, DP*n*, where *n* is the display point number. *Figure 4.16* 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. Configure one of the user-configurable pushbuttons for ALTMODE functionality. Press this button (which asserts the ALTMODE Device Word bit) to toggle between normal and alternate displays. ALTMODE deasserts after the front-panel time-out expires.

Figure 4.16 Display Point Settings

Figure 4.17 shows a Boolean Quantity Display Point configuration example. To configure a Boolean display point, refer to *Figure 4.17* 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.

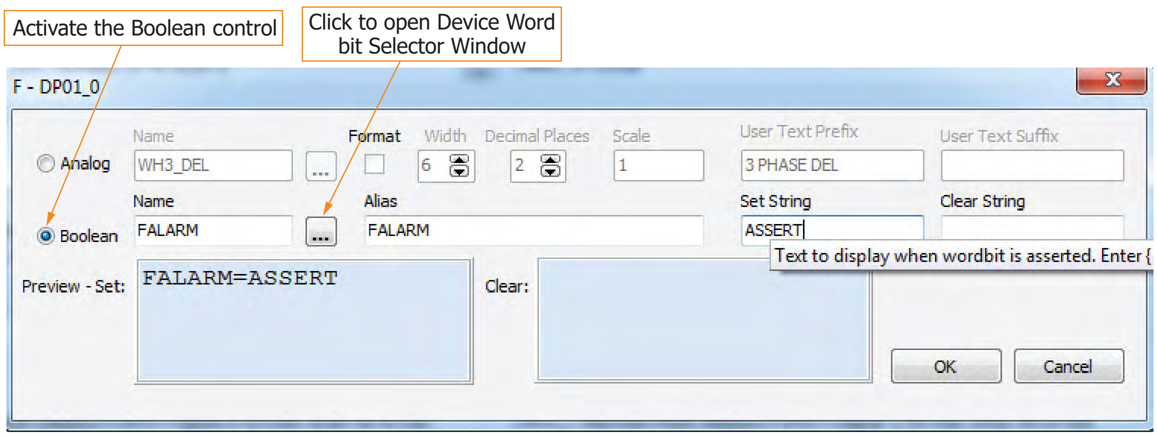


Figure 4.17 Boolean Quantity Display Point Builder

An analog quantity display point configuration example is shown in *Figure 4.18*. 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.

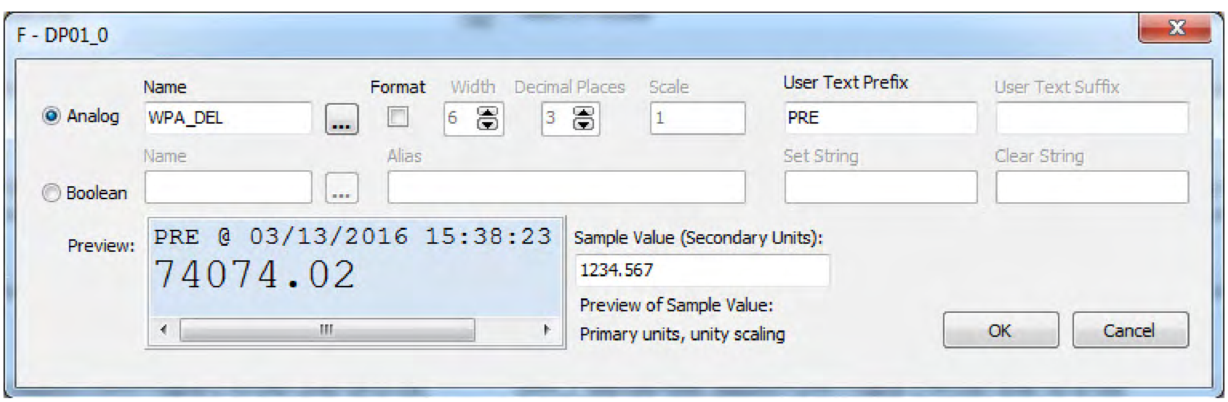


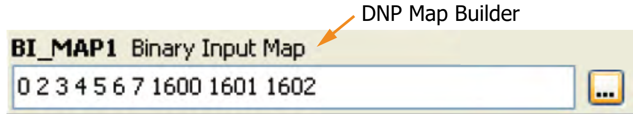
Figure 4.18 Analog Quantity Display Point Configuration Example

The display points follow analog quantities scaling settings. Preview the display points by entering a sample value in secondary units. Select the **Format** check box to apply conditional scaling to the display point.

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

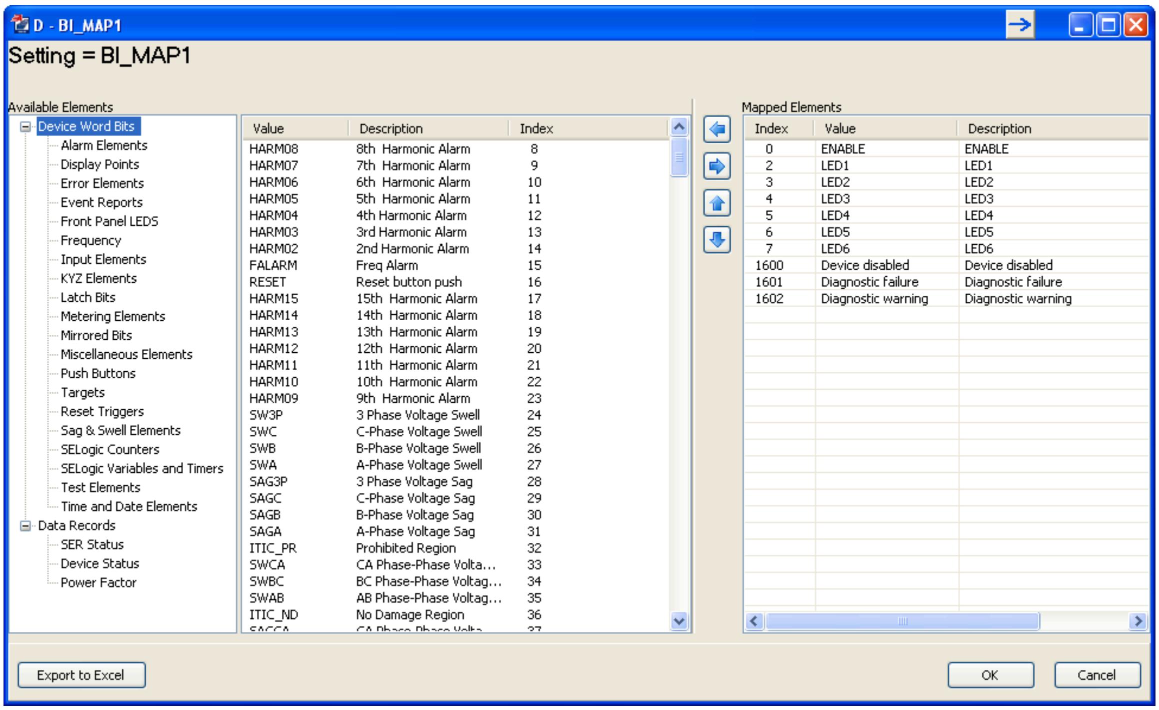


Figure 4.19 DNP Map Builder Window

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 buttons between the columns.

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 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.

The QuickSet HMI displays instantaneous meter information, captures reports, and allows test and control of the SEL-735. To access the Meter and Control interface, select **Tools > HMI > HMI** in the main QuickSet window, as shown in *Figure 4.20*.

To maneuver through the windows, select the HMI tree-view list until the required display appears on the right side.

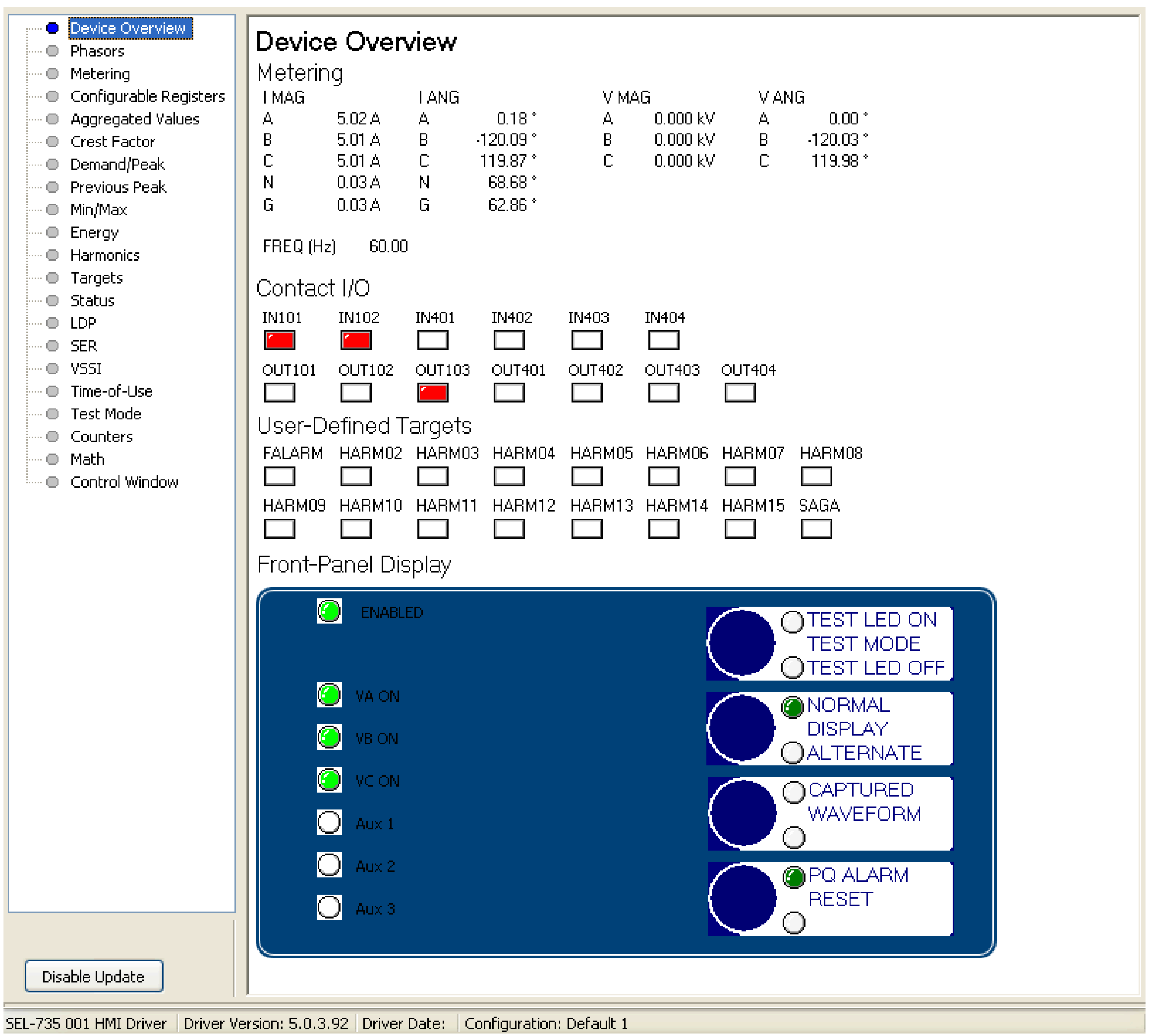


Figure 4.20 Device Overview HMI Window

Follow these guidelines to control the Device Overview HMI.

➤ Left-click any simulated LED to change the displayed color to correspond with asserted and deasserted states.

➤ Left-click the text label next to each pushbutton to create custom text labels. *Figure 4.20* 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 4.21* shows an example of the Phasors window.

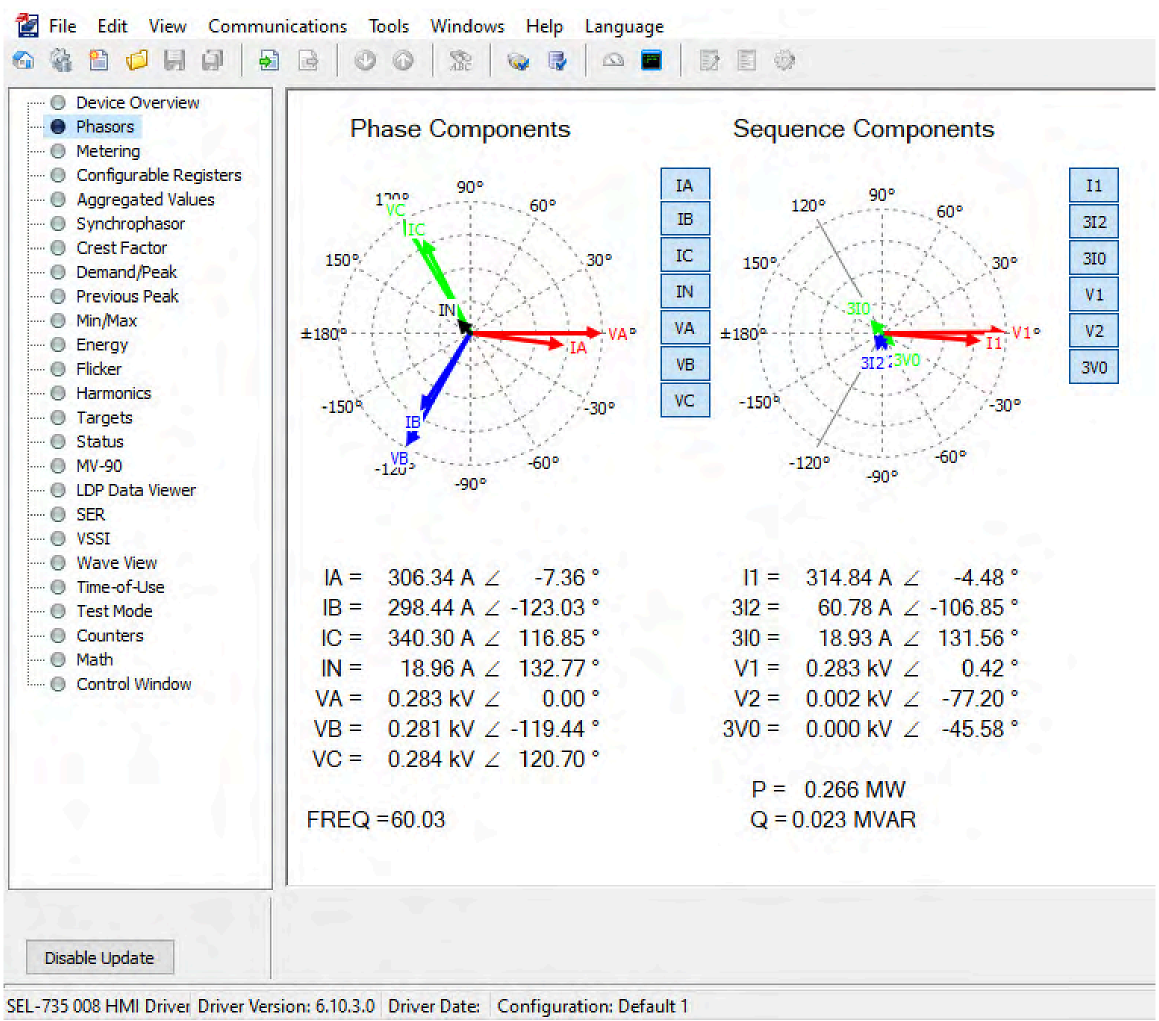


Figure 4.21 Phasors HMI Window

Follow these guidelines to control the Phasors HMI.

- Click 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 4.22* shows the Metering HMI with rms quantities. Note that Q under the RMS windows will display fundamental VARS if CALCQ is set to FUND.

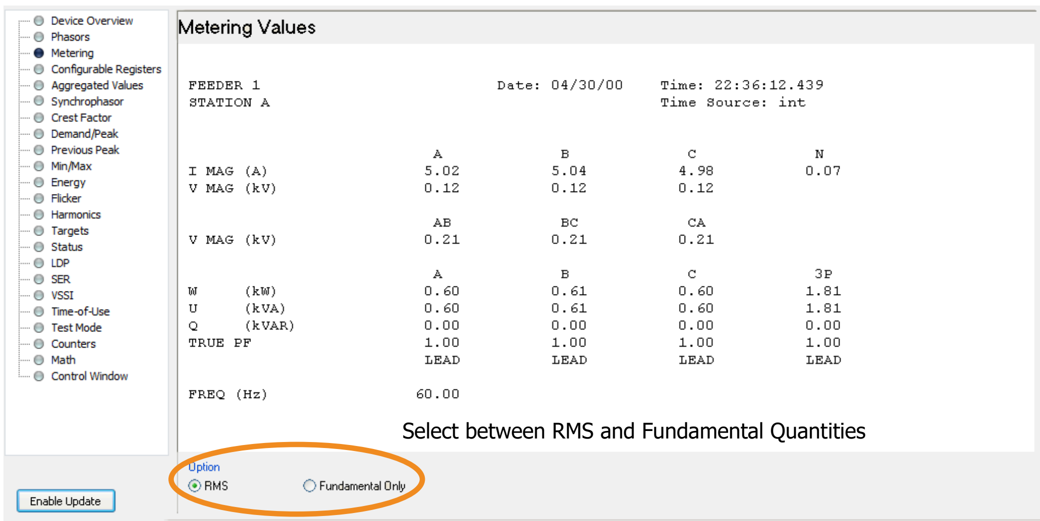


Figure 4.22 Metering HMI Window With RMS Quantities Shown

Configurable Registers

The Configurable Registers HMI displays each Configurable Registers instantaneous value.

Aggregated Values

The Aggregated Values HMI displays each aggregated values analog quantity.

Synchrophasors

The Synchrophasor HMI displays the Synchrophasor metering values as it is displayed through use of the **MET PM** command in a terminal window. This display allows you to view instantaneous data, schedule a data capture for a future time, or view the last scheduled capture. If the Continuous Waveform Streaming protocol is enabled, the HMI and the **MET PM** command will not display Synchrophasor data.

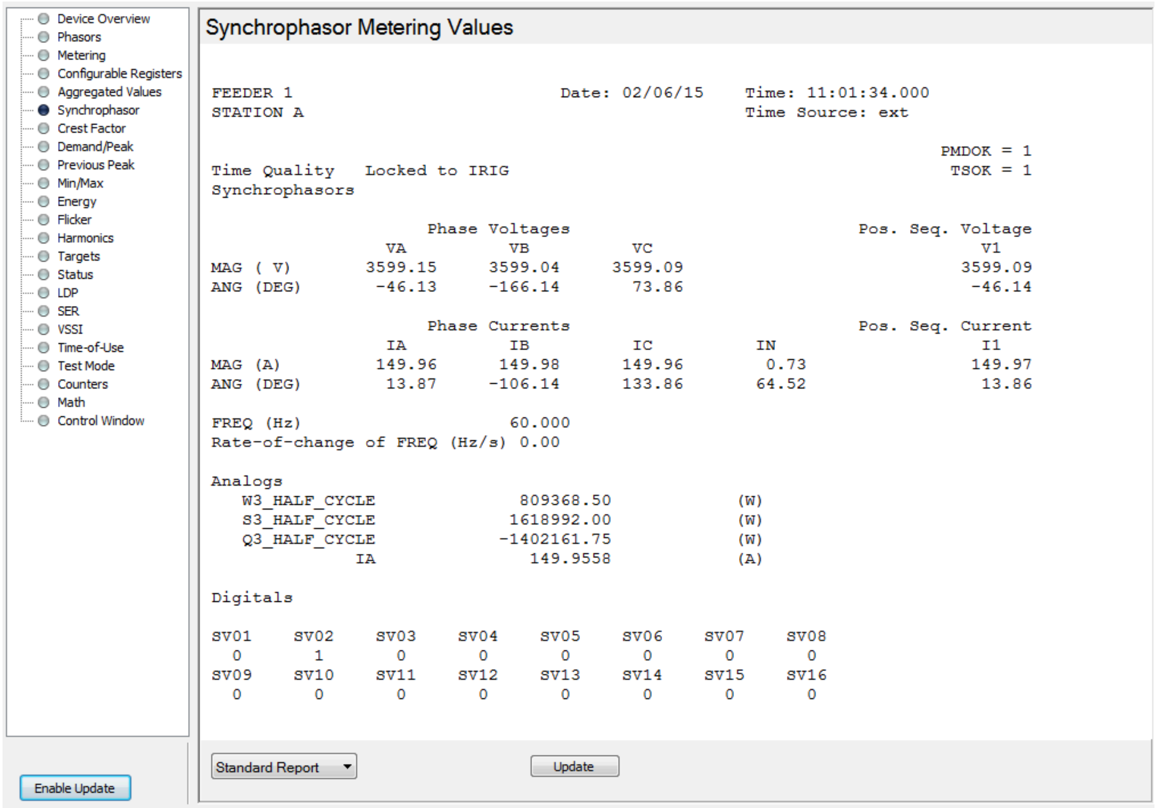


Figure 4.23 Synchrophasor HMI

Crest Factor

The Crest Factor HMI displays the maximum and minimum crest factor recorded and allows you to reset the crest factor.

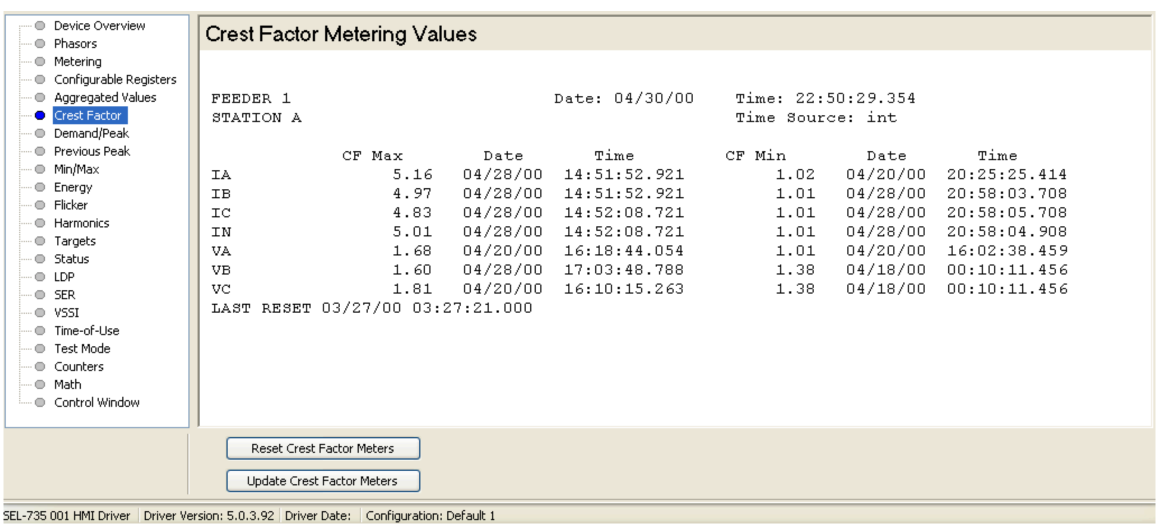


Figure 4.24 Crest Factor HMI Window

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

Demand/Peak

The Demand/Peak HMI displays and resets demand and peak demand data. *Figure 4.25* shows an example of the Demand/Peak HMI window.

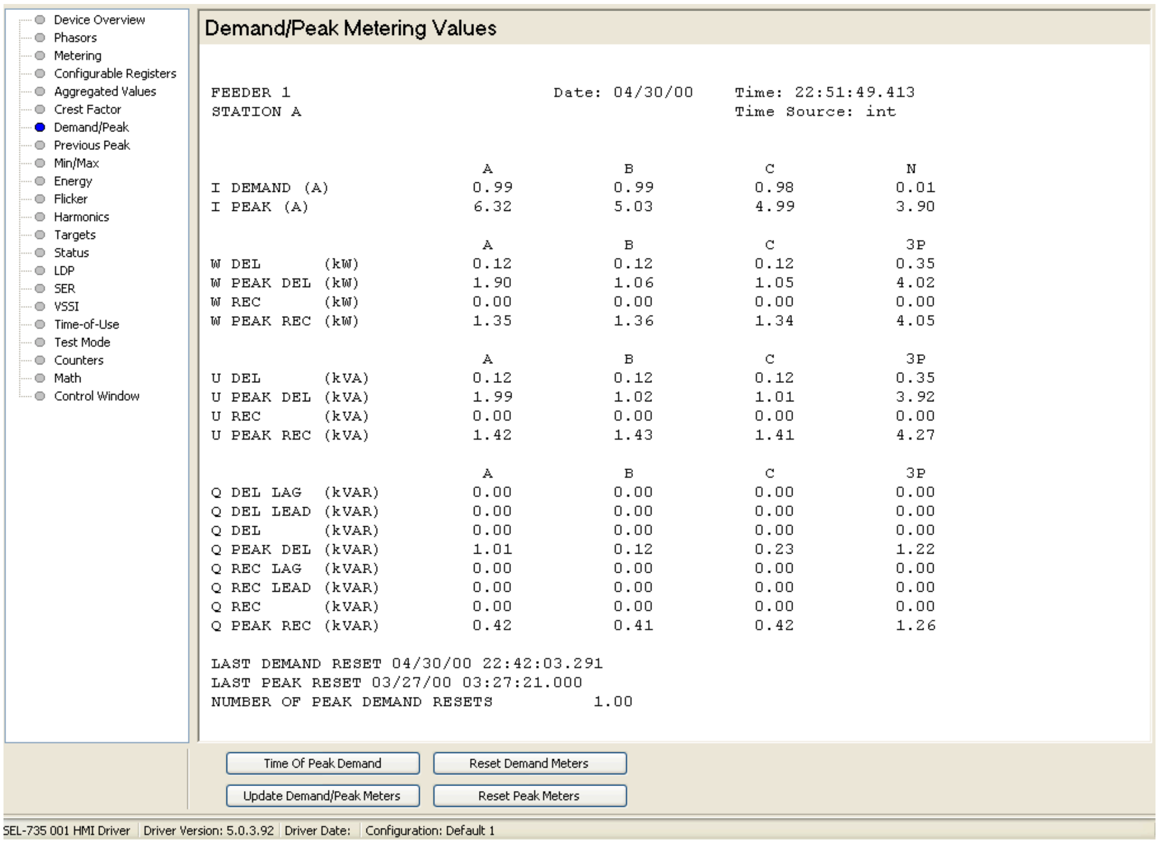


Figure 4.25 Demand/Peak HMI Window

Follow these guidelines to control the Demand/Peak HMI.

- ➤ Click **Time of Peak Demand** to view the date and time associated with each peak demand.
- ➤ Click **Update Demand/Peak Meters** to populate the HMI with the most recent demand data.
- ➤ Click **Reset Demand Meters** to reset demand meter data and record the date and time of the reset.
- ➤ Click **Reset Peak Meters** to reset demand meter data and record the date and time of the reset.

Previous Peak

The Previous Peak HMI displays previous peak demand.

Click **Update Previous Peak Meters** to update the Previous Peak HMI with the most recent previous peak data.

Min/Max

The Min/Max HMI allows you to view Min and Max data and reset Min and Max meter data.

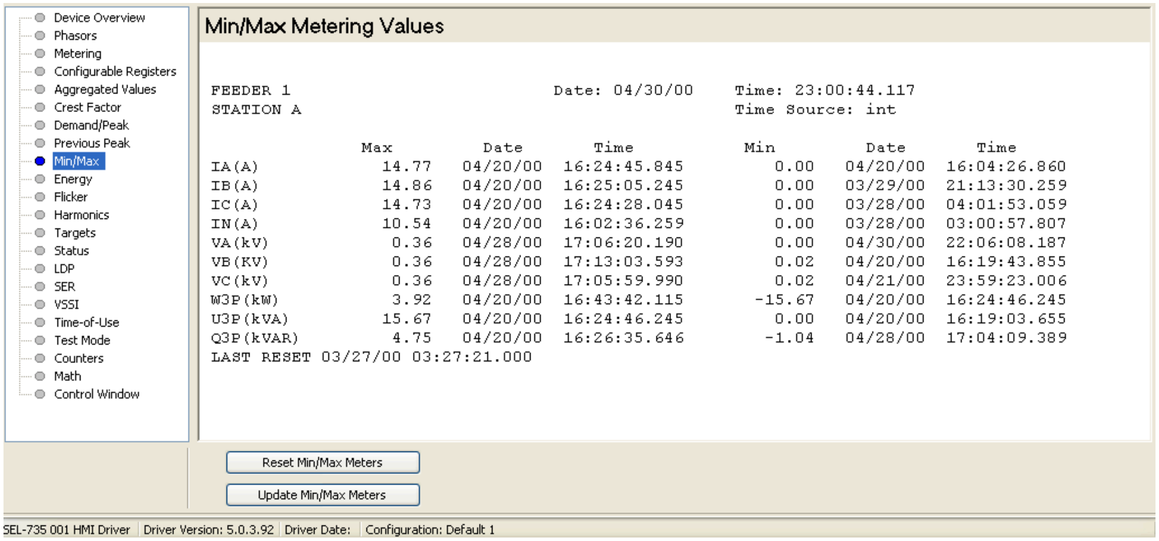


Figure 4.26 Min/Max HMI Window

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 the **Update Flicker** button near the lower left-hand corner of the Flicker HMI, as shown in *Figure 4.27*.

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

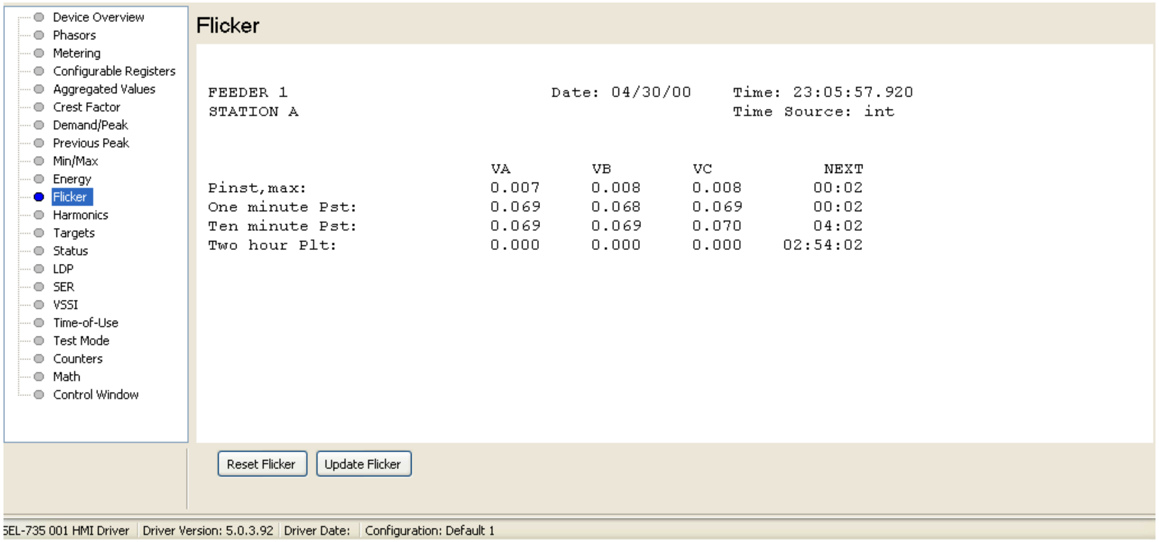


Figure 4.27 Flicker HMI Window

Harmonics

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

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 4.28* shows the Status HMI window.

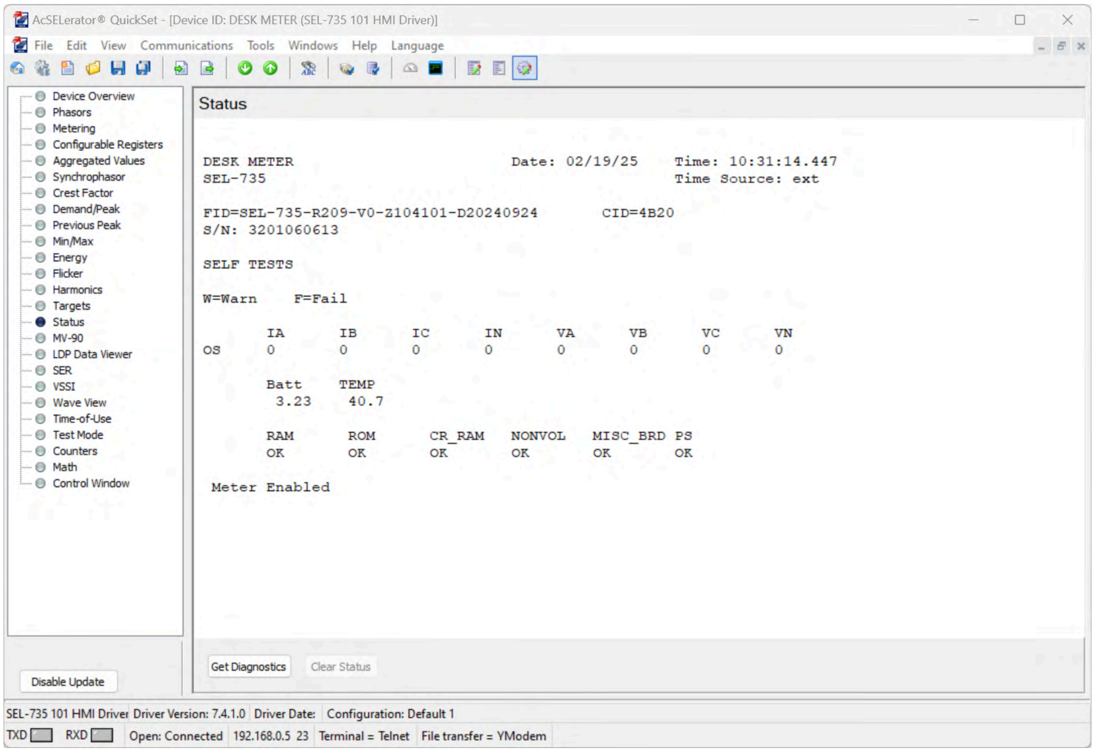


Figure 4.28 Status HMI Window

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. This file contains device information such as VSSI, SER, and audit logs. The file can then be sent to SEL for help in troubleshooting the device.

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

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

See *Section 10: 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 MIRRORED BITS communications by channel
- ➤ Clear Event data
- ➤ Trigger and Event
- ➤ Pulse Output Contacts for a variable amount of time
- ➤ Reset Device Word bits
- ➤ Set the Date and Time
- ➤ Set, Clear, and Pulse Remote Bits
- ➤ Change Access Level 1, Access Level E, and Access Level 2 passwords

Figure 4.29 shows an example of the Control Window HMI.

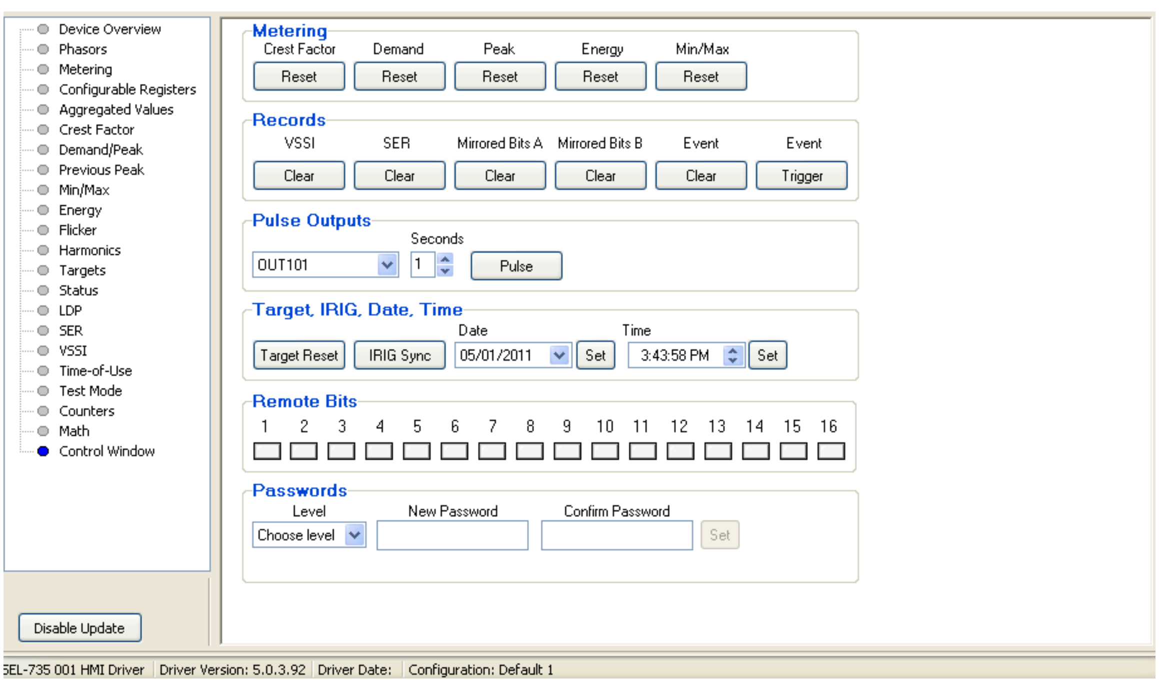


Figure 4.29 Control Window HMI

Retrieve Event Reports

You can use QuickSet to retrieve and view event reports. 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, the **Event History** window opens similar to *Figure 4.30*, except that QuickSet lists all of the events stored on the meter. If the meter does not contain any events, QuickSet prompts you with this information.

Step 2. Select the event or events to retrieve.

Step 3. Choose the event type.

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.

QuickSet retrieves the selected events from the meter and opens the **Save Event Report** window similar to *Figure 4.31*.

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

Step 6. Click **Save**.

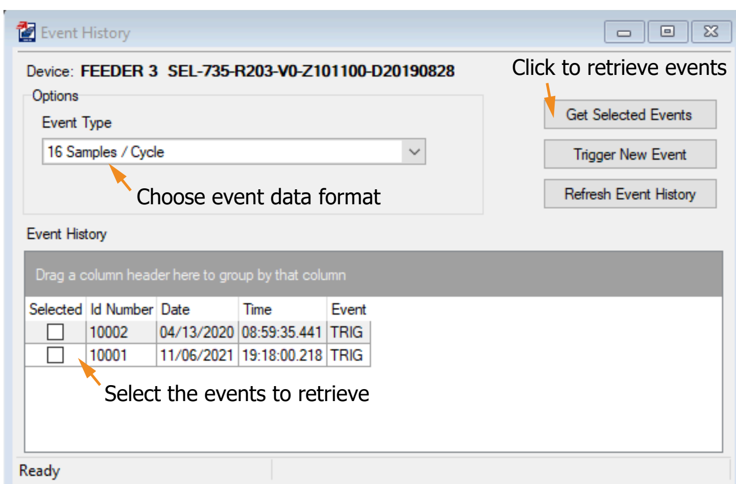


Figure 4.30 Event History Window

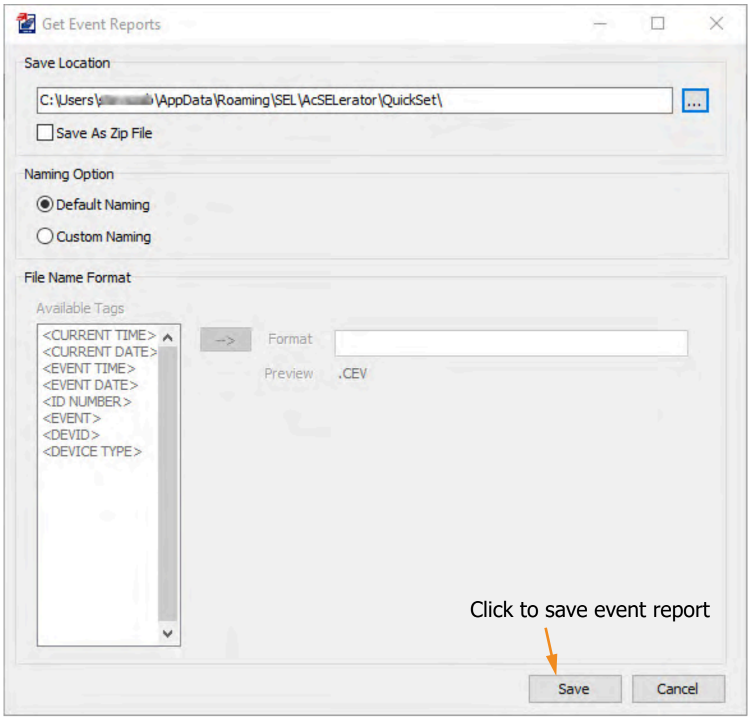


Figure 4.31 Save Event Report Window

View Event Reports

To view event reports from QuickSet, you must install SYNCHROWAVE Event SEL-5601-2 Software. Download the 60-day free trial version from *selinc.com* or by using SEL Compass. Follow the steps below to view an event report.

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

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

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

Step 3. Click **Open**.

QuickSet opens SYNCHROWAVE Event and displays the oscillography of the event report.

Chart Viewer

View Charts Offline

Use QuickSet to import reports saved on a computer and chart the data without needing to connect to a device. Event reports from other SEL devices may also be opened by using the same procedure. Perform the following steps in QuickSet to view charts offline.

Step 1. Click **Tools > Chart Viewer**.

Step 2. Click **Import** and browse to a report file saved on your computer. The file format of the report can be any of the following:

- Chart file (.csv)
- Report file (.txt)
- SSI Report file (.ssi)
- LDP Report file (.ldp)
- LDP Binary file (.bin)

Step 3. Once the file is imported, the window charts the report. Any of the charting tools (shown in *Figure 4.32*) can be used to edit the view.

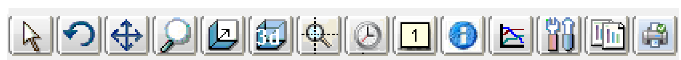


Figure 4.32 Chart Viewer Toolbar

Alternatively, perform the following steps to display charts using data directly from the QuickSet terminal window (as shown in *Figure 4.33*).

Step 1. Click **Tools > Chart Viewer**.

Step 2. Click **Export** to open a separate window.

Step 3. Copy data from the QuickSet terminal window and paste it into the **Export** window.

Step 4. Click **Chart** to graphically display the data.

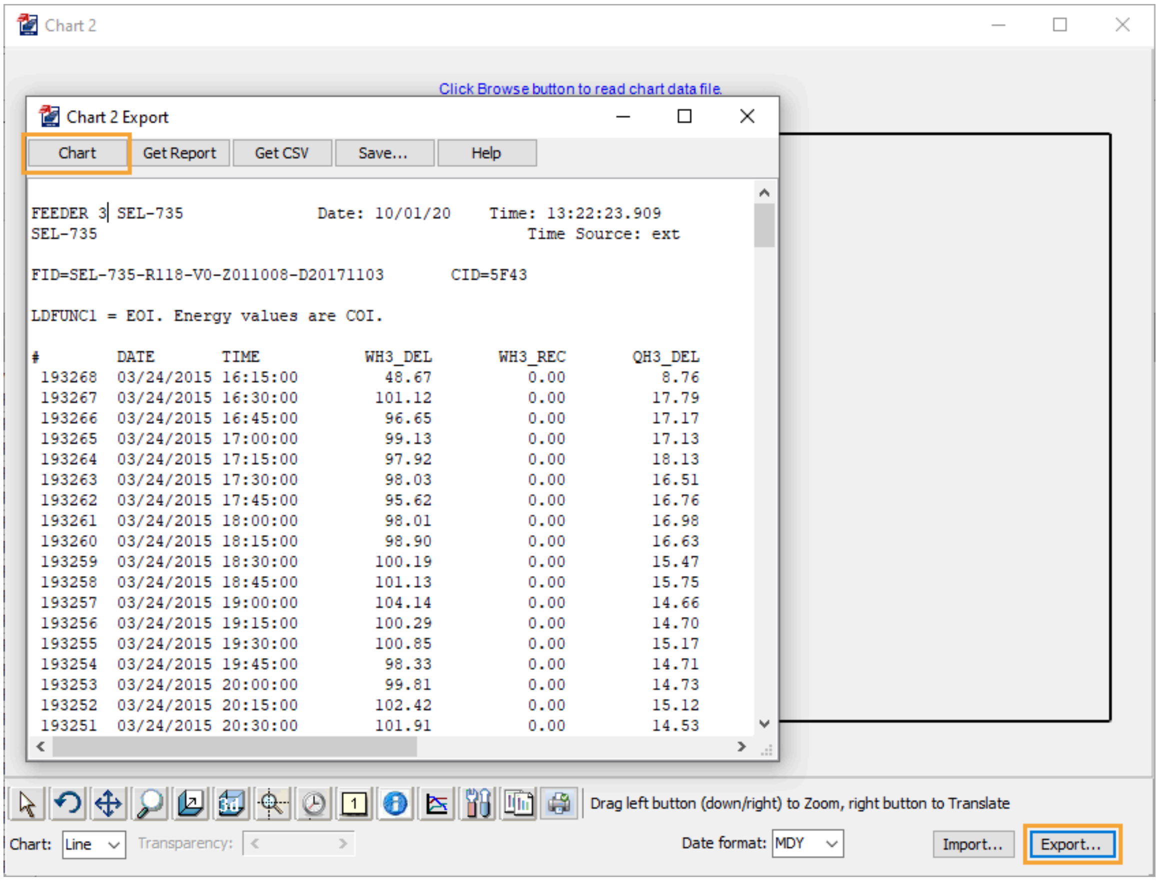


Figure 4.33 Chart Data From ACSELERATOR QuickSet Terminal Window

Convert Chart Formats

Convert reports to a different file format by using the charting tool. After importing a report by following the steps outlined in View Charts Offline, click **Save** to save the report as a .csv or .txt file. Click **Get Report** or **Get CSV** to display the data in a .txt or .csv file, respectively, in the chart viewer Export window.

Wave View

SEL-735 meters with the Advanced PQ and Recording option include the Wave View monitoring tool in the QuickSet HMI. Wave View allows you to view voltage and current waveforms in near real time through use of oscilloscope-like functionality. Waveforms in Wave View can be viewed immediately without having to retrieve and import files. The HMI provides the time-domain display as well as the frequency spectrum of any waveform captured.

Figure 4.34 shows an example screen capture of the Wave View HMI window.

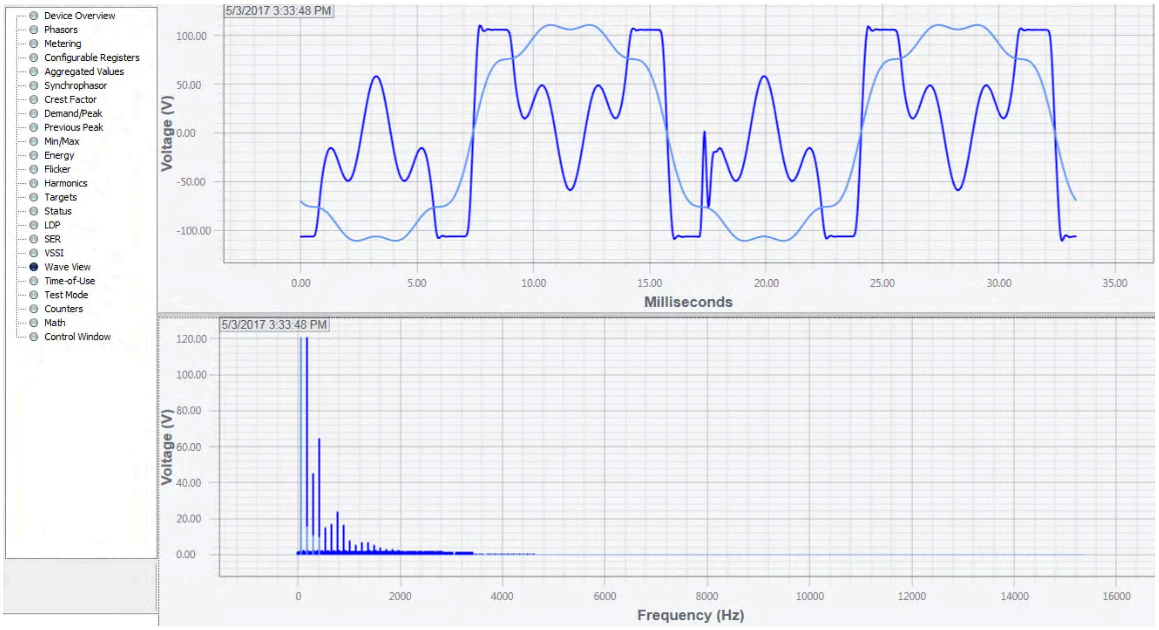


Figure 4.34 Capture of a Waveform and Frequency Spectrum Through Use of the Wave View HMI Tool

Click **Capture Waveform** to start recording at the set Sampling option. The recorder can sample at 128 or 512 samples/cycle. The recording time can vary from 2 to 60 cycles. To achieve 5 Hz bin resolution, Wave View must capture at least 12 cycles. The frequency spectrum is available as a histogram or line chart with units as magnitude, percent, or dB.

Right-click elements in the chart such as the series or axes to change properties of that element. Right-click the chart background to change general chart properties.

The Wave View features allow you to export waveform data to CSV format by clicking the **Export Data** button. Once exported, the CSV file can be displayed on the HMI again by importing it into Wave View.

Wave View operates independently of the Event Report recorder.

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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)	**MID**	:=
Terminal Identifier (20 characters)	**TID**	:=

Current and Potential Transformer Ratios

Phase Current Transformer Ratio CTR:1 (1.0000–10000)	**CTR**	:=
Potential Transformer Ratio PTR:1 (1.0000–10000)	**PTR**	:=

Analog Quantity Scaling Settings

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

Instrument Transformer Compensation

For the following settings, replace *x* with the Phase A, B, or C, and replace *n* with the calibration point number. Form 5 meters do not have Phase B CT compensation. Form 5 and Form 36 meters do not have Phase B PT compensation.

Enable ITC for Current (N, 1–6)	**EITCI**	:=
Secondary Amps for Calibration Point *n* (0.01–20.00 A)	**ICAL_*n***	:=
CT Ratio Correction Factor (0.9800–1.0200)	**IRCF*x*_*n***	:=
CT Phase Angle Minutes (–300.0 to 300.0)	**IPAM*x*_*n***	:=
Enable ITC for Voltage (N, 1–6)	**EITCV**	:=
Secondary Volts for Calibration Point *n* (5.00–300.00 V)	**VCAL_*n***	:=
PT Ratio Correction Factor (0.9800–1.0200)	**VRCF*x*_*n***	:=
PT Phase Angle Minutes (–300.0 to 300.0)	**VPAM*x*_*n***	:=

Global Settings

Gain Adjustment Settings

Watt Gain % (–10.00 to 10.00)	**WGAIN**	:=
VAR Gain % (–10.00 to 10.00)	**VARGAIN**	:=
Flicker Reference Voltage (VBASE, 120, 230)	**FLICREF**	:=
3-Phase Apparent Power Calc (ARITH, VECTOR)	**CALC3U**	:=
VAR Calc (VECTOR, FUND)	**CALCQ**	:=

Advanced Global Settings

Watt/VAR angle cutoff (OFF, 1–10 degrees)	**ANGCUT**	:=
Starting Current Threshold (*x*–10 mA) (*x* is 1.0 mA for CL2/10/20 meters and 5.0 mA for CL10/20 meters)	**IST**	:=
Starting Current Type (ALL, RMS_ONLY)	**IST_TYPE**	:=
Phase Rotation (ABC, ACB)	**PHROT**	:=
Date Format (MDY, YMD, DMY)	**DATE_F**	:=
IRIG Time Source Type (IRIG, IEEE[a]) (Hidden and forced to IEEE if EPMIP >0)	**TSTYPE**	:=
Offset from UTC (–24.00 to +24.00 hours)	**UTC_OFF**	:=
Time Change Flag Threshold (1–59 s)	**TIME_CHG**	:=
Line Frequency Synchronization (Y, N)	**LINEFREQ**	:=

[a] When TSTYPE := IEEE, the device requires IEEE C37.118 control bits to be sent from the IRIG clock. If TSTYPE is set to IEEE, but control bits are not included in the IRIG signal, then the Device Word bit TIRIG will continually toggle.

Synchrophasors

Messages per Second (1, 2, 5, 10, 25, or 50 when frequency := 50 Hz) (1, 2, 4, 5, 10, 12, 15, 20, 30, or 60 when frequency := 60 Hz)	**MRATE**	:=
Station Name (16 characters)	**PMSTN**	:=
PMU Hardware ID (1–65534)	**PMID**	:=
Phase Data Set, Voltages (V1, PH, ALL, NA)	**PHDATAV**	:=
Phase Voltage Angle Compensation (–179.99 to +180.00 deg)	**VCOMP**	:=
Phase Data Set, Currents (I1, PH, ALL, NA)	**PHDATAI**	:=
Phase Angle Current Compensation (–179.99 to +180.00 deg)	**ICOMP**	:=
Number of PMU Analog Values (0–4)	**NUMANA**	:=
PMU Analog Quantity 1	**PMUAQ1**	:=
PMU Analog Quantity 2	**PMUAQ2**	:=

PMU Analog Quantity 3	**PMUAQ3**	:=
PMU Analog Quantity 4	**PMUAQ4**	:=
Number of 16-bit Digital Status Words (0, 1)	**NUMDSW**	:=
Trigger Reason Bit 1 (SELOGIC)	**TREA1**	:=
Trigger Reason Bit 2 (SELOGIC)	**TREA2**	:=
Trigger Reason Bit 3 (SELOGIC)	**TREA3**	:=
Trigger Reason Bit 4 (SELOGIC)	**TREA4**	:=
PMU Trigger (SELOGIC)	**PMTRIG**	:=

Front Panel

Front-Panel Display Settings

Front-Panel Time-out (OFF, 1–120 min)	**FP_TO**	:=
Front-Panel LCD Contrast (1–8)	**FP_CONT**	:=
Display Update Rate in seconds (1–60 sec)	**SCROLD**	:=

Front-Panel Display Point Settings

Replace *n* with the display point value 01–50.

Logic String	**DP*n***	:=
Alternate Display when Logic = 1 (64 characters, enter NA to null)	**DP*n*_1**	:=
Normal Display when Logic = 0 (64 characters, enter NA to null)	**DP*n*_0**	:=

Front-Panel LED Logic Settings

Replace *n* with the LED value 01–14. T07_LED–T14_LED are available only if the corresponding PB0*n*FCN (where *n* = 1–4) button is set to NA. Refer to *Four User-Configurable Pushbuttons and LEDs on page 54* for more details.

First Pushbutton Function (TEST, ALT, WAVCAP, RSTPQALRM, RESETPE, RESETPD, LAMPTEST, NA)	**PB01FCN**	:=
Second Pushbutton Function (TEST, ALT, WAVCAP, RSTPQALRM, RESETPE, RESETPD, LAMPTEST, NA)	**PB02FCN**	:=
Third Pushbutton Function (TEST, ALT, WAVCAP, RSTPQALRM, RESETPE, RESETPD, LAMPTEST, NA)	**PB03FCN**	:=
Fourth Pushbutton Function (TEST, ALT, WAVCAP, RSTPQALRM, RESETPE, RESETPD, LAMPTEST, NA)	**PB04FCN**	:=
Front-Panel LED*n* Logic	**T*n*_LED**	:=

RESET Button Function (RESETPE, RESETPD, LAMPTEST)	**RESETFCN**	:=
Reset Peak Demand Inhibit Time (OFF, 0.01–2250.00 hours)	**RPDEMINH**	:=

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 the following table) (*Hidden if EDEM set to THM or BLOK*)	**DMSI**	:=

DMTC Value	DMSI Range
1	1 min
5	5, 1 min
10	10, 5, 2, 1 min
15	15, 5, 3, 1 min
30	30, 15, 10, 6, 5, 3, 1 min
60	60, 30, 20, 15, 12, 10, 6, 5, 3, 1 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 units; 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) (Hidden if ETLLC = N)	**ELCU**	:=
Transformer Iron Losses Compensation (Y, N) (Hidden if ETLLC = N)	**ELFE**	:=
Transformer Copper Watt Losses (0.00001–10000.00000 kW)	**LWCU**	:=
Transformer Iron Watt Losses (0.0001–10000.00000 kW)	**LWFE**	:=
Transformer 3-Phase MVA Rating (0.00001–10000.00000 MVA)	**MVA**	:=
Primary Line-to-Line Metered Voltage (0.00001–10000.00000 kV)	**KVLL**	:=
Transformer Percentage Impedance (0.001%–19.999%)	**%Z**	:=
Transformer Percentage Exciting Current (0.001%–19.999%)	**%IMAG**	:=

Supply and Load Line Losses Settings

Supply Line Resistance (0.0000–999.9999 ohms)	**SLR**	:=
Supply Line Reactance (0.0000–999.9999 ohms)	**SLX**	:=
Load Line Resistance (0.0000–999.9999 ohms)	**LLR**	:=
Load Line Reactance (0.0000–999.9999 ohms)	**LLX**	:=
Power Transformer Turns Ratio (VSupply/VLoad)	**XFTR**	:=

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)

Phase *n* KWh Delivered (0–999999999999.999 kWh)	**KWH*n*_DEL**	:=
Phase *n* KWh Received (0–999999999999.999 kWh)	**KWH*n*_REC**	:=
Phase *n* KVAh Delivered (0–999999999999.999 kVAh)	**KUH*n*_DEL**	:=
Phase *n* KVAh Received (0–999999999999.999 kVAh)	**KUH*n*_REC**	:=
Phase *n* KVARh Delivered Lag (0–999999999999.999 kVARh)	**KQH*n*_DEL_LG**	:=
Phase *n* KVARh Delivered Lead (0–999999999999.999 kVARh)	**KQH*n*_DEL_LD**	:=
Phase *n* KVARh Received Lag (0–999999999999.999 kVARh)	**KQH*n*_REC_LG**	:=
Phase *n* KVARh Received Lead (0–999999999999.999 kVARh)	**KQH*n*_REC_LD**	:=
Phase *n* Volt-Hours (0–999999999999.999 Vh)	**VH*n***	:=
Phase *n* Amp-Hours (0–999999999999.999 Ah)	**IH*n***	:=

Meter Energy Preload Settings (Uncompensated)

Phase *n* KWh Delivered (0–999999999999.999 kWh)	**KWH*n*_DEL_UC**	:=
Phase *n* KWh Received (0–999999999999.999 kWh)	**KWH*n*_REC_UC**	:=
Phase *n* KVARh Delivered Lag (0–999999999999.999 kVARh)	**KQH*n*_DEL_LG_UC**	:=
Phase *n* KVARh Delivered Lead (0–999999999999.999 kVARh)	**KQH*n*_DEL_LD_UC**	:=
Phase *n* KVARh Received Lag (0–999999999999.999 kVARh)	**KQH*n*_REC_LG_UC**	:=
Phase *n* KVARh Received Lead (0–999999999999.999 kVARh)	**KQH*n*_REC_LD_UC**	:=

Configurable Registers

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

Configurable Register (1–1000)	**CONFIGREG**	:=
Analog Quantity (Analog Quantity)	**NAME**	:=
Alias String (39 chars max)	**ALIAS**	:=
Units String (15 chars max)	**UNITS**	:=
Decimal Places (0–6)	**DECIMALS**	:=
Leading Zeros (Y, N)	**LEADINGZEROS**	:=
Large Font (Y, N)	**LARGEFONT**	:=
User Scale (Y, N)	**SCALEUSER**	:=

Scale (-1×10^{10} to 1×10^{10})	**SCALEVALUE** :=
Offset (-1×10^{10} to 1×10^{10})	**OFFSET** :=
Scale Type (PRIMARY, SECONDARY)	**SCALETYPE** :=
Units Type (UNITY, KILO, MEGA)	**UNITSTYPE** :=
Rollover Type (DIALS, VALUE)	**ROLLOVERTYPE** :=
Rollover Dials (5–12)	**ROLLOVERDIALS** :=
Rollover Value (0 to 1×10^{15})	**ROLLOVERVALUE** :=

Inputs/Outputs

KYZ Pulse Outputs

KYZ Pulse n Settings

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

KE*n* Scale (PRI, SEC)	**KE*n*_SCALE** :=
Watthour Constant *n* (0.0001–9999.0000)	**KE*n*** :=
KE*n* Units (UNITY, KILO, MEGA)	**KE*n*_UNIT** :=
Demand Type to Output *n*	**KYZD*n*** :=
KYZ Minimum Pulse Width *n* (25, 50, 75, 100 ms)	**KYZPW*n*** :=
KYZ Output Contact (Available only with solid-state output contacts)	**KE*n*_OUT** :=

KYZ Pulse Test Mode Setting

Watthour Constant (0.0001–9999)	**KET** :=

Output Contacts

Output Contact Equations

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

Output Contact 1	**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 of 01–04.

AO*n* Analog Quantity	**AO*n*AQ**	:=
AO*n* Analog Quantity Low (–2147483647.000 to +2147483647)	**AO*n*AQL**	:=
AO*n* Analog Quantity High (–2147483647.000 to +2147483647)	**AO*n*AQH**	:=
AO*n* Low Analog Output Value (±1.200 or ±24.000)	**AO*n*L**	:=
AO*n* High Analog Output Value (±1.200 or ±24.000)	**AO*n*H**	:=

Events and Logging

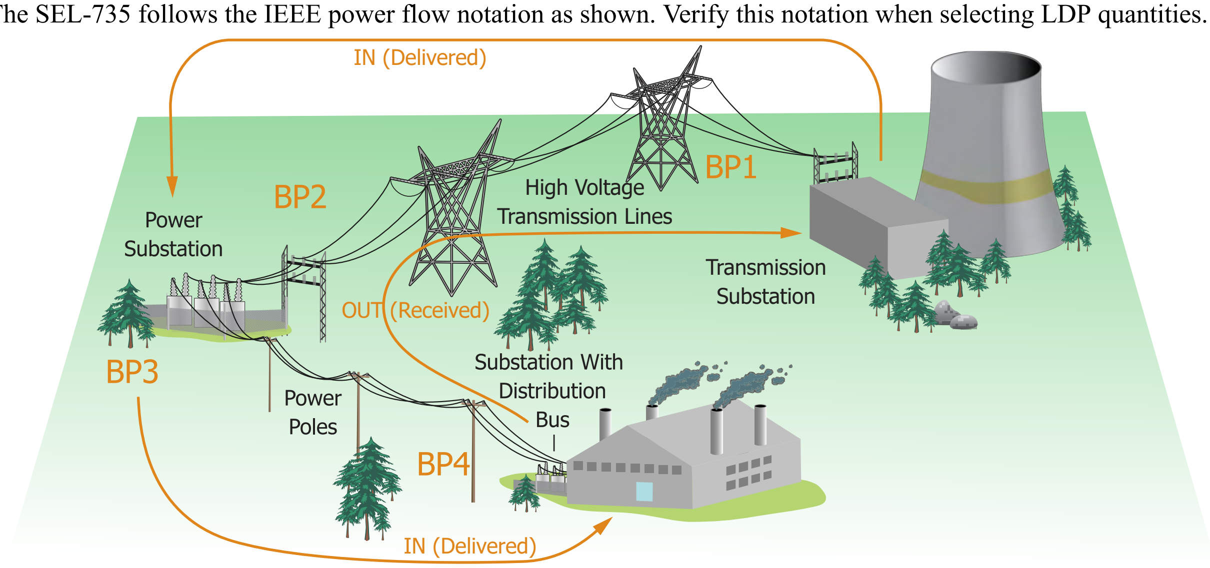
Load Profile Settings

The SEL-735 supports as many as 32 recorders, each having 16 channels, with an acquisition rate of 3–59 s or 1–120 min intervals. The load profile settings LDLIST tool presents a list of all available LDP values.

The meter reading software built into QuickSet quickly retrieves, graphs, and exports LDP data in .HHF or .CSV formats. Third-party meter reading software, such as MV-90 from Itron, can automatically read LDP data from the SEL-735. The data are also available through the SEL Ymodem, Modbus, and DNP protocols.

Note, the number of recorders available depends on the Power Quality and Recording option selected (Basic and Intermediate: 12, Advanced: 32) and the date and time configuration settings.

The SEL-735 follows the IEEE power flow notation as shown. Verify this notation when selecting LDP quantities.



Billing Recorder

The billing recorder is always the first recorder. Note, energy quantities in this recorder are always recorded as Change Over Interval (COI).

Recorder Function (EOI, AVG, COI, MAX, MIN) Recorder function variables are described in *Table 6.1*.	**LDFUNC1**	:=
Load Profile List (16 elements max, NA to null)	**LDLIST1**	:=
Load Profile Acquisition Rate (3–59 s; 1, 2, 3, 5, 10, 15, 30, 60, 120 minutes) (3–59 s requires Advanced or Intermediate PQ and Recording)	**LDAR1**	:=
Load Profile Maximum Duration (0.05–7300.00 days)	**LMDUR1**	:=

Recorder n

For additional recorders, replace *n* with a value of 2–32.

Recorder Function (EOI, AVG, COI, MAX, MIN)	**LDFUNC*n***	:=
Load Profile List (16 elements max, NA to null)	**LDLIST*n***	:=
Load Profile Acquisition Rate (3–59 s; 1, 2, 3, 5, 10, 15, 30, 60, 120 minutes) (3–59 s requires Advanced or Intermediate PQ and Recording)	**LDAR*n***	:=
Load Profile Maximum Duration (0.05–7300.00 days)	**LMDUR*n***	:=

Voltage Sag/Swell/Interruption Settings

Voltage Base (20.00–300.00 V_{L-N} for Form 9 and 36 meters. 20.00–480.00 V_{L-L} for Form 5 meters.)	**VBASE**	:=
AVG_TIME (OFF, 1–10 min)	**AVG_TIME**	:=
The following Voltage/Sag/Swell/Interruption Settings are in percent of VBASE.		
L-N Voltage Interrupt (OFF, 5.00–99.00)	**VINT**	:=
Voltage Interruption Hysteresis (0.00–10.00)	**VINTHYS**	:=
L-N Voltage Sag (OFF, 10.00–99.00)	**VSAG**	:=
Voltage Sag Hysteresis (0.00–10.00)	**VSAGHYS**	:=
L-N Voltage Swell (OFF, 101.00–180.00)	**VSWELL**	:=
Voltage Swell Hysteresis (0.00–10.00)	**VSWELHYS**	:=
Voltage RMS Window (HALF, ONE cycle)	**VRMSWIN**	:=

In a Voltage Swell event, VSWELHYS defines a voltage level lower than the VSWELL trigger that, once reached, causes the meter to consider the voltage profile to be recovering and stop recording VSSI data.

With Voltage Sag, the voltage level of VSAGHYS is the voltage level greater than the VSAG trigger that, once reached, causes the meter to consider the voltage profile to be recovering and stop recording the VSSI data.

Harmonics Settings

Harmonic Triggers

Replace *n* with the harmonic component 02–15.

The following Harmonic Alarm settings are in percent of Fundamental.

Harmonic Trigger Quantities (ALL, VOLTAGE, CURRENT)	**HARMTRIG**	:=
*n*th Harmonic Threshold (OFF, 3–100%)	**HARM*n***	:=

Harmonic Grouping

Harmonic Calculation Method (HARM, GROUP, SUBGROUP, INTERHARM) (Requires Advanced PQ and Recording)	**HARMCAL**	:=

Sequential Events Recorder Settings

Replace *n* with the Sequential Events Recorder number 1–3.

Auto-Removal Enable (Y, N)	**ESERDEL**	:=
Number of Counts (2–20)	**SRDLCNT**	:=
Removal Time (0.5–90.0 s) (For more details, refer to *Sequential Events Recorder (SER) Report on page 239*.)	**SRDLTIM**	:=
Sequential Events Recorder *n* (24 elements max, NA to null)	**SER*n***	:=

Event Report

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

ER Trigger List *n*	**ER*n***	:=
Waveform Capture Sample Rate (16, 128, 512 samples per cycle)	**SRATE**	:=
Event Length (15, 30, 60, 120, 300, 600 cycles) (Only 15 cycles available with Basic PQ and Recording) (600 cycles not available when SRATE = 512)	**LER**	:=
Prefault Length (1–595 cycles)	**PRE**	:=

SELOGIC Control Equations

Latch Bits

Latch Bit Settings

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

Set Latch Bit LT*n*	**SET*n***	:=
LReset Latch Bit LT*n*	**RST*n***	:=

Control Equations

Replace *n* with the SELOGIC control equation number 01–16.

SELOGIC Control Equation Variable SV*n*	**SV*n***	:=
SV*n* Timer Pickup (0.000–1000000.000 s)	**SV*n*PU**	:=
SV*n* Timer Dropout (0.000–1000000.000 s)	**SV*n*DO**	:=

Math Variables

Math Variable Equations

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

SELOGIC Math Equation Variable MV*n*	**MV*n***	:=

Counter Equations

Counter Equation Settings

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

Current Value (0–999999) (SC*n*CV must be less than or equal to SC*n*PV)	**SC*n*CV**	:=
Counter Preset Value (1–999999)	**SC*n*PV**	:=
Reset (SELOGIC Equation)	**SC*n*R**	:=
Load (SELOGIC Equation)	**SC*n*LD**	:=
Count Up (SELOGIC Equation)	**SC*n*CU**	:=
Count Down (SELOGIC Equation)	**SC*n*CD**	:=

MIRRORED BITS Communications Equations

Replace *n* with the Transmit Mirrored Bit number 1–8.

MIRRORED BITS Channel A

Channel A, transmit bit *n*	**TMB*n*A**	:=

MIRRORED BITS Channel B

Channel B, transmit bit *n*	**TMB*n*B**	:=

Reset Trigger Equations

Reset Trigger SELOGIC Equations

Demand Reset (SELOGIC Equation)	**RSTDEM**	:=
Peak Demand Reset (SELOGIC Equation)	**RSTPKDM**	:=
Reset Peak Demand Counters (SELOGIC Equation)	**RPKDMCT**	:=
Reset Energy (SELOGIC Equation)	**RSTENRG**	:=
Reset Power Quality Alarm (SELOGIC Equation)	**RPQALRM**	:=

Communications

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) (If the password jumper is installed, MAXACC does not limit the port's access level and all ports enable regardless of the EPORT setting.)	**MAXACC**	:=
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 is only available if E61850 > 0)	**EGSE**	:=
Enable SNTP (OFF, UNICAST, MANYCAST, BROADCAST)	**ESNTP**	:=
Enable DNP3 LAN/WAN Sessions (0–5)	**EDNP**	:=
Enable PMU Sessions (0–2) (EPMIP and ECWSIP cannot be enabled at the same time.)	**EPMIP**	:=
Enable CWS Sessions (0–2) (EPMIP and ECWSIP cannot be enabled at the same time.)	**ECWSIP**	:=

(ETELNET, EMODBUS, E61850, EGSE, ESNTP, EFTPSERV, ETCPKA, EDNP, EPMIP, and ECWSIP 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-Out (OFF, 1–30 min)	**TIDLE**	:=
IP Address	**IPADDR**	:=
Subnet Mask	**SUBNETM**	:=
Default Router	**DEFRTR**	:=

The following table 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 192.0.1.1 to 192.255.254.254.

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)	**KAIDLE**	:=
TCP Keep-Alive Interval Range (1–20 s)	**KAINTV**	:=
TCP Keep-Alive Count Range (1–20 messages)	**KACNT**	:=

FTP Settings

The following settings are used if EFTPSERV = Y.

FTP User Name	**FTPUSER**	:=
FTP Connect Banner	**FTPCBAN**	:=
FTP Idle Time-Out (5–255 min)	**FTPIDLE**	:=

SNTP Settings

The following settings are only used if ESNTP ≠ OFF.

Primary Server IP Address	**SNTPPSIP**	:=
Backup Server IP Address (SNTPBSIP only available if ESNTP = UNICAST)	**SNTPBSIP**	:=
SNTP IP (Local) Port Number (1–65534)	**SNTPPORT**	:=

SNTP Update Rate (15–3600 s)	**SNTPRATE** :=
SNTP Time-Out (5–20 s) (SNTPTO only available if ESNTP = UNICAST or MANYCAST)	**SNTPTO** :=

DNP Ethernet Session Settings

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

DNP TCP and UDP Port (1–65534) (DNPNUM applies to all Ethernet DNP sessions.)	**DNPNUM** :=
DNP Address (0–65519) (DNPADR applies to all Ethernet DNP sessions.)	**DNPADR** :=

PMU Session Settings

PMU Output 1 Transport Scheme (OFF, TCP, UDP_S, UDP_T, UDP_U)	**PMOTS1** :=
PMU Output 1 Client IP (Remote) Address (www.xxx.yyy.zzz)	**PMOIPA1** :=
PMU Output 1TCP/IP (Local) Port Number (1–65534)	**PMOTCP1** :=
PMU Output 1 UDP/IP Data (Remote) Port Number (1–65534)	**PMOUDP1** :=
PMU Output 2 Transport Scheme (OFF, TCP, UDP_S, UDP_T, UDP_U)	**PMOTS2** :=
PMU Output 2 Client IP (Remote) Address (www.xxx.yyy.zzz)	**PMOIPA2** :=
PMU Output 2 TCP/IP (Local) Port Number (1–65534)	**PMOTCP2** :=
PMU Output 2 UDP/IP Data (Remote) Port Number (1–65534)	**PMOUDP2** :=

CWS Session Settings

CWS Output 1 Client IP (Remote) Address (www.xxx.yyy.zzz)	**CWSOIPA1** :=
CWS Output 1 UDP/IP Data (Remote) Port Number (1–65534)	**CWSOUDP1** :=
CWS Output 2 Client IP (Remote) Address (www.xxx.yyy.zzz)	**CWSOIPA2** :=
CWS Output 2 UDP/IP Data (Remote) Port Number (1–65534)	**CWSOUDP2** :=

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

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

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 and FTP Communications Protocols* 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 MIRRORED BITS protocol. Refer to *Appendix F: MIRRORED BITS Communications* for details.
SPEEDs 57600 and 115200 are not available on Port F.

Baud Rate (300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200)	**SPEED** :=
Data Bits (6, 7, 8)	**BITS** :=
Parity (O, E, N) {Odd, Even, None}	**PARITY** :=
Stop Bits (1, 2)	**STOP** :=
Enable Hardware Handshaking (Y, N, MBT)	**RTSCTS** :=

(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) (Set T_OUT = 0 for no port time-out.)	**T_OUT** :=
Enable Port Power (Y, N) (Enable or disable Pin 1 +5 V power on EIA-232 Port 2 or Port 3. Port power is disabled by default. Port 2 and Port 3 combined current draw is 400 mA.)	**EPP** :=
Send Auto Messages to Port (Y, N) (AUTO only available if PROTO = SEL or LMD. Set AUTO = Y to allow automatic messages at the serial port.)	**AUTO** :=
Fast Operate Enable (Y, N) (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.)	**FASTOP** :=

LMD Protocol Settings

The following settings are used if PROTO = LMD.

LMD Prefix (@, #, $, %, &)	**PREFIX** :=
LMD Address (1–99)	**ADDR** :=
LMD Settling Time (0.00–30.00 s)	**SETTLE** :=

Modem Settings

Modem Initialization AT String (ATSTRING is only available if COMMINF = MODEM.)	**ATSTRING** :=

DNP Serial Settings

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

DNP Address (0–65519)	**DNPADR** :=
DNP Address to Report to (1–65519)	**REPADR** :=
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 Deadband Counts

Amps Reporting Deadband Counts (0–32767)	**ANADBA** :=
Volts Reporting Deadband Counts (0–32767)	**ANADBV** :=
Misc Data Reporting Deadband Counts (0–32767)	**ANADBM** :=

Time-Outs

Minutes for Request Interval (I, M, 1–32767)	**TIMERQ**	:=
Seconds to Select/Operate Time-Out (0.0–30.0)	**STIMEO**	:=
Event Message Confirm Time-Out (1–50 s)	**ETIMEO**	:=

Data Link

Retries (0–15)	**DRETRY**	:=
Seconds to Time-Out (0–5) (DTIMEO only available if DRETRY > 0.)	**DTIMEO**	:=

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)	**URETRY**	:=
Unsolicited Message Offline Time-Out (1–5000 s)	**UTIMEO**	:=

Serial Control Lines

Minimum Seconds from DCD to TX (0.00–1.00)	**MINDLY**	:=
Maximum Seconds from DCD to TX (0.00–1.00)	**MAXDLY**	:=
Settle Time from RTS On to TX (OFF, 0.00–30.00 s)	**PREDLY**	:=
Settle Time from TX to RTS OFF (0.00–30.00 s)	**PSTDLY**	:=

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)	**DNPMAP[*n*]**	:=
Transport Protocol (UDP, TCP)	**DNPTR[*n*]**	:=
Master IP Address (zzz.yyy.xxx.www)	**DNPIP[*n*]**	:=

UDP Response Port (REQ, 1–65534)	**DNPUDP[*n*]**	:=
DNP Address to Report To (1–65519)	**REPADR[*n*]**	:=

Event Data by Class

Class for Binary Event Data (0–3)	**ECLASSB[*n*]**	:=
Class for Counter Event Data (0–3)	**ECLASSC[*n*]**	:=
Class for Analog Event Data (0–3)	**ECLASSA[*n*]**	:=

Scaling Decimal Places

Amps Scaling Decimal Places (0–6)	**DECPLA[*n*]**	:=
Voltages Scaling Decimal Places (0–6)	**DECPLV[*n*]**	:=
Misc Data Scaling Decimal Places (0–6)	**DECPLM[*n*]**	:=
Energy Counter Scaling Decimal Places (0–6)	**DECPLE[*n*]**	:=

Reporting Deadband Counts

Amps Reporting Deadband Counts (0–32767)	**ANADBA[*n*]**	:=
Volts Reporting Deadband Counts (0–32767)	**ANADBV[*n*]**	:=
Misc Data Reporting Deadband Counts (0–32767)	**ANADBM[*n*]**	:=

Time-Outs

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

Data Link

Seconds to Send Data Link Heartbeat (0–7200)	**DNPINA[*n*]**	:=

Class 0 Reporting

Class 0 Response Counter Object (20, 21, Both)	**CZPCT[*n*]**	:=

Unsolicited Messages

Enable Unsolicited Reporting (Y, N)	**UNSOL[*n*]**	:=

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

Enable Unsolicited Reporting at Power-Up (Y, N)	**PUNSOL[*n*]**	:=
Number of Events to Transmit On (1–200)	**NUMEVE[*n*]**	:=

Oldest Event to Transmit On (0–99999 s)	**AGEEVE[*n*]** :=
Unsolicited Message Max Retry Attempts (2–10)	**URETRY[*n*]** :=
Unsolicited Message Offline Time-Out (1–5000 s)	**UTIMEO[*n*]** :=

DNP Map Settings

DNP Map n

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

Binary Input *n*	**BI_MAP*n*** :=
Binary Output *n*	**BO_MAP*n*** :=
Analog Input *n*	**AI_MAP*n*** :=
Analog Output *n*	**AO_MAP*n*** :=
Counter Input *n*	**CO_MAP*n*** :=

Fast Messages

Enable Energy Message (Y, N)	**FMR1** :=
Enable 4-Quadrant Demand Message (Y, N)	**FMR2** :=
Enable 4-Quadrant Peak Demand Message (Y, N)	**FMR3** :=
Enable 4-Quadrant Meter Message (Y, N)	**FMR4** :=
Uncompensated Quantities in Fast Message (Y, N)	**FMQ_UC** :=

Modem Settings

The following settings are only available when COMMINF = MODEM.

Dial Out When a New Event Is Recorded (Y, N) (DIALOUT only available on Modem ports and PROTO = SEL)	**DIALOUT** :=
Event Notification String (30 chars max) (EVE_STR only available on Modem port and DIALOUT = Y)	**EVE_STR** :=
ID Command String (20 chars max) (ID_CMD only available on Modem port and DIALOUT = Y)	**ID_CMD** :=
Connection ID String (20 chars max) (CONN_ID only available on Modem ports and DIALOUT = Y)	**CONN_ID** :=
Modem Connected to Port (Y, N) (MODEM only available when PROTO = DNP and COMMINF = 232 or the physical port is an EIA-232 port)	**MODEM** :=
Modem Initialization at String (30 chars max) (ATSTRING only available on Modem port)	**ATSTRING** :=
Modem Startup String (30 chars max)	**MSTR** :=

Phone Number for Dial-Out (30 chars max)	**PH_NUM**	:=
Time to Attempt Dial (5–300 s)	**MDTIME**	:=
Time Between Dial-Out Attempts (5–3600 s)	**MDRET**	:=

(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) (SLAVEID is only available when PROTO = MOD)	**SLAVEID**	:=

SECTION 5

Metering

Overview

This section explains the following SEL-735 functions.

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: Analog Quantities and Device Word Bits* for a list of all supported analog quantities.

Wiring Form Configurations

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 **FOR *x*** (*x* is the desired form factor: 5 [Form 5], 9 [Form 9], or 36 [Form 36]) command from Access Level 2.

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

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

This manual occasionally describes analog quantity update rates as 10/12 cycles. The meter processes and updates these analog quantities every 10 cycles for 50-Hz systems and every 12 cycles for 60-Hz systems, per IEC 61000-4-30.

The standard describes very specific calculation and aggregation methods. The following list describes how to configure the SEL-735 to meet the exact definitions.

- By default, the meter samples voltage sag/swell/interruption disturbances over a half-cycle window to detect shorter events, instead of a 1-cycle window. To comply with IEC 61000-4-30 Class A, set the VRMSWIN setting to ONE cycle.
- The SEL-735 provides instantaneous interharmonic values without aggregation.
- By default, the meter aggregates integer harmonics with a 5 Hz bin width centered around the nominal harmonic frequency. To comply with IEC 61000-4-30 Class A, set HARMCAL to SUBGROUPS to enable a 15 Hz bin width for harmonic calculations.

To avoid generating a discontinuity in 10/12-cycle data at the 10-minute tick as prescribed by IEC 61000-4-30 section 4.4 *Measurement aggregation over time intervals*, the SEL-735 frequency-based 10/12-cycle aggregation data synchronize to real time. This method ensures correct reporting of a single power system disturbance occurring at a 10-minute interval. The response from the SEL-735 aggregation values meets all accuracy criteria of IEC 62586-2.

The meter must cross at least two 10-minute boundaries after turning on or after a time change before it synchronizes aggregated data to the clock. The TS10MIN and TS2HR Device Word bits will assert on the 10-minute or 2-hour boundary when the meter time changes by an amount greater than the TIME_CHG setting. Consequently, the Device Word bits deassert only on the next 10-minute or 2-hour boundary when there is no time change or a time change less than the TIME_CHG setting.

Measurement Aggregation

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

Analog Quantities

The following quantities are available as aggregated quantities (refer to *Appendix G: Analog Quantities and Device Word Bits* for corresponding names and update rates):

- 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:

$\text{Value}_{\text{Aggregate}}$ = the time-aggregated value
Input = the value to aggregate
N = the number of accumulations performed during the aggregation period

The smallest resolution of data processing is one 10/12 cycle block.

Aggregation Interval	N	Input
150/180 cycles	15	10/12-cycle data
10 minutes	3000[a]	10/12-cycle data
2 hour	12	10-minute data

[a] This value varies depending on the system frequency.

Aggregation Time Periods

150/180 Cycles (3 Seconds)

The meter aggregates 15 consecutive 10/12-cycle data synchronized to the system frequency.

10 Minute

Each 10-minute aggregation period begins on the 10/12-cycle boundary after the 10-minute tick of the RTC.

2 Hour

The meter aggregates 12 consecutive sets of 10-minute values to calculate each 2-hour quantity.

Aggregation Reset

The 10-minute and 2-hour aggregated values and time stamps reset any time the device resets or the system time changes more than the TIME_CHG setting. 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.

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

Device Word Bit	Definition
ITIC_ND	ITIC No Damage Region
ITIC_PR	ITIC Prohibited Region
ITIC_SR	ITIC Safe Operation Region
SAG*x*	Voltage sag on phase *x*
SW*x*	Voltage swell on phase *x*
INT*x*	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

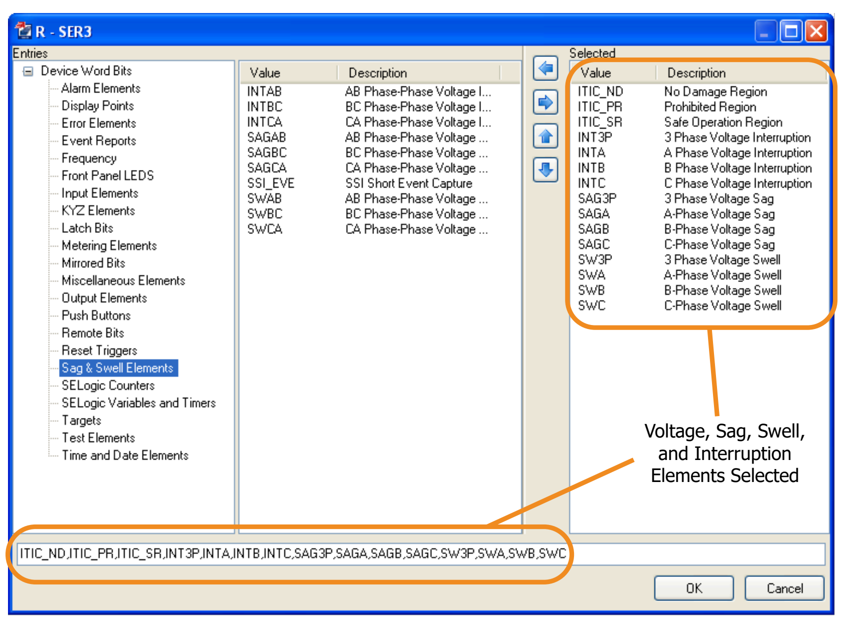


Figure 5.1 Selected Sag and Swell Elements in a Sequential Events Recorder

Logging

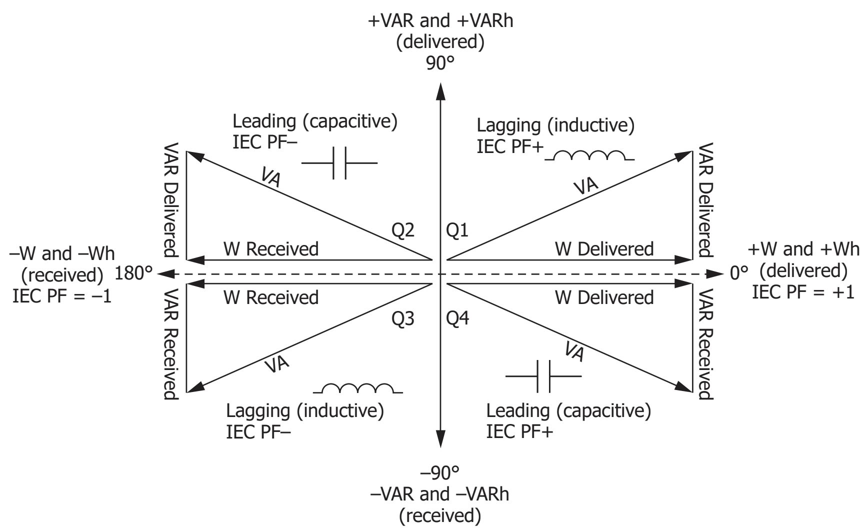
By default, advanced and intermediate recording meters have load profile recorders configured to log aggregated data in accordance with *Table 5.2*.

Table 5.2 Default Load Profile Recorder Aggregated Data

Load Profile Recorder Number	Aggregated Data
2	3-second aggregated voltages, currents, voltage THD, current THD, and voltage imbalance
3	10-second aggregated frequency
4	10-minute aggregated voltages, currents, voltage THD, current THD, and voltage imbalance
5	10-minute and 2-hour aggregated flicker
6	2-hour aggregated voltages, currents, voltage THD, current THD, and voltage imbalance

Four-Quadrant VAR Metering

The SEL-735 calculates four-quadrant volt-ampere reactive (VAR) values, following the IEC VAR sign convention as illustrated in *Figure 5.2*. *Appendix G: Analog Quantities and Device Word Bits* lists each four-quadrant quantity and the update rate. The meter updates the four-quadrant VAR metering every 10/12 cycles.



Quadrant	Power Factor	IEC PF Used in SEL Meter	IEEE PF	Watts	VARs
1	Lag	+	–	Delivered (+)	Delivered (+)
2	Lead	–	+	Received (–)	Delivered (+)
3	Lag	–	–	Received (–)	Received (–)
4	Lead	+	+	Delivered (+)	Received (–)

Note: The SEL meter displays power flow as delivered or received, but you may encounter other naming conventions such as import, export, and produce per IEC 61557-12 2018, Annex C.

Figure 5.2 IEC VAR Sign Convention

The SEL-735 displays these both graphically and as analog values, as shown in *Figure 5.3*.

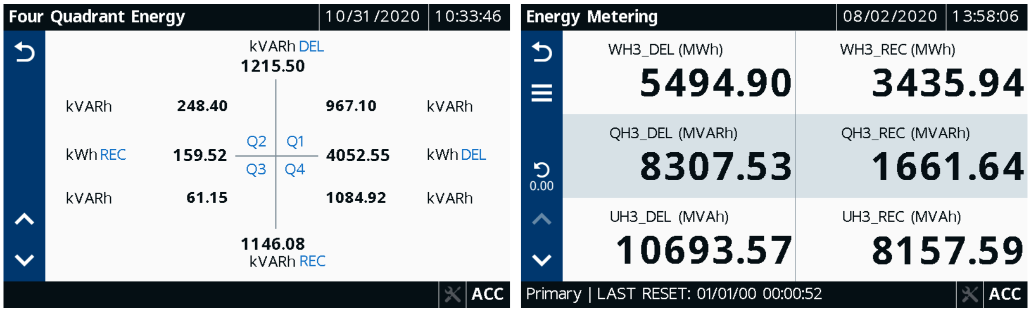


Figure 5.3 SEL Meter Four Quadrant Metering Displays

The SEL-735 displays power flow as delivered or received.

Figure 5.4 demonstrates the power flow convention of the SEL-735.

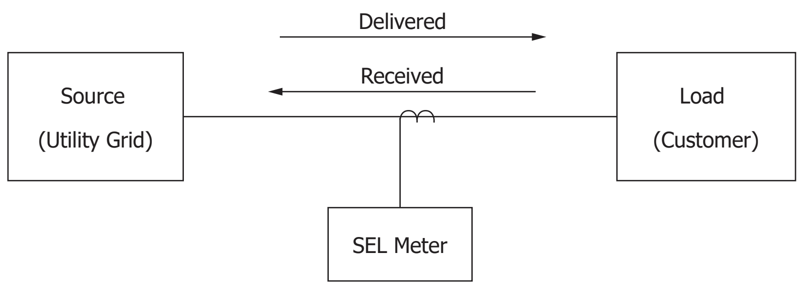


Figure 5.4 SEL-735 Power Flow Notations

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[a]	Definition
EQ*x*1	VARs in Quadrant 1
EQ*x*2	VARs in Quadrant 2
EQ*x*3	VARs in Quadrant 3
EQ*x*4	VARs in Quadrant 4

[a] x = A, B, C, or 3P.

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 can 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 can use the following equation to determine the proper Ratio Correction Factor setting.

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

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 can use the following equation to determine the proper Phase Angle Minutes setting.

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

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**

IRCF*x*_1 := **1.02**

IPAM*x*_1 := **270**

ICAL_2 := **0.10**

IRCF*x*_2 := **1.015**

IPAM*x*_2 := **240**

ICAL_3 := **0.20**

IRCFx_3 := **1.0142**

IPAM*x*_3 := **72**

ICAL_4 := **0.50**

IRCF*x*_4 := **1.0101**

IPAM*x*_4 := **60**

ICAL_5 := **1.00**

IRCF*x*_5 := **1.0050**

IPAM*x*_5 := **60**

ICAL_6 := **2.00**

IRCF*x*_6 := **1.0010**

IPAM*x*_6 := **57**

Figure 5.5 shows the Ratio Correction Factor vs. the calibration point of the CT example given.

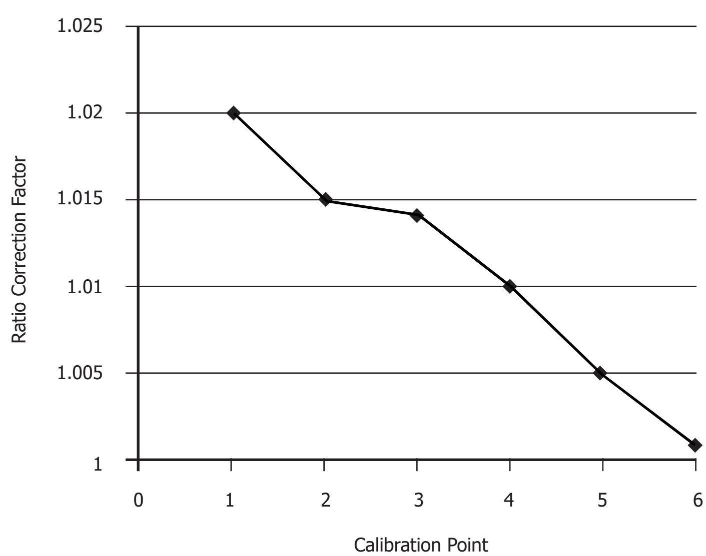


Figure 5.5 Ratio Correction Factor vs. Calibration Point

Figure 5.6 shows the CT Phase Angle Minutes correction vs. the calibration point of the CT example given.

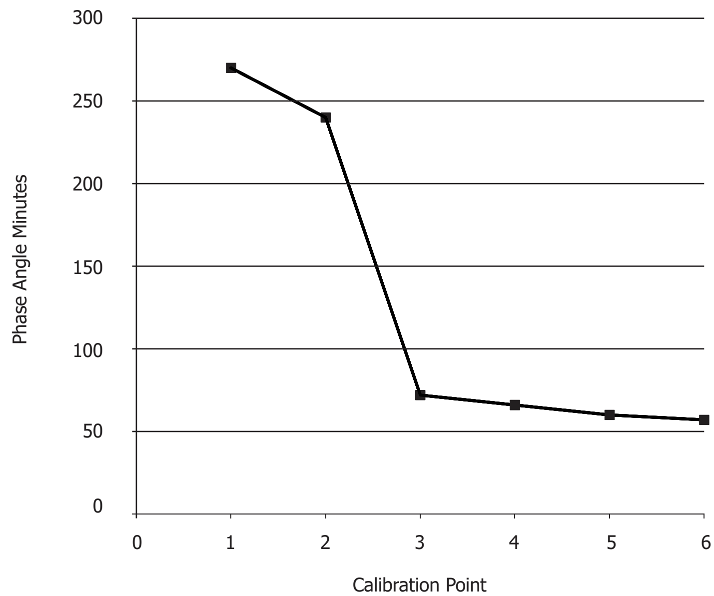


Figure 5.6 Phase Angle Minutes vs. Calibration Point

Frequency Tracking

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

- 1/2 Cycle Fundamental Frequency (FREQ)
- 10-Second Average Frequency (FREQ_PQ)
- Synchrophasor Frequency
- Synchrophasor Rate-of-Change of Frequency

Fundamental Frequency

The SEL-735 tracks frequency based on the voltage inputs with the following conditions:

- V*x*_FUND greater than 11 V, where *x* = A, B, or C for Form 9 and Form 36 meters, and *x* = AB, BC, CA for Form 5 meters
- Rate-of-change of fundamental frequency is less than 0.9 Hz per second
- Frequency reporting range is between 40 and 70 Hz

If the voltage magnitude and rate of change system conditions are not met, the meter reports the system nominal frequency (50/60 Hz). If the frequency exceeds the measurement limits of 40 Hz to 70 Hz, the meter clamps to the nearest limit. The SEL-735 FREQ analog quantity is calculated by measuring the time between rising-to-rising and falling-to-falling zero crossings, so it has a one-cycle delay but is updated every half cycle.

Power Quality Frequency

The FREQ_PQ analog quantity is a 10-second averaging of the FREQ analog quantity. While the calculations use 16 sample per cycle data, they are not affected by the variable sample rate because the times are based on the FRC values which are a fixed rate quantity. This quantity complies with IEC 61000-4-30, Class A requirements.

The SEL-735 asserts the FREQY Device Word bit when tracking the FREQ value and asserts the PFREQY Device Word bit when tracking the 10-second FREQ_PQ value. PFREQY cannot assert until the meter has been monitoring a stable frequency for 10 seconds.

Synchrophasor Frequency

Synchrophasors use fixed rate samples (1,200 samples per second) to produce phasor information that is used to calculate the phasor rotation/frequency. The phasor generation has a 2+ cycle delay, but the phasor information is updated at a 1,200 Hz rate.

Analog variables added to the synchrophasor IEEE C37.118.2 payload section of the protocol are updated no faster than the 10/12 cycles rate. The analog quantities added will be transmitted with the synchrophasor measurement data as quickly as 60 per second, but the values change at a 10/12 cycle rate, including the 1/2 cycle updated variables.

Synchrophasor frequency and rate-of-change-of-frequency (ROCOF) measurements are calculated according to the IEEE C37.118 specification and are shown in the following equations, starting with the angle of the phasor measurement.

For each rectangular-form complex reference phasor, X, the angle of the phasor in radians shall be determined by using *Equation 5.1* and *Equation 5.2*:

$$X_{ang} = \mathrm{atan2}\left(X_{Im}, X_{Re}\right)\ (\mathrm{radians})$$

Equation 5.1

and

$$X_{ang\_diff}\ (k) = X_{ang}\ (k) - X_{ang}\ (k-1)\ (\mathrm{radians})$$

Equation 5.2

Calculate frequency at moment *k* by using the following equation, where *n* is the nominal frequency in Hz and each sample is 1/*n* seconds apart:

$$f(k) = \frac{n}{(2 \bullet \pi)} \bullet \left(\frac{3}{2} \bullet X_{ang\_diff}\ (k) - \frac{1}{2} \bullet X_{ang\_diff}\ (k-1)\right)$$

Equation 5.3

Calculate ROCOF at moment *k* using the following equation, where *n* is the nominal frequency in Hz and each sample is 1/*n* seconds apart:

$$\mathrm{ROCOF}(k) = \frac{n^2}{(2 \bullet \pi)} \bullet \left(2 \bullet X_{ang\_diff}\ (k) - 3 \bullet X_{ang\_diff}\ (k-1) + X_{ang\_diff}\ (k-2)\right)$$

Equation 5.4

Table 5.5 summarizes the frequency command characteristics.

Table 5.5 Frequency Command Characteristics

Command	Tracking	Pickup	Frequency Accuracy	Max df/dt	Update Rate	Calculation Method
FREQ_PQ	FREQ analog quantity, else 50/60 Hz	>11 V 40–70 Hz, 40–70 Hz clamp	±0.001 Hz	Must be stable for 10 seconds per the calculation method	10 s	10 s average frequency of FREQ, IRIG time
FREQ	VA, else VC, else 50/60 Hz	>11 V 40–70 Hz, 40–70 Hz clamp	±0.01 Hz	±0.9 Hz/s	1/2 cycle	Five 1/2-cycles Olympic filtered, rolling and recalculated 1/2-cycle, FREQ
FREQ_PMU	Positive Sequence, else 50/60 Hz	11 V > 40–80 Hz, 40–80 Hz clamp	±0.005 Hz at stable frequency ±0.001 Hz Stable frequencies between 59–61 Hz or 49–51 Hz	Frequency max df/dt accuracy dependent on time, max df/dt measurement roughly ±300 Hz/s	2/fs, max 60 hz = 16.67 ms, MRATE reporting time specified.	Derived from phase measurement $f = \frac{d\theta}{dt}$

Demand Metering

You can choose between the following 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 5.6*.

Table 5.6 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 5.7* shows the response of thermal, rolling, and block demand meters to a 1.0 per unit step energy input.

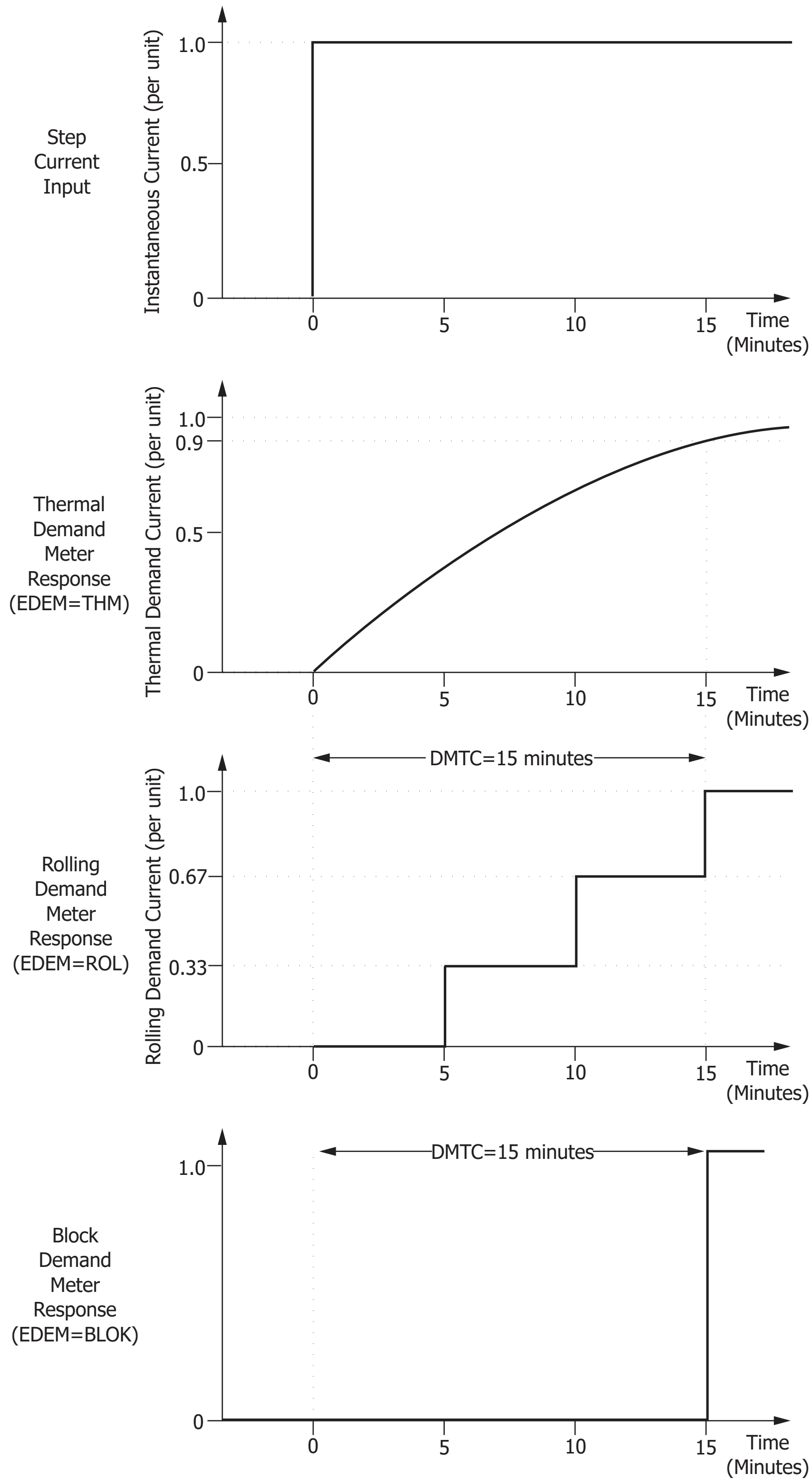


Figure 5.7 Response of Thermal, Rolling, and Block Demand Meters to a Step Input (Setting DMTC = 15 Minutes)

Thermal Demand Meter Response (EDEM = THM)

The thermal demand meter response in *Table 5.6* to the step current input is analogous to the series RC circuit in *Figure 5.8*.

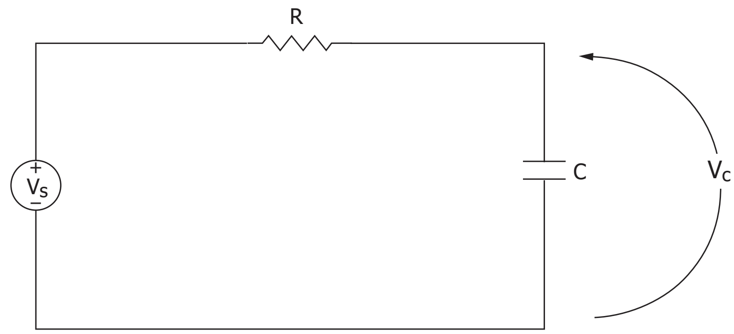


Figure 5.8 Voltage V_S Applied to Series RC Circuit

Thermal demand uses the following algorithm.

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

where:

$T_{constant} = \dfrac{\ln(10)}{\text{DMTC} \bullet 60}$
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 5.8* corresponds to the step current input in *Figure 5.7* (top).

Voltage V_C across the capacitor in *Figure 5.8* corresponds to the response of the thermal demand meter in *Figure 5.7* (middle).

If voltage V_S in *Figure 5.8* has been at zero (V_S = 0.0 per unit) for some time, voltage V_C across the capacitor in *Figure 5.8* 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 5.7* (middle) to the step current input (top).

In general, because voltage V_C across the capacitor in *Figure 5.8* 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 5.7* 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 5.7* 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 5.7* 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:

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

N = number of input values accumulated in the subinterval
sample = the analog quantity to calculate demand

Table 5.7 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	1	6	15
					5	12
					3	10
					1	6
						5
						3
						1

The following is a step-by-step calculation of the rolling demand response example in *Figure 5.7* (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.

Rolling demand meter response at Time = 0 minutes = $\frac{0.0}{3}$ = 0.0 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 5.8*.

Table 5.8 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 5.9*.

Table 5.9 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 5.10*.

Table 5.10 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.

Refer to *Appendix G: Analog Quantities and Device Word Bits* for the quantity names and update rates. The meter updates the demand quantities based on the DMTC time period.

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 (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 5.5* shows the predictive demand calculation.

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

Equation 5.5

where:

Avg = average of demand values observed during the elapsed period ($T_{Elapsed}$)
$T_{Elapsed}$ = (DMTC – $T_{Remaining}$)[a]
Present = most recent demand value
$T_{Remaining}$ = time remaining in the present DMTC[b] period
DMTC = demand metering time constant

[a] If the time since device power up is less than the DMTC time period, $T_{Elapsed}$ = Time since power up.
[b] If EDEM = ROL, use the time remaining in the present DMSI period.

If the user changes any settings related to demand, the meter resets the predictive demand to zero. If the calculated predictive demand value exceeds the PREDAL setting for 15 consecutive calculations (approximately three seconds), the meter asserts the PREDAL Device Word bit. Conversely, when the calculated predictive demand value drops below the PREDAL setting for 15 consecutive calculations, the meter deasserts the PREDAL Device Word bit. *Figure 5.9* shows the processing of the predictive demand logic.

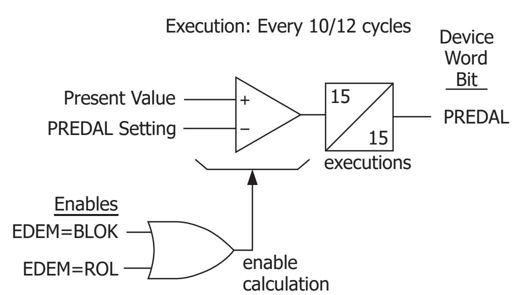


Figure 5.9 PREDAL Logic

The following examples in this section illustrate demand current.

Demand Metering Elements

Setting	Associated Function
DMTC	Time Constant (Min)
DBLOCK	Prevent capturing of peak demand for specified minutes after device power up (min)
FLTBLK	Prevent assertion of the FAULT and DFAULT bits
EOIPT	Assert EOIP device bit for specified seconds at end of each demand interval
PRED	Predicted Peak Demand Quantity used in predictive demand
PREDAL	Peak Demand Alarm Level (Pri) to assert the PREDAL Relay Word bit

View or Reset Demand Metering Information

Via QuickSet HMI

The ACSELERATOR QuickSet SEL-5030 Software HMI can display and reset present and peak demand metering. *Table 5.11* shows the demand values available through the QuickSet HMI.

Table 5.11 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.

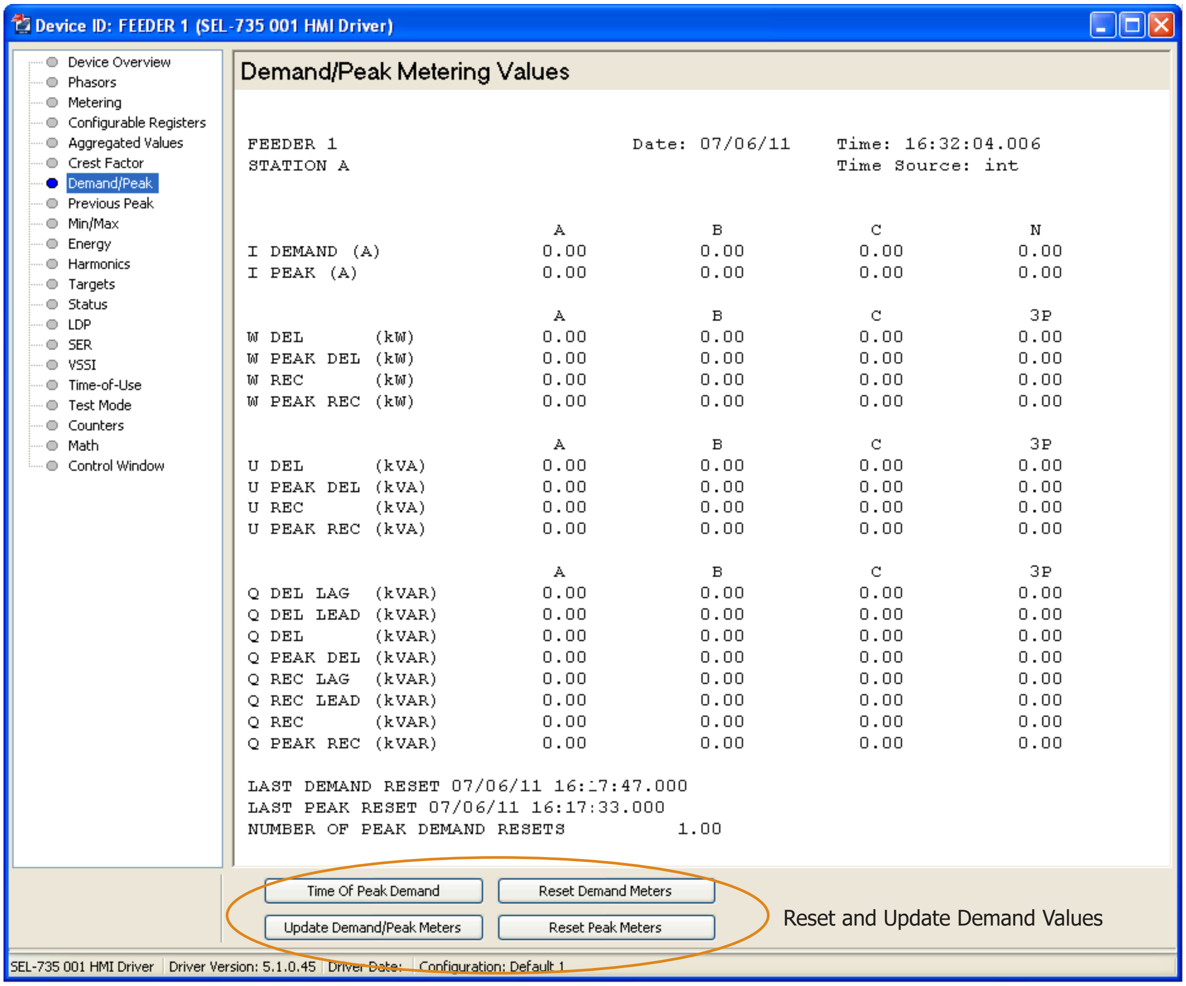


Figure 5.10 Demand/Peak Metering Values HMI Window

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

➤ Show Demand/Peak Meters:

Click **Update Demand/Peak Meters** to show the demand values listed in *Table 5.11*.

NOTE
There may be a delay of as long as two times the DMTC setting before the rolling demand values update.

➤ Show Time of Peak Demand:

Click **Time of Peak Demand** to show the time and date of all peak demands.

➤ Reset Demand Meters:

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

➤ Reset Peak Meters:

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

Via LCD 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 (Access Level 2 access is required)
Reset Peak	Reset all peak demand values and record the time and date of reset (Access Level E access is required)

Step 4. Press **ENT**.

Step 5. Enter the Access Level 2 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 Color Touchscreen Front Panel

Show Demand and Peak Demand Data

Step 1. Press the Home button.

Step 2. Select the `METER` folder.

Step 3. Select the Demand or Peak Demand app.

Step 4. Use the up and down arrow to view the quantity you want.

Reset Demand Meters

Step 1. Press the Home button.

Step 2. Select the METER folder.

Step 3. Select the Peak Demand app.

Step 4. Press the reset icon.

Step 5. Enter the Access Level 2 password.

Step 6. When prompted to Reset Peak Demand, select Yes.

The SEL-735 displays Peak Demand Reset Successful upon a successful reset.

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 RSTPKDM 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 190*.

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. Refer to *Appendix G: Analog Quantities and Device Word Bits* for the quantity names and update rates.

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

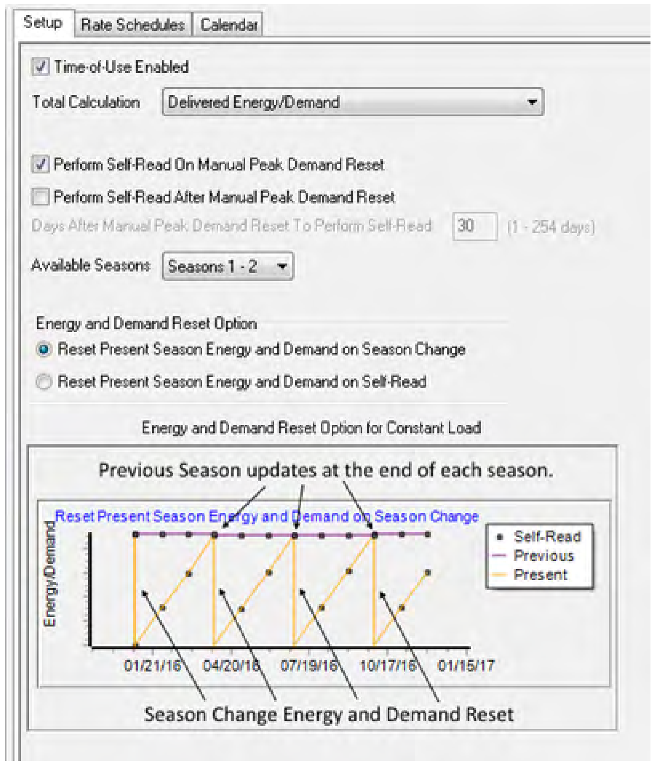


Figure 5.11 Setup Page

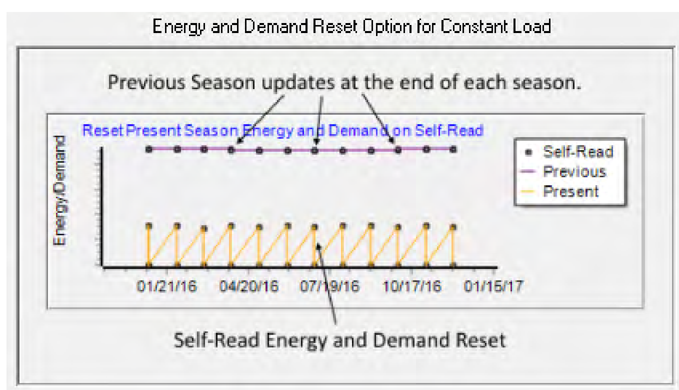


Figure 5.12 Reset Present Season Energy and Demand on Self-Read

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.

Energy and Demand Reset Option

NOTE
Regardless of the Energy and Demand Reset Option, Previous Season Energy and Demand registers reset only at season change.

The diagram on the bottom of the **TOU Setup** page shows the presently selected Energy and Demand Reset option. Select **Reset Present Season Energy and Demand on Season Change** for the meter to perform the Present Season TOU Energy and Demand reset on season change (as shown in *Figure 5.11*). Select **Reset Present Season Energy and Demand on Self-Read** for the meter to perform Present Season TOU Energy and Demand reset at the time of a self-read (as shown in *Figure 5.12*).

Rate Schedules Tab

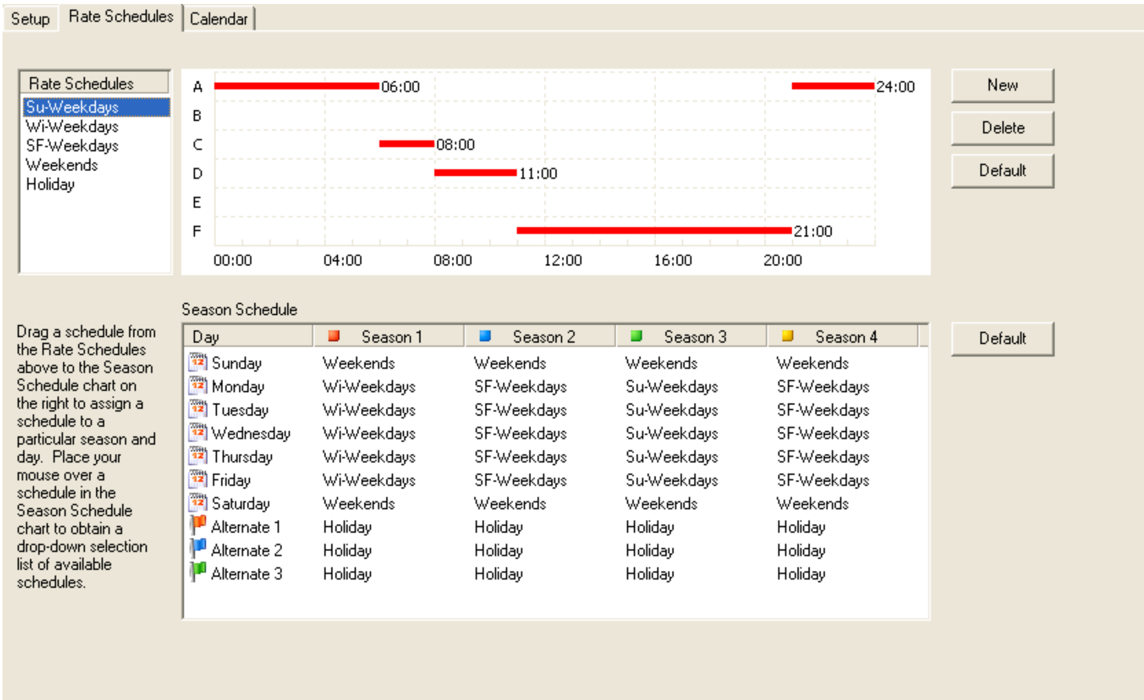


Figure 5.13 Rate Schedules Page

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 the **New** button, or right-click in the **Rate Schedules** window and select **New** from the drop-down menu shown in *Figure 5.14*.

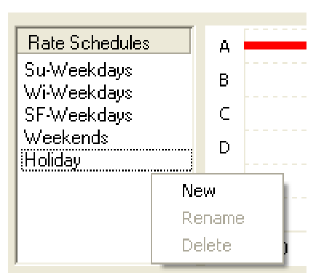


Figure 5.14 Schedule Drop-Down Menu

Delete a Rate Schedule

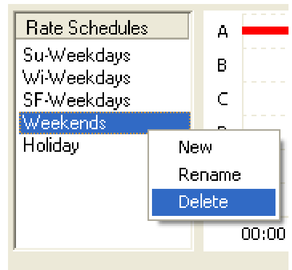


Figure 5.15 Deleting a Rate Schedule

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.

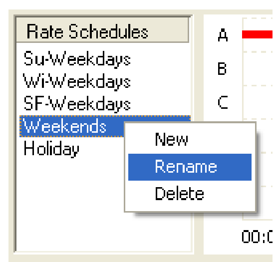


Figure 5.16 Renaming a Rate Schedule

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 5.17*) 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 5.17 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

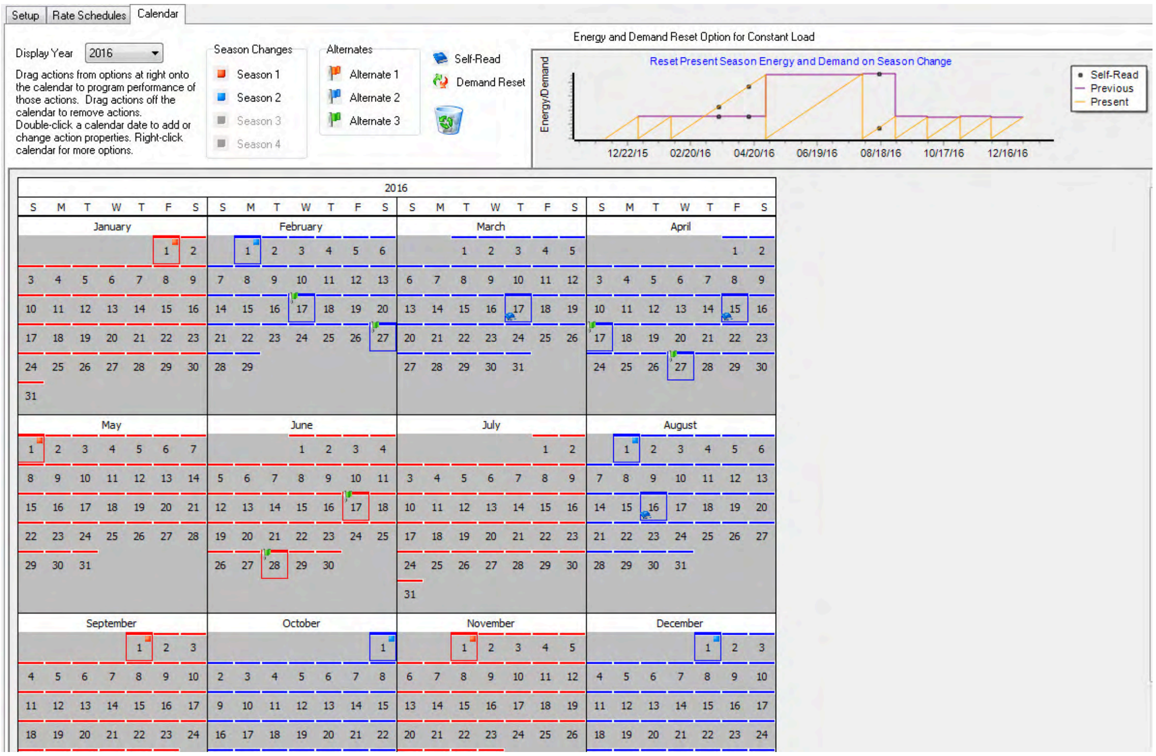


Figure 5.18 Calendar Page

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 for the **Perform Self-Read On Manual Peak Demand Reset** option.

The chart at the upper right corner of the Calendar page depicts the self-read events and when the Present and Previous Season TOU data registers reset.

The chart updates when changes are made to self-read events or season start and end dates.

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 5.19*. The **Calendar Entry Editor** will appear as in *Figure 5.20*. Select the action you want and determine how you want this action to repeat.

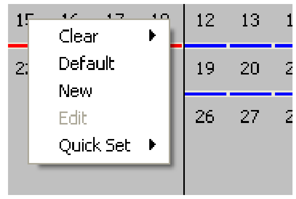


Figure 5.19 Calendar Entry Drop-Down Menu

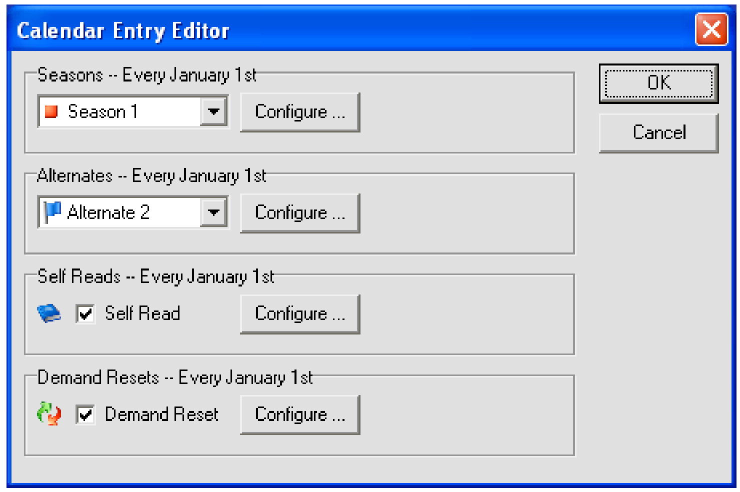


Figure 5.20 Calendar Entry Editor

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

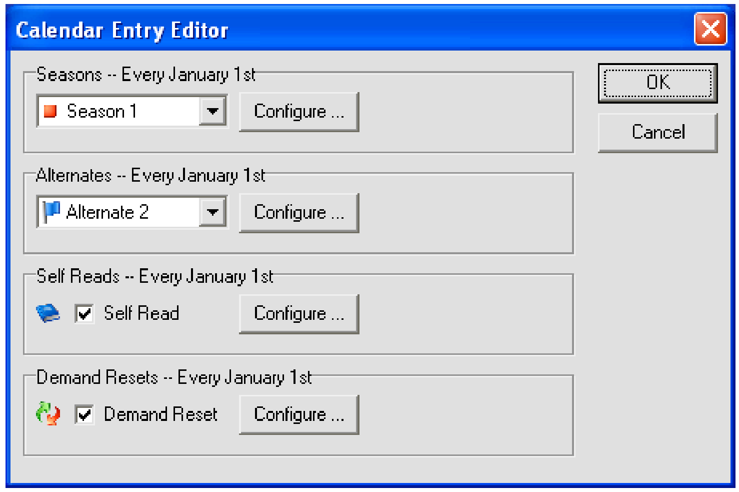


Figure 5.21 Calendar Entry Editor

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

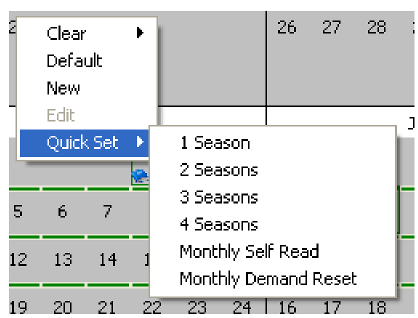


Figure 5.22 Quick Set Menu

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 5.22*).

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 5.23*).

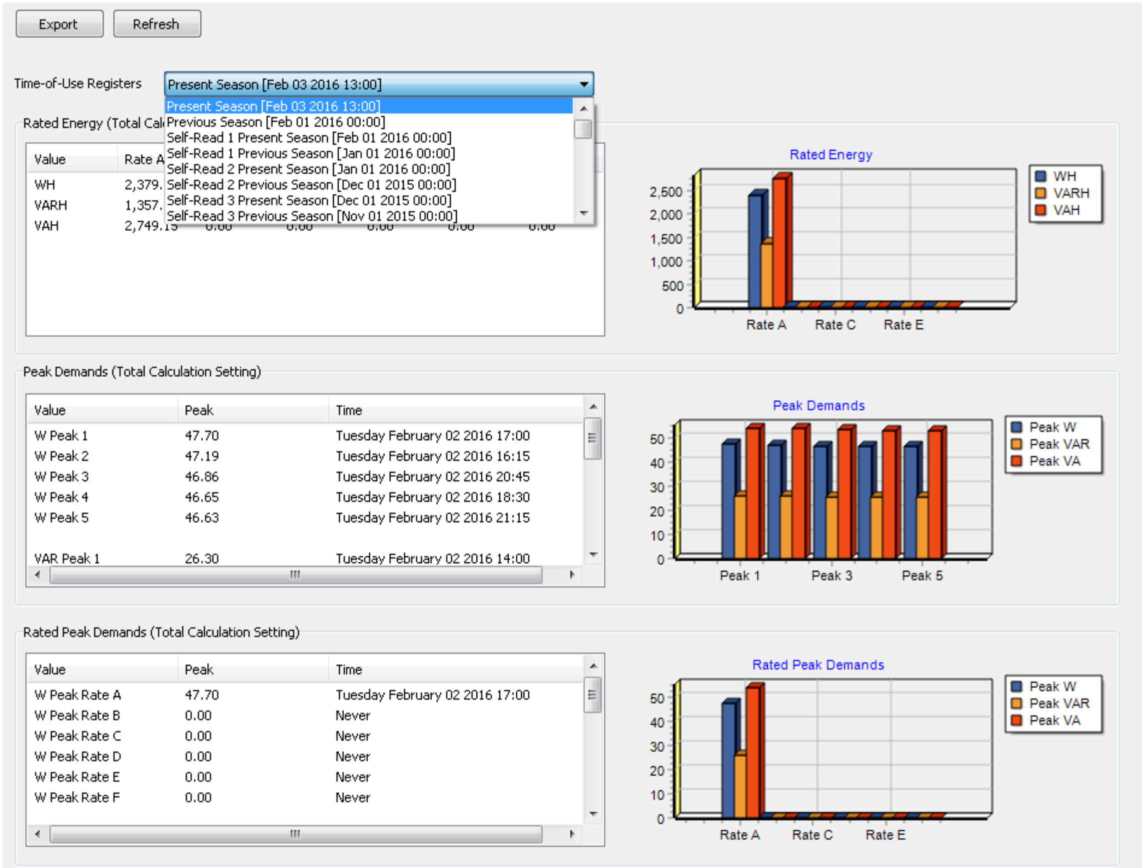


Figure 5.23 TOU Data Page

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

Press **Export** 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 and FTP Communications Protocols* 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 5.12 Available Time-of-Use Data

Rated Energy Block
Rate X MWH "Total"[a]
Rate X VARH "Total"[a]
Rate X VAH "Total"[a]
Rate X WH Received[a]
Rate X VARH Received[a]
Rate X UH Received[a]
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
Rated Peak Demand Block
5 Max MW "Total" Peak Demands
5 Max UR "Total" Peak Demands
5 Max U "Total" Peak Demands
Rate X MW "Total" Peak Demand[a]
PF at Max MW "Total" Peak Demand[a]
PF at Rate X MW "Total" Peak Demand[a]
Rate X UR "Total" Peak Demand[a]
PF at Max UR "Total" Peak Demand
PF at Rate X UR "Total" Peak Demand[a]
Rate X U "Total" Peak Demand[a]
PF at Max U "Total" Peak Demand

PF at Rate X U "Total" Peak Demand[a]
Rated Peak Demand Time Block
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[a]
Time stamp of Rate X UR "Total" Peak Demand[a]
Time stamp of Rate X U "Total" Peak Demand[a]
Rated Cumulative Demand Block
MW "Total" Cumulative Peak Demand
Rate X MW "Total" Cumulative Peak Demand[a]
UR "Total" Cumulative Peak Demand
Rate X UR "Total" Cumulative Peak Demand[a]
U "Total" Cumulative Peak Demand
Rate X U "Total" Cumulative Peak Demand[a]
Demand Reset Block
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
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

[a] 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 5.24*).

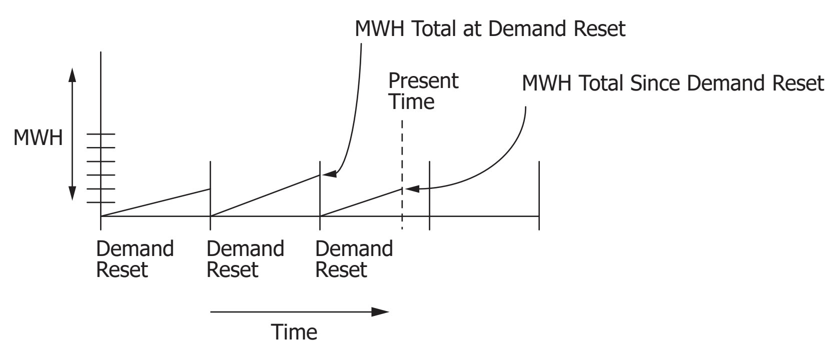


Figure 5.24 Total At/Since Demand Reset

MW/MVAR "Total" Cumulative Demand

The sum of the peak demand between each demand reset without regard to rate (see *Figure 5.25*).

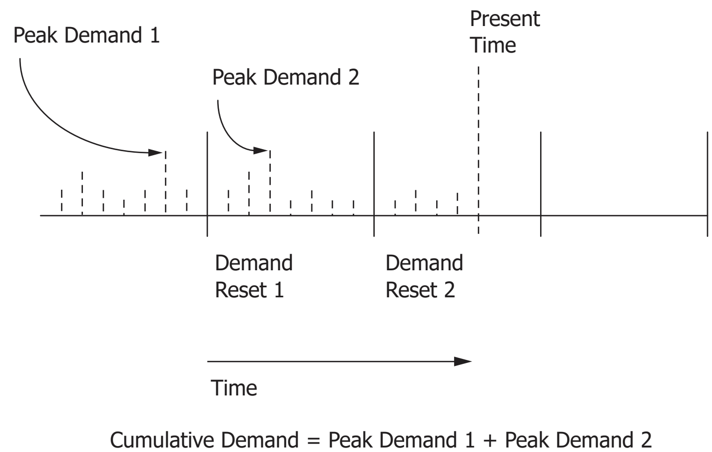


Figure 5.25 Peak Cumulative Demand

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 ACSELERATOR 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

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 watt-hours by adding watt-hours for the most recent interval to the previously accumulated watt-hour value.

$$\mathrm{Wh}(n)_x = \frac{P \bullet \Delta t}{3600} + \mathrm{Wh}\left(n - 1\right)_x$$

Equation 5.6

where:

P = the active power measured over the time interval Δt

n = the index for the most recent, non-overlapping interval Δt

WH(n – 1) = the accumulated energy from all prior intervals

Δt = 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.

In the SEL-735, the resulting sum of per-phase VARH measurements determines the direction of the three-phase analog quantity. At any instant, three-phase VARH will report only as delivered or received, although each phase may vary.

For example, if

QHA_DEL = 1 VARH

QHB_DEL = 1 VARH

QHC_REC = 4 VARH

then QH3_DEL = 0 VARH

QH3_REC = 2 VARH

Refer to *Appendix G: Analog Quantities and Device Word Bits* for the analog quantity names and the update rates. The meter updates the energy quantities every 10/12 cycles.

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 5.13* lists the scaling differences between fixed scaling Recorder 1 and configurable scaling for Recorders 2–32. If you need different scaling for individual analog quantities, create a configurable register and use it in the load profile recorder. See *Configurable Registers on page 211*.

Table 5.13 Load Profile Recorder Scaling

Load Profile Recorder	Quantity	Scaling Applied
1 (Billing Recorder)	Energy	Primary, Kilo
	Volts and Power	Primary, Kilo
	Current	Primary, Unity
2–32 (PQ Recorders)	Energy	PRI_SCA, ENRG_SCA
	Power	PRI_SCA, POWR_SCA
	Volts	PRI_SCA, VOLT_SCA
	Current	PRI_SCA, Unity

Energy data in Load Profile Recorder 1 (billing recorder) always reports energy as change-over-interval. This composes the consumed energy during each LDP interval and will not roll over.

When energy analog quantities are in the PQ recorders and the recorder function is set 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.

Fast Meter and Fast Messages

The SEL-735 reports Fast Meter Message and Fast Message analog quantities independent of the scaling settings.

Analog Quantity[a]	Scaling
Current	Unity
Voltage	Kilo
Power	Mega
Energy[b]	Kilo

[a] The analog quantities are primary quantities.
[b] Energy rollover occurs 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 5.26* shows the Energy Metering Values HMI Window.

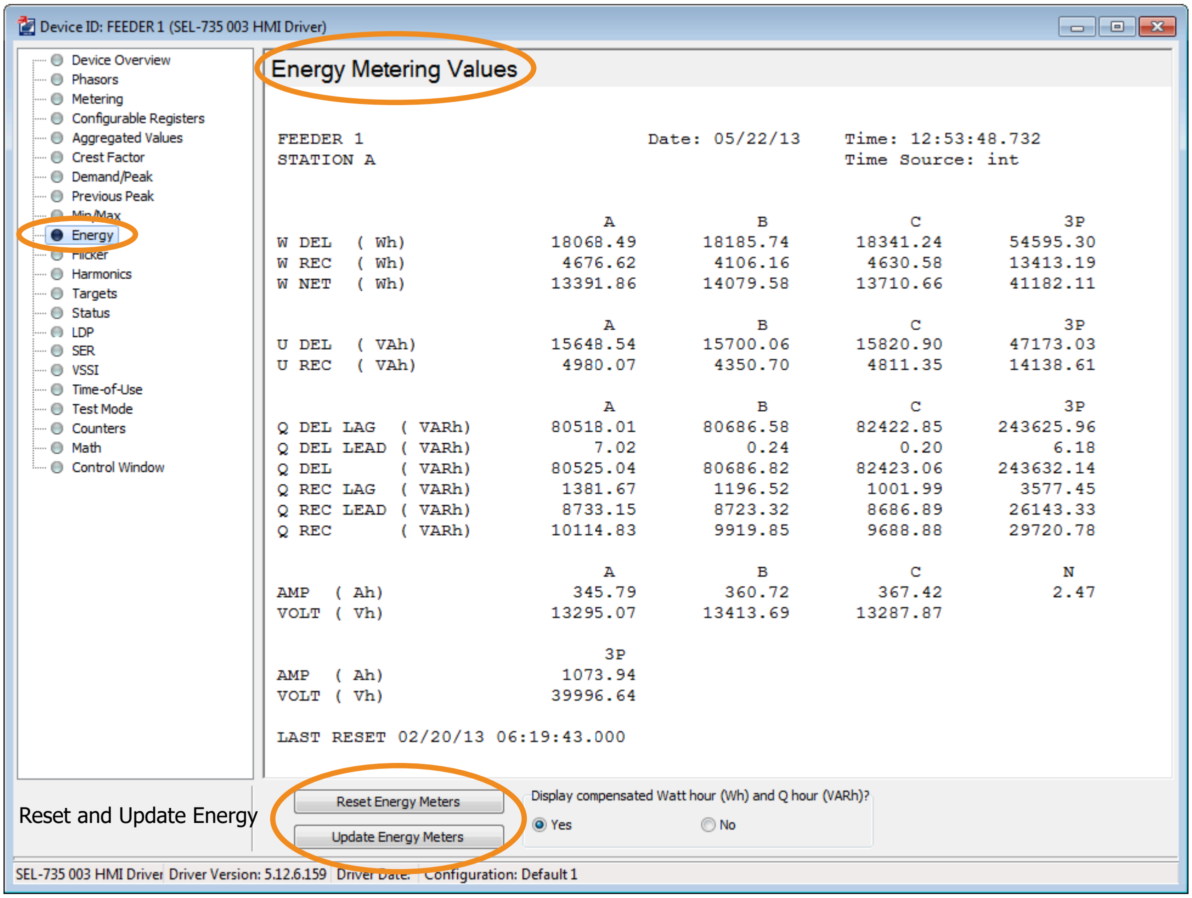


Figure 5.26 Energy Metering Values HMI Window

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

- Reset Energy Meter Data:

  Click **Reset Energy Meters** to reset all energy data and record the time and date of reset.

- Show Energy Meter Data:

  Click **Update Energy Meters** 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

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 Access Level 2 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 170*.

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 zeros rms watts. The ANGCUT setting supports cut-off angles from 1° to 10° in 1° increments.

When Phasors 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 Phasors 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 VA, 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.

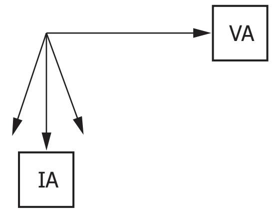


Figure 5.27 Power Factor = ±0.02

See *Table 5.14* for an example of when the ANGCUT setting affects power and energy calculations.

Table 5.14 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°

To Set ANGCUT

In QuickSet, the ANGCUT setting is located under **General > Global**. Select **Advanced**, then select your angle from the drop-down list, as shown in *Figure 5.28*.

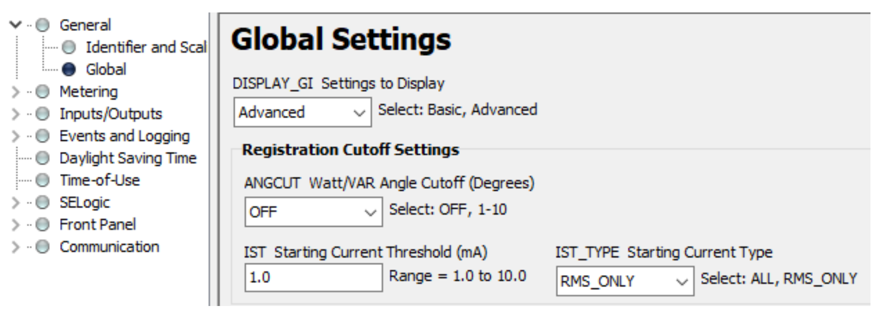


Figure 5.28 ANGCUT Setting Location in QuickSet

To Set CALCQ

The SEL-735 offers the CALCQ setting to modify the way the SEL-735 calculates reactive power. In QuickSet, the CALCQ setting is located under **General > Global**. Select **Advanced**, then select your VAR calculation method from the drop-down list, as shown in *Figure 5.29*. Selecting VECTOR will use the full spectrum VAR calculation method, including all harmonics in the VAR measurements. Selecting FUND will use the fundamental VAR calculation method. This will exclude harmonics when calculating reactive power. See *Voltage, Current, and Power Calculations on page 216* for more detail on the calculations methods.

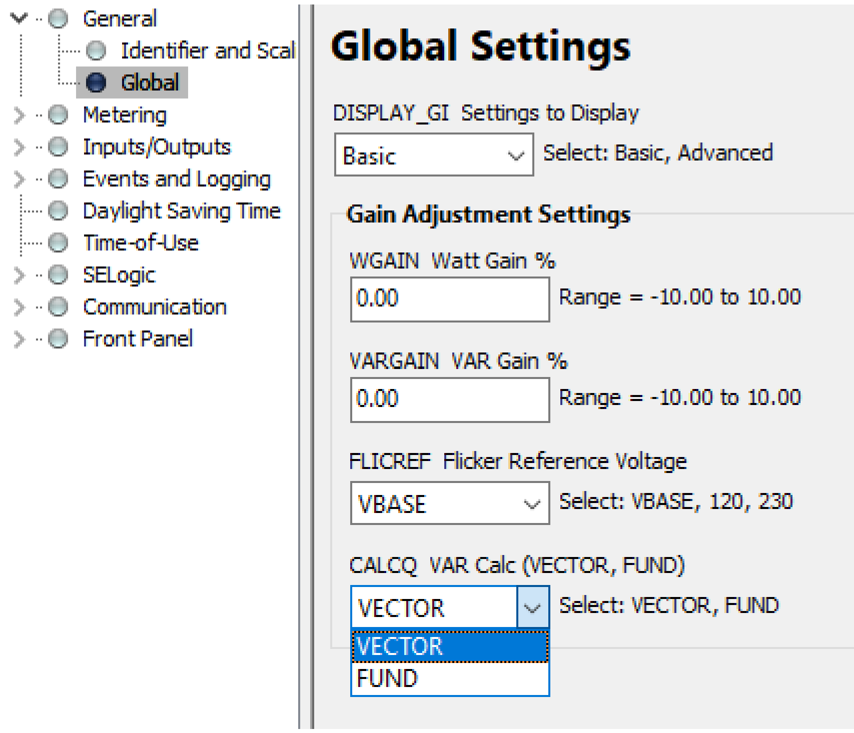


Figure 5.29 CALCQ Setting Location in QuickSet

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 5.30 shows the Min/Max meter data.

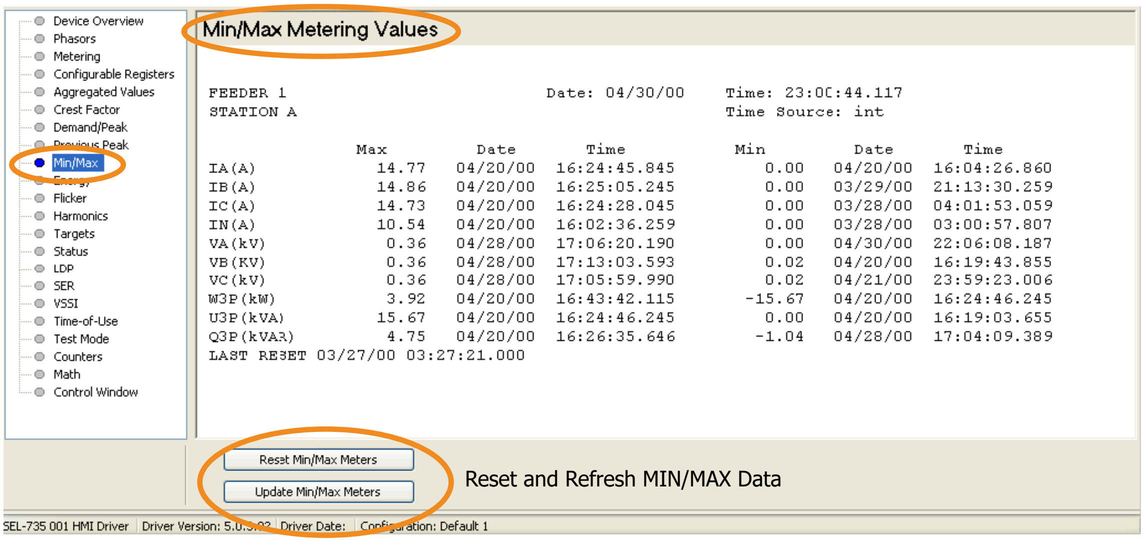


Figure 5.30 Min/Max Metering Values HMI Window

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

- Reset Min/Max Meter Data:

  Click **Reset Min/Max Meters** to reset all Min/Max data and record the date and time of reset.

- Show Min/Max Meter Data:

  Click **Update Energy Meters** 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 Access Level 2 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.

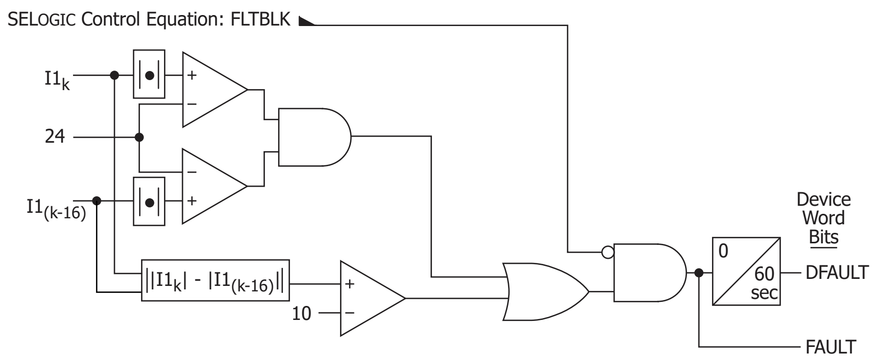


Figure 5.31 FAULT and DFAULT Device Word Bit Logic

Refer to *Appendix G: Analog Quantities and Device Word Bits* for the analog quantity names.

The meter updates the min/max metering quantities every 10/12 cycles.

NOTE
The minimum/maximum metering 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.

Elements

FAULT: Device Word bit that asserts along with the DFAULT Device Word bit if the positive-sequence current exceeds 24 A or the metered current rises 10 A between any two power system cycles. *Figure 5.31* illustrates when the FAULT and DFAULT bits assert. Peak demand, minimum/maximum metering, energy, and crest factor metering cease and VSSI is not armed when the FAULT and DFAULT Device Word bits assert. Energy starts accumulating and VSSI resumes when the FAULT Device Word bit deasserts.

DFAULT, Delayed Fault: DFAULT Device Word bit asserts when the FAULT bit asserts and remains asserted for 60 seconds after removal of the fault condition (i.e., when FAULT deasserts). Peak Demand, Max/Min, and Crest Factor metering resumes when the DFAULT Device Word bit deasserts.

FLTBLK, Fault Bit Block SELOGIC control equation: SELOGIC control equation setting FLTBLK (Fault block) must be deasserted (logical 0) for the FAULT Device Word bit to assert during a fault on the system. Configure FLTBLK to override, when asserted, the FAULT Device Word bit. The default setting for FLTBLK is deasserted.

Crest Factor Metering

Along with total harmonic distortion, crest factor is an indication of power quality. A sinusoidal waveform crest factor is 1.414, and a square wave crest factor is 1.0. The SEL-735 records the maximum and minimum crest factor metering values.

The SEL-735 uses the equation shown in *Equation 5.7* to calculate crest factor values.

$$\text{Crest Factor} = \frac{\text{Peak Value}}{\text{rms Value}}$$

Equation 5.7

View or Reset Crest Factor Metering Information

Via ACSELERATOR HMI

The ACSELERATOR QuickSet HMI displays and controls all crest factor data. *Figure 5.32* shows the crest factor data as viewed from the ACSELERATOR QuickSet HMI.

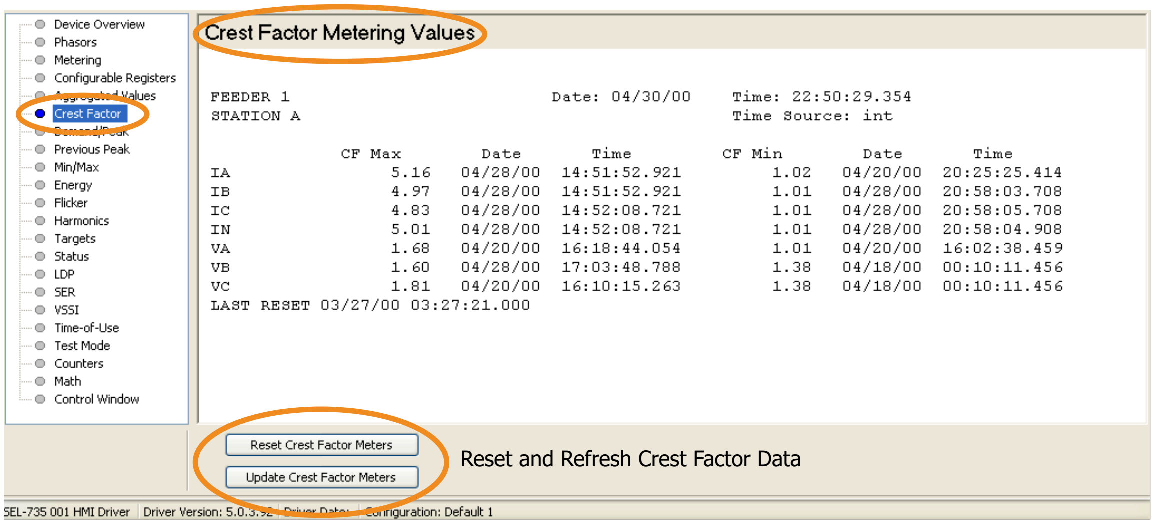


Figure 5.32 Crest Factor Metering Values HMI Window

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

- Reset Crest Factor Data:

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

- Show Crest Factor Data:

  Click **Update Crest Factor Meters** 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 consecutive 10/12-cycle periods.

Refer to *Appendix G: Analog Quantities and Device Word Bits* for the analog quantity names. The meter updates the crest factor metering quantities every 10/12 cycles. The crest factor values are stored into nonvolatile memory every minute.

Harmonic Metering

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, Groups, and Subgroups

The SEL-735 calculates component harmonics, harmonic groups, harmonic subgroups, and interharmonic subgroups 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.

Example: Third order harmonic group for a 60 Hz system includes interharmonic frequencies from 150 Hz to 210 Hz.

Harmonic Subgroup:

Square root of the sum of squares of the rms value of a harmonic and the two spectral components immediately adjacent to it. Please refer to IEC 61000-4-7:2002-08 for further explanation of harmonic subgroup calculations.

Interharmonic Subgroup:

Example: Third order interharmonic subgroup for a 60 Hz system includes interharmonic frequencies from 190 Hz to 230 Hz.

Settings

The HARMCAL setting determines if harmonic quantities are individual only, grouped, sub-grouped, or report interharmonics. *Table 5.16* and *Figure 5.33* explain the effect of the HARMCAL setting on analog quantities.

Table 5.15 HARMCAL Setting Values

HARMCAL Setting Value	Description
HARM	Component Harmonics
GROUP	Harmonic Group
SUBGROUP	Harmonic Subgroup
INTERHARM	Interharmonic Subgroup

Table 5.16 Effects of HARMCAL on Analog Quantities

Harmonic AQ Group	HARMCAL = HARM	HARMCAL = GROUP	HARMCAL = SUBGROUP	HARMCAL = INTERHARM
Harmonic Magnitudes (example: HRMM3_VA)	Harmonic only	Harmonic group	Harmonic subgroup	Interharmonic subgroup
Harmonic Percentages (example: HRM3_VA)	Harmonic only	Harmonic group	Harmonic subgroup	Interharmonic subgroup[a]
Aggregated Harmonic Magnitudes (example: HRMM3_VA_3SEC)	Harmonic only	Harmonic group	Harmonic subgroup	Interharmonic subgroup
Harmonic Power (example: HRMP3_B)	Harmonic only	Harmonic only	Harmonic only	Harmonic only
Total Harmonic Distortion (example: THDVA)	Harmonic only	Harmonic only	Harmonic only	Harmonic only
Group Total Harmonic Distortion (example THDGVA)	Harmonic group	Harmonic group	Harmonic subgroup	Interharmonic subgroup[a]
Aggregated Total Harmonic Distortion (example: THDVA_3SEC)	Harmonic only	Harmonic group	Harmonic subgroup	Interharmonic subgroup
Harmonic Angles (example HRMA3_VA)	Harmonic only	Harmonic only	Harmonic only	Harmonic only

[a] Only fundamental component in the denominator.

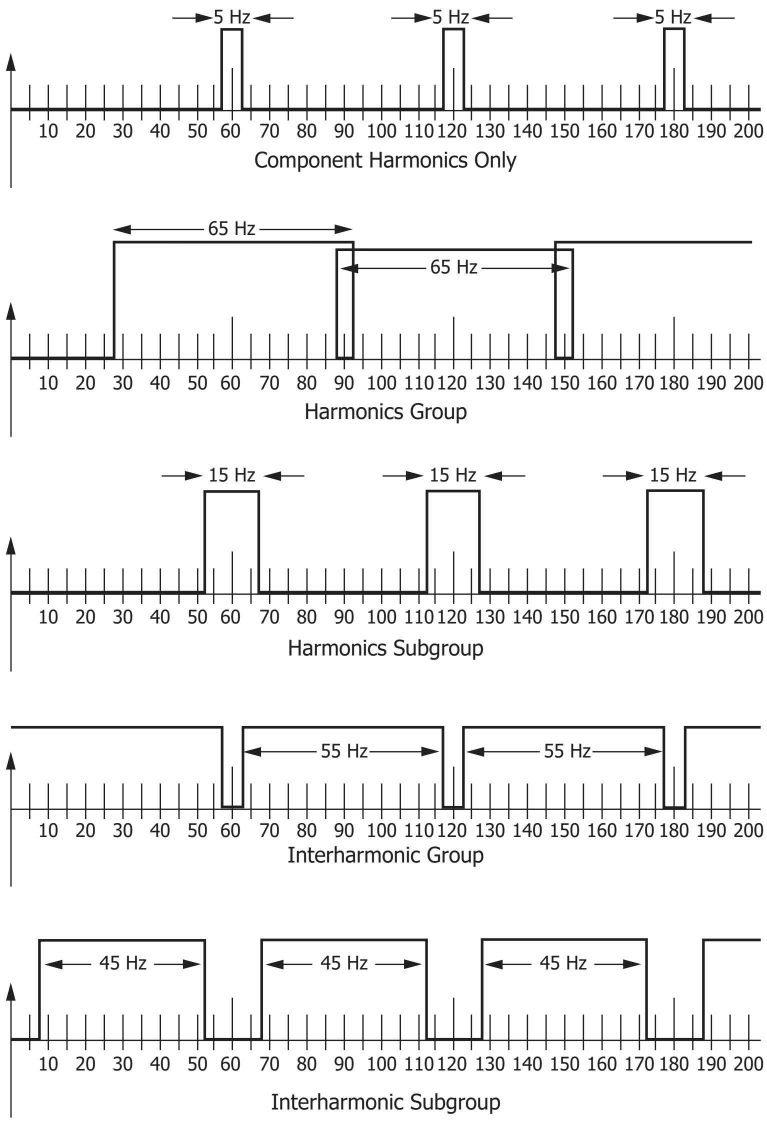


Figure 5.33 IEC Grouping of Spectral Components for Harmonics and Interharmonics

Interharmonic values calculated as per IEC 61000-4-30 are also reported and displayed graphically over the ACSELERATOR QuickSet HMI.

Harmonic Metering in Form 5 and 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).

Because Phase B voltage and current are both calculated from Phase A and Phase C in Form 5 metering, no harmonic quantities are calculated for Phase B.

Harmonic Percentage

The meter converts harmonic magnitudes into a percentage of the fundamental.

Table 5.17 Minimum Required Magnitudes for Harmonic Percentage Calculations

Harmonic Quantity	Minimum Required Magnitude
Voltage	3.0 V_{RMS}
Current	3 mA_{RMS}

If the voltage or current harmonic is below the minimum threshold, the meter reports zero for that particular harmonic percentage.

NOTE
When the SEL-735 is set up as a Form 5 or Form 36 meter, it 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.

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 and also latches the PQALRM word bit. 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 3rd 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 HARMCAL 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° to +180.00°.

Each harmonic magnitude and angle has an associated analog quantity (see *Appendix G: Analog Quantities and Device Word Bits*) that uses the following format.

HRMM*xx_yy* = Harmonic Magnitude

HRMA*xx_yy* = Harmonic Angle

where:
xx = the harmonic number (1–50 or 1–15)
yy = the specific current or voltage phase (IA, IB, IC, IN, VA, VB, or VC)

You can use the ACSELERATOR QuickSet HMI to view harmonic magnitudes and angles. The meter updates the harmonic analog quantities every 10/12 cycles. The aggregated harmonic analog quantities update based on the aggregation period.

Interharmonic Magnitudes

Advanced power quality meters calculate interharmonic magnitudes as high as the 63rd harmonic. The ACSELERATOR QuickSet HMI displays individual interharmonic magnitudes, with text and graphical views as high as the 63rd harmonic.

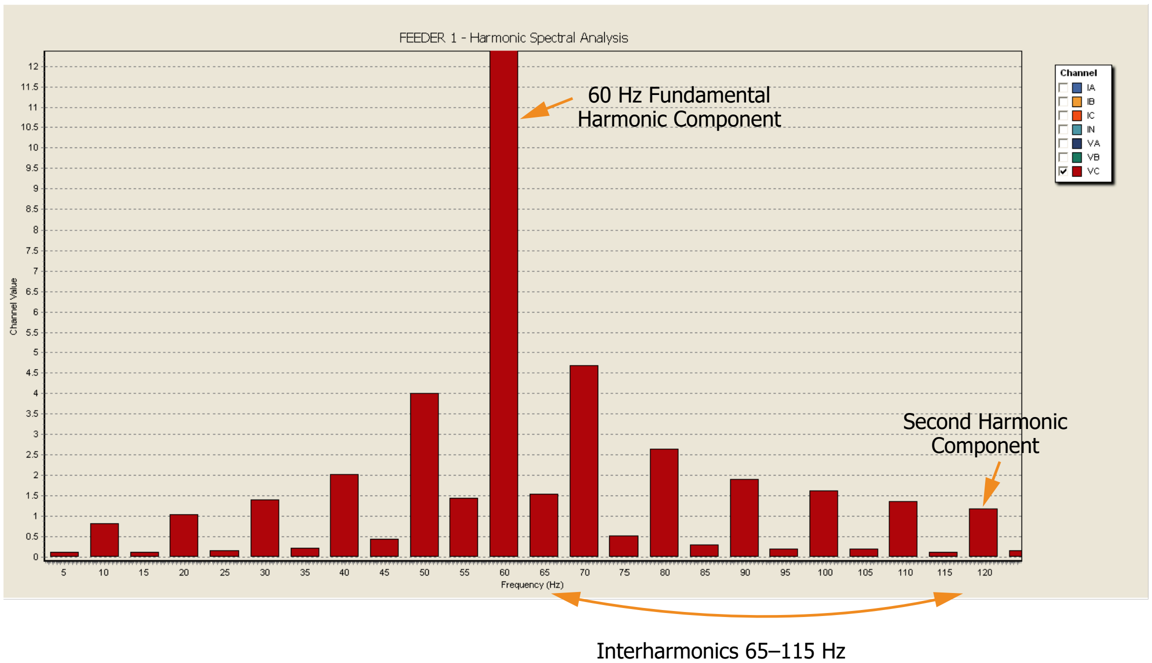


Figure 5.34 Interharmonics vs. Integer-Harmonics Example

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.

$$\text{K-FACTOR\_x} = \frac{\sum_{h=1}^{25} I_{xh}^2 \; h^2}{\sum_{h=1}^{25} I_{xh}^2}$$

Equation 5.8

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.

The meter updates the K-factor every 10/12 cycles.

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.

$$Dx = \left(\frac{Px\_avg}{Px} - 1\right) 100$$

Equation 5.9

where:

Dx = the distortion power ratio for the respective phase
Px_avg = the average power for the respective phase
Px = the fundamental power for the respective phase

You can use the ACSELERATOR QuickSet HMI or the front-panel LCD to display distortion power data.

The meter updates Distortion Power factor every 10/12 cycles.

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.

$$THDX = \left(\frac{\sqrt{\sum_{n=2}^{ht} HX_n^2}}{HX_1}\right) 100$$

Equation 5.10

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)
HX_n = the harmonic value of the respective harmonic
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 or subgroups instead of harmonic components.

The meter calculates THDG depending on the HARMCAL setting. The THDG value is the ratio of the rms harmonic groups, harmonic subgroups, or interharmonic subgroups divided by fundamental rms component as defined in *Table 5.16*.

The meter calculates THDG per phase as follows.

$$\mathrm{THDGX} = \left(\frac{\sqrt{\sum_{n=2}^{ht} HX_{gn}^2}}{HX_{g1}}\right) 100$$

Equation 5.11

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)
HX_{gn} = the harmonic group, harmonic subgroup, or interharmonic subgroup value of the respective harmonic[a]
HX_{g1} = the harmonic group or subgroup value of the fundamental frequency
n = the harmonic number

[a] Refer to IEC 61000-4-7:2002–2008 for THDG calculations.

The ACSELERATOR QuickSet HMI software displays THD and THDG data.

The meter updates the THD/THDG analog quantities every 10/12 cycles and the aggregated THD/THDG analog quantities based on the aggregation period. Refer to *Appendix G: Analog Quantities and Device Word Bits* for details.

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.

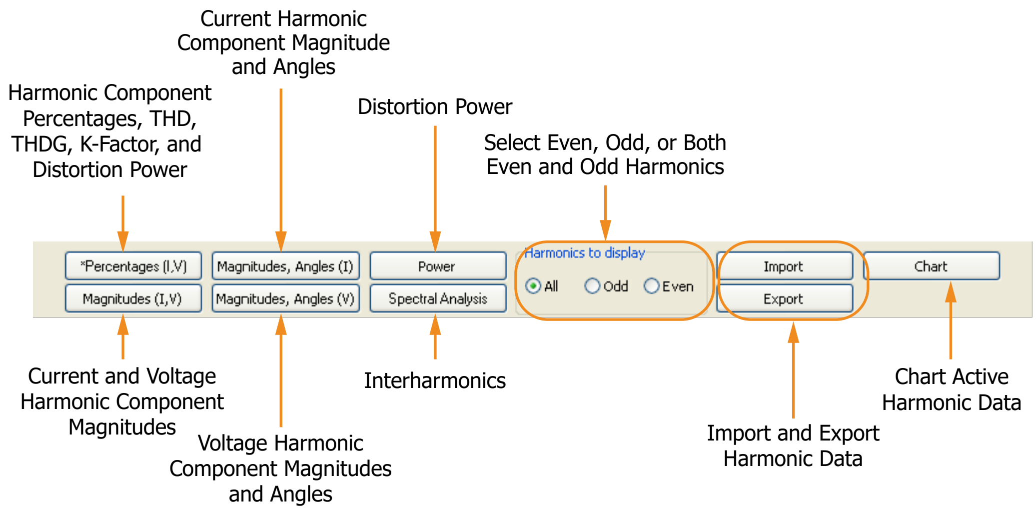


Figure 5.35 Harmonics HMI Toolbar

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 the **UP ARROW** or **DOWN ARROW** pushbuttons 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. The meter updates the short-term flicker analog quantities every 1 minute and 10 minutes, and the long-term flicker analog quantities every 2 hours. Refer to *Appendix G: Analog Quantities and Device Word Bits*. The meter updates the maximum instantaneous flicker value for the three phases every 10/12 cycles.

The SEL-735, in compliance with the IEC Flickermeter standard, uses either 120 V or 230 V as the reference voltage for flicker measurements. The FLICREF setting allows you to configure the SEL-735 to perform flicker measurements with either VBASE, 120 V, or 230 V as the reference voltage. This provides the flexibility to choose the reference voltage for flicker measurements at a voltage that is not dependent on the VBASE setting.

If FLICREF is set to VBASE, and VBASE <176 V, the SEL-735 processes flicker measurements per the standard for 120 V flickermeters. If FLICREF is set to VBASE, and VBASE ≥176 V, the SEL-735 processes flicker measurements per the standard for 230 V flickermeters.

View Flicker Data via the ACSELERATOR QuickSet HMI

Use ACSELERATOR QuickSet HMI to view and reset flicker data. *Figure 5.36* shows the flicker window as it displays on the ACSELERATOR QuickSet HMI.

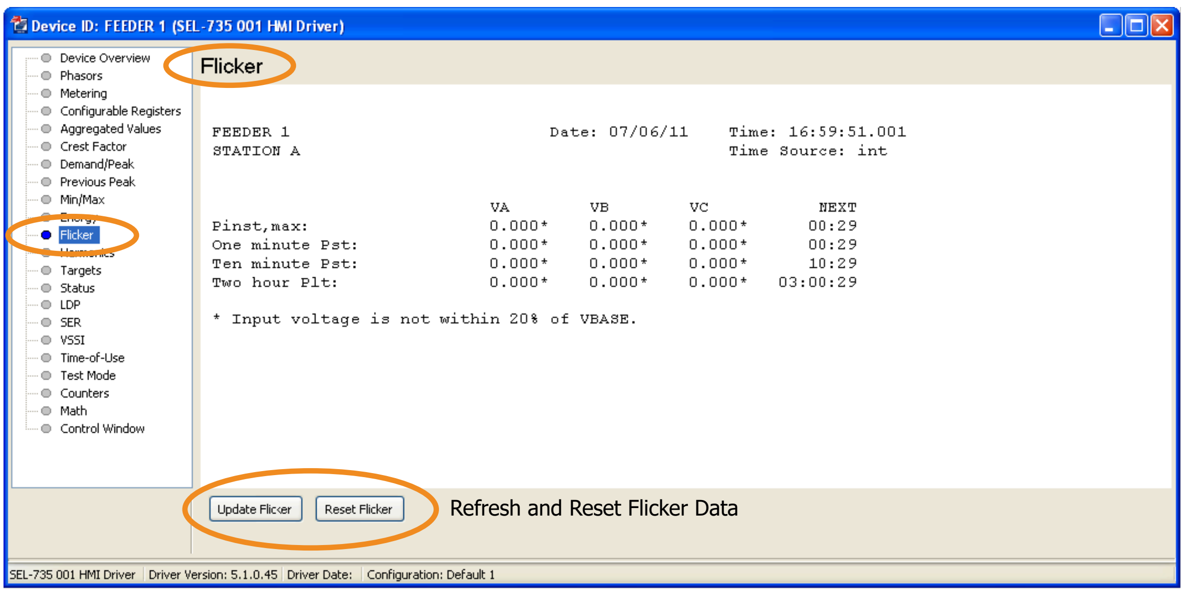


Figure 5.36 Flicker HMI Window

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 5.37* shows the diagram of the billing and metering points. *Table 5.18* 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 and current quantities are never compensated.

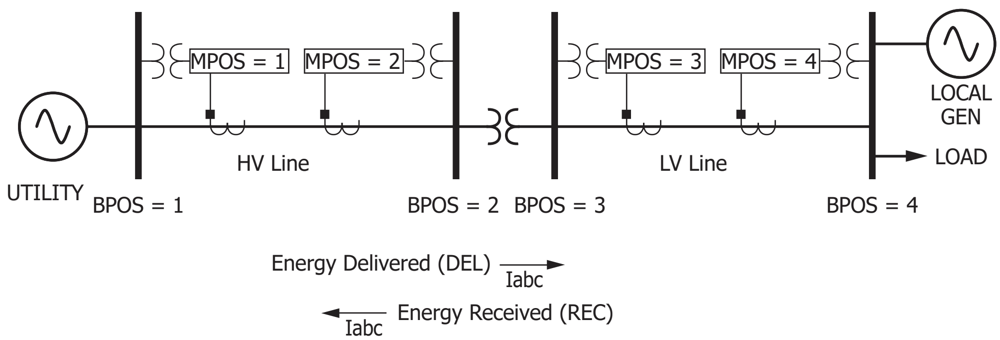


Figure 5.37 Meter and Billing Positions

Table 5.18 Transformer and Line-Loss Adjustments

Billing Position (BPOS)	Meter Position (MPOS)	Supply Line Constant, T1	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

Billing Position (BPOS)	Meter Position (MPOS)	Supply Line Constant, T1	Load Line Constant, T2	Change to Calculated Power
3				Load line losses added
4				No adjustment

[a] 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 meter updates the Transformer and Line Loss Compensation analog quantities every 10/12 cycles. Refer to *Appendix G: Analog Quantities and Device Word Bits* for the analog quantity names. *Figure 5.38* shows all transformer and line-loss analog quantities in configurable registers. See *Configurable Registers on page 211* 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	LWFECC	XFMR PhC FE	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0006	LVFECA	XFMR PhA FE	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0007	LVFECB	XFMR PhB FE	kVAR	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0008	LVFECC	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	SPBLL	SOURCE LINE PhB	kW	N	1.00	0.00	KILO	PRIMARY	DIALS	9	0	3	N	N
CFG0025	SPCLL	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 5.38 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 5.20*.

You must enable transformer/line-loss 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 5.19* to calculate transformer/line-loss compensation. The meter calculates the transformer and line-loss analog quantities, shown in *Table 5.20*, automatically without further input from the operator.

Table 5.19 Required User Input

	Setting	Description
Transformer Losses	MVA	Base transformer three-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
Line Losses	SLR	Supply line resistance, ohms
	SLX	Supply line inductive reactance, ohms
	LLR	Load line resistance, ohms
	LLX	Load line inductive reactance, ohms
	XFTR	Power transformer turns ratio $\frac{V_{Supply}}{V_{Load}}$

Table 5.20 Analog Quantities: Transformer and Line Losses

	Setting	Description
Transformer Losses	3PWFE	Three-phase active power iron loss, watts
	3PVFE	Three-phase reactive power iron loss, VARs
	LWFEC*x*	Individual phase transformer active power iron loss, watts
	LVFEC*x*	Individual phase transformer reactive power iron loss, VARs
	3PWCU	Three-phase active power copper loss, watts
	3PVCU	Three-phase reactive power copper loss, VARs
	LWCUC*x*	Individual phase transformer active power copper loss, watts
	LVCUC*x*	Individual phase transformer reactive power copper loss, VARs
	TTL	Three-phase total transformer loss, VA
	TVAL*x*	Individual phase transformer loss, VA
Source Line Losses	SPLL	Total source line active power loss, watts
	SQLL	Total source line reactive power loss, VARs
	SP*x*L	Individual phase source line active power loss, watts
	SQ*x*L	Individual phase source line reactive power loss, VARs
Load Line Losses	LPLL	Total load line active power loss, watts
	LQLL	Total load line reactive power loss, VARs
	LP*x*L	Individual phase load line active power loss, watts
	PQ*x*L	Individual phase load line reactive power loss, VARs

Transformer Loss Calculations

Equation 5.12 through *Equation 5.17* 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). The transformer losses are calculated in single phase.

Base Copper Loss, MW

$$\text{LWCUB} = \frac{\left(\frac{\text{LWCU}}{3}\right)}{1000}$$

Equation 5.12

Base Iron Loss, MW

$$\text{LWFEB} = \frac{\left(\frac{\text{LWFE}}{3}\right)}{1000}$$

Equation 5.13

Base Copper Loss, MVA

$$\text{VACUB} = \frac{\%\text{Z}}{100} \bullet \text{MVA}$$

Equation 5.14

Base Iron Loss, MVA

$$\text{VAFEB} = \frac{\%\text{IMAG}}{100} \bullet \text{MVA}$$

Equation 5.15

The meter then converts the base watt and VA parameters into base VAR parameters, as shown in *Equation 5.16* and *Equation 5.17*.

Base Copper Losses, MVAR

$$\text{LVCUB} = \sqrt{\text{VACUB}^2 - \text{LWCUB}^2}$$

Equation 5.16

Base Iron Losses, MVAR

$$\text{LVFEB} = \sqrt{\text{VAFEB}^2 - \text{LWFEB}^2}$$

Equation 5.17

Next, the meter uses the settings KVLL and MVA as shown in *Equation 5.18* and *Equation 5.19* 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

$$\mathrm{DICF} = \frac{\sqrt{3} \bullet \mathrm{KVLL}}{\mathrm{MVA} \bullet 1000}$$

Equation 5.18

Dynamic Voltage Correction Factor, Per Unit

$$\mathrm{DVCF} = \frac{\sqrt{3}}{\mathrm{KVLL}}$$

Equation 5.19

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 5.20–Equation 5.29* (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

$$\mathrm{LWFECx} = \mathrm{LWFEB} \bullet (\mathrm{Vx} \bullet \mathrm{DVCF})^2$$

Equation 5.20

Primary Iron Losses, MVAR

NOTE
The metering industry has standardized on the principle that reactive iron losses are proportional to the fourth power of the voltage.

$$\mathrm{LVFECx} = \mathrm{LVFEB} \bullet (\mathrm{Vx} \bullet \mathrm{DVCF})^4$$

Equation 5.21

Three-Phase Iron Loss, MW

$$\mathrm{3PWFE} = \mathrm{LWFECA} + \mathrm{LWFECB} + \mathrm{LWFECC}$$

Equation 5.22

Three-Phase Iron Loss, MVAR

$$\mathrm{3PVFE} = \mathrm{LVFECA} + \mathrm{LVFECB} + \mathrm{LVFECC}$$

Equation 5.23

Copper Losses

Primary Copper Losses, MW

$$\mathrm{LWCUCx} = \mathrm{LWCUB} \bullet (\mathrm{Ix} \bullet \mathrm{DICF})^2$$

Equation 5.24

Primary Copper Losses, MVAR

$$LVCUCx = LVCUB \bullet (Ix \bullet DICF)^2$$

Equation 5.25

Three-Phase Copper Loss, MW

$$3PWCU = LWCUCA + LWCUCB + LWCUCC$$

Equation 5.26

Three-Phase Copper Loss, MVAR

$$3PVCU = LVCUCA + LVCUCB + LVCUCC$$

Equation 5.27

Iron and Copper Losses

Total Transformer Loss, MVA

$$TTL = \sqrt{(3PWCU + 3PWFE)^2 + (3PVCU + 3PVFE)^2}$$

Equation 5.28

Total Per-Phase Transformer Losses, MVA

$$TVALx = \sqrt{(LWFECx + LWCUCx)^2 + (LVFECx + LVCUCx)^2}$$

Equation 5.29

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 5.18*.

Supply Line Loss

Supply Line Watt Losses

$$SPxL = (Ix \bullet T_1)^2 \bullet \frac{SLR}{1X10^6} \text{ MW}$$

Equation 5.30

Supply Line VAR Losses

$$SQxL = (Ix \bullet T_1)^2 \bullet \frac{SLX}{1X10^6} \text{ MVAR}$$

Equation 5.31

Total Supply Line Watt Losses

$$SPLL = SPAL + SPBL + SPCL \ \ MW$$

Equation 5.32

Total Supply Line VAR Losses

$$SQLL = SQAL + SQBL + SQCL \ \ MVAR$$

Equation 5.33

Load Line Loss

Load Line Watt Losses

$$LPxL = (Ix \bullet T_2)^2 \bullet \frac{LLR}{1X10^6} \ \ MW$$

Equation 5.34

Load Line VAR Losses

$$LQxL = (Ix \bullet T_2)^2 \bullet \frac{LLX}{1X10^6} \ \ MVAR$$

Equation 5.35

Total Load Line Watt Losses

$$LPLL = LPAL + LPBL + LPCL \ \ MW$$

Equation 5.36

Total Load Line VAR Losses

$$LQLL = LQAL + LQBL + LQCL \ \ MVAR$$

Equation 5.37

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 5.21* lists available attributes, their default value, and range.

Table 5.21 Configurable Register Attributes

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

Attribute	Description	Default Value	Range
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
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	$-10x10^9$ to $10x10^9$
Offset	User-defined offset. Hidden and forced to default value if Scale User is set to N.	0	$-10x10^9$ to $10x10^9$
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 divides all values by $1x10^6$; KILO divides all values by $1x10^3$; UNITY divides 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	$0–1x10^{15}$

Configuration

ACSELERATOR QuickSet settings software simplifies setup of configurable registers. The Configurable Registers setup window, as shown in *Figure 5.39*, 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 5.21*. 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 5.39*.

Step 2. Enter in the Options section the attributes you want, as explained in *Table 5.21*.

Step 3. Use the Interfaces section to view how the meter will pass the configurable register result to interfaces.

1. Enter a number in the Interfaces section.
2. 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.

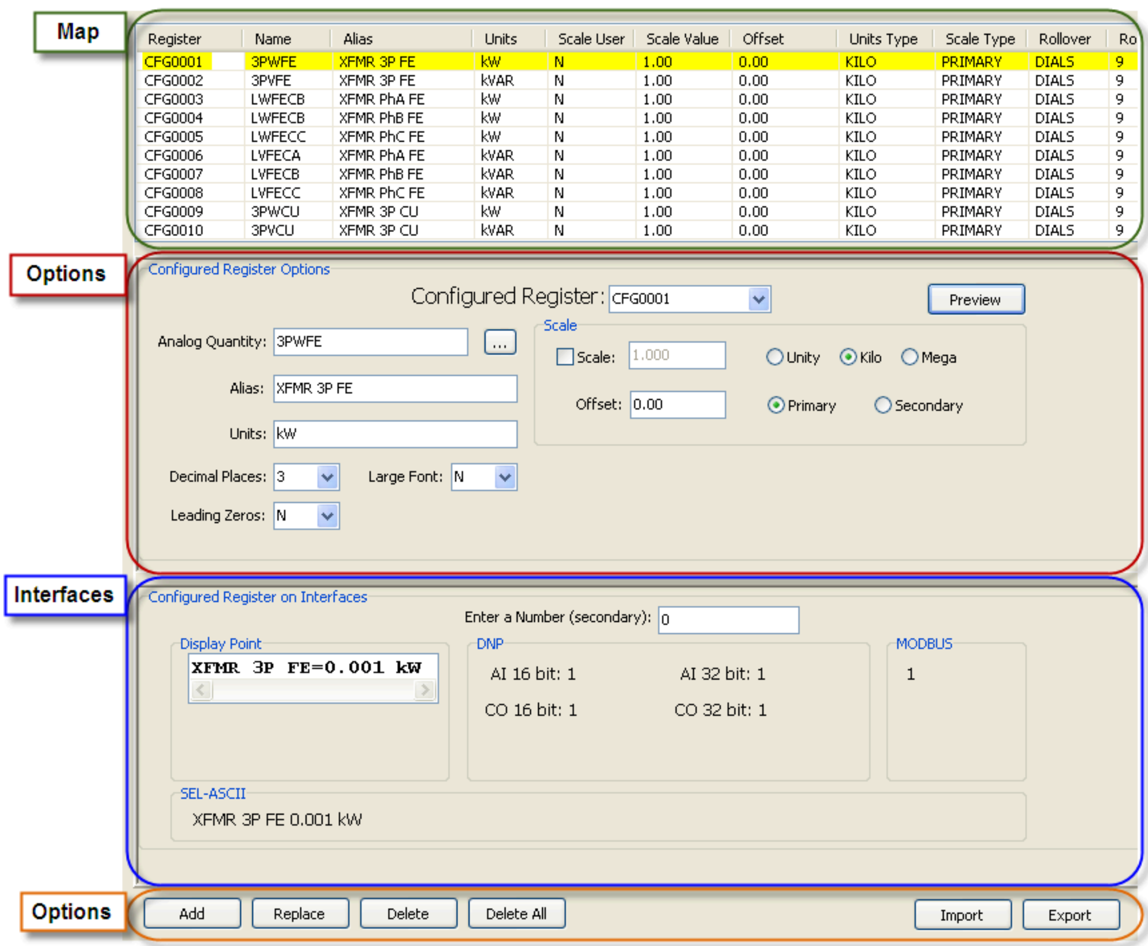


Figure 5.39 Configurable Registers Settings Window

Calculation and Update Rate

The meter calculates the configurable register results as follows.

$$\text{Result} = \text{AnalogQuantities} \bullet \text{Scale} + \text{Offset}$$

where:

Result = the value of the configurable register
AnalogQuantities = 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 5.40 shows an example of a configurable register on the front-panel LCD in large font.

Figure 5.40 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 5.22* 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 5.22*, for which 3PWFE and 3PVFE provided configuration in kilowatt and kilovar units.

Table 5.22 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 5.41*.

Step 8. Open the spreadsheet you just created.

The imported configurable registers display in the ACSELERATOR QuickSet Configurable Registers setting map, as shown previously in *Figure 5.38*. You can also export the configurable registers map to a CSV file, as shown in *Figure 5.41*.

NOTE
The meter erases old configurable registers when you import a new map.

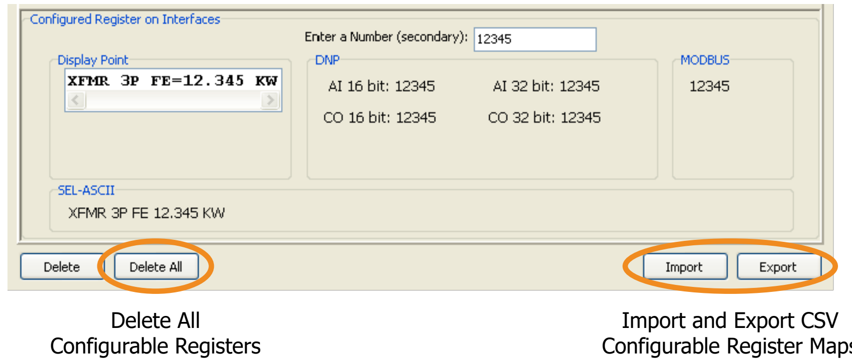


Figure 5.41 Configurable Registers Configuration Tool

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 3.0 2015.

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 zeros some or all current registrations, depending on the Starting Current Type setting chosen. *Table 5.23* summarizes the behavior of the Starting Current Type setting.

Table 5.23 Starting Current Type Setting Behavior

Starting Current Type Setting	Behavior
RMS_ONLY (default value)	When the rms current magnitude of a given phase is less than the Starting Current Threshold value, the meter zeros the associated rms current analog quantity and the quantities derived from it. The meter continues to register the fundamental current while the rms current magnitude is less than the Starting Current Threshold.
ALL	When the rms current magnitude of a given phase is less than the Starting Current Threshold value, the meter zeros the associated rms and fundamental analog quantities, the quantities derived from it, and the current registration in event reports and VSSI.

Neutral Current

For Form 9 and Form 36 meters, the SEL-735 calculates the vectorial sum of the three-phase currents to calculate the neutral current, IN. The following equation shows this calculation.

$$IN = IA + IB + IC$$

For Form 5 meters, the SEL-735 assumes that the neutral current is zero. The meter calculates the vectorial sum of phase currents IA and IC to determine IB, as the following equation shows.

$$IB = -(IA + IC)$$

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.

$$VBC = -VCB$$

The meter uses VAB and VCB to calculate VCA, as follows.

$$VCA = VCB - VAB$$

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.

$$VBN = -(VAN + VCN)$$

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.

$$Xx = \sqrt{\frac{\sum_{0}^{N-1}[s(n)]^2}{N}}$$

where:

N = total number of samples
n = index number
s(n) = array of periodic *v* or *i* samples corresponding to X
Xx = 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 Fundamental Power

The meter calculates per-phase and three-phase fundamental active power, reactive power, and apparent power. These analog quantities are updated every half cycle.

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 when used in logic equations and 10/12 cycles for all other interfaces.

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.

$$\text{MAG} = \frac{\sum_{i=1}^{i=4}\sqrt{x_i^2 + y_i^2}}{4}$$

$$\text{ANG} = \tan^{-1}\left(\frac{y_1}{x_1}\right)$$

where x_i and y_i are discrete samples taken 90° apart.

Analog Quantities

The SEL-735 provides the analog quantities (shown in *Figure 5.22*) based on the meter form.

Table 5.24 Fundamental-Only Voltage, Current, and Power

Meter Form	Analog Quantities
Form 9 and Form 36	V*x*_FUND and V*x*_ANG where *x* is A, B, C, AB, BC, or CA
	I*x*_FUND and I*x*_ANG where *x* is A, B, C
	W*x*_FUND, S*x*_FUND, Q*x*_FUND where *x* is A, B, C, or 3
Form 5	V*x*_FUND and V*x*_ANG where *x* is AB, BC, or CA
	I*x*_FUND and I*x*_ANG where *x* is A, B, C
	W3_FUND, S3_FUND, Q3_FUND

Fundamental Power

Form 9 and Form 36

Active power (W*x*_FUND), reactive power (Q*x*_FUND), and apparent power (S*x*_FUND) calculations use filtered, 16-samples/cycle voltage and current samples as source data.

$$\text{Wx\_FUND} = \text{Vx\_FUND} \bullet \text{Ix\_FUND} \bullet \cos\left(\text{Vx\_ANG} - \text{Ix\_ANG}\right)$$

$$\text{Qx\_FUND} = \text{Vx\_FUND} \bullet \text{Ix\_FUND} \bullet \sin\left(\text{Vx\_ANG} - \text{Ix\_ANG}\right)$$

$$\text{Sx\_FUND} = \text{Vx\_FUND} \bullet \text{Ix\_FUND}$$

where x = A, B, or C

Three-phase fundamental active (W3_FUND) and reactive power (Q3_FUND) are calculated by summing per-phase quantities.

$$\text{W3\_FUND} = \text{WA\_FUND} + \text{WB\_FUND} + \text{WC\_FUND}$$
$$\text{Q3\_FUND} = \text{QA\_FUND} + \text{QB\_FUND} + \text{QC\_FUND}$$

Form 9 and Form 36 meters use the arithmetic sum to calculate three-phase apparent power (S3_FUND).

$$\text{S3\_FUND} = \text{SA\_FUND} + \text{SB\_FUND} + \text{SC\_FUND}$$

Form 5

Three-phase fundamental active (W3_FUND) and reactive power (Q3_FUND) use the following equations.

$$\text{W3\_FUND} = \text{VAB\_FUND} \bullet \text{IA\_FUND} \bullet \cos\left(\text{VAB\_ANG} - \text{IA\_ANG}\right) + \text{VCB\_FUND} \bullet \text{IC\_FUND} \bullet \cos\left(\text{VCB\_ANG} - \text{IC\_ANG}\right)$$
$$\text{Q3\_FUND} = \text{VAB\_FUND} \bullet \text{IA\_FUND} \bullet \sin\left(\text{VAB\_ANG} - \text{IA\_ANG}\right) + \text{VCB\_FUND} \bullet \text{IC\_FUND} \bullet \sin\left(\text{VCB\_ANG} - \text{IC\_ANG}\right)$$

Form 5 meters use the vectorial sum method to calculate the three-phase apparent power (S3_FUND). Note that U is used for VA in rms, the same values when fundamental are named S. For example, U3 is the rms equivalent to S3_FUND.

$$\text{S3\_FUND} = \sqrt{\text{W3\_FUND}^2 + \text{Q3\_FUND}^2}$$

10/12-Cycle Power Calculations

Form 9 and Form 36

Active power (Wx), reactive power (Qx), and apparent power (Ux) calculations use unfiltered 128-samples/cycle voltage and current samples as source data.

All reactive analog quantities (Qx) will follow the calculation method defined in the setting CALCQ.

Active per-phase uncompensated power in Form 9 and Form 36 meters are calculated as follows.

$$\text{Wx} = \frac{1}{\text{N}} \sum_{\text{n}=0}^{\text{N}-1} \left(\text{Vxn} \bullet \text{Ixn}\right)$$

where:
x = A, B, C
Vxn, Ixn = discrete samples
N = the total number of samples in a 10/12-cycle period

Active three-phase uncompensated power is calculated as the sum of per-phase quantities.

$$\text{W3} = \text{WA} + \text{WB} + \text{WC}$$

Apparent per-phase power is calculated using per-phase rms quantities.

$$Ux = Ix \bullet Vx$$

where:
Ix, Vx = the respective phase rms quantities

Form 9 and Form 36 meters use the arithmetic sum to calculate uncompensated three-phase apparent power.

$$U3 = UA + UB + UC$$

Uncompensated reactive power calculations use the following equations if CALCQ is set to VECTOR. The sign of the fundamental reactive power applies to the calculation results.

Per-phase quantities in Form 9 and Form 36 meters:

$$Qx = \sqrt{Ux^2 - Wx^2}$$

where:
x = A, B, or C

Uncompensated reactive power calculations use the following equations if CALCQ is set to FUND. The sign of the fundamental reactive power applies to the calculation results.

Per-phase quantities in Form 9 and Form 36 meters:

$$Qx = Qx\_Fund$$

where:
x = A, B, or C

Reactive three-phase power is calculated as the sum of per-phase quantities.

$$Q3 = QA + QB + QC$$

Form 5

Three-phase active uncompensated power calculations use the following equations.

$$W3 = \frac{1}{N} \sum_{n=0}^{N-1} (VAB \bullet IA + VCB \bullet IC)$$

Reactive uncompensated power calculations use the following equations if CALCQ is set to VECTOR. The sign of the fundamental reactive power applies to the calculation results.

$$Q3 = \sqrt{UA^2 - WA^2} + \sqrt{UC^2 - WC^2}$$

Reactive uncompensated power calculations use the following equations if CALCQ is set to FUND. The sign of the fundamental reactive power applies to the calculation results.

$$Q3 = Q3\_Fund$$

Form 5 meters calculate the three-phase apparent power per the CALC3U setting. If CALC3U is set to VECTOR (default), the meter uses the vectorial sum.

$$U3 = \sqrt{3W^2 + 3Q^2}$$

If CALC3U is set to ARITH, the meter uses the arithmetic sum. If significant harmonics and signal distortion is present, SEL recommends setting CALC3U to ARITH.

$$U3 = |VAB| \bullet |IA| + |VCB| \bullet |IC|$$

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.

$$PFTx = \frac{Wx}{Ux}$$

where:
x = A, B, C, or 3

The half-cycle fundamental-only quantities define the displacement power factor, as in the follow equation.

$$PFDx = \frac{Wx\_FUND}{Sx\_FUND}$$

where:
x = A, B, C, or 3

The meter updates the true power factor every 10/12 cycles and the displacement power factor every half cycle.

Symmetrical Components

The meter calculates the zero-, positive-, and negative-sequence components' magnitude and angle for both voltage and current. The meter updates the symmetrical components and analog quantities every half cycle.

Symmetrical Component Calculations

Definitions

Ia, Ib, Ic, In, Va, Vb, Vc, Vab, Vbc, Vs magnitudes and angles

Ia = A-phase current (secondary)

Ib = B-phase current (secondary)

Ic = C-phase current (secondary)

In = separate current (secondary; the corresponding current input is commonly used as a separate neutral [zero-sequence] current input)

Va = A-phase-to-neutral voltage (secondary)

Vb = B-phase-to-neutral voltage (secondary)

Vc = C-phase-to-neutral voltage (secondary)

Vab = A-phase-to-B-phase voltage (secondary)

Vbc = B-phase-to-C-phase voltage (secondary)

Vs = separate voltage (secondary; the corresponding voltage input is commonly used for synchronism check or as a separate zero-sequence voltage input, depending on the relay)

Current Calculations

Currents (ABC Rotation)

$$I_1 = \frac{1}{3} \bullet \left(Ia + a \bullet Ib + a^2 \bullet Ic\right) = \text{positive-sequence current}$$
$$I_2 = \frac{1}{3} \bullet \left(Ia + a^2 \bullet Ib + a \bullet Ic\right) = \text{negative-sequence current}$$
$$I_0 = \frac{1}{3} \bullet \left(Ia + Ib + Ic\right) = \text{zero-sequence current}$$

where:
$a = 1\angle 120°$
$a^2 = 1\angle 240°$

Currents (ACB Rotation)

$$I_1 = \frac{1}{3} \bullet \left(Ia + a^2 \bullet Ib + a \bullet Ic\right) = \text{positive-sequence current}$$
$$I_2 = \frac{1}{3} \bullet \left(Ia + a \bullet Ib + a^2 \bullet Ic\right) = \text{negative-sequence current}$$
$$I_0 = \frac{1}{3} \bullet \left(Ia + Ib + Ic\right) = \text{zero-sequence current}$$

where:
$a = 1\angle 120°$
$a^2 = 1\angle 240°$

Voltage Calculations

Voltages (Wye-Connected, ABC Rotation)

$$V_1 = \frac{1}{3} \bullet \left(Va + a \bullet Vb + a^2 \bullet Vc\right) = \text{positive-sequence voltage}$$
$$V_2 = \frac{1}{3} \bullet \left(Va + a^2 \bullet Vb + a \bullet Vc\right) = \text{negative-sequence voltage}$$
$$V_0 = \frac{1}{3} \bullet \left(Va + Vb + Vc\right) = \text{zero-sequence voltage}$$

where:
$a = 1\angle 120°$
$a^2 = 1\angle 240°$

Voltages (Wye-Connected, ACB Rotation)

$$V_1 = \frac{1}{3} \bullet \left(Va + a^2 \bullet Vb + a \bullet Vc\right) = \text{positive-sequence voltage}$$

$$V_2 = \frac{1}{3} \bullet \left(Va + a \bullet Vb + a^2 \bullet Vc\right) = \text{negative-sequence voltage}$$

$$V_0 = \frac{1}{3} \bullet \left(Va + Vb + Vc\right) = \text{zero-sequence voltage}$$

where:
$a = 1\angle 120°$
$a^2 = 1\angle 240°$

Voltages (Delta-Connected, ABC Rotation)

$$V_1 = \frac{1}{3} \bullet \left(Vab - a^2 \bullet Vbc\right) = \text{positive-sequence voltage}$$

$$V_2 = \frac{1}{3} \bullet \left(Vab - a \bullet Vbc\right) = \text{negative-sequence voltage}$$

V_0: zero-sequence voltage cannot be calculated for delta-connected voltages.

where:
$a = 1\angle 120°$
$a^2 = 1\angle 240°$

Voltages (Delta-Connected, ACB Rotation)

$$V_1 = \frac{1}{3} \bullet \left(Vab - a \bullet Vbc\right) = \text{positive-sequence voltage}$$

$$V_2 = \frac{1}{3} \bullet \left(Vab - a^2 \bullet Vbc\right) = \text{negative-sequence voltage}$$

V_0: zero-sequence voltage cannot be calculated for delta-connected voltages.

where:
$a = 1\angle 120°$
$a^2 = 1\angle 240°$

Average and Imbalance Calculations

The meter updates the voltage and current imbalance and three-phase average analog quantities every 10/12 cycles. Both negative-sequence imbalance and zero-sequence imbalance calculations are available.

Negative-sequence imbalance calculations use the following equation.

$$X\_IMB = \frac{X2\_MAG}{X1\_MAG} \bullet 100$$

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 V_IMB as zero. If I1 is less than 10 mA, the meter reports I_IMB as zero.

Zero-sequence imbalance calculations use the following equation:

$$X0\_IMB = \frac{\left(\frac{3X0\_MAG}{3}\right)}{X1\_MAG} \bullet 100$$

where:
X = I or V (current or voltage)
X0 and X1 = the zero-sequence and positive-sequence components, respectively

Form 5 meters report a zero value for the zero-sequence voltage imbalance because the quantity is electrically undefined for delta connections.

Average value calculations use the following equation.

$$X\_AVE = \frac{XA + XB + XC}{3}$$

where:
X = I or V (current or voltage rms value)

Voltage and Frequency Deviation Calculations

The meter updates the voltage deviation quantities every 10/12 cycles and the frequency deviation quantity every half cycle. Refer to *Appendix G: Analog Quantities and Device Word Bits* for the analog quantity names.

Voltage and frequency deviation calculations use the following equation.

$$DEV\_Vx = \frac{Vx}{V_{Nominal}} \bullet 100$$

where:
X = A, B, or C
$V_{Nominal}$ = VBASE

The meter uses the following equation to calculate the percent frequency deviation.

$$DEV\_F = \frac{FREQ}{f_{Nominal}} \bullet 100$$

where:
FREQ = the frequency of the analog quantity
$f_{Nominal}$ = the nominal frequency of the power system

Primary and Secondary Time Sources

The SEL-735 accepts time input from IRIG-B, SNTP, Modbus, DNP3, MV90, and the meter front panel or QuickSet.

The meter categorizes time sources as either Primary Time Sources or Secondary Time Sources.

IRIG-B is the only Primary Time Source. SNTP, Modbus, DNP3, MV90, and user-initiated time changes are Secondary Time Sources, as shown in *Table 5.25*.

Table 5.25 Time Source Classifications for the SEL-735

Primary Time Sources	Secondary Time Sources
IRIG-B	SNTP
	Modbus
	DNP3
	MV90
	user-initiated

When the meter is connected to a secondary time source, the meter accepts each time change as a separate event, and asserts the bit TIMESET for each event. When the meter is connected to a Primary Time Source, the meter synchronizes its clock to that time source.

When synchronized to an IRIG-B time source, the meter asserts the IRIGOK Device Word bit and discards time changes from Secondary Time Sources.

When the IRIG-B time is of sufficient accuracy for Synchrophasor (IEEE C37.118) measurements, the SEL-735 also asserts TSOK.

Meter Time Reporting

The SEL-735 accepts time input from IRIG, Modbus, DNP3, MV90, SNTP, the front panel, QuickSet, and the command line interface.

Some interfaces to the meter use UTC time instead of the local time zone. This common reference assists in coordinating information across an area spanning several time zones. The SEL-735 accepts time input from SNTP as UTC time, and all other time inputs as local time.

The SEL-735 reports in UTC time on the IEC 61850 and IEEE C37.118 interfaces, and reports in local time on every other interface.

The UTC_OFF setting defines the offset between UTC and local time, except when the time source is IRIG and the IRIG type (setting TSTYPE) is set to IEEE. If TSTYPE = IEEE, the meter uses the UTC offset hours from the IRIG control bits. In this case, the device requires IEEE C37.118 control bits to be included in the IRIG signal.

Table 5.26 details the time reported by the meter based on the Time Source.

Table 5.26 Examples of Meter Time Reported on Various Interfaces

Time Source	Time Input to the Meter	Offset From UTC Setting (UTC_OFF)	Daylight-Saving Time (DST) in Meter	Meter Interface	Time Reported by Meter for the Interface
Modbus, DNP, MV-90, Internal Clock	13:00	–7	+1	Synchrophasors	NA
				IEC 61850	19:00 (Time input to meter – UTC_OFF – DST)
				Remaining Interfaces	13:00 (Time input to meter)
IRIG—IEEE	13:00	–7	+1	Synchrophasors	19:00 (Time input to the meter – UTC offset from control bits – DST value from control bits)

Time Source	Time Input to the Meter	Offset From UTC Setting (UTC_OFF)	Daylight-Saving Time (DST) in Meter	Meter Interface	Time Reported by Meter for the Interface
				IEC 61850	19:00 (Time input to the meter – UTC offset from control bits – DST value from control bits)
				Remaining Interfaces	13:00 (Time input to meter)
IRIG—non-IEEE	13:00	–7	+1	Synchrophasors	NA
				IEC 61850	19:00 (Time input to meter – UTC_OFF – DST)
				Remaining interfaces	13:00 (Time input to meter)
SNTP	07:00	–7	+1	Synchrophasors	NA
				IEC 61850	07:00 (Time input to the meter)
				Remaining interfaces	1:00 (Time input to the meter + UTC_OFF + DST)

Line Synchronization

The line synchronization feature provides clock accuracy of ±0.1 PPM when no external time source is present. This feature requires a stable power system frequency connected to a wide-area grid that maintains an average frequency of 50 or 60 Hz.

Line synchronization requires applying at least 13 V, the minimum voltage for frequency measurement, to the meter. There is also a two-hour acclimation period before the real-time clock is synchronized if the meter has been turned off for more than two hours.

The line synchronization feature employs an IIR filter with a 50-day time constant that limits the meter time drift to ±1 second per 24-hour period given a power system frequency swing that produces a ±60 second drift per 24-hour period. This satisfies the IEC 61000-4-30 time-clock uncertainty Class A requirement when an external signal is unavailable/unused. The 50-day time constant ensures temporary frequency excursions from the wide-area grid do not drastically perturb the internal real-time clock synchronization and ensures time stability.

The LINEFREQ setting is off by default. Enable the LINEFREQ setting to synchronize the internal real-time clock to the power system frequency.

Daylight-Saving Time

By default, the meter ships with the 2007 United States daylight-saving time (DST) calendar. The meter begins DST on the second Sunday in March at 2:00 a.m. and ends DST on the first Sunday in November at 2:00 a.m.

To enable DST, choose **Daylight Saving Time** from the QuickSet settings editor tree and select **Enable Daylight Saving Time Settings**. Enter or accept the default **Start Time** and **Stop Time**, then select **Start Dates** and **Stop Dates** to select the present DST schedule.

If the meter is connected to an external time source, disable the DST setting in the SEL-735 to avoid time-source conflicts.

The Effects of Time Changes

Metering and power quality monitoring functions depend on time moving forward at a constant rate. Changing time in the meter affects these calculations. For example, demand is calculated as average power over a specified demand interval, DMTC. Changing time in the meter during a demand interval may result in the measured demand being less than the actual demand. As another example, aggregated analog quantities are calculated over a specified aggregated time period. Changing time during the aggregated interval causes erroneous aggregated values.

The magnitude of error introduced in the calculations because of a change in time is directly proportional to the size of the time change. Changing the time by 1 second results in a lower error compared to changing the time by 30 seconds. The SEL-735 supports the TIME_CHG setting to allow users to configure the time change threshold. The SEL-735 flags data affected by time changes greater than the TIME_CHG threshold. This flagging indicates to the user that the associated data were affected by a time change event greater than the configured TIME_CHG time change threshold and therefore may include more error than acceptable. The meter does not flag any data for time changes less than the TIME_CHG threshold.

On non-DST forward time changes, the meter publishes data of the exited interval and the new interval. The meter flags the affected data and removes flagging at the end of the first complete interval. Data are not published for the skipped intervals. On non-DST backward time changes, the meter skips the first repeated interval, flags the affected data, and removes flagging at the end of the first non-repeated complete interval.

Figure 5.42 shows some sample time changes relative to the TIME_CHG threshold, and shows when data flagging occurs. The SEL-735 publishes and flags data at the Time Interval Boundary after a time change that is greater than the TIME_CHG setting, then clears the flags at the next Time Interval Boundary.

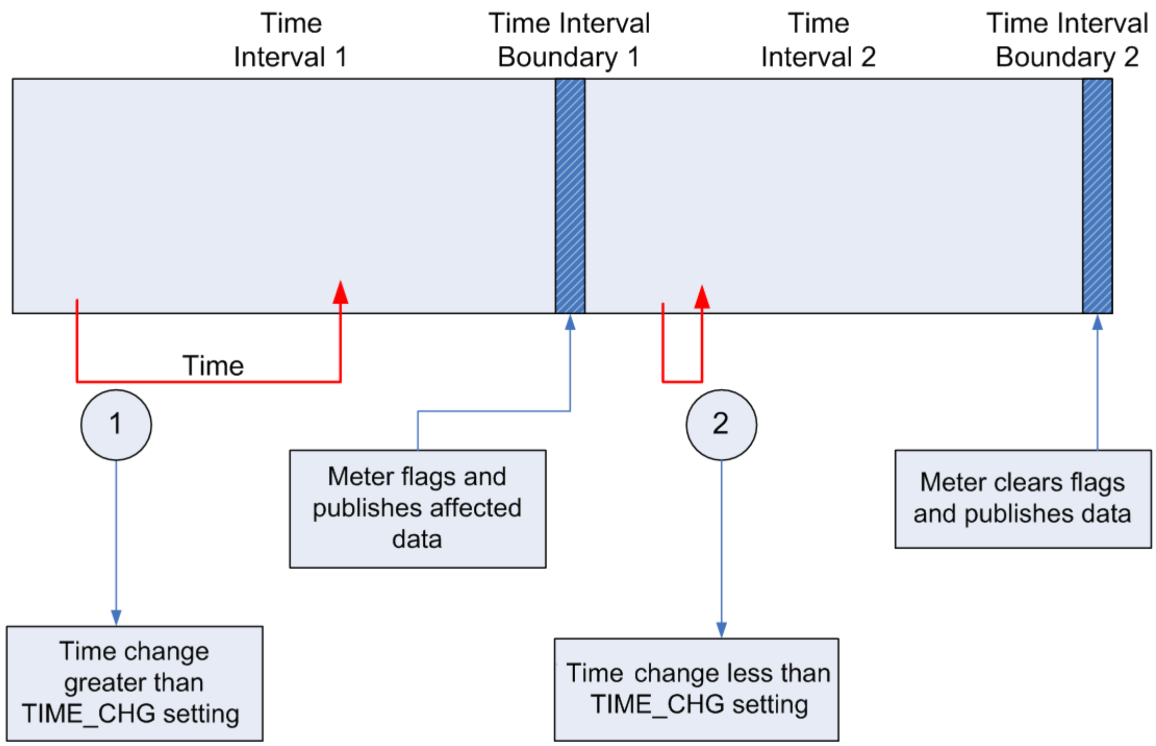


Figure 5.42 Time Changes and Data Flagging Based on the TIME_CHG Setting

SECTION 6

Logging

Introduction

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 event 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

The SEL-735 provides as many as 32 independent load profile recorders. Each load profile recorder has its own settings, as shown in *Table 6.1*. Refer to *Table 1.3* for the number of LDP recorders available in each PQ model option. The first LDP recorder is the billing recorder.

Table 6.1 lists the settings associated with each LDP recorder.

NOTE
Changes to an LDP recorder setting cause its data **and** the data from subsequent recorder to be cleared. For example, if you add a channel to LDLIST2, recorders 2–32 will be cleared.

Table 6.1 Load Profile Recorder Settings

Name	Range	Description
LDFUNC*n*	EOI, COI, AVG, MAX, MIN	Recorder Function, see *Table 6.2* for a description of each available recorder function.
LDLIST*n*	Analog Quantity (as many as 16)	Logged quantity list. You can list as many as 16 quantities. Enter 0 or NA to nullify the recorder.
LDAR*n*	3–59 s[a] ; 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.

Name	Range	Description
LMDUR*n*	0.05 to 7300 days	Logged Values Maximum Duration. The meter starts to overwrite logged values after the period set by LMDUR.

[a] Only available for Advanced and Intermediate PQ and Recording options.

Change LDFUNC*n* according to the LDP recorder function you want. Refer to Billing Recorder for details on the LDP recorder 1 LDFUNC functionality. 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 non-energy quantities in the billing recorder according to the recorder LDFUNC setting. For example, if the LDFUNC1 is chosen as AVG, the meter logs the average value of non-energy quantities and logs the COI (change-over-interval) value for the energy quantities. Demand quantities are not available when LDFUNC1 = AVG. 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*. Note that within the configuration register, you must select the correct scaling. The configuration registers scaling supersede the scaling when selected.

Table 6.3 Billing Recorder (LDP Recorder One) Scaling

Quantity Type	Scaling
Current (Amperes)	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.

Load Profile Presets

Load profile presets help users quickly configure Load Profile Recorder settings. The load profile presets auto-populate the recorders with predefined recorder configurations that are targeted toward common load profile recorder configurations.

Table 6.4 summarizes the channels for each load profile preset for each Power Quality and Recording option. Note, the billing recorder is never modified by any preset. Presets are available starting with SEL-735 firmware versions R201-V0 and higher.

Table 6.4 Summary of Load Profile Presets

<table>
<tr><th>Power Quality and Recording Option</th><th># of Recorders</th><th colspan="2">Summary of Channels</th></tr>
<tr><td colspan="4">Basic</td></tr>
<tr><td>N/A</td><td>N/A</td><td colspan="2">Basic option has no load profile presets available</td></tr>
<tr><td colspan="4">Intermediate</td></tr>
<tr><td>Clear All Recorder Configurations</td><td>N/A</td><td colspan="2">Clears all recorders excluding the billing recorder</td></tr>
<tr><td>SEL-735 Default Recorder Configuration</td><td>12</td><td colspan="2">Default recorder configuration for a new Intermediate SEL-735 meter</td></tr>
<tr><td>Intermediate Power Quality</td><td>10</td><td rowspan="3">One-minute average: Voltages, Currents, Frequency, Power Factor
PQ Frequency</td><td>One-minute average: Real/Apparent/Reactive Power
Imbalance, Power Factor, Flicker, THD, Harmonics (2nd–9th)</td></tr>
<tr><td>Odd Harmonics (%, 17th)</td><td>9</td><td>One-minute average: Real/Apparent/Reactive Power
THD, Odd Harmonics (3rd–17th)</td></tr>
<tr><td>Harmonics (%, 17th)</td><td>7</td><td>THD, Harmonics (2nd–17th)</td></tr>
<tr><td colspan="4">Advanced</td></tr>
<tr><td>Clear All Recorder Configurations</td><td>N/A</td><td colspan="2">Clears all recorders excluding the Billing Recorder</td></tr>
<tr><td>SEL-735 Default Recorder Configuration</td><td>25</td><td colspan="2">Default recorder configuration for a new Advanced SEL-735 meter</td></tr>
<tr><td>Advanced Power Quality</td><td>16</td><td rowspan="4">One-minute average: Voltages, Currents, Frequency, Power Factor, Real/Apparent/Reactive Power, Symmetrical Components, Imbalance
PQ Frequency</td><td>Imbalance, Power Factor, Crest Factor, Flicker, THD, Harmonics (2nd–17th)</td></tr>
<tr><td>Harmonics (%, 33rd)</td><td>17</td><td>THD, Harmonics (2nd–33rd)</td></tr>
<tr><td>Odd Harmonics (%, 33rd)</td><td>11</td><td>THD, Odd Harmonics (3rd–33rd)</td></tr>
<tr><td>IEEE 519 (Odd—49th, Even—16th)</td><td>30</td><td>Three-second and ten-minute aggregated THD, Harmonics (Odd—49th, Even—16th)</td></tr>
</table>

Power Quality and Recording Option	# of Recorders	Summary of Channels	
EN 50160	16		Ten-minute aggregated Voltage, Voltage Imbalance, THD, Flicker, Harmonics (2nd–26th)
IEEE 519 for Synchrowave Reports (All, 50th, 3-second)	19	Three-second aggregated THD, Harmonics 1st–50th	

Most Recent LDP Data as Analog Quantities

For all LDP channels, the meter provides the most recent data as analog quantities. These LDP analog quantities are available to the front panel, SELOGIC, configurable registers, and the LDP recorders. Refer to *Appendix G: Analog Quantities and Device Word Bits* for more information.

Settings Changes

Settings changes you apply to the LDP recorder cause erasure of record values. QuickSet prompts you before sending the settings and erasing LDP data. For all of the recorders, demand quantities are not available when LDFUNC = AVG.

NOTE
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.

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 QuickSet, with display of the available recorder memory.

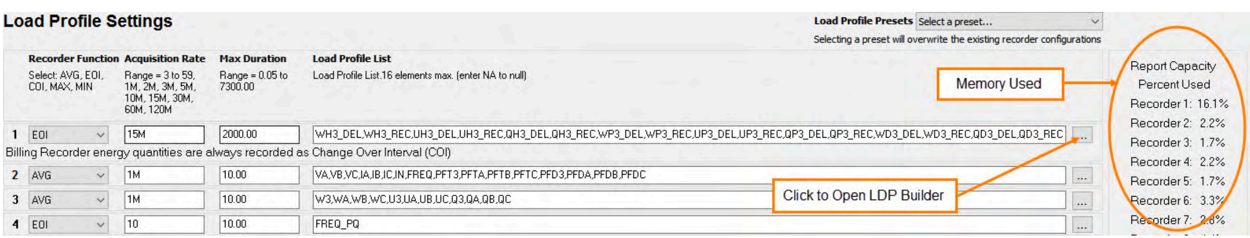


Figure 6.1 LDP Settings Interface

LDP Retrieval

Use the 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.

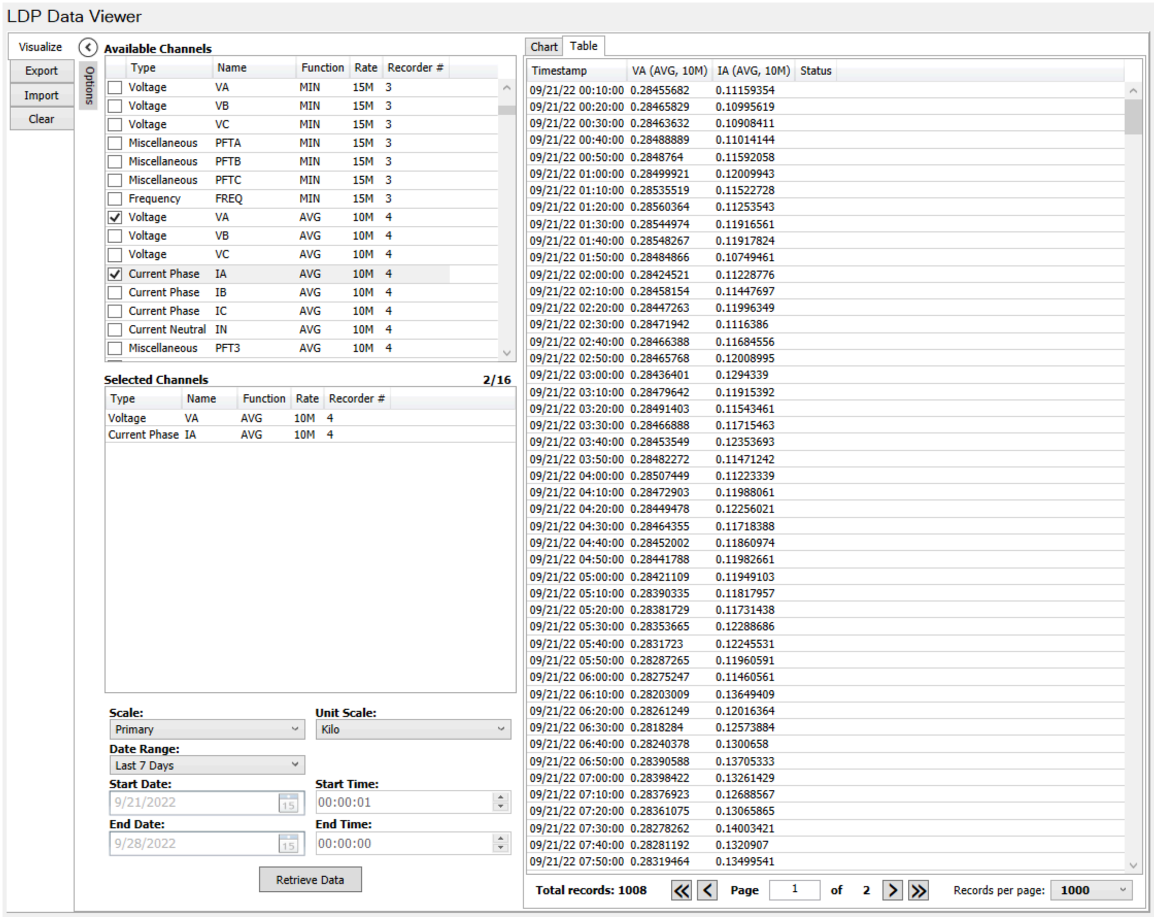


Figure 6.2 LDP HMI Window

Use the following guidelines to retrieve LDP data.

➤ 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. QuickSet exports the LDP data according to the scale factors you have chosen.

➤ Select the Report Type as Standard or MV-90.

  ➢ QuickSet formats the Standard report to SEL standards.

  ➢ 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. 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.

  NOTE
  On export, the HMI interprets event codes and includes the description along with LDP data.

  - 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. QuickSet reads all of the LDP data before the export.

The tabular view of LDP data provides a status code to indicate certain events that may impact the measurements. *Table 6.5* defines the LDP status bits.

Table 6.5 LDP Status Bits in CSV Export

Bit	Meaning
1	Daylight-saving 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 backward during interval
5	Skipped interval (used for invalid or corrupted data)
6	TEST mode data
7	Data Overwrite (used when data are erased during a read)

LDP Data Viewer

The new LDP Data Viewer option allows selection of channels for monitoring or clearing, independent of the LDP recorder. Data can be viewed in tabular or graphical form.

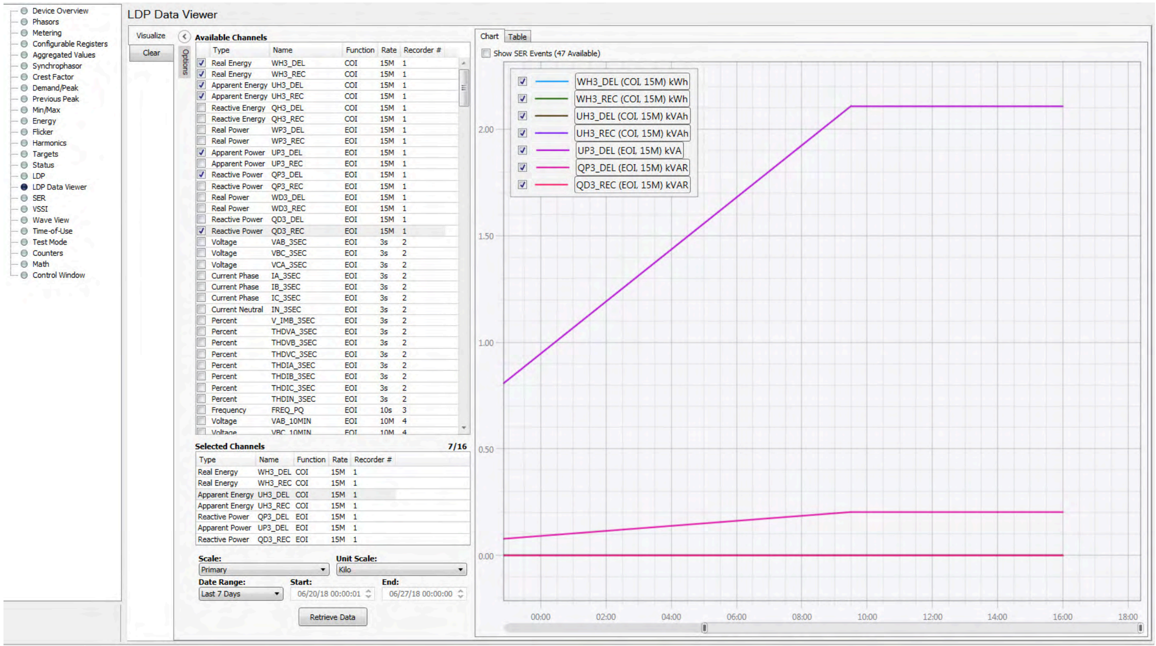


Figure 6.3 LDP Data Viewer

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 by 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 pre-trigger data. Adjust the pre-trigger 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 unfiltered COMTRADE event records at various cycle lengths and samples per cycle. See *Figure 6.4*. The meter also generates CEV event records at 16 samples per cycle. CEV event records are filtered to provide fundamental-only waveforms. The reports contain neither harmonics nor interharmonics. CEV event records contain date, time, currents, voltages, frequency, and Device Word bits.

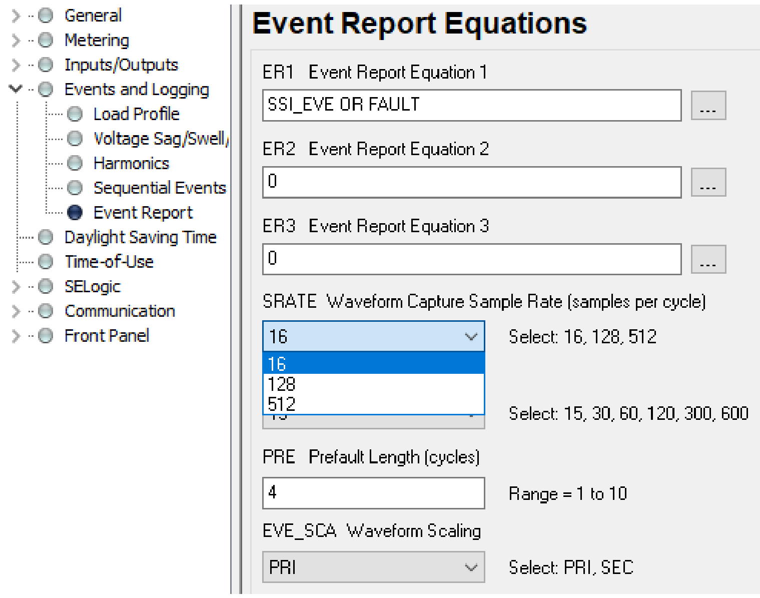


Figure 6.4 Selecting Sample Rate and Event Length in QuickSet

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 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, QuickSet, and DNP3 interfaces. The QuickSet interface includes graphical representation of disturbances with additional analysis options.

Waveform Capture Event Reports

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 QuickSet HMI
- The **Captured Waveform** button is pressed on the front of the meter

Programmable SELOGIC Control Equation Settings ERn

The programmable SELOGIC control equation event report trigger settings ER1, ER2, and ER3 are set to trigger standard event reports. When setting ER*n* detects a rising edge, the meter latches the PQALRM word bit and 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.

ER1 := **SSI_EVE OR FAULT**

ER2 := **0**

ER3 := **0**

Trigger Event Report

Follow the steps below to manually trigger an event.

Step 1. Open the QuickSet HMI Control window and ensure communications with the meter are successful.

Step 2. In the **Records** section, left-click the **Trigger** button as shown in *Figure 6.5*.

QuickSet prompts you with `Trigger an event?`

Step 3. Click **Yes**.

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 6.5 shows how to trigger events by using the QuickSet HMI Control window.

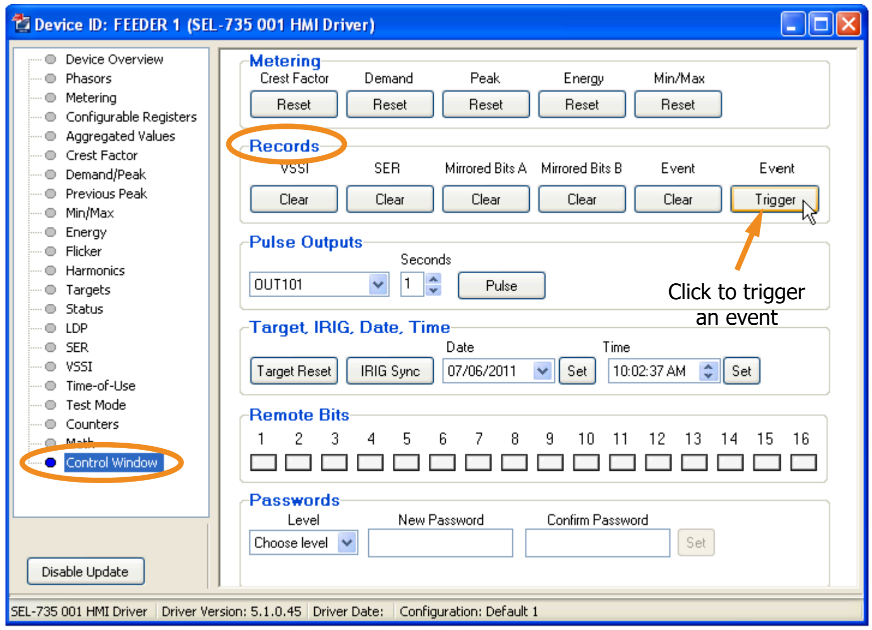


Figure 6.5 Trigger an Event Via QuickSet HMI Control Window

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 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
- Ten-second average frequency at the beginning of the 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 QuickSet HMI Control window and ensure communications with the meter are successful.

Step 2. In the **Records** section, left-click the **Event Clear** button as shown in *Figure 6.6*.

QuickSet prompts you with `Clear History Buffer?`

Step 3. Click **Yes**.

QuickSet clears all events stored on the meter.

Figure 6.6 shows how to clear events from the meter by using the QuickSet HMI Control window.

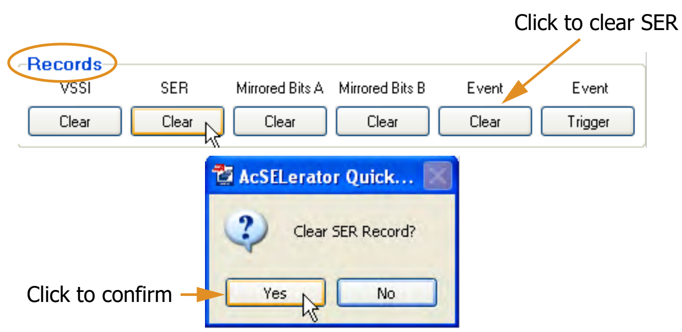


Figure 6.6 Clear Events From Meter

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 SER automatically records entries to indicate device startup, daylight-saving time, other time changes, and settings change conditions.

The meter records the entries (in seconds) as follows for time-change events greater than the TIME_CHG setting value and less than 10000 seconds.

```
Time Changed by <source> [+/-] xxxxx.xs
```

where:

`<source>` = IRIG-D, IRIG-P2, IRIG-P3, SNTP, DST, DNP, MODBUS, ASCII, or HMI.

The meter displays `10,000.0s` for all time-change events greater than 10000 seconds.

Figure 6.7 shows the time-change entries in the SER report.

```
1130490378                        Date: 01/16/16    Time: 09:00:09.133
STATION A                                           Time Source: int

FID=SEL-735-X168-V4-Z008005-D20151224       CID=E686

#      Date      Time           Element           State

   20 01/05/16  10:26:27.109   SALARM             Asserted
   19 01/05/16  10:26:28.109   SALARM             Deasserted
   18 01/14/16  08:30:48.998   SALARM             Asserted
   17 01/14/16  08:30:49.998   SALARM             Deasserted
   16 01/14/16  16:00:24.077   Power loss
   15 01/16/16  12:10:09.087   Power restored
   14 01/16/16  13:07:36.270   SALARM             Asserted
   13 01/16/16  13:07:37.270   SALARM             Deasserted
   12 01/16/16  11:00:00.008   Time changed by ASCII    -08257.2s
   11 01/16/16  13:24:43.748   IRIG Selection IRIG-D
   10 01/16/16  13:24:43.748   Time changed by IRIG-D   +08303.7s
    9 01/16/16  13:24:43.748   TIRIG              Asserted
    8 01/16/16  13:25:04.839   TSOK               Asserted
    7 01/16/16  13:25:05.023   PMDOK              Asserted
    6 01/16/16  13:34:27.247   TIRIG              Deasserted
    5 01/16/16  13:34:44.014   TSOK               Deasserted
    4 01/16/16  13:34:44.022   PMDOK              Deasserted
    3 01/16/16  13:34:46.022   PMDOK              Asserted
    2 01/16/16  13:34:50.022   PMDOK              Deasserted
    1 01/16/16  09:00:00.008   Time changed by ASCII   >-10000.0s
```

Figure 6.7 SER Time-Change Entries

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 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 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 supports SER chatter criteria settings SRDLCNT and SRDLTIM to determine the quantity and time limits over which multiple SER entries are considered excessive. For example, for the settings shown in *Figure 6.8*, the meter publishes all multiple entries of the same Device Word bit but ignores entries if more than five entries (SRDLCNT setting) occur within one second (SRDLTIM setting). The meter resumes recording the Device Word bit once the chatter conditions are false. Use the ESERDEL setting (as shown in *Figure 6.8*) to enable or disable the SER chatter settings. The meter retains a minimum of 80,000 of the most recent SER entries in nonvolatile memory.

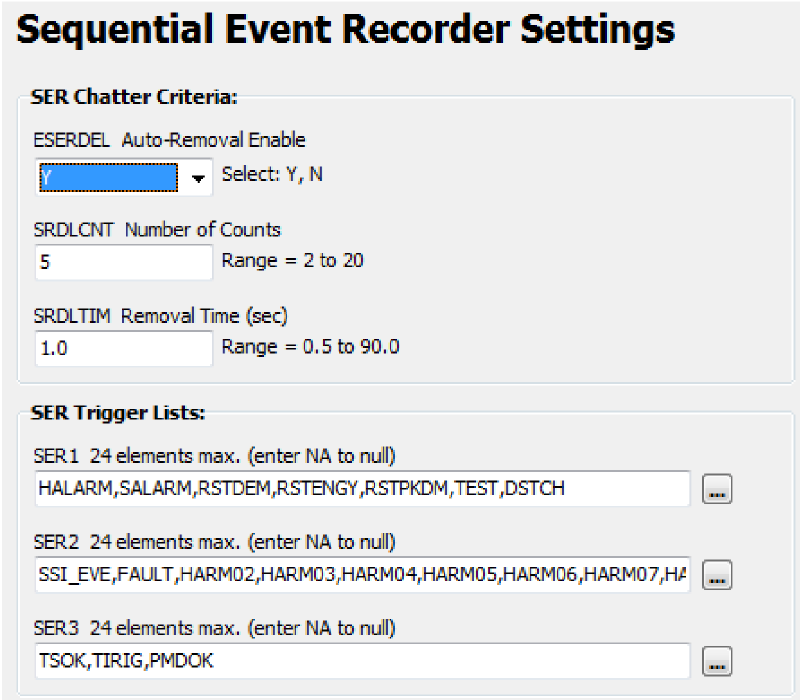


Figure 6.8 SER Chatter Criteria Settings

Perform the following steps to create an SER list.

Step 1. Open a QuickSet settings instance.

Step 2. Navigate to the **Events and Logging > Sequential Events Recorder** window.

Step 3. Click the **SER*n*** ellipse button.

QuickSet opens the SER list builder shown in *Figure 6.9*.

Step 4. Select the desired Device Word bits to add to the list.

Step 5. Click the right arrow.

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 6.9 shows how to open the SER list builder and how to create an SER list.

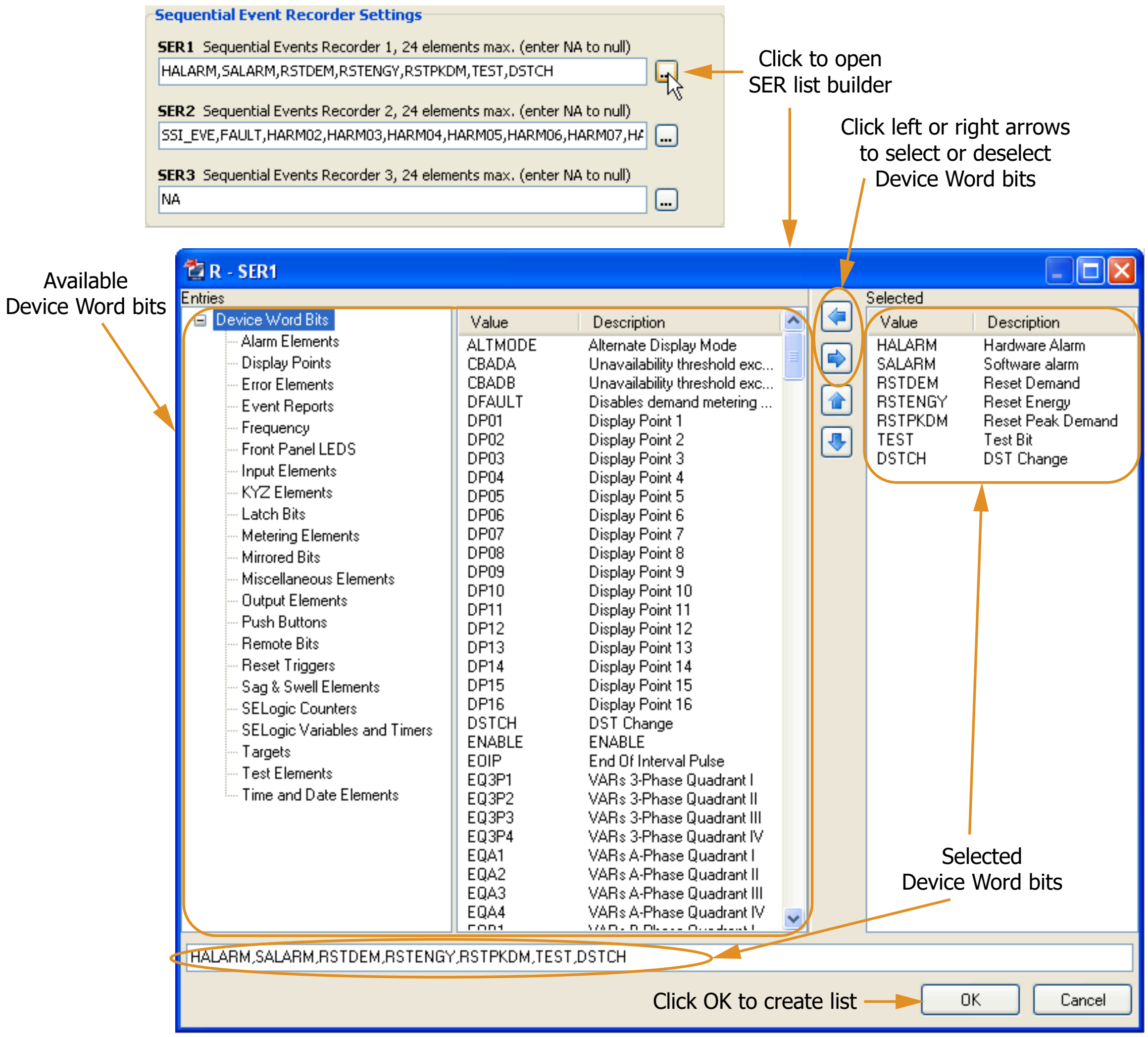


Figure 6.9 SER List Builder

Retrieve SER Reports

Follow the steps below to retrieve SER data stored on the meter.

Step 1. Open the 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 select the **Get all SER** check box 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 6.10 shows the QuickSet HMI SER window where you can retrieve and export SER reports.

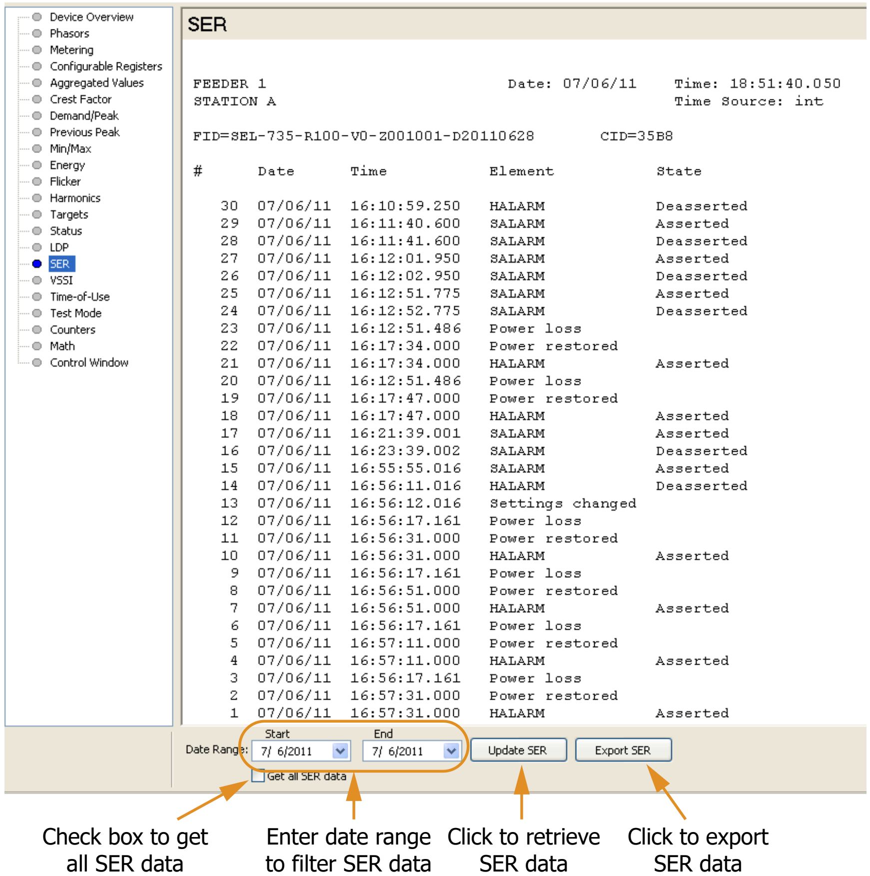


Figure 6.10 SER HMI Window

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 QuickSet HMI Control window and ensure communications with the meter are successful.

Step 2. Retrieve the desired SER data as explained previously.

QuickSet exports the SER data displayed in the SER HMI window.

Step 3. Click **Export SER**.

QuickSet opens up the **Save As** window.

Step 4. Set the file format to export a .csv or .txt file.

Step 5. Click **Save**.

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 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 6.11*.

Step 3. QuickSet prompts you `Clear SER Record?`

Step 4. Click **Yes**.

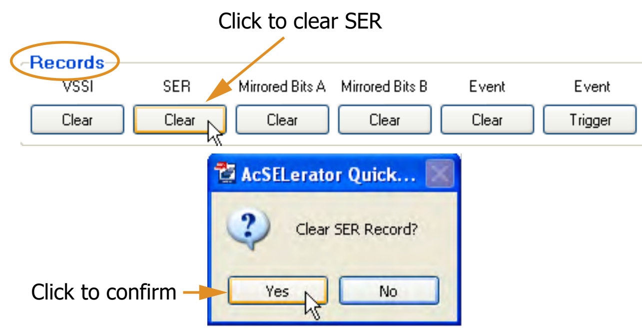


Figure 6.11 Clear SER Report From Meter

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 QuickSet software interface includes graphical representation of disturbances with additional analysis options as shown in *Figure 6.12*.

The SEL-735 records VSSI data by 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 270 independent disturbances and a minimum of 60,000 detailed entries. Refer to *Table 1.3* for the number of records available for each PQ model option. 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.

By default, the meter calculates half-cycle voltage and current rms quantities for SSI detection. Sixteen-samples/cycle data provide the source for the calculation, and the half-cycle rms calculation updates every 1/16 cycle.

When VRMSWIN is set to one cycle, the meter calculates one-cycle voltage and current rms quantities for SSI detection. Sixteen-samples/cycle data provide the source for the calculation, and the one-cycle rms calculation updates every half cycle. If VRMSWIN is set to ONE, an additional 5 ms delay is applied to all VSSI measurements.

VSSI Settings

The VBASE setting defines the nominal phase-to-neutral secondary voltage applied to Form 9 and Form 36 connections, and phase-to-phase voltage applied to Form 5 connections. All VSSI settings are referenced from the VBASE voltage.

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 average rms voltage over the time period and updated every 10/12 cycles. VBASE is not updated during VSSI conditions. The calculated VBASE value is clamped to the available configurable range for the VBASE setting. Set AVG_Time to OFF to disable the dynamic VBASE feature.

Table 6.6 VSSI Settings

Setting Name	Description	Entry Options
VBASE	The meter reference voltage for VSSI trigger conditions.	20–300 (Volts Sec)
VRMSWIN[a]	The cycle window in which the voltage phases are analyzed.	HALF, ONE (cycles)
VINT	The % of VBASE voltage when an interrupt VSSI report is triggered	5–99 (% of VBASE)
VINTHYS	The margin % of VBASE above VINT to stop an interrupt VSSI Report.	0.00–10 (% of VBASE)
VSAG	The % of VBASE voltage when a SAG VSSI report is triggered	5–99 (% of VBASE)
VSAGHYS	The margin % of VBASE above VSAG to stop a sag VSSI Report.	0.00–10 (% of VBASE)
VSWELL	The % of VBASE voltage when a SWELL VSSI report is triggered	101–180 (% of VBASE)
VSWELHYS	The margin % of VBASE below VSWELL to stop a swell VSSI Report.	0.00–10 (% of VBASE)
AVG_TIME	Enables a dynamic VBASE value, calculated every [*x*] minutes.	1–10 (minutes), OFF (Disable)

[a] Set to ONE to comply with IEC 61000-4-30 Class A requirements. Changing the setting will erase events.

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.

The meter does not record a separate event if a VSSI event occurs on one phase during an existing event on another phase.

VSSI Summary Report

The VSSI report in the QuickSet HMI displays the summary VSSI reports as shown in *Figure 6.12*. 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 6.12 shows an example VSSI summary in the QuickSet HMI VSSI window.

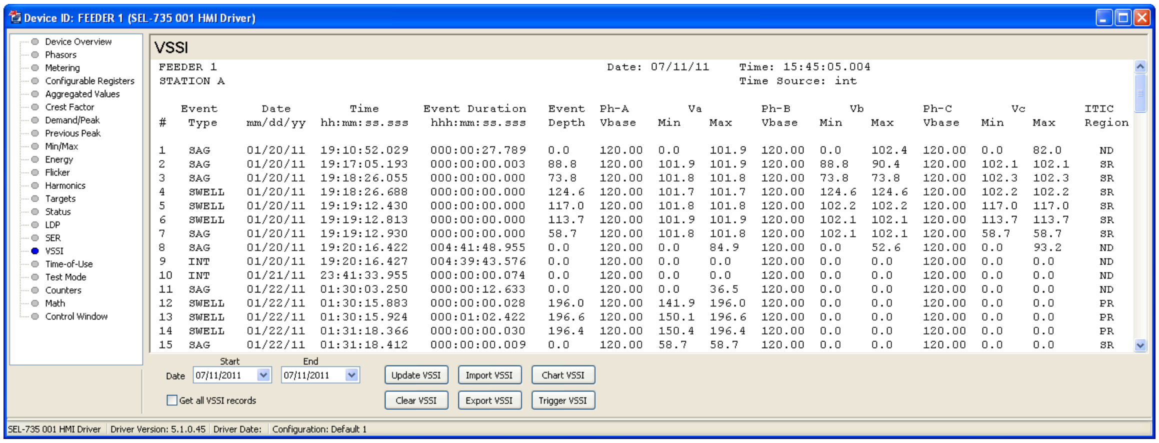


Figure 6.12 Example VSSI Response in QuickSet

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)

If VRMSWIN is set to one cycle, the VSSI summary report will display two rows of identical information, because the quantity is updated every half cycle.

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 6.7* and *Table 6.8* 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 6.7 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 6.7 State of the Voltage Sag/Swell/Interruption Device Word Bits

Symbol	Meaning[a]	
	Meter Form 9 and Form 36 Column A represents A-Phase Column B represents B-Phase Column C represents C-Phase	Meter Form 5 Column A represents VAB Column B represents VBC Column C represents VCA
.	No VSSI bits asserted for phase	
O	Overvoltage (SW*p* asserted)	
U	Undervoltage (SAG*p* asserted)	
I	Interruption (INT*p* asserted; SAG*p* asserted, unless setting VSAG := OFF)	

[a] Replace p with A-, B-, or C-Phase.

Table 6.8 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 (post-disturbance at 4 samples per cycle)	As many as 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 6.13* for a partial VSSI report. The VSSI report example shows a three-phase voltage interruption lasting about 2.80 seconds with the meter entering daily sampling mode.

```
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

                             Current(%I nom.)            Vbase  Volt   Vbase  Volt   Vbase  Volt  Ph  ST
#     Date     Time          Ia    Ib    Ic    Ig    In   (Vsec) %Vbase (Vsec) %Vbase (Vsec) %Vbase ABC

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  .UU 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 6.13 Example Voltage Sag/Swell/Interruption (VSSI) Report (Meter Form 9)

VSSI Device Word Bits

Upon a voltage disturbance, the meter asserts Device Word Bits that offer a binary disturbance summary, and latches the PQALRM word bit. Mapping these VSSI Device Word Bits to the SER allows rapid analysis of a disturbance and its corresponding CBEMA/ITIC region.

SECTION 7

Inputs/Outputs and SELOGIC Control Equations

Overview

This section explains the settings and operation of the logic inputs/outputs and SELOGIC control equations for the SEL-735.

Inputs/Outputs on page 249

- KYZ Outputs
- Output Contacts
- DC Analog Outputs
- Optoisolated Inputs
- Remote Control Bits

SELOGIC Control Equations on page 259

- Latch Control Bits
- SELOGIC Control Equation Variables/Timers
- Math Variables
- Virtual Bits
- MIRRORED 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*n*_SCALE, KE*n*, KET, KE*n*_UNIT, KYZD*n*, KYZPW*n*, KE*n*_OUT	KYZD*n*, KYZDT
Output Contacts	OUT*n*	Word bits OUT*n*
Analog Outputs	AO*n*AQ, AO*n*AQL, AO*n*AQH, AO*n*L, AO*n*H	Current Output
Optoisolated Inputs	IN*n*D	IN*n* 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*n*_SCALE	KE*n* Scale. Sets the scale of KE*n*.	SEC	PRI, SEC
KE*n*	Watt-hour constant. Sets the KYZ pulse energy constant.	1.8000	0.0001–9999
KE*n*_UNIT	KE*n* Units. Sets the units of KE*n*.	UNITY	UNITY, KILO, MEGA
KYZD*n*[a]	Demand Type to Output *n*. Sets the energy analog quantity for output.	WH3_DEL	Energy Quantities
KYZPW*n*	KYZ Minimum Pulse Width *n*. Sets the minimum pulse width.	25 ms	25, 50, 75, 100 ms
KE*n*_OUT	KYZ Output. Maps the KYZ pulses to an output contact.	OFF	OFF, OUT401–OUT404

[a] 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 10: Testing and Troubleshooting* for more details of the meter while it is in TEST mode.

The settings KE*n*, KE*n*_SCALE, and KE*n*_UNIT determine the number of KYZ triggers or KYZ state transitions. The meter calculates the number of KYZ triggers by 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:

t = time in hours

$R_{previous}$ = Energy remaining from the previous calculation of the number of KYZ triggers

K_e = KE*n* • KE*n*_UNIT / trigger

where:

KE*n*_UNIT = 1 if KE*n*_UNIT = UNITY

KE*n*_UNIT = 1000 if KE*n*_UNIT = KILO

KE*n*_UNIT = 1000000 if KE*n*_UNIT = MEGA

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 non-zero 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 by using ACSELERATOR QuickSet SEL-5030 Software without having to enter any logic expressions.

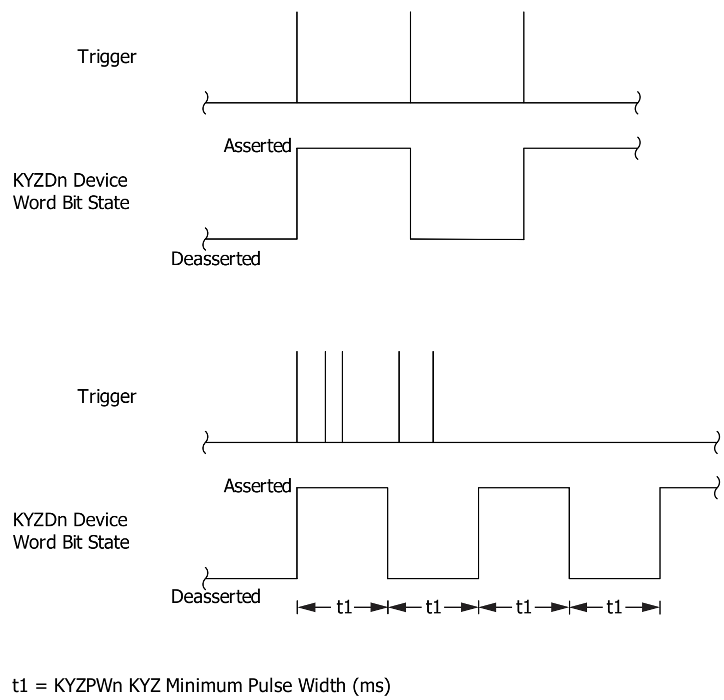


Figure 7.1 KYZ Pulse Pickup

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 setting as 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:

$$\text{Total Energy (Pri)} = \text{Number of triggers} \bullet \text{CTR} \bullet \text{PTR} \bullet \text{KEn\_UNIT}$$
$$\text{Total Energy (Sec)} = \text{Number of triggers} \bullet \text{KEn\_UNIT}$$

If KE*n*_SCALE is set to PRI:

$$\text{Total Energy (Pri)} = \text{Number of triggers} \bullet \text{KEn\_UNIT}$$
$$\text{Total Energy (Sec)} = \text{Number of triggers} \bullet \text{KEn\_UNIT} \bullet (\text{CTR} \bullet \text{PTR})$$

Equation 7.2

where:
KEn_UNIT = 1 if KEn_UNIT = UNITY
KEn_UNIT = 1000 if KEn_UNIT = KILO
KEn_UNIT = 1000000 if KEn_UNIT = MEGA

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 **Pulse**. 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

The **PULSE** command has no effect on an already asserted/energized contact output. For a deasserted/de-energized output, the **PULSE** command asserts the output for the user-defined time period (in seconds). This also applies to KYZ outputs.

Apply the following command syntax to use the **PULSE** command from a terminal window.

=>> **PULSE** *m n* **<Enter>**

where:

m = the output contact to pulse/operate (e.g., OUT101) or the SALARM Device Word bit

n = The time period (in seconds) for which the specified element is pulsed. If *n* is not entered, it defaults to 1 s. The maximum time period is 30 s.

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.

OUT103 = 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 ±1.2 mA or ±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 AO*xx*AQ is set to OFF the meter hides the associated settings.

Table 7.4 Analog Output Settings and Default Settings

Setting[a]	Definition	Default	Range
AO*xx*AQ	Analog Quantity. Sets the analog quantity for the output.	OFF	OFF, valid analog quantities
AO*xx*AQL	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
AO*xx*AQH	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
AO*xx*L	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
AO*xx*H	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

[a] 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.

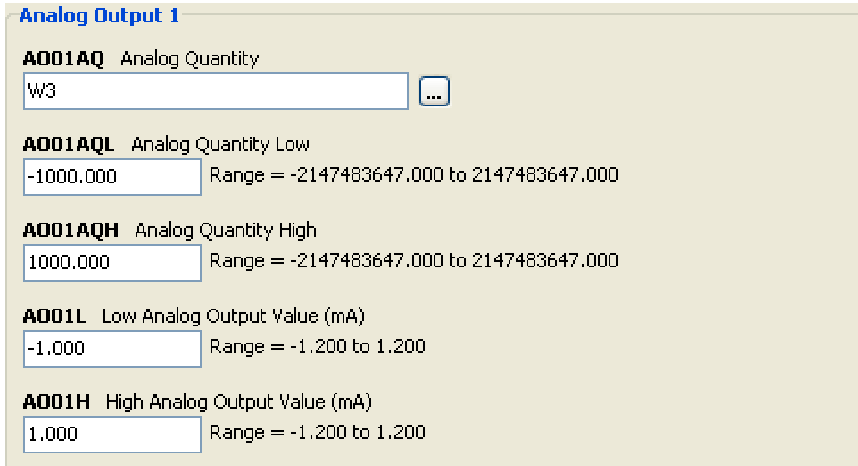


Figure 7.3 Analog Output Settings Example

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.

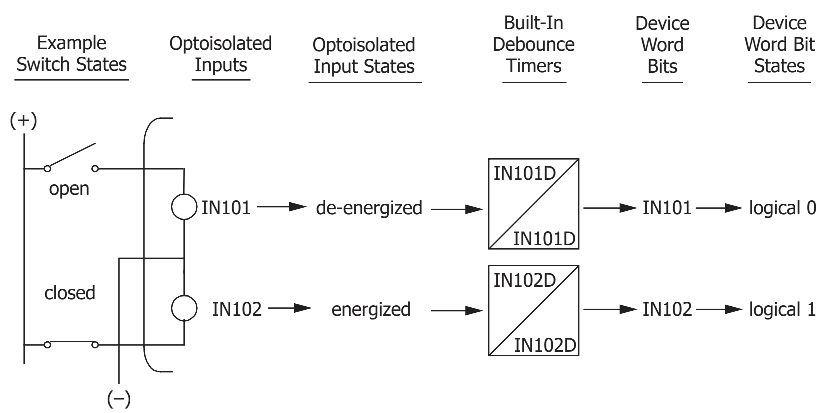


Figure 7.4 Example Operation of Optoisolated Inputs IN101–IN102

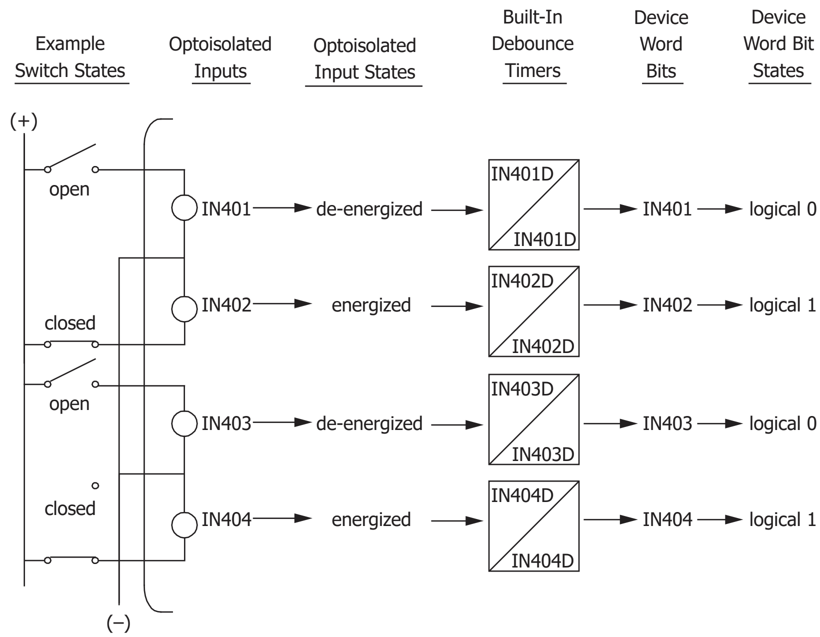


Figure 7.5 Example Operation of Optoisolated Inputs IN401–IN404, Extra I/O Board

Input Debounce Timers

Table 7.5 Input Debounce Default Settings and Valid Ranges

Setting	Definition	Default	Range
IN101D–IN102D (standard)	Input *n* Debounce Time. Sets the debounce time of the input.	5 ms	0–8, AC
IN401D–IN404D (optional)	Where *n* 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, refer to *Using the HMI on page 116*.

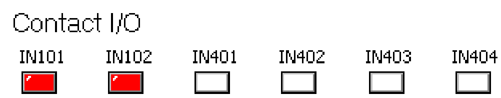


Figure 7.6 Contact I/O Status Shown in ACSELERATOR QuickSet HMI Device Overview Window

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.

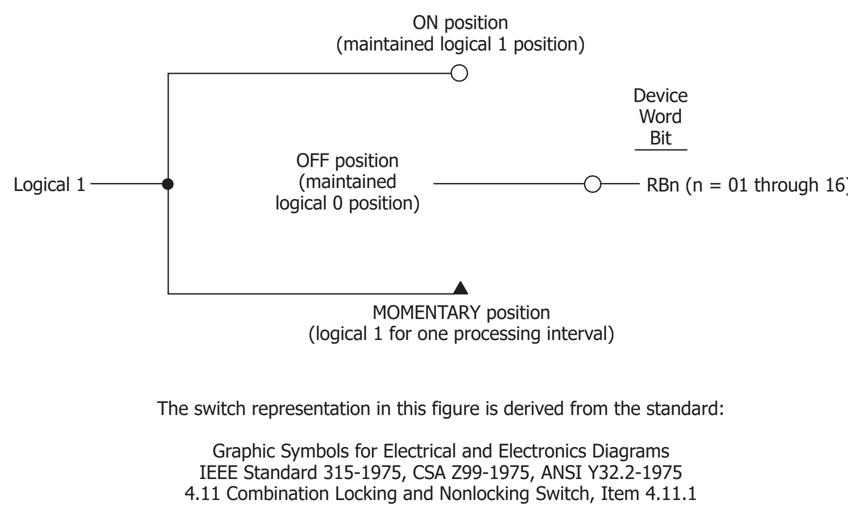


Figure 7.7 Remote Control Switches Drive Remote Bits RB01–RB16

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.

NOTE
If the remote bit is initially asserted before the **Pulse** command, the remote bit deasserts after completion of the command.

Step 4. Press **OK** or **Apply** to assert the command.

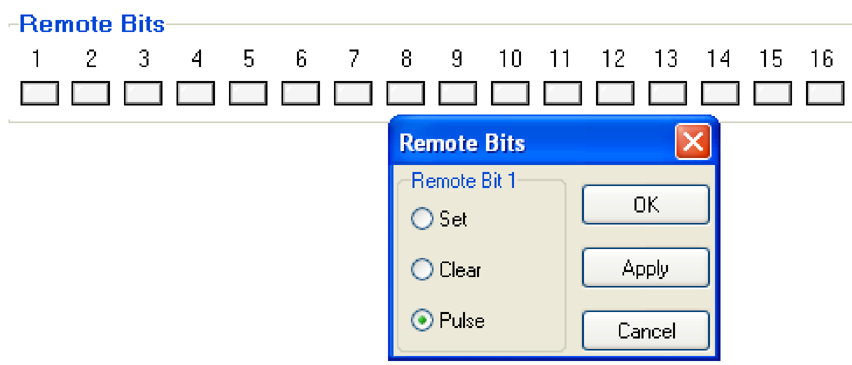


Figure 7.8 Control Remote Bits Through ACSELERATOR QuickSet HMI

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

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*
Counter Variables	SC*n*CV, SC*n*PV, SC*n*R, SC*n*LD, SC*n*CU, SC*n*CD	SC*n*, SC*n*R, SC*n*LD, SC*n*CU, SC*n*CD, SC*n*QU, SC*n*QD
MIRRORED BITS Equations	TMB*n*A, TMB*n*BT, RMB*n*A, RMB*n*B	TMB*n*A, TMB*n*B
Reset Trigger Equations	RSTDEM, RSTPKDM, RPKDMCT, RSTENGY, RPQALRM	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

Operator	Function	Function type
<, >, <=, >=	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 by 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.

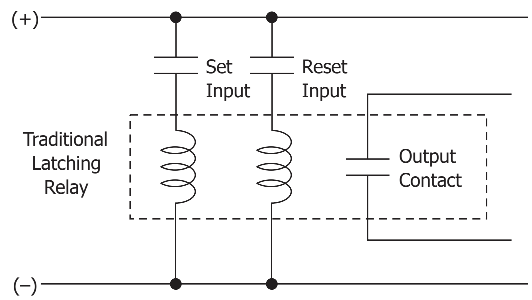


Figure 7.9 Traditional Latching Relay

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).

Figure 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
SET*n*	SELOGIC control equation that, when evaluates as TRUE, sets the latch bit. Enter **NA** to disable.	NA	SELOGIC control equation
RST*n*	SELOGIC control equation that, when evaluates as TRUE, resets the latch bit. Enter **NA** to disable.	NA	SELOGIC control equation

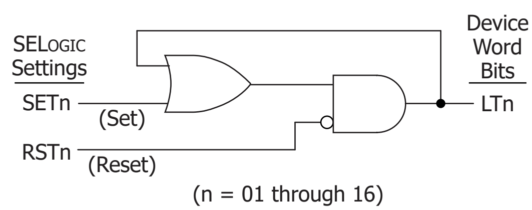


Figure 7.10 Latch Control Switches Drive Latch Bits LT01–LT16

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.

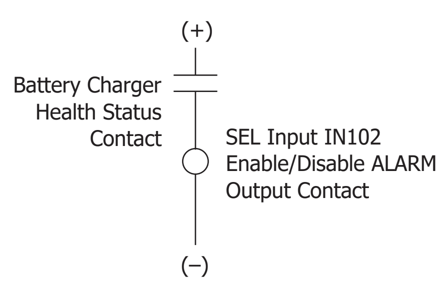


Figure 7.11 Battery Charger Health Status Contact Pulses Input IN102 to Enable/Disable ALARM Output Contact

You may implement this **ALARM** output contact logic by 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.

SET01 := **(R_TRIG IN102) AND (NOT LT01)**

RST01 := **(R_TRIG IN102) AND LT01**

OUT103 := **NOT (SALARM OR HALARM) OR (NOT LT01)**

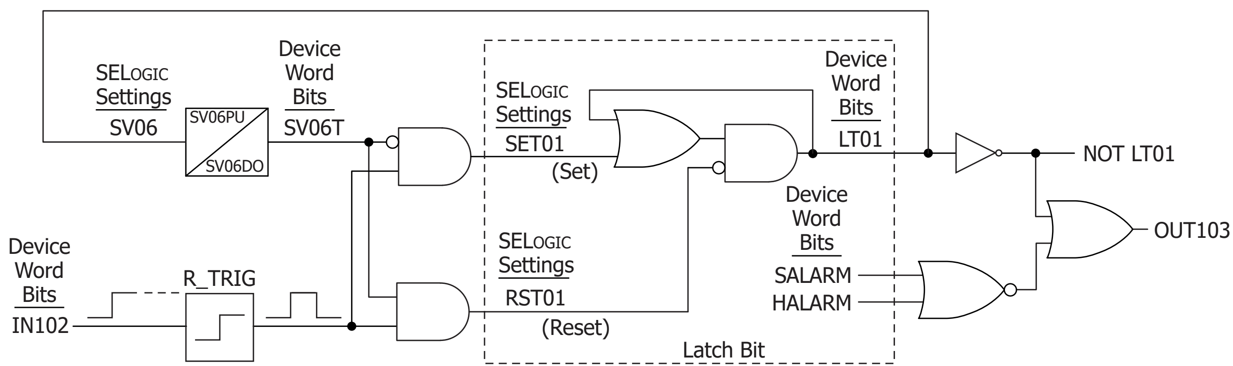


Figure 7.12 Single Input to Control ALARM

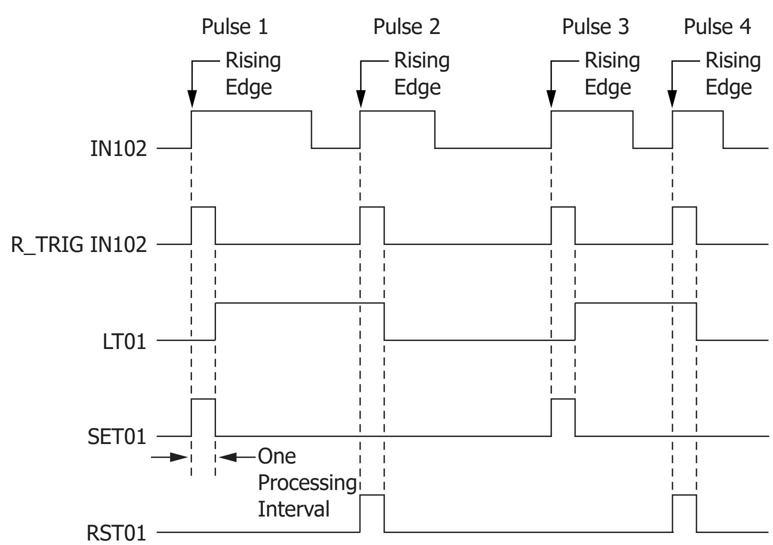


Figure 7.13 Latch Control Switch Operation Time Line

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.

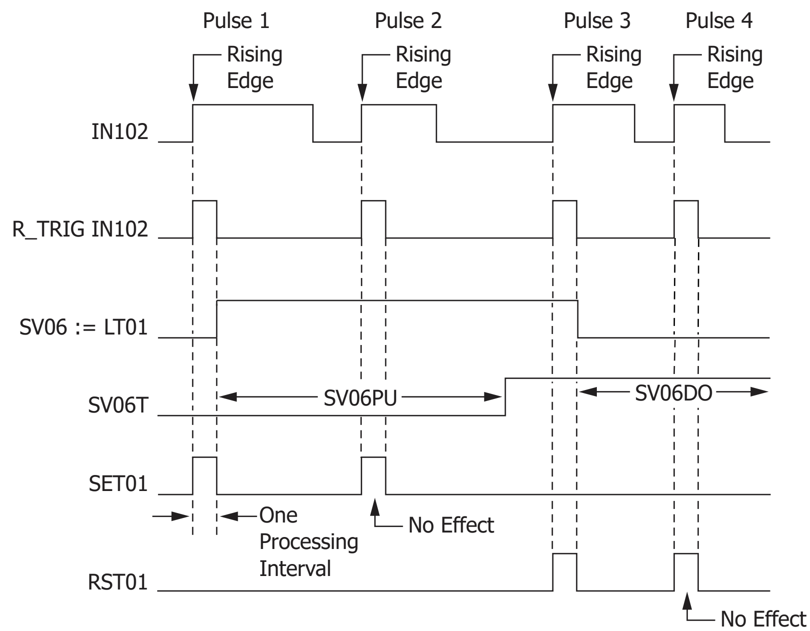


Figure 7.14 Latch Control Switch (With Time-Delay Feedback) Operation Time Line

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 SET*n* or RST*n* (*n* = 01–16), it is possible for the retained states of the latch bits to change, subject to the newly enabled settings SET*n* or RST*n*.

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*.

Because of the finite number of writes to nonvolatile memory, you should make changes to latch bit settings with care. Settings SET*n* and RST*n* cannot result in continuous cyclical operation of Latch Bit LT*n*. Use timers to qualify conditions set in settings SET*n* and RST*n*. If you use any optoisolated inputs in settings SET*n* and RST*n*, 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. SELOGIC control variables can process numerical values as high as 24 bits. The meter will reject settings if any element in a SELOGIC equation exceeds 16777215.99.

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
SV*n*	SELOGIC control equation that, when evaluated as TRUE, asserts the variable input	NA	SELOGIC control equation
SV*n*PU	Time required for the variable input to remain asserted before the variable output (SV*n*T) asserts	0.000 seconds	0.000 to 1000000.000
SV*n*DO	Time required for the variable input to remain deasserted before the variable output (SV*n*T) deasserts	0.000 seconds	0.000 to 1000000.000

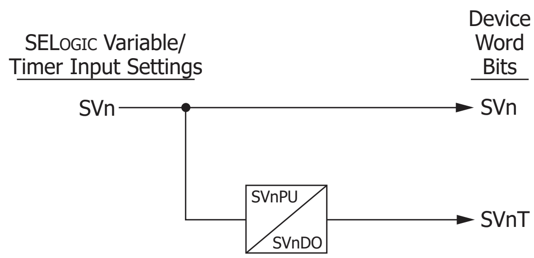


Figure 7.15 SELOGIC Control Equation Variables and Timers

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 SV*n* and SV*n*T (*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 OR OUT101) AND (OUT102 OR OUT401**

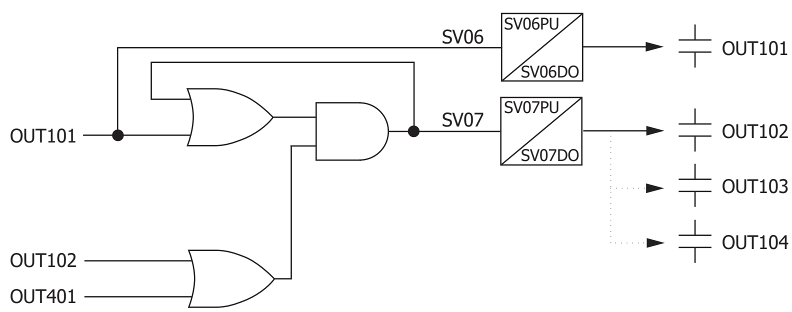


Figure 7.16 Example Use of SELOGIC Variables/Timers

Math Variables

The SEL-735 comes with 16 SELOGIC control equation Math Variables. Math Variables store the results of math calculations, as high as a value of 2^{24}. If a Math Variable exceeds 16777215.99, the values freeze.

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 enable updates.

➤ Click the **Disable Update** to disable updates.

ACSELERATOR QuickSet displays the present SELOGIC control equation math variable values, as *Figure 7.17* shows.

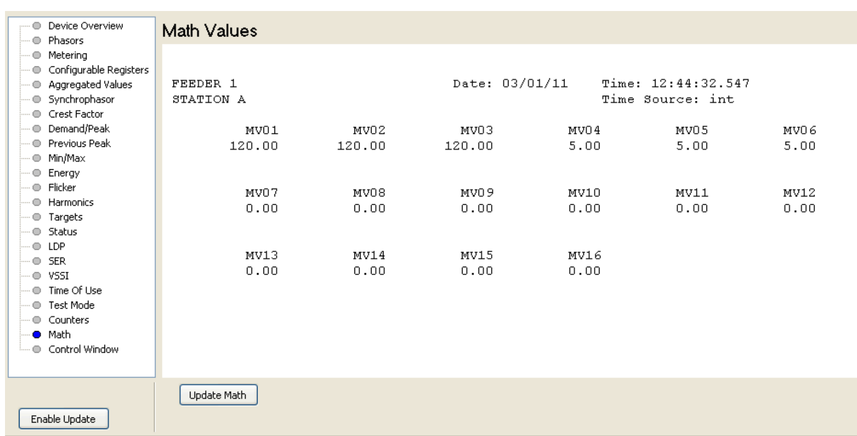


Figure 7.17 Math Variables Shown in HMI Math Window

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

Setting	Description	Default	Range
SC*n*CV	Current value of counter SC*n*. Use this setting to preload a value into the counter when sending settings to the device.	0	0–999999
SC*n*PV	Preset value and the maximum value of the counter. The preset value is loaded into the counter when the load preset logic equation result evaluates as true.	1	1–999999
SC*n*R	Reset logic equation. When the equation is true, the counter is reset to zero.	NA	SELOGIC control equation
SC*n*LD	Load preset logic equation. When the equation is true, the counter is loaded with the preset value.	NA	SELOGIC Expression
SC*n*CU	Count up logic equation. When the equation asserts true (detects the rising edge), the counter value increments by one.	NA	SELOGIC Expression
SC*n*CD	Count down logic equation. When the equation asserts true (detects the rising edge), the counter value decrements 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 (SC*n*CV) of the active settings editor. When you send the settings back to the meter, QuickSet prompts you to send the SC*n*CV settings. If you choose not to send the SC*n*CV settings, then the device loads zero into the SC*n*CV setting.

Table 7.13 SELOGIC Control Equation Counter Outputs

Name	Type	Description
SC*n*QU	Output, Word Bit	Word bit asserts when the counter current value equals the preset value.
SC*n*QD	Output, Word Bit	Word bit asserts when the counter current value equals zero.
SC*n*	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 > 150000)** # start the generator immediately

SV10 := **NOT(SV10T)** # 10 second period

SC01CU := **R_TRIG SV10 AND (WD3_DEL > 100000) OR F_TRIG SV10 AND (WD3_DEL > 125000)** # increment counter SC01, faster when the demand is higher than 125000.00

SC01CD := **R_TRIG SV10 AND (WD3_DEL < 100)** # decrement counter SC01 when the demand is below 100000.00

OUT402 := **(SC01 > 48)** # warning that diesel generator is about to start

OUT401 := **SC01QU** # start generator signal

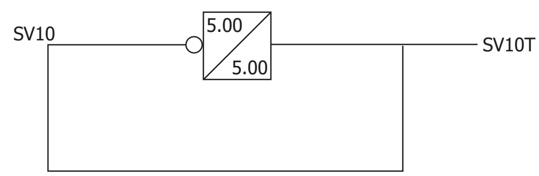


Figure 7.18 SELogic Variable SV10 Timing Logic

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.

$$\text{Preset Value} = \frac{10 \text{ minutes} \bullet 60 \text{ s/minute}}{10 \text{ x/count}} = 60 \text{ s/count}$$

Figure 7.19 is provided as a reference to this example.

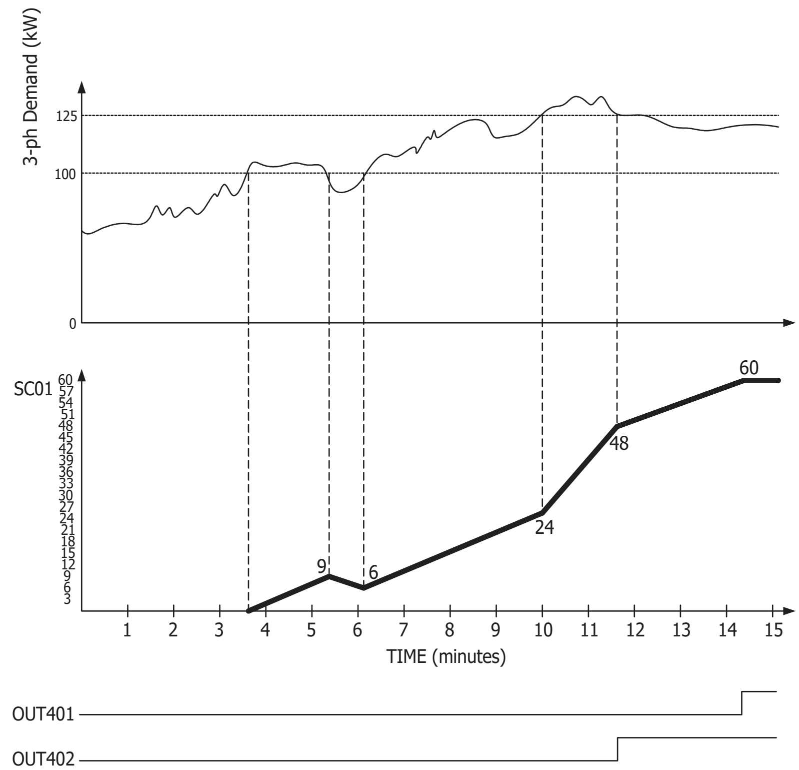


Figure 7.19 SELOGIC Control Equation Counter Example

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 TMB1*x*–TMB8*x*, where *x* is the channel specifier (A or B), The device controls Transmitted MIRRORED BITS through the corresponding

SELOGIC control equations. The device labels Received MIRRORED BITS as RMB1*x*–RMB8*x*. 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, see *Appendix F: MIRRORED BITS Communications*.

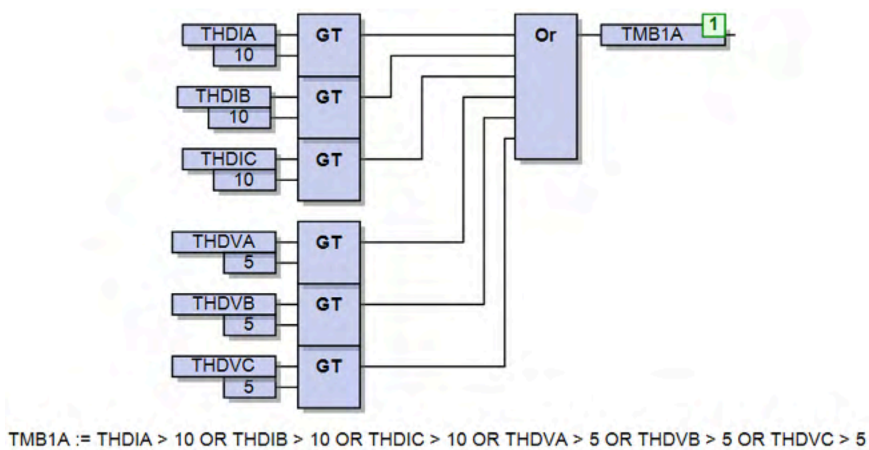


Figure 7.20 MIRRORED BITS Channel A

View MIRRORED BITS via QuickSet HMI

View transmitted and received MIRRORED BITS status through 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. 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 MIRRORED BITS Targets Shown in ACSELERATOR QuickSet HMI

Reset Trigger Equations

The Reset Trigger equations are SELOGIC control equations that reset demand, peak demand, peak demand reset count, energy values, and the PQALRM Device Word bit. The valid inputs for these equations are remote bits and remote analogs. The Reset Trigger equations assert on the rising edge of the inputs and assert the related Device Word bits RSTDEM, RSTPKDM, RPKDMCT, RSTENGY, and RPQALRM as well.

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.

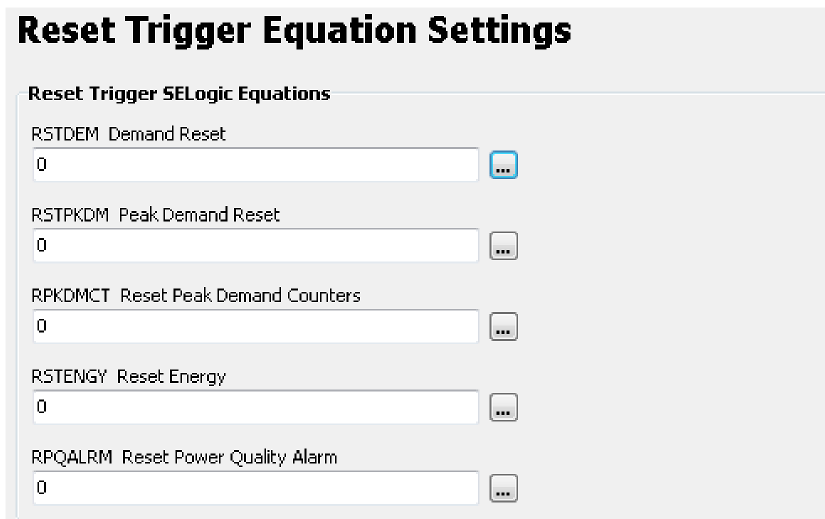


Figure 7.22 Reset Trigger Equation Settings

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.

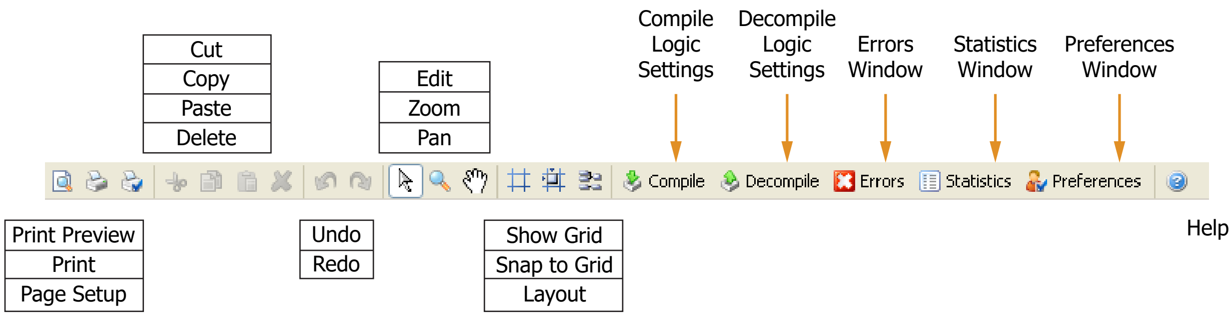


Figure 7.23 Graphical Logic Editor Toolbar

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.

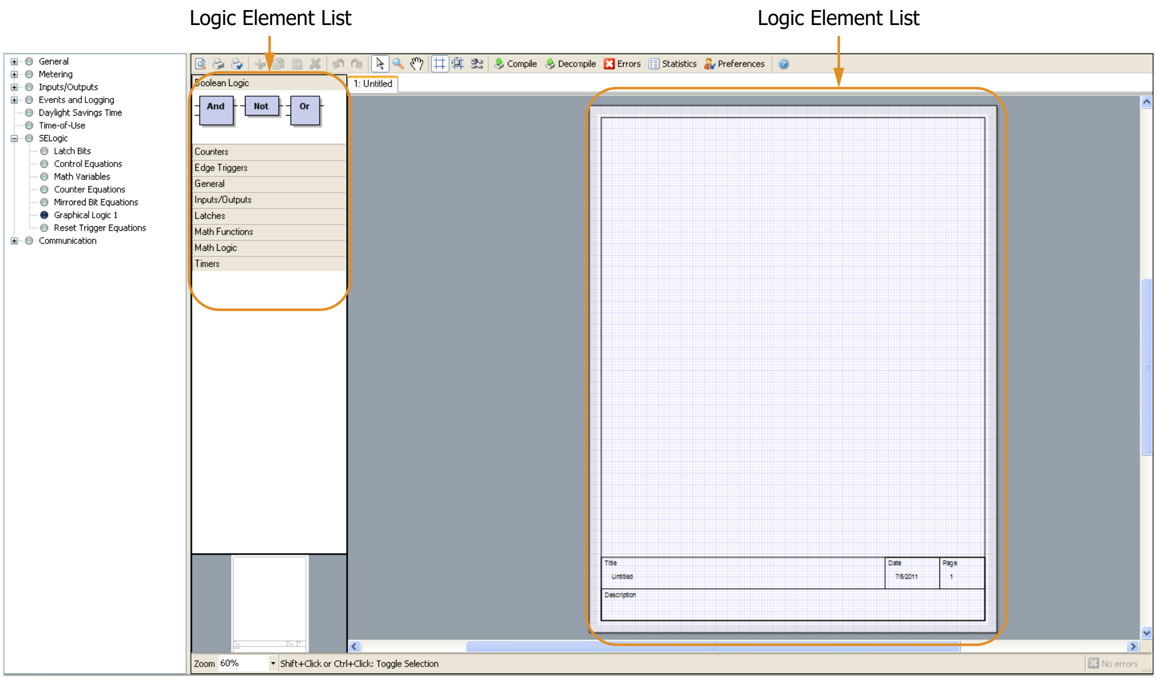


Figure 7.24 Graphic Logic Editor Window

When you first drag in an 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.

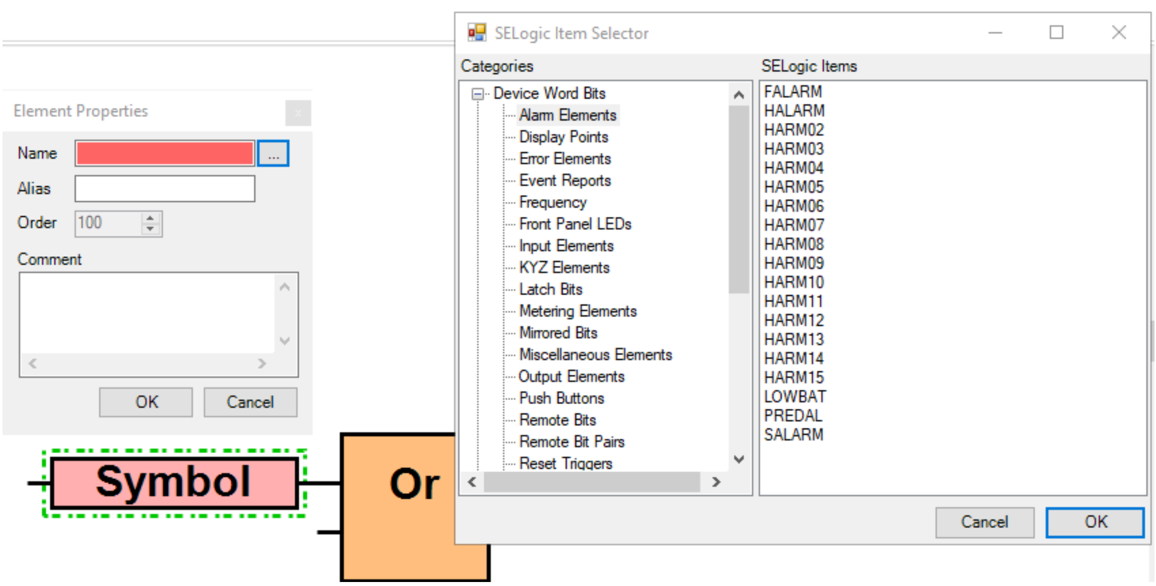


Figure 7.25 Graphical Logic Editor Element Control

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.

SECTION 8

Communications

Overview

There are various options for communicating with the SEL-735. The meter communications ports consist of the following:

- ➤ USB Type-C
- ➤ EIA-232
- ➤ EIA-485
- ➤ Internal Telephone Modem
- ➤ 10/100BASE-T Ethernet RJ45 Port
- ➤ 100BASE-FX Fiber-Optic Ethernet LC Port
- ➤ Type 2 Optical Port

This section explains the available communications options for the SEL-735. It details the available ports, functions of the different ports, and pinouts where applicable.

This section also includes a command summary and command explanations.

Communications Options

Port Options

The SEL-735 includes a front-panel connector that can be configured as per *Table 8.1*.

NOTE
The touchscreen option model is only available with USB Type-C.

Table 8.1 SEL-735 Front Port Options

Type	Availability	Chassis Part Number
Type 2 Optical Port	Non-Touchscreen Option	(H, V)
EIA-232	Non-Touchscreen Option	(A, B)
USB Type-C Port	Touchscreen Option Only	L

Table 8.2 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

Slot B, Main Board Communications Options	Ethernet Port 1	Serial Port 2	Serial Port 3
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

Table 8.3 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. The LEDs on the back of the meter show the active channel on Port 4, A, B, or C.

Table 8.3 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 by using a standard telephone cable and RJ-11 jack.

For a list of modem-related settings and definitions, see *Table 8.4*. 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.34, V.32bis, V.32, V.22bis, V.22, and Bell 212A protocols. V.90 and V.92 modem protocols are not yet approved for use by the internal modem.

Table 8.4 Modem Settings

Setting Name	Setting Value	Description
COMMINF	Modem	Communications Interface Selection (232, 485, MODEM)
ATSTRING	ATHX0E0&D0S0=1&K3[a]	Modem Initialization AT String: initialization string used by the internal modem (as many as 30 characters)

Setting Name	Setting Value	Description
PH_NUM	15093321890[b]	Phone Number for Dial-Out: can contain modem dial control characters (as many as 30 characters)
MDTIME	60[a]	Time to Attempt Dial: time, in seconds, from initiating a dial-out attempt to termination because of no connection
MDRET	120[a]	Time Between Dial-Out Attempts: time from termination on dial-out attempt until a retry dial-out attempt

[a] Default SW setting.
[b] 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 compose the factory-default string.

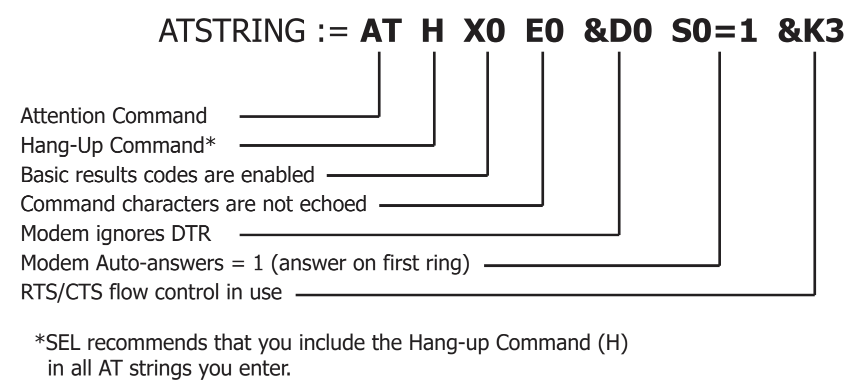


Figure 8.1 Factory-Default AT String

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 website at *selinc.com/products/735/*).

Table 8.5 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

Command	Description
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 8.6 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 SEL by contacting customer service (*selinc.com/support*).

CFR Part 68 Telecom

1. This equipment complies with Part 68 of the 47 CFR rules and the requirements adopted by the ACTA. Located on this equipment is a label that contains, among other information, the registration number and ringer equivalence number (REN) for this equipment or a product identifier in the format: US:AAAEQ##Txxxx

   If requested, this number must be provided to the telephone company.
2. A plug and jack used to connect this equipment to the premises wiring and telephone network must comply with the applicable 47 CFR Part 68 rules and requirements adopted by the ACTA. It's designed to be connected to a compatible modular jack that is also compliant.
3. The ringer equivalence number (REN) is used to determine the number of devices that may be connected to a telephone line. Excessive RENs on a telephone line may result in the devices not ringing in response to an incoming call. In most but not all areas, the sum of RENs should not exceed five (5.0). To be certain of the number of devices that may be connected to a line, as determined by the total RENs, contact the local telephone company. For products approved after July 23, 2001, the REN for this product is part of the product identifier that has the format US:AAAEQ##Txxxx. The digits represented by ## are the REN without a decimal point (e.g., 03 is a REN of 0.3). For earlier products, the REN is separately shown on the label.
4. If this equipment causes harm to the telephone network, the telephone company will notify you in advance that temporary discontinuance of service may be required. But if advance notice isn't practical, the telephone company will notify the customer as soon as possible. Also, you will be advised of your right to file a complaint with the FCC if you believe it is necessary.
5. The telephone company may make changes in its facilities, equipment, operations or procedures that could affect the operation of the equipment. If this happens, the telephone company will provide advance notice in order for you to make necessary modifications to maintain uninterrupted service.
6. If trouble is experienced with this equipment, please contact Multi-Tech Systems, Inc. at the address shown below for details of how to have the repairs made. If the equipment is causing harm to the telephone network, the telephone company may request that you disconnect the equipment until the problem is resolved.
7. Connection to party line service is subject to state tariffs. Contact the state public utility commission, public service commission or corporation commission for information.

8. No repairs are to be made by you. Repairs are to be made only by Multi-Tech Systems or its licensees. Unauthorized repairs void registration and warranty.
9. If your system has specially wired alarm equipment connected to the telephone line, ensure the installation of this equipment does not disable your alarm equipment.

   If you have questions about what will disable alarm equipment, consult your telephone company or a qualified installer.
10. Connection to party line service is subject to state tariffs. Contact the state public utility commission, public service commission or corporation commission for information.
11. This equipment is hearing aid compatible.
12. Manufacturing Information on telecommunications device (modem):

    Manufacturer: Multi-Tech Systems, Inc.

    Trade Name: SocketModem

    Model Number: MT5692SMI

    Registration No: US:AU7MM01BMT5692SMI

    Ringer Equivalence: 0.1B

    Modular Jack (USOC): RJ11C or RJ11W (single line)

    Service Center in USA: Multi-Tech Systems, Inc.

    2205 Woodale Drive

    Mounds View, MN 55112 U.S.A.

    (763) 785-3500

    (763) 785-9874 Fax

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 Real-Time Automation Controllers.

Port Connector and Communications Cables

USB-C

The SEL-735 touchscreen option features a plug-and-play USB Type-C port on the front panel. This port functions as a high-speed serial port, featuring SEL ASCII support. It does not, however, require speed configuration. All Touchscreen models are shipped with a 10-foot USB Type-A-to-Type-C cable (SEL-C497). This cable is not proprietary; however, in SEL's testing of many brands, some did not work properly. The SEL cable will connect. If you are not able to connect a different brand cable, you may want to try a different USB Type-A-to-USB Type-C cable.

Ethernet

The SEL-735 can be ordered with an optional Ethernet port in one of the following configurations.

- Copper (10/100BASE-T)
- Fiber (100BASE-FX/LX)

Connect to the port by using a standard RJ45 connector with the copper option or a standard LC connector with the fiber-optic 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 Router: 192.168.0.1

The Ethernet port accommodates six simultaneous sessions that can include any combination of Telnet, Modbus, IEC 61850, Synchrophasors, or DNP3, but 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 8.7* describes each LED. *Figure 8.2* shows the location of status LEDs.

Table 8.7 Ethernet Port LED Description

LED	Description
Green	Tx or Rx Activity
Yellow	Link

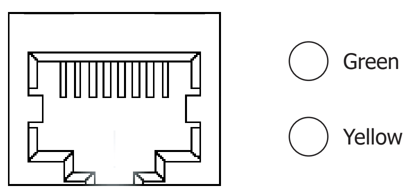


Figure 8.2 Ethernet Port Status LEDs

Serial

IRIG-B

The SEL-735 provides as many as three options for the IRIG-B signal input. You can use the dedicated IRIG-B input or IRIG-B inputs on Serial **Port 3** or **Port 2**. The SEL-735 automatically switches to one of the IRIG-B time sources when one is present. If you want to connect to a device that produces an IRIG-B signal output (such as an RTAC or SEL communications processor), 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 8.9* lists SEL communications cables. See *Primary and Secondary Time Sources on page 224* and *The Effects of Time Changes on page 227*.

Serial Port Pinouts

Figure 8.3 shows the DB-9 connector pinouts for the SEL-735 serial ports.

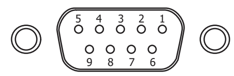


Figure 8.3 DB-9 Connector Pinout for EIA-232 and EIA-485 Serial Ports

Table 8.8 Port Pinout Functions

Pin	EIA-232 Port 2, Port 3[a]	EIA-232 Port F, 4C	EIA-485 Port 3, Port 4A
1	+5 Vdc	N/C	+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

[a] Port 2 and Port 3 combined current draw is 400 mA.

SEL-735 Communications Cables

Table 8.9 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. Use the SEL-5801 SEL Cable Selector program for more information on SEL cables, including the pinouts of cables.

Table 8.9 SEL-735 Communications Cables

Communications Type	Function	Cable Designation	IRIG-B Support?
Serial	SEL-735 to PC, DB-9 Serial	SEL-C234A [R]	No
		SEL-C235	No
		SEL-C287 [R]	No
	SEL-735 to PC, Optical Probe	ABACUS A6Z (DB-9)	No
		ABACUS A9U (USB)	No
	SEL-735 to PC, USB to Serial	SEL-C662	No
	SEL-735 to other IED	SEL-C273A [R]	Yes
	SEL-735 to PC, USB-A to USB-C	SEL-C497[a]	No

Communications Type	Function	Cable Designation	IRIG-B Support?
Ethernet	SEL-735 to PC or other IED	SEL-CA605 [R]	No

[a] This cable is not proprietary; however, in our testing, some lesser-known brands did not work properly. If you are not able to connect with a non-SEL cable, try a different brand/type USB Type-A-to-USB Type-C cable.

For long-distance communications as far 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

Communications and Protocol Settings

The SEL-735 supports SEL ASCII/Compressed ASCII, SEL Fast Operate/Fast Meter, MIRRORED BITS Communications, SEL Distributed Port Switch (LMD), Modbus RTU/TCP, DNP3 serial and LAN/WAN, FTP, TCP/IP, Y-Modem, SNTP, IEC 61850, Telnet, MV-90, and IEEE C37.118-2014 (Synchrophasor measurements), as shown in *Table 8.10*. The Ethernet port supports six simultaneous communications sessions, including five DNP3 LAN/WAN sessions. Port 4 supports three communications options, but only one is available at a time. All other ports (Port 2, Port 3, and Port F) can operate independently as configured in settings and concurrently with all other ports.

To change the communications parameters, select the desired communications port followed by Communications in the QuickSet settings editor tree.

Table 8.10 Available Communications Protocols

Protocols	Ethernet[a] (Port 1[b])	Serial: EIA-485, Modem, and EIA-232 (Port 2, Port 3, Port 4[a, b])	Front Port USB-C	Front Port (EIA-232 and Optical)
SEL ASCII/ Compressed ASCII	•	•	•	•
Modbus RTU		•		•
Modbus TCP	•			
DNP3	•	•		•
Fast Operate/Fast Meter		•	•	•
MIRRORED BITS		•		
Distributed Port Switch (LMD)		•		
FTP	•			
SNTP	•			
IEC 61850	•			
Telnet	•			
Y-Modem	•	•		
MV-90	•	•		

Protocols	Ethernet[a] (Port 1[b])	Serial: EIA-485, Modem, and EIA-232 (Port 2, Port 3, Port 4[a, b])	Front Port USB-C	Front Port (EIA-232 and Optical)
IEEE C37.118-2014 (Synchrophasors)	•			
Continuous Waveform Streaming Protocol	•			

[a] Additional cost option.
[b] The Ethernet port accommodates six simultaneous sessions that can include any combination of Telnet, Modbus, IEC 61850, Synchrophasors, Continuous Waveform Streaming, or DNP3, but supports a maximum of five DNP3 LAN/WAN and Modbus sessions.

SEL Fast Meter and 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 communications.

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>**

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.

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 lower than 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 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>**

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.

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.

MV-90 Translation

The meter provides MV-90 support via SEL ASCII protocol.

Modbus RTU

The meter provides Modbus RTU support. *Appendix E: Modbus and FTP Communications Protocols* 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 281*).

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 on page 288*.

SNTP

The SEL-735 provides SNTP support via the Ethernet port (**PORT 1**). See *Simple Network Time Protocol (SNTP) on page 289*.

IEEE C37.118.1 Synchrophasors

The SEL-735 provides synchrophasor support via the Ethernet port (**PORT 1**). The meter supports two synchrophasor sessions. See *Appendix I: Synchrophasors*.

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 8.11* describes the automatic messages.

Table 8.11 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 *Waveform Capture Event Reports on page 237*.
Self-Test Warning or Failure	The meter sends a status report each time it detects a self-test warning or failure condition. See *Meter Self-Tests on page 331*.

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 *SEL-735 Meter Command Summary* 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. To enable an FTP session in the meter, select **Y** for the EFTPSERV setting. The default value for EFTPSERV is **N**.

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 from 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 IEC 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 in 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. In addition, the access level does not restrict the user's connection to the FTP server. Disabling the 2AC access level will not disable access to the FTP server.

MMS is enabled when Port 1 setting E61850 is set to 1 or higher. MMS authentication is supported (see *MMS on page 483*).

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.

Simple Network Time Protocol (SNTP)

When ESNTP is enabled (Port 1 setting ESNTP is not OFF), the meter internal clock synchronizes to the time of day served by a Network Time Protocol (NTP) server. The meter uses a simplified version of NTP called the Simple Network Time Protocol (SNTP). SNTP is a secondary time source (see *Primary and Secondary Time Sources on page 224*).

SNTP as Main or Backup Time Source

If an IRIG-B time source is connected and either Device Word bits TSOK or TIRIG assert, then the meter synchronizes the internal time-of-day clock to the incoming IRIG-B time-code signal, even if SNTP is configured in the meter and an NTP server is available. If the IRIG-B source is disconnected (TIRIG deassert), the meter synchronizes the internal time-of-day clock to the NTP server if available. In this way, an NTP server acts as either the main time source, or as a backup time source to the more accurate IRIG-B time source.

Creating an NTP Server

Three SEL application notes available from the SEL website describe how to create an NTP server.

AN2009-10: Using an SEL-2401, SEL-2404, or SEL-2407 to Serve NTP Via the SEL-3530 RTAC

AN2009-38: Using SEL Satellite-Synchronized Clocks With the SEL-3332 or SEL-3354 to Output NTP

AN2010-03: Using an SEL-2401, SEL-2404, or SEL-2407 to Create a Stratum 1 Linux NTP Server

Configuring SNTP Client in the Meter

To enable SNTP in the meter, make Port 1 setting ESNTP = UNICAST, MANYCAST, or BROADCAST. *Table 8.12* shows each setting associated with SNTP.

Table 8.12 Settings Associated With SNTP

Setting	Prompt	Range	Default	Description
ESNTP	SNTP Enable (OFF, UNICAST, MANYCAST, BROADCAST)	UNICAST, MANYCAST, BROADCAST	OFF	Selects the mode of operation of SNTP. See descriptions in *SNTP Operation Modes on page 291*.
SNTPRATE[a]	SNTP Request Update Rate (15–3600 s)	15–3600 s	60	Determines the rate at which the meter asks for updated time from the NTP server when ESNTP = UNICAST or MANYCAST. Determines the time the meter will wait for an NTP broadcast when ESNTP = BROADCAST.
SNTPTO	SNTP Timeout (5–20 s)	5–20 s	5	Determines the time the meter will wait for the NTP master to respond when ESNTP = UNICAST or MANYCAST.
SNTPPIP	SNTP Primary Server IP Address (w.x.y.z)[b]	Valid IP Address	192.168.1.110	Selects primary NTP server when ESNTP = UNICAST, or broadcast address when ESNTP = MANYCAST or BROADCAST.
SNTPBIP	SNTP Backup Server IP Address (w.x.y.z)[c]	Valid IP Address	192.168.1.111	Selects backup NTP server when ESNTP = UNICAST.
SNTPPOR[d]	SNTP IP Local Port Number (1–65534)	1–65534	123	Ethernet port used by SNTP. Leave at default value unless otherwise required.

[a] This setting is: Hidden if ESNTP = OFF; Hidden and forced to 5 if ESNTP = BROADCAST.
[b] Where: w: 0–126, 128–239, x: 0–255, y: 0–255, z: 0–255.
[c] Where: w: 0–126, 128–223, x: 0–255, y: 0–255, z: 0–255.
[d] This setting is hidden if ESNTP ≠ UNICAST.

SNTP Operation Modes

The following sections explain the setting associated with each SNTP operation mode (UNICAST, MANYCAST, and BROADCAST).

ESNTP = UNICAST

In the unicast mode of operation, the SNTP client in the meter requests time updates from the primary (IP address setting SNTPPIP) or backup (IP address setting SNTPBIP) NTP server at a rate defined by setting SNTPRATE. If the NTP server does not respond with the period defined by the sum of setting SNTPTO and SNTPRATE, the meter tries the other SNTP server. When the meter successfully synchronizes to the primary NTP time server, Device Word bit TSNTPP asserts. When the meter successfully synchronizes to the backup NTP time server, Device Word bit TSNTPB asserts.

ESNTP = MANYCAST

In the manycast mode of operation, the meter initially sends an NTP request to the broadcast address contained in setting SNTPPIP. The meter continues to broadcast requests at a rate defined by setting SNTPRATE. When a server replies, the meter sets that server as the primary NTP server, and switches to UNICAST mode, asserts Device Word bit TSNTPP, and thereafter requests updates from the primary server. If the NTP server stops responding for time SNTPTO, the meter deasserts TSNTPP and begins to request time from the broadcast address again until a server responds.

ESNTP = BROADCAST

While ESNTP = BROADCAST, the meter will listen for and synchronize to specified NTP broadcasts based on the SNTPPIP setting. If SNTPPIP = 0.0.0.0, the meter listens for and synchronizes to any broadcasting NTP server. When synchronized, the meter asserts Device Word bit TSNTPP. Device Word bit TNSTPP deasserts if the meter does not receive a valid broadcast within the SNTPT0 setting value after the period defined by setting SNTPRATE.

SNTP Accuracy Considerations

SNTP time synchronization accuracy is limited by the accuracy of the SNTP server and by the networking environment. The highest degree of SNTP time synchronization can be achieved by minimizing the number of switches and routers between the SNTP server and the meter.

If the setting ESNTP = UNICAST or MANYCAST, and the meter is installed on a low-traffic network with one Ethernet switch between the meter and the SNTP server, the meter time synchronization error to the SNTP server is typically less than ±5 ms.

Command Summary

The *SEL-735 Meter Command Summary* 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 view information (settings, metering, etc.), but not 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).

For a list of all the available commands from a terminal prompt with the required access level, refer to *SEL-735 Meter Command Summary*; for more details on each command, please contact SEL customer service (*selinc.com/support*).

Command Explanations

Audit Log Command

The log function tracks activity on the SEL-735. It allows for auditing of several functions initiated when a user changes select items on the meter. The **LOG** command is only available on the ASCII terminal in QuickSet and displays the list of activities from the system log in chronological order. This includes all categories listed in *Table 8.13*. The LOG function can log and store a total number of 72,000 activities.

NOTE
The audit log is different than event logging, described in Section 6: Logging.

The **LOG** command will retrieve the following items:

- Log Number
- Date
- Time
- Source of the change causing the logged activity (IP address, port, HMI, etc.)
- Logged activity

To retrieve an activity or activities, use the following command syntax.

LOG [<Category>] [[<Count>] (Or) [<Date Range>]]

The command can also be used without parameters by simply entering the **LOG** command, which will retrieve all activities logged in the meter.

LOG Command Parameters (Optional)

Choose from the following categories.

Table 8.13 LOG Command Category Parameters

Parameter	Category	Events Included in the Category
ACC	Access Changes	➤ Access level changes that are authenticated or with disabled passwords ➤ Passwords displayed with the **PAS** command
PWD	Password Changes	➤ Password is changed
DAT	Returns all the results of the following five commands	
ER	Energy Reset	➤ Device energy registers reset
D	Demand Reset	➤ Device demand registers reset
P	Peak Demand Reset	➤ Device peak demand registers reset
LDP	Load Profile Recorder Reset	➤ Device load profile recorder reset
SER	Sequential Events Recorder Reset	➤ Device sequential events recorder reset
SET	Changes to Settings and Password (PWD) Parameters	➤ Settings change started ➤ Settings change complete ➤ Time or date change, including time change duration
RST	Settings Reset and Device Restore	➤ Setting reset started, completed ➤ Setting reset completed or interrupted ➤ Device restore started ➤ Device restore completed or interrupted
FW	Firmware Upgrades	➤ Entered SELBOOT ➤ Firmware write started ➤ Firmware write completed ➤ Firmware upgrade successful or unsuccessful

Parameter	Category	Events Included in the Category
DR	Diagnostic Restart	➤ Device restarted due to internal diagnostics
PWR	Power Cycle and Demand Restart (D)	➤ Device power down and power restored
CLR	System LOG Clearing	➤ Clear successful, with count of number of times the log has been cleared ➤ Clear interrupted
TS	Touchscreen Changes (Touchscreen Model Only)	➤ Custom screen send started ➤ Custom screen completed ➤ Custom screen unsuccessful

LOG SET, for example, will provide a list of all settings changes.

Count (Optional, but does not work combined with Date Range) returns the log of the most recent activities.

LOG 5 returns a list of the last five logged items.

Date Range (Optional but does not work combined with Count) provides the log of all items on a selected date or a date range.

Table 8.14 Date Range Parameters

Date Range	Description	Example
mm/dd/yyyy	When the user inputs a single date, return all records from the specified date.	06/16/2020
mm/dd/yyyy mm/dd/yyyy	When the user inputs a date range (dates separated by a space), return all records from the first specified date to and including the second specified date.	06/16/2020 08/15/2020

Example: LOG 06/16/2020

or

LOG 06/16/2020 08/15/2020

This first example provides the log of all items only on June 16, 2020. The second example provides a log of all items in the date range including June 16, 2020 to and including August 15, 2020.

Combining Parameters

The **LOG** command can have multiple parameters. For example, **LOG PWD 06/16/2020 08/15/2020** returns the log of any password (PWD) changes in the date range including June 16, 2020 to and including August 15, 2020. Date range cannot be used with the count parameter.

LOG ACC 10 returns the log for the last ten times the meter was accessed (ACC). The count parameter cannot be used with the date range parameter.

LOG Output

The log output provides the Log Number, Date, Time, Source of the change causing the logged activity (IP address, port, HMI, etc.), and the Logged event.

For example, **LOG 8** returns the following message:

```
656 12/07/21 21:40:55.964 10.203.10.18   SEL - Access level change to 2AC successful
657 12/07/21 21:41:00.874 10.203.10.18   SEL - Access level change to CAL successful
658 12/07/21 21:44:35.894 HMI             Access level change to 2AC successful
659 12/07/21 21:44:37.554 HMI             Energy reset
660 12/07/21 21:45:20.734 10.203.10.18   SEL - Demand reset
661 12/07/21 21:47:53.594 10.203.10.18   SEL - Access level change to 2AC successful
662 12/07/21 21:48:01.944 10.203.10.18   SEL - Port F settings save started
663 12/07/21 21:48:02.004 10.203.10.18   SEL - Port F settings save complete
```

This table shows the most recent 8 log items for events on December 7, 2021. For example, record 659 shows that at 21:44:37.554, the energy was reset from the meter HMI. Record 660 shows that at 21:45:20.734, the demand was reset from IP address 10.203.10.18.

FIL Command

The **FILE** command uses Ymodem 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
FILE DIR	Return a list of files.	1
FILE READ *filename*	Transfer settings file *filename* from the meter to the PC.	1
FILE WRITE *filename*	Transfer settings file *filename* from the PC to the meter.	2
FILE SHOW *filename*	Displays contents of the file *filename*.	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 in the following table.

Command Variant	Description	Access Level
GOO	Display GOOSE information.	1
GOO *k*	Display GOOSE information *k* times.	1
GOO S	Display a list of GOOSE subscriptions with their ID.	1
GOO S *n*	Display GOOSE statistics for subscription ID *n*.	1
GOO S ALL	Display GOOSE statistics for all subscriptions.	1
GOO S *n* L	Display GOOSE statistics for subscription ID *n* including error history.	1
GOO S ALL L	Display GOOSE statistics for all subscriptions including error history.	1
GOO S *n* C	Clear GOOSE statistics for subscription ID *n*.	1
GOO S ALL C	Clear GOOSE statistics for all subscriptions.	1

The information displayed for each GOOSE IED is described in the following table.

<table>
<tr><th>Information Field</th><th>Description</th></tr>
<tr><td><code>Transmit GOOSE Control Reference</code></td><td>This field represents the GOOSE control reference information that includes the IED name, ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and GSEControl name (GSE Control Block Name) (e.g., SEL_735CFG/LLN0GOGooseDSet13).</td></tr>
<tr><td><code>Receive GOOSE Control Reference</code></td><td>This field represents the goCbRef (GOOSE Control Block Reference) information that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and cbName (GSE Control Block Name) (e.g., SEL_735CFG/LLN0GOGooseDSet13).</td></tr>
<tr><td><code>MultiCastAddr</code> (Multicast Address)</td><td>This hexadecimal field represents the GOOSE multicast address.</td></tr>
<tr><td><code>Ptag</code></td><td>This three-bit decimal field represents the priority tag value, where spaces are used if the priority tag is unknown.</td></tr>
<tr><td><code>Vlan</code></td><td>This 12-bit decimal field represents the virtual LAN (Local Area Network) value, where spaces are used if the virtual LAN is unknown.</td></tr>
<tr><td><code>StNum</code> (State Number)</td><td>This hexadecimal field represents the state number that increments with each state change.</td></tr>
<tr><td><code>SqNum</code> (Sequence Number)</td><td>This hexadecimal field represents the sequence number that increments with each retransmitted GOOSE message sent.</td></tr>
<tr><td><code>TTL</code> (Time to Live)</td><td>This field contains the time (in ms) before the next message is expected.</td></tr>
<tr><td><code>Code</code></td><td>When appropriate, this text field contains warning or error condition text that is abbreviated as follows:
<table>
<tr><th>Code Abbreviation</th><th>Explanation</th></tr>
<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>
</table></td></tr>
<tr><td><code>Transmit Data Set Reference</code></td><td>This field represents the DataSetReference (Data Set Reference) that includes the IED name, LN0 lnClass (Logical Node Class), and GSEControl datSet (Data Set Name) (e.g., SEL_735/LLN0$DSet13).</td></tr>
<tr><td><code>Receive Data Set Reference</code></td><td>This field represents the datSetRef (Data Set Reference) that includes the iedName (IED name), ldInst (Logical Device Instance), LN0 lnClass (Logical Node Class), and datSet (Data Set Name) (e.g., SEL_735/LLN0$DSet13).</td></tr>
<tr><td><code>Ctrl Ref/ ControlBlockReference</code></td><td>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/LLN0GOGooseDSet13)</td></tr>
<tr><td><code>AppID</code></td><td>This is the application identifier as a decimal number.</td></tr>
<tr><td><code>From</code></td><td>This is the date and time the current statistics collection started.</td></tr>
<tr><td><code>To</code></td><td>This is the date and time the GOOSE statistics command was executed.</td></tr>
<tr><td><code>Accumulated downtime duration</code></td><td>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.</td></tr>
<tr><td><code>Maximum downtime duration</code></td><td>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.</td></tr>
</table>

Information Field	Description
Date & time maximum downtime began	This is the date and time the recorded maximum downtime started.
Number of messages received out-of-sequence (OOS)	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.
Number of time-to-live (TTL) violations detected	This represents the total number of times a message was not received within the expected period/interval.
Number of messages incorrectly encoded or corrupted	This represents the total number of messages that were identified with this subscription but were either incorrectly encoded or encoded with an incorrect data set.
Number of messages lost due to receive overflow	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.
Calculated max. sequential messages lost due to OOS	This represents the maximum estimated number of messages that were missed after receiving a message with a higher state or sequence number than expected.
Calculated number of messages lost due to OOS	This represents the total of all estimated number of messages lost as a result of state or sequence number skip in received messages.

An example response to the **GOOSE** commands is shown in *Figure 8.4*.

```
#>GOO <Enter>
GOOSE Transmit Status
 MultiCastAddr   Ptag:Vlan AppID  StNum      SqNum      TTL    Code
----------------------------------------------------------------------------
SEL_735_DevCFG/LLN0$GO$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$GO$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$GO$GOOSE_msg_1
 01-0C-CD-01-00-05  :      5    101          0          0      2000
 Data Set: SEL_735_MonCFG/LLN0$goose_1_1

=>>GOO S 1 L
 SubsID 1
----------------------------------------------------------------------------
 Ctrl Ref: SEL_735_MonCFG/LLN0$GO$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
TEST DB	Display the present status of digital and analog overrides.	2
TEST DB A *name value*	Force protocol analog element *name* to override *value*.	2
TEST DB D *name value*	Force protocol digital element *name* to override *value*.	2
TEST DB *name* OFF	Clear (analog or digital) override for element *name*.	2
TEST DB OFF	Clear all analog and digital overrides.	2

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.

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.

To override analog data in a communications interface, enter the following from Access Level 2 or higher.

```
=>>TEST DB A name value <Enter>
```

NOTE
When using the **TEST DB** command to generate values for IEC 61850 testing, you may need to override all current and voltage angles (IAFA, VAFA, etc.) to ensure the expected phase relationship.

NOTE
When you use the **TEST DB** command, specifying a negative value may yield an unexpected display in some instances.

where *value* is a numerical value and *name* is an analog label from *Table H.16–Table H.18* (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>
```

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.27*) 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 by 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.

SEL-735 Meter Command Summary

Access Level	Command	Description
0	**ACC**	Move to Access Level 1
0	**BNA**	Binary names
0	**CAS**	Compressed ASCII data configuration
0	**DNA**	Compressed names
0	**EXI**	Terminate a Telnet session. Only available when connected via Telnet
0	**ID**	Compressed ASCII Fast Meter ID
0	**QUI**	Quit to Access Level 0
0	**SNS**	Compressed SER settings
1	**2AC**	Move to Access Level 2
1	**CEV**	Compressed event report, 16 samples per cycle
1	**COM**	Display Mirrored Bits channel statistics
1	**COM C**	Reset Mirrored Bits channel statistics
1	**COU**	Display SELogic counters
1	**CHI**	Compressed history
1	**CCR**	Compressed calibration error report
1	**CST**	Compressed status
1	**CTR C [A]**	COMTRADE format event report, config
1	**CTR D [A]**	COMTRADE format event report, data
1	**DAT**	Show date
1	**DNP[*n*]**	Show DNP map
1	**DNP DVAR S**	Show the current analog input variation
1	**DNP DVAR H**	Show the command syntax
1	**EAC**	Move to Energy Access Level
1	**EVE**	Latest event report, 16 samples per cycle
1	**EVE C**	Compressed event report
1	**EVE D**	1/16-cycle resolution Device Word bit data
1	**EVE L, EVE R**	Raw, unfiltered event report
1	**EVE M**	1/16-cycle resolution Mirrored Bits data
1	**FIL DIR**	List all device files and directories
1	**FIL READ**	Transfer settings and other files from meter
1	**FIL SHOW**	Display file contents
1	**GOO**	Display GOOSE transmit and receive information
1	**HIS**	Summary event reports
1	**IRI**	Force synchronize to IRIG

Access Level	Command	Description
1	**LDP[*n*]**	Display report for load profile recorder, where *n* is the LDP recorder number
1	**LOG**	Audit log function
1	**MAT**	Displays results of SELogic math variable equations
1	**MET**	Display fundamental metering data
1	**MET A**	Display aggregated values
1	**MET CF**	Display crest factor quantities
1	**MET CFG**	Display configurable registers values
1	**MET D**	Display compensated demand data
1	**MET D P**	Display compensated peak demand data
1	**MET D P U**	Display uncompensated peak demand data
1	**MET D T**	Display the timestamps of the peak demands
1	**MET D T U**	Display the timestamps of the uncompensated peak demands
1	**MET D U**	Display uncompensated demand data
1	**MET E**	Display energy data
1	**MET FL**	Display flicker data
1	**MET H [E, O]**	Display harmonic data (E = even, O = odd, None = all)
1	**MET H A [E, O]**	Display all harmonic spectral analysis (E = even, O = odd, None = all)
1	**MET H I [E, O]**	Display current harmonic data (E = even, O = odd, None = all)
1	**MET H M [E, O]**	Display harmonic magnitude data (E = even, O = odd, None = all)
1	**MET H P [E, O]**	Display harmonic power data (E = even, O = odd, None = all)
1	**MET H V [E, O]**	Display voltage harmonic data (E = even, O = odd, None = all)
1	**MET L**	Display transformer/line losses
1	**MET M**	Display maximum and minimum values
1	**MET PM**	Display synchrophasor data
1	**MET PM *time***	Display synchrophasor data at time *time*
1	**MET PM HIS**	Display the most recently captured MET PM report
1	**MET RMS**	Display rms metering data
1	**NAG**	Display the Nagle state for YModem file transfers over the Ethernet port
1	**QUI**	Quit to Access Level 0
1	**SER**	Display Sequential Events Recorder records
1	**SHO**	Display settings
1	**SSI**	Display voltage sag/swell/interruption (VSSI) report
1	**STA**	Display self-test status
1	**STA E**	Display EEPROM messages
1	**TAR**	Display Device Word bits
1	**TIM**	Show time
1	**TOG**	Resets NEWEVNT Device Word bit

Access Level	Command	Description
1	**TRI**	Trigger an event
1	**VER**	Display version and configuration information
E	**DAT *date***	Set date
E	**LDP[*n*] C**	Reset load profile recorder, where n is the LDP recorder number
E	**MET CF R**	Clear crest factor metering
E	**MET M R**	Clear max/min metering
E	**MET P R**	Clear peak demand metering
E	**QUI**	Quit to Access Level 0
E	**TIM *time***	Set time
2	**CAL**	Go to Access Level C
2	**CON *x***	Control remote bits *x*
2	**DNP[*n*]**	Show DNP map
2	**DNP DVAR *x***	Set Object 30 default variation to numeric value *x*, 1–5 (see *Table D.10*)
2	**DNP DVAR C**	Resets the Object 30 to default variation 4 and Object 32 to default variation to 2
2	**FIL WRITE**	Write setting files to the meter
2	**FOR *x***	Change meter form, where *x* = 5, 9, or 36
2	**HIS C**	Clear event and history records
2	**L_D**	Load new firmware (this command does not work from the front panel)
2	**LOO**	Initiate/clear Mirrored Bits loopback
2	**MET D R**	Clear demand metering
2	**MET E R**	Reset energy metering
2	**MET FL P *seconds***	Display flicker Pinst value every 1/8th power system cycle for as long as 60 seconds
2	**MET FL R**	Reset flicker metering quantities
2	**NAG [ON, OFF]**	Set the Nagle algorithm state for YModem file transfers over the Ethernet port
2	**PAR**	Display or modify the part number
2	**PAS**	Set passwords
2	**PUL**	Pulse output contact
2	**QUI**	Quit to Access Level 0
2	**SER [C, D]**	Display or clear SER
2	**SET**	Change settings
2	**SSI C**	Clear SSI data (including SSI summary) from the meter
2	**SSI R**	Reset SSI processing
2	**SSI S**	Display SSI summary report
2	**SSI T**	Trigger an event and store SSI data.
2	**TEST AGG**	Capture and display 10/12-cycle data
2	**TEST DB A *name value***	Override analog label name with value in communications interface

Access Level	Command	Description
2	**TEST DB D *name value***	Override Device Word bit name with value in communications interface, where value = 0 or 1
2	**TEST MODE**	Display Test Mode parameters
2	**VER**	Display version and configuration information
SELBOOT	**BAU rate**	Set baud rate to 300, 1200, 2400, 4800, 9600, 19200, 38400 (57600 or 115200 if Port 2 or Port 3) bps
SELBOOT	**BFI**	Display the SELBOOT version
SELBOOT	**ERA**	Erase the existing firmware
SELBOOT	**EXI**	Exit this program and restart the device
SELBOOT	**FID**	Display the firmware identification (FID)
SELBOOT	**HEL**	Print a help list of commands
SELBOOT	**REC**	Receive new firmware for the device by using Xmodem

S E C T I O N   9

Touchscreen and Custom Screen Settings

Overview

The SEL-735 Meter with the touchscreen display option provides you with the ability to customize screens to meet your system needs. ANSI and IEC symbols, along with analog and digital labels are available for you to create detailed single-line diagrams, display breaker status, and monitor power flow. In addition, you can create as many as 25 display screens to show the status of various meter elements via Device Word bits or to show analog quantities for commissioning or day-to-day operations, as shown in *Figure 9.1*. These screens can be designed with the help of ACSELERATOR Bay Screen Builder SEL-5036 Software in conjunction with ACSELERATOR QuickSet SEL-5030 Software.

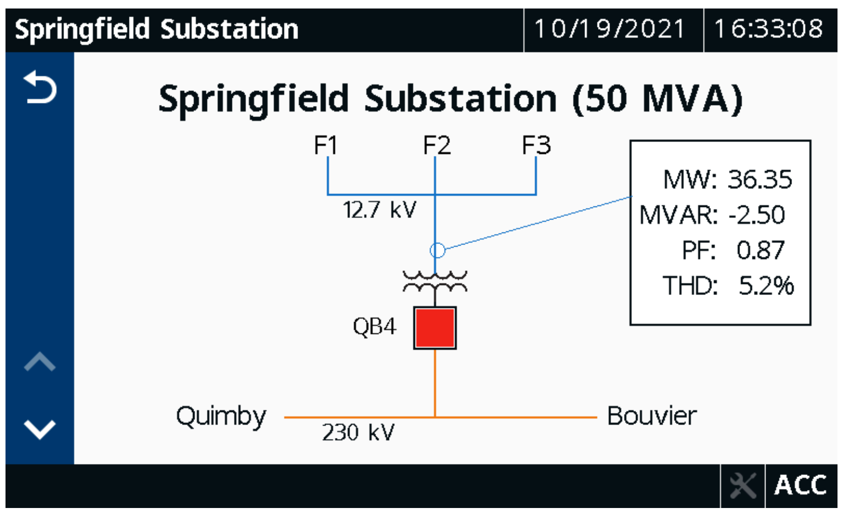


Figure 9.1 Color Touchscreen Using Bay Screen Builder

Color Touchscreen

Display Settings

Use these settings to configure the touchscreen. Pressing the **HOME** pushbutton on the front panel takes you to the screen configured as part of the FPHOME setting. By default, FPHOME is set to the Home screen, which displays the Home screen folders and applications. You can set FPHOME to any screen that you like to view when the **HOME** pushbutton is pressed (see *Table 3.13* for the list of available screens).

To help prevent unauthorized access to password-protected functions, the SEL-735 provides a front-panel time-out setting, FPTO. The time-out resets each time you press a front-panel pushbutton or the screen detects a touch. When the time-out expires, the access level resets to Access Level 1 and switches to the rotating display if at least one screen is configured as part of the rotating display settings, FPRD*kk* (*kk* = 01–25), if not, the display switches to the Home screen. The rotating display transition time setting FPDUR defines the duration that each screen is displayed on the rotating display. Set FPDUR to a transition time most suitable to your application.

Use the FPBAB setting to control the backlight active brightness.

Table 9.1 Display Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Display Home Screen		FPHOME := HOME
Display Time-Out	1–30 min	FPTO := 15
Rotating Display Transition Time	3–15 s	FPDUR := 5
Backlight Active Brightness	1–10	FPBAB := 6

Rotating Display Settings

The SEL-735 allows you to configure as many as 25 screens for the rotating display. Configure the settings FPRD*kk* (*kk* = 01–25) to the screens most suitable to your application. Refer to *Table 3.13* for the list of screens available as part of the FPRD*kk* settings.

Table 9.2 Rotating Display Screen Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Rotating Display Screen Settings (kk = 01–25)		
Rotating Display 01	See *Table 3.13*	FPRD01 := Custom Screen 1
Rotating Display *kk*	See *Table 3.13*	FPRD*kk* :=

Pushbutton Settings

The pushbutton settings FPPB*nn* (*nn* = 01–04) allow you to quickly navigate to a specific screen by pressing the programmed pushbutton. Refer to *Table 3.13* for the list of screens available for the FPPB*nn* settings. Note that a given pushbutton can be configured to navigate to a specific screen but can also be used in SELOGIC control equations (e.g., PB01 Device Word bit). The meter does not prevent you from configuring a pushbutton for two purposes. Refer to *Section 3: Front-Panel Operation* for more information on configuring a pushbutton. Make sure to set dual-purpose pushbuttons with care to ensure safe operation.

Table 9.3 Pushbutton Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Pushbutton Settings (nn = 01–04)		
Pushbutton *nn* HMI Screen	OFF, see *Table 3.13*	FPPB*nn* := OFF

Analog Labels Settings

The analog labels settings are only available if the designed custom screen has at least one analog label. When QuickSet detects one or more analog labels as part of the bay screen, it populates the corresponding settings. The SEL-735 supports as many as 500 analog labels. Set ALAB*qq* (*qq* = 01–500) to display the desired analog quantity on the bay screen. Refer to *Table G.1* for the list of analog quantities available to program into analog labels. Analog Labels 1–243 will have default values regardless of the screen they appear in.

Table 9.4 Analog Label Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Analog Label Settings (qq = 01–500)[a]		
Analog Quantity	Analog Quantity	ALAB*qq* :=

[a] The default Analog Label settings correspond with the default Custom Display screens and can be viewed in QuickSet.

Digital Labels Settings

The digital labels settings are only available if the designed bay screen has at least one digital label. When QuickSet detects one or more digital labels as part of the bay screen, it populates the corresponding settings. The SEL-735 supports as many as 500 digital labels. Set DLAB*qq* (*qq* = 01–500) to display the desired Device Word bits on the bay screen. Refer to *Table G.1* for the list of Device Word bits available to program into digital labels.

Table 9.5 Digital Label Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Digital Label Settings (qq = 01–500)		
Device Word Bit	Device Word Bit	DLAB*qq* :=

Breaker Settings

Breaker settings are only available for screens with breakers. When QuickSet detects a breaker symbol as part of the custom screen, it populates the corresponding settings. The BK01TTY is forced to 3. The breaker on the single-line is forced to monitor-only. Set the BK01CS, BK01OS, and BK01AS settings to the corresponding SELOGIC bits that indicate close, open, and alarm status. The meter does not support breaker alarm logic, but it can be programmed using SELOGIC control equations.

Table 9.6 Breaker Settings

Setting Prompt	Setting Range	Setting Name := Factory Default
Breaker Trip Type	3	BK01TTY := 3
Breaker Mode	MONITOR	BK01MOD := MONITOR
Breaker Close Status	Device Word Bit	BK01CS :=

Setting Prompt	Setting Range	Setting Name := Factory Default
Breaker Open Status	Device Word Bit	BK01OS :=
Breaker Alarm Status	Device Word Bit	BK01AS := NA

Disconnect Switch Settings

The disconnect switch settings are only available for screens with disconnects. When QuickSet detects one or more disconnect symbols as part of the custom screen, it populates the corresponding settings. The SEL-735 supports five monitor-only, two-position disconnects. The setting 2D*nn*MOD (*nn* = 01–05) is forced to MONITOR by default and is not settable. Set the 2DS*nn*CS, 2DS*nn*OS, and 2DS*nn*AS settings to the corresponding SELOGIC bits that indicate close, open, and alarm status.

SECTION 10

Testing and Troubleshooting

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 10.3* shows an example setup of the SEL-735, test standard, and three-phase test source. *Figure 10.1* shows an example setup of the SEL-735, test standard, and single-phase test source.

TEST Mode Characteristics

During TEST mode, the meter uses the optical port (on some models) 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.

- Freezes billing data, including energy and demand
- Stores present demand values
- Disables all KYZ outputs except for KYZDT
- Stops storing LDP data
- Disables updates to Device Word bits except for TEST
- Updates TEST mode energy and demand registers
- Meter accuracy tests
- Meter values display in secondary with unity scaling

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 through-production 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 SEL-5030 Software 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 0.1 and IEC 0.1 S accuracy class 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. SEL recommends at least five test pulses for full load tests and two test pulses for light load tests for an optimal accuracy test duration. This is to assure consistency with the ANSI and IEC accuracy standards. Because of the variance of testing equipment and procedures, SEL recommends a settling period of 5 seconds of applied test voltage and current prior to starting any accuracy test.

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, contact SEL customer support (*selinc.com/support*).

Testing Methods and Tools

Test Features

The following features shown in *Table 10.1* assist in meter testing. These features are available via the touchscreen display or QuickSet HMI. Please see the appropriate section for further details of each test feature.

Table 10.1 Meter Testing Features

Feature	Function
INSTANTANEOUS Measurements	The **INSTANTANEOUS** data show 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.
SER Elements	The SER report 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	TARGETS 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.
PULSE OUTPUT Contact	The Pulse Outputs allow 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 AGG Terminal Command	The **TEST AGG** command captures specified analog quantities and stores their value in volatile memory for a specified number of 10/12 cycles. This command exists to aide in the demonstration of the device's compliance to IEC 61000-4-30 aggregation.

Test Quantities

Table 10.2 lists the available TEST mode quantities and provides 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 meter will then use the new selected quantity as the test quantity.

Table 10.2 TEST Mode Quantities

TEST Mode Quantities	Analog Quantity Name	Analog Quantity Description	Availability
Three-Phase Quantities	WH3_ *y*[a]	Watt-hours delivered or received	Three-line display only
	WH3*x*[b]_NET	Watt-hours, NET	Three-line display only
	QH3*x*[b]_NET	VAR-hour, NET	Three-line display only
	UH3_ *y*[a]	VA-hours delivered—hours delivered or received	
	QH3_ *y*[a]	VAR-hours delivered or received	
	QH3_*y*[a]_*z*[c]	VAR-hours delivered or received and leading or lagging	Three-line display only
	VH3	Volt-hours	Three-line display only

TEST Mode Quantities	Analog Quantity Name	Analog Quantity Description	Availability
	IH3	Ampere-hours	Three-line display only
Single-Phase Quantities	WH*x*[b]_*y*[a]	Watt-hours delivered or received	
	WH*x*[b]_NET	Watt-hours, NET	Three-line display only
	UH*x*[b]_*y*[a]	VA-hours delivered—hours delivered or received	
	QH*x*[b]_*y*[a]	Watt-hours delivered or received	
	QH*x*[b]_*y*[a]_*z*[c]	VAR-hours delivered or received and leading or lagging	Three-line display only
	VH*x*[b]	Volt-hours	Three-line display only
	IH*x*[b]	Ampere-hours	Three-line display only
	IHN	Neutral-phase ampere-hours	

[a] Replace y with DEL or REC to indicate power flow delivered or received.
[b] Replace x with A, B, or C to indicate the phase.
[c] Replace z with LD or LG to indicate leading or lagging power.

TEST Mode Connections

Figure 10.1 shows the typical wiring diagram for Form 9 single-phase tests. *Figure 10.3* 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 10.2 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.

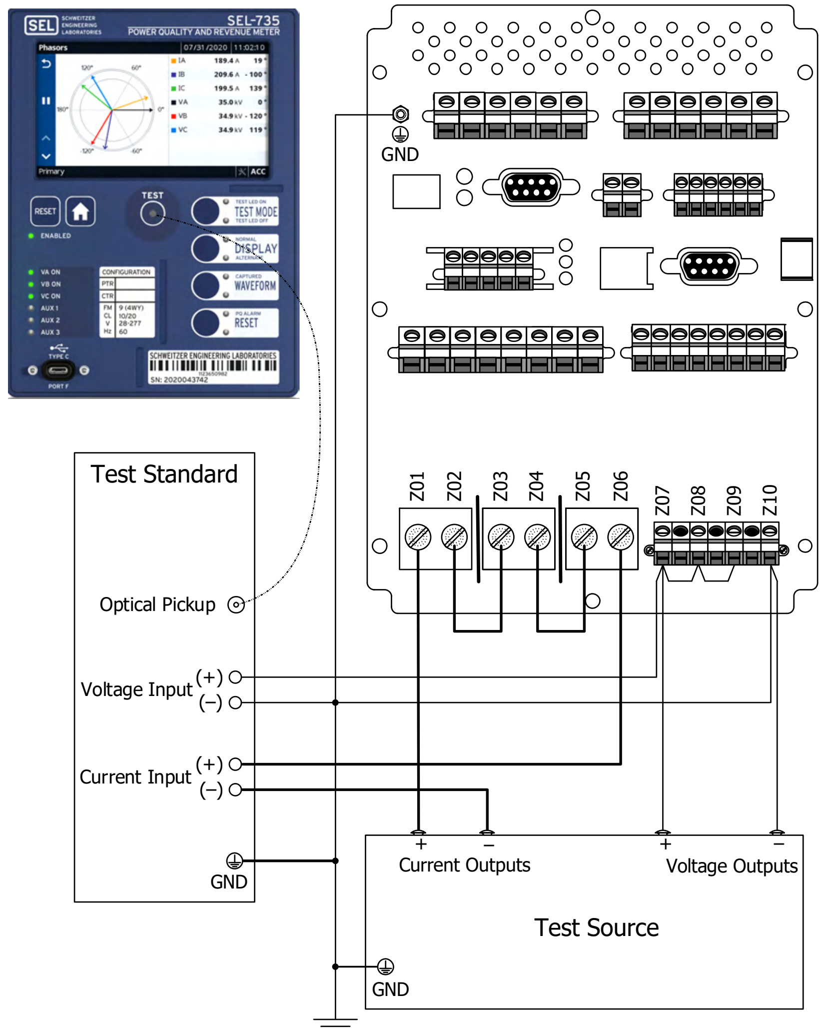


Figure 10.1 Typical TEST Mode Connections for a Form 9 SEL-735 Using a Single-Phase Test Source

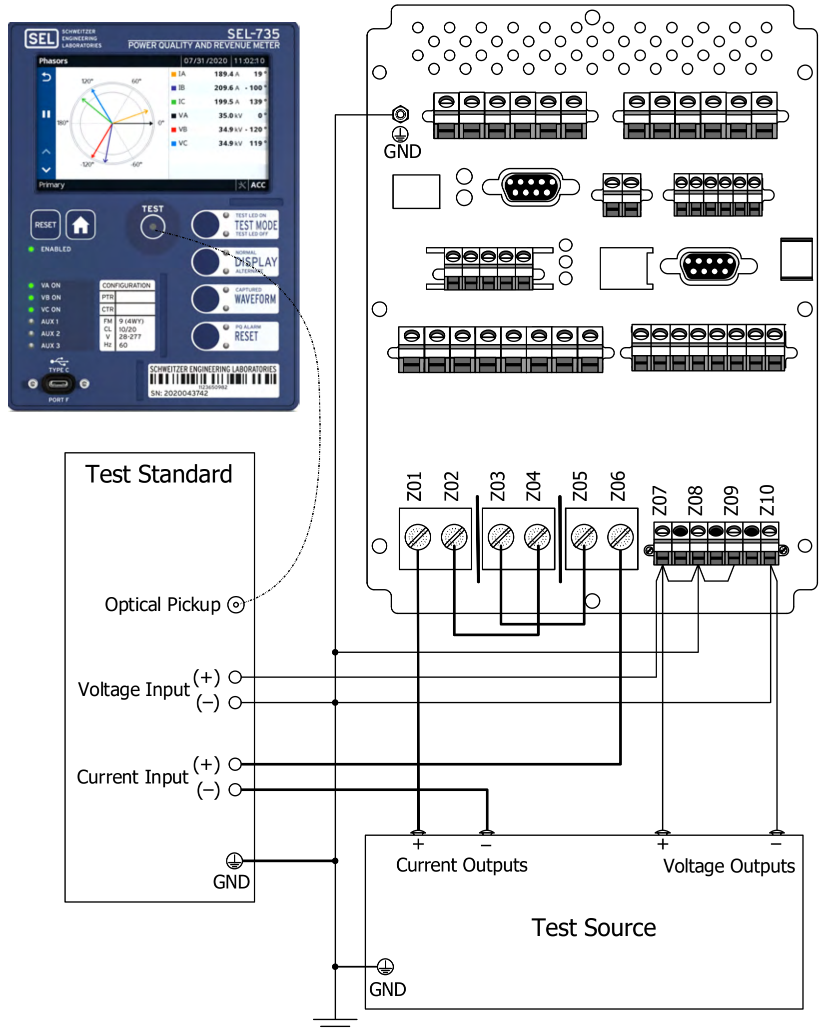


Figure 10.2 Typical TEST Mode Connections for a Form 36 SEL-735 Using a Single-Phase Test Source

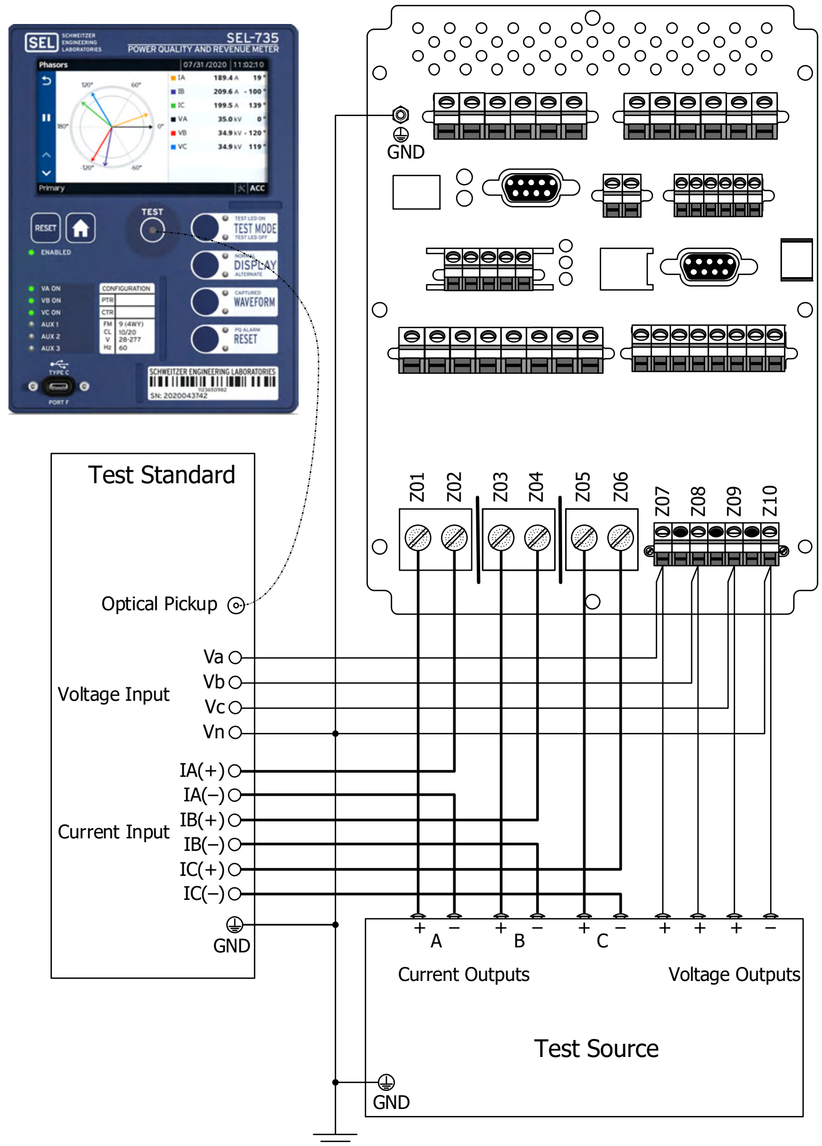


Figure 10.3 Typical TEST Mode Connections for a Form 9 SEL-735 Using a Three-Phase Test Source

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

    See *Reset the Present Test on page 324* for more details.

- Test Mode Quantity

  The active Test Mode Quantity displays on the front-panel display during TEST mode. A change to this quantity resets the test time but does not cause the meter to exit TEST mode.

- ➤ Watthour 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. See *Transformer/ Line-Loss Compensation on page 204* 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 10.3 summarizes the TEST mode options available during TEST mode.

Table 10.3 TEST Mode Options

TEST Mode Option	Option Description
Select Test Quantity	Select the energy analog quantity you want to test
Watthour 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

You can enter Test Mode via the touchscreen, user-configurable pushbuttons, or QuickSet (HMI or terminal). The front-panel menu option is only available on meters with the three-line display.

Three-Line Display

Use the LCD navigation menu, ACSELERATOR QuickSet HMI, the user-configurable pushbutton configured for TEST MODE, or a terminal prompt to enter TEST mode. Use one of the following three communications methods to enter TEST mode.

User-Configurable Pushbuttons

1. Press the user-configurable pushbutton configured for TEST MODE. *Figure 10.4* shows the default configuration of the user-configurable pushbuttons.
2. If prompted, enter a valid Access Level 2 password.

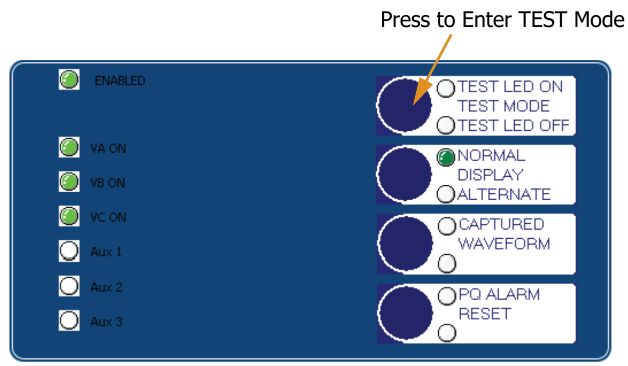


Figure 10.4 User-Configurable TEST Mode Pushbutton (Default Configuration)

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 **Enter Test Mode**.

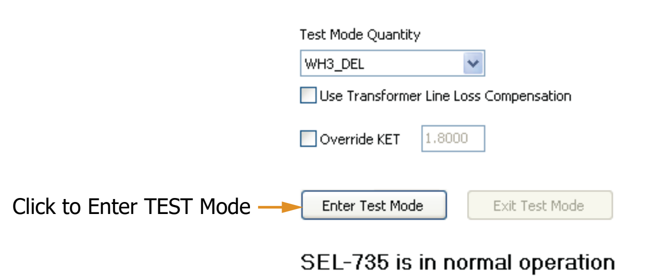


Figure 10.5 TEST Mode HMI

Figure 10.6 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.

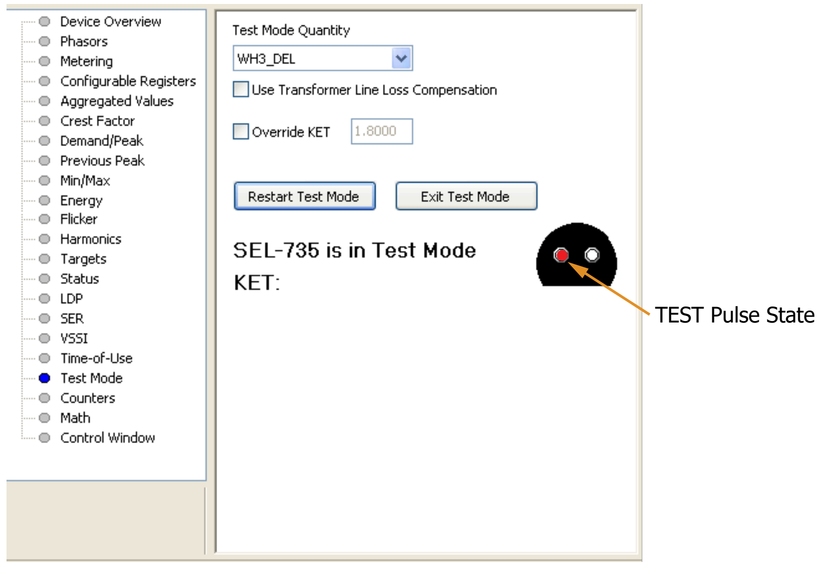


Figure 10.6 ACSELERATOR QuickSet HMI TEST Mode Display

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 Access Level 2 password.

   When the meter enters TEST mode, 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 (e.g., HyperTerminal) that uses ASCII commands to communicate with the meter.

Perform the following steps to enter Test Mode via a terminal prompt.

1. Open a terminal prompt and connect to any rear-panel serial port.
2. Log in to Access Level 2.
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 10.2*.

   If you include `[TLLC]` then the meter uses transformer/line-loss compensation while in TEST mode.

Touchscreen Display

Step 1. From the Home screen, navigate to the Test Mode application and tap the tile.

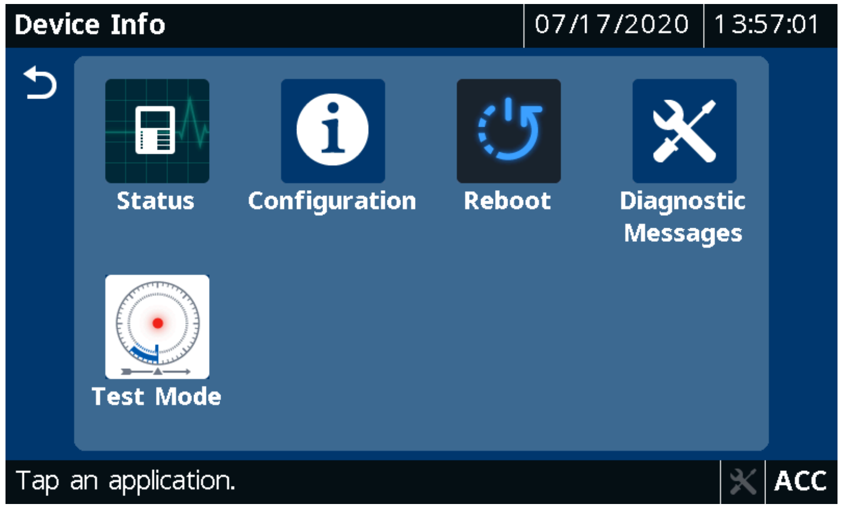


Figure 10.7 Test Mode Icon on Device Info Screen

Step 2. When prompted, enter the valid Access Level 2 password.

Step 3. On the **Enter Test Mode?** confirmation screen, select **Yes** to enter test mode and pause normal operation. The Test Mode - Energy Screen appears. Billing registers are frozen until the user exits Test Mode.

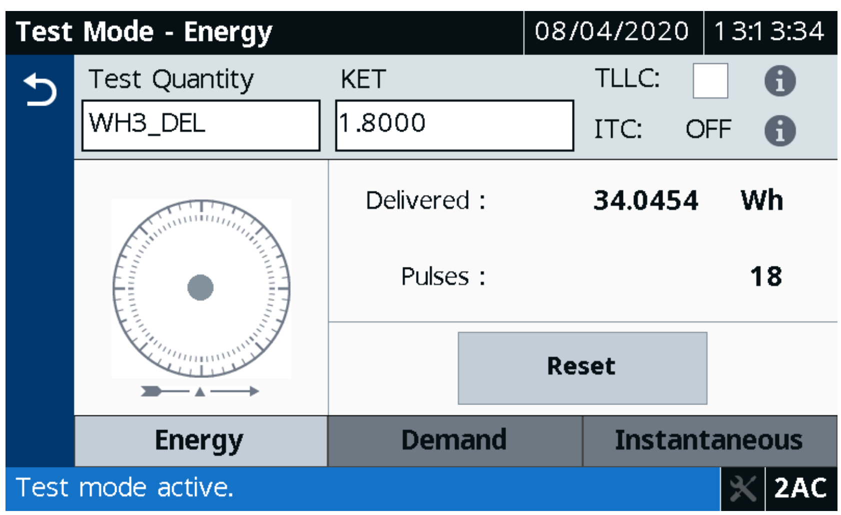


Figure 10.8 Test Mode Screen-Energy

Step 4. To view other Test Mode quantities, select **Demand** and **Instantaneous**.

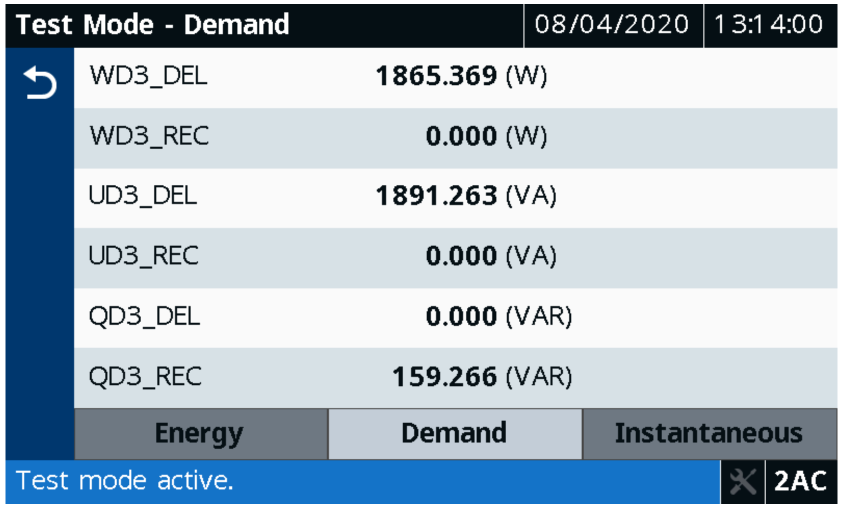


Figure 10.9 Test Mode Screen-Demand

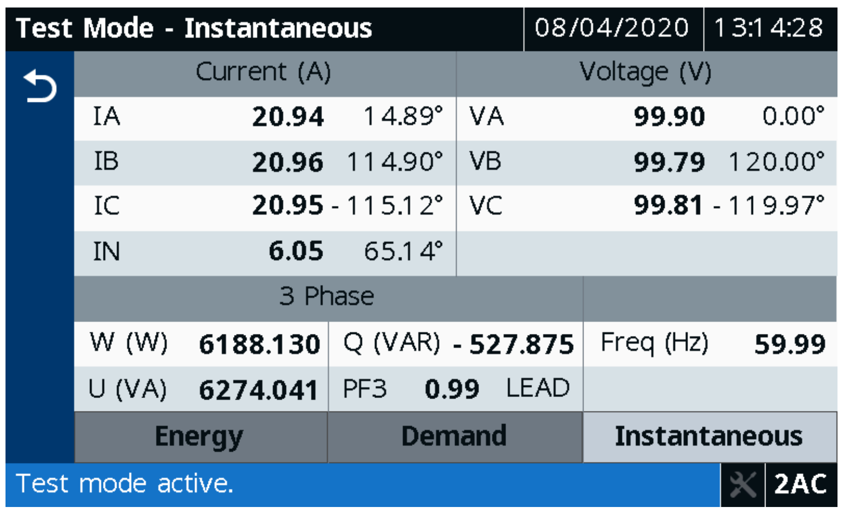


Figure 10.10 Test Mode Screen-Instantaneous

Exit TEST Mode

You can exit Test Mode via the touchscreen or QuickSet (HMI or terminal). The front-panel **ESC** button option is only available on meters with the three-line display. The meter restores all normal metering functions when it exits TEST mode. Use one of the following four communications methods to exit TEST mode.

Three-Line Display

QuickSet HMI

NOTE

This option is only available if you entered TEST mode via the QuickSet HMI.

Click the **Exit TEST Mode** button.

Front-Panel Menu Buttons

Press the **ESC** button twice.

Terminal Prompt

Enter the **TEST MODE OFF** command at the terminal prompt.

In addition to the previous 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.

Touchscreen Display

Step 1. From the TEST Mode application, press the return button.

Step 2. On the **Exit Test Mode?** confirmation screen, select **YES** to exit test mode and resume normal operation.

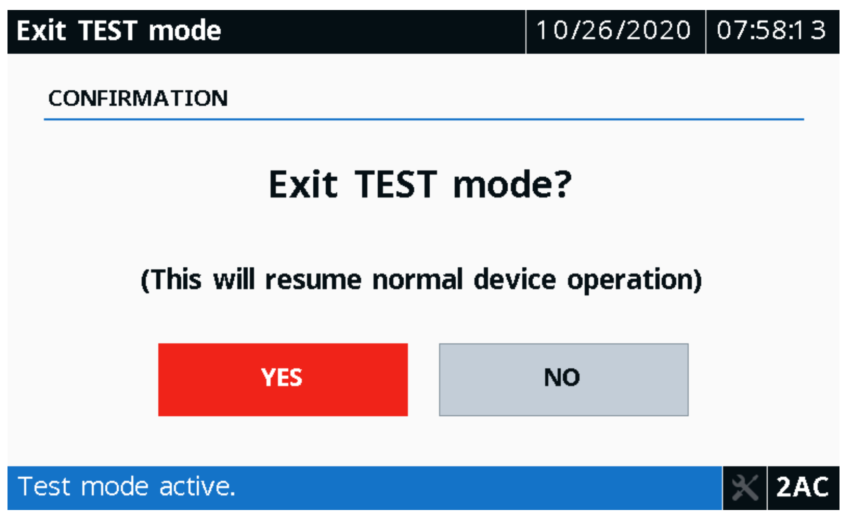


Figure 10.11 Exit Test Mode

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.

QuickSet HMI

NOTE
This option is only available if you entered TEST mode via the ACSELERATOR QuickSet HMI.

Click the **Restart TEST Mode** button.

Touchscreen Display

Press **Reset** on the Test Mode – Energy screen.

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 319* 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.

Step 1. Press **ENT**.

Step 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 in to Access Level 1 or higher.

Step 3. Enter the command **TAR *[name]***, 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.

For 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.

NOTE
You can also enter the command as **TAR [row number]**, where [row number] is the Device Word bit row number.

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 10.12 shows the solid-state outputs contacts OUT401–OUT404, each with configured for different applications. See below for explanations of the different applications.

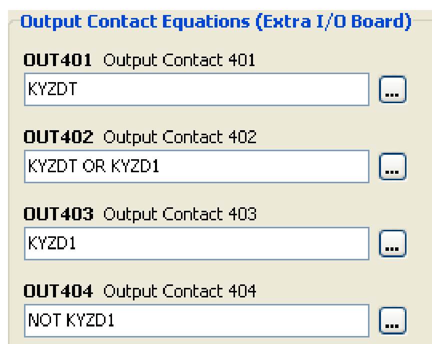


Figure 10.12 Solid-State Output Contact KYZ Options

Form A Test Pulse Output

Figure 10.12 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 accuracy 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 10.12 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 10.12 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 10.12 shows OUT404 configured as a Form A KYZ pulse output contact in the state opposite to that of 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.

TEST AGG Command

TEST AGG is a Level 2 command mainly used to demonstrate that the SEL-735 complies with IEC 61000-4-30 aggregation. The meter captures and then displays the following data for the specified number of 10/12 cycles:

- Time stamp of when the 10/12 cycle completed
- Duration of the 10/12 cycle in seconds.
- Value of the identified analog quantities

Usage:

```
=>>TEST AGG <number  of 10/ 12 cycles> <chan1> [chan2] ....[chan16] <Enter>
```

where as many as 16 analog quantities can be specified.

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 10.13 shows a graphic of the jumpers located on the CPU board:

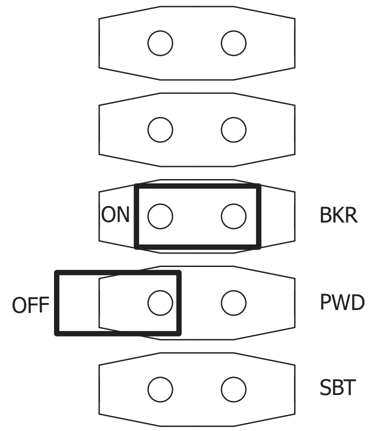


Figure 10.13 Jumper Header—Password and Breaker Jumpers

Table 10.4 lists each of the jumpers and the default position of each.

Table 10.4 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 (1, E, 2, and C) without having to enter a password. The disable password protection jumper is not available on some hardware configurations.

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 for a list of commands available from SELBOOT.

Gain Adjustment

To ensure that the SEL-735 exceeds the requirements of ANSI and IEC accuracy standards, 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 10.1* shows the calculation the SEL-735 performs with the gain adjustment settings.

$$X_{\text{Adjusted}} = X_{\text{Measured}} \bullet \left(1 + \frac{\text{Adjustment}}{100}\right)$$

Equation 10.1

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 314*). Record the results from the accuracy test, and modify the WGAIN and VARGAIN settings to compensate for any error.

Example 10.1 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 10.1* or *Figure 10.3*.

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 pulses • 1.8 Wh/pulse = 18 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.

Watt-hours registered by the meter = 18.0000 Wh

Watt-hours registered by the standard = 18.0108 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 10.2* to calculate the percent error between the meter and the standard:

$$\begin{aligned} \%\text{ERROR} &= \left(\frac{\text{Wh\_meter}}{\text{Wh\_standard}}\right) \bullet 100 \\ &= \left(\frac{18.0000}{18.0108}\right) \bullet 100 \\ &= 99.94\% \end{aligned}$$

Equation 10.2

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 – % 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
```

Step 4. Verify the new gain adjustment setting by testing the meter at the following points:

Step 1. 5 A or greater

Step 2. 0.25 to 0.5 A

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, contact SEL customer service (selinc.com/support).

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 10.5*):

- 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 10.5 Meter Self-Tests

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[a]	Warning	+2.3 V	No	Pulse	Measures the clock battery voltage
TEMP[a]	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
Critical RAM SELOGIC Executable	Failure	Checksum	Yes	Latched	Read/write test on SELOGIC executable RAM

Self-Test	Condition	Limits	Meter Disabled	Alarm Output	Description
Critical RAM Setting	Failure	Checksum	Yes	Latched	Read/write test on settings RAM
Critical RAM Code	Failure	Checksum	Yes[b]	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.

[a] BATT and TEMP are meter diagnostic analog quantities. The meter updates them at approximately one second typical.
[b] 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 on page 332*.

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.

1. Press the **ESC** pushbutton for 5 seconds.
2. The meter should turn on LCD contrast display bar.

3. Use the **LEFT ARROW** and **RIGHT ARROW** pushbuttons to adjust the contrast.
4. 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 the 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 non-energized 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 restarts at zero.
➤ As much as one minute of SELOGIC counter data are lost.

Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com/support
Email: info@selinc.com

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APPENDIX A

Firmware and Manual Versions

Firmware

Determining the Firmware Version in Your Meter

To determine the firmware version, view the status report in your SEL-735 by using any port **STAT** command or from the front-panel. The status report displays the firmware identification (FID) label. On SEL-735 models with the color touchscreen, go to **Home > Device Info > Status** for the firmware identification. The display shows `FID`, and the firmware number is shown in the format **SEL-735-R###-V#**. The rest of the characters are truncated.

The firmware version will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

The firmware cannot be field-downgraded. Contact your application engineer for more details.

NOTE
SEL-735 devices originally shipped with firmware version R1XX cannot be field-upgraded to firmware version R2XX.

A standard release is identified by a change in the R-number of the device FID string.

Existing firmware:

FID=SEL-735-**R200**-V0-Z102100-Dxxxxxxxx

Standard release firmware:

FID=SEL-735-**R201**-V0-Z102100-Dxxxxxxxx

A point release is identified by a change in the V-number of the device FID string.

Existing firmware:

FID=SEL-735-R200-**V0**-Z102100-Dxxxxxxxx

Point release firmware:

FID=SEL-735-R200-**V1**-Z102100-Dxxxxxxxx

The date code is after the D. For example, the following is firmware revision number 201, date code June 21, 2018.

FID=SEL-735-R201-V0-Z100100-**D20180621**

Revision History

Table A.1 and *Table A.2* list the firmware versions, revision descriptions, and corresponding instruction manual date codes. The most recent firmware version is listed first.

Starting with revisions published after March 1, 2022, changes that address security vulnerabilities are marked with "[Cybersecurity]". Other improvements to cybersecurity functionality that should be evaluated for potential cybersecurity importance are marked with "[Cybersecurity Enhancement]".

Table A.1 Firmware Revision History for R200 Series Firmware

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-735-R209-V1-Z104101-D20250228	Includes all the functions of SEL-735-R209-V0-Z104101-D20240924 with the following additions: ➤ Addressed an issue where, in rare cases, communicating over a serial port using SEL Fast Message or Fast Meter protocols could cause the device to fail to enable.	20250228
SEL-735-R209-V0-Z104101-D20240924	➤ [Cybersecurity Enhancement] Modified the PAS command to not display device passwords. ➤ Added Continuous Waveform Streaming Protocol. ➤ Removed the command to clear the audit log.	20240924
SEL-735-R208-V2-Z103100-D20250228	Includes all the functions of SEL-735-R208-V1-Z103100-D20240429 with the following additions: ➤ Addressed an issue where, in rare cases, communicating over a serial port using SEL Fast Message or Fast Meter protocols could cause the device to fail to enable.	20250228
SEL-735-R208-V1-Z103100-D20240429	Includes all the functions of SEL-735-R208-V0-Z103100-D20240306 with the following additions: ➤ Improved fundamental current measurement accuracy.	20240429
SEL-735-R208-V0-Z103100-D20240306	➤ Modified the demand metering behavior for partial demand intervals. ➤ Added the General setting CALCQ with options FUND and VECTOR to select the VAR calculation method. ➤ Added vector-calculated VAR analog quantities.	20240306
SEL-735-R207-V7-Z102100-D20250228	Includes all the functions of SEL-735-R207-V6-Z102100-D20231006 with the following additions: ➤ Addressed an issue where, in rare cases, communicating over a serial port using SEL Fast Message or Fast Meter protocols could cause the device to fail to enable.	20250228
SEL-735-R207-V6-Z102100-D20231006	Includes all the functions of SEL-735-R207-V5-Z102100-D20230410 with the following additions: ➤ [Cybersecurity] Removed advanced diagnostic commands from the 2AC and CAL access levels. ➤ Improved the IEEE C37.118 protocol to include Continuous Time Quality (CTQ) bits. ➤ Addressed an issue where, in rare cases, automated Ymodem file transfers over Telnet could cause the Ethernet port to stop responding.	20231006
SEL-735-R207-V5-Z102100-D20230410	Includes all the functions of SEL-735-R207-V4-Z102100-D20230323 with the following additions: ➤ Revised the firmware to support new hardware component suppliers. ➤ Addressed an issue where, in rare cases, the SEL-735 might not apply changes to meter form or accept new hardware configurations.	20230410

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-735-R207-V4-Z102100-D20230323	Includes all the functions of SEL-735-R207-V3-Z102100-D20230203 with the following addition: ➤ Revised the firmware to support new hardware component suppliers.	20230323
SEL-735-R207-V3-Z102100-D20230203	Includes all the functions of SEL-735-R207-V2-Z102100-D20230112 with the following addition: ➤ Improved the LMD protocol connection handling to address cases that could cause the EIA-485 port to prevent communications on a common bus.	20230203
SEL-735-R207-V2-Z102100-D20230112	Includes all the functions of SEL-735-R207-V1-Z102100-D20220601 with the following additions: ➤ Addressed an issue where the meter might not enable upon power cycle after a Port 1 Ethernet settings change. ➤ Modified test mode to display energy quantity labels as secondary values with unity scaling on the front panel. ➤ [Cybersecurity] Addressed an Ethernet security vulnerability that could result in loss of communications and LDP recording.	20230112
SEL-735-R207-V1-Z102100-D20220601	Includes all the functions of SEL-735-R207-V0-Z102100-D20220413 with the following addition: ➤ Revised the firmware to support new hardware component suppliers.	20220601
SEL-735-R207-V0-Z102100-D20220413	➤ Added DNP3 Short-Float Analog Inputs (Object 30, Variation 5). ➤ Added terminal commands for configuration of default DNP3 Analog Input variations.	20220413
SEL-735-R206-V5-Z102100-D20250228	Includes all the functions of SEL-735-R206-V4-Z102100-D20231006 with the following additions: ➤ Addressed an issue where, in rare cases, communicating over a serial port using SEL Fast Message or Fast Meter protocols could cause the device to fail to enable.	20250228
SEL-735-R206-V4-Z102100-D20231006	Includes all the functions of SEL-735-R206-V3-Z102100-D20230410 with the following additions: ➤ [Cybersecurity] Removed advanced diagnostic commands from the 2AC and CAL access levels. ➤ Addressed an issue where, in rare cases, automated Ymodem file transfers over Telnet could cause the Ethernet port to stop responding.	20231006
SEL-735-R206-V3-Z102100-D20230410 **Note:** This manual previously indicated R206-V3 with date code 20230323, but the firmware released with date code 20230410.	Includes all the functions of SEL-735-R206-V2-Z102100-D20220601 with the following additions: ➤ Addressed an issue where the meter might not enable upon power cycle after a Port 1 Ethernet settings change. ➤ Modified test mode to display energy quantity labels as secondary values with unity scaling on the front panel. ➤ Improved the LMD protocol connection handling to address cases that could cause the EIA-485 port to prevent communications on a common bus. ➤ [Cybersecurity] Addressed an Ethernet security vulnerability that could result in loss of communications and LDP recording. ➤ Revised the firmware to support new hardware component suppliers.	20230410
SEL-735-R206-V2-Z102100-D20220601	Includes all the functions of SEL-735-R206-V1-Z102100-D20211214 with the following addition: ➤ Revised the firmware to support new hardware component suppliers.	20220601

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-735-R206-V1-Z102100-D20211214	Includes all the functions of SEL-735-R206-V0-Z102100-D20210513 with the following additions: ➤ Addressed an issue in SEL-735 color touchscreen meters with firmware R205-V0 through R206-V0 where the meter could disable in rare cases while multiple VSSI, SER, or event reports are being triggered. ➤ Added audit log recording of password jumper and time change events. ➤ Updated the color touchscreen to improve the display properties and display performance (see *Table A.3*).	20211214
SEL-735-R206-V0-Z102100-D20210513	➤ Modified the default touchscreen settings to correctly display energy values on the default Custom Display Package "Monthly Energy and Peak Demand" screen. ➤ Enhanced restarts on diagnostic issue. ➤ Modified workflow when upgrading I/O cards to ensure the meter part number is accurate.	20210513
SEL-735-R205-V2-Z102100-D20210305	Includes all the functions of SEL-735-R205-V1-Z102100-D20210125 with the following addition: ➤ Addressed an issue where a brief voltage dip on the power supply could, in rare circumstances, cause incorrect metering.	20210305

SEL-735-R205-V1-Z102100-D20210125	Includes all the functions of SEL-735-R205-V0-Z102100-D20201014 with the following additions:
	➤ Addressed an issue where the synchrophasor messages could report incorrect voltage in the following cases:
	  ➢ Color touchscreen meters with firmware version R205-V0 when VBASE < 180 or VBASE > 250.
	  ➢ All meters with firmware versions R201-V0, R203-V0, and R205-V0 when VBASE > 250.
	➤ Addressed an issue where voltages were not displaying correctly on the color touchscreen Wave View application.
		20210125

SEL-735-R205-V0-Z102100-D20201014 **Note:** Firmware revision R204 did not production release.	➤ Added color touchscreen with USB-C front port model option. ➤ Added audit log **LOG** command, which reports device access, settings modifications, and revenue data resets. ➤ Modified front-panel infrared **TEST** LED behavior change. ➤ Modified the settings file device identifier string. ➤ Modified the SEL ASCII settings prompts and order in settings files. ➤ Improved processing that could cause communication response times to be approximately two seconds longer on four-hour intervals. ➤ Modified test mode to display energy quantities as secondary values with unity scaling on the front panel.	20201014
SEL-735-R203-V4-Z101100-D20250228	Includes all the functions of SEL-735-R203-V3-Z101100-D20231006 with the following additions: ➤ Addressed an issue where, in rare cases, communicating over a serial port using SEL Fast Message or Fast Meter protocols could cause the device to fail to enable.	20250228
SEL-735-R203-V3-Z101100-D20231006	Includes all the functions of SEL-735-R203-V2-Z101100-D20230410 with the following additions: ➤ [Cybersecurity] Removed advanced diagnostic commands from the 2AC and CAL access levels. ➤ Addressed an issue where, in rare cases, automated Ymodem file transfers over Telnet could cause the Ethernet port to stop responding.	20231006

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-735-R203-V2-Z101100-D20230410 **Note:** This manual previously indicated R203-V2 with date code 20230323, but the firmware released with date code 20230410.	Includes all the functions of SEL-735-R203-V1-Z101100-D20220601 with the following additions: ➤ Addressed an issue where the meter might not enable upon power cycle after a Port 1 Ethernet settings change. ➤ Improved the LMD protocol connection handling to address cases that could cause the EIA-485 port to prevent communications on a common bus. ➤ [Cybersecurity] Addressed an Ethernet security vulnerability that could result in loss of communications and LDP recording. ➤ Revised the firmware to support new hardware component suppliers.	20230410
SEL-735-R203-V1-Z101100-D20220601	Includes all the functions of SEL-735-R203-V0-Z101100-D20190828 with the following addition: ➤ Revised the firmware to support new hardware component suppliers.	20220601
SEL-735-R203-V0-Z101100-D20190828 **Note:** Firmware revision R202 did not production release.	➤ Replaced the INCIHQ setting with the HARM, GROUP, and SUBGROUP selections for the HARMCAL setting on Advanced PQ options. ➤ Added the INTERHARM selection to HARMCAL to calculate interharmonic subgroups on Advanced PQ options. ➤ Updated the **TEST AGG** command to provide 10/12 cycle measurements for as many as 16 parameters instead of three. ➤ Extended the range of frequency tracking from 13 V down to 11 V. ➤ Added first order, aggregated harmonic analog quantities in compliance with IEC 61000-4-30 Class A and IEC 61000-4-7.	20190828
SEL-735-R201-V4-Z100100-D20231006 **Note:** This manual previously indicated R201-V4 with settings version Z101100, but the firmware released with settings version Z100100.	Includes all the functions of SEL-735-R201-V3-Z100100-D20230410 with the following additions: ➤ [Cybersecurity] Removed advanced diagnostic commands from the 2AC and CAL access levels. ➤ Addressed an issue where, in rare cases, automated Ymodem file transfers over Telnet could cause the Ethernet port to stop responding.	20231006
SEL-735-R201-V3-Z100100-D20230410 **Note:** This manual previously indicated R201-V3 with date code 20230323, but the firmware released with date code 20230410.	Includes all the functions of SEL-735-R201-V2-Z100100-D20220601 with the following additions: ➤ Addressed an issue where the meter might not enable upon power cycle after a Port 1 Ethernet settings change. ➤ Improved the LMD protocol connection handling to address cases that could cause the EIA-485 port to prevent communications on a common bus. ➤ [Cybersecurity] Addressed an Ethernet security vulnerability that could result in loss of communications and LDP recording. ➤ Revised the firmware to support new hardware component suppliers.	20230410
SEL-735-R201-V2-Z100100-D20220601	Includes all the functions of SEL-735-R201-V1-Z100100-D20210204 with the following addition: ➤ Revised the firmware to support new hardware component suppliers.	20220601

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-735-R201-V1-Z100100-D20210204	**Note:** Firmware version R201-V1 is not intended for field upgrades. Includes all the functions of SEL-735-R201-V0-Z100100-D20180621 with the following addition: ➤ Improved support for manufacturing optimization.	20210204
SEL-735-R201-V0-Z100100-D20180621	➤ Modified the firmware to pause data updates over DNP after the TEST bit asserts to indicate the meter is in Test Mode. Previously data updates were paused prior to the TEST bit asserting. Data updates resume on exiting Test Mode. ➤ Increased flash memory from 128 MB to 1 GB on Advanced PQ options, from 128 MB to 256 MB on Intermediate PQ options, and from 32 MB to 128 MB on Basic PQ options. ➤ Increased the number of LDP channels from 192 to 512 in models with the Advanced PQ option. ➤ Added Device Word bits TSLDP*n* and analog quantities LDP*n*CH for additional LDP recorders. ➤ Increased the number of records for LDP, SER, VSSI, and waveform event report storage up to a factor of 10. See *Table 1.2: SEL-735 Power Quality and Recording Options* for records available per PQ model option. ➤ Added support for firmware upgrades over Ethernet. ➤ Added digitally signed firmware. ➤ Reduced the downtime during firmware upgrades. ➤ Improved the ACSELERATOR QuickSet® SEL-5030 Software HMI workflow to view, export, and import LDP data. ➤ Modified firmware to make Device Word bits from Row 50 through Row 77 available over Modbus.	20180621

Table A.2 Firmware Revision History for R100 Series Firmware

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-735-R119-V2-Z011008-D20230323	Includes all the functions of SEL-735-R119-V1-Z011008-D20210305 with the following additions: ➤ Addressed an issue where the meter might not enable upon power cycle after a Port 1 Ethernet settings change. ➤ Improved the LMD protocol connection handling to address cases that could cause the EIA-485 port to prevent communications on a common bus. ➤ [Cybersecurity] Addressed an Ethernet security vulnerability that could result in loss of communications and LDP recording.	20230323
SEL-735-R119-V1-Z011008-D20210305	Includes all the functions of SEL-735-R119-V0-Z011008-D20180621 with the following addition: ➤ Addressed an issue where a brief voltage dip on the power supply could, in rare circumstances, cause incorrect metering.	20210305
SEL-735-R119-V0-Z011008-D20180621	➤ Modified the firmware to pause data updates over DNP after the TEST bit asserts to indicate the meter is in Test Mode. Previously data updates were paused prior to the TEST bit asserting. Data updates resume on exiting Test Mode.	20180621

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-735-R118-V1-Z011008-D20171103	➤ Added a new HMI tool, Wave View, to view waveforms in near real time and analyze its frequency spectrum. ➤ Added the LINEFREQ setting to synchronize the internal real-time clock to the power system frequency. ➤ Improved the throughput of the Ymodem transfer over Telnet. ➤ Increased the CTR setting upper limit from 6000 to 10000. ➤ Added an optional parameter *n* to all MET commands to process the output *n* times, such as MET M *n*. ➤ Removed range restrictions on IP address settings to allow addresses such as 192.0.0.XXX. ➤ Modified LDLIST*n* settings rules to restrict uncompensated demand quantities when LDFUNC = AVG. ➤ Modified the front panel menu to hide Port 1 settings if the meter is not configured for Ethernet. ➤ Addressed an issue where the Test Mode HMI may time out within a minute of entering Test Mode, regardless of the port time-out setting. ➤ Addressed an issue in Test Mode where the meter may continue to apply TLLC after it was disabled through the QuickSet HMI. ➤ Addressed an issue where a cancel command for SEL ASCII data could interrupt binary Fast Messages if present on the same port. ➤ Updated the list of flicker measurement quantities available through QuickSet to match the quantities available according to the configured PQ and recording option. ➤ Enhanced meter accuracy under nonsinusoidal, light-load conditions.	20171103
SEL-735-R117-V2-Z010007-D20170814	Includes all the functions of SEL-735-R117-V1-Z010007-D20170307 with the following addition: ➤ Resolved an issue where certain Ethernet traffic could disable devices when IEC 61850 is enabled.	20170814
SEL-735-R117-V1-Z010007-D20170307	Includes all the functions of SEL-735-R117-V0-Z010007-D20170119 with the following additions: ➤ Modified the behavior of LDP recorders to report energy data from the partial intervals affected by power loss and restoration events when the LDFUNC setting is either COI or EOI. ➤ Added FREQ analog quantity in the CEV event report file.	20170307
SEL-735-R117-V0-Z010007-D20170119	➤ Improved the calculation of aggregated measurements to comply with test requirements of IEC 62586-2 as referenced by IEC 61000-4-30. ➤ Added new analog quantities to report zero-sequence imbalance calculation in addition to negative-sequence imbalance calculation for IEC 61000-4-30 Class A compliance. ➤ Added a new setting HARMCAL to determine if harmonic values report according to the Harmonic Group definition or Harmonic Subgroup definition per IEC 61000-4-30 Class A requirements. ➤ Added a new setting to process one-cycle VSSI quantities to comply with IEC 61000-4-30 Class A requirements. ➤ Improved the accuracy of flicker measurements from IEC 61000-4-30 Class S compliance to Class A compliance. ➤ Modified diagnostic entries to indicate the firmware revision number in which a diagnostic failure occurred. ➤ Added a message to the front-panel LCD display to notify users if the meter is undergoing a firmware upgrade, and when it is completed.	20170119

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
	➤ Modified the default display formatting on the front-panel to better represent the data type of the displayed quantity. ➤ Corrected an issue where cycling power or changing the date on the day of a scheduled DST would incorrectly assert the DST Device Word bit. ➤ Addressed an issue where DNP Map 1 settings could revert to default values without reporting a diagnostic error. ➤ Addressed an issue where changing event report settings during an event capture could corrupt the event report data and displays `Invalid History Data`. ➤ Corrected an issue in firmware versions R115-V4, R116-V0, and R116-V1 where a high number of VSSI events occurring continuously for many minutes could cause the meter to disable and display `Vector 5`. ➤ Addressed an issue where if six Ethernet sessions are enabled in firmware versions R100–R105, upgrading to R106 or higher would reset the Port 1 settings to their default.	
SEL-735-R116-V2-Z009006-D20170814	Includes all the functions of SEL-735-R116-V1-Z009006-D20160628 with the following addition: ➤ Resolved an issue where certain Ethernet traffic could disable devices when IEC 61850 is enabled.	20170814
SEL-735-R116-V1-Z009006-D20160628	Includes all the functions of SEL-735-R116-V0-Z009006-D20160407 with the following additions: ➤ Modified the GOOSE subscriber performance to update a mapped quantity with the present value from an incoming message when quality flag changes from bad to good. ➤ Modified the behavior of remote analogs and virtual bits to reset to zero when the meter receives a new CID file. ➤ Modified the GOOSE performance to synchronize the Boolean state in the outgoing messages to the state of the Device Word bits in the meter.	20160628
SEL-735-R116-V0-Z009006-D20160407	➤ Added most recent LDP records as analog quantities. ➤ Improved the functionality of LDP Recorder 1 to accept AVG as a logging function. ➤ Added the ability to reset TOU Present Season data on a self-read based on the Energy and Demand Reset Option setting. ➤ Modified the **PULSE** command to pulse KYZ outputs in addition to the other digital outputs. ➤ Added one- and three-minute subintervals for rolling demand. ➤ Modified the scaling of energy quantities in Fast Messages from mega to kilo units. ➤ Increased the number of display points from 16 to 50. ➤ Enhanced the functionality of the front-panel **ESC** pushbutton to perform an LCD screen pixel test. ➤ Added the number of peak demand resets as an analog quantity. ➤ Added the arithmetic method of calculating three-phase apparent power in Form 5 meters based on the CALC3U setting. ➤ Enhanced the functionality of display points to include the date, time, and value for TOU peak demand quantities. ➤ Added the ability to configure the front-panel pushbuttons. ➤ Added the ability to reset peak demand from the front-panel **RESET** pushbutton. ➤ Added a logic equation to reset the PQALRM Device Word bit. ➤ Added a logic equation to reset the peak demand reset counter. ➤ Allowed peak demand, energy, and maximum/minimum metering resets from a user-configurable front-panel pushbutton. ➤ Added FLICREF setting to calculate flicker based on 120 V, 230 V, or the VBASE setting as the reference voltage. ➤ Provided additional TOU nonrated energy analog quantities.	20160407

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-735-R115-V5-Z008005-D20170814	Includes all the functions of SEL-735-R115-V4-Z008005-D20151217 with the following addition: ➤ Resolved an issue where certain Ethernet traffic could disable devices when IEC 61850 is enabled.	20170814
SEL-735-R115-V4-Z008005-D20151217	Includes all the functions of SEL-735-R115-V3-Z008005-D20151012 with the following additions: ➤ Modified the firmware to avoid duplicate time stamps in the VSSI report. ➤ Improved the response time of MMS, DNP, Modbus, ASCII, Fast Meter, Fast Messages, Telnet, and FTP communications protocols. ➤ Improved the calculation of VSSI event duration for events that occur during a time change. ➤ Addressed an issue where complete VSSI data may not be retrievable when requested by date if there is a time discontinuity because of a time change in the meter.	20151217
SEL-735-R115-V3-Z008005-D20151012	Includes all the functions of SEL-735-R115-V2-Z008005-D20150929 with the following addition: ➤ Resolved an issue where the Time-of-Use feature will record all energy and demand data only in the first programmed rate for each schedule. This issue existed on firmware version R113-V0 through R115-V2.	20151012
SEL-735-R115-V2-Z008005-D20150929	Includes all the functions of SEL-735-R115-V1-Z008005-D20150908 with the following addition: ➤ Modified firmware to resolve a settings exchange incompatibility between the SEL-735 and ACSELERATOR QuickSet.	20150929
SEL-735-R115-V1-Z008005-D20150908	Includes all the functions of SEL-735-R115-V0-Z008005-D20150519 with the following addition: ➤ Resolved an issue where the Ethernet port could become unresponsive when a DNP/IP master on a TCP session polls for a large amount of data, then either disconnects or is disconnected by another DNP/IP master connecting to the same session.	20150908
SEL-735-R115-V0-Z008005-D20150519	➤ Corrected an issue where the meter restarted or stopped operating during file transfers in the presence of a saturated network. ➤ Resolved an issue that caused the SEL-735 to place incorrect values into the energy preload settings and SELOGIC counter value settings during an FTP settings read.	20150519
SEL-735-R114-V0-Z008005-D20150403	➤ Modified the order of the Digital Status Word bits in the IEEE C37.118.2 synchrophasor messages to match the order defined in the synchrophasor configuration frame.	20150403

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-735-R113-V0-Z008005-D20150324	➤ Added P Class IEEE C37.118 synchrophasors and associated configuration settings. ➤ Increased the maximum VBASE setting value in Form 5 meters from 300 V_{L-L} to 480 V_{L-L}. ➤ Resolved an issue where the KYZ contacts, when configured for net metering, only pulsed when the accumulated energy resulted in an increase to either the net delivered or net received value of the Net Energy registers. ➤ Added support for IRIG-B control bits as required by IEEE C37.118-2011. ➤ Removed Form 36, B-Phase voltage Instrumentation Transformer Compensation (ITC) settings. ➤ The End of Interval Pulse (EOIP) now asserts when a user or an external time source advances the meter clock across a demand interval boundary. ➤ Added a Time-Change Threshold (TIME_CHG) setting allowing users to adjust the threshold for time changes beyond which the meter flags affected data. ➤ Increased the DNP event buffer size from 10 messages per event type to 1024 messages per event type. ➤ Improved the typical timekeeping drift from 50 seconds per month to 5 seconds per month. ➤ Improved the timekeeping accuracy to comply with IEC 61000-4-30 Class A requirements. ➤ Enhanced harmonic, and interharmonic measurements to comply with IEC 61000-4-30 Class A. ➤ Resolved an issue where the DNP Restart Bit asserted when a DNP client restored a TCP session; now the DNP Restart Bit only asserts when the SEL-735 restarts. ➤ DNP Frozen Counters now maintain their value when the DNP client disconnects and restores the DNP session.	20150324
SEL-735-R112-V0-Z006004-D20141223	➤ Added an EIA-232 front-port option for vertical chassis meters.	20141223
SEL-735-R111-V0-Z006004-D20141107	➤ 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 CL2/10/20 meter or 2.5 A is applied to the CL10/20 meter. Now, current and power measurements do not fluctuate under those conditions. ➤ 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.	20141107
SEL-735-R110-V1-Z006004-D20170814	Includes all the functions of SEL-735-R110-V0-Z006004-D20140507 with the following addition: ➤ Resolved an issue where certain Ethernet traffic could disable devices when IEC 61850 is enabled.	20170814
SEL-735-R110-V0-Z006004-D20140507	➤ 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. ➤ 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. ➤ Modified the port power behavior and added the Enable Port Power setting. Previously, EIA-232 ports always supplied +5 V power from Pin 1.	20140507

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-735-R109-V0-Z005004-D20131015	➤ Corrected an issue where a serial port that was in an XOFF state would not time out. ➤ Increased the accuracy of energy data reported over DNP when configured to report more than two decimal places. ➤ Increased the accuracy of the energy and demand data stored in Load Profile Recorders (LDP) 2–12. ➤ 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. ➤ Added Form 36 (2-1/2 element) metrology. ➤ Corrected the Voltage Sag/Swell/Interruption (VSSI) initialization voltage threshold. ➤ Corrected a potential issue where issuing the **MET A** command might cause the meter communications port to stop responding to some commands. ➤ Corrected an issue that caused the KYZ pulses to use compensated energy quantities when uncompensated quantities were selected. ➤ Corrected an issue that caused the meter to reject some valid display point settings. ➤ Corrected an issue where the meter diagnostics reported `OFFSET WARN` on VA, VB, VC, and VN when the meter was starting up. ➤ Improved the ease of use of the TPORT setting on the meter HMI. ➤ 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). ➤ 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. ➤ Changed diagnostic data structure which clears old diagnostic messages during a firmware upgrade to R109.	20131015
SEL-735-R108-V0-Z004003-D20130906	➤ 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.	20130906

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-735-R107-V0-Z004003-D20130701 **Note:** Firmware revision R106 did not production release.	➤ Added gratuitous Address Resolution Protocol (ARP) messages to network communications. ➤ 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. ➤ Added IEC 61850 protocol with MMS Reporting and GOOSE. ➤ Added File Transfer Protocol (FTP). ➤ Added TCP Keep-Alive settings. ➤ Added Simple Network Time Protocol (SNTP). ➤ Added Instrument Transformer Compensation (ITC). ➤ Added active and reactive uncompensated analog quantities. ➤ Corrected an issue where the meter reported zero fundamental-only reactive power when the power angle was less than 1 degree. ➤ Corrected the dynamic base voltage feature where the meter reported incorrect Voltage Sag/Swell/Interruption data. ➤ Changed the factory-default display point formatting. ➤ Corrected an issue where sending design templates to the device at 9600 baud would fail. ➤ Corrected an issue where the meter disabled and reported NONVOL FAIL because of temporary nonvolatile memory issues. ➤ Added virtual bits VB001–VB128. ➤ Corrected an issue where the SER Power Loss entries were not in chronological order with other SER entries. ➤ 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. ➤ Corrected an issue that could be encountered while sending a file via YMODEM.	20130701
SEL-735-R105-V0-Z003002-D20130228	➤ Resolved an issue where meters with firmware version R100 through R104 where having DST enabled and TOU disabled would cause the front-panel LEDs to illuminate and the HMI to lock up. ➤ Added fundamental-only power values updated every 1/2 cycle. ➤ Added support for single-mode fiber-optic port.	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	➤ The length of unfiltered event reports is now two cycles more than the LER setting. ➤ The maximum prefault duration in unfiltered event reports is now two cycles more than the PRE setting. ➤ Improved VSSI logic to detect immediate transitions between Interrupts and Swells. ➤ Corrected power calculations for Form 5 single-phase testing. ➤ Corrected filtered event report scaling for Form 5 meters. ➤ Corrected SELOGIC Variable Timer accuracy. ➤ Modified COMTRADE CFG files to represent variable sampling rate.	20120608
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	➤ Added option for front-panel EIA-232 serial port. ➤ Added option for 100 A fault recording.	20110818
SEL-735-R100-V0-Z001001-D20110628	➤ Initial version.	20110628

SEL Display Package Versions

The SEL-735 with the touchscreen display option has display packages for the SEL display and default custom display. *Table A.3* lists the display package version, a description of the modifications, and the instruction manual date code that corresponds to the display package versions. The most recent firmware version is listed first.

Table A.3 SEL Display Package Revision History

SEL Display Package Version	Revisions	Release Date
2.0.50735.3	➤ Added support for new hardware component suppliers. ➤ Modified the color touchscreen backlight brightness for more consistent dimming while in standby mode. ➤ Improved the performance of the touchscreen display in rotating display mode. ➤ Resolved an issue where the backlight could flicker during power-up.	20211214
2.0.50735.1	➤ Initial release.	20201014

Instruction Manual

The date code at the bottom of each page of this manual reflects the creation or revision date.

Table A.4 lists the instruction manual release dates and a description of modifications. The most recent instruction manual version is listed first.

Table A.4 Instruction Manual Revision History

Date Code	Summary of Revisions
20250228	**Section 4** ➤ Updated *Figure 4.28: Status HMI Window*. **Section 5** ➤ Updated *Load Profile Recorder*. **Section 6** ➤ Updated *VSSI Settings*. **Appendix A** ➤ Updated for firmware version R209-V1, R208-V2, R207-V7, R206-V5, and R203-V4. **Appendix K** ➤ Updated *Table K.1: IP Port Numbers*.
20250131	**Section 1** ➤ Updated *Table 1.3: SEL-735 Power Quality and Recording Options* and *Table 1.4: SEL-735 Compliance With IEC 61000-4-30 Power Quality Standard*. ➤ Added Continuous Waveform Streaming (CWS) to *Communications Protocols* in *Specifications*.
20240924	**General** ➤ Added *Appendix J: Continuous Waveform Streaming*. **Section 3** ➤ Updated *Password Command* in *Access Levels*. **Section 4** ➤ Updated *Synchrophasors* in *Using the HMI.*

Date Code	Summary of Revisions
	Settings Sheets ➤ Added Enable CWS Sessions to *Port Security Settings* in *Communications*. ➤ Added *CWS Session Settings* to *DNP Ethernet Session Settings* in *Communications Settings*. **Section 5** ➤ Updated *Harmonic Magnitudes and Angles* in *Harmonic Metering*. **Section 8** ➤ Added Continuous Waveform Streaming Protocol to *Table 8.10: Available Communications Protocols*. ➤ Removed *Reset the Log* from *Audit Log Command* in *Command Explanations*. **Section 10** ➤ Updated *Password Jumper, PWD (Not Installed by Default)* in *Main Board Jumpers*. **Appendix A** ➤ [Cybersecurity Enhancement] Updated for firmware version R209-V0. ➤ Added a note to R201-V4 in *Table A.1: Firmware Revision History for R200 Series Firmware* regarding a settings version number correction. **Appendix G** ➤ Updated *Table G.1: Analog Quantities Available to Internal Interface Types*. **Appendix I** ➤ Added information regarding ECWSIP to *General Settings for Synchrophasors* and *Table I.3: SEL-735 Ethernet Port Settings for Synchrophasors*. **Appendix K** ➤ Added *Network Access Security* to *Access Control*. **Command Summary** ➤ Removed MEM command. ➤ Removed MET P R command from Access Level 2. ➤ Updated PAS command.
20240429	**Section 5** ➤ Added equation in *Fundamental-Only Magnitudes and Angles*. **Appendix A** ➤ Updated for firmware version R208-V1. **Glossary** ➤ Updated description of *Distortion Power Ratio (Dx)*.
20240306	**Section 1** ➤ Updated *Communications Connections*. ➤ Updated *Compliance*, *Power Supply*, *Energy Accuracy (Form 5 and Form 9 Only)*, and *Type Tests* in *Specifications*. **Section 2** ➤ Updated *PC System Requirements for QuickSet* under *Mount Meter*. ➤ Updated *Table 2.2: Essential Initial Settings*. ➤ Updated *Three-Line Display Models* in *Configure and Check Meter Status Through the Front-Panel Pushbuttons*. **Section 4** ➤ Updated *Metering* under *Using the HMI*. **Setting Sheets** ➤ Updated *Gain Adjustment Settings* in *Global Settings*. **Section 5** ➤ Added *To Set CALCQ* in *Preload Energy Values*. ➤ Updated *Transformer Loss Calculations* in *Transformer/Line-Loss Compensation*. ➤ Updated *Equation 5.12* and *Equation 5.13*. ➤ Updated *Form 9 and Form 36* and *Form 5* in *10/12-Cycle Power Calculations*. ➤ Updated *The Effects of Time Changes* in *Voltage, Current, and Power Calculations*. **Section 6** ➤ Updated *Waveform Capture Event Records in Event Reports Overview*.

Date Code	Summary of Revisions
	Section 8 ➤ Updated *Ethernet* in *Port Connector and Communications Cables*. Section 10 ➤ Updated *Table 10.2: TEST Mode Quantities*. Appendix A ➤ Updated for firmware versions R208-V0. Appendix E ➤ Updated *Table E.26: Modbus Register Map*. Appendix G ➤ Updated *Table G.1: Analog Quantities Available to Internal Interface Types*. ➤ Updated *Table G.13: Advanced: Fundamental Only*. ➤ Added *Table G.14: Advanced: Half-Cycle Fundamental Power* and *Table G.22: Advanced: Vector Method*.
20231006	Appendix A ➤ Updated for firmware versions R207-V6, R206-V4, R203-V3, and R201-V4.
20230410	Appendix A ➤ Updated for firmware version R207-V5. ➤ Updated the date code for firmware versions R206-V3, R203-V2, and R201-V3.
20230323	Section 5 ➤ Added *Demand Metering Elements*. ➤ Added *Via Color Touchscreen Front Panel* to *View or Reset Demand Metering Information*. ➤ Updated *Harmonic Metering in Form 5 and Form 36 Meters*. Appendix A ➤ Updated for firmware versions R207-V4, R206-V3, R203-V2, R201-V3, and R119-V2. ➤ Updated description of firmware version R207-V2. Appendix B ➤ Clarified options with regard to upgrading power quality features. Appendix H ➤ Updated *GOOSE*.
20230203	Appendix A ➤ Updated for firmware version R207-V3.
20220112	Section 6 ➤ Updated *VSSI Settings*. Section 8 ➤ Updated *Access Control*. Section 10 ➤ Updated *TEST Mode Characteristics*. Appendix A ➤ Updated for firmware version R207-V2. Appendix E ➤ Updated *02h Read Input Status Command*. ➤ Updated *Table E.15: SEL-735 Device Output Coils*.
20221102	Section 1 ➤ Added UKCA Mark in *Specifications*.
20220930	Section 1 ➤ Updated *Operating Temperature* in *Specifications*. Section 2 ➤ Updated *Figure 2.15: QuickSet Communication Parameters*. ➤ Updated *Table 2.4: Default SEL-735 Settings and Required QuickSet Communications Parameters*.

Date Code	Summary of Revisions
	Section 5 ➤ Updated *Table 5.26: Examples of Meter Time Reported on Various Interfaces*. Section 6 ➤ Updated *LDP HMI Window*. ➤ Removed *Table 6.5: LDP Field Format*. ➤ Updated *Table 6.5: LDP Status Bits in CSV Export*. ➤ Updated *VSSI Settings*. Section 7 ➤ Updated *HMI View*. Section 9 ➤ Removed *Custom Screens*, *Example: Customize a Screen to Show Most Recent LDP Data and Time-of-Use Quantities*, and *Bay Screen Builder Design Symbols*. Appendix G ➤ Updated *Table G.13: Advanced: Fundamental Only*. Appendix H ➤ Updated ID command responses. SEL-735 Meter Command Summary ➤ Updated MET H command descriptions.
20220601	Section 1 ➤ Updated *Specifications*. Settings Sheets ➤ Updated *Harmonic Triggers*. Section 5 ➤ Updated *Fast Meter and Fast Messages*. Appendix A ➤ Updated for firmware versions R201-V2, R203-V1, R206-V2, and R207-V1.
20220413	Section 1 ➤ Removed *100BASE-LX10 Fast Ethernet Fiber-Optic Port* from *Specifications*. Section 8 ➤ Updated *Table 8.2: SEL-735 Meter Models and Available Main Board Communications Options*. Appendix A ➤ Updated for firmware version R207-V0. Appendix D ➤ Updated *Default Variations*. ➤ Updated *Class Scaling and Deadbands*. ➤ Updated *Table D.10: SEL-735 DNP Object List*. ➤ Added *Table D.11: Default Variations for Object 30 and Object 32*. Command Summary ➤ Added DNP DVAR commands.
20220317	Section 1 ➤ Updated *Figure 1.2: Rear-Panel Layout*. ➤ Updated *Specifications*. Section 2 ➤ Updated *Mount Meter*. Section 3 ➤ Updated *Ethernet Protocol*. Section 4 ➤ Updated *Configure QuickSet Communications*.

Date Code	Summary of Revisions
	Section 5 ➤ Updated *Figure 5.2: IEC VAR Sign Convention*. ➤ Updated *Figure 5.4: SEL-735 Power Flow Notations*. ➤ Updated *Table 5.5: Frequency Command Characteristics*. **Section 6** ➤ Updated *Waveform Capture Event Reports*. **Section 8** ➤ Updated *Communications and Protocol Settings*.
20220103	**Preface** ➤ Updated *Safety Information*. **Section 1** ➤ Updated *Specifications*. **Section 2** ➤ Updated *Physical Location*.
20211214	**Section 8** ➤ Updated *Command Summary*. **Appendix A** ➤ Updated for firmware version R206-V1. ➤ Added *SEL Display Package Versions*.
20210730	**Section 1** ➤ Updated *Front-Panel Layout*. ➤ Updated *Rear-Panel Layout*. ➤ Updated *Specifications*. **Section 2** ➤ Added *Figure 2.3: Panel Cutout Sheet*. ➤ Updated *Installation and Wiring Bracket Mounting*. ➤ Added *Figure 2.13: Form 6, 2 1/2-Element, Four-Wire Wye Wiring Diagram*. **Section 3** ➤ Updated *Password Parameters*. ➤ Added *Changing Color Touchscreen Password*. **Section 4** ➤ Updated *Overview*. ➤ Added *Install QuickSet*. ➤ Added *Configure QuickSet Communications*. ➤ Updated *Using the HMI*. **Settings Sheets** ➤ Updated *Load Profile Settings*. **Section 5** ➤ Updated *Wiring Form Configurations*. ➤ Updated *Four-Quadrant VAR Metering*. ➤ Updated *Frequency Tracking*. ➤ Added *To Set ANGCUT*. ➤ Updated *Figure 5.36: Meter and Billing Positions*. ➤ Added *Symmetrical Component Calculations*. ➤ Added *Current Calculations*. ➤ Added *Voltage Calculations*. **Section 8** ➤ Updated *Table 8.9: SEL-735 Communications Cables*. ➤ Updated *Communications Protocols*. **Section 10** ➤ Updated *Accuracy Testing*.

Date Code	Summary of Revisions
	Appendix D ➤ Updated *Table D.9: DNP3 Device Profile*. Appendix E ➤ Changed appendix name to *Modbus and FTP Communications Protocols*. ➤ Updated *Table E.26: Modbus Register Map*. ➤ Added *FTP Communications Protocol*. Appendix G ➤ Updated *Table G.5: Frequency*. ➤ Updated *Advanced Analog Quantity List*.
20210513	Appendix A ➤ Updated for firmware version R206-V0.
20210305	Appendix A ➤ Updated for firmware versions R119-V1 and R205-V2.
20210204	Appendix A ➤ Updated for firmware version R201-V1.
20210125	Appendix A ➤ Updated for firmware version R205-V1.
20201026	Section 3 ➤ Added *Figure 3.15: Meter RMS*. ➤ Updated *Configuration*.
20201014	Section 1 ➤ Added *Front-Panel Options*. ➤ Updated *Table 1.3: SEL-735 Power Quality and Recording Options* and *Table 1.4: SEL-735 Compliance With IEC 61000-4-30 Power Quality Standards*. ➤ Updated *Specifications*. Section 2 ➤ Updated *Figure 2.7: Form 5, 2-Element, Three-Wire Delta Wiring Diagram*, *Figure 2.6: Form 9, 3-Element, Four-Wire Wye Wiring Diagram*, and *Figure 2.9: Form 36, 2 1/2-Element, Four-Wire Wye Wiring Diagram*. ➤ Added *Configure and Check Meter Status Through the Touchscreen Display*. Section 3 ➤ Updated for touchscreen display model. Section 5 ➤ Updated *Frequency Tracking*. ➤ Updated *Harmonic Metering*. Section 8 ➤ Added *Table 8.1: SEL-735 Front Port Options*. ➤ Updated *Port Connector and Communications Cables*. ➤ Added *Audit Log Command*. Section 9 ➤ Added new *Section 9: Touchscreen and Custom Screen Settings*. Section 10 ➤ Updated *Table 10.1: Meter Testing Features* and *Table 10.2: TEST Mode Quantities*. ➤ Updated *TEST Mode Operations*. ➤ Added *Touchscreen Display*. Appendix A ➤ Updated for firmware version R205. Appendix D ➤ Updated *Table D.11: Control Field*. Appendix G ➤ Updated *Table G.25: SEL-735 Device Word Bits*.

Date Code	Summary of Revisions
	Appendix J ➤ Added new *Appendix J: Cybersecurity Features*.
20190828	**Settings Sheets** ➤ Removed setting IBCHIQ. ➤ Added HARM and INTERHARM to setting HARMCAL options. **Section 5** ➤ Added interharmonic subgroup information to *Harmonic Components, Groups, and Subgroups*. **Section 6** ➤ Added *Load Profile Presets*. ➤ Updated *Figure 6.1: LDP Settings Interface*. **Section 9** ➤ Updated *Table 9.1: Meter Testing Features*. ➤ Added *TEST AGG Command*. **Appendix A** ➤ Updated for firmware version R203. **Appendix G** ➤ Updated *Table G.7: Aggregation*. ➤ Updated *Table G.14: Advanced: Harmonics*.
20190115	**Preface** ➤ Updated *General Safety Marks*. **Section 1** ➤ Updated *Specifications*. **Section 6** ➤ Added *Table 6.5: LDP Status Bits*.
20180906	**Section 3** ➤ Updated *Normal Operation*. **Section 5** ➤ Updated *Energy Calculations*. ➤ Updated *Equation 5.26* through *Equation 5.33* . ➤ Updated *Status Current* and *Table 5.21: Starting Current Type Setting Behavior*. ➤ Updated *10/12-cycle Power Calculations*. **Section 6** ➤ Added a note to *LDP Retrieval*.
20180621	**Preface** ➤ Updated *Safety Information*. **Section 1** ➤ Updated *Table 1.2: SEL-735 Power Quality and Recording Options* and *Table 1.3: SEL-735 Compliance With IEC 61000-4-30 Power Quality Standard*. ➤ Updated *Specifications*. **Section 2** ➤ Updated *Make Rear-Panel Connections*. **Settings Sheets** ➤ Updated *Load Profile Settings*. **Section 5** ➤ Updated *IEC 61000-4-30 Testing and Measurement Techniques—Power Quality Measurement Methods*. ➤ Updated *Four-Quadrant VAR Metering*. ➤ Updated *Frequency Tracking*. ➤ Updated *Predictive Demand Meter Response (EDEM = ROL or BLOK)*. ➤ Updated *Fundamental Power*. ➤ Updated *Line Synchronization*.

Date Code	Summary of Revisions
	Section 6 ➤ Updated *Load Profile Report*. ➤ Updated *Making SER Trigger Settings*. ➤ Updated *Voltage Sag/Swell/Interruption (VSSI) Report*. Section 8 ➤ Updated *Internal Modem*. ➤ Added *CFR Part 68 Telecom*. ➤ Updated *Command Summary*. Appendix A ➤ Added *Table A.1: Firmware Revision History for R200 Series Firmware*. ➤ Updated for firmware versions R119, R200, and R201. Appendix B ➤ Updated appendix. Appendix E ➤ Updated *Table E.26: Modbus Register Map*. Appendix G ➤ Updated *Table G.5: Frequency*, *Table G.7: Aggregation*, and *Table G.25: SEL-735 Device Word Bits*.
20180208	Section 1 ➤ Updated *Specifications*. Section 9 ➤ Updated *Accuracy Testing*. ➤ Updated *Gain Adjustment*.
20171103	Section 1 ➤ Updated *Operating Environment* in *Specifications*. Section 4 ➤ Added *Wave View*. ➤ Added LINEFREQ setting. Appendix A ➤ Updated for firmware version R118-V1. ➤ Added more detail to Summary of Revisions for firmware version R117-V0.
20170814	Appendix A ➤ Updated for firmware versions R110-V1, R115-V5, R116-V2, and R117-V2.
20170119	Section 1 ➤ Added *Table 1.2: SEL-735 Power Quality and Recording Options* and updated *Table 1.3: SEL-735 Compliance With IEC 61000-4-30 Power Quality Standard*. ➤ Updated *Specifications*. Section 2 ➤ Added *Connection Diagrams*. Settings Sheets ➤ Updated *Supply and Load Line Losses Settings*. Section 5 ➤ Updated *IEC 61000-4-30 Testing and Measurement Techniques—Power Quality Measurement Methods*. ➤ Updated *Aggregation Time Periods*. ➤ Updated *Logging*. ➤ Updated *Predictive Demand Meter Response (EDAM = ROL or BLOK)*. ➤ Updated *Table 5.16: Required User Input*. ➤ Updated *Average and Imbalance Calculations*. ➤ Updated *Meter Time Reporting*. Section 6 ➤ Updated *Standard Event Summary*. ➤ Updated *Voltage Sag/Swell/Interruption (VSSI) Report*.

Date Code	Summary of Revisions
	Section 7 ➤ Updated SELOGIC *Control Variables/Timers*. ➤ Updated *Math Variables*. ➤ Updated *Reset Trigger Equations*. Section 8 ➤ Updated *File Transfer Protocol (FTP) and MMS File Transfer*. Appendix A ➤ Updated for firmware version R117. Appendix D ➤ Updated *Binary/Frozen Counters*. ➤ Added *Event Summary Information*. Appendix G ➤ Updated *Table G.1: Analog Quantities Available to Internal Interface Types*. ➤ Updated *Table G.4: Energy*. ➤ Updated *Table G.7: Aggregation*. ➤ Updated *Table G.9: Advanced: Date and Time*. ➤ Updated *Table G.13: Advanced: Fundamental Only*. ➤ Updated *Table G.22: Advanced: Voltage and Current Imbalance and Average*. ➤ Updated *Table G.26: SEL-735 Device Word Bit Definitions*.
20160628	Appendix A ➤ Updated for firmware version R116-V1. Appendix H ➤ Updated *GOOSE Performance*.
20160407	Section 1 ➤ Updated *Metering/Monitoring* in *Specifications*. Section 2 ➤ Updated *Configure and Check Meter Status*. Section 3 ➤ Updated *Access Levels*. ➤ Added *Table 3.1: Access Level Functionality*. ➤ Updated *Front-Panel Operations*. ➤ Updated *Display Points*. Section 4 ➤ Updated *Figure 4.8: Display Point Settings*. ➤ Updated *Figure 4.10: Analog Quantity Display Point Configuration Example*. ➤ Updated *Using the Human-Machine Interface (HMI)*. Settings Sheets ➤ Updated *Global Settings*, *Front Panel*, *Events and Logging*, and SELOGIC *Control Equations*. Section 5 ➤ Updated *Demand Metering*. ➤ Updated *Table 5.6: Demand Meter Settings and Settings Ranges*. ➤ Updated *Figure 5.8: PREDAL Logic*. ➤ Updated *TOU Setup*. ➤ Updated *Energy Metering*. ➤ Updated *Figure 5.29: FAULT and DFAULT Device Word Bit Logic*. ➤ Updated *Flicker Metering*. ➤ Updated *Voltage, Current, and Power Calculations*. Section 6 ➤ Updated *Load Profile Report*. ➤ Updated *Sequential Events Recorder (SER) Report*. Section 7 ➤ Updated *Inputs/Outputs*.

Date Code	Summary of Revisions
	Appendix A ➤ Updated for firmware version R116-V0. Appendix C ➤ Added *Table C.3: SEL-735 Fast Meter Commands*. Appendix G ➤ Updated *Table G.1: Analog Quantities Available to Internal Interface Types*. ➤ Updated *Basic Analog Quantity List*. ➤ Added *Table G.24: SSI Summary Record(s)*. ➤ Added *Table G.25: LDP Most Recent Records*. ➤ Updated *Table G.27: SEL-735 Device Word Bits* to include DP17–DP50.
20151217	Section 1 ➤ Updated *Specifications*. Appendix A ➤ Updated for firmware version R115-V4.
20151012	Appendix A ➤ Updated for firmware version R115-V3.
20150929	Appendix A ➤ Updated for firmware version R115-V2.
20150908	Appendix A ➤ Updated for firmware version R115-V1.
20150519	Section 1 ➤ Updated *Table 1.2: SEL-735 Compliance With IEC 61000-4-30 Power Quality Standard*. ➤ Added *Table 1.3: SEL-735 Waveform Capture Settings Options for Event Reports*. Appendix A ➤ Updated for firmware version R115.
20150403	Appendix A ➤ Updated for firmware version R114.
20150324	Section 1 ➤ Updated *Table 1.2: SEL-735 Feature Availability*. ➤ Updated *Specifications*. Section 2 ➤ Updated *Configure and Check Meter Status* to include note about *Analog Quantity Scaling*. Section 3 ➤ Updated the overview of Access Level EAC. Section 4 ➤ Updated *Aggregated Registers* to *Aggregated Values*. ➤ Added *Synchrophasors*. Settings Sheets ➤ Updated *Instrument Transformer Compensation*. ➤ Updated *Global Settings*. ➤ Added *Synchrophasor* Settings. ➤ Updated *Voltage Sag/Swell/Interruption Settings*. ➤ Updated *Ports*. ➤ Moved *DNP Ethernet Session Settings*. ➤ Added *PMU Session Settings*. Section 5 ➤ Updated *IEC 61000-4-30 Testing and Measurement Techniques—Power Quality Measurement Methods*. ➤ Updated *Measurement Aggregation*. ➤ Added *Time Sources* and *The Effects of Time Changes* under the heading, *Voltage, Current, and Power Calculations*.

Date Code	Summary of Revisions
	Section 8 ➤ Updated *Port Connector and Communications Cables*. ➤ Added *Synchrophasors* and *SNTP* to *Communications Protocols*. ➤ Removed *Table 8.11: Command Summary* and made it a separate section. **Appendix A** ➤ Updated for firmware version R113. **Appendix D** ➤ Updated *Overview* and *Table D.5 DNP3 Device Profile*. **Appendix E** ➤ Updated *Table E.24 Modbus Enumeration Definitions*. **Appendix G** ➤ Updated *Overview*. ➤ Updated *Table G.5: Frequency*, *Table G.10: Advanced: Diagnostics*, *Table G.25: SEL-735 Device Word Bit Definitions*, and *Table G.25: SEL-735 Device Word Bit Definitions*. **Appendix H** ➤ Updated *GOOSE Performance*. **Glossary** ➤ Added *RTC*. **Command Summary** ➤ Updated *Command Summary*.
20141223	**Preface** ➤ Updated *Safety Information*. **Section 1** ➤ Updated *Table 1.2: SEL-735 Feature Availability*. ➤ Updated *Specifications*. **Section 2** ➤ Updated to include EIA-232 front-port option for vertical chassis meters. ➤ Updated *Figure 2.11: SEL-735 Model Option Table*. **Section 4** ➤ Updated *Settings*. **Settings** ➤ Updated *Voltage Sag/Swell/Interruption Settings*. ➤ Updated *Communications Settings*. **Section 5** ➤ Updated *Flicker Metering*. ➤ Updated *Table 5.18: Configurable Register Attributes*. **Section 7** ➤ Updated *Table 7.12: SELOGIC Control Equation Counter Inputs*. **Appendix A** ➤ Updated for firmware revision R112. **Appendix H** ➤ Updated *IEC 61850 Operation*.
20141107	**Appendix A** ➤ Updated for firmware version R111.
20140507	**Section 1** ➤ Updated *SEL-735 Meter Forms and Models* section. ➤ Updated *Specifications* section. **Section 3** ➤ Added explanation of number of characters per line displayed by the LCD.

Date Code	Summary of Revisions
	Settings Sheets ➤ Added settings IST and IST_TYPE to *Advanced Global Settings*. ➤ Added setting EPP to *Communications Settings*. Section 5 ➤ Added command syntax of **FORM** command in *Form Factor Support*. ➤ Added *Starting Current* section. Section 8 ➤ Changed description of green LED in *Table 8.6: Ethernet Port LED Description*. Appendix A ➤ Updated for firmware version R110. Command Summary ➤ Added **MET D**, **MET D P**, **MET D P U**, **MET D T**, **MET D T U**, and **MET D U** commands.
20140313	Section 1 ➤ Updated *Specifications* section.
20131015	Section 1 ➤ Updated for Form 36 Metering. Section 5 ➤ Added Form 36 Metering. Appendix A ➤ Updated for firmware version R109.
20130906	Appendix A ➤ Updated for firmware version R108.
20130701	Section 5 ➤ Added *Instrument Transformer Compensation*. ➤ Updated *Transformer/Line Loss Compensation*. Section 8 ➤ Added *FTP* and *MMS*. ➤ Added *Command Explanations*. Appendix A ➤ Updated for firmware version R107. Appendix G ➤ Added new uncompensated analog quantities. Appendix H ➤ Added *Appendix H: IEC 61850 Communications*.
20130515	Section 1 ➤ Updated *Specifications* for single-mode fiber-optic support. Section 5 ➤ Corrected transformer line-loss compensation equations. Section 8 ➤ Updated *Table 8.1: Meter Models and Available Main Board Communications Options* for single-mode fiber-optic support.
20130228	Section 5 ➤ Corrected *Demand Metering* explanation. Section 8 ➤ Corrected *SEL-735 Command Summary*. Appendix A ➤ Updated for firmware version R105.

Date Code	Summary of Revisions
	Appendix G ➤ Revised *Table G.1: Analog Quantities Available to Internal Interface Types* and analog quantities.
20121005	Section 1 ➤ Updated *Output Contacts Pickup/Dropout Time* in *Specifications*. Section 5 ➤ Added Neutral Current. Appendix A ➤ Updated for firmware version R104.
20120608	Appendix A ➤ Updated for firmware version R103.
20120319	Section 1 ➤ Updated *Table 1.2: SEL-735 Feature Availability*. ➤ Updated *Figure 1.2:SEL-735 Inputs, Outputs, and Communications Ports*. ➤ Added *Fiber-Optic Ethernet Port* in *Specifications*. Section 2 ➤ Updated *Figure 2.6: Four-Wire Wye and Three-Wire Delta Wiring Diagrams*. ➤ Updated *Table 2.4: Default SEL-735 Settings and Required ACSELERATOR QuickSet Communications Parameters*. Section 3 ➤ Use of Configurable Registers in Display Points added in *Display Points*. Settings ➤ Added *Table SET.2* and introductory text in *Communications Settings*. Section 5 ➤ Updated thermal demand algorithm in *Comparison of Thermal, Rolling, and Block Demand Meters*. ➤ Updated *Figure 5.28: FAULT and DFAULT Device Word Bit Logic*. ➤ Changed amount for maximum positive-sequence current in *Fault Detection*. ➤ Removed basic underpower quality and recording option in *Table 5.14: Flicker Quantities Available*. ➤ Updated *Table 5.17: Configurable Register Attributes*. ➤ Updated *Table 5.18: Configurable Register Spreadsheet Example*. ➤ Updated *Figure 5.33: Meter and Billing Positions* and *Table 5.15: Transformer and Line Loss Adjustments.* Section 7 ➤ Removed reference to logic updates in processing cycle in *Output Contacts*. ➤ Updated *Example* and *Figure 7.3: Analog Output Settings Example* in *DC Analog Output*. Section 8 ➤ Updated *Ethernet* section in *Port Connector and Communications Cables*. ➤ Updated *Table 8.7: Port Pinout Functions*. ➤ Updated *Table 8.10: Command Summary*. Appendix D ➤ Updated *VSSI Summary Records*. ➤ Removed *Event Summary Records*. Appendix G ➤ Updated *Table G.1: Analog Quantities Available to Internal Interface Types*. Command Summary ➤ Updated with additional commands.
20111216	Appendix A ➤ Updated for firmware version R102.
20111111	Section 1 ➤ Updated Waveform Capture duration values in *Table 1.2: SEL-735 Feature Availability*. ➤ Added Fiber-Optic Ethernet Port specifications to *Specifications* section. Appendix A ➤ Updated for firmware version R102.

Date Code	Summary of Revisions
20110818	Section 1 ➤ Modified for 100 A fault recording addition. Appendix A ➤ Updated for firmware version R101.
20110628	➤ Initial version.

APPENDIX B

SEL-735 Upgrade Instructions

Overview

These instructions describe how to install various SEL-735 upgrades including firmware, meter form changes, and basic to intermediate power quality features. The firmware upgrade will be either a standard release or a point release. A standard release adds new functionality to the firmware beyond the specifications of the existing version. A point release is reserved for modifying firmware functionality to conform to the specifications of the existing version.

A standard release is identified by a change in the R-number of the device firmware identification (FID) string.

Existing firmware:

FID=SEL-735-**R200**-V0-Z102100-Dxxxxxxxx

Standard release firmware:

FID=SEL-735-**R201**-V0-Z102100-Dxxxxxxxx

A point release is identified by a change in the V-number of the device FID string.

Existing firmware:

FID=SEL-735-R200-**V0**-Z102100-Dxxxxxxxx

Point release firmware:

FID=SEL-735-R200-**V1**-Z102100-Dxxxxxxxx

Typically, the release date is after the D. For example, the following is firmware revision number 201, release date June 21, 2018.

FID=SEL-735-R201-V0-Z100100-**D20180621**

Equipment Needed

Obtain the following equipment prior to performing this procedure:

NOTE
If you are using Ethernet communication to upgrade the meter, ensure that the PC has access to a meter on a network.

- Communications cable
  - Port F:
    - Infrared Optical: SEL-C660 or SEL-C661
    - DB-9 serial: SEL-C234A or SEL-C662
    - USB-C: SEL-C497
  - Port 2 or Port 3 (DB-9 serial): SEL-C234A or SEL-C662
  - Port 1 (Ethernet): SEL-CA605
- SEL-735 Access Level 1, Access Level 2, and Access Level C passwords

Installation

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

⚠ **IMPORTANT**

Contact SEL if you would like to purchase an upgrade. Field upgrading is only supported from basic to intermediate power quality. Upgrading to advanced power quality requires the meter to be returned to SEL. SEL charges for upgrades to the power quality and recording option or to enable IEC 61850. If you purchased an upgrade, please refer to the SEL-735 Upgrade Software Kit for the passwords.

NOTE

The fastest upgrades will be over Ethernet. The slowest upgrades will be over Port F.

Step 1. If using Ethernet communication, ensure that the PC can connect to the SEL-735 via Telnet. Otherwise, use a supported serial communications cable to connect the PC to the SEL-735.

Step 2. Double-click the SEL-735 Upgrade Software shortcut saved on the desktop or from the Start menu to run the software.

Step 3. Choose either the Ethernet or serial communications method.

For Ethernet communication, enter the IP address of the SEL-735 in the text field.

For serial communication, select the COM port of the PC that is connected to the SEL-735. 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.

Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com/support
Email: info@selinc.com

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APPENDIX C

SEL Communications Processors

SEL Communications Protocols

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 autoconfiguration 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.

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

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*.

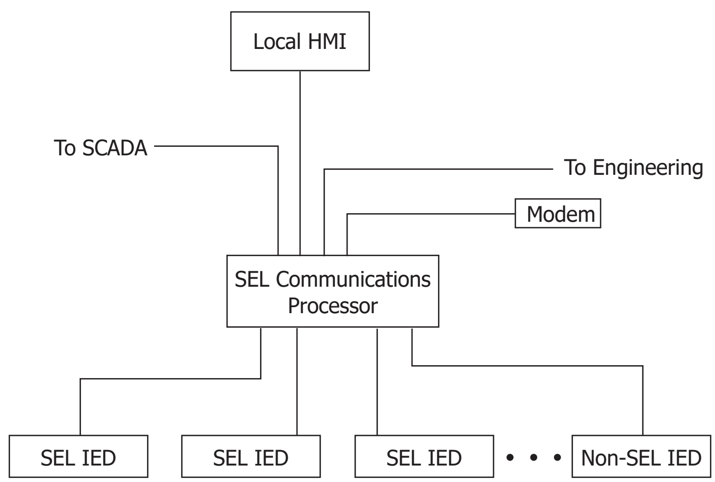

Figure C.1 SEL Communications Processor Star Integration Network

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.

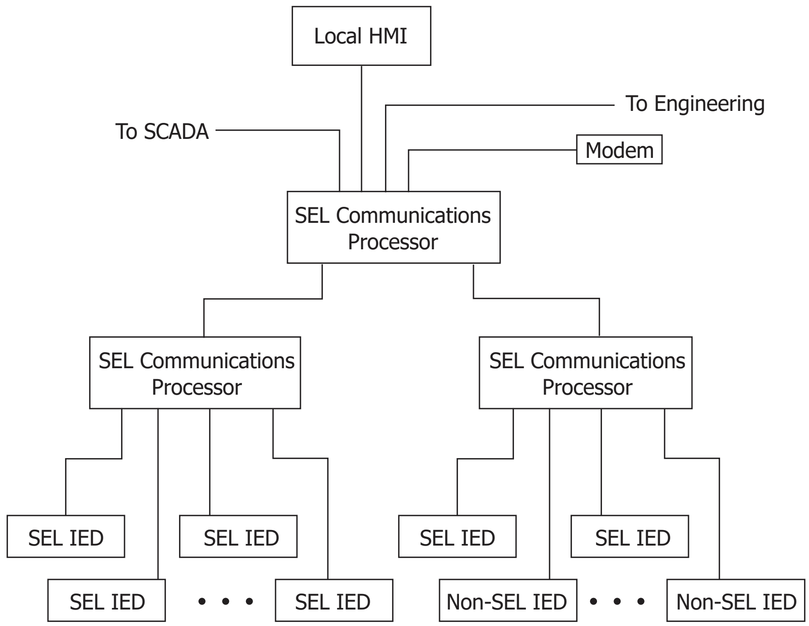

Figure C.2 Multitiered SEL Communications Processor Architecture

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

Protocol	Connect to
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[a]	Modbus Plus peers with global data and Modbus Plus masters
FTP (File Transfer Protocol)[b]	FTP clients
Telnet[b]	Telnet servers and clients
UCA2 GOMSFE[b]	UCA2 protocol masters
UCA2 GOOSE[b]	UCA2 protocol and peers

[a] Requires SEL-2711 Modbus Plus protocol card.
[b] 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 ACSELERATOR 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 human-machine interface (HMI).

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

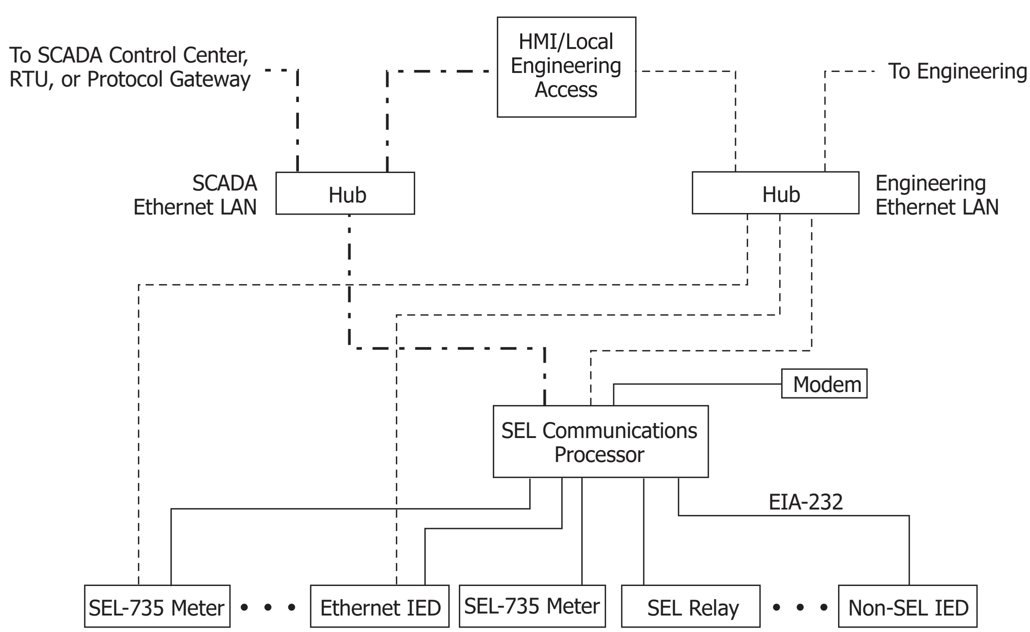

Figure C.3 Enhancing Multidrop Networks With SEL Communications Processors

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.

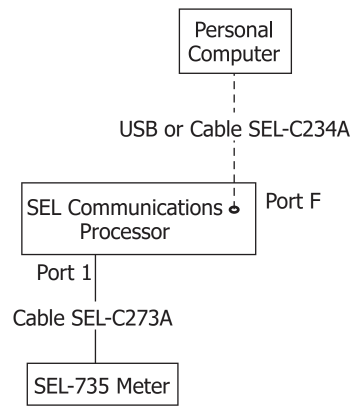

Figure C.4 Example SEL Meter and SEL Communications Processor Configuration

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 autoconfiguration for this device
PORTID	"Meter 1"	Name of connected meter[a]
BAUD	19200	Channel speed of 19200 bits per second[a]
DATABIT	8	Eight data bits[a]
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

[a] Automatically collected by the SEL communications processor during autoconfiguration.

Data Collection

The SEL communications processor collects data from the SEL-735 through use of the automessages listed in *Table C.6*. Disable automessages 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 **FMR1**
20DEM4Q	Four-quadrant demand metering data; enable and disable with **FMR2**
20PEAK4Q	Four-quadrant peak demand metering data; enable and disable with **FMR3**
20MET4Q	Four-quadrant power system metering data; enable and disable with **FMR4**

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 in 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

Region	Data Collection Message Type	Region Name	Description
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

Overview

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 (Binary inputs 1600–1604 are Device Status DNP points—refer to *Table D.6*). DNP point 1603, which is the settings change or device restart bit, always returns a value of zero but triggers a solicited message/DNP event. Alternatively, map a SELOGIC control variable to a DNP binary input for settings change indication.

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 deadband 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 Places 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. Decimal points can be included, but the total number of digits stays the same. For example, with two decimal places, energy will roll over at 9,999,999.99. If you want a different rollover 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 to 1. This data point is available as point index 6000 in Binary Input and Counter Input data object types. The meter clears this new VSSI summary data point after 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 deadbands in counts of analog input values. Analog inputs LDP most recent record points behave similarly to the binary counter LDP most recent record points.

Event Summary Information

The SEL-735 provides data related to waveform capture event reports as DNP Analog Inputs 6000–6005. See *Table D.6* for a description of the point indices.

If DNP is enabled, the meter powers up with DNP points 6000–6005 containing the most recent event report data, as available from the **HIS** command. When a new event occurs, binary input point 1604 is asserted. To update the summary event analog points, operate the binary output point 40 by performing a CLOSE, TRIP, LATCH_ON, or PULSE_ON operation.

The point index 6000 holds the event type data, which is a 16-bit composite value. *Table D.3* shows the upper byte value which represents the cause of the event.

Table D.3 Upper Byte Values

Value	Event Cause
1	Trigger command
2	Pulse command (Not supported)
4	Trip element (Not supported)
8	ER element

Analog Outputs

The SEL-735 accepts analog output values from the master for use in SELOGIC control equations and the 4 AO/4 DO 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.
- 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 serial port for DNP, set the port PROTO setting to DNP. Refer to *SEL-735 Settings Sheets on page 131* for a list of all DNP settings.

Default Data Map

Table D.4 shows the SEL-735 default DNP data map. The remapping feature customizes the data map for your application. See *Configurable Data Mapping on page 380*.

Table D.4 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.5 shows the default response for each object when a DNP master requests variation 0.

Table D.5 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

The default variation of Analog Inputs can be changed using the **DNP DVAR** commands below. These changes affect all DNP sessions on the meter.

➤ **DNP DVAR** (1–5) allows the default variation for Object 30 queries set to 1 through 5, as defined in Table D.10. This requires Access Level 2 access.

➤ **DNP DVAR C** (Clear) resets the object 30 default variation to 4, and object 32 variation to 2. This requires Access Level 2 access.

- **DNP DVAR S** (Show) returns the current variation. This requires Access Level 1 access.
- **DNP DVAR H** (Help) returns the command syntax. This requires Access Level 1 access.

These commands are also listed in the *SEL-735 Meter Command Summary*.

After accepting the DNP changes, the meter will reset all active DNP sessions.

Configurable Data Mapping

One of the most powerful features of the DNP3 implementation is the ability to remap data with per-point scaling and deadbands. 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 SEL-5030 Software can remap, apply per-point scaling, and apply deadbands to DNP points. The map consists of five indices, as *Overview on page 375* 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 reorder DNP Binary Outputs.

Step 1. In the settings tree, navigate to the desired DNP map and object type.

QuickSet 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 reorder 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.

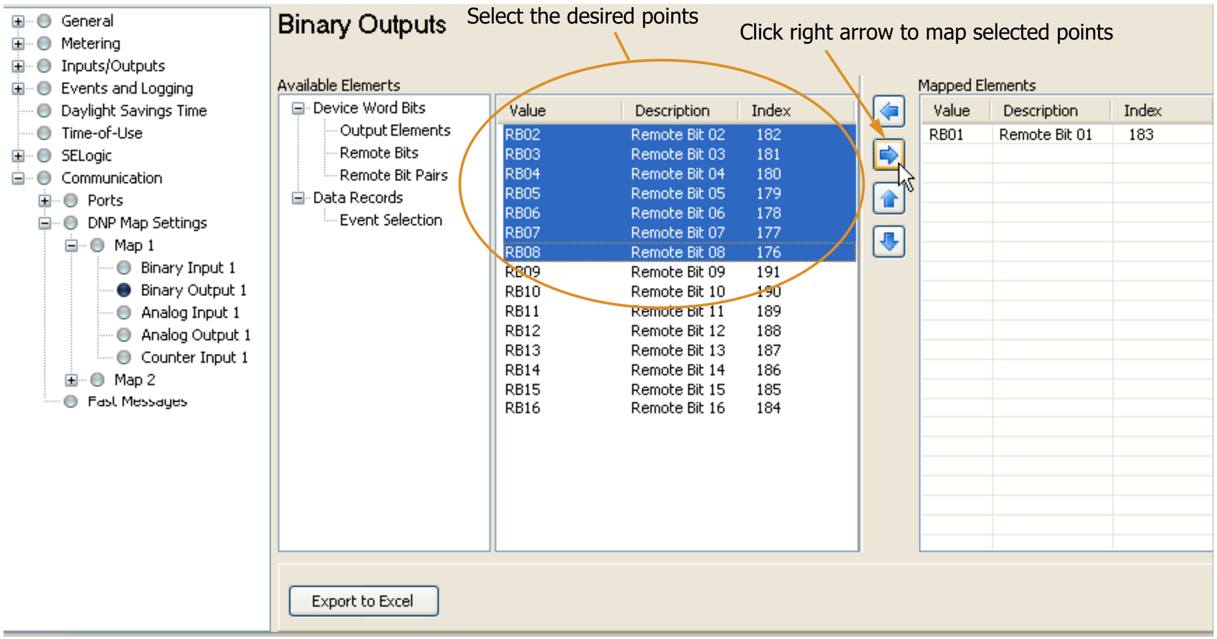

Figure D.1 Mapping DNP Binary Outputs

Figure D.2 shows an example of using the DNP map builder to reorder the points of the custom map.

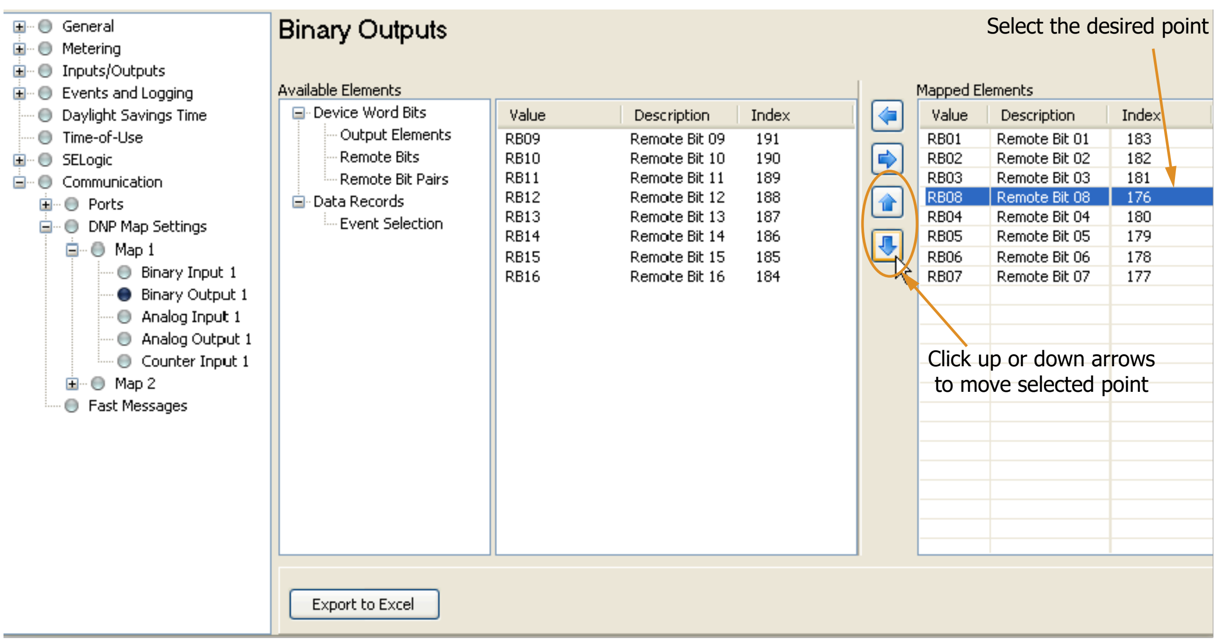

Figure D.2 Reorder DNP Binary Outputs

Per-Point Scaling and Deadbands

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 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 deadband.

Step 1. In the QuickSet settings tree, navigate to the desired Analog Input DNP map.

QuickSet displays the DNP map builder similar to *Figure D.3*.

Step 2. Double-click the desired mapped element.

The scaling and deadband 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 deadband.

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.

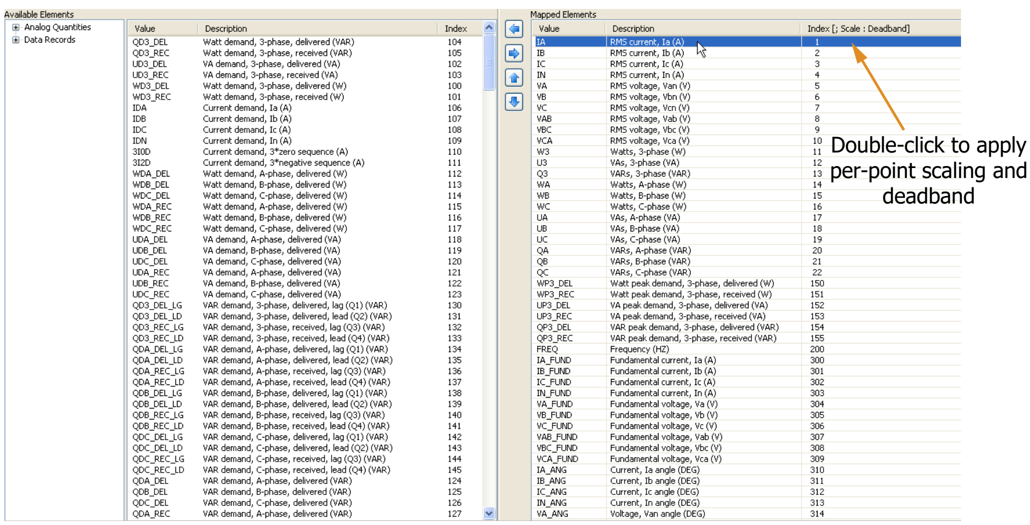

Figure D.3 DNP Map Builder

Figure D.4 shows the window opened when you double-click on a mapped element.

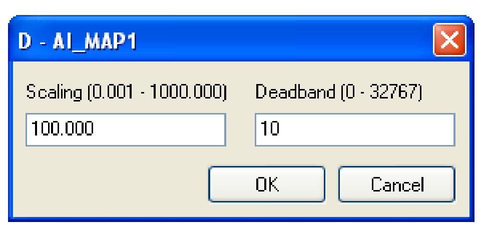

Figure D.4 Scaling and Deadband Window

Figure D.5 shows the DNP map builder with per-point scaling and deadband applied to IA.

Figure D.5 Per-Point Scaling and Deadband Applied

Class Scaling and Deadbands

The SEL-735 applies class scaling (DECPLA, DECPLV, DECPLE, and DECPLM) and deadband (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.

The following list of quantities available as Analog Inputs are automatically scaled by 100 to ensure hundredths precision is available. If a per-point scale factor is configured in the DNP Map for any of these points, this automatic scaling will not occur. Deadband values are applied against scaled values. When Analog Inputs are sent as short float variation, the automatic scaling by 100 is removed because decimal precision is available. Deadbands are still applied as scaled integer values.

Frequencies:

FREQ, FREQ_PQ

Angles:

IA_ANG, IB_ANG, IC_ANG, IN_ANG, VA_ANG, VB_ANG, VC_ANG, VAB_ANG, VBC_ANG, VCA_ANG

Power Factors

PFD3, PFT3, PFDA, PFDB, PFDC, PFTA, PFTB, PFTC

Table D.6 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.6 DNP3 Device Profile

DNP Object Type	Index	Description	Scaling/Deadband
DNP BINARY INPUT POINT MAP			
	Status of Word Bits and Word Bits in SER Settings		
01,02	000–583	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)	

DNP Object Type	Index	Description	Scaling/Deadband
	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	
DNP BINARY OUTPUT POINT MAP			
	Remote Bit Pairs		
10,12	30–37	Remote Bit Pairs RB01, RB02–RB15, RB16	
	Event Selection		
10,12	40	Read Next Event	
DEVICE WORD BIT CONTROLS			
10,12	81–84	OUT404–OUT401	
10,12	85–87	OUT103–OUT101	
10,12	176–183	RB08–RB01	
10,12	184–191	RB16–RB09	
DNP COUNTER POINT MAP			
	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
20,22	13, 14, 15, 16	WHA_NET, WHB_NET, WHC_NET, WH3_NET (In some older SEL devices, these elements are named EA_NET, EB_NET, EC_NET, E3_NET, respectively)	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

DNP Object Type	Index	Description	Scaling/Deadband
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
	Configured Registers		
20,22	1001–2000	CFG0001–CFG1000	None
	LDP 50 Records 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
		Selected Recorder Record 1:	
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

DNP Object Type	Index	Description	Scaling/Deadband
20,22	3022	Channel 13 Data	DECPLM
20,22	3023	Channel 14 Data	DECPLM
20,22	3024	Channel 15 Data	DECPLM
20,22	3025	Channel 16 Data	DECPLM
Record 2–50:			
20,22	3026–4152	Record 2–50	
LDP Most Recent Records			
20,22	5000	LDP Data Ready (Most Recent)	None
Recorder 1:			
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
Recorder 2–32:			
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	
20,22	5301–5325	Recorder 13	
20,22	5326–5350	Recorder 14	
20,22	5351–5375	Recorder 15	
20,22	5376–5400	Recorder 16	
20,22	5401–5425	Recorder 17	

DNP Object Type	Index	Description	Scaling/Deadband
20,22	5426–5450	Recorder 18	
20,22	5451–5475	Recorder 19	
20,22	5476–5500	Recorder 20	
20,22	5501–5525	Recorder 21	
20,22	5526–5550	Recorder 22	
20,22	5551–5575	Recorder 23	
20,22	5576–5600	Recorder 24	
20,22	5601–5625	Recorder 25	
20,22	5626–5650	Recorder 26	
20,22	5651–5675	Recorder 27	
20,22	5676–5700	Recorder 28	
20,22	5701–5725	Recorder 29	
20,22	5726–5750	Recorder 30	
20,22	5751–5775	Recorder 31	
20,22	5776–5800	Recorder 32	
	VSSI Summary Records		
20,22	6000	New VSSI Summary	None
		Summary 1:	
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
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
		Summary 2–10:	
20,22	6022–6210	Summary 2–10	

DNP Object Type	Index	Description	Scaling/Deadband
DNP ANALOG INPUT POINT MAP			
	Voltage, Current, and Power		
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
		Demand, Present Interval	
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
		Demand, Peak	
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

DNP Object Type	Index	Description	Scaling/Deadband
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
		Frequency	
30,32	200	FREQ	100/ANADBM
30,32	201	FREQ_PQ	100/ANADBM
		Fundamental-Only Voltage, Current, and Power	
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
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
		Configured Registers	
30,32	1001–2000	CFG001–CFG1000	None/ANADBM
		Power Factor	
30,32	3000	PFD3	100/ANADBM
30,32	3001	PFT3	100/ANADBM

DNP Object Type	Index	Description	Scaling/Deadband
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
		LDP Most Recent Record	
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
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	

DNP Object Type	Index	Description	Scaling/Deadband
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	
30,32	5301–5325	Recorder 13	
30,32	5326–5350	Recorder 14	
30,32	5351–5375	Recorder 15	
30,32	5376–5400	Recorder 16	
30,32	5401–5425	Recorder 17	
30,32	5426–5450	Recorder 18	
30,32	5451–5475	Recorder 19	
30,32	5476–5500	Recorder 20	
30,32	5501–5525	Recorder 21	
30,32	5526–5550	Recorder 22	
30,32	5551–5575	Recorder 23	
30,32	5576–5600	Recorder 24	
30,32	5601–5625	Recorder 25	
30,32	5626–5650	Recorder 26	
30,32	5651–5675	Recorder 27	
30,32	5676–5700	Recorder 28	
30,32	5701–5725	Recorder 29	
30,32	5726–5750	Recorder 30	
30,32	5751–5775	Recorder 31	
30,32	5776–5800	Recorder 32	
		Event Summary Information	
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
DNP ANALOG OUTPUT POINT MAP			
		Remote Analog Outputs	
40,41	00–31	RA00–RA31	

DNP Object Type	Index	Description	Scaling/Deadband
		LDP Recorder and Start-Time Selection	
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.7 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
DNPIPn	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*n*	Transport Protocol. Selects between TCP and UDP protocols.	TCP, UDP	TCP
DNPUDP*n*	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.
- ➤ 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.8 summarizes the main options, listed from least to most efficient, and indicates the corresponding key settings.

Table D.8 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 non-zero 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 non-zero 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 non-zero value Set UNSOL = Y Set NUMEVE and AGEEVE to adjust the response rate

Device Profile

Table D.9 contains the standard DNP3 device profile information. The example device profile in the DNP3 subset definitions replaces traditional device profile check boxes with presentation of only relevant selections.

Table D.9 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

Parameter	Value
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 rollover	32 bits
Sends multifragment responses	No

Object Table

Table D.10 lists the objects and variations with supported function codes and qualifier codes.

Table D.10 SEL-735 DNP Object List

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[a]	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[a]	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[a]	Binary Output Status	1	0, 1, 6, 7, 8	129	0, 1

Obj.	Var.	Description	Request (supported)		Response (may generate)	
			Funct. Codes (dec)	Qual. Codes (hex)	Funct. Codes (dec)	Qual. Codes (hex)
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[a]	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[a]	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[a]	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[a]	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[a]	16-Bit Analog Input Without Flag	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
30	5	Short Floating Point Analog Input	1	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
32	0	Analog Change Event—All Variations	1	6, 7, 8		

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[a]	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
32	7	Short Floating Point Analog Change Event With Time	1	6, 7, 8	129	17, 28
34	1	16-Bit Analog Reporting Deadband	1, 2	0, 1, 6, 7, 8, 17, 28	129	0, 1, 17, 28
34	2	32-Bit Analog Reporting Deadband	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[a]	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[a]	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			

[a] Default variation.

Default variation for Object 32 is linked to the default variation for Object 30 as shown in *Table D.11*:

Table D.11 Default Variations for Object 30 and Object 32

Object 30 Variation	Object 32 Variation
1 32-bit with flag	3 32-bit with time
2 16-bit with flag	4 16-bit with time
3 32-bit without flag	1 32-bit without time
4 16-bit without flag	2 16-bit without time
5 Short Floating Point Analog Input with flag	7 Short Floating Point Analog Change Event with time

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.12*.

Table D.12 Control Field

	Trip/Close Pairs		Code Selection Operation			
Index	**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
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[a]	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

[a] Indices 81–87 output for a one-second pulse.

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, except Indices 81–87, which pulse the corresponding output for the SELOGIC pulse for one second regardless of the code selection. 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 and FTP Communications Protocols

Overview

This appendix describes Modbus communications features that the SEL-735 supports. For 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

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	1–247
Function Code	1	Supported Modbus function codes
Data Region	0–251	0–255 (each byte)
Cyclical Redundancy Check (CRC)	2	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

If 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 (*n*)
n 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 zeros 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 toward 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 (*n*)
n 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 zeros to make an even byte.

Table E.8 defines input numbers.

Table E.8 Device Input Coils

Input Coil Number	Input Coil Name	Notes
0	IN101	
1	IN102	

Input Coil Number	Input Coil Name	Notes
2	IN401	Returns 0 if not installed
3	IN402	Returns 0 if not installed
4	IN403	Returns 0 if not installed
5	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 Coil 0 is IN101 and Input 5 is IN404). 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 (*n*)
n 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.12*.

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 (*n*)
n 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

Error	Error Code Returned	Communication Counter Increments
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
0–2	OUT101–OUT103	
3–6	OUT401–OUT404	Returns 0 if not installed
7–22	RB01–RB16	
23–38	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 Singe 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 by 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

Bytes	Field
1 byte	Bytes of Data (*n*)
n 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 password to the password registers by 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 Events Recorder Register Operation

You can read the Sequential Events 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	P1DU	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	

Field	Definition	Server Action	Notes
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[a]	Description	Range	Number of Registers Used
INT	Integer, signed	–32767 to 32767	1
INT*x*	Integer, signed with scale factor *x*	–32767 to 32767	1
UINT	Integer, unsigned	0 to 65535	1
UNIT*x*	Integer, unsigned with scale factor *x*	0 to 65535	1
LONG	Long, signed, most significant word in lower address register	–2147483647 to 2147483647	2
LONG*y*	Long, signed with scale factor *y*	–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

[a] 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

Enumerated Registers	Register Addresses	Value	Definition
Time Source	206	0	Internal
		1	External
Selected record: Type	218	0	Device settings changed
		1	Power restored
		2	Power loss
		3	Time change greater than TIME_CHG.
		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 *n*: 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

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
Device Configuration					
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
Control and I/O Commands					
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
Status					
100–149	0064–0095	Device Word Bit Status		R	BITMAP
150–159	0096–009F	Reserved		R	UINT
Communication Counters					
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

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
169	00A9	Bad Packet Length		R	UINT
170–179	00AA–00B3	Reserved		R	UINT
Diagnostics					
180	00B4	BATT		R	ENUM
181	00B5	TEMP		R	ENUM
182	00B6	Reserved		R	UINT
Time					
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
Sequential Events Recorder					
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			

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
253–259	00FD–0103	Selected Record + 5			
260–266	0104–010A	Selected Record + 6			
267–273	010B–0111	Selected Record + 7			
247–280	0112–0118	Selected Record + 8			
281–287	0119–011F	Selected Record + 9			
288–349	0120–015D	Reserved		R	UINT
Voltage, Current, and Power					
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	VB		R	LONG100
362–363	016A–016B	VC		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
Demand—Present Interval					
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

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
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
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

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
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
Demand—Peak					
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
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

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
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
Energy					
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

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
624–625	0270–0271	WHA_NET	Note that in some older SEL devices, WHA_NET, WHB_NET, WHC_NET, and WH3_NET are named EA_NET, EB_NET, EC_NET, and E3_NET, respectively.	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
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

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
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
Frequency					
900	0384	FREQ		R	UINT100
901	0385	FREQ_PQ		R	UINT100
902–909	0386–038D	Reserved		R	UINT
Power Factor					
910	038F	PFD3		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	UINT
924	039C	LDPFTC		R	UINT
925	039D	LDPFT3		R	UINT
926–999	039E–03E7	Reserved		R	UINT
Configured Registers					
1000–1001	03E8–03E9	CFG0001		R	LONG
1002–2997	03EA–0BB5	CFG0002–CFG0999		R	LONG
2998–2999	0BB6–0BB7	CFG1000		R	LONG

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
3000–3999	0BB8–0F9F	Reserved		R	UINT
Fundamental-Only Voltage, Current, and Power					
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

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
4066–4067	0FE2–0FE3	Q3_DEL_LD		R	LONG100
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
Load Profile					
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

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
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
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

Address		Name	Notes	Read (R) Write (W)	Data Types
Decimal	Hexadecimal				
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
User-Mapped Registers					
9100–9224	238C–2408	Mapped Register		RW	UINT
9225–9349	2409–2485	Mapped Register Value		R	UINT
9350–10099	2486–2773	Reserved		R	UINT
Status (Extended)					
10100–10127	2774–278F	Device Word Bit Status		R	BITMAP
10128–65535	2790–FFFF	Reserved		R	UINT

FTP Communications Protocol

File Transfer Protocol (FTP) is a method of transferring files from one location to another over the internet. It is often used when communicating with remote networks. This provides a step-by-step guide to transferring files for an SEL device using FTP with various methods and software. This includes SEL QuickSet, Filezilla, Windows 10 File Explorer, and the command prompt. Each method has its advantages and disadvantages. Sometimes it is will be advantageous to use one method over the other, whether you are using a public device, a Windows 10 OS, or a Linux OS.

SEL QuickSet

Step 1. Open SEL QuickSet.

Step 2. Select **Communication > Network**.

Step 3. In File Transfer Option, select **FTP**.

Step 4. In Host IP Address, enter the IP Address for the unit.

Step 5. Set Port Number (FTP) to 21.

Step 6. Enter the Access Level 2 password.

Step 7. Select **OK**.

Step 8. Select **Tools > Events > Get Event Files**.

Step 9. Select the desired event file.

Step 10. Select **Get Selected Events**.

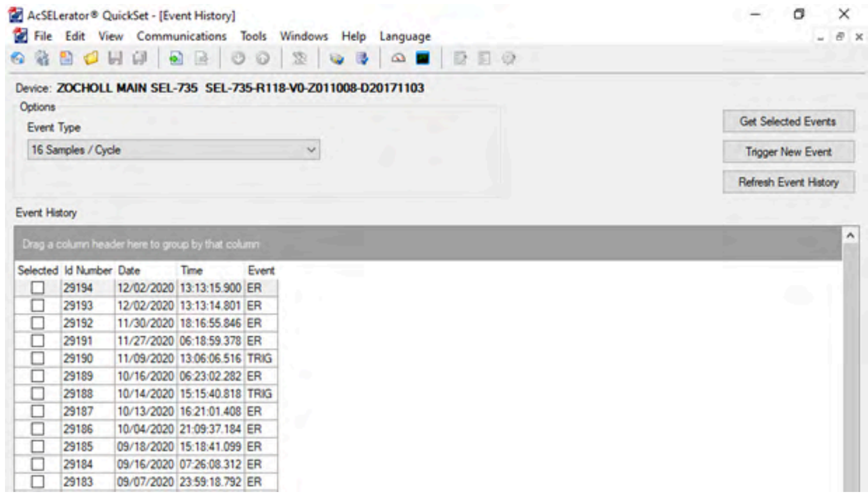

Figure E.1 QuickSet Event History Screen

FileZilla

Step 1. Install FileZilla: https://filezilla-project.org/download.php?type=client

Step 2. Open FileZilla and select **file** in the top left corner, then select **Site Manager**.

Step 3. Select the new site and name it.

Step 4. Input **IP Address** for the host and **21** for the port.

Step 5. Input the default username for the User: FTPUSER

Step 6. Select **Transfer Setting**. Check **Limit number of simultaneous connections**. Ensure **Maximum number of connections:** is set to 1.

Step 7. Select **Connect**.

Step 8. The password is the Access Level 2 Password provided (default: TAIL).

Step 9. Select **OK**, then select **OK** again.

Step 10. Select the EVENTS folder.

Step 11. Right-click on the desired event and select **Download**.

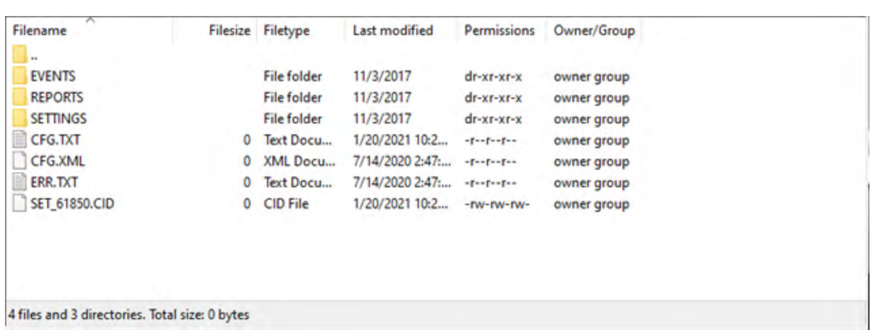

Figure E.2 FileZilla Screen

Windows Explorer FTP

Step 1. Open the file explorer program.

Step 2. Select the top search bar and enter **ftp://(Your IP Address Here)**.

Step 3. Enter the default username (FTPUSER) and the Access Level 2 password (default is TAIL).

Step 4. A new file explorer tab should now open (Note: If you are asked to enter the password again after opening the new file explorer tab, close the request window and proceed).

Step 5. Select the EVENTS folder. Right-click on the desired event. Select **Copy**, then paste it into your desired location.

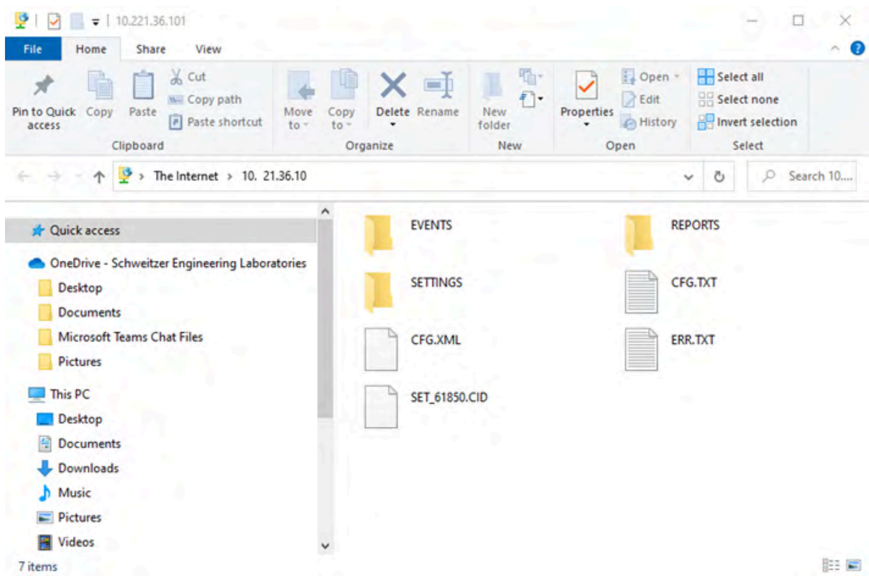

Figure E.3 Windows Explorer

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APPENDIX F

MIRRORED BITS Communications

Overview

MIRRORED BITS 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 (A or B), and control for these bits comes from corresponding SELOGIC 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

Port Connections

See *Table 8.8*.

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*x*) 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*x* 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*x* only after successful synchronization (according to the following description) and two consecutive messages pass all of the data checks described previously. After ROK*x* reasserts, security counters (for which the following text provides descriptions) can delay passage of data the meter receives.

Transfer of received data to RMB1*x*–RMB8*x* 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*x* 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 ROKx, 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*x* 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, ROKx is deasserted, and another user-accessible flag, LBOK*x*, 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 428*)

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*x*.

You would typically combine RBAD*x* 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*x*.

You would typically combine CBAD*x* 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.

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.

  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 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 BITS 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 ±1 second.

```
PPM Mirrored Bits Channel Bad Pickup(1-10000)     CBADPU= 1000    ?
```

Use the CBADPU setting to determine the ratio of channel downtime 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.

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.25* 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.

NOTE
Configured Registers process at 200 ms (10/12 cycles) intervals. If the update rate of the quantity selected for the configurable register is slower than 10/12 cycles, the register updates at the rate of the analog quantity selected.

NOTE
Update rate is based on the number of analog outputs in use. For example, the update rate is 4 cycles when 4 analog outputs are in use, and the update rate is 3 cycles when 3 analog outputs are in use.

NOTE
SELOGIC processes every half cycle. The SELOGIC variables update rate is based on the selected quantity update rate.

Table G.1 Analog Quantities Available to Internal Interface Types

Internal Interface Type	Available Analog Quantities
Configured Registers	All analog quantities except DATE, TIME, DATE_TIME, SSI summary records, and Configured Registers
Load Profile	Voltage, Current, and Power; Demand, Peak Demand, Previous Demand; Energy; Frequency; Power Factor; Aggregation; Configured Registers; Diagnostics; DNP Remote Analog Outputs; Flicker; Harmonics; Maximum/Minimum, Crest Factor; Monthly Frozen/Consumed Values; SELOGIC; Symmetrical Components; Time-of-Use Metering; Transformer Settings; Voltage and Current Imbalance and Average; Voltage and Frequency Deviation; and LDP<01–32>CH<01–16> quantities

Internal Interface Type	Available Analog Quantities
Display Points	Voltage, Current, and Power; Demand, Peak Demand, Previous Demand; Energy; Frequency; Power Factor; Aggregation; Configured Registers; Diagnostics; DNP Remote Analog Outputs; Flicker; Fundamental Only; Harmonics; Maximum/Minimum, Crest Factor; Monthly Frozen/Consumed Values; SELOGIC; Symmetrical Components; Time-of-Use Metering; Transformer and Line Losses; Voltage and Current Imbalance and Average; Voltage and Frequency Deviation Date and Time: DATE, TIME, DATE_TIME; Present, Previous, Self-Read Previous (S1PREV), and Self-Read Present (S1PRES) quantities from Time-of-Use, Peak Demand (including Time-of-Use), Maximum/Minimum, Crest Factor, and LDP<01–12>CH<01–16> quantities
Custom Screens	All analog quantities
Analog Outputs	Voltage, Current, and Power; Demand, Peak Demand, Previous Demand; Energy; Frequency; Power Factor; Aggregation; Configured Registers; Diagnostics; DNP Remote Analog Outputs; Flicker; Fundamental Only; Harmonics; Maximum/Minimum, Crest Factor; Monthly Frozen/Consumed Values; SELOGIC; Symmetrical Components; Transformer Settings; Voltage and Current Imbalance and Average; Voltage and Frequency Deviation
SELOGIC[a]	Voltage, Current, and Power; Demand, Peak Demand, Previous Demand; Energy; Frequency; Power Factor; Aggregation; Configured Registers; Diagnostics; DNP Remote Analog Outputs; Flicker; Fundamental Only; Harmonics; Maximum/Minimum, Crest Factor; Monthly Frozen/Consumed Values; SELOGIC; Symmetrical Components; Time-of-Use Metering; Transformer Settings; Voltage and Current Imbalance and Average; Voltage and Frequency Deviation; Fundamental-Only Voltage and Current; Half-Cycle Fundamental Power; (excludes DATE, TIME, and DATE_TIME)
KYZ Pulse Outputs	Energy
Predictive Demand	Demand
Test Mode Output	Energy (excludes uncompensated values)
IEC 61850	Voltage, Current, and Power; Demand, Peak Demand, Previous Demand; Energy; Frequency; Power Factor; Aggregation; Configured Registers; Diagnostics; DNP Remote Analog Outputs; Flicker; Fundamental Only; Harmonics; Maximum/Minimum, Crest Factor; Monthly Frozen/Consumed Values; SELOGIC; Symmetrical Components; Time-of-Use Metering; Transformer Settings; Voltage and Current Imbalance and Average; Voltage and Frequency Deviation; SSI Summary Record(s); and Date/Time (excludes DATE, TIME, and DATE_TIME)
Synchrophasor Analog Quantities	Voltage, Current, and Power; Demand, Peak Demand, Previous Demand; Energy; Frequency; Power Factor; Aggregation; Configured Registers; Diagnostics; DNP Remote Analog Outputs; Flicker; Fundamental Only; Harmonics; Maximum/Minimum, Crest Factor; Monthly Frozen/Consumed Values; SELOGIC; Symmetrical Components; Time-of-Use Metering; Transformer Settings; Voltage and Current Imbalance and Average; Voltage and Frequency Deviation; CFG0001–CFG1000

[a] Analog quantities in SELOGIC are represented 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
- IEEE C37.118 (See *NUMANA, PMUAQ1, PMUAQ2, PMUAQ3, and PMUAQ4 on page 522*)

Analog Quantity Scaling

The SEL-735 supports analog quantity scaling in unity, kilo, or mega scales based on 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 in most external interfaces. Set PRI_SCA = Y to scale analog quantities in primary units, and set PRI_SCA = N to scale analog quantities in secondary units. SELOGIC uses secondary values even if PRI_SCA = Y.

Analog quantities used in the IEC 61850 interface are always in primary units regardless of the Analog Quantity Scaling settings, 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.

Analog quantities published in IEEE C37.118.2 Synchrophasor messages are always in primary units and scaling is in unity regardless of the Analog Quantity Scaling settings.

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.6 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	Update Rate[a]
Current			
Ix	Phase A, B, or C RMS Current	Amperes	10/12 cycles
IN	Neutral RMS Current	Amperes	10/12 cycles
Voltage			
Vx	Phase A, B, or C RMS Line-to-Neutral Voltage	Volts	10/12 cycles
VAB, VBC, VCA	Phase A-B, B-C, or C-A RMS Line-to-Line Voltage	Volts	10/12 cycles
Power			
W3	Three-phase Watts	Watts	10/12 cycles
W3_UC[b]	Three-phase Watts, uncompensated	Watts	10/12 cycles
U3	Three-phase apparent power	Volt-Amperes	10/12 cycles
Q3	Three-phase reactive power	Volt-Amperes reactive	10/12 cycles
Q3_UC[b]	Three-phase reactive power, uncompensated	Volt-Amperes reactive	10/12 cycles
Power, More			
Wx	Phase A, B, or C Watts	Watts	10/12 cycles
Wx_UC[b]	Phase A, B, or C Watts, uncompensated	Watts	10/12 cycles
Ux	Phase A, B, or C apparent power	Volt-Amperes	10/12 cycles
Qx	Phase A, B, or C reactive power	Volt-Amperes reactive	10/12 cycles
Qx_UC[b]	Phase A, B, or C reactive power, uncompensated	Volt-Amperes reactive	10/12 cycles

[a] Some of the meter analog quantity update rates are specified as 10/12 cycles. This means the meter processes and updates the analog quantities every 10 cycles for 50 Hz systems and 12 cycles for 60 Hz systems.
[b] Uncompensated values are not affected by transformer/line-loss compensation, regardless of whether ETLLC is set to Y or N.

Table G.3 Demand, Peak Demand, Previous Demand

Name	Description	Units	Update Rate
Demand, Present Interval, Three Phase			
WD3_DEL	Watt demand, 3Φ delivered	Watts	DMTC and DMSI time period
WD3_DEL_UC[a]	Watt demand, 3Φ delivered, uncompensated	Watts	DMTC and DMSI time period
WD3_REC	Watt demand, 3Φ received	Watts	DMTC and DMSI time period
WD3_REC_UC[a]	Watt demand, 3Φ received, uncompensated	Watts	DMTC and DMSI time period

Name	Description	Units	Update Rate
UD3_DEL	Volt-amp demand, 3Φ delivered	Volt-Amperes	DMTC and DMSI time period
UD3_REC	Volt-amp demand, 3Φ received	Volt-Amperes	DMTC and DMSI time period
QD3_DEL	Volt-amp reactive demand, 3Φ delivered	Volt-Amperes reactive	DMTC and DMSI time period
QD3_DEL_UC[a]	Volt-amp reactive demand, 3Φ delivered, uncompensated	Volt-Amperes reactive	DMTC and DMSI time period
QD3_REC	Volt-amp reactive demand, 3Φ received	Volt-Amperes reactive	DMTC and DMSI time period
QD3_REC_UC[a]	Volt-amp reactive demand, 3Φ received, uncompensated	Volt-Amperes reactive	DMTC and DMSI time period
Demand, Present Interval, More, Current			
IDx	Phase A, B, or C current demand	Amperes	DMTC and DMSI time period
IDN	Neutral current demand	Amperes	DMTC and DMSI time period
3I0D	Current demand, 3Φ zero sequence	Amperes	DMTC and DMSI time period
3I2D	Current demand, 3Φ negative sequence	Amperes	DMTC and DMSI time period
Demand, Present Interval, More, Real Power			
WDx_DEL	Phase A, B, or C watt demand, delivered	Watts	DMTC and DMSI time period
WDx_DEL_UC[a]	Phase A, B, or C watt demand, delivered, uncompensated	Watts	DMTC and DMSI time period
WDx_REC	Phase A, B, or C watt demand, received	Watts	DMTC and DMSI time period
WDx_REC_UC[a]	Phase A, B, or C watt demand, received, uncompensated	Watts	DMTC and DMSI time period
Demand, Present Interval, More, Apparent Power			
UDx_DEL	Phase A, B, or C apparent power demand, delivered	Volt-Amperes	DMTC and DMSI time period
UDx_REC	Phase A, B, or C apparent power demand, received	Volt-Amperes	DMTC and DMSI time period
Demand, Present Interval, More, Reactive Power			
QDx_DEL	Phase A, B, or C reactive power demand, delivered	Volt-Amperes reactive	DMTC and DMSI time period
QDx_DEL_UC[a]	Phase A, B, or C reactive power demand, delivered, uncompensated	Volt-Amperes reactive	DMTC and DMSI time period
QDx_REC	Phase A, B, or C reactive power demand, received	Volt-Amperes reactive	DMTC and DMSI time period
QDx_REC_UC[a]	Phase A, B, or C reactive power demand, received, uncompensated	Volt-Amperes reactive	DMTC and DMSI time period

Name	Description	Units	Update Rate
Demand, Present Interval, More, Reactive Power, 4-Quadrant			
QDx_DEL_LG	Three-phase, Phase A, B, or C lagging reactive power demand, delivered (Quadrant 1)	Volt-Amperes reactive	DMTC and DMSI time period
QDx_DEL_LG_UC[a]	Three-phase, Phase A, B, or C lagging reactive power demand, delivered (Quadrant 1), uncompensated	Volt-Amperes reactive	DMTC and DMSI time period
QDx_DEL_LD	Three-phase, Phase A, B, or C leading reactive power demand, delivered (Quadrant 2)	Volt-Amperes reactive	DMTC and DMSI time period
QDx_DEL_LD_UC[a]	Three-phase, Phase A, B, or C leading reactive power demand, delivered (Quadrant 2), uncompensated	Volt-Amperes reactive	DMTC and DMSI time period
QDx_REC_LG	Three-phase, Phase A, B, or C lagging reactive power demand, received (Quadrant 3)	Volt-Amperes reactive	DMTC and DMSI time period
QDx_REC_LG_UC[a]	Three-phase, Phase A, B, or C lagging reactive power demand, received (Quadrant 3), uncompensated	Volt-Amperes reactive	DMTC and DMSI time period
QDx_REC_LD	Three-phase, Phase A, B, or C leading reactive power demand, received (Quadrant 4)	Volt-Amperes reactive	DMTC and DMSI time period
QDx_REC_LD_UC[a]	Three-phase, Phase A, B, or C leading reactive power demand, received (Quadrant 4), uncompensated	Volt-Amperes reactive	DMTC and DMSI time period
Demand, Peak			
PEAK_DMND_RST_CNT	Number of Peak Demand Resets	NA	On peak demand reset
WP3_DEL	Active power peak demand, 3Φ delivered	Watts	DMTC and DMSI time period
WP3_DEL_UC[a]	Active power peak demand, 3Φ delivered, uncompensated	Watts	DMTC and DMSI time period
WP3_REC	Active power peak demand, 3Φ received	Watts	DMTC and DMSI time period
WP3_REC_UC[a]	Active power peak demand, 3Φ received, uncompensated	Watts	DMTC and DMSI time period
UP3_DEL	Apparent power peak demand, 3Φ delivered	Volt-Amperes	DMTC and DMSI time period
UP3_REC	Apparent power peak demand, 3Φ received	Volt-Amperes	DMTC and DMSI time period
QP3_DEL	Reactive power peak demand, 3Φ delivered	Volt-Amperes reactive	DMTC and DMSI time period
QP3_DEL_UC[a]	Reactive power peak demand, 3Φ delivered, uncompensated	Volt-Amperes reactive	DMTC and DMSI time period
QP3_REC	Reactive power peak demand, 3Φ received	Volt-Amperes reactive	DMTC and DMSI time period
QP3_REC_UC[a]	Reactive power peak demand, 3Φ received, uncompensated	Volt-Amperes reactive	DMTC and DMSI time period
Demand, Peak, More, Current			
IPx	Phase A, B, or C current peak demand	Amperes	DMTC and DMSI time period
IPN	Neutral current peak demand	Amperes	DMTC and DMSI time period

Name	Description	Units	Update Rate
3I0P	Current peak demand, 3Φ zero sequence	Amperes	DMTC and DMSI time period
3I2P	Current peak demand, 3Φ negative sequence	Amperes	DMTC and DMSI time period
Demand, Peak, More, Real Power			
WPx_DEL	Phase A, B, or C active power peak demand, delivered	Watts	DMTC and DMSI time period
WPx_REC	Phase A, B, or C active power peak demand, received	Watts	DMTC and DMSI time period
Demand, Peak, More, Apparent Power			
UPx_DEL	Phase A, B, or C apparent power peak demand, delivered	Volt-Amperes	DMTC and DMSI time period
UPx_REC	Phase A, B, or C apparent power peak demand, received	Volt-Amperes	DMTC and DMSI time period
Demand, Peak, More, Reactive Power			
QPx_DEL	Phase A, B, or C reactive power peak demand, delivered	Volt-Amperes reactive	DMTC and DMSI time period
QPx_DEL_UC	Phase A, B, or C reactive power peak demand, delivered, uncompensated	Volt-Amperes reactive	DMTC and DMSI time period
QPx_REC	Phase A, B, or C reactive power peak demand, received	Volt-Amperes reactive	DMTC and DMSI time period
QPx_REC_UC	Phase A, B, or C reactive power peak demand, received, uncompensated	Volt-Amperes reactive	DMTC and DMSI time period
Demand, Peak, More, Reactive Power, 4-Quadrant			
QPx_DEL_LG	Three-phase, Phase A, B, or C lagging reactive power peak demand, delivered (Quadrant 1)	Volt-Amperes reactive	DMTC and DMSI time period
QPx_DEL_LG_UC[a]	Three-phase, Phase A, B, or C lagging reactive power peak demand, delivered (Quadrant 1), uncompensated	Volt-Amperes reactive	DMTC and DMSI time period
QPx_DEL_LD	Three-phase, Phase A, B, or C leading reactive power peak demand, delivered (Quadrant 2)	Volt-Amperes reactive	DMTC and DMSI time period
QPx_DEL_LD_UC[a]	Three-phase, Phase A, B, or C leading reactive power peak demand, delivered (Quadrant 2), uncompensated	Volt-Amperes reactive	DMTC and DMSI time period
QPx_REC_LG	Three-phase, Phase A, B, or C lagging reactive power peak demand, received (Quadrant 3)	Volt-Amperes reactive	DMTC and DMSI time period
QPx_REC_LG_UC[a]	Three-phase, Phase A, B, or C lagging reactive power peak demand, received (Quadrant 3), uncompensated	Volt-Amperes reactive	DMTC and DMSI time period
QPx_REC_LD	Three-phase, Phase A, B, or C leading reactive power peak demand, received (Quadrant 4)	Volt-Amperes reactive	DMTC and DMSI time period
QPx_REC_LD_UC[a]	Three-phase, Phase A, B, or C leading reactive power peak demand, received (Quadrant 4), uncompensated	Volt-Amperes reactive	DMTC and DMSI time period
Demand, Previous Peak			
WPP3_DEL	Three-phase active power previous peak demand, delivered	Watts	On peak demand reset

Name	Description	Units	Update Rate
WPP3_DEL_UC[a]	Three-phase active power previous peak demand, delivered, uncompensated	Watts	On peak demand reset
WPP3_REC	Three-phase active power previous peak demand, received	Watts	On peak demand reset
WPP3_REC_UC[a]	Three-phase active power previous peak demand, received, uncompensated	Watts	On peak demand reset
UPP3_DEL	Three-phase apparent power previous peak demand, delivered	Volt-Amperes	On peak demand reset
UPP3_REC	Three-phase apparent power previous peak demand, received	Volt-Amperes	On peak demand reset
QPP3_DEL	Three-phase reactive power previous peak demand, delivered	Volt-Amperes reactive	On peak demand reset
QPP3_DEL_UC[a]	Three-phase reactive power previous peak demand, delivered, uncompensated	Volt-Amperes reactive	On peak demand reset
QPP3_REC	Three-phase reactive power previous peak demand, received	Volt-Amperes reactive	On peak demand reset
QPP3_REC_UC[a]	Three-phase reactive power previous peak demand, received, uncompensated	Volt-Amperes reactive	On peak demand reset
Demand, Previous Peak, More, Current			
IPP*x*	Phase A, B, or C current previous peak demand	Amperes	On peak demand reset
IPPN	Neutral current previous peak demand	Amperes	On peak demand reset
3I0PP	Current previous peak demand, 3 • zero sequence	Amperes	On peak demand reset
3I2PP	Current previous peak demand, 3 • negative sequence	Amperes	On peak demand reset
Demand, Previous Peak, More, Real Power			
WPPx_DEL	Phase A, B, or C active power previous peak demand, delivered	Watts	On peak demand reset
WPPx_DEL_UC[a]	Phase A, B, or C active power previous peak demand, delivered, uncompensated	Watts	On peak demand reset
WPPx_REC	Phase A, B, or C active power previous peak demand, received	Watts	On peak demand reset
WPPx_REC_UC[a]	Phase A, B, or C active power previous peak demand, received, uncompensated	Watts	On peak demand reset
Demand, Previous Peak, More, Apparent Power			
UPPx_DEL	Phase A, B, or C apparent power previous peak demand, delivered	Volt-Amperes	On peak demand reset
UPPx_REC	Phase A, B, or C apparent power previous peak demand, received	Volt-Amperes	On peak demand reset
Demand, Previous Peak, More, Reactive Power			
QPPx_DEL	Phase A, B, or C reactive power previous peak demand, delivered	Volt-Amperes reactive	On peak demand reset

Name	Description	Units	Update Rate
QPPx_DEL_UC[a]	Phase A, B, or C reactive power previous peak demand, delivered, uncompensated	Volt-Amperes reactive	On peak demand reset
QPPx_REC	Phase A, B, or C reactive power previous peak demand, received	Volt-Amperes reactive	On peak demand reset
QPPx_REC_UC[a]	Phase A, B, or C reactive power previous peak demand, received, uncompensated	Volt-Amperes reactive	On peak demand reset
Demand, Previous Peak, More, Reactive Power, 4-Quadrant			
QPPx_DEL_LG	Three-phase, Phase A, B, or C lagging reactive power previous peak demand, delivered (Quadrant 1)	Volt-Amperes reactive	On peak demand reset
QPPx_DEL_LG_UC[a]	Three-phase, Phase A, B, or C lagging reactive power previous peak demand, delivered (Quadrant 1), uncompensated	Volt-Amperes reactive	On peak demand reset
QPPx_DEL_LD	Three-phase, Phase A, B, or C leading reactive power previous peak demand, delivered (Quadrant 2)	Volt-Amperes reactive	On peak demand reset
QPPx_DEL_LD_UC[a]	Three-phase, Phase A, B, or C leading reactive power previous peak demand, delivered (Quadrant 2), uncompensated	Volt-Amperes reactive	On peak demand reset
QPPx_REC_LG	Three-phase, Phase A, B, or C lagging reactive power previous peak demand, received (Quadrant 3)	Volt-Amperes reactive	On peak demand reset
QPPx_REC_LG_UC[a]	Three-phase, Phase A, B, or C lagging reactive power previous peak demand, received (Quadrant 3), uncompensated	Volt-Amperes reactive	On peak demand reset
QPPx_REC_LD	Three-phase, Phase A, B, or C leading reactive power previous peak demand, received (Quadrant 4)	Volt-Amperes reactive	On peak demand reset
QPPx_REC_LD_UC[a]	Three-phase, Phase A, B, or C leading reactive power previous peak demand, received (Quadrant 4), uncompensated	Volt-Amperes reactive	On peak demand reset

[a] Uncompensated values are not affected by transformer/line-loss compensation, regardless of whether ETLLC is set to Y or N.

Table G.4 Energy

Name	Description	Units	Update Rate[a]
Energy			
WH3_DEL	Three-phase delivered active energy	Watt-hours	10/12 cycles
WH3_DEL_UC[b]	Three-phase delivered active energy, uncompensated	Watt-hours	10/12 cycles
WH3_REC	Three-phase received active energy	Watt-hours	10/12 cycles
WH3_REC_UC[b]	Three-phase received active energy, uncompensated	Watt-hours	10/12 cycles
UH3_DEL	Three-phase delivered apparent energy	Volt-Amperes hours	10/12 cycles
UH3_REC	Three-phase received apparent energy	Volt-Amperes hours	10/12 cycles
QH3_DEL	Three-phase delivered reactive energy	Volt-Amperes-reactive hours	10/12 cycles
QH3_DEL_UC[b]	Three-phase delivered reactive energy, uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QH3_REC	Three-phase received reactive energy	Volt-Amperes-reactive hours	10/12 cycles
QH3_REC_UC[b]	Three-phase received reactive energy, uncompensated	Volt-Amperes-reactive hours	10/12 cycles

Name	Description	Units	Update Rate[a]
Energy, More, Real Energy			
WHA_DEL	Wh, AΦ, delivered	Watt-hours	10/12 cycles
WHA_DEL_UC[b]	Wh, AΦ, delivered, uncompensated	Watt-hours	10/12 cycles
WHB_DEL	Wh, BΦ, delivered	Watt-hours	10/12 cycles
WHB_DEL_UC[b]	Wh, BΦ, delivered, uncompensated	Watt-hours	10/12 cycles
WHC_DEL	Wh, CΦ, delivered	Watt-hours	10/12 cycles
WHC_DEL_UC[b]	Wh, CΦ, delivered, uncompensated	Watt-hours	10/12 cycles
WHA_REC	Wh, AΦ, received	Watt-hours	10/12 cycles
WHA_REC_UC[b]	Wh, AΦ, received, uncompensated	Watt-hours	10/12 cycles
WHB_REC	Wh, BΦ, received	Watt-hours	10/12 cycles
WHB_REC_UC[b]	Wh, BΦ, received, uncompensated	Watt-hours	10/12 cycles
WHC_REC	Wh, CΦ, received	Watt-hours	10/12 cycles
WHC_REC_UC[b]	Wh, CΦ, received, uncompensated	Watt-hours	10/12 cycles
WHA_NET	Wh, AΦ, net (delivered—received)	Watt-hours	10/12 cycles
WHA_NET_UC	Wh, AΦ, net (delivered—received), uncompensated	Watt-hours	10/12 cycles
WHB_NET	Wh, BΦ, net (delivered—received)	Watt-hours	10/12 cycles
WHB_NET_UC	Wh, BΦ, net (delivered—received), uncompensated	Watt-hours	10/12 cycles
WHC_NET	Wh, CΦ, net (delivered—received)	Watt-hours	10/12 cycles
WHC_NET_UC	Wh, CΦ, net (delivered—received), uncompensated	Watt-hours	10/12 cycles
WH3_NET	Wh, 3Φ, net (delivered—received)	Watt-hours	10/12 cycles
WH3_NET_UC	Wh, 3Φ, net (delivered—received), uncompensated	Watt-hours	10/12 cycles
Energy, More, Apparent Energy			
UHA_DEL	VAh, AΦ, delivered	Volt-Amperes hours	10/12 cycles
UHB_DEL	VAh, BΦ, delivered	Volt-Amperes hours	10/12 cycles
UHC_DEL	VAh, CΦ, delivered	Volt-Amperes hours	10/12 cycles
UHA_REC	VAh, AΦ, received	Volt-Amperes hours	10/12 cycles
UHB_REC	VAh, BΦ, received	Volt-Amperes hours	10/12 cycles
UHC_REC	VAh, CΦ, received	Volt-Amperes hours	10/12 cycles
Energy, More, Reactive Energy			
QHA_DEL	VARh, AΦ, delivered	Volt-Amperes-reactive hours	10/12 cycles
QHA_DEL_UC[b]	VARh, AΦ, delivered, uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHB_DEL	VARh, BΦ, delivered	Volt-Amperes-reactive hours	10/12 cycles
QHB_DEL_UC[b]	VARh, BΦ, delivered, uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHC_DEL	VARh, CΦ, delivered	Volt-Amperes-reactive hours	10/12 cycles
QHC_DEL_UC[b]	VARh, CΦ, delivered, uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHA_REC	VARh, AΦ, received	Volt-Amperes-reactive hours	10/12 cycles

Name	Description	Units	Update Rate[a]
QHA_REC_UC[b]	VARh, AΦ, received, uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHB_REC	VARh, BΦ, received	Volt-Amperes-reactive hours	10/12 cycles
QHB_REC_UC[b]	VARh, BΦ, received, uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHC_REC	VARh, CΦ, received	Volt-Amperes-reactive hours	10/12 cycles
QHC_REC_UC[b]	VARh, CΦ, received, uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QH3_NET	VARh, 3Φ, (delivered—received)	Volt-Amperes-reactive hours	10/12 cycles
Energy, More, Reactive Energy, 4-Quadrant			
VARH3_DEL_LG	VARh, 3Φ, delivered, lag (Q1)	Volt-Amperes-reactive hours	10/12 cycles
QH3_DEL_LG	VARh, 3Φ, delivered, lag (Q1)	Volt-Amperes-reactive hours	10/12 cycles
QH3_DEL_LG_UC[b]	VARh, 3Φ, delivered, lag (Q1), uncompensated	Volt-Amperes-reactive hours	10/12 cycles
VARH3_DEL_LD	VARh, 3Φ, delivered, lead (Q2)	Volt-Amperes-reactive hours	10/12 cycles
QH3_DEL_LD	VARh, 3Φ, delivered, lead (Q2)	Volt-Amperes-reactive hours	10/12 cycles
QH3_DEL_LD_UC[b]	VARh, 3Φ, delivered, lead (Q2), uncompensated	Volt-Amperes-reactive hours	10/12 cycles
VARH3_REC_LG	VARh, 3Φ, received, lag (Q3)	Volt-Amperes-reactive hours	10/12 cycles
QH3_REC_LG	VARh, 3Φ, received, lag (Q3)	Volt-Amperes-reactive hours	10/12 cycles
QH3_REC_LG_UC[b]	VARh, 3Φ, received, lag (Q3), uncompensated	Volt-Amperes-reactive hours	10/12 cycles
VARH3_REC_LD	VARh, 3Φ, received, lead (Q4)	Volt-Amperes-reactive hours	10/12 cycles
QH3_REC_LD	VARh, 3Φ, received, lead (Q4)	Volt-Amperes-reactive hours	10/12 cycles
QH3_REC_LD_UC[b]	VARh, 3Φ, received, lead (Q4), uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHA_DEL_LG	VARh, AΦ, delivered, lag (Q1)	Volt-Amperes-reactive hours	10/12 cycles
QHA_DEL_LG_UC[b]	VARh, AΦ, delivered, lag (Q1), uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHA_DEL_LD	VARh, AΦ, delivered, lead (Q2)	Volt-Amperes-reactive hours	10/12 cycles
QHA_DEL_LD_UC[b]	VARh, AΦ, delivered, lead (Q2), uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHA_REC_LG	VARh, AΦ, received, lag (Q3)	Volt-Amperes-reactive hours	10/12 cycles
QHA_REC_LG_UC[b]	VARh, AΦ, received, lag (Q3), uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHA_REC_LD	VARh, AΦ, received, lead (Q4)	Volt-Amperes-reactive hours	10/12 cycles
QHA_REC_LD_UC[b]	VARh, AΦ, received, lead (Q4), uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHB_DEL_LG	VARh, BΦ, delivered, lag (Q1)	Volt-Amperes-reactive hours	10/12 cycles
QHB_DEL_LG_UC[b]	VARh, BΦ, delivered, lag (Q1), uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHB_DEL_LD	VARh, BΦ, delivered, lead (Q2)	Volt-Amperes-reactive hours	10/12 cycles
QHB_DEL_LD_UC[b]	VARh, BΦ, delivered, lead (Q2), uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHB_REC_LG	VARh, BΦ, received, lag (Q3)	Volt-Amperes-reactive hours	10/12 cycles
QHB_REC_LG_UC[b]	VARh, BΦ, received, lag (Q3), uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHB_REC_LD	VARh, BΦ, received, lead (Q4)	Volt-Amperes-reactive hours	10/12 cycles
QHB_REC_LD_UC[b]	VARh, BΦ, received, lead (Q4), uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHC_DEL_LG	VARh, CΦ, delivered, lag (Q1)	Volt-Amperes-reactive hours	10/12 cycles

Name	Description	Units	Update Rate[a]
QHC_DEL_LG_UC[b]	VARh, CΦ, delivered, lag (Q1), uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHC_DEL_LD	VARh, CΦ, delivered, lead (Q2)	Volt-Amperes-reactive hours	10/12 cycles
QHC_DEL_LD_UC[b]	VARh, CΦ, delivered, lead (Q2), uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHC_REC_LG	VARh, CΦ, received, lag (Q3)	Volt-Amperes-reactive hours	10/12 cycles
QHC_REC_LG_UC[b]	VARh, CΦ, received, lag (Q3), uncompensated	Volt-Amperes-reactive hours	10/12 cycles
QHC_REC_LD	VARh, CΦ, received, lead (Q4)	Volt-Amperes-reactive hours	10/12 cycles
QHC_REC_LD_UC[b]	VARh, CΦ, received, lead (Q4), uncompensated	Volt-Amperes-reactive hours	10/12 cycles
Energy, More, Volt-Hours			
VHA	Vh, Van (Vab if Form 5)	Volt-hours	10/12 cycles
VHB	Vh, Vbn (Vbc if Form 5)	Volt-hours	10/12 cycles
VHC	Vh, Vcn (Vca if Form 5)	Volt-hours	10/12 cycles
VH3	Vh, 3Φ	Volt-hours	10/12 cycles
Energy, More, Amp-Hours			
IHA	Ah, Ia	Ampere-hours	10/12 cycles
IHB	Ah, Ib	Ampere-hours	10/12 cycles
IHC	Ah, Ic	Ampere-hours	10/12 cycles
IHN	Ah, In	Ampere-hours	10/12 cycles
IH3	Ah, 3Φ	Ampere-hours	10/12 cycles

[a] Some of the meter analog quantity update rates are specified as 10/12 cycles. This means the meter processes and updates the analog quantities every 10 cycles for 50 Hz systems and 12 cycles for 60 Hz systems.
[b] Uncompensated values are not affected by transformer/line-loss compensation, regardless of whether ETLLC is set to Y or N.

Table G.5 Frequency

Name	Description	Units	Update Rate
Frequency			
FREQ	Fundamental frequency	Hertz	1/2 cycle
FREQ_PQ	Power quality frequency measurement	Hertz	10 seconds to lock, updated every 10 seconds
PMU Frequency	Synchrophasor frequency measurement	Hertz	Minimum of 1 per second to a maximum of 1 per cycle
DF_DT	Synchrophasor rate-of-change of frequency measurement	$1/s^2$	Minimum of 1 per second to a maximum of 1 per cycle

Table G.6 Power Factor

Name	Description	Units	Update Rate
Power Factor, Three Phase			
PFD3	Displacement PF, 3Φ	Unitless	Half-cycle
PFT3	True PF, 3Φ	Unitless	10/12 cycles
Power Factor, More, Displacement Power Factor			
PFDA	Displacement PF, AΦ	Unitless	Half-cycle

Name	Description	Units	Update Rate
PFDB	Displacement PF, BΦ	Unitless	Half-cycle
PFDC	Displacement PF, CΦ	Unitless	Half-cycle
LDPFDA	Lead/Lag indication, AΦ (1 = Lead, 0 = Lag)	Unitless	Half-cycle
LDPFDB	Lead/Lag indication, BΦ (1 = Lead, 0 = Lag)	Unitless	Half-cycle
LDPFDC	Lead/Lag indication, CΦ (1 = Lead, 0 = Lag)	Unitless	Half-cycle
LDPFD3	Lead/Lag indication, 3Φ (1 = Lead, 0 = Lag)	Unitless	Half-cycle
Power Factor, More, True Power Factor			
PFTA	True PF, AΦ	Unitless	10/12 cycles
PFTB	True PF, BΦ	Unitless	10/12 cycles
PFTC	True PF, CΦ	Unitless	10/12 cycles
LDPFTA	Lead/Lag indication, AΦ (1 = Lead, 0 = Lag)	Unitless	10/12 cycles
LDPFTB	Lead/Lag indication, BΦ (1 = Lead, 0 = Lag)	Unitless	10/12 cycles
LDPFTC	Lead/Lag indication, CΦ (1 = Lead, 0 = Lag)	Unitless	10/12 cycles
LDPFT3	Lead/Lag indication, 3Φ (1 = Lead, 0 = Lag)	Unitless	10/12 cycles

[a] Some of the meter analog quantity update rates are specified as 10/12 cycles. This means the meter processes and updates the analog quantities every 10 cycles for 50 Hz systems and 12 cycles for 60 Hz systems.

Advanced Analog Quantity List

Table G.7–Table G.25 list the advanced analog quantities. Note that "advanced" refers to the more detailed analog quantities, not the level of meter you are using. Most variables work on the basic, intermediate, and advanced models.

Table G.7 Aggregation

Name	Description	Units	Update Rate[a]
Advanced: Aggregation, Voltage (Replace n with 3SEC, 10MIN, or 2HR)			
VA_*n*	Aggregated rms voltage, Van	Volts	Depends on the aggregation period
VB_ *n*	Aggregated rms voltage, Vbn	Volts	Depends on the aggregation period
VC_*n*	Aggregated rms voltage, Vcn	Volts	Depends on the aggregation period
VAB_*n*	Aggregated rms voltage, Vab	Volts	Depends on the aggregation period
VBC_*n*	Aggregated rms voltage, Vbc	Volts	Depends on the aggregation period
VCA_*n*	Aggregated rms voltage, Vca	Volts	Depends on the aggregation period
Advanced: Aggregation, Current (Replace n with 3SEC, 10MIN, or 2HR)			
IA_*n*	Aggregated rms current, Ia	Amperes	Depends on the aggregation period

Name	Description	Units	Update Rate[a]
IB_*n*	Aggregated rms current, Ib	Amperes	Depends on the aggregation period
IC_*n*	Aggregated rms current, Ic	Amperes	Depends on the aggregation period
IN_*n*	Aggregated rms current, In	Amperes	Depends on the aggregation period
Advanced: Aggregation, Imbalance (Replace n with 3SEC, 10MIN, or 2HR)			
V_IMB_*n*	Aggregated negative-sequence voltage imbalance	%	Depends on the aggregation period
I_IMB_*n*	Aggregated negative-sequence current imbalance	%	Depends on the aggregation period
V0_IMB_*n*	Aggregated zero-sequence voltage imbalance	%	Depends on the aggregation period
I0_IMB_*n*	Aggregated zero-sequence current imbalance	%	Depends on the aggregation period
Advanced: Aggregation, Power (Replace n with 3SEC, 10MIN, or 2HR)			
W3_*n*	Aggregated watts, 3Φ	Watts	Depends on the aggregation period
U3_*n*	Aggregated VAs, 3Φ	Volt-Amperes	Depends on the aggregation period
Q3_*n*	Aggregated VARs, 3Φ	Volt-Amperes reactive	Depends on the aggregation period
WA_*n*	Aggregated watts, AΦ	Watts	Depends on the aggregation period
WB_*n*	Aggregated watts, BΦ	Watts	Depends on the aggregation period
WC_*n*	Aggregated watts, CΦ	Watts	Depends on the aggregation period
UA_*n*	Aggregated VAs, AΦ	Volt-Amperes	Depends on the aggregation period
UB_*n*	Aggregated VAs, BΦ	Volt-Amperes	Depends on the aggregation period
UC_*n*	Aggregated VAs, CΦ	Volt-Amperes	Depends on the aggregation period
QA_*n*	Aggregated VARs, AΦ	Volt-Amperes reactive	Depends on the aggregation period
QB_*n*	Aggregated VARs, BΦ	Volt-Amperes reactive	Depends on the aggregation period
QC_*n*	Aggregated VARs, CΦ	Volt-Amperes reactive	Depends on the aggregation period
Advanced: Aggregation, 1st–63rd Harmonic (Replace m with 1–63 and n with 3SEC, 10MIN, or 2HR)			
HRMM*m*_IA_*n*	*m*th Harmonic, aggregated current, Ia	Amperes	Depends on the aggregation period
HRMM *m*_IB_*n*	*m*th Harmonic, aggregated current, Ib	Amperes	Depends on the aggregation period

Name	Description	Units	Update Rate[a]
HRMM*m*_IC_ *n*	*m*th Harmonic, aggregated current, Ic	Amperes	Depends on the aggregation period
HRMM*m*_IN_*n*	*m*th Harmonic, aggregated current, In	Amperes	Depends on the aggregation period
HRMM *m*_VA_*n*	*m*th Harmonic, aggregated voltage, Van (Vab if Form 5)	Volts	Depends on the aggregation period
HRMM*m*_VB_*n*	*m*th Harmonic, aggregated voltage, Vbn (Vbc if Form 5)	Volts	Depends on the aggregation period
HRMM*m*_VC_*n*	*m*th Harmonic, aggregated voltage, Vcn (Vca if Form 5)	Volts	Depends on the aggregation period
Advanced: Aggregation, Total Harmonic Distortion (Replace n with 3SEC, 10MIN, or 2HR)			
THDIA_ *n*	THD %, aggregated Ia	%	Depends on the aggregation period
THDIB_ *n*	THD %, aggregated Ib	%	Depends on the aggregation period
THDIC_ *n*	THD %, aggregated Ic	%	Depends on the aggregation period
THDIN_ *n*	THD %, aggregated In	%	Depends on the aggregation period
THDVA_ *n*	THD %, aggregated Van (Vab if Form 5)	%	Depends on the aggregation period
THDVB_*n*	THD %, aggregated Vbn (Vbc if Form 5)	%	Depends on the aggregation period
THDVC_*n*	THD %, aggregated Vcn (Vca if Form 5)	%	Depends on the aggregation period

[a] The meter updates the quantities every 3 seconds, 10 minutes, or 2 hours if n is replaced with 3SEC, 10MIN, or 2HR, respectively.

Table G.8 Advanced: Configured Registers

Name	Description	Units	Update Rate[a]
Advanced: Configurable Registers (Replace nnnn = 0001–1000)			
CFG*nnnn*	User-configured register	User-defined	10/12 cycles

[a] Some of the meter analog quantity update rates are specified as 10/12 cycles. This means the meter processes and updates the analog quantities every 10 cycles for 50 Hz systems and 12 cycles for 60 Hz systems.

Table G.9 Advanced: Date and Time

Name	Description	Range	Update Rate
Advanced: Date and Time			
DATE[a]	Present date	0–31	Approximately 1 s
TIME[a]	Present time		Approximately 1 s
DATE_TIME[a]	Present date and time		Approximately 1 s
YEAR	Year number	0000–9999	Half-cycle
DAYY	Day of year number	1–366	Half-cycle
WEEK	Week number	1–52	Half-cycle

Name	Description	Range	Update Rate
DAYW	Day of week number (Sunday, DAYW=1)	1–7	Half-cycle
MINSM	Minutes since midnight	0–1439	Half-cycle

[a] Only available to Display points.

Table G.10 Advanced: Diagnostics

Name	Description	Units	Update Rate
Advanced: Diagnostics			
BATT	Real-time clock battery voltage	V	Approximately 1 s
TEMP	Internal device temperature	Celsius	Approximately 1 s

Table G.11 Advanced: DNP Remote Analog Outputs

Name	Description	Units	Update Rate
Advanced: DNP Remote Analog Outputs (Replace nn with 00–31)			
RA*nn*	DNP analog outputs		As packets received

Table G.12 Advanced: Flicker

Name	Description	Units	Update Rate[a]
Advanced: Flicker			
PINST_VA	Maximum instantaneous flicker, Van (Vab if Form 5)	Unitless	10/12 cycles
PINST_VB	Maximum instantaneous flicker, Vbn (Vbc if Form 5)	Unitless	10/12 cycles
PINST_VC	Maximum instantaneous flicker, Vcn (Vca if Form 5)	Unitless	10/12 cycles
PST_1MIN_VA	Short-term flicker, 1 minute, Van (Vab if Form 5)	Unitless	1 min (synchronized to clock time)
PST_1MIN_VB	Short-term flicker, 1 minute, Vbn (Vbc if Form 5)	Unitless	1 min (synchronized to clock time)
PST_1MIN_VC	Short-term flicker, 1 minute, Vcn (Vca if Form 5)	Unitless	1 min (synchronized to clock time)
PST_10MIN_VA	Short-term flicker, 10 minute, Van (Vab if Form 5)	Unitless	10 min (synchronized to clock time)
PST_10MIN_VB	Short-term flicker, 10 minute, Vbn (Vbc if Form 5)	Unitless	10 min (synchronized to clock time)
PST_10MIN_VC	Short-term flicker, 10 minute, Vcn (Vca if Form 5)	Unitless	10 min (synchronized to clock time)
PLT_VA	Long-term flicker, 2 hour, Van (Vab if Form 5)	Unitless	2 hrs (synchronized to clock time)
PLT_VB	Long-term flicker, 2 hour, Vbn (Vbc if Form 5)	Unitless	2 hrs (synchronized to clock time)
PLT_VC	Long-term flicker, 2 hour, Vcn (Vca if Form 5)	Unitless	2 hrs (synchronized to clock time)
SEC_PINST	Seconds until PINST and PST_1MIN update	Seconds	10/12 cycles
SEC_PST	Seconds until PST 10 minute update	Seconds	10/12 cycles
SEC_PLT	Seconds until PLT 2 hour update	Seconds	10/12 cycles

[a] Some of the meter analog quantity update rates are specified as 10/12 cycles. This means the meter processes and updates the analog quantities every 10 cycles for 50 Hz systems and 12 cycles for 60 Hz systems.

Table G.13 Advanced: Fundamental Only

Name	Description	Units	Update Rate[a]	SELogic Update Rate
Advanced: Fundamental Only				
IA_FUND	Current magnitude, Ia	Amperes	10/12 cycles	Half-cycle
IB_FUND	Current magnitude, Ib	Amperes	10/12 cycles	Half-cycle
IC_FUND	Current magnitude, Ic	Amperes	10/12 cycles	Half-cycle
IN_FUND	Current magnitude, In	Amperes	10/12 cycles	Half-cycle
VA_FUND	Voltage magnitude, Van	Volts	10/12 cycles	Half-cycle
VB_FUND	Voltage magnitude, Vbn	Volts	10/12 cycles	Half-cycle
VC_FUND	Voltage magnitude, Vcn	Volts	10/12 cycles	Half-cycle
VAB_FUND	Voltage magnitude, Vab	Volts	10/12 cycles	Half-cycle
VBC_FUND	Voltage magnitude, Vbc	Volts	10/12 cycles	Half-cycle
VCA_FUND	Voltage magnitude, Vca	Volts	10/12 cycles	Half-cycle
IA_ANG	Current, Ia angle	Degrees	10/12 cycles	Half-cycle
IB_ANG	Current, Ib angle	Degrees	10/12 cycles	Half-cycle
IC_ANG	Current, Ic angle	Degrees	10/12 cycles	Half-cycle
IN_ANG	Current, In angle	Degrees	10/12 cycles	Half-cycle
VA_ANG	Voltage, Van angle	Degrees	10/12 cycles	Half-cycle
VB_ANG	Voltage, Vbn angle	Degrees	10/12 cycles	Half-cycle
VC_ANG	Voltage, Vcn angle	Degrees	10/12 cycles	Half-cycle
VAB_ANG	Voltage, Vab, angle	Degrees	10/12 cycles	Half-cycle
VBC_ANG	Voltage, Vbc angle	Degrees	10/12 cycles	Half-cycle
VCA_ANG	Voltage, Vca angle	Degrees	10/12 cycles	Half-cycle
Advanced: Fundamental Only, Power, 3-Phase				
W3_FUND	Fundamental watts, 3Φ	Watts	10/12 cycles	Half-cycle
S3_FUND	Fundamental VAs, 3Φ	Volt-Amperes	10/12 cycles	Half-cycle
Q3_FUND	Fundamental VARs, 3Φ	Volt-Amperes reactive	10/12 cycles	Half-cycle
Advanced: Fundamental Only, Power, More				
Wx_FUND	Fundamental watts; Phase A, B, or C	Watts	10/12 cycles	Half-cycle
Sx_FUND	Fundamental VAs; Phase A, B, or C	Volt-Amperes	10/12 cycles	Half-cycle
Qx_FUND	Fundamental VARs; Phase A, B, or C	Volt-Amperes reactive	10/12 cycles	Half-cycle
Advanced: Fundamental Only, Power, More, 4-Quadrant Reactive Power				
Qx_DEL_LG	Fundamental VARs, delivered, lag (Q1); Phase A, B, or C, or 3-Phase	Volt-Amperes reactive	10/12 cycles	Half-cycle
Qx_DEL_LD	Fundamental VARs, delivered, lead (Q2); Phase A, B, or C, or 3-Phase	Volt-Amperes reactive	10/12 cycles	Half-cycle

Name	Description	Units	Update Rate[a]	SELogic Update Rate
Qx_REC_LG	Fundamental VARs, received, lag (Q3); Phase A, B, or C, or 3-Phase	Volt-Amperes reactive	10/12 cycles	Half-cycle
Qx_REC_LD	Fundamental VARs, received, lead (Q4); Phase A, B, or C, or 3-Phase	Volt-Amperes reactive	10/12 cycles	Half-cycle

[a] Some of the meter analog quantity update rates are specified as 10/12 cycles. This means the meter processes and updates the analog quantities every 10 cycles for 50 Hz systems and 12 cycles for 60 Hz systems.

Table G.14 Advanced: Half-Cycle Fundamental Power

Name	Description	Units	Update Rate	SELogic Update Rate
Advanced: Half-Cycle Fundamental Power, 3-Phase				
W3_HALF_CYCLE	Half-cycle fundamental watts, 3Φ	Watts	Half-cycle	Half-cycle
S3_HALF_CYCLE	Half-cycle fundamental VAs, 3Φ	Volt-Amperes	Half-cycle	Half-cycle
Q3_HALF_CYCLE	Half-cycle fundamental VARs, 3Φ	VARS	Half-cycle	Half-cycle
Advanced: Half-Cycle Fundamental Power, More				
Wx_HALF_CYCLE	Half-cycle fundamental watts; Phase A, B, or C	Watts	Half-cycle	Half-cycle
Sx_HALF_CYCLE	Half-cycle fundamental VAs; Phase A, B, or C	Volt-Amperes	Half-cycle	Half-cycle
Qx_HALF_CYCLE	Half-cycle fundamental VARs; Phase A, B, or C	Volt-Amperes reactive	Half-cycle	Half-cycle

Table G.15 Advanced: Harmonics

Name	Description	Units	Update Rate[a]
Advanced: Harmonics, Total Harmonic Distortion			
THDIx	Current THD; Phase A, B, or C	%	10/12 cycles
THDIN	Neutral current THD	%	10/12 cycles
THDVx	Voltage THD; Phase A, B, or C (Vab, Vbc, or Vca if Form 5)	%	10/12 cycles
Advanced: Harmonics, Total Harmonic Distortion per HARMCAL Setting			
THDGIx	Current THD per HARMCAL setting; Phase A, B, or C	%	10/12 cycles
THDGIN	Neutral current THD per HARMCAL setting	%	10/12 cycles
THDGVx	Voltage THD per HARMCAL setting; Phase A, B, or C (Vab, Vbc, or Vca if Form 5)	%	10/12 cycles
Advanced: Harmonics, K-Factor			
KFx	K-factor ratio; Phase A, B, or C	Unitless	10/12 cycles
Advanced: Harmonics, Distortion Power Ratio			
DPx	Distortion power ratio; Phase A, B, or C, or 3-Phase	Unitless	10/12 cycles
Advanced: Harmonics, Percentage of Fundamental, 1st–63rd (Replace n with 1–63)			
HRM*n*_Ix	*n*th Current harmonic %; Phase A, B, or C	%	10/12 cycles
HRM*n*_IN	*n*th Neutral current harmonic %	%	10/12 cycles

Name	Description	Units	Update Rate[a]
HRM*n*_Vx	*n*th Voltage harmonic %; Phase A, B, or C (Vab, Vbc, or Vca if Form 5)	%	10/12 cycles
Advanced: Harmonics, Magnitude and Angle, 1st–63rd (Replace n with 1–63)			
HRMM*n*_Ix	*n*th Harmonic current magnitude; Phase A, B, or C Form 5 meters: HRMM*n*_IB reports zero	Amperes	10/12 cycles
HRMA*n*_Ix	*n*th Harmonic current angle; Phase A, B, or C Form 5 meters: HRMA*n*_IB reports zero	Degrees	10/12 cycles
HRMM*n*_IN	*n*th Harmonic neutral current magnitude	Amperes	10/12 cycles
HRMA*n*_IN	*n*th Harmonic current magnitude	Degrees	10/12 cycles
HRMM*n*_Vx	*n*th Harmonic voltage magnitude; Phase A, B, or C For Form 5 meters: HRMM*n*_VA reports Vab harmonics HRMM*n*_VB is forced to zero HRMM*n*_VC reports Vcb harmonics	Volts	10/12 cycles
HRMA*n*_Vx	*n*th Harmonic voltage angle; Phase A, B, or C For Form 5 meters: HRMA*n*_VA reports Vab harmonics HRMA*n*_VB is forced to zero HRMA*n*_VC reports Vcb harmonics	Degrees	10/12 cycles
Advanced: Harmonics, Power, 2nd–63rd (Replace n with 2–63)			
HRMP*n*_x	*n*th Harmonic active power; Phase A, B, C, or three-phase	Watts	10/12 cycles

[a] Some of the meter analog quantity update rates are specified as 10/12 cycles. This means the meter processes and updates the analog quantities every 10 cycles for 50 Hz systems and 12 cycles for 60 Hz systems.

Table G.16 Advanced: Maximum/Minimum, Crest Factor

Name	Description	Units	Update Rate[a]
Advanced: Maximum/Minimum Current			
IxMX	Maximum phase A, B, or C current	Amperes	10/12 cycles
INMX	Maximum neutral current	Amperes	10/12 cycles
IxMN	Minimum phase A, B, or C current	Amperes	10/12 cycles
INMN	Minimum neutral current	Amperes	10/12 cycles
Advanced: Maximum/Minimum Voltage			
VxMX	Phase A, B, or C maximum voltage (Vab, Vbc, or Vca if Form 5)	Volts	10/12 cycles
VxMN	Phase A, B, or C minimum voltage (Vab, Vbc, or Vca if Form 5)	Volts	10/12 cycles
Advanced: Maximum/Minimum Power			
W3MX	Watts, 3Φ maximum	Watts	10/12 cycles
U3MX	VAs, 3Φ maximum	Volt-Amperes	10/12 cycles
Q3MX	VARs, 3Φ maximum	Volt-Amperes reactive	10/12 cycles
W3MN	Watts, 3Φ minimum	Watts	10/12 cycles
U3MN	VAs, 3Φ minimum	Volt-Amperes	10/12 cycles
Q3MN	VARs, 3Φ minimum	Volt-Amperes reactive	10/12 cycles
Advanced: Maximum/Minimum Crest Factor, Current			
IxCFMX	Phase A, B, or C maximum current crest factor	Unitless	10/12 cycles

Name	Description	Units	Update Rate[a]
INCFMX	Maximum neutral current crest factor	Unitless	10/12 cycles
IxCFMN	Phase A, B, or C minimum current crest factor	Unitless	10/12 cycles
INCFMN	Minimum neutral current crest factor	Unitless	10/12 cycles
Advanced: Maximum/Minimum Crest Factor, Voltage			
VxCFMX	Phase A, B, or C maximum voltage crest factor (Vab, Vbc, or Vca if Form 5)	Unitless	10/12 cycles
VxCFMN	Phase A, B, or C minimum voltage crest factor (Vab, Vbc, or Vca if Form 5)	Unitless	10/12 cycles

[a] Some of the meter analog quantity update rates are specified as 10/12 cycles. This means the meter processes and updates the analog quantities every 10 cycles for 50 Hz systems and 12 cycles for 60 Hz systems.

Table G.17 Advanced: Monthly Frozen/Consumed Values

Name	Description	Units	Update Rate
Advanced: Monthly, DST, and Season Change Energy			
ENGY_STA	Energy set status present month	Unitless	Approximately 1 s
ENGY_STA_1M	Energy set status previous month	Unitless	Start of every month
ENGY_STA_2M	Energy set status two months previous	Unitless	Start of every month
FWH3_DEL	Frozen Wh 3Φ delivered, start of present month	Watt-hours	Start of every month
FWH3_DEL_1M	Frozen Wh 3Φ delivered, start of previous month	Watt-hours	Start of every month
FWH3_DEL_2M	Frozen Wh 3Φ delivered, start of two months previous	Watt-hours	Start of every month
FWH3_REC	Frozen Wh 3Φ received, start of present month	Watt-hours	Start of every month
FWH3_REC_1M	Frozen Wh 3Φ received, start of previous month	Watt-hours	Start of every month
FWH3_REC_2M	Frozen Wh 3Φ received, start of two months previous	Watt-hours	Start of every month
CWH3_DEL	Consumed Wh 3Φ delivered, present month	Watt-hours	Approximately 1 s
CWH3_DEL_1M	Consumed Wh 3Φ delivered, previous month	Watt-hours	Start of every month
CWH3_DEL_2M	Consumed Wh 3Φ delivered, two months previous	Watt-hours	Start of every month
CWH3_REC	Consumed Wh 3Φ received, present month	Watt-hours	Approximately 1 s
CWH3_REC_1M	Consumed Wh 3Φ received, previous month	Watt-hours	Start of every month
CWH3_REC_2M	Consumed Wh 3Φ received, two months previous	Watt-hours	Start of every month
ENGY_STA_DCE	DST change event energy set status	Unitless	Approximately 1 s
FDWH3_DEL	Frozen Wh 3Φ delivered, at DST change	Watt-hours	On DST event
FDQH3_DEL	Frozen VARh 3Φ delivered, at DST change	Volt-Amperes-reactive hours	On DST event
CDWH3_DEL	Consumed Wh 3Φ delivered, between recent two DST changes	Watt-hours	Approximately 1 s
ENGY_STA_SCE	Season change event energy set status	Unitless	Approximately 1 s
FSWH3_DEL	Frozen Wh 3Φ delivered, at TOU season change	Watt-hours	On season change

Name	Description	Units	Update Rate
FSQH3_DEL	Frozen VARh 3Φ delivered, at TOU season change	Volt-Amperes-reactive hours	On season change
CSWH3_DEL	Consumed Wh 3Φ delivered, between recent two TOU season changes	Watt-hours	Approximately 1 s

Table G.18 Advanced: SELOGIC

Name	Description	Units	Update Rate
Advanced: SELOGIC: (Replace n with 01–16)			
SC*n*	SELOGIC counter *n* present value		Half-cycle
MV*n*	SELOGIC math variable *n* present value		Half-cycle

Table G.19 Advanced: Symmetrical Components

Name	Description	Units	Update Rate
Advanced: Symmetrical Components			
3I0_MAG	Current, 3Φ zero-sequence	Amperes	Half-cycle
I1_MAG	Current, positive-sequence	Amperes	Half-cycle
3I2_MAG	Current, 3Φ negative-sequence	Amperes	Half-cycle
3V0_MAG	Voltage, 3Φ zero-sequence	Volts	Half-cycle
V1_MAG	Voltage, positive-sequence	Volts	Half-cycle
V2_MAG	Voltage, negative-sequence	Volts	Half-cycle
3I0_ANG	Current, 3Φ zero-sequence, angle	Degrees	Half-cycle
I1_ ANG	Current, positive-sequence, angle	Degrees	Half-cycle
3I2_ ANG	Current, 3Φ negative-sequence, angle	Degrees	Half-cycle
3V0_ ANG	Voltage, 3Φ zero-sequence, angle	Degrees	Half-cycle
V1_ ANG	Voltage, positive-sequence, angle	Degrees	Half-cycle
V2_ ANG	Voltage, negative-sequence, angle	Degrees	Half-cycle

Table G.20 Advanced: Time-of-Use Metering

Name	Description	Units	Update Rate
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	For Z = PRES: 10/12 cycles For Z = PREV: On season change For Z = S*n*PRES or S*n*PREV: On self-read event
Z_UH_<A–F>_TOT	VAh, 3Φ, rate <A–F>, total	Volt-Amperes hours	
Z_QH_<A–F>_TOT	VARh, 3Φ, rate <A–F>, total	Volt-Amperes-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-Amperes hours	
Z_QH_<A–F>_REC	VARh, 3Φ, rate <A–F>, received	Volt-Amperes-reactive hours	

Name	Description	Units	Update Rate
Advanced: Time-of-Use Metering, Energy, Nonrated Energy			
Z_WH_TOT	Wh, 3Φ, nonrated, total	Watt-hours	For Z = PRES: 10/12 cycles For Z = PREV: On season change For Z = S*n*PRES or S*n*PREV: On self-read event
Z_UH_TOT	VAh, 3Φ, nonrated, total	Volt-Amperes hours	
Z_QH_TOT	VARh, 3Φ, nonrated, total	Volt-Amperes-reactive hours	
Z_WH_REC	Wh, 3Φ, nonrated, received	Watt-hours	
Z_UH_REC	VAh, 3Φ, nonrated, received	Volt-Amperes hours	
Z_QH_REC	VARh, 3Φ, nonrated, received	Volt-Amperes-reactive hours	
Z_QH_DEL_LD	VARh, 3Φ, nonrated, delivered, leading	Volt-Amperes-reactive hours	
Z_QH_DEL_LG	VARh, 3Φ, nonrated, delivered, lagging	Volt-Amperes-reactive hours	
Z_QH_REC_LD	VARh, 3Φ, nonrated, received, leading	Volt-Amperes-reactive hours	
Z_QH_REC_LG	VARh, 3Φ, nonrated, received, lagging	Volt-Amperes-reactive hours	
Z_WH_TOT_SINCE_RESET	Wh, 3Φ, nonrated, total since peak demand reset	Watt-hours	For Z = PRES: 10/12 cycles For Z = PREV: On season change For Z = S*n*PRES or S*n*PREV: On self-read event
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-Amperes hours	
Z_UH_TOT_AT_RESET	VAh, 3Φ, nonrated, total at peak demand reset	Volt-Amperes hours	
Z_QH_TOT_SINCE_RESET	VARh, 3Φ, nonrated, total since peak demand reset	Volt-Amperes-reactive hours	
Z_QH_TOT_AT_RESET	VARh, 3Φ, nonrated, total at peak demand reset	Volt-Amperes-reactive hours	
Advanced: Time-of-Use Metering, Demand, Rated Peak Demand			
Z_W_<A–F>_PD	Watts, 3Φ, rate <A–F>, total peak demand	Watts	For Z = PRES: 10/12 cycles For Z = PREV: On season change For Z = S*n*PRES or S*n*PREV: On self-read event
Z_PF_AT_W_<A–F>_PD	PF at watts, 3Φ, rate <A–F>, total peak demand	Unitless	
Z_U_<A–F>_PD	VAs, 3Φ, rate <A–F>, total peak demand	Volt-Amperes	
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-Amperes 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	

Name	Description	Units	Update Rate
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	VAs, 3Φ rate <A–F>, received peak demand	Volt-Amperes	
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-Amperes 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	For Z = PRES: 10/12 cycles For Z = PREV: On season change For Z = S*n*PRES or S*n*PREV: On self-read event
Z_PF_AT_W_1_PD	PF at watts, 3Φ, nonrated, 1 total peak demand	Unitless	
Z_U_<1–5>_PD	VAs, 3Φ, nonrated, <1–5> peak demand	Volt-Amperes	
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-Amperes 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	VAs, 3Φ, nonrated, <1–5> received peak demand	Volt-Amperes	
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-Amperes 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	For Z = PRES: 10/12 cycles For Z = PREV: On season change For Z = S*n*PRES or S*n*PREV: On self-read event
Z_U_<A–F>_CD	VAs, 3Φ, rate <A–F>, cumulative demand	Volt-Amperes	
Z_Q_<A–F>_CD	VARs, 3Φ, rate <A–F>, cumulative demand	Volt-Amperes reactive	

Name	Description	Units	Update Rate
Advanced: Time-of-Use Metering, Demand, Cumulative Demand, Nonrated			
Z_W_CD	Watts, 3Φ, nonrated, cumulative demand	Watts	For Z = PRES: 10/12 cycles For Z = PREV: On season change For Z = S*n*PRES or S*n*PREV: On self-read event
Z_U_CD	VAs, 3Φ, nonrated, cumulative demand	Volt-Amperes	
Z_Q_CD	VARs, 3Φ, nonrated, cumulative demand	Volt-Amperes reactive	
Advanced: Time-of-Use Metering, Demand, Cumulative Demand, Reset Relative			
Z_W_MAX_AT_RESET	Watts, 3Φ, peak demand at reset	Watts	For Z = PRES: 10/12 cycles For Z = PREV: On season change For Z = S*n*PRES or S*n*PREV: On self-read event
Z_Q_MAX_AT_RESET	VARs, 3Φ, peak demand at reset	Volt-Amperes 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_MIN_PF_AT_RESET	Minimum PF, 3Φ, at reset	Unitless	
Z_MIN_PF_SINCE_RESET	Minimum PF, 3Φ, since reset	Unitless	
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.21 Advanced: Transformer and Line Losses

Name	Description	Units	Update Rate[a]
Advanced: Transformer and Line Losses, Transformer Iron Losses			
3PWFE	Watts, 3Φ, iron losses	Watts	10/12 cycles
3PVFE	VARs, 3Φ, iron losses	Volt-Amperes reactive	10/12 cycles
LWFECA	Watts, AΦ, iron losses	Watts	10/12 cycles
LWFECB	Watts, BΦ, iron losses	Watts	10/12 cycles
LWFECC	Watts, CΦ, iron losses	Watts	10/12 cycles
LVFECA	VARs, AΦ, iron losses	Volt-Amperes reactive	10/12 cycles
LVFECB	VARs, BΦ, iron losses	Volt-Amperes reactive	10/12 cycles
LVFECC	VARs, CΦ, iron losses	Volt-Amperes reactive	10/12 cycles
Advanced: Transformer and Line Losses, Transformer Copper Losses			
3PWCU	Watts, 3Φ, copper losses	Watts	10/12 cycles
3PVCU	VARs, 3Φ, copper losses	Volt-Amperes reactive	10/12 cycles
LWCUCx	Phase A, B, or C copper watt losses	Watts	10/12 cycles
LVCUCx	Phase A, B, or C copper VAR losses	Volt-Amperes reactive	10/12 cycles
Advanced: Transformer and Line Losses, Total Transformer Losses			
TTL	VAs, 3Φ, total transformer losses	Volt-Amperes	10/12 cycles
TVALx	Phase A, B, or C total transformer losses	Volt-Amperes	10/12 cycles

Name	Description	Units	Update Rate[a]
Advanced: Transformer and Line Losses, Supply Line Losses			
SPLL	Watts, 3Φ, supply line losses	Watts	10/12 cycles
SQLL	VARs, 3Φ, supply line losses	Volt-Amperes reactive	10/12 cycles
SPxL	Phase A, B, or C supply line watt losses	Watts	10/12 cycles
SQxL	Phase A, B, or C supply line VAR losses	Volt-Amperes reactive	10/12 cycles
Advanced: Transformer and Line Losses, Load Line Losses			
LPLL	Watts, 3Φ, load line losses	Watts	10/12 cycles
LQLL	VARs, 3Φ, load line losses	Volt-Amperes reactive	10/12 cycles
LPxL	Phase A, B, or C load line watt losses	Watts	10/12 cycles
LQxL	Phase A, B, or C load line VAR losses	Volt-Amperes reactive	10/12 cycles

[a] Some of the meter analog quantity update rates are specified as 10/12 cycles. This means the meter processes and updates the analog quantities every 10 cycles for 50 Hz systems and 12 cycles for 60 Hz systems.

Table G.22 Advanced: Vector Method

Name	Description	Units	Update Rate[a]
Advanced: Vector Method, Power, 3-Phase			
Q3_VECTOR	Vector VARS, 3Φ	VARS	10/12 cycles
Advanced: Vector Method, Power, More			
QA_VECTOR	Vector VARS, Phase A	Volt-Amperes reactive	10/12 cycles
QB_VECTOR	Vector VARS, Phase B	Volt-Amperes reactive	10/12 cycles
QC_VECTOR	Vector VARS, Phase C	Volt-Amperes reactive	10/12 cycles

[a] Some of the meter analog quantity update rates are specified as 10/12 cycles. This means the meter processes and updates the analog quantities every 10 cycles for 50 Hz systems and 12 cycles for 60 Hz systems.

Table G.23 Advanced: Transformer Settings

Name	Description	Units	Update Rate
Advanced: Transformer Settings			
PTR	Potential transformer ratio	Ratio:1	On settings change
CTR	Phase current transformer ratio	Ratio:1	On settings change

Table G.24 Advanced: Voltage and Current Imbalance and Average

Name	Description	Units	Update Rate[a]
Advanced: Voltage and Current Imbalance and Average			
V_IMB	Negative-sequence voltage imbalance	%	10/12 cycles
I_IMB	Negative-sequence current imbalance	%	10/12 cycles
V0_IMB	Zero-sequence voltage imbalance	%	10/12 cycles
I0_IMB	Zero-sequence current imbalance	%	10/12 cycles
V_AVE	3-phase average voltage	Volts	10/12 cycles

Name	Description	Units	Update Rate[a]
I_AVE	3-phase average current	Amperes	10/12 cycles

[a] Some of the meter analog quantity update rates are specified as 10/12 cycles. This means the meter processes and updates the analog quantities every 10 cycles for 50 Hz systems and 12 cycles for 60 Hz systems.

Table G.25 Advanced: Voltage and Frequency Deviation

Name	Description	Units	Update Rate[a]
Advanced: Voltage and Frequency Deviation			
DEV_Vx	Voltage deviation from VBASE; Phase A, B, or C (Vab, Vbc, or Vca if Form 5)	%	10/12 cycles
DEV_F	Frequency deviation from nominal	%	Half-cycle

[a] Some of the meter analog quantity update rates are specified as 10/12 cycles. This means the meter processes and updates the analog quantities every 10 cycles for 50 Hz systems and 12 cycles for 60 Hz systems.

Table G.26 LDP Most Recent Records

Name	Description	Units	Update Rate
Advanced: LDP Most Recent Data (Replace n with 01–32)			
LDP*n*CH01	Recorder Channel 1 Data	User-defined	Depends on LDAR setting
LDP*n*CH02	Recorder Channel 2 Data	User-defined	Depends on LDAR setting
LDP*n*CH03	Recorder Channel 3 Data	User-defined	Depends on LDAR setting
LDP*n*CH04	Recorder Channel 4 Data	User-defined	Depends on LDAR setting
LDP*n*CH05	Recorder Channel 5 Data	User-defined	Depends on LDAR setting
LDP*n*CH06	Recorder Channel 6 Data	User-defined	Depends on LDAR setting
LDP*n*CH07	Recorder Channel 7 Data	User-defined	Depends on LDAR setting
LDP*n*CH08	Recorder Channel 8 Data	User-defined	Depends on LDAR setting
LDP*n*CH09	Recorder Channel 9 Data	User-defined	Depends on LDAR setting
LDP*n*CH10	Recorder Channel 10 Data	User-defined	Depends on LDAR setting
LDP*n*CH11	Recorder Channel 11 Data	User-defined	Depends on LDAR setting
LDP*n*CH12	Recorder Channel 12 Data	User-defined	Depends on LDAR setting
LDP*n*CH13	Recorder Channel 13 Data	User-defined	Depends on LDAR setting
LDP*n*CH14	Recorder Channel 14 Data	User-defined	Depends on LDAR setting
LDP*n*CH15	Recorder Channel 15 Data	User-defined	Depends on LDAR setting
LDP*n*CH16	Recorder Channel 16 Data	User-defined	Depends on LDAR setting

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.27 SEL-735 Device Word Bits

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	PQALRM	RPQALRM	RSTDEM	EOIP	RSTPKDM	MATHERR
7	63–56	FLTBLK	FAULT	DFAULT	TEST	IRIGOK	SSI_EVE	MIU	LOWBAT
8	71–64	SESNCH	DSTCH	DSTP	DST	TIRIG	RATECH	TESTDB	SETCH
9	79–72	*	RPKDMCT	SPSECP	LPSEC	TSNTPB	TSNTTP	TSOK	PMDOK
10	87–80	OUT101	OUT102	OUT103	OUT401[a]	OUT402[a]	OUT403[a]	OUT404[a]	SALARM
11	95–88	IN101	IN102	IN401[a]	IN402[a]	IN403[a]	IN404[a]	*	HALARM
12	103–96	KYZD1	KYZD2	KYZD3	KYZD4	KYZDT	RSTENGY	PREDAL	PPOWER
13	111–104	RMB8A	RMB7A	RMB6A	RMB5A	RMB4A	RMB3A	RMB2A	RMB1A
14	119–112	TMB8A	TMB7A	TMB6A	TMB5A	TMB4A	TMB3A	TMB2A	TMB1A
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
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	*	*

Target Row	DNP Index	7	6	5	4	3	2	1	0
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	LOGFULL[a]	*
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	VB125	VB126	VB127	VB128
66	535–528	*	*	*	PMTRIG	TREA4	TREA3	TREA2	TREA1
67	543–536	TQUAL8	TQUAL4	TQUAL2	TQUAL1	*	*	*	*
68	551–544	TS10SEC	TS1MIN	TS10MIN	TS2HR	TSDEM	*	*	TIMESET
69	559–552	TSLDP1	TSLDP2	TSLDP3	TSLDP4	TSLDP5	TSLDP6	TSLDP7	TSLDP8

Target Row	DNP Index	7	6	5	4	3	2	1	0
70	567–560	TSLDP9	TSLDP10	TSLDP11	TSLDP12	*	*	DP17	DP18
71	575–568	DP19	DP20	DP21	DP22	DP23	DP24	DP25	DP26
72	583–576	DP27	DP28	DP29	DP30	DP31	DP32	DP33	DP34
73	591–584	DP35	DP36	DP37	DP38	DP39	DP40	DP41	DP42
74	599–592	DP43	DP44	DP45	DP46	DP47	DP48	DP49	DP50
75	607–600	TSLDP13	TSLDP14	TSLDP15	TSLDP16	TSLDP17	TSLDP18	TSLDP19	TSLDP20
76	615–608	TSLDP21	TSLDP22	TSLDP23	TSLDP24	TSLDP25	TSLDP26	TSLDP27	TSLDP28
77	623–616	TSLDP29	TSLDP30	TSLDP31	TSLDP32	*	*	*	*

[a] Optional feature.

Table G.28 SEL-735 Device Word Bit Definitions

Row	Bit		Definition
0[a]	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

Row	Bit		Definition
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
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	AB Phase-Phase Voltage Interruption
	2	INTBC	BC Phase-Phase Voltage Interruption
	1	INTCA	CA Phase-Phase Voltage Interruption
	0	ITIC_SR	CBEMA/ITIC safe region
6	7	ALTMODE	Alternate display mode
	6	EVNTCPT	Event capture
	5	PQALRM	Power quality alarm
	4	RPQALRM	Reset PQ Alarm
	3	RSTDEM	Present demand value reset
	2	EOIP	End of Interval Pulse asserted (demand)
	1	RSTPKDM	Peak demand value reset
	0	MATHERR	Math 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

Row	Bit		Definition
	3	IRIGOK	Meter time set by using active IRIG-B
	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	DSTP	DST event pending
	4	DST	DST active
	3	TIRIG	Same as IRIGOK
	2	RATECH	Rate change bit asserted
	1	TESTDB	Test database command active
	0	SETCH	Settings change bit asserted
9	7	*	Not used
	6	RPKDMCT	Reset Peak Demand Counter
	5	LPSECP	Leap second pending[b]
	4	LPSEC	Leap second occurred[b]
	3	TSNTPB	Backup SNTP Server Active
	2	TSNTPP	Primary SNTP Server Active
	1	TSOK	Time source OK for PMU data
	0	PMDOK	PMU data OK
10	7	OUT101	Output contact **OUT101** asserted
	6	OUT102	Output contact **OUT102** asserted
	5	OUT103	Output contact **OUT103** asserted
	4	OUT401[c]	Output contact **OUT401** asserted
	3	OUT402[c]	Output contact **OUT402** asserted
	2	OUT403[c]	Output contact **OUT403** asserted
	1	OUT404[c]	Output contact **OUT404** asserted
	0	SALARM	Software alarm asserted
11	7	IN101	Optoisolated input **IN101** asserted
	6	IN102	Optoisolated input **IN102** asserted
	5	IN401[c]	Optoisolated input **IN401** asserted
	4	IN402[c]	Optoisolated input **IN402** asserted
	3	IN403[c]	Optoisolated input **IN403** asserted
	2	IN404[c]	Optoisolated input **IN404** asserted
	1	*	Not used
	0	HALARM	Hardware alarm

Row	Bit		Definition
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	PPOWER	+5V sourced on an EIA-232 port
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
	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

Row	Bit		Definition
	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, unavailable beyond threshold
	5	RBADB	Channel B, outage beyond threshold
	4	ROKB	Channel B, received data ok
	3	LBOKA	Channel A, looped back ok
	2	CBADA	Channel A, unavailable beyond threshold
	1	RBADA	Channel A, outage beyond threshold
	0	ROKA	Channel A, received data ok
18	7	SV01	SELOGIC variable SV01 is TRUE
	6	SV02	SELOGIC variable SV02 is TRUE
	5	SV03	SELOGIC variable SV03 is TRUE
	4	SV04	SELOGIC variable SV04 is TRUE
	3	SV01T	SELOGIC timer output SV01T asserted
	2	SV02T	SELOGIC timer output SV02T asserted
	1	SV03T	SELOGIC timer output SV03T asserted
	0	SV04T	SELOGIC timer output SV04T asserted
19	7	SV05	SELOGIC variable SV05 is TRUE
	6	SV06	SELOGIC variable SV06 is TRUE
	5	SV07	SELOGIC variable SV07 is TRUE
	4	SV08	SELOGIC variable SV08 is TRUE
	3	SV05T	SELOGIC timer output SV05T asserted
	2	SV06T	SELOGIC timer output SV06T asserted
	1	SV07T	SELOGIC timer output SV07T asserted
	0	SV08T	SELOGIC timer output SV08T asserted
20	7	SV09	SELOGIC variable SV09 is TRUE
	6	SV10	SELOGIC variable SV10 is TRUE
	5	SV11	SELOGIC variable SV11 is TRUE
	4	SV12	SELOGIC variable SV12 is TRUE
	3	SV09T	SELOGIC timer output SV09T asserted
	2	SV10T	SELOGIC timer output SV10T asserted
	1	SV11T	SELOGIC timer output SV11T asserted
	0	SV12T	SELOGIC timer output SV12T asserted

Row	Bit		Definition
21	7	SV13	SELOGIC variable SV13 is TRUE
	6	SV14	SELOGIC variable SV14 is TRUE
	5	SV15	SELOGIC variable SV15 is TRUE
	4	SV16	SELOGIC variable SV16 is TRUE
	3	SV13T	SELOGIC timer output SV13T asserted
	2	SV14T	SELOGIC timer output SV14T asserted
	1	SV15T	SELOGIC timer output SV15T asserted
	0	SV16T	SELOGIC 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

Row	Bit		Definition
	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
	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

Row	Bit		Definition
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
	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

Row	Bit		Definition
	3	T02_LED	LED 02 asserted
	2	T01_LED	LED 01 asserted
	1	*	Not used
	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
	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

Row	Bit		Definition
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
	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

Row	Bit		Definition
	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
	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

Row	Bit		Definition
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
	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

Row	Bit		Definition
	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	VB049	Virtual Bit
	6	VB050	Virtual Bit
	5	VB051	Virtual Bit
	4	VB052	Virtual Bit
	3	VB053	Virtual Bit
	2	VB054	Virtual Bit
	1	VB055	Virtual Bit
	0	VB056	Virtual Bit

Row	Bit		Definition
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

Row	Bit		Definition
	3	VB093	Virtual Bit
	2	VB094	Virtual Bit
	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

Row	Bit		Definition
66	7	*	Not used
	6	*	Not used
	5	*	Not used
	4	PMTRIG	PMU Trigger
	3	TREA4	PMU Trigger Reason Bit 4
	2	TREA3	PMU Trigger Reason Bit 3
	1	TREA2	PMU Trigger Reason Bit 2
	0	TREA1	PMU Trigger Reason Bit 1
67	7	TQUAL8	IRIG Time Quality Bit 4
	6	TQUAL4	IRIG Time Quality Bit 3
	5	TQUAL2	IRIG Time Quality Bit 2
	4	TQUAL1	IRIG Time Quality Bit 1
	3	*	Not used
	2	*	Not used
	1	*	Not used
	0	*	Not used
68	7	TS10SEC	Timeset > TIME_CHG in 10 s interval
	6	TS1MIN	Timeset > TIME_CHG in 1 min interval
	5	TS10MIN	Timeset > TIME_CHG in 10 min interval
	4	TS2HR	Timeset > TIME_CHG in 2 hr interval
	3	TSDEM	Timeset > TIME_CHG in demand interval
	2	*	Not used
	1	*	Not used
	0	TIMESET	Timeset from secondary source
69	7	TSLDP1	Timeset > TIME_CHG in LDP1 interval
	6	TSLDP2	Timeset > TIME_CHG in LDP2 interval
	5	TSLDP3	Timeset > TIME_CHG in LDP3 interval
	4	TSLDP4	Timeset > TIME_CHG in LDP4 interval
	3	TSLDP5	Timeset > TIME_CHG in LDP5 interval
	2	TSLDP6	Timeset > TIME_CHG in LDP6 interval
	1	TSLDP7	Timeset > TIME_CHG in LDP7 interval
	0	TSLDP8	Timeset > TIME_CHG in LDP8 interval
70	7	TSLDP9	Timeset > TIME_CHG in LDP9 interval
	6	TSLDP10	Timeset > TIME_CHG in LDP10 interval
	5	TSLDP11	Timeset > TIME_CHG in LDP11 interval
	4	TSLDP12	Timeset > TIME_CHG in LDP12 interval

Row	Bit		Definition
	3	*	Not used
	2	*	Not used
	1	DP17	Display point 17 asserted
	0	DP18	Display point 18 asserted
71	7	DP19	Display point 19 asserted
	6	DP20	Display point 20 asserted
	5	DP21	Display point 21 asserted
	4	DP22	Display point 22 asserted
	3	DP23	Display point 23 asserted
	2	DP24	Display point 24 asserted
	1	DP25	Display point 25 asserted
	0	DP26	Display point 26 asserted
72	7	DP27	Display point 27 asserted
	6	DP28	Display point 28 asserted
	5	DP29	Display point 29 asserted
	4	DP30	Display point 30 asserted
	3	DP31	Display point 31 asserted
	2	DP32	Display point 32 asserted
	1	DP33	Display point 33 asserted
	0	DP34	Display point 34 asserted
73	7	DP35	Display point 35 asserted
	6	DP36	Display point 36 asserted
	5	DP37	Display point 37 asserted
	4	DP38	Display point 38 asserted
	3	DP39	Display point 39 asserted
	2	DP40	Display point 40 asserted
	1	DP41	Display point 41 asserted
	0	DP42	Display point 42 asserted
74	7	DP43	Display point 43 asserted
	6	DP44	Display point 44 asserted
	5	DP45	Display point 45 asserted
	4	DP46	Display point 46 asserted
	3	DP47	Display point 47 asserted
	2	DP48	Display point 48 asserted
	1	DP49	Display point 49 asserted

Row	Bit		Definition
	0	DP50	Display point 50 asserted

[a] Row 0 Device Word Bits are not available via the Front-Panel HMI Targets menu, SELOGIC, or Report Settings.
[b] Only set when connected to IRIG with IEEE C37.118 control bits.
[c] Optional feature.

APPENDIX H

IEC 61850 Communications

Features

The SEL-735 Power Quality and Revenue Meter supports the following features using Ethernet and IEC 61850:

- **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.17* 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.

  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.

- **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 Sisco, 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 on page 480*
- *IEC 61850 Operation on page 481*
- *IEC 61850 Configuration on page 494*
- *Logical Nodes on page 499*

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, 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

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 Generic Object Models for Substation and Feeder Equipment (GOMSFE) 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	Device fundamental quantities
A	Data Object	Phase amperes
phsA	Sub-Data Object	Phase A
.cVal	Data Attribute	Complex value
mag	Sub-Data Object	Magnitude
f	Data Type	Float32

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 499* 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—data sets and report control blocks

Logical Device	Description
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.

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 288*.

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 Access Level 2 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 by 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 (RA00–RA31) 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 288* 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)

NOTE
The meter will reset all remote analogs and virtual bits to zero on receiving a new CID file.

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

Data sets are configured through use of 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 data sets 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 data sets can be configured to represent the desired data to be monitored.

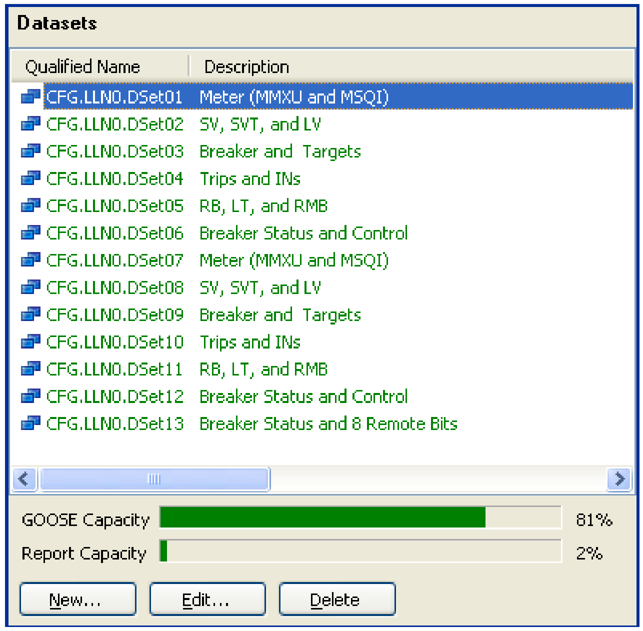


Figure H.1 SEL-735 Datasets

Within ACSELERATOR Architect, IEC 61850 data sets have the following purposes:

- GOOSE: You can use predefined or edited data sets, or create new data sets for outgoing GOOSE transmission.

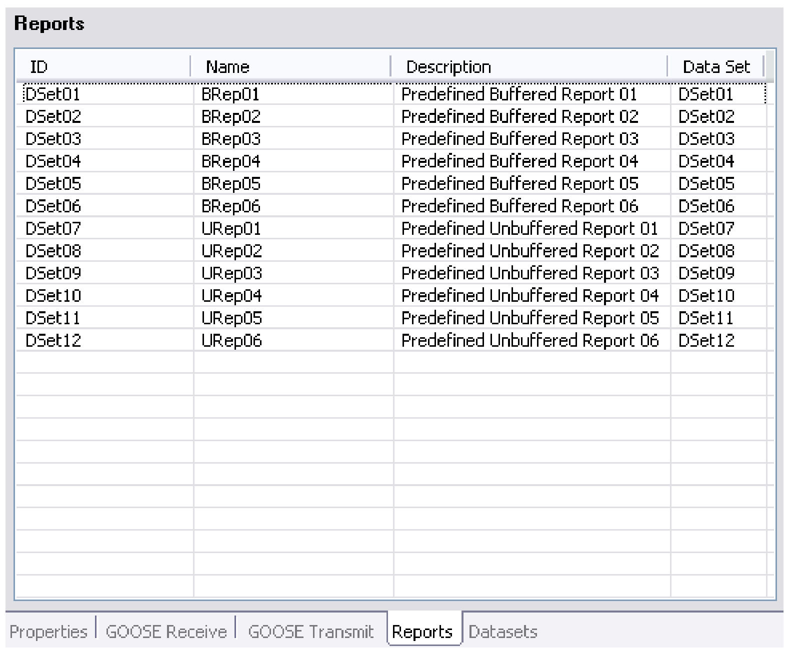
  NOTE
  Do not edit the dataset names used in reports. Changing or deleting any of those dataset names will cause a failure in generating the corresponding report.

- Reports: Twelve predefined data sets (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 data set contains and so define what data an IEC 61850 client receives with a report.
- MMS: You can use predefined or edited data sets, or you can create new data sets to be monitored by MMS clients.

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 data sets assigned to each report are shown in *Figure H.2* and are available by default via IEC 61850. The number of reports (12), the data set 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 data set to present different data attributes for each report beyond the predefined data sets.



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[a,b]	YES[a]	FALSE
PurgeBuf	YES[a]		FALSE
EntryId	YES		0

[a] Exhibits a pulse behavior. Write a one to issue the command. Once command is accepted will return to zero. Always read as zero.
[b] 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 data set is smaller than the allowed maximum size, or when the encoded report does not include the entire data set, 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[a]	FALSE

[a] 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 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 non-zero 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 data set.

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 non-zero value, a report is sent to that client containing the current data for all FCDAs within the report data set 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 non-zero BufTm attribute, a BufTm timer is started upon receiving notification of the change of a member of a data set, 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 data set 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 Sisco, Inc.

The settings needed to browse an SEL-735 with an MMS browser are shown in the following table.

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 time stamp 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 time stamp is applied to all data and quality attributes (Boolean, Bstrings, Analogs, etc.) in the same fashion when a data or quality change is detected.

NOTE
The Leap Second bit field is always set to TRUE for the time data object.

Functionally Constrained Data Attributes (FCDA) mapped to points assigned to the SER report have SER-accuracy time stamps for data change events. To ensure that you will get SER-quality time stamps for changes to certain points, you must include those points in the SER report. All other FCDAs are scanned for data changes on a 1/2-second interval and have 1/2-second time-stamp 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 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 via the Ethernet port, as defined by IEC 61850-7-1:2003(E), IEC 61850-7-2:2003(E), and IEC 61850-8-1:2004(E).

Outgoing GOOSE messages are processed in accordance with the following constraints.

➤ The user can define as many as 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 data set to multiple GOOSE control blocks.

➤ The SEL-735 will transmit all configured GOOSE messages immediately upon successful initialization. If a GOOSE message is not retriggered, the meter retransmits that GOOSE message based on the configured esel:MinTime and esel:MaxTime from the CID file. The first transmission occurs immediately upon the GOOSE triggering. The second transmission occurs esel:MinTime later. The third transmission occurs esel:MinTime after the second. The fourth transmission occurs twice esel:MinTime after the third. All subsequent transmissions occur at the esel:MaxTime interval. For example, if esel:MinTime is 8 ms and esel:MaxTime is 100 ms, the intervals between transmissions will be

8 ms, 8 ms, 16 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).

NOTE
The minimum retransmit interval that the SEL-735 supports is 10 ms for 50 Hz systems and 8 ms for 60 Hz systems.

- 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 validates the following contents prior to accepting the incoming message:
  - Source broadcast MAC address
  - Dataset Reference
  - Application ID
  - GOOSE Control Reference
- The GOOSE protocol processes every message with a data change and incremented status number as follows:
  - Identifies the quantities in the GOOSE message mapped to the input data points.
  - Compares the identified data quantities from an incoming GOOSE message against a local version of the quantities.
  - Updates the local version with the new available data and passes the data to the remaining interfaces of 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 of Outgoing Messages

Response time is the delay between an analog or Boolean quantity change and when the meter transmits the message with the updated quantity.

For analog value changes greater than the deadband, the typical response time is within 0.5 seconds.

NOTE

Heavy system burdening may cause as long as five seconds in response time. Several simultaneous communications sessions running at high polling rates or rapidly changing Device Word bits cause heavy system burdening.

For Boolean state changes, the response time depends on the number of Device Word bits (DWBs) changing state in a transmit data set. The meter processes as many as 16 DWBs that change state in every half power system cycle. *Table H.7* lists the typical and worst-case response times.

Table H.7 GOOSE Response Time for DWB State Changes

Maximum DWBs Changing State	Typical (ms)	Worst-Case (ms)
16	6	10
32	15	20
64	25	40
96	32	60
All 128	75	80

If Boolean quantities change state faster than the GOOSE protocol can publish, the meter goes into synchronization mode. In synchronization mode, the meter will not publish all state changes in favor of publishing the most recent state. Once the changes slow down, it will take as many as 250 ms to synchronize the state of Boolean quantities in the transmit messages to the state of DWBs in the meter. For example, if all 128 Boolean change state every 1/2 cycle for more than 12 cycles, the meter goes into synchronization mode. Once the DWBs stop rapidly changing, the meter reports the present status of all Boolean triggers within 250 ms.

Throughput of Outgoing Messages

The SEL-735 publishes as many as 24 messages every 200 ms. These 24 messages include as many as 8 initial outgoing GOOSE messages and all the subsequent retransmit messages. If the total transmitted messages exceed 24 in a period of 200 ms, the meter will publish the additional messages in the next 200 ms period. This delay adds to the transmit response time specified in Table H.7.

To avoid GOOSE message delays, limit the maximum number of message transmissions to 24 within a 200 ms period. You can achieve this by configuring the esel:MinTime and esel:MaxTime settings in the CID file and minimizing use of the same DWBs in all transmit data sets. See *Table H.8* for an example of how many GOOSE messages the meter transmits, based on the number of data sets affected by DWBs changing state and esel:MinTime and esel:MaxTime settings.

Table H.8 Number of Transmit Messages for Boolean State Change Event

Transmit Datasets	Boolean State Change Events in a 200 ms Period[a]	esel:MinTime (ms)	esel:MaxTime (ms)	GOOSE Messages Sent in 200 ms Period		
				Initial Messages	Retransmit Messages	Total Messages
1	1	8	1000	1	3	4
4	1	8	1000	4	12	16
8	1	60	1000	8	16	24
8	1	120	1000	8	8	16

[a] A Boolean state change event can include as many as 16 DWBs changing at once.

Response Time of Incoming Messages

Response time is the delay from receipt of an incoming message to the change of state in a Virtual Bit or a Remote Analog Quantity.

The meter processing time for incoming GOOSE messages depends on the number of quantities mapped in the message. *Table H.9* lists the typical and worst-case response times.

Table H.9 GOOSE Response Time for Incoming Messages

Maximum Quantities Mapped	Typical (ms)	Worst-Case (ms)
16 Remote Analogs (RA)	40	60
32 Virtual Bits (VB)	43	60
128 VBs and 32 RAs	60	100

Throughput of Incoming Messages

The SEL-735 accepts as many as 24 incoming messages every 200 ms. These 24 messages include both subscribed and unsubscribed messages. If the total received messages exceed 24 in a 200 ms period, the meter will accept the additional messages in the next 200 ms period. This delay adds to the receive response time specified in *Table H.9*.

To avoid GOOSE message delays, limit the total number of GOOSE incoming messages on the network to 24 in any 200 ms period. You can achieve this by configuring the Layer 2 Ethernet network for VLAN filtering or MAC filtering and configuring the GOOSE publisher devices for minimal retransmit messages.

GOOSE Construction Tips

- Avoid adding the default quality attribute to GOOSE transmit data sets unless required by some other type of IED. The meter only publishes GOOSE messages if the default quality attribute is GOOD_QUALITY.
- Make GOOSE publications as small as possible. Include in the GOOSE publication only the information required by subscribing devices.
- 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

Table H.10 lists IEC 61850 settings. These settings are only available if your device includes the optional IEC 61850 protocol. The IEC 61850 protocol is an option in all variants of the SEL-735; basic, intermediate, and advanced; and should be ordered that way. IEC 61850 protocol can be upgraded to any of the variants of the SEL-735 meters—contact SEL to make the upgrade. The meter must have an Ethernet port.

Table H.10 IEC 61850 Settings

Label	Description	Range	Default
E61850	IEC 61850 MMS client sessions enable	0–6	0
EGSE	IEC 61850 GSE message enable	Y[a], N	N

[a] 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.

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.

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 296* 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-R206-V1-Z102100-D20211214","08A4"
"BFID=SLBT-735-R300-V0-Z000000-D20180503","0933"
"CID=08F7","0262"
"DEVID=FEEDER 1","03C0"
"DEVCODE=57","0313"
"PARTNO=0735LX20944EXXXXXX16201XX","08F6"
"CONFIG=11112200","03EB"
"SEL DISPLAY PACKAGE=2.0.50735.3","07F6"
"CUSTOMER DISPLAY PACKAGE=2.706628878","09A5"
"SPECIAL=0000000Y","044C"
"iedName=PARSE FAILURE","0360"
"type=PARSE FAILURE","026F"
"configVersion=PARSE FAILURE","0609"
=>>
```

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-R206-V1-Z102100-D20211214","08A4"
"BFID=SLBT-735-R300-V0-Z000000-D20180503","0933"
"CID=08F7","0262"
"DEVID=FEEDER 1","03C0"
"DEVCODE=57","0313"
"PARTNO=0735LX20944EXXXXXX16201XX","08F6"
"CONFIG=11112200","03EB"
"SEL DISPLAY PACKAGE=2.0.50735.3","07F6"
"CUSTOMER DISPLAY PACKAGE=2.706628878","09A5"
"SPECIAL=0000000Y","044C"
"iedName=SEL735_005_ICD_1","0360"
"type=SEL_735","026F"
"configVersion=ICD-735-R100-V0-Z000000-D20130512","0609"
=>>
```

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 data sets.
- Read non-SEL IED Capability Description (ICD) and CID files and determine the available IEC 61850 messaging options.
- Use or edit preconfigured data sets 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 deadband 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 deadband value. ACSELERATOR Architect allows a deadband to be changed during the CID file configuration. Check and set the deadband 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.11 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.12 Flicker Measurement Logical Node Class Definition

IEC 61850 Logical Node Class: MFLK				
Attribute Name	**Attribute Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, LN-Prefix, and LN-Instance-ID, according to IEC 61850-7-2.		
Data				
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

[a] 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.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table H.13 Voltage Variation Logical Node Class Definition

IEC 61850 Logical Node Class: QVVR				
Attribute Name	**Attribute Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, LN-Prefix, and LN-Instance-ID, according to IEC 61850-7-2.		
Data				
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		

[a] 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.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table H.14 Energy Quantities Logical Node Class Definition

IEC 61850 Logical Node Class: MMTR				
Attribute Name	**Attribute Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, LN-Prefix, and LN-Instance-ID, according to IEC 61850-7-2.		
Data				
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	Ampere-hours		E

[a] 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.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Table H.15 Metering Statistics Logical Node Class Definition

IEC 61850 Logical Node Class: MSTA				
Attribute Name	**Attribute Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
LNName		The name shall be composed of the class name, LN-Prefix, and LN-Instance-ID, according to IEC 61850-7-2.		
Data				
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

IEC 61850 Logical Node Class: MSTA				
Attribute Name	**Attribute Type**	**Explanation**	**T[a]**	**M/O/C/E[b]**
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

[a] 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.
[b] M: Mandatory; O: Optional; C: Conditional; E: Extension.

Logical Nodes

Table H.16 through *Table H.18* show the logical nodes (LNs) supported in the SEL-735 and the Device Word bits or analog quantities mapped to those LNs.

Table H.16 shows the LNs associated with the annunciation element, defined as Logical Device ANN.

Table H.16 Logical Device: ANN (Annunciation)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = ST			
ALMGGIO1	Ind01.stVal	ENABLE	Indication that Enabled LED is asserted
ALMGGIO1	Ind02.stVal	HALARM	
ALMGGIO1	Ind03.stVal	SALARM	
ALMGGIO1	Ind04.stVal	SETCHG	Pulses for one second whenever settings are changed
ALMGGIO1	Ind05.stVal	RSTDEM	
ALMGGIO1	Ind06.stVal	RSTENGY	
ALMGGIO1	Ind07.stVal	RSTPKDM	
ALMGGIO1	Ind08.stVal	TEST	
ALMGGIO1	Ind09.stVal	SESNCH	
ALMGGIO1	Ind10.stVal	DSTCH	
ALMGGIO1	Ind11.stVal	MATHERR	
Power Quality Indicators			
PQGGIO2	Ind01.stVal	PQALRM	
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	

Logical Node	Attribute	Data Source	Comment
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	
SSIGGIO3	Ind06.stVal	SWB	
SSIGGIO3	Ind07.stVal	SWC	
SSIGGIO3	Ind08.stVal	SW3P	
SSIGGIO3	Ind09.stVal	INTA	
SSIGGIO3	Ind10.stVal	INTB	

Logical Node	Attribute	Data Source	Comment
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	

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	SV01T–SV16T	
LTGGIO18	Ind01.stVal–Ind16.stVal	LT01–LT16	
VBGGIO19	Ind001.stVal–Ind128.stVal	VB001–VB128	
SCGGIO21	IntIn01.stVal–IntIn16.stVal	SC01–SC16	
Functional Constraint = MX			
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	
PFLLIGGIO20	AnIn1.Mag.f	LDPFDA	
PFLLIGGIO20	AnIn2.Mag.f	LDPFDB	
PFLLIGGIO20	AnIn3.Mag.f	LDPFDC	
PFLLIGGIO20	AnIn4.Mag.f	LDPFD3	
PFLLIGGIO20	AnIn5.Mag.f	LDPFTA	
PFLLIGGIO20	AnIn6.Mag.f	LDPFTB	
PFLLIGGIO20	AnIn7.Mag.f	LDPFTC	
PFLLIGGIO20	AnIn8.Mag.f	LDPFT3	

Table H.17 shows the LNs associated with control elements, defined as Logical Device CON.

Table H.17 Logical Device: CON (Remote Control)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = ST			
RBGGIO1	SPCSO01.stVal–SPCSO08.stVal	RB01–RB08	
RBGGIO2	SPCSO09.stVal–SPCSO16.stVal	RB09–RB16	

Table H.18 shows the LNs associated with metering elements, defined as Logical Device MET.

Table H.18 Logical Device: MET (Metering)

Logical Node	Attribute	Data Source	Comment
Functional Constraint = ST			
Three-Phase Energy Quantities			
TPMMTR1	TotWh.actVal	WH3_NET	
TPMMTR1	TotVArh.actVal	QH3_NET	
TPMMTR1	SupWh.actVal	WH3_REC	

Logical Node	Attribute	Data Source	Comment
TPMMTR1	SupVArh.actVal	QH3_REC	
TPMMTR1	DmdWh.actVal	WH3_DEL	
TPMMTR1	DmdVArh.actVal	QH3_DEL	
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	
A-Phase Energy Quantities			
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-Phase Energy Quantities			
BPMMTR3	TotWh.actVal	WHB_NET	
BPMMTR3	SupWh.actVal	WHB_REC	
BPMMTR3	SupVArh.actVal	QHB_REC	
BPMMTR3	DmdWh.actVal	WHB_DEL	
BPMMTR3	DmdVArh.actVal	QHB_DEL	
BPMMTR3	DmdVArh1.actVal	QHB_DEL_LG	
BPMMTR3	DmdVArh2.actVal	QHB_DEL_LD	
BPMMTR3	SupVArh1.actVal	QHB_REC_LG	
BPMMTR3	SupVArh2.actVal	QHB_REC_LD	

Logical Node	Attribute	Data Source	Comment
BPMMTR3	SupVAh.actVal	UHB_REC	
BPMMTR3	DmdVAh.actVal	UHB_DEL	
BPMMTR3	Vh.actVal	VHB	
BPMMTR3	Ah.actVal	IHB	
C-Phase Energy Quantities			
CPMMTR4	TotWh.actVal	WHC_NET	
CPMMTR4	SupWh.actVal	WHC_REC	
CPMMTR4	SupVArh.actVal	QHC_REC	
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	
Uncompensated Three-Phase Energy Quantities			
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	
Uncompensated A-Phase Energy Quantities			
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	

Logical Node	Attribute	Data Source	Comment
UCAPMMTR6	DmdVArh2.actVal	QHA_DEL_LD_UC	
UCAPMMTR6	SupVArh1.actVal	QHA_REC_LG_UC	
UCAPMMTR6	SupVArh2.actVal	QHA_REC_LD_UC	
Uncompensated B-Phase Energy Quantities			
UCBPMMTR7	TotWh.actVal	WHB_NET_UC	
UCBPMMTR7	SupWh.actVal	WHB_REC_UC	
UCBPMMTR7	SupVArh.actVal	QHB_REC_UC	
UCBPMMTR7	DmdWh.actVal	WHB_DEL_UC	
UCBPMMTR7	DmdVArh.actVal	QHB_DEL_UC	
UCBPMMTR7	DmdVArh1.actVal	QHB_DEL_LG_UC	
UCBPMMTR7	DmdVArh2.actVal	QHB_DEL_LD_UC	
UCBPMMTR7	SupVArh1.actVal	QHB_REC_LG_UC	
UCBPMMTR7	SupVArh2.actVal	QHB_REC_LD_UC	
Uncompensated C-Phase Energy Quantities			
UCCPMMTR8	TotWh.actVal	WHC_NET_UC	
UCCPMMTR8	SupWh.actVal	WHC_REC_UC	
UCCPMMTR8	SupVArh.actVal	QHC_REC_UC	
UCCPMMTR8	DmdWh.actVal	WHC_DEL_UC	
UCCPMMTR8	DmdVArh.actVal	QHC_DEL_UC	
UCCPMMTR8	DmdVArh1.actVal	QHC_DEL_LG_UC	
UCCPMMTR8	DmdVArh2.actVal	QHC_DEL_LD_UC	
UCCPMMTR8	SupVArh1.actVal	QHC_REC_LG_UC	
UCCPMMTR8	SupVArh2.actVal	QHC_REC_LD_UC	
VSSI			
PQQVVR1	VVaRcd.vvaTyp	SSIR1_TYPE	
PQQVVR1	VVaRcd.vvaTsta	SSIR1_TS	
PQQVVR1	VarStr.stVal	SSI_EVE	
Functional Constraint = MX			
Device Demand, Peak Demand, and Previous Peak Demand Quantities			
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	

Logical Node	Attribute	Data Source	Comment
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	
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	

Logical Node	Attribute	Data Source	Comment
PIDMSTA1	SupVAr2.phsA.Mag.f	QDA_REC_LD	
PIDMSTA1	SupVAr2.phsB.Mag.f	QDB_REC_LD	
PIDMSTA1	SupVAr2.phsC.Mag.f	QDC_REC_LD	
Device Peak Demand			
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	
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	

Logical Node	Attribute	Data Source	Comment
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	
Device Previous Peak Demand			
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	
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	

Logical Node	Attribute	Data Source	Comment
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	
Uncompensated Device Present Interval Demand			
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	
UCPIDMSTA4	SupTotVAr2.Mag.f	QD3_REC_LD_UC	
UCPIDMSTA4	SupW.phsA.Mag.f	WDA_REC_UC	
UCPIDMSTA4	SupW.phsB.Mag.f	WDB_REC_UC	

Logical Node	Attribute	Data Source	Comment
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	
Uncompensated Device Peak Demand			
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	

Logical Node	Attribute	Data Source	Comment
UCPKDMSTA5	SupVAr.phsC.Mag.f	QPC_REC_UC	
UCPKDMSTA5	DmdW.phsA.Mag.f	WPA_DEL_UC	
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	

Logical Node	Attribute	Data Source	Comment
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	
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	
Device Flicker Quantities			
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	PhpiMaxTms.cVal.mag.f	SEC_PINST	
METMFLK1	PhPstTms.cVal.mag.f	SEC_PST	
METMFLK1	TmsPhpltTms.cVal.mag.f	SEC_PLT	
Device Fundamental Quantities			
FUNDMMXU1	TotW.Mag.f	W3_FUND	
FUNDMMXU1	TotVAr.Mag.f	Q3_FUND	
FUNDMMXU1	TotVA.Mag.f	S3_FUND	

Logical Node	Attribute	Data Source	Comment
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	
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	

Logical Node	Attribute	Data Source	Comment
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	
Device RMS Quantities			
RMSMMXU2	TotW.Mag.f	W3	
RMSMMXU2	TotVAr.Mag.f	Q3	
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	

Logical Node	Attribute	Data Source	Comment
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	
Uncompensated Device RMS Quantities			
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	
Device Sequence/Imbalance Quantities			
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	
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	
Device Power Quality Quantities			
PQMHAI1	Hz.Mag.f	FREQ_PQ	
PQMHAI1	HKf.phsA.cVal.mag.f	KFA	
PQMHAI1	HKf.phsB.cVal.mag.f	KFB	
PQMHAI1	HKf.phsC.cVal.mag.f	KFC	
PQMHAI1	ThdA.phsA.cVal.mag.f	THDIA	

Logical Node	Attribute	Data Source	Comment
PQMHAI1	ThdA.phsB.cVal.mag.f	THDIB	
PQMHAI1	ThdA.phsC.cVal.mag.f	THDIC	
PQMHAI1	ThdA.neut.cVal.mag.f	THDIN	
PQMHAI1	ThdPhV.phsA.cVal.mag.f	THDVA	
PQMHAI1	ThdPhV.phsB.cVal.mag.f	THDVB	
PQMHAI1	ThdPhV.phsC.cVal.mag.f	THDVC	
PQMHAI1	ThdPPV.phsA.cVal.mag.f	THDVA	
PQMHAI1	ThdPPV.phsB.cVal.mag.f	THDVB	
PQMHAI1	ThdPPV.phsC.cVal.mag.f	THDVC	
Max Crest Factor			
PQMHAI1	HCfPhV.phsA.cVal.mag.f	VACFMX	
PQMHAI1	HCfPhV.phsB.cVal.mag.f	VBCFMX	
PQMHAI1	HCfPhV.phsC.cVal.mag.f	VCCFMX	
PQMHAI1	HCfPPV.phsAB.cVal.mag.f	VACFMX	
PQMHAI1	HCfPPV.phsBC.cVal.mag.f	VBCFMX	
PQMHAI1	HCfPPV.phsCA.cVal.mag.f	VCCFMX	
PQMHAI1	HCfA.phsA.cVal.mag.f	IACFMX	
PQMHAI1	HCfA.phsB.cVal.mag.f	IBCFMX	
PQMHAI1	HCfA.phsC.cVal.mag.f	ICCFMX	
PQMHAI1	HCfA.neut.cVal.mag.f	INCFMX	
VSSI			
PQQVVR1	VVa.Mag.f	SSIR1_DEPTH	
PQQVVR1	VVaTm.Mag.f	SSIR1_DUR	

APPENDIX I

Synchrophasors

Overview

Synchrophasor measurement refers to the concept of providing phasor measurements (including magnitude and angle) taken on a synchronized schedule with the ability to gather these data points from multiple locations.

The SEL-735 Meter provides Phasor Measurement Unit (PMU) capabilities when connected to a high-accuracy IRIG-B time source, such as the SEL-2488 Satellite-Synchronized Clock. Synchrophasor data are available via the **MET PM** ASCII command and the IEEE C37.118.2-2011 Protocol (when configured with an Ethernet port).

The SEL-735 is a producer (not a consumer/client) of synchrophasor data. The synchrophasor data produced in the SEL-735 are available on the **MET PM** command and on the IEEE C37.118.2 protocol (not in SELOGIC or in analog quantities).

The availability of an accurate time reference over a large geographic area allows multiple devices, such as SEL-735 meters, to synchronize the gathering of power system data. Synchrophasors are still measured if the high-accuracy time source is not connected, however, the synchrophasor angle data are not accurate. The Device Word bits TSOK and PMDOK both assert when the meter is synchronized to a high-accuracy time source and can produce synchrophasor data. See *Prerequisites for Synchrophasor Data on page 519* for more information.

The SEL-735 General settings group contain the synchrophasor settings, including the choice of transmitted synchrophasor data sets. The Port 1 Ethernet settings group configure synchrophasor communications. See *General Settings for Synchrophasors on page 519* and *Ethernet Port Settings for Synchrophasor Protocol IEEE C37.118.2 on page 523*.

The SEL-735 timekeeping function generates status Device Word bits and time quality information that are important for synchrophasor measurements. The user-defined portion of the synchrophasor data message contains SELOGIC variables and programmable digital trigger information. See *Synchrophasor Device Word Bits on page 525*.

Synchrophasor Measurement

NOTE
All references to IEEE C37.118.1 in this document are references to "IEEE C37.118.1-2011 as amended by IEEE C37.118.1a-2014."

The SEL-735 time-stamps voltage and current measurements with time from the IRIG time source to produce filtered phasor data that complies with IEEE C37.118.1. Synchrophasors are specifically filtered to remove the influence from harmonics and any signal other than the fundamental waveform (nominally 50 or 60 Hz).

The phase angle is measured relative to an absolute time reference, which is represented by a cosine function in *Figure I.1*. *Figure I.1* shows the time and angle reported by synchrophasors for two time instances. During conditions described by the standard, the SEL-735 synchrophasor values can be directly compared to values from other phasor measurement units that conform to IEEE C37.118.1.

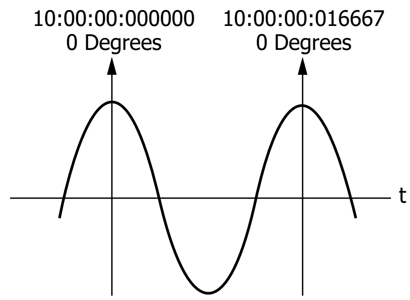


Figure I.1 Phase Angle of Waveform at Two Time Instances

The TSOK Device Word bit asserts when the SEL-735 determines that the IRIG-B time source has sufficient accuracy. The SEL-735 measures synchrophasors in the absence of an accurate source, however, the SEL-735 suppresses the **MET PM** command.

The SEL-735 scales the phasors in primary units, as determined by group settings PTR and CTR.

When synchrophasor measurement is enabled, the SEL-735 creates the synchrophasor data at a user-configurable rate.

The SEL-735 supports the protocol defined in IEEE C37.118.2-2011, Standard for Synchrophasor Data Transfer for Power Systems. The value of synchrophasor data increases greatly when the data can be shared over a communications network in real time. The SEL-735 publishes data in the format defined by IEEE C37.118.2 which allows for a centralized device to collect data efficiently from several PMUs. Some possible uses of a system-wide synchrophasor system include the following:

- Power system state measurement
- Wide-area network control schemes
- Small-signal analysis
- Power system disturbance analysis

Prerequisites for Synchrophasor Data

The SEL-735 supports the IEEE C37.118.2 protocol through an Ethernet port. The EIA-232, EIA-485, and Ethernet ports support the **MET PM** command.

Follow these steps to ensure synchrophasor measurement accuracy:

1. Connect the SEL-735 to a high-accuracy IRIG clock with low jitter and absolute time accuracy of 1 µs or better and with IEEE C37.118 control bits enabled. Under these conditions, the Device Word bits TSOK, TIRIG, and PMDOK assert.
2. Maintain current signals as listed in Specifications, and set VBASE to the appropriate nominal voltage.
3. Maintain a positive-sequence voltage greater than or equal to 5 percent of VBASE (apply balanced three-phase voltages).
4. Set UTC_OFF to match the UTC offset of the IRIG signal.

New Functionality in IEEE C37.118.1-2011-Compliant Synchrophasor

When compared to IEEE C37.118-2005, IEEE C37.118.1 has several differences, some of which are outlined here.

Performance Classes. IEEE C37.118.1 introduced two performance classes, P Class and M class. The SEL-735 provides P class synchrophasors. P class (protection) is for applications requiring faster response and less filtering. M class (measurement) is for applications that require more filtering and do not require minimal reporting delay.

Specified Latency. IEEE C37.118.1 introduced message latency requirements. In this context, message latency is defined as the time interval between when an event occurs on the power system to the time that it is reported in data. The SEL-735 meets the message latency requirements for P class synchrophasors when using a UDP transport scheme (see PMOTS1 and PMOTS2).

Dynamic Performance. IEEE C37.118.1 introduced dynamic performance requirements, whereas the 2005 standard only specified performance when the power system was in steady state. The details of this difference and the impact on installed units is beyond the scope of this document. The SEL-735 complies with all P class performance requirements (dynamic and steady-state) of the standard.

Rate-of-Change of Frequency (ROCOF). IEEE C37.118.1 introduced requirements on the responsiveness of ROCOF beyond that of the 2005 standard. One effect of these changes is to make ROCOF more sensitive to noise, so care should be taken before applying the ROCOF value to a control scheme.

General Settings for Synchrophasors

The synchrophasor settings in the General settings group are used to configure the PMU for synchrophasors. The settings are listed in *Table I.1*.

The Port 1 enable setting EPMIP must be set to 1 or 2 before the remaining SEL-735 synchrophasor settings are available. EPMIP and ECWSIP cannot both be enabled at the same time.

Table I.1 PMU Settings in the SEL-735 for IEEE C37.118 Protocol in General Settings

Setting	Description	Default
MRATE	Messages per second (1, 2, 5, 10, 25, or 50 when frequency := 50 Hz) (1, 2, 4, 5, 10, 12, 15, 20, 30, or 60 when frequency := 60 Hz)	50 or 60
PMSTN	Station name (16 characters)	STATION A
PMID	PMU hardware ID (1–65534)	1
PHDATAV	Phasor data set, voltages (V1, PH, ALL, NA)	PH
VCOMP	Phase voltage angle compensation (–179.99 to 180 deg)	0.00
PHDATAI	Phasor data set, currents (I1, PH, ALL, NA)	PH
ICOMP	Phase current angle compensation (–179.99 to 180 deg)	0.00
NUMANA	Number of analog quantities (0–4)	0
PMUAQ1[a]	PMU analog quantity 1	W3_HALF_CYCLE
PMUAQ2[b]	PMU analog quantity 2	S3_HALF_CYCLE
PMUAQ3[c]	PMU analog quantity 3	Q3_HALF_CYCLE
PMUAQ4[d]	PMU analog quantity 4	THDVA
NUMDSW	Number of 16-bit digital status words (0, 1)	0
TREA1	Trigger Reason bit 1 (SELOGIC)	0
TREA2	Trigger Reason bit 2 (SELOGIC)	0
TREA3	Trigger Reason bit 3 (SELOGIC)	0
TREA4	Trigger Reason bit 4 (SELOGIC)	0
PMTRIG	PMU trigger (SELOGIC)	TREA1 OR TREA2 OR TREA3 OR TREA4

[a] Hidden if NUMANA < 1.
[b] Hidden if NUMANA < 2.
[c] Hidden if NUMANA < 3.
[d] Hidden if NUMANA < 4.

Definitions follow for the settings in *Table I.1*.

MRATE

MRATE selects the message rate in messages per second for synchrophasor data streaming on the Ethernet port.

Choose the MRATE setting that suits the needs of your PMU application.

PMSTN and PMID

PMSTN and PMID define the name and number of the PMU. The PMSTN setting is an ASCII string with as many as 16 characters. The PMID setting is a numeric value. Use your utility or synchrophasor data concentrator naming convention to determine these settings.

PHDATAV

PHDATAV selects which voltage synchrophasors to include in the data packet. Consider the burden on your synchrophasor processor and offline storage requirements when deciding how much data to transmit.

- PHDATAV := V1 transmits only positive-sequence voltage, V_1
- PHDATAV := PH transmits V_A, V_B, and V_C or V $_{AB}$, V_{BC}, and V_{CA} for Form 5 meters
- PHDATAV := ALL transmits V_1, V_A, V_B, and V_C or V_{AB}, V_{BC}, and V_{CA} for Form 5 meters
- PHDATAV := NA does not transmit any voltages

Content of IEEE C37.118.2 Data Packets on page 528 describes the order of synchrophasors inside the data packet.

PHDATAI

PHDATAI selects which current synchrophasors to include in the data packet. Consider the burden on your synchrophasor processor and offline storage requirements when deciding how much data to transmit.

- PHDATAI := I1 transmits only positive-sequence current, I_1
- PHDATA1 := PH transmits I_A, I_B, I_C, and I_N
- PHDATAI := ALL transmits I_1, I_A, I_B, I_C, and I_N
- PHDATAI := NA does not transmit any currents

Content of IEEE C37.118.2 Data Packets on page 528 describes the order of synchrophasors inside the data packet.

Synchrophasors are only transmitted if specified to be included by the PHDATAV and PHDATAI settings. For example, if PHDATAV := ALL and PHDATAI := I1, selected phase voltages are transmitted first, followed by positive-sequence current and positive-sequence voltage.

VCOMP and ICOMP

The VCOMP setting allows correction for any steady-state voltage phase errors (from the potential transformers or secondary wiring). The ICOMP setting allows correction for any steady-state current phase errors (from the current transformers or secondary wiring).

The instrumentation transformers (PTs or CTs) and the interconnecting cables introduce a phase shift in the measured signal. Settings VCOMP and ICOMP, entered in degrees, are added to the measured phasor angles to create the corrected phasor angles, as shown in *Figure I.2* and *Figure I.3*. The VCOMP and ICOMP settings may be positive or negative values. Alternatively, use Instrument Transformer Compensation (ITC) to correct for the phase shift (see *Instrument Transformer Compensation on page 156* for details). ITC corrects for phase-angle shift on all metering interfaces whereas VCOMP and ICOMP only correct for phase-angle shift on the synchrophasors interface.

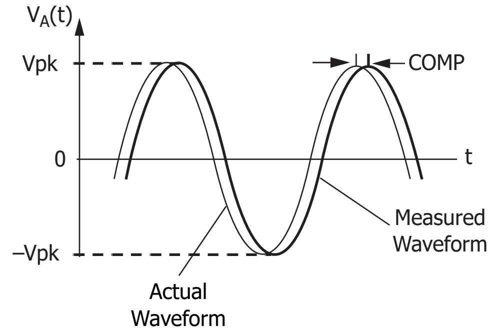


Figure I.2 Waveform at Meter Terminals May Have a Phase Shift

If the time shift on the PT measurement path COMP = 0.784 ms and the nominal frequency, $freq_{nominal}$ = 60 Hz, use *Equation I.1* to obtain the correction angle:

$$0.784 \bullet 10s^{-3} \bullet 60s^{-1} \bullet 360° = 16.934°$$

Equation I.1

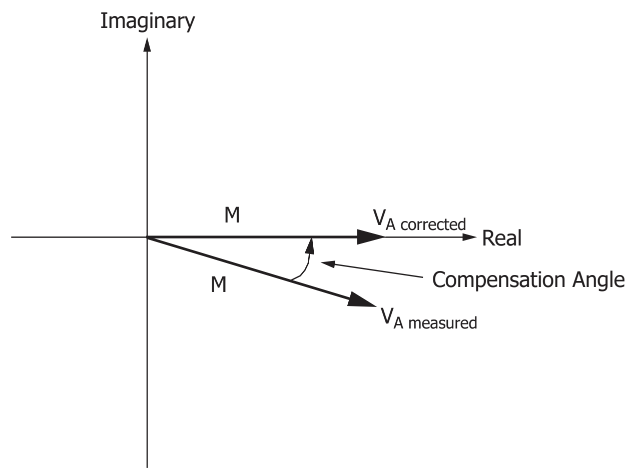


Figure I.3 Correction of Measured Phase Angle

NUMANA, PMUAQ1, PMUAQ2, PMUAQ3, and PMUAQ4

NUMANA selects the number of user-definable analog quantities to be included in the synchrophasor data stream.

- Setting NUMANA := 0 sends no user-definable analog quantities.
- Setting NUMANA := 1–4 sends the user-definable analog quantities, as set in settings PMUAQ1–PMUAQ4.

The format of the user-defined analog data is 32-bit floating point. The meter updates these analog quantities every 200 ms.

NUMDSW

NUMDSW selects the number of user-definable digital status words to be included in the synchrophasor data stream. The meter updates these digital bits every power system cycle.

The inclusion of binary data can help indicate logic status or other operational data to the synchrophasor processor.

- Setting NUMDSW := 0 sends no user-definable binary status words.
- Setting NUMDSW := 1 sends the user-definable binary status word, as listed in *Table I.2*.

Table I.2 User-Defined Digital Status Word Selected by the NUMDSW Setting

NUMDSW Setting	Digital Status Words Sent	Total Number of Bytes Used for Digital Values
0	None	0
1	[SV01, SV02…SV16]	2

TREA1, TREA2, TREA3, TREA4, and PMTRIG

These settings define the programmable trigger bits as allowed by IEEE C37.118.1.

Each of the four Trigger Reason settings, TREA1–TREA4, and the PMU Trigger setting, PMTRIG, are SELOGIC control equations in the General settings group. The SEL-735 evaluates these equations and places the results in Device Word bits with the same names: TREA1–TREA4 and PMTRIG.

The trigger reason equations represent the Trigger Reason bits in the STAT field of the data packet. After the trigger reason bits are set to convey a message, assert the PMTRIG equation to signal the synchrophasor processor to read the TREA1–TREA4 fields.

You can use these bits to send various messages at a low bandwidth via the synchrophasor message stream. You can also use Digital Status Words to send binary information.

Use these Trigger Reason bits if your synchrophasor system design requires these bits. The SEL-735 synchrophasor processing and protocol transmission are not affected by the status of these bits.

Ethernet Port Settings for Synchrophasor Protocol IEEE C37.118.2

IEEE C37.118.1-compliant synchrophasors are available over the IEEE C37.118.2 protocol via the Ethernet port. *Table I.3* shows the associated Ethernet port settings.

Table I.3 SEL-735 Ethernet Port Settings for Synchrophasors

Setting	Description	Default
EPMIP[a]	Enable PMU sessions (0–2)	0[b]
PMOTS1	PMU output 1 transport scheme (OFF, TCP, UDP_S, UDP_T, UDP_U)	OFF
PMOIPA1	PMU output 1 client IP (remote) address (www.xxx.yyy.zzz)	192.168.1.3

Setting	Description	Default
PMOTCP1[c]	PMU output 1 TCP/IP (local) port number (1–65534)	4712
PMOUDP1[d]	PMU output 1 UDP/IP data (remote) port number (1–65534)	4713
PMOTS2	PMU output 2 transport scheme (OFF, TCP, UDP_S, UDP_T, UDP_U)	OFF
PMOIPA2	PMU output 2 client IP (remote) address (www.xxx.yyy.zzz)	192.168.1.4
PMOTCP2[e]	PMU output 2 TCP/IP (local) port number (1–65534)	4722
PMOUDP2[f]	PMU output 2 UDP/IP data (remote) port number (1–65534)	4713

[a] Invalid if ECWSIP > 0.
[b] Set EPMIP > 0 to enable other settings in this group.
[c] Hidden if PMOTS1 = UDP_S.
[d] Hidden if PMOTS1 = TCP.
[e] Hidden if PMOTS2 = UDP_S.
[f] Hidden if PMOTS2 = TCP.

Definitions follow for the settings in *Table I.3*.

PMOTS1 and PMOTS2

PMOTS1 and PMOTS2 select the PMU output transport scheme for session 1 and 2, respectively.

- PMOTS*n* := OFF disables the connection.
- PMOTS*n* := TCP establishes a single, persistent TCP socket for transmitting and receiving synchrophasor messages (both commands and data), as illustrated in *Figure I.4*.

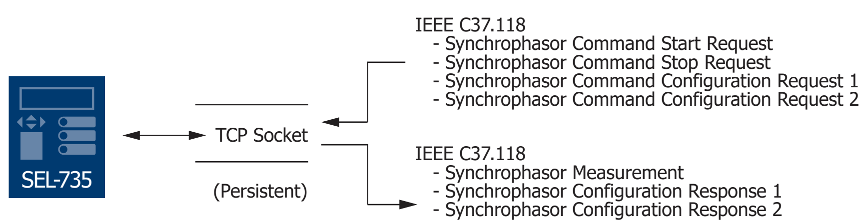


Figure I.4 TCP Connection

- PMOTS*n* := UDP_T establishes two socket connections. A nonpersistent TCP connection is used for receiving synchrophasor command messages as well as synchrophasor configuration and header response messages. A persistent UDP connection is used to transmit synchrophasor data messages. *Figure I.5* depicts the UDP_T connection.

➤ PMOTS*n* := UDP_U uses the same connection scheme as the UDP_T except the synchrophasor configuration and header response messages are sent over the UDP connection, as shown in *Figure I.5*.

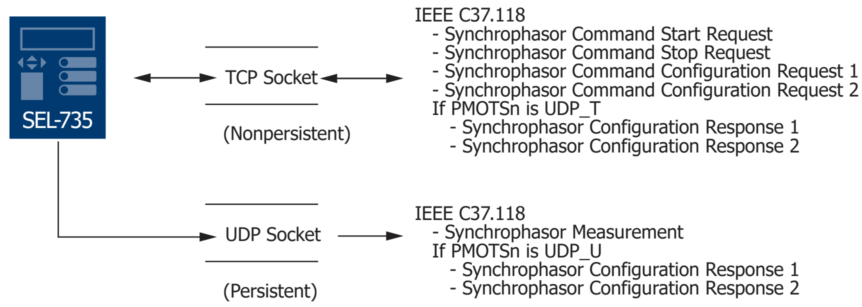


Figure I.5 UDP_T and UDP_U Connections

➤ PMOTS*n* := UDP_S establishes a single persistent UDP socket to transmit synchrophasor messages. With this communications scheme, the meter sends a `Synchrophasor Configuration Response 2` once every minute, as shown in *Figure I.6*.

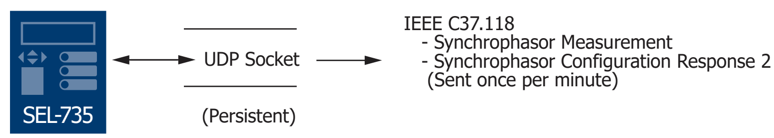


Figure I.6 UDP_S Connection

When PMOTS ≠ UDP_S, the SEL-735 does not begin transmitting synchrophasors until it receives a start data command from the synchrophasor processor. The meter stops synchrophasor transmission when it receives the stop data command from the synchrophasor processor. The SEL-735 only responds to configuration block request messages when it is in the non-transmitting mode.

When PMOTS = UDP_S, the SEL-735 transmits synchrophasors upon startup, automatically sends configuration frames every minute, and does not process any synchrophasor commands.

The SEL-735 will meet the message latency requirements specified in section 5.5.9 of IEEE C37.118.1 when PMOTS = UDP_S, UDP_T, or UDP_U.

Synchrophasor Device Word Bits

Table I.4 and *Table I.5* list the SEL-735 Device Word bits that are related to synchrophasor measurement. The Synchrophasor Trigger Device Word bits in *Table I.4* follow the state of the SELogic control equations of the same name, listed at the bottom of *Table I.1*. These Device Word bits are included in the IEEE C37.118 synchrophasor data frame STAT field.

Table I.4 Synchrophasor Trigger Device Word Bits

Name	Description
PMTRIG	Trigger (SELogic)
TREA4	Trigger Reason bit 4 (SELogic)
TREA3	Trigger Reason bit 3 (SELogic)

Name	Description
TREA2	Trigger Reason bit 2 (SELOGIC)
TREA1	Trigger Reason bit 1 (SELOGIC)

The Time Synchronization Device Word bits in *Table I.5* indicate the present status of the timekeeping function of the SEL-735.

Table I.5 Time Synchronization Device Word Bits

Name	Description
IRIGOK	Asserts while meter time is based on IRIG-B time source.
TSOK	Time Synchronization OK. Asserts while time is based on an IRIG-B time source of sufficient accuracy for synchrophasor measurement.
PMDOK	Phasor measurement data OK. Asserts when the SEL-735 is enabled and able to produce Synchrophasor data. A few seconds may be necessary for PMDOK to assert when the meter is first turned on, after any of the settings are changed, or when an IRIG-B time signal is first connected.

View Synchrophasors Using the MET PM Command

The **MET PM** ASCII command provides a means to view a SEL-735 synchrophasor measurement over a serial or Telnet connection.

There are multiple ways to use the **MET PM** command:

- ➤ As a test tool, to verify connections, phase rotation, and scaling
- ➤ As an analytical tool, to capture synchrophasor data at an exact time, to compare this information with similar data captured in other phasor measurement unit(s) at the same time
- ➤ As a method of periodically gathering synchrophasor data through a communications processor

The **MET PM** command displays the same set of analog synchrophasor information, regardless of the General settings PHDATAV and PHDATAI. The **MET PM** command functions even when the SEL-735 is not equipped with an Ethernet port, or when IEEE C37.118.2 is not set up on an Ethernet port.

The **MET PM** command provides an extended feature set by matching the synchrophasor and analog quantity scaling with the SEL-735 global analog quantity scaling settings such as primary/secondary and unity, kilo, and mega multipliers.

The **MET PM** command only operates when the SEL-735 is connected to a high-accuracy time source, as indicated by Device Word bit TSOK = logical 1.

Figure I.7 shows a sample **MET PM** command response. The command response is also available via the **HMI > Meter PM** menu in ACSELERATOR QuickSet SEL-5030 Software, and has a similar format to *Figure I.7*.

The **MET PM** *time* command schedules the SEL-735 to display the synchrophasor measurement at a specified time, in 24-hour format. For example, entering the command **MET PM 10:57:59** results in a response similar to *Figure I.7* with the time stamp 10:57:59.000. For the **MET PM** time response to transmit over a port, the port must not have timed out at the time when the scheduled command runs. To later retrieve the results of a scheduled command, use the **MET PM HIS** command.

```
=>MET PM <Enter>

FEEDER 1                         Date: 02/06/15    Time: 10:57:59.000
STATION A                                          Time Source: ext


                                                                  PMDOK = 1
Time Quality   Locked to IRIG                                      TSOK = 1
Synchrophasors

                     Phase Voltages                      Pos. Seq. Voltage
                 VA          VB          VC                           V1
MAG ( V)       3599.16     3599.05     3599.06                     3599.09
ANG (DEG)       -44.42     -164.43       75.56                      -44.43

                     Phase Currents                      Pos. Seq. Current
                 IA          IB          IC          IN               I1
MAG (A)         149.96      149.99      149.97        0.74           149.97
ANG (DEG)        15.57     -104.43      135.56       66.07            15.57

FREQ (Hz)                    60.000
Rate-of-change of FREQ (Hz/s) 0.01

Analogs
   W3_HALF_CYCLE              809595.06            (W)
   S3_HALF_CYCLE             1618808.00            (VA)
   Q3_HALF_CYCLE            -1401818.50            (VAR)
              IA               149.9571            (A)

Digitals

SV01    SV02    SV03    SV04    SV05    SV06    SV07    SV08
  0       1       0       0       0       0       0       0
SV09    SV10    SV11    SV12    SV13    SV14    SV15    SV16
  0       0       0       0       0       0       0       0
```

Figure I.7 Sample MET PM Command Response

IEEE C37.118.2 Synchrophasor Protocol

The SEL-735 complies with IEEE Standard for Synchrophasor Data Transfer for Power Systems, IEEE C37.118.2-2011. The protocol is available on the Ethernet port (Port 1).

NOTE

The SEL-735 takes exception to two requirements in this standard related to the STAT field:

1. The configuration change bit asserts after a configuration change, not one minute prior to a configuration change.

2. The trigger bits are completely user-defined, not preset as specified in the standard.

This section highlights some of the important features and options of the protocol that are available in the meter.

Settings Affect Message Contents

Select how often to transmit the synchrophasor messages (MRATE) and which phasors to transmit (PHDATAV and PHDATAI).

The meter can include as many as four user-programmable analog quantities in the synchrophasor message, as controlled by General setting NUMANA, and 0 or 16 digital status values, as controlled by General setting NUMDSW.

The SEL-735 always includes the results of four synchrophasor trigger reason bits (TREA1–TREA4), and the PMU trigger (PMTRIG) in the synchrophasor message.

Protocol Operation

The SEL-735 only transmits synchrophasor messages over the Ethernet port if PMOTS1 or PMOTS2 ≠ OFF. The connected device is typically a synchrophasor processor, such as the SEL-3373. The synchrophasor processor controls the PMU functions of the SEL-735 with IEEE C37.118 commands, including commands to start and stop synchrophasor data transmission, and commands to request a configuration block from the meter, so the synchrophasor processor can automatically build a database structure. The SEL-735 indicates in the configuration change bit when a configuration change occurs, so the synchrophasor processor can request a new configuration block and keep its database up-to-date.

Content of IEEE C37.118.2 Data Packets

Synchrophasors are transmitted in the order indicated in *Table I.6* from the top to the bottom of the table. Real values are transmitted first, and imaginary values are transmitted second.

Table I.6 Synchrophasor Order in Data Stream (Voltages and Currents in PHASORS Field)

Synchrophasors[a] Rectangular Format (Real, Imaginary) 32-Bit Floating Point Format	Included When Settings Are as Follows:
IAPM IBPM ICPM INPM	PHDATAI := PH or ALL
VAPM VBPM VCPM	PHDATAV := PH or ALL (if meter is Form 9 or Form 36)
VABPM VBCPM VCAPM	PHDATAV := PH or ALL (if meter is Form 5)
I1PM	PHDATAI := I1 or ALL
V1PM	PHDATAV := V1 or ALL

[a] Synchrophasors are transmitted as primary rms values with unity scaling. The meter uses settings CTR and PTR to scale the values.

APPENDIX J

Continuous Waveform Streaming

Overview

The SEL-735 can stream time-synchronized 3 ksps voltage and current samples via the Continuous Waveform Streaming (CWS) protocol. It supports unidirectional responseless streaming of data through separate configuration and data frames. The device can provide two UDP streams for redundancy. This protocol cannot be enabled at the same time as synchrophasors. The Continuous Waveform Streaming protocol is available with the purchase of a device software bundle or as a standalone meter upgrade.

The availability of an accurate time reference over a large geographic area allows multiple devices, such as SEL-735 meters, to synchronize the gathering of power system waveforms. CWS is still output if the high-accuracy time source is not connected. The Device Word bits TSOK and PMDOK both assert when the meter is synchronized to a high-accuracy time source.

The SEL-735 time-stamps voltage and current measurements. Each sample is an instantaneous point on the raw measured waveform with no scaling applied. The protocol includes the values of the PTR and CTR settings. The receiver must scale the measurements.

CWS can be used in applications such as the following:

- Real-time power system oscillography monitoring
- Continuous waveform recording
- Software-based metering and calculations

The Port 1 Ethernet settings group configures CWS communications. See *Ethernet Port Settings on page 530* for more information.

Prerequisites

The SEL-735 supports Continuous Waveform Streaming through an Ethernet port. CWS is only available on intermediate and advanced power quality meters, and must be purchased via the Continuous Waveform Streaming option in the communications part number configuration.

SEL recommends the following to ensure an optimal configuration for CWS:

- Connect the SEL-735 to a high-accuracy IRIG clock with low jitter and an absolute time accuracy of 1 µs or better. Under these conditions, the Device Word bits TSOK, TIRIG, and PMDOK assert.
- Maintain current and voltage magnitudes within the measurement ranges defined in the SEL-735 specifications.
- Ensure synchrophasors are disabled.
- Set UTC_OFF to match the UTC offset of the IRIG signal.

Ethernet Port Settings

Continuous Waveform streaming is available via the Ethernet port. *Table J.1* shows the associated Ethernet port settings.

Table J.1 Ethernet Port Settings for Continuous Waveform Streaming

Setting	Description	Default
ECWSIP	Enable CWS sessions (0–2)	0[a]
CWSOIPA*x*	CWS output client IP (remote) address (www.xxx.yyy.zzz)	192.168.1.2
CWSOUDP*x*	CWS Output UDP/IP data (remote) port number (1–65534)	4073

[a] Set ECWSIP > 0 to enable other settings in this group. To enable ECWSIP, EPMIP must be set to 0.

Protocol Specifications

This section highlights the protocol specifications. The SEL-735 only enables Continuous Waveform Streaming if ECWSIP is greater than or equal to 1.

Waveforms

Continuous waveforms are transmitted in the order indicated in *Table J.2* from the top to the bottom of the table. If the meter is in form 9 or form 36, the device will stream line-to-neutral voltages. If the meter is in form 5, the device will stream line-to-line voltages.

Table J.2 Waveforms

3 ksps Waveforms	Units	Description
IA	A	Phase A, Current, Instantaneous
IB	A	Phase B, Current, Instantaneous
IC	A	Phase C, Current, Instantaneous
VA (form 9 and 36) or VAB (form 5)	V	Phase A or AB, Voltage, Instantaneous
VB (form 9 and 36) or VBC (form 5)	V	Phase B or BC, Voltage, Instantaneous
VC (form 9 and 36) or VCA (form 5)	V	Phase C or CA, Voltage, Instantaneous

Configuration and Data Frames

CWS is a low-overhead protocol based on the IEEE C37.118 and COMTRADE standards. It supports unidirectional responseless streaming of data through separate configuration and data frames. The receiver monitors for configuration frames, then parses all following data messages that share a ChannelID with a known configuration frame.

Table J.3 Configuration Frame

Field	Size (Bytes)	Type	Comment
FrameID	2	Uint16	Frame type designation and protocol version. (version 1)
Size	4	Uint32	Total number of bytes that follow, not including FrameID and Size fields. (63 bytes + number of bytes in ChannelName)
ChannelID	8	Uint64	Device Serial Number and stream index.
PktCount	2	Uint16	Used to identify changes to the configuration. Starts at 0, increments when changed.
NumAnalogs	2	Uint16	Number of analog values per SampleSet. 4 byte int32 values. Analogs are as defined in *Table J.2*.
NumDigitals	2	Uint16	Number of digitals per SampleSet. Grouped in blocks of 16 into a Uint16. This value is always zero.
SampleRate	4	Int32	A value of 3000 to indicate 3 ksps fixed sample rate.
Scalars	4 * NumAnalogs	Float32 array	One scalar per analog signal. PTR or CTR * Analog to calculate scaled value.
ChannelName	2-21	String	Set to the value of the TID setting.
SignalNames	21	String	NumAnalogs as defined in *Table J.2*.

Table J.4 Data Frame

Field	Size (Bytes)	Type	Comment
FrameID	2	Uint16	Frame type designation and protocol version. (version 1)
Size	4	Uint32	Total packet size not including FrameID and Size fields. (1218 bytes)
ChannelID	8	Uint64	Device Serial Number and stream index.
PktCount	2	Uint16	Continuously increments once per packet.
Timestamp	8	Int64	Nanoseconds since Epoch in UTC.
SampleSets	1200	Byte array	50 samples in chronological order.

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APPENDIX K

Cybersecurity Features

Access Control

The SEL-735 meter has several mechanisms for managing electronic access. These include ways to limit access, provide for user authentication, and monitor electronic and physical access.

Physical Port Controls

Each physical serial port and the Ethernet port can be individually disabled using the EPORT setting. By default, all the ports are enabled. It is good security practice to disable unused ports.

IP Ports

When using Ethernet, there are several IP ports available within the SEL-735. Many of these IP port numbers are configurable. All IP ports can be disabled. *Table K.1* describes each of these.

Table K.1 IP Port Numbers

IP Port Default	Port Selection Setting	Network Protocol	Default Port State	Port Enable Setting	Purpose
21	--	TCP	Disabled	EFTPSERV	FTP protocol access for file transfer of settings and reports
23	TPORT	TCP	Enabled	ETELNET	Telnet access for general engineering terminal access
102	--	TCP	Disabled	E61850	IEC 61850 MMS for SCADA functionality
123	SNTPPORT	UDP	Disabled	ESNTP	SNTP time synchronization
502	--	TCP	Enabled	EMOD	MODBUS for SCADA functionality
4712/4713	PMOTCP1/ PMOUDP1	TCP/UDP	Disabled	PMOTS1	Synchrophasor data output, Session 1
4722/4713	PMOTCP2/ PMOUDP2	TCP/UDP	Disabled	PMOTS2	Synchrophasor data output, Session 2
4703	CWSOUDP1	UDP	Disabled	ECWSIP	Continuous Waveform Streaming data output port, Session 1
4703	CWSOUDP2	UDP	Disabled	ECWSIP	Continuous Waveform Streaming data output port, Session 2

IP Port Default	Port Selection Setting	Network Protocol	Default Port State	Port Enable Setting	Purpose
20000	DNPNUM	TCP/UDP	Disabled	EDNP	TCP and UDP to listen for incoming DNP requests
20000	DNPUDP/ DNPUDP2/ DNPUDP3/ DNPUDP4/ DNPUDP5	UDP	Disabled	EDNP	Response port for UDP responses for each possible DNP session

Authentication and Authorization

The SEL-735 supports four levels of access, Access Level 1, Access Level E, Access Level 2, and Access Level C, as described in *Access Levels on page 47*. Refer to this section to learn how each level is accessed and how to change passwords. It is good security practice to change the default passwords of each access level and to use a unique password for each level.

The MAXACC setting limits the level of access for each port. This permits you to operate under the principle of least privilege, restricting ports to the levels necessary for the functions performed on those ports. For example, Port 1 can be set to Access Level 2, whereas Port 2 can be set to Access Level 1.

The SEL-735 supports strong passwords with as many as eight characters, using any printable character, allowing users to select complex passwords if they so choose. SEL recommends including at least one of each of the following: lowercase letter, uppercase letter, number, and special character.

Ethernet protocols Telnet and FTP require the proper passwords to gain access to level-protected functions. Ethernet protocol MMS requires a password to gain access if MMS authentication is enabled via the CID file. See *Section 8: Communications* for more information on access restrictions for the Ethernet protocols.

Monitoring and Logging

The SEL-735 provides the SALARM Device Word bit for monitoring meter access. SALARM pulses for approximately one second whenever a user gains access to Level 2 or higher, when an incorrect password is entered, or when a setting is changed.

This bit can be mapped for SCADA monitoring via DNP3, IEC 61850, Modbus, or SEL Fast Message. It can also be added to the SER for later analysis or assigned to output contacts for alarm purposes.

The SEL-735 SER is a useful tool for capturing a variety of meter events. In addition to capturing state changes of user-selected Device Word bits, it captures all power-ups and settings changes. See *Sequential Events Recorder (SER) Report on page 239* for more information about SER.

The audit log function tracks activity on the SEL-735, capable of storing 72,000 records. It is intended to allow for auditing of several functions initiated when a user changes select items on the meter. The **LOG** command is only available on the ASCII terminal in ACSELERATOR QuickSet SEL-5030 Software and displays the list of activities from the system log in chronological order. This includes all categories listed in *Table 8.13*. See *Audit Log Command on page 292* for details about using the audit log function.

Network Access Security

Network access of cybersecurity assets must be managed with the utmost level of scrutiny. Communications to the SEL-735 should be restricted to a trusted network that is isolated from the internet and protected behind a firewall. Network access to the device should be limited to only those strictly necessary for operation, and any unused protocols available via Ethernet Port 1 should be disabled. It is crucial to never expose any critical infrastructure equipment to the internet.

Physical Access Security

Physical security of cybersecurity assets is a common concern. SEL-735 meters can be installed within a control house that provides physical security. Sometimes, meters are installed in panels or enclosures within the switchyard. The SEL-735 provides tools to help manage physical security, especially when the unit is installed in the switch yard.

Physical ingress can be monitored by wiring a door sensor to one of the SEL-735 contact inputs. This input can then be mapped for SCADA monitoring and added to the SER log so that you can monitor when physical access to the meter occurs.

It is also possible to wire an electronic latch to an SEL-735 contact output. You could then map this output for SCADA control.

Configuration Management

The SEL-735 provides mechanisms to help users manage meter configuration. All settings changes are logged to the SER log. Analysis of this log indicates if any unauthorized settings changes occurred. The SALARM Device Word bit also indicates changes in the meter configuration by pulsing for approximately one second when any of the following occur:

- Settings are changed or saved
- A password changes
- A login attempt fails
- Access level changes to Access Level 2 or higher

See *Meter Self-Tests on page 331* for more information regarding the Device Word bit SALARM.

QuickSet Device Manager allows users to compare and version new settings against known valid settings. The Device Manager Compare/Merge feature can compare setting from multiple meters against a known valid template. This feature is useful for changing settings on existing meters and setting up new devices to ensure secure configuration.

See *Compare Using Device Manager* in *Section 4: Asset Management Using Device Manager* of the ACSELERATOR QuickSet SEL-5030 Instruction Manual for more information regarding the Compare/Merge feature of Device Manager.

The SEL-735 can be paired with physical sealing covers to prevent unauthorized access to the meter. The physical sealing covers, in combination with a wire seal, show evidence of tampering if unauthorized access is attempted. These covers are available for both front and rear-panel protection.

Malware Protection

The SEL-735 has inherent and continuous monitoring for malware. For a full description of this, see *selinc.com/mitigating_malware/*.

Security Vulnerabilities

If SEL finds a security vulnerability with the SEL-735, it will be disclosed using our standard security notification process. Visit *selinc.com/support/security-notifications/* for more a full description of this process.

Settings Erasure

NOTE
Do not erase the settings when sending the meter to SEL for service. SEL needs to be able to see how the meter was configured to properly diagnose any problems.

It is often desirable to erase the settings from the meter when the meter is removed from service. You can completely erase all the configuration settings from the SEL-735 by using this procedure:

Step 1. Go to Access Level C. See *Access Levels on page 47*.

Step 2. Execute the **R_S** command.

Step 3. Allow the meter to restart.

Once this procedure is complete, all internal instances of user settings and passwords return to default. Metering data is also erased.

Glossary

A Abbreviation for Amps or Amperes; unit of electrical current flow.

a Output A meter control output that closes when the output meter asserts.

Acceptance Testing 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.

Access Level 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.

Access Level 0 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.

Access Level 1 A meter command level you use to monitor (view) meter information. The default access level for the meter front panel.

Access Level 2 The most secure access level, from which you have total meter functionality and control of all settings types.

Access Level E 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.

ACSELERATOR QuickSet SEL-5030 Software A Windows-based program that simplifies settings and provides analysis support.

Analog Quantities Variables represented by such fluctuating measurable quantities as frequency, current, and voltage.

AND Operator Logical AND. An operator in Boolean SELOGIC control equations that requires fulfillment of conditions on both sides of the operator before the equation is true.

Anti-Aliasing Filter A low-pass filter that blocks frequencies too high for the given sampling rate to accurately reproduce.

Apparent Power (S) 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.

ASCII 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.

ASCII Terminal A terminal without built-in logic or local processing capability that can only send and receive information.

Assert 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.

AT Modem Command Set Dialing String Standard 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.

Automatic Messages 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 Output A meter control output that opens when the output meter asserts.

Bandpass Filter A filter that passes frequencies within a certain range and blocks all frequencies outside this range.

Bit Label The identifier for a particular bit.

Bit Value Logical 0 or logical 1.

Blondel's Theorem 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.

Boolean Logic Statements Statements consisting of variables that behave according to Boolean logic operators such as AND, NOT, and OR.

c Output A breaker auxiliary contact that you can set to serve either as an a contact or as a b contact.

Checksum 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.

CID Checksum identification of the firmware.

Class Designation 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.

Cold Start Beginning a system from application of power without carryover of previous system activities.

Commissioning Testing 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.

Common Inputs Meter control inputs that share a common terminal.

Communications Protocol A language for communication among devices.

Comparison 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.

Conditioning Timers 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.

Contact Input See Control Input.

Contact Output See Control Output.

Control Input Meter inputs for monitoring the state of external circuits. Connect auxiliary meter and circuit breaker contacts to the control inputs.

Control Output Meter outputs that affect the state of other equipment. Connect control outputs and SCADA systems.

Counter Variable or device such as a register or storage location that either records or represents the number of times an event occurs.

CT Current transformer.

CTR Current transformer ratio.

Data Bit 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.

Data Label The identifier for a particular data item.

Data Objects Individual pieces of UCA data created from instances of common class components or data items that are instances of standard data types.

DCE Devices Data communication equipment devices (modems).

Deadband The range of variation an analog quantity can traverse before causing a response.

Deassert 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.

Debounce Time The time that masks the period when meter contacts continue to move after closing; debounce time covers this indeterminate state.

Default Data Map The default map of objects and indices that the SEL-735 uses in DNP protocol.

Delta A phase-to-phase series connection of circuit elements, particularly voltage transformers or loads.

Demand Meter A measuring function that calculates a rolling average, block, or thermal average, block, of instantaneous measurements over time.

Device Word Bit 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.

Dial 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.

Dial Multiplier 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.

Distortion Power Ratio (Dx)

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:

If Px_avg > Px:

$$Dx = \left(\frac{Px\_avg}{Px} - 1\right) 100$$

where:

Dx is the distortion power ratio for the respective phase

Px_avg is the average power for the respective phase

Px is the fundamental power for the respective phase

Else:

$$Dx = 0$$

DMSI Period

The subinterval time of the demand meter time constant in demand metering.

DMTC Period

The time of the demand meter time constant in demand metering.

DNP (Distributed Network Protocol)

Manufacturer-developed, hardware-independent communications protocol.

Dropout Time

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.

DTE Devices

Data terminal equipment (computers, terminals, printers, meters, etc.).

Dumb Terminal

See ASCII terminal.

Earth(ing)

Electrical term to describe the ground or earth as the reference point in an electrical circuit from which voltages are measured. In this manual, the term earth and earthing are used synonymously with ground and grounding, respectively.

EIA-232

Electrical definition for point-to-point serial data communications interfaces, based on the standard EIA/TIA-232. Formerly known as RS-232.

EIA-485

Electrical standard for multidrop serial data communications interfaces, based on the standard EIA/TIA-485. Formerly known as RS-485.

Element

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.

Energy Metering

Energy metering provides a look at imported power, exported power, and net usage over time.

ESD (Electrostatic Discharge)

The sudden transfer of charge between objects at different potentials caused either by direct contact or induction by an electrostatic field.

Ethernet

A network physical and data link layer defined by IEEE 802.2 and IEEE 802.3.

Event History

A quick look at recent meter activity that includes a standard report header, event number, date, time, type, and targets.

Event Report A text-based collection of data the meter stores in response to a triggering condition, such as an ASCII **TRI** command. The data show meter measurements before and after the trigger, in addition to the states of elements each processing interval.

Event Summary 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.

F_TRIG Falling-edge trigger. Boolean SELOGIC control equation operator that triggers an operation upon logic detection of a falling edge.

Fail-Safe 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.

Falling Edge Transition from logical 1 to logical 0.

Fast Meter SEL binary serial port command used to collect metering data with SEL devices.

Fast Operate SEL binary serial port command used to perform control with SEL devices.

Firmware The nonvolatile program stored in the meter that defines meter operation.

Flash Memory A type of nonvolatile meter memory used for storing large blocks of nonvolatile data.

Flicker 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.

Form See Meter Form.

Function Code A code that defines how you manipulate an object in DNP3 protocol.

Fundamental Frequency 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.

Global Settings General settings including those for date format, phase rotation, control inputs, ASCII report scaling, and time and date management.

GPS Global Positioning System. Source of position and high-accuracy time information.

Group Total Harmonic Distortion 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.

GUI Graphical user interface.

Hexadecimal Address A register address consisting of a numeral with an "h" suffix or a "0x" prefix.

HMI Human-machine interface.

IA, IB, IC Measured A-phase, B-phase, and C-phase currents.

IED Intelligent electronic device.

Input Conditioning The establishment of debounce time and assertion level.

Instantaneous Meter 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.

IRIG-B A time-code input that the meter can use to set the internal meter clock.

Jitter Time, amplitude, frequency, or phase-related abrupt, spurious variations in duration, magnitude, or frequency.

K-factor 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.

K_e or KYZ Output Constant A pulse constant for the KYZ outputs of a solid-state meter, programmable in unit-hours per pulse.

K_h or Watt-hour Constant 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_h is essentially meaningless because there is no disk. However, ANSI C12.10 requires that K_h be displayed on the faceplate.

K_t or Test Constant 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.

KYZ Output 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.

L/R Circuit inductive/resistive ratio.

Latch Bits Nonvolatile storage locations for binary information.

LED Light-emitting diode. Used as indicators on the meter front panel.

LMD SEL Distributed Port Switch protocol.

Logical 0 A false logic condition, dropped-out element, or deasserted control input or control output.

Logical 1 A true logic condition, picked-up element, or asserted control input or control output.

Low-Level Test Interface 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.

Maintenance Testing Testing that confirms that the meter is measuring ac quantities accurately and verifies correct functioning of auxiliary equipment and scheme logic.

Math Operators Operators that you use in the construction of math SELOGIC control equations to manipulate numerical values and provide a numerical base-10 result.

Maximum Dropout Time The maximum time interval following a change of input conditions between the deassertion of the input and the deassertion of the output.

Maximum/Minimum Meter 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.

Meter Form 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. The SEL-735 supports Form 5, 9, and 36 and variants that are under 600 V_{LL} (347 V_{LN}) not requiring a PT.

MID 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.

MIRRORED BITS Communications 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.

MMS Manufacturing Messaging Specification. A data exchange protocol used by UCA.

Model Model of device (or component of a device) including the data, control access, and other features in UCA protocol.

Negation Operator A SELOGIC control equation math operator that changes the sign of the argument. The argument of the negation operation is multiplied by –1.

Negative-Sequence A configuration of three-phase currents and voltages. The currents and voltages have equal magnitude, a phase displacement of 120°, 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.

NEMA National Electrical Manufacturers' Association.

NONVOL Nonvolatile memory where the meter stores meter settings, event reports, SER records, and other nonvolatile data.

Nonvolatile Memory Meter memory that persists over time to maintain the contained data even when the meter is de-energized.

NOT Operator A logical operator that produces the inverse value.

Optical Port 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.

OR Operator 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.

Parentheses Operator Math operator. Use paired parentheses to control the execution of operations in a SELOGIC control equation.

PC Personal computer.

Peak Demand Metering 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.

Phase Rotation 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°.

Pickup Time 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.

Pinout The definition or assignment of each electrical connection at an interface. Typically refers to a cable, connector, or jumper.

Port Settings Communications port settings such as Data Bits, Speed, and Stop Bits.

Positive-Sequence 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.

Power Factor 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.

PT Potential transformer. Also referred to as a voltage transformer or VT.

PTR Potential transformer ratio.

Qualifier Code Specifies type of range for DNP3 objects. With the help of qualifier codes, DNP master devices can compose the shortest, most concise messages.

R_TRIG Rising-edge trigger. Boolean SELOGIC control equation operator that triggers an operation upon logic detection of a rising edge.

RAM Random-Access Memory. Volatile memory where the meter stores intermediate calculation results, Device Word bits, and other data.

Reactive Power (Q) 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.

Reactive Power Average (Q_{AVE}) Reactive power (Q) average over a one-second interval. Q_{AVE} is forced to zero when the apparent power (S) is less than or equal to real power (P) • 0.001.

Reactive Power Three Phase (Q3P) Three-phase instantaneous reactive power measured in VAR.

Real Power (P) Power that produces actual work. The portion of apparent power that is real, not imaginary.

Real Power Average (P_{AVE}) Real power averaged over a one-second interval.

Real Power Three Phase (P3P) Three-phase real power measured in watts.

Register 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."

Remapping The process of selecting data from the default map and configuring new indices to form a smaller data set optimized to your application.

Remote Bit A Device Word bit with a state that is controlled by serial port commands, including the **CONTROL** command, a binary Fast Operate command, DNP binary output operation, or a UCA control operation.

Report Settings Event report and Sequential Events Recorder settings.

Residual Current The sum of the measured phase currents. In normal, balanced operation, this current is very small or zero.

Rising Edge Transition from logical 0 to logical 1, or the beginning of an operation.

RMS 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.

Rolling Demand A sliding time-window arithmetic average in demand metering.

RTC Real-Time Clock. Internal clock set by time sets (IRIG, SNTP, etc.) and used to measure time duration and produce time stamps.

RTU Remote terminal unit.

RXD Received data.

SCADA Supervisory control and data acquisition.

Self-Contained Meter 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.

Self-Test 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.

SELOGIC Control Equation 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.

SELOGIC Expression Builder A rules-based editor within QuickSet for programming SELOGIC control equations.

SELOGIC Math Variables Math calculation result storage locations.

Sequencing Timers Timers designed for sequencing automated operations.

Sequential Events Recorder 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.

SER Sequential Events Recorder or the meter serial port command to request a report of the latest sequential events.

Settle/Settling Time Time required for an input signal to result in an unvarying output signal within a specified range.

Stator 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.

Status Failure A severe out-of-tolerance internal operating condition. The meter issues a status failure message and enters a disabled state.

Status Warning 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.

Strong Password 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 lowercase alphabetic characters, "." (period), and "-" (hyphen).

Synchrophasor A phasor calculated from data samples using an absolute time signal. The phasors from remote sites have a defined common phase relationship; also known as synchronized phasor.

Telnet 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.

Terminal Emulation Software Software that can be used to send and receive ASCII text messages and files via a computer serial port.

Thermal Demand Thermal demand is a continuous exponentially increasing or decreasing accumulation of metered quantities; used in demand metering.

Thermal Withstand Capability The capability of equipment to withstand a predetermined temperature value for a specified time.

Time Delay on Pickup The time interval between initiation of a signal at one point and detection of the same signal at another point.

Time-of-Use Metering A metering method that records demand during selected periods of time so consumption during different time periods can be billed at different rates.

Total Harmonic Distortion (THD) 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 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 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	**ACC**	Move to Access Level 1
0	**BNA**	Binary names
0	**CAS**	Compressed ASCII data configuration
0	**DNA**	Compressed names
0	**EXI**	Terminate a Telnet session. Only available when connected via Telnet
0	**ID**	Compressed ASCII Fast Meter ID
0	**QUI**	Quit to Access Level 0
0	**SNS**	Compressed SER settings
1	**2AC**	Move to Access Level 2
1	**CEV**	Compressed event report, 16 samples per cycle
1	**COM**	Display Mirrored Bits channel statistics
1	**COM C**	Reset Mirrored Bits channel statistics
1	**COU**	Display SELogic counters
1	**CHI**	Compressed history
1	**CCR**	Compressed calibration error report
1	**CST**	Compressed status
1	**CTR C [A]**	COMTRADE format event report, config
1	**CTR D [A]**	COMTRADE format event report, data
1	**DAT**	Show date
1	**DNP[*n*]**	Show DNP map
1	**DNP DVAR S**	Show the current analog input variation
1	**DNP DVAR H**	Show the command syntax
1	**EAC**	Move to Energy Access Level
1	**EVE**	Latest event report, 16 samples per cycle
1	**EVE C**	Compressed event report
1	**EVE D**	1/16-cycle resolution Device Word bit data
1	**EVE L, EVE R**	Raw, unfiltered event report
1	**EVE M**	1/16-cycle resolution Mirrored Bits data
1	**FIL DIR**	List all device files and directories
1	**FIL READ**	Transfer settings and other files from meter
1	**FIL SHOW**	Display file contents
1	**GOO**	Display GOOSE transmit and receive information
1	**HIS**	Summary event reports
1	**IRI**	Force synchronize to IRIG

Access Level	Command	Description
1	**LDP[*n*]**	Display report for load profile recorder, where *n* is the LDP recorder number
1	**LOG**	Audit log function
1	**MAT**	Displays results of SELogic math variable equations
1	**MET**	Display fundamental metering data
1	**MET A**	Display aggregated values
1	**MET CF**	Display crest factor quantities
1	**MET CFG**	Display configurable registers values
1	**MET D**	Display compensated demand data
1	**MET D P**	Display compensated peak demand data
1	**MET D P U**	Display uncompensated peak demand data
1	**MET D T**	Display the timestamps of the peak demands
1	**MET D T U**	Display the timestamps of the uncompensated peak demands
1	**MET D U**	Display uncompensated demand data
1	**MET E**	Display energy data
1	**MET FL**	Display flicker data
1	**MET H [E, O]**	Display harmonic data (E = even, O = odd, None = all)
1	**MET H A [E, O]**	Display all harmonic spectral analysis (E = even, O = odd, None = all)
1	**MET H I [E, O]**	Display current harmonic data (E = even, O = odd, None = all)
1	**MET H M [E, O]**	Display harmonic magnitude data (E = even, O = odd, None = all)
1	**MET H P [E, O]**	Display harmonic power data (E = even, O = odd, None = all)
1	**MET H V [E, O]**	Display voltage harmonic data (E = even, O = odd, None = all)
1	**MET L**	Display transformer/line losses
1	**MET M**	Display maximum and minimum values
1	**MET PM**	Display synchrophasor data
1	**MET PM *time***	Display synchrophasor data at time *time*
1	**MET PM HIS**	Display the most recently captured MET PM report
1	**MET RMS**	Display rms metering data
1	**NAG**	Display the Nagle state for YModem file transfers over the Ethernet port
1	**QUI**	Quit to Access Level 0
1	**SER**	Display Sequential Events Recorder records
1	**SHO**	Display settings
1	**SSI**	Display voltage sag/swell/interruption (VSSI) report
1	**STA**	Display self-test status
1	**STA E**	Display EEPROM messages
1	**TAR**	Display Device Word bits
1	**TIM**	Show time
1	**TOG**	Resets NEWEVNT Device Word bit

Access Level	Command	Description
1	**TRI**	Trigger an event
1	**VER**	Display version and configuration information
E	**DAT *date***	Set date
E	**LDP[*n*] C**	Reset load profile recorder, where n is the LDP recorder number
E	**MET CF R**	Clear crest factor metering
E	**MET M R**	Clear max/min metering
E	**MET P R**	Clear peak demand metering
E	**QUI**	Quit to Access Level 0
E	**TIM *time***	Set time
2	**CAL**	Go to Access Level C
2	**CON *x***	Control remote bits *x*
2	**DNP[*n*]**	Show DNP map
2	**DNP DVAR *x***	Set Object 30 default variation to numeric value *x*, 1–5 (see *Table D.10*)
2	**DNP DVAR C**	Resets the Object 30 to default variation 4 and Object 32 to default variation to 2
2	**FIL WRITE**	Write setting files to the meter
2	**FOR *x***	Change meter form, where *x* = 5, 9, or 36
2	**HIS C**	Clear event and history records
2	**L_D**	Load new firmware (this command does not work from the front panel)
2	**LOO**	Initiate/clear Mirrored Bits loopback
2	**MET D R**	Clear demand metering
2	**MET E R**	Reset energy metering
2	**MET FL P *seconds***	Display flicker Pinst value every 1/8th power system cycle for as long as 60 seconds
2	**MET FL R**	Reset flicker metering quantities
2	**NAG [ON, OFF]**	Set the Nagle algorithm state for YModem file transfers over the Ethernet port
2	**PAR**	Display or modify the part number
2	**PAS**	Set passwords
2	**PUL**	Pulse output contact
2	**QUI**	Quit to Access Level 0
2	**SER [C, D]**	Display or clear SER
2	**SET**	Change settings
2	**SSI C**	Clear SSI data (including SSI summary) from the meter
2	**SSI R**	Reset SSI processing
2	**SSI S**	Display SSI summary report
2	**SSI T**	Trigger an event and store SSI data.
2	**TEST AGG**	Capture and display 10/12-cycle data
2	**TEST DB A *name value***	Override analog label name with value in communications interface

Access Level	Command	Description
2	**TEST DB D *name value***	Override Device Word bit name with value in communications interface, where value = 0 or 1
2	**TEST MODE**	Display Test Mode parameters
2	**VER**	Display version and configuration information
SELBOOT	**BAU rate**	Set baud rate to 300, 1200, 2400, 4800, 9600, 19200, 38400 (57600 or 115200 if Port 2 or Port 3) bps
SELBOOT	**BFI**	Display the SELBOOT version
SELBOOT	**ERA**	Erase the existing firmware
SELBOOT	**EXI**	Exit this program and restart the device
SELBOOT	**FID**	Display the firmware identification (FID)
SELBOOT	**HEL**	Print a help list of commands
SELBOOT	**REC**	Receive new firmware for the device by using Xmodem

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0	**SNS**	Compressed SER settings
1	**2AC**	Move to Access Level 2
1	**CEV**	Compressed event report, 16 samples per cycle
1	**COM**	Display Mirrored Bits channel statistics
1	**COM C**	Reset Mirrored Bits channel statistics
1	**COU**	Display SELogic counters
1	**CHI**	Compressed history
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1	**CTR C [A]**	COMTRADE format event report, config
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1	**DAT**	Show date
1	**DNP[*n*]**	Show DNP map
1	**DNP DVAR S**	Show the current analog input variation
1	**DNP DVAR H**	Show the command syntax
1	**EAC**	Move to Energy Access Level
1	**EVE**	Latest event report, 16 samples per cycle
1	**EVE C**	Compressed event report
1	**EVE D**	1/16-cycle resolution Device Word bit data
1	**EVE L**, **EVE R**	Raw, unfiltered event report
1	**EVE M**	1/16-cycle resolution Mirrored Bits data
1	**FIL DIR**	List all device files and directories
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1	**FIL SHOW**	Display file contents
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1	**MET A**	Display aggregated values
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1	**MET CFG**	Display configurable registers values
1	**MET D**	Display compensated demand data
1	**MET D P**	Display compensated peak demand data
1	**MET D P U**	Display uncompensated peak demand data
1	**MET D T**	Display the timestamps of the peak demands
1	**MET D T U**	Display the timestamps of the uncompensated peak demands
1	**MET D U**	Display uncompensated demand data
1	**MET E**	Display energy data
1	**MET FL**	Display flicker data
1	**MET H [E, O]**	Display harmonic data (E = even, O = odd, None = all)
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1	**MET H M [E, O]**	Display harmonic magnitude data (E = even, O = odd, None = all)
1	**MET H P [E, O]**	Display harmonic power data (E = even, O = odd, None = all)
1	**MET H V [E, O]**	Display voltage harmonic data (E = even, O = odd, None = all)
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1	**MET M**	Display maximum and minimum values
1	**MET PM**	Display synchrophasor data
1	**MET PM *time***	Display synchrophasor data at time *time*
1	**MET PM HIS**	Display the most recently captured MET PM report
1	**MET RMS**	Display rms metering data
1	**NAG**	Display the Nagle state for YModem file transfers over the Ethernet port
1	**QUI**	Quit to Access Level 0
1	**SER**	Display Sequential Events Recorder records
1	**SHO**	Display settings
1	**SSI**	Display voltage sag/swell/interruption (VSSI) report
1	**STA**	Display self-test status
1	**STA E**	Display EEPROM messages
1	**TAR**	Display Device Word bits
1	**TIM**	Show time
1	**TOG**	Resets NEWEVNT Device Word bit

Access Level	Command	Description
1	**TRI**	Trigger an event
1	**VER**	Display version and configuration information
E	**DAT *date***	Set date
E	**LDP[*n*] C**	Reset load profile recorder, where n is the LDP recorder number
E	**MET CF R**	Clear crest factor metering
E	**MET M R**	Clear max/min metering
E	**MET P R**	Clear peak demand metering
E	**QUI**	Quit to Access Level 0
E	**TIM *time***	Set time
2	**CAL**	Go to Access Level C
2	**CON *x***	Control remote bits *x*
2	**DNP[*n*]**	Show DNP map
2	**DNP DVAR *x***	Set Object 30 default variation to numeric value *x*, 1–5 (see *Table D.10*)
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2	**MET E R**	Reset energy metering
2	**MET FL P *seconds***	Display flicker Pinst value every 1/8th power system cycle for as long as 60 seconds
2	**MET FL R**	Reset flicker metering quantities
2	**NAG [ON, OFF]**	Set the Nagle algorithm state for YModem file transfers over the Ethernet port
2	**PAR**	Display or modify the part number
2	**PAS**	Set passwords
2	**PUL**	Pulse output contact
2	**QUI**	Quit to Access Level 0
2	**SER [C, D]**	Display or clear SER
2	**SET**	Change settings
2	**SSI C**	Clear SSI data (including SSI summary) from the meter
2	**SSI R**	Reset SSI processing
2	**SSI S**	Display SSI summary report
2	**SSI T**	Trigger an event and store SSI data.
2	**TEST AGG**	Capture and display 10/12-cycle data
2	**TEST DB A *name value***	Override analog label name with value in communications interface

Access Level	Command	Description
2	**TEST DB D *name value***	Override Device Word bit name with value in communications interface, where value = 0 or 1
2	**TEST MODE**	Display Test Mode parameters
2	**VER**	Display version and configuration information
SELBOOT	**BAU rate**	Set baud rate to 300, 1200, 2400, 4800, 9600, 19200, 38400 (57600 or 115200 if Port 2 or Port 3) bps
SELBOOT	**BFI**	Display the SELBOOT version
SELBOOT	**ERA**	Erase the existing firmware
SELBOOT	**EXI**	Exit this program and restart the device
SELBOOT	**FID**	Display the firmware identification (FID)
SELBOOT	**HEL**	Print a help list of commands
SELBOOT	**REC**	Receive new firmware for the device by using Xmodem